Final report

EU Water saving potential (Part 1 –Report)

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The views set out and the analysis presented are those of the authors and do not necessarily represent the views of the Commission in general or of DG Environment.

1 Executive Summary

In recent years, a growing concern has been expressed throughout the EU regarding drought events and water scarcity. For an increasing number of EU Member States not limited anymore to Southern Europe as it was traditionally the case, the occurrence of seasonal or longer term droughts and water scarcity situations have become a noticeable reality in recent years.

In order to support the European Commission in the preparation of a Communication on water scarcity and droughts, a study was commissioned to assess the EU water saving potential.

The study addresses the savings that can by achieved via technical measures without major changes in human behaviour or production patterns. Furthermore, it looks towards instruments such as water pricing, drought management plans or labelling that can foster the implementation of these measures.

This report concentrates on the four main water users, namely public water supply (including households), agriculture, industry and tourism. It is based on a large literature review and data synthesis of existing studies and experiences of water savings in Europe but also outside Europe (e.g. Australia). This literature review is complemented by four detailed case studies in Spain, Greece, the UK and France that illustrate the feasibility of implementation and likely impacts of potential water savings measures.

The study has revealed high data gaps and data uncertainty in estimating today’s water abstraction and consumption, current applications of water saving technologies or future trends in water consumption and withdrawals. Thus, results presented in this report provide an order of magnitude of the water saving potential at EU level but detailed figures should be used with caution. In addition, a detailed analysis at river basin level would be necessary to take into account the regional specificities of water uses.

Key findings

Total water abstraction in the European Union (EU 27) amounts to about 247 000 million m³/year. On average, 44% of total water abstraction in EU is used for energy production, 24% for agriculture, 17% for public water supply and 15% for industry.

As regards **public water supply** (including households, public sector and small businesses), the reduction of leakage in water supply networks, water saving devices and more efficient household appliances have the potential for up to 50% water savings. These water saving technologies are easy to introduce and implement and they also have short payback periods, further enhancing their uptake possibilities. Applying the above mentioned measures would allow for a reduction in water consumption from 150 litres/person/day (average in the EU) to a low 80 litres/person/day. A similar reduction could be applied to public water supply, leading to an estimate of potential saving up to 33% of today’s abstraction.

In **agriculture**, water savings can be carried out with improvements in irrigation infrastructure and technologies. Potential water savings resulting from improvements in the conveyance efficiency of irrigation systems ranges between 10 to 25% of their water withdrawals. Water savings resulting from improving application efficiency are estimated at 15% to 60% of water use. Additional water savings can be expected from changes in irrigation practices (30%), use of more drought-resistant crops (up to 50%) or reuse of treated sewage effluent (around 10%). The potential water savings in the irrigation sector would amount to 43% of the current agricultural volume abstracted.

Industries that use large amounts of water include the paper & pulp, textile, leather (tanning), oil and gas, chemical, pharmaceutical, food, energy, metal and mining sub-sectors. Based on the examples found the application of technical measures (e.g. changes in processes leading to less water demand, higher recycling rates or the use of rainwater) can lead to estimated savings between 15 and 90% with an global estimate up to 43% of today's water abstraction. A particular sub-sector of industry is electricity production. Electricity production uses large quantities of water for abstracting fuel and for cooling purposes in thermoelectric power plants. However, as usually a large proportion of the water abstracted in the energy sector flows back to the local environment, the benefits of water saving in this sector is marginal; therefore the global estimate of the total EU water saving potential does not involve this sector.

The **tourism sector** can represent a key water user in some areas of Europe. Technical water saving measures for the tourism sector are similar to those for households. The sector has the potential to increase water use efficiency significantly by installing newer appliances in guest rooms, cafe areas, kitchens, etc. Since some of the measures identified in the report show a potential for a maximum of 80-90% savings, tourist accommodations could considerably reduce costs by buying more efficient appliances that only have payback periods of 3 years or less. In the case of irrigation of golf courses and sporting areas, more efficient irrigation techniques or rain water harvesting could provide additional savings up to 70%.

Clearly, the potential water saving volumes estimated are large and stress the potential for policy action at EU level.

Water savings will help addressing water scarcity and droughts. They will also deliver financial and economic benefits. Such benefits include delayed or avoided procurement of additional water supply infrastructures, reduction in sewage and wastewater treatment capacity or reduced water bills. Further water saving can also bring environmental benefits beside reduced stress in a river basins such as reduced fertiliser use, reduce soil erosion and leaching. It should be noted however that “net” water savings leading to environmental improvements in the status of aquatic ecosystems will only be achieved if all water saved in one sector is not used elsewhere by the same or another sector! Last but not least, water savings will also bring additional ancillary benefits, for example by reducing energy consumption, electricity bills and thus CO_2 emissions – thus contributing to climate change strategies and policy actions.

2 General Introduction and aim of the study

Due to the increase in droughts and long-term imbalances of water supply in Europe, concern about water availability and the need for water saving in Member States has been rising. Awareness of the need for sound water quantity management has slowly been mounting in the recent years. Member States called for a more concrete European Action to deal with and prevent these issues. An in-depth assessment was carried out by the European Commission in October 2006, in which the principle sectoral water users were identified; the extent water scarcity and drought issues impact the economy, society, and the environment was studied; and possible gaps in the implementation of existing EU policy instruments were highlighted. This assessment revealed that current water management practices have a large margin for improvement, especially with respect to water saving potential.

But what is the true potential for water saving in the European Union? No comprehensive effort has been made so far at EU level to find out this information. Yet, this information is needed to take decisions about the future activities with respect to droughts and water scarcity.

Without information on the potential for water saving, questions about future industrial and agricultural production, ecosystem restoration, immigration policy, land use and urban growth will be much harder to answer, or, worse, the answers provided will be wrong.

As a result of this assessment, the European Commission realised the need to explore possible suggestions and measures to be taken, to address water scarcity and droughts. A Communication was adopted on 18 July 2007 by the Commission and the supportive Impact Assessment assessing the different cost and benefits of the various measures to achieve water savings should provide a starting point for water saving on the EU scale.

In this context, this project supports the IA of the Communication by analysing and quantifying the EU water saving potential by 2030. In order to assess all possibilities for water savings, the main sectors using water (Agriculture, Tourism, Households, Energy, and Industry) were identified and analysed. By comparing possible water savings to a “no policy change” scenario, water saving strategies for various regions and needs were assessed, taking climate change into account. Within these assessments, economic, social and environmental impacts (costs and benefits) of the water saving options were considered. Potential overlaps in implementing options at the same time were also identified. Additionally, each measure was quantified for its water saving potential, expressed in volume and monetary terms.

Conclusions from this study offer practical tools for the development of a European strategy for water savings, by avoiding overexploitation, non-conventional water production and promoting integrated water saving measures on a regional scale.

3 Definition of water saving and methodology for calculating savings

3.1 Definition of main terms

Water saving is considered as one measure to avoid water scarcity and to improve aquatic ecosystems in the European Union[1]. However up to now there has been no concretised definition for the term *water saving*. In order to set up an appropriate definition for the purpose of the study, some additional terms have to be clarified:

- Water demand/use means the total volume of water needed to satisfy the different water services[2], including volumes 'lost' during transport, for example leaks from pipes and evaporation.
- Water supply satisfies the water demand by providing water from various sources. This can be by withdrawals from natural hydrological regime in the river basin (surface and groundwater abstraction), rain water harvesting, water imports from other river basins and non-conventional production of water. Non-conventional sources of water include: (i) The production of freshwater by desalination of brackish water or saltwater; and (ii) The reuse of urban or industrial waste waters (with or without treatment), which increases the overall efficiency of use of water (extracted from primary sources). They are accounted for separately from natural renewable water resources[3].
- Water abstraction, is the process of taking water from a natural hydrological regime (ground or surface water) either temporarily (e.g. for cooling purpose) or permanently (e.g. for drinking water).
- Rain water harvesting is the process of collecting, diverting and storing rainwater from an area (usually roofs or another surface catchment area) for direct or future use. It does not reduce the demand, but it can reduce the water abstraction needs. For further details see Annex I.
- Water reuse is the use of former wastewater that has been treated and purified for reuse, rather than discharged into a body of water. Water reuse also does not reduce the demand, but it can reduce the water abstraction needs. It should be noted that the reuse of water might be limited in some cases because of quality issues and that the quality of water reused must be adapted to the end-use.
- Water consumption can be defined as Water abstracted which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, consumed by man or livestock, ejected directly into sea, or otherwise removed from freshwater resources. Water losses during transport of water between the points or points of abstractions and point or points of use are excluded.[4].

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1 European Commission, Water scarcity drafting Group (2006): Water scarcity Management in the context of the WFD, Policy Summary.

2 In this study water service refers to water supply and waste water removal.

3 http://www.fao.org/ag/agl/aglw/aquastat/water_res/indexglos.htm.

4 http://glossary.eea.europa.eu/EEAGlossary/W/water_consumption.

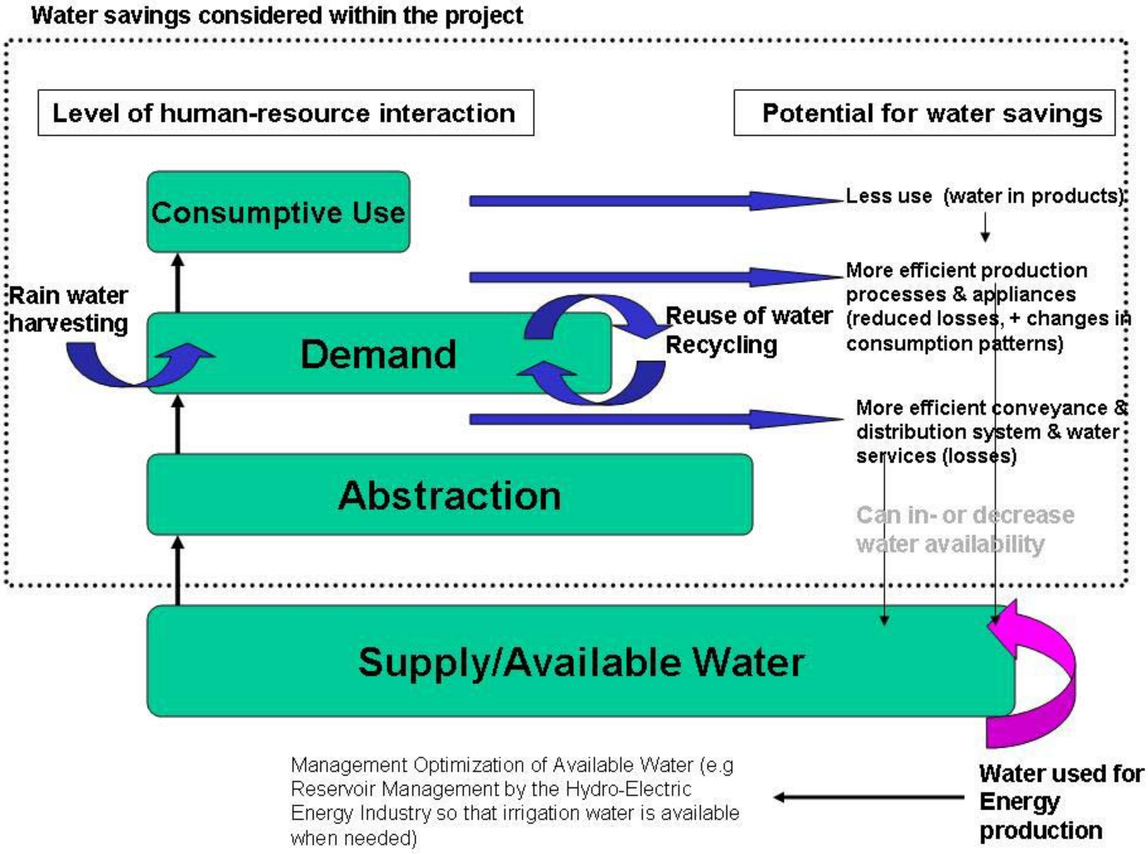

Figure 1: The concept of water saving

Having the above mentioned definitions in mind, water saving can be defined as the reduction of the total water supply needs within a river basin[5]. It is important to consider the river basin approach, as in several cases water is saved in one area or by one sector but used further downstream or by a different sector. This has to be considered as a "dry" saving that, at the end of the basin, does not reduce the total supply needs. Dry savings just shift the supply needs from one sector or region to another, because any water saved is already committed for use by a downstream user.

In comparison, "wet" savings are those that effectively lead to changes in supply needs and can reduce water scarcity. In this context, it should be noted that unconventional production of water or water transfers cannot be considered as water saving measures. Such measures increase the supply within a river basin by providing additional waters from outside the basin.

Measure to save water can be taken on the supply (e.g. abstraction permissions), demand (e.g. reduce leakages) or consumption side (e.g. reduce the water in certain products). It can be achieved by improving the efficiency of various uses of water without decreasing services or by cutting back the use of a resource, even if that means cutting back the goods and services produced by using that resource.

These measures can follow multiple approaches towards water savings, namely:

- Technical measures – like water saving devices, water flow meters;
- Economic instruments – pricing, charges, but also new allocation mechanisms;

[5] Plan Bleu (no year) Part 2, Six Sustainability Issues, Chapter Water, available at http://www.planbleu.org/red/pdf/Partie2-Eau_uk.pdf.

- Institutional changes to accompany the implementation of measures;
- Information measures- like public awareness campaigns;
- Regulatory changes – like abstraction limits, changes in water rights.

As mentioned before, many technologies and policies are available for reducing water use. In this context, the theoretical maximum water-use efficiency occurs when society actually uses the minimum amount of water necessary to do something. In reality, however, this theoretical maximum efficiency is rarely, if ever, achieved or even computed because the technology is not available or commercialised, the economic cost is too high, or societal or cultural preferences rule out particular approaches.

When applying water saving measures on the demand side, the interconnections in the hydrological cycle – between upstream and downstream, but also between ground and surface water - should be considered. For example, an irrigated area with surface irrigation shifting to drip irrigation can be considered as a water saving measure, as it reduces losses and increases irrigation efficiency. However, if some users are pumping groundwater that is recharged from these irrigated areas, improving efficiency will reduce pressure on the surface system but will reduce recharge to groundwater, thus possibly imposing new constraints on groundwater users. Indeed, water lost in one area might be used further downstream, which needs to be accounted for.

3.2 Methodology to calculate EU water savings

As previous mentioned the main aim of this study is to calculate the EU water saving potential and to analyse the cost and benefits of different water saving measures. In order to achieve this aim, several methodologies have been applied. These are in particular:

- Due to the short time given there was no time for collecting primary data. So information was obtained from published literature (for example, national state of the environment reports and reports produced by international organisations such as Eurostat and the Food and Agriculture Organization),
- In order to illustrate the different measures for water saving among the four sectors assessed several examples from in and outside the EU have been collected. These illustrations are captured in small boxes. As far as information was available a reference to costs and benefits was made.
- The overall water saving potential has been calculated sector specific. Chapter 5 explains the different calculation methods in detail.
- Detailed assessment of four case studies.

3.2.1 Limitations of the methodologies

The “true” potential for EU wide water savings will always be uncertain, because of wide variations in national/ regional water use, prices, efficiency technologies, and many other factors. As a result, the estimates provided here should be used with caution and an understanding that they are only as good as the assumptions and methods used to develop them.

This report is based on information derived from a variety of national and international publications, studies, yearbooks and databases. The compiled data, however, is variable depending on the sources considered. This is especially true for data related to water abstraction and sectoral use. In the various countries considered different definitions of the concepts analysed and different ways of establishing and structuring records obviously exist.

For example, there are different approaches to the definition of urban water use (also described as Public Water Supply) with regards to the inclusion of municipal water use and of industries supplied through the urban network. Similarly the definition of industrial use may vary between countries, for example by including in the industrial share the use of cooling water for thermal and nuclear power plants and the water used for hydroelectric power production, which could as well be counted in the energy sector. Efforts of harmonising the concepts of different water uses and streamlining the corresponding records are still ongoing. Until a higher degree of harmonisation and data coverage is reached the available data should be interpreted with great care.

Therefore it is urged that these kinds of estimates are also carried out on the local and regional level –especially in water scarce areas and those that are facing droughts -, where uncertainties and data problems may be more readily resolved.

- The common measure of how much water we withdraw for a task does not tell us how much water is actually delivered to the point of use.
- The amount of water used to provide goods or services tells nothing about how much water is actually required to produce those things.
- Research and data are available telling us how much water is used to flush a toilet, or produce a computer chip, or grow cotton in California's Central Valley, but very little research has been done to tell us the minimum amount of water required to flush human wastes down a toilet, or to produce a chip, or to grow a crop of cotton.

3.2.2 Data gaps and uncertainties

The use of water varies greatly from country to country and from region to region. Data on water use by regions and by different economic sectors are among the most sought after in the water resources area. Ironically, these data are often the least reliable and most inconsistent of all water-resources information[6]. The availability of good data directly aggregated at the EU level or even at national level was a major constraint to carry out a comprehensive assessment of water saving potential. It has been stated before by other studies that reliable and comprehensive data on water supply and demand is hard to come by[7]. In the following these data limitations throughout the report are highlighted and explained. Further, several problems are related to a very inhomogeneous different data sets. They come from a wide variety of sources and are collected using a wide variety of approaches, with few formal standards. The data also come from different years, making direct intercomparisons difficult. It is important to consider these gaps and uncertainties related to the existing data in order to see the figures presented in the following in the right context.

In the following data gaps and major uncertainties for each sector are displayed:

Households

- Residential landscape area is highly uncertain;
- Residential and commercial landscape water use is poorly understood or measured;
- Distribution of residential water-using appliances, by type and use, is not well known;

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[6] Gleick, P.H. (2006): Table 2: Freshwater Withdrawal, by Country and Sector (2006 Update). Available at http://www.worldwater.org/data.html.

[7] Gleick, P.H.; Burns, W.C.G., Chalecki, E. L.; Cohen, M.; Cushing, K.; Cao, M., Amar, R; Wolff, R. Gary H.; Wong, A. (2002): The World's Water 2002–2003: The Biennial Report on Freshwater Resources, Washington, D.C.: Island Press; Boberg, Jill (2005): Liquid Assets: how demographic changes and water management policies affect freshwater resources, Compton Foundation.

- Application of existing saving techniques is unknown;
- Changes in Behaviour are hardly to estimate but consist of a high saving potential.

Industry

- Water consumption and demand varies widely among the different subsectors;
- Rates of industrial water reuse are poorly reported;
- Current application of water saving measures are mostly unknown.

Agriculture

- Uncertainty about flow returns that are essentials to convert gross-dry water saving to net-wet savings;
- Some case studies show that the skills of the farmers have the highest impact on yield and water use efficiency i.e. more that the irrigation system itself. This is not straight forward to modelise;
- The variable with greater impact in water use is cropping pattern and the evolution of cropping pattern in Europe is subject to uncertainty due to the forthcoming debates on the agricultural policy and World Market scenarios (e.g. evolution in crop prices for food and bioenergy);
- The future impact of energy crops cultivation is unknown;
- Scenarios for future crop pattern and changes in extension of cultivated area (irrigated and rain fed) are subject to great uncertainty;
- Heterogeneity (depending on soil conditions and agricultural practices) for estimate real water saving;
- Uncertainty of the values of water saving efficiency on improved irrigation systems;
- Gaps regarding the data of water use for agricultural purposes e.g. some vague data on real value of groundwater abstraction and recharge;
- With regard to the national syntheses of the Article 5 reports submitted so far, a number of unregulated activities of water abstraction and their impacts are not known but might be significant in certain cases[8];
- Information on efficiency rates of different irrigation systems in the Member States are often unknown or not up to date.

Tourism

- Current water consumption and use;
- Total number of tourists, hotel, camping sites and other tourist facilities is only roughly estimated at the EU level;
- The application of water saving measures in tourism sector is quite unknown;

[8] Water Research Centre (WRc) (2005): Review of the Article 5 Report for agricultural pressures, MS summary report, on behalf of the Environment Directorate General of the European Commission, draft report, April 2005.

- Future development of the sector.

In addition to these sector specific data also the information on future water demand and the uptake of water saving techniques is quite uncertain (see section 4.2)

4 Where Are We Today? Current EU water abstraction and uses

Analysing and comparing information on abstraction and use of water in different countries is problematical because often times the data from different sources do not correspond with one another. Although data are normally consistent, there are also numerous cases in which the information given is clearly contradictory[9].

Total water abstraction in the European Union (EU 27) amounts to about 247 020 Million m³/year (see Table 1).

Table 1: Sectoral use of water in Europe[10]

Member States	Total abstraction (10^6 m³ /year)	Urban (10^6 m³ /year)	Industry (10^6 m³ /year)	Agriculture (10^6 m³ /year)	Energy (10^6 m³ /year)
AT	3 366	603	1 217	100	1 851
BE	7 228	720	1 249	23	5 132
DE	40 364	5 557	5 603	616	25 026
DK	634	423	53	322	6.3
ES	26 054	3 840	743	21 338	6 253
FI	2 408	402	1 566	50	241
FR	29 820	5 812	3 583	3 120	18 488
GR	8 907	872	110	7 700	89
IE	11 76	470	250	-	282
IT	56 200	10 116	9 554	25 852	7306
LU	66	38	14	-	-
NL	3 994	1 245	46	76	6 190
PT	9 883	759	373	8 767	1 285
SE	2 688	923	1 406	150	108
UK	15 895	6 250	1 621	1 896	-
Total EU15	**208 683**	**38 030**	**27 388**	**70 010**	**72 257**
BG	5 833	1 075	300	865	4 433
CY	175	39	4	122	-
CZ	1 839	777	349	12	570
EE	1 471	71	27	36	1 089
HU	5 591	746	228	502	-
LT	2 768	127	57	53	3 045
LV	258	17	43	47	20.6
MT	17	20	0.4	7	-

[9] European Environment Agency (EEA) (1999): Sustainable water use in Europe. Part 1: Sectoral use of water. EEA, Copenhagen.

[10] Data from NEWCRONOS, Eurostat, (2002) supplemented by projections conducted by the Water Research Centre (WRc)

PL	11 599	2 218	646	1 033	6 727
RO	7 343	2 462	916	1 018	2 423
SI	304	220	85	0.2	-
SK	1 139	395	642	70	-
New MS	**38 337**	**8 167**	**3 297**	**3 765**	**18 308**
Total EU 27	**247 020**	**46 197**	**30 685**	**73 775**	**90 565**

The principal source of abstracted freshwater in Europe is surface water, with the remainder coming from groundwater sources [11] and minor contributions from desalination of seawater (in Spain and Cyprus). However, between 2000 and 2004 alone three major desalination plants were installed in Spain with a combined capacity of 157.7 mio. m^3 per year (Gleick et al. 2007)[12], and this amount can easily increase in the future. It should also be noted, however, that there is a reversal trend in the use of non fresh water sources (Marine and brackish water) in Bulgaria, where the amount was reduced from 710.8 mio. m^3 per year in 1990 to 370.9 mio. m^3 per year in 2003[13].

The Dobris Assessment[14] revealed that over the two decades from 1970 to 1990 total water abstraction generally increased in Europe (Figure 2). This trend, however, masked great variability between countries. During that time, abstraction increases were particularly marked in southern European countries, as well as in the majority of countries in eastern and western Europe; more water was abstracted in the late 1980s than in any time period before. Stabilisation or even a decrease in abstraction did occur by mid 1990 in some of these countries, including Austria, Bulgaria, The Netherlands and Switzerland. This was also the case in the Nordic countries: Sweden and Finland.

[11] European Commission (2006): Working Paper on Water Scarcity and Droughts

[12] Gleick, P.H.; Burns, W.C.G., Chalecki, E. L.; Cohen, M.; Cushing, K.; Cao, M., Amar, R; Wolff, R. Gary H.; Wong, A. (2002): The World's Water 2002–2003: The Biennial Report on Freshwater Resources, Washington, D.C.: Island Press

[13] Eurostat data on Other sources of water (mio m3/year).

[14] European Environment Agency (1995): Europe's Environment - The Dobris Assessment, available: http://reports.eea.europa.eu/92-826-5409-5/en

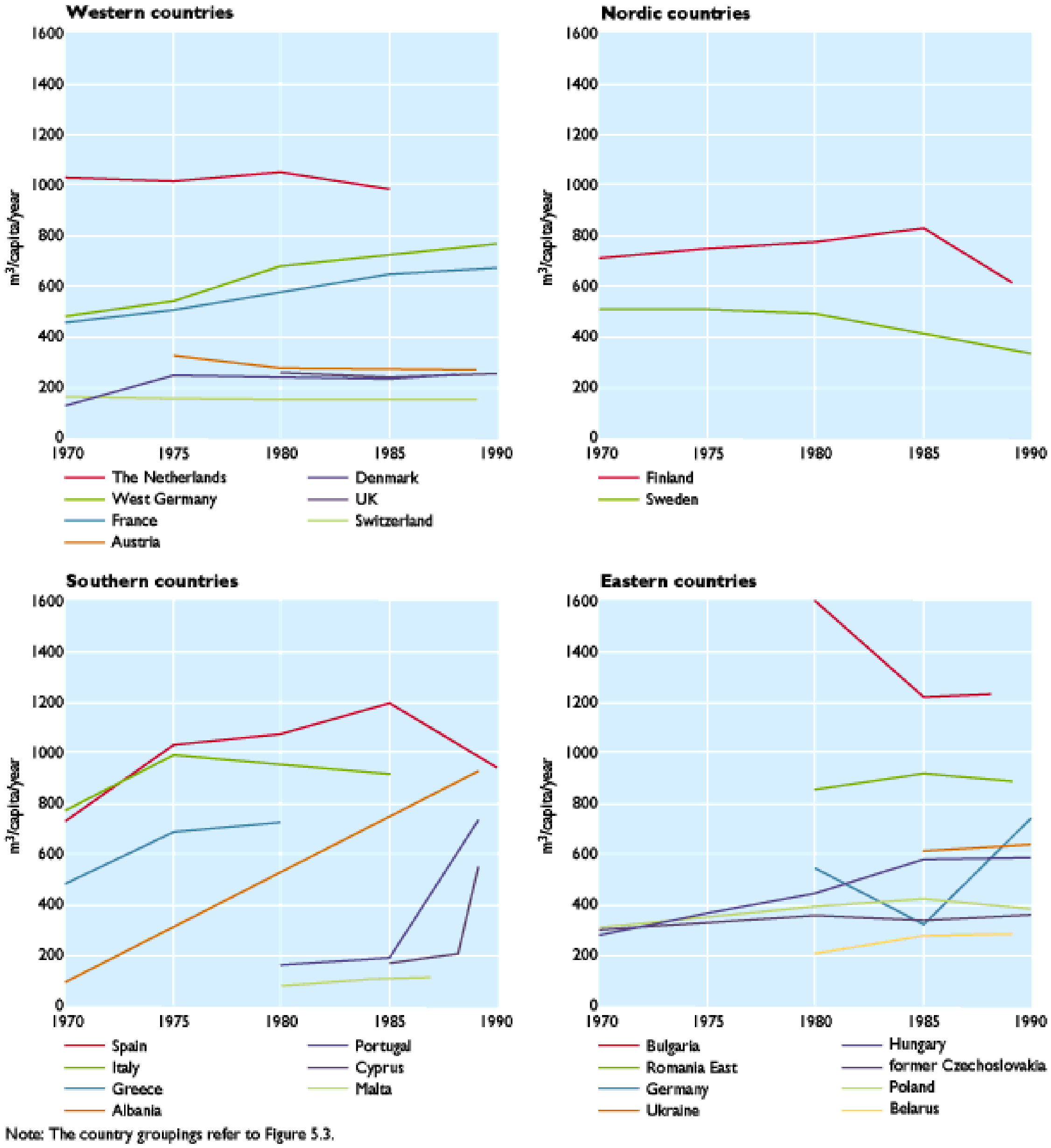


Figure 2: Total water abstraction between 1970 and 1990 in Europe[15]

Recent data indicate that this trend has continued, and total water abstraction has now also decreased in the eastern and southern European countries (Figure 3), which has lead to an overall decrease on the European scale of more than 10%, according to the data available.

[15] European Environment Agency (1995): Europe's Environment - The Dobris Assessment, available: http://reports.eea.europa.eu/92-826-5409-5/en

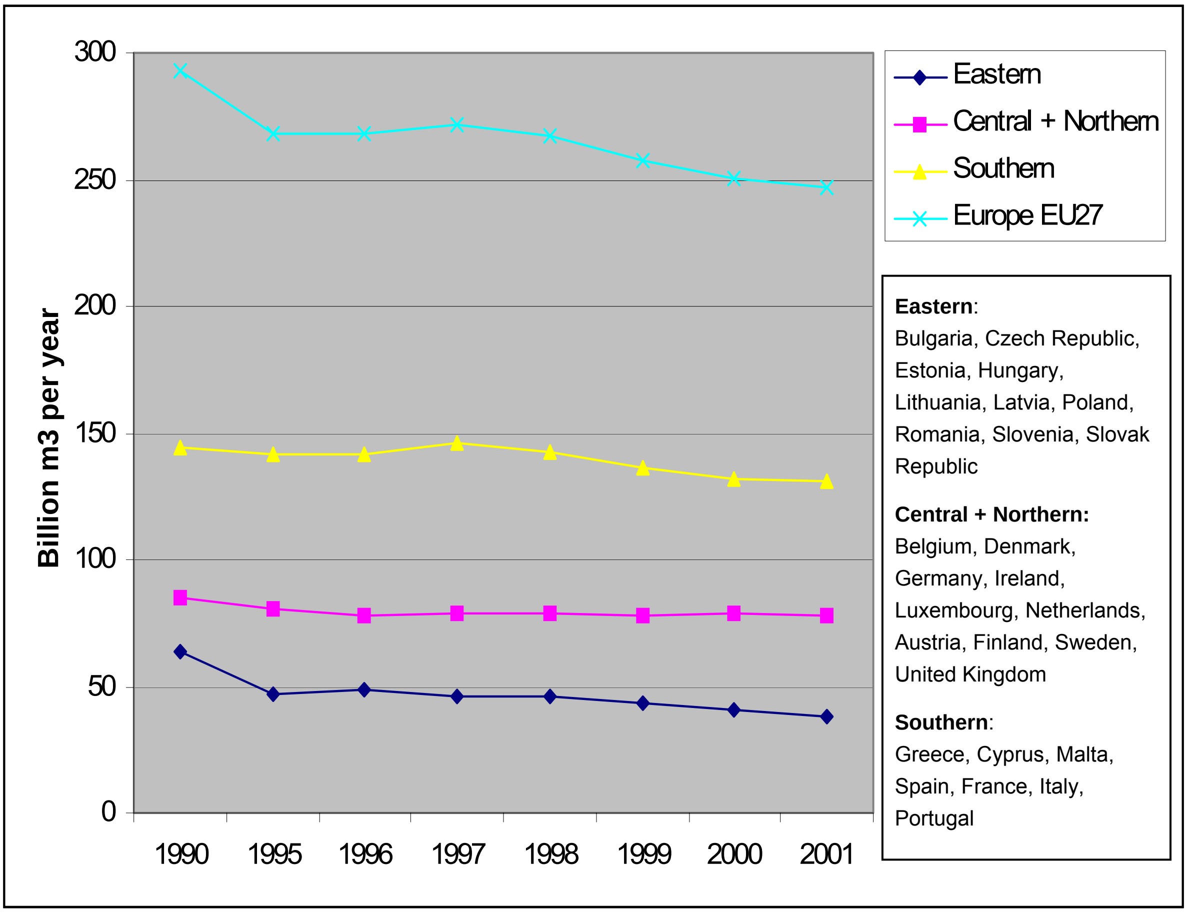
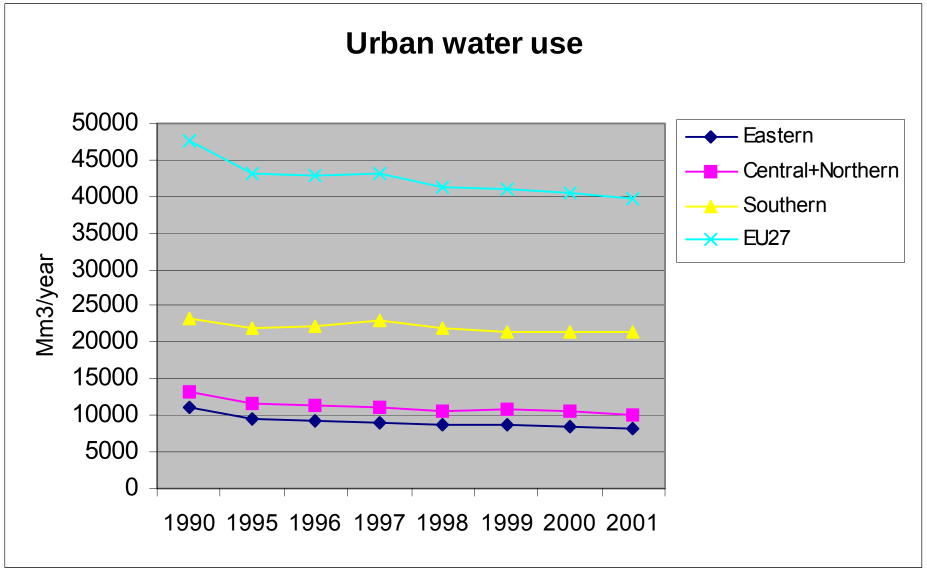


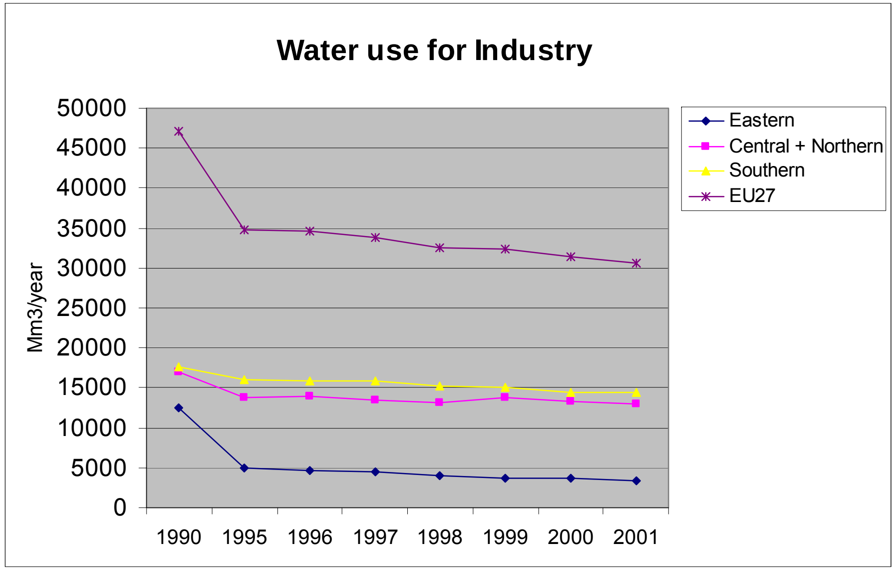
Figure 3: Total water abstraction between 1990-2001 in Europe[16]

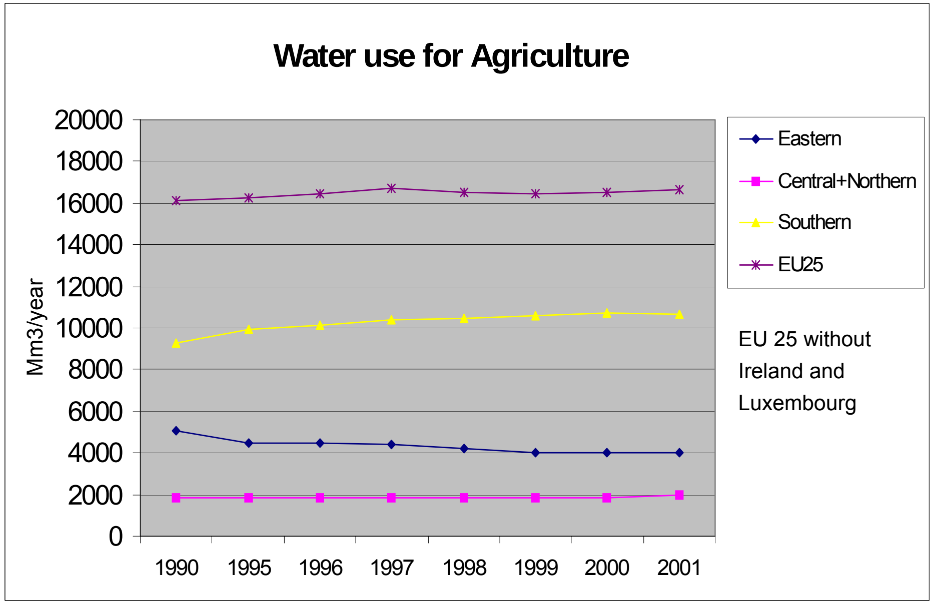
4.1 Sectoral water use

Table 1 also shows the water abstraction per sector. The amount of water abstracted per sector does not always sum up to the total abstraction for each country. This indicates again that data provided by the countries are of different quality and it is likely that the interpretation of water abstraction for different sectors might also vary between states.

[16] Data from NEWCRONOS, Eurostat, (2002) supplemented by projections conducted by the Water Research Centre (WRc)







Note:

Eastern: Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, Slovak Republic

Central + Northern: Belgium, Denmark, Germany, Ireland, Luxembourg, Netherlands, Austria, Finland, Sweden, United Kingdom

Southern: Greece, Cyprus, Malta, Spain, France, Italy, Portugal

Figure 4: The development of sectoral water use (based on Eurostat)

As indicates, each of the three sectors has developed differently. There was a downwards trend in urban and industry sector water use between 1990 and 2001. This trend in urban consumption can be explained due to an increased application of water saving technologies in the central, northern and southern countries. In the eastern EU countries, the new economic conditions after 1990 led to water supply companies increasing the price of water and installing water meters in houses, which resulted in people using less water. These new economic conditions also explain the drastic reduction in industrial water use between 1990 and 1995, when industrial production collapsed in the eastern European countries or was replaced by more efficient technologies.

In comparison, the agricultural sector clearly shows an upward trend in water use. However, this upward trend is mainly driven by southern countries, as eastern countries show a declining line and central and northern European countries remain almost stable.

No trend graph could be produced for the energy sector because there are too many data gaps over the years for the different regions considered.

4.2 Future developments of EU water demand and savings “no policy change” scenario

4.2.1 General Assumptions

This chapter presents estimations how the water demand could evolve in the future (up to 2030) assuming that no public policy changes are instituted. It is based on a study carried out on behalf of the EEA[17] and presents quantitative scenarios of future water use up to 2030 in 30 European countries (the EU plus 5 EEA member countries), including some additional assumptions regarding biomass and CAP development. The European Outlook on Water Use report assessed four sectors, namely industry, electricity production, agriculture and the domestic sector. Tourism is not considered, but it can be assumed that parts of its use are covered within the domestic sector. The main assumptions developed by the European Outlook on Water Use are described in the following sections in order to prepare a solid basis for the detailed scenarios in section 4.2.7. Furthermore, the assumptions made in the European Outlook on Water Use are supplemented by additional assumptions resulting from recent policy developments. These are, in particular, the effects of the latest CAP reform in 2003 and potential pressures from the new European Biomass policy. In both cases, uncertainties are rather high and the influences on water demand are currently considered as rather low (see section 4.2.3).

Predicting the future is always a difficult task, especially in cases of strong independencies between sectors and high variations across Europe. Therefore, the assumptions below are subject to high uncertainties. However, the European Outlook on Water Use report represents the most compressive study on future water use in Europe and, therefore, gives an indication of how water use in Europe might develop if no further action is taken.

4.2.2 Household sector

Water use in the household sector will strongly be influenced by EU population development and the way of live. The European Union’s population is set to grow just slightly up until 2025 due to immigration, before starting to drop: 458 Million m^3 in 2005, 469.5 Million m^3 in 2025 (+ 2%), then 468.7 Million m^3 in 2030 (+ 1,1%)[18].

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[17] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

[18] European Commission (2005): Communication from the Commission - Green Paper “Confronting demographic change: a new solidarity between the generations, ”COM(2005) 94 final.

Changes in lifestyle are contributing to the rise in resource use. People are increasingly living in individual households, which tend to be less efficient, requiring more resources per capita than larger households. As has already been mentioned, a 2-person household uses 300 litres of water per day, 2 single households use 210 litres each[19].

Domestic water use may also be affected by climate change, since rising temperatures may increase water use for garden watering and personal hygiene. Although no evidence is available for an overall climate-related trend in the past, domestic water use is sensitive to changes in temperature and rainfall. Kindler and Russell (1984)[20] observed that residential water use is inversely correlated with rainfall and positively correlated with average temperature[21]. A correlation between temperature and domestic water use has also been shown by several studies for the US, particularly for periods of peak demand[22]. A statistical analysis of water use in New York City showed that when daily temperatures are above 25°C, per-capita water use increases by 11 litres per 1°C (roughly 2% of current daily per-capita use)[23].

4.2.3 Agricultural sector

When considering agriculture impacts on water resources, three important trends have to be considered:

Biomass Production

With respect to agriculture, it is necessary to mention that the important issue of biomass production for energy purposes is not deeply considered. Growing bioenergy crops on agricultural land can create additional pressure on water resources, as bioenergy crops optimised for rapid growth generally consume more water than natural flora or many food crops do. The Commission's Biomass Action Plan expects a potential increase of energy crops from agriculture from 2 Mtoe in 2003 to 102-142 Mtoe in 2030[24].

Currently little information is available on how growing biomass for energy purpose will influence water demand in Europe. A first indication is given by Fraiture, C. et al (no year)[25], who estimated the water withdrawal for irrigation of energy crops at around 1% in 2030. Even if this amount of irrigation for biofuel crops will be negligible, in some regions biomass might put additional pressure on water. Some biomass crops /e.g. sugarcane) compete directly

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19 European Commission (2005): Commission staff working Document, Annex to the communication from the Council and the European Parliament on Thematic Strategy on the Urban Environment Impact Assessment, {COM(2005) 718 final}.

20 Kindler, J.; Russell, C. (eds). (1984): Modeling Water Demand. Academic Press, New York.

21 Quoted in Feenstra, J.F.; Burton, I.; Smith, J. B.; Tol, R.S.J. (1998): Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies. UNEP/IVM.

22 RFF – Resources for the Future (1997): Climate Issues Brief No. 3. Water Resources and Climate Change. Kenneth Frederick. http://www.rff.org/Documents/RFF-CCIB-03.pdf.; Illinois University (2002): Predictive Models of Water Use: an analytical bibliography. Research Report of the Department of Geography, Department of Economics, Southern Illinois University Carbondale, Carbondale, IL 62901, February, 2002.; Gutzler, D.S.; Nims, J.S. (2005): Interannual Variability of Water Demand and Summer Climate in Albuquerque, New Mexico. Journal of Applied Meteorology 44, p. 1777-1787.

23 Intergovernmental Panel on Climate Change (IPCC) (2007): Fourth Assessment Report. WGII – Climate Change Impacts, Adaptation and Vulnerability.

24 European Commission (2005): Biomass action plan, COM (2005) 628 final{SEC(2005) 1573} Brussels, 7.12.2005.

25 Fraiture, C.; Giordano, M.; Yongsong, L. (no year) Biofuels: implications for agricultural water use.

with food crops for irrigation water. Others have been observed to lower the water table, reduce stream yields and make wells less reliable. Certain practices, such as harvesting residues, cultivating tree crops without undergrowth, and planting species, which do not generate adequate amounts or types of litter, can reduce the ability of rainfall to infiltrate the soil and replenish groundwater supplies, exacerbating problems of water over-consumption[26].

It is important to better understand the relationship between the growing biomass demand and water use in Europe in order to avoid water scarcity in the future.

Effects of the latest CAP reform and future CAP development

The CAP reform of June 2003 introduced the possibility for Member States to dissociate agricultural subsidies from the production level. The main idea behind "decoupling" under the new single farm payment scheme (SPS) is to continue with income support to the agricultural community with less or no effects on what and how much is produced[27]. The solution proposed, in economic theory, is lump-sum transfers, which would not give rise to welfare losses, as opposed to the effects of price support or input based subsidies[28]. Such a fully decoupled policy does not influence production decisions by the farmers and permits free market determination of prices. In other words, a farmer who received a larger entitlement in the past for a particular type of production (e.g. for irrigated land or maize) would no longer be obliged to continue with this favoured type of production in order to take advantage of the higher payments. The farmer's decision on what to produce would be based more on the economics of the market than by any obligation established by the CAP[29].

With the introduction of the single payment system, Member States may opt for full **decoupling**, as described above, or its partial implementation in order to combat the abandonment of land (**partial decoupling**). In the case of partial decoupling, aid will be paid to farmers partly as a single payment (independent of production volume) and partly as an additional payment (dependent on the output produced). For arable crops, Member States may allocate per hectare payments up to 25% of the total amount or up to 40% if they decide to retain the additional premium for durum wheat. For other products, different regulations exist. It can be expected that in the future the option for partially decoupling will be removed and all agricultural products will be fully decoupled by 2012. Until then, partly decoupled CAP payments will influence the decision making process on what to produce on a farm level.

At this stage, only little knowledge on the effects from decoupling is available[30]. From an initial rough assessment,[31] full decoupling may lead to changes in farming practice. These

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[26] Kartha, S (2006): Environmental Effects of Bioenergy, In Bioenergy and Agriculture, Promises and challenges, Focus 14 • Brief 4 of 12 • December 2006, available at http://www.ifpri.org/2020/focus/focus14/focus14_04.pdf.

[27] The CAP also aims to help farmers, via rural development measures, to adjust their businesses and land management methods to changing agricultural practices and to society's demands. Agricultural and rural development policy increasingly includes individuals and groups, other than farmers, who are active in rural areas.

[28] Andersson, F.C.A (2004): Decoupling: The concept and past experiences, available at http://www.sli.lu.se/IDEMA/WPs/IDEMA_deliverable_1.pdf..

[29] Interwies, E; Dworak, T.; Görlach, B.; Best, A. (2006): WFD and Agriculture Linkages at the EU Level, Final Paper about Incentive water pricing and cost recovery in the WFD Elements for linking EU Agricultural and Water Policies.

[30] ACTeon (2007): Draft workshop proceedings of the workshop. How can economics best support water policy decision making?, Taking stock of the first years of WFD implementation, Ungersheim (France), May 2 to 4, 2007.

changes may vary widely and are expected to be greatest in less favoured areas. Nevertheless, on a regional basis and within specific catchments, decoupling could probably lead in some cases to more intensive practices[32], resulting in no reduction in water use (see box below.)

Illustration 1

Impact of CAP reform on water consumption in south west of France33

The simulation of CAP reform impacts was undertaken on the irrigated area of the Neste river system, a relatively well known irrigated perimeter of 80 000 ha in the south west of France. Main irrigated crops are maize (66%), soybean (17%) and pea (9%). In order to characterise the agricultural production system, 11 categories of farming systems were defined.

A model of farming strategies has been elaborated for each category, with an objective towards maximisation of the farm income. After calibration of this model, the impacts of two scenarios were simulated: decoupling at 75% (partly decoupling) and full decoupling of subsidies.

As a main result there is no reduction of total water use induced by decoupling at 75%. Irrigated area shows a decrease reaching 5 to 30% depending on the production. Irrigated area of seeds crop, which generate highest added value, does not change. Thus, decoupling induces an intensification of irrigation. Before 2003 reform, subsidies coupled to cultivated area encouraged farmers to sow larger superficies to activate this land linked subsidy, even by risking a lack of water. Decoupling system offers an income warranted whatever the area sown. Farmers prefer not to risk water shortages, which is why they reduce irrigated area but maximise the water applied on this area. Remaining area can be sown with rainfed crops (wheat, sunflower). Full decoupling seems to entail a larger reduction of irrigated area (15 to 30%), with a slight reduction of water consumption.

Regarding the water price impact on water, demand shows that partial decoupling (75%) decreases the threshold price at which level water consumption falls.

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[31] Currently a there is a European Commission's Sixth Framework Programme research project (IDEMA - Contract No SSPE-CT-2003-502171) carried out, aiming to develop methods and tools to provide a comprehensive socio-economic assessment of the impact of decoupling on the EU farm sector. For further information please see http://www.sli.lu.se/IDEMA/idemahome.asp.

[32] GFA-RACE; IEEP (2004): Impacts of CAP Reform. Agreement on Diffuse Water Pollution from Agriculture, Final Report prepared for Department for Environment, Food and Rural Affairs.; Schmid, E.; Sinabell, F. (2004): Implication of the CAP Reform 2003 for Rural Development in Austria. Working paper, Nr.: DP-06-2004, Institute for Sustainable Economic Development, Department of Economics and Social Sciences, University of Natural Resources and Applied Life Sciences Vienna.; Ganzert, C.; Hebauer,C.; Heißenhuber, A.; Hofstetter, M.; Kantelhardt, J. (2003): Reform der gemeinsamen Agrarpolitik - Analysen und Konsequenzen aus Naturschutzsicht. Abschlussbericht zum Forschungs- und Entwicklungsvorhaben „Reform der Gemeinsamen Agrarpolitik – Agenda 2007" (FKZ 80181020). Bonn: Bundesamt für Naturschutz..

[33] Based on the study lead by Gleyses, G. (2006): Mise en oeuvre de la PAC: impact de la réforme de juin 2003 sur la demande en eau d'irrigation – rapport final – CEMAGREF – June 2006..

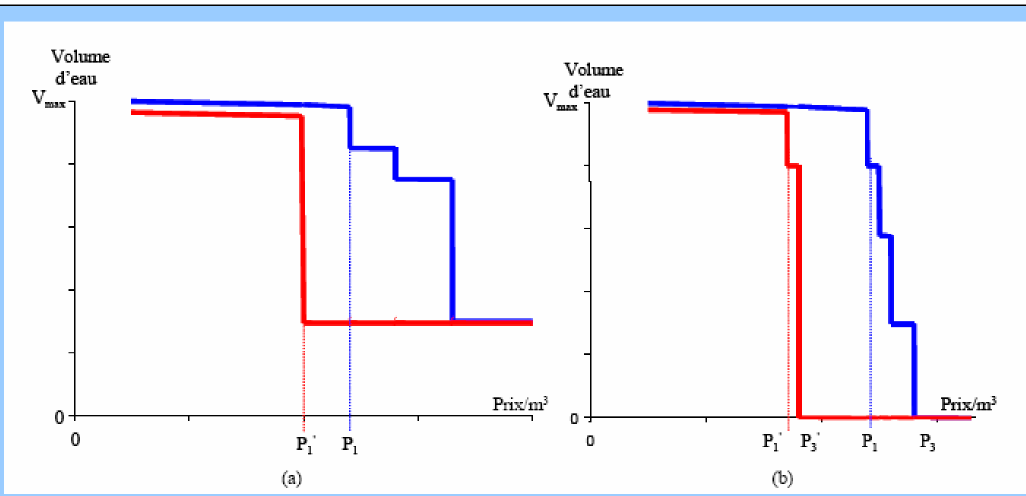

Figure 5: Water demand functions depending on prices.

a): Production system: Maize + seed crops + cattle breeding

b): Production system: Cash crop only: maize + soybean.

Reference (before 2003)
75% decoupling scenario

A similar picture can also be obtained from a study analysing the impacts of the Mid Term Review on the water demand in the agriculture of four Mediterranean Members States: France, Greece, Italy and Spain. On the basis of the existing literature, possible effects of Midterm Review implementation have been identified in terms of reallocation of cultivated land area (e.g. cultivated versus non cultivated, irrigated versus non irrigated land, etc), total water demand, water demand per hectare and farmers' income[34]. The study concludes that water demand management is not a major concern of the CAP and, accordingly, CAP impact on water quality and – even more - water quantity issues are limited. More specifically oriented policy measures are needed to achieve more sustainable water management. More marked effects in terms of reduction of water demand are expected from the forthcoming reform of Common Market Organization[35] of fruit and vegetables and wine sector, while in most cases arable crops still remain only as a valuable alternative to irrigated production and their reform affect the "opportunity" cost of irrigated crops.

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) expects that irrigation water demand may increase substantially due to higher temperatures and increased variability of precipitation, even if the average yearly amount of precipitation were to remain the same. While water use efficiency of certain plant species may be enhanced by the fertilising effect of increased atmospheric CO_2 concentration, this effect is likely to be offset by the drying in

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[34] Scardigno, A; Viaggi, D. (2007): Intermedia Report on "The impacts of the 2003 CAP reform on water demand for irrigation in the European Mediterranean countries, available at: http://www.planbleu.org/publications/atelier_eau_saragosse/Synthese_rapport_PAC_EN.pdf.

[35] The main tasks of the market organisations include fixing single prices for agricultural products on all European markets, granting aid to producers or operators in the sector, establishing mechanisms to control production and organising trade with non-member countries.

many areas where irrigation plays an essential role[36]. However, the effects are likely to vary between different European regions.

The highest increase in irrigation water use is projected for the Mediterranean region and some parts of Central and Eastern Europe, where there will be an increased drought risk as a consequence of climate change. In southern Europe, increases in water demand in the range of 2-4% for maize and 6-10% for potato by 2050 are expected[37]. In addition, irrigation may become necessary in countries, such as Ireland, where it has not played an important role in the past, which would lead to an increase of agricultural water use. At the same time, this development is offset to some extent by an improving water use efficiency in irrigation. However, in regions where precipitation is likely to increase (i.e. in parts of northern Europe) irrigation water demand may also be reduced.

In **conclusion,** with the introduction of full decoupling, there is no longer a direct link between production and the amount of payments per hectare. Farmers will produce goods more according to market demand, and production decisions on a farm level will be based on profit margins. This can be applied in the same way for food and non food production (such a biomass).

As long as water is free of charge or prices are low, there is no need to save water, as it does not affect a farmer's competitiveness. Rather, irrigation allows in general higher gross margins and reduces vulnerability of production and may, therefore, increase in some areas[38]. In areas where the water prices are high, a shift from irrigated to dryland crops may be expected, as the margins for dry land crops on the market will be higher as those for irrigated crops[39] are. This would result in water savings. In other words, decoupling provides the basis for making water pricing work.

4.2.4 Tourism

The tourism sector was not covered by the European Outlook on Water Use, and some developments on the future water need can be assumed as part of the water needs for the domestic sector. Due to the lack of indicators and detailed information, only a rough picture on the future development can be given[40]:

- International arrivals which are only a small part of the tourism industry in Europe are forecasted to rise from 414 Million in 2003 to 717 Million in 2020, which mean they will have nearly doubled in two decades (2000–2020). The growth rates will be higher in central and eastern Europe.
- There is a trend to more frequent and shorter breaks. This result is mainly due to the reduction and greater flexibility of weekly working hours as well as to changes in the transport sector. For example, low cost air travel and the evolution of Internet booking leads to less time and costs being used up by the journey itself and its preparation.

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[36] Intergovernmental Panel on Climate Change (IPCC) (2007): Fourth Assessment Report. WGII – Climate Change Impacts, Adaptation and Vulnerability.

[37] Giannakopoulos, C., Bindi, M. Moriondo, M.; LeSager, P.; Tin, T. (2005): Climate Change Impacts in the Mediterranean Resulting from a 2°C Global Temperature Rise. WWF report, Gland Switzerland. http://assets.panda.org/downloads/medreportfinal8july05.pdf..

[38] Masarutto, A. (2002): Irrigation water demand in Europe: the impact of Agenda 2000 and the Water Framework Directive.

[39] Fonseca, M.; Martinez, E. (2005): Modelling new EU agricultural policies: global Guidelines, local strategies.

[40] Leidner, M. (2004): The European tourism industry - A multi-sector with dynamic markets Structures, developments and importance for Europe's economy, available at http://ec.europa.eu/enterprise/library/lib-tourism/doc/european_tourism_industry.pdf.

- The above mentioned demographic trend in Europe is characterised by a growing share of people older than 65, which will rise from 16.2% in 1999 to 26.3% in 2040. Health, spa and 'keep fit' tourism are likely to be among the segments to benefit particularly from this demographic change. Furthermore, older people tend to spend longer periods in tourist destinations that they consider pleasant living conditions, in particular in southern Europe in the off-season.
- Sustainable tourism will become an important issue in Europe. This development is on one hand driven by consumer demands and on the other hand by the European Commission, which started a process in 2003 by setting up basic orientations for the sustainability of European tourism[41].

From this rough information it is difficult to estimate how water use in the sector may develop in detail. A general positive trend leading to higher water use can be estimated because of the general upwards trend of the sector.

4.2.5 Industry (including electricity)

Industrial water use is now of less importance and the water intensity of different industries (m^3 per gross value added) is a major uncertainty. This may change over the next 30 years and key questions are: what will industries be and how much water will they use? It is difficult to predict how industry in Europe will develop in a global market and the developments in each sub sector might be different. Overall, economic growth in the EU-25 is projected to reach 2.3% in 2000-2020[42], and therewith it can be assumed that water use will also increase if no incentives for savings are set. Water consumption by industry may also increase with rising temperatures because of additional cooling needs.

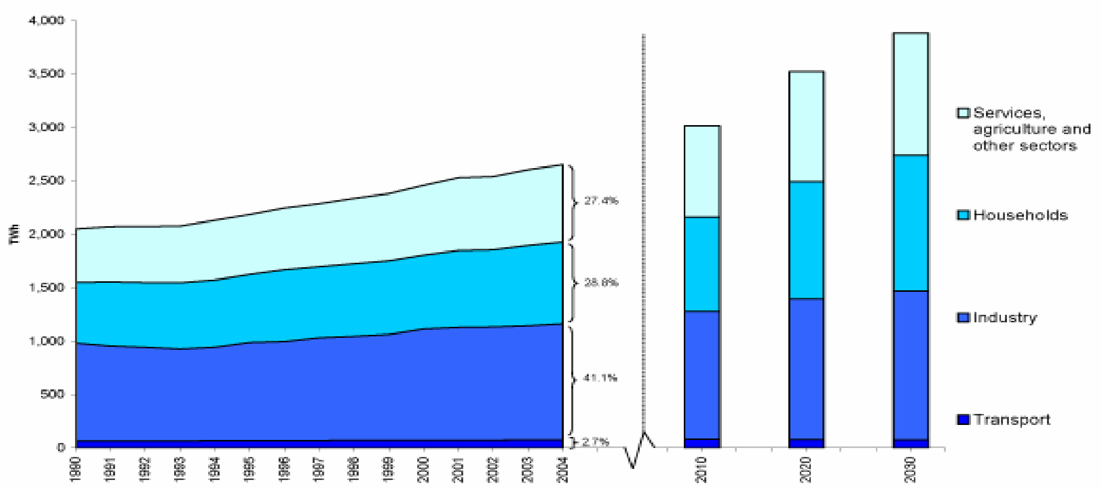


Figure 6: Electricity demand

According to the "business as usual" scenario of the International Energy Association, this growth in industry as well as the growth of domestic electricity demand (e.g. increased use of

41 European Commission (2003): Basic orientations for the sustainability of European tourism, COM(2003) 716, Brussels 21.11.2003.

42 Mantzos, L.; Zeka-Paschou, M. (2005): Energy Baseline Scenarios for the Clean Air for Europe (CAFE) programme, PRIMES model v.2, Final report to DG Environment, available at http://ec.europa.eu/environment/air/cafe/general/pdf/scenarios_cafe.pdf.

air conditioning) will lead to a doubling of electricity demand between 2004 and 2030 (see chapter 5.4[43]) and may increase the water use for cooling of thermal power plants.[44]

At the same time, water use in the electricity production sector could significantly decline if it is assumed that all new power stations will have dry cooling rather than once-through cooling.

4.2.6 Technological improvements

Based on historical data, technological improvement was also estimated in the baseline scenario developed in the European Outlook on Water Use. These improvements will lead to a water efficiency improvement of about 1% for the domestic, electricity production and manufacturing sector and between 0.4 to 0.5% for the agricultural sector per year. Between 2000 and 2030, the estimated savings due technological improvements are between 25% and 36% depending on the sector. Without technological improvements in these sectors, the water use would be between 34% and 56% higher. However, it should be noted that currently many water saving initiatives are going on, which may lead to more water saving measures in the future.

4.2.7 The baseline scenario – what would happen without further measures?

The scenario input data described in the previous chapters were taken as input into the WaterGAP model to compute future water use, water availability, and water stress in 5-year intervals until 2030. The WaterGAP model was developed at the Centre for Environmental Systems Research at the University of Kassel in Germany, in co-operation with the National Institute of Public Health and the Environment of the Netherlands. The aim of the model is to provide a basis (i) to compare and assess current water resources and water use in different parts of the world, and (ii) to provide an integrated long-term perspective of the impacts of global change on the water sector. As a result, the following conclusions can be drawn for the different reporting units mentioned in Table 2. It should be noted that the recent developments with respect to biomass and other renewables are not considered in the model. The influence of biomass on water use is widely unknown so far. Renewable electricity production from solar and wind might further decrease the water use in energy consumption.

Table 2: Reporting regions of the WaterGAP model

Reporting region	Countries
Northern Europe	Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, The Netherlands, Sweden, United Kingdom, Norway, Switzerland
Southern Europe	France, Greece, Italy, Portugal, Spain
New EU Member States since 2004	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, Slovenia
New EU Member States since 2007 and Turkey	Bulgaria, Romania, Turkey
EU 30	All countries listed above

43 European Environment Agency (EEA) (2006): Fact sheet EN18 Electricity Consumption, available at: http://reports.eea.europa.eu/eea_report_2006_8/en/factsheets/EN18_EU-25_Electricityconsumption.pdf.

44 Intergovernmental Panel on Climate Change (IPCC) (2007): Fourth Assessment Report. WGII – Climate Change Impacts, Adaptation and Vulnerability.

4.2.7.1 Northern Countries

Figure 7 shows the water use in northern European countries. In the domestic sector of northern European countries, water withdrawals tend to stabilise and then slowly decline because per capita water use in households and businesses reaches its saturation point and the efficiency of water use continues to improve. The amount of water is estimated to decline by 18% from 29 045 Million m³ in 2000 to 23 924 Million m³ in 2030.

Manufacturing output increases and this tends to increase water use, but improving efficiency of water use in this sector tends to dampen the increase somewhat. A continuous increase in water use in the manufacturing industry of 30% between 2000 and 2030 is calculated. Water withdrawals for electricity sharply decrease since older power stations will be replaced by new ones with more less water using cooling (see section 5.4 on water for energy production). Therefore, in the electricity sector, the expected water uses for cooling will decrease by 73%.

Agricultural water use in northern Europe only constitutes a minor 3% of total water withdrawal in 2000. Because of slightly higher temperatures and precipitation, the amount of water withdrawal for irrigation is predicted to decline by 11% between 2000 and 2030.

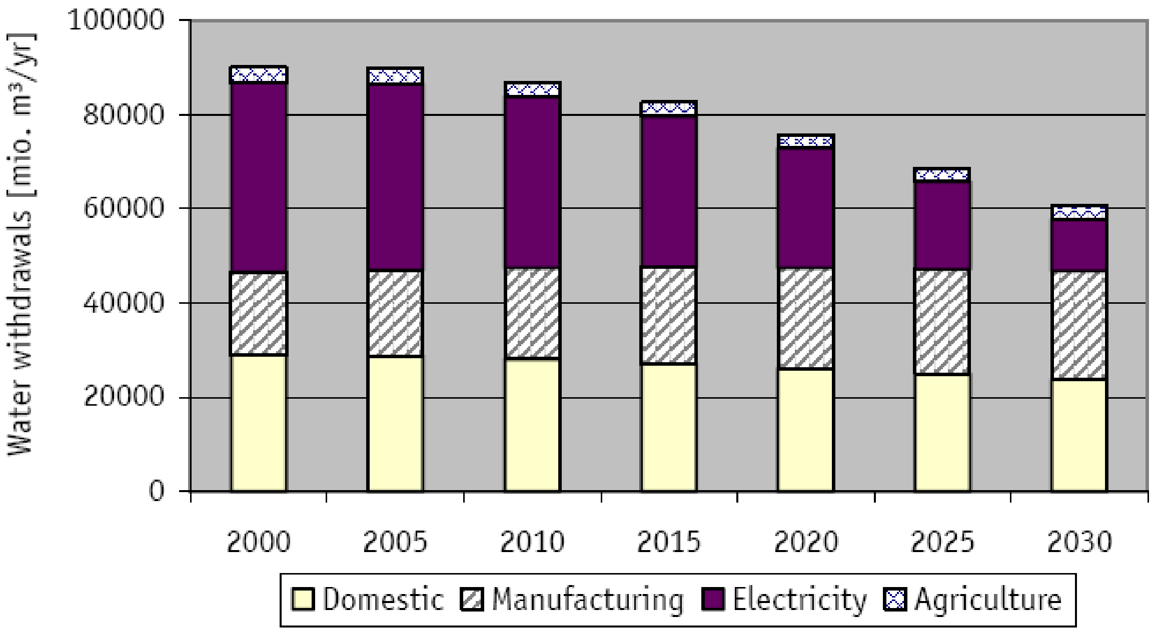


Figure 7: Calculated water use in the EU Northern Countries

4.2.7.2 Southern Countries

With respect to energy production, manufacturing and domestic use, the trends are similar to those in northern Europe between 2000 and 2030. The water withdrawals for the electricity sector are estimated to be 63% lower; for the manufacturing sector an increase by 24% is expected and in the domestic sector, water withdrawals increase slightly, and then stabilise.

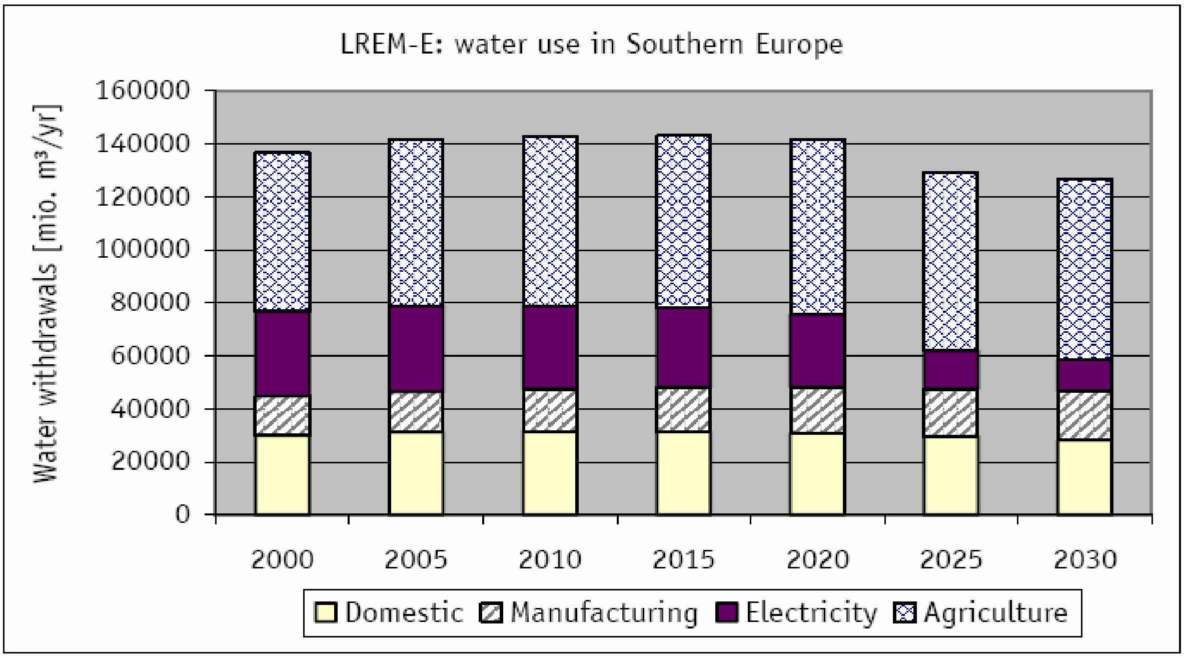


Figure 8: Calculated water use in the EU Southern Countries

A different picture has to be drawn for the agricultural sector. On the one hand, gross irrigation water requirements increase by 14% because of a somewhat warmer and drier climate and the further development of the total area irrigated. This area is expected to increases by 27% between 2000 and 2030. On the other hand, this region makes steady progress in improving the efficiency of irrigation water use. The net result of these changes is an increase in irrigation water withdrawals of 32% (including the expansion of irrigated areas) in 2030 compared to 2000. If the irrigated area is kept constant, a net increase of 5% in irrigation water withdrawals is computed for the year 2030 compared to 2000.

4.2.7.3 New EU Member States since 2004

According to the calculations carried out in the WaterGAP, two sectors are very dynamic in this region. On one hand, water withdrawals are assumed to decline in the electrical production sector because of increased efficiency in plants (up to 75%) and on the other hand, withdrawals in the domestic sector might steadily increase. In the case of convergence, the domestic water withdrawals increase from 5 025 Million m³ to 8 753 Million m³ (+74%) between 2000 and 2030. The increase in domestic water withdrawals can be explained by a continuous increase in population, which is the main driving force in this sector. Furthermore, water withdrawals will double in the manufacturing sector from 2 236 Million m³ in 2000 to 4 340 Million m³ in 2030. The increase in water use is a result of the economic developments that can be expected in this region. As shown in Figure 17, the use of water per person is far below the EU average in some of these Member States. Agricultural water use remains about the same because the need of more irrigation due to higher temperatures, which can be compensated by more efficient techniques (See also Figure 9).

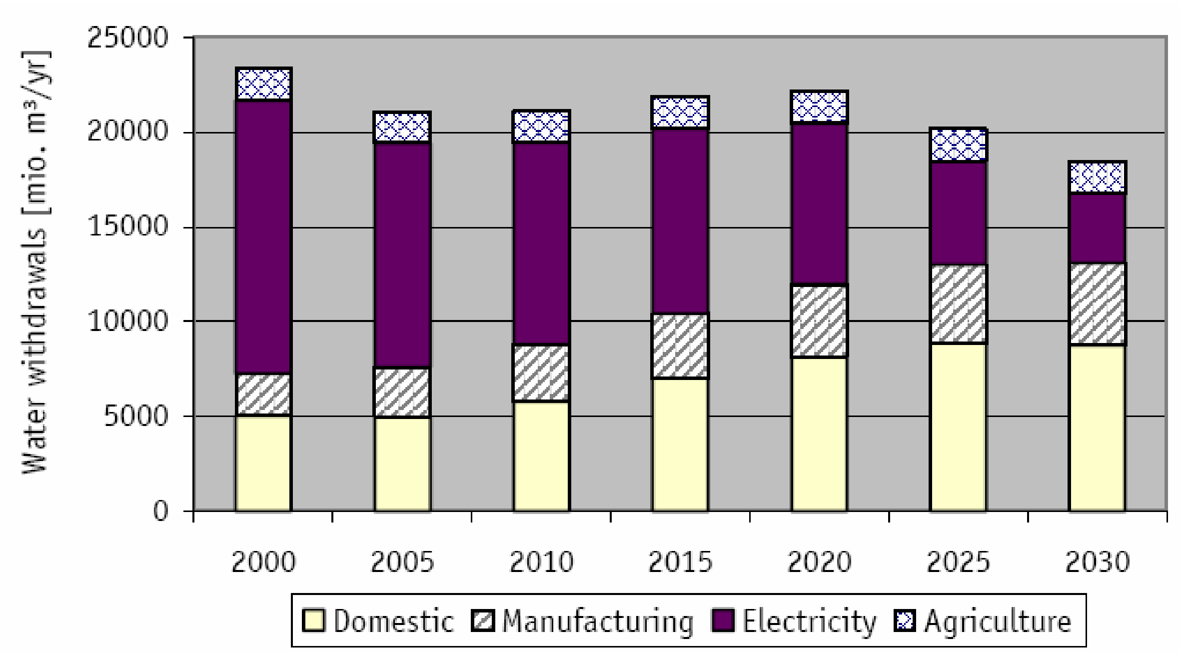


Figure 9: Calculated water use in the EU Member States since 2004

4.2.7.4 New EU Member States since 2007 and Turkey

At the time the WaterGAP model was run, Turkey, Bulgaria, Romania, and Croatia were candidates to become member of the European Union. Meanwhile Bulgaria and Romania are EU Member States. The WaterGAP model was only calculated for three of the former four candidate countries, namely Turkey, Bulgaria, Romania. For the energy sector, the same trend as for the other regions can be assumed, leading to a decrease of water use.

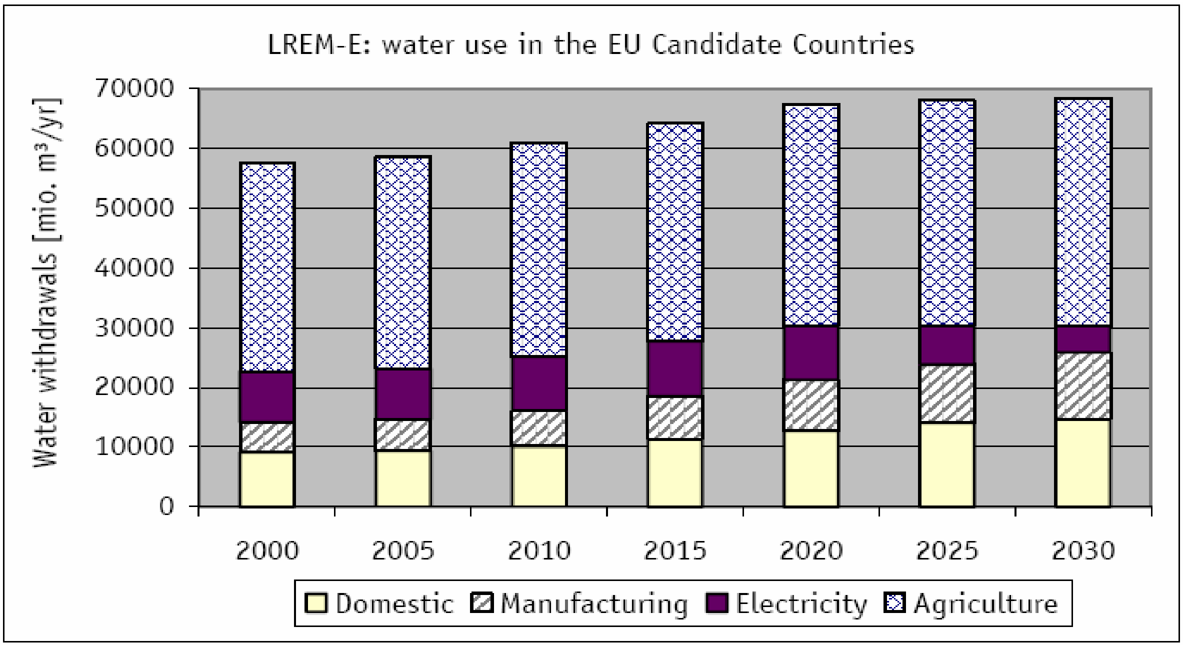


Figure 10: Calculated water use in the EU Member States since 2007 and Turkey

The manufacturing sector will double its withdrawals because of expanded industrial production from 4 968 Million m³ in the year 2000 to 11 143 Million m³ in the year 2030. Also, withdrawals in the domestic sector are estimated to increase, as higher incomes lead to higher per capita water use (Bulgaria and Romania). For Turkey, not only a higher water use per capita is expected, also a population increase by 23.5 Million inhabitants (+35%) between 2000 and 2030 is projected. Hence, in the case of convergence, the domestic water withdrawals increase from 9 230 Million m³ to 14 728 Million m³ (+60%) between 2000 and 2030.

Water withdrawals in the agricultural sector are predicted to have a small net increase (by 10% between 2000 and 2030) for the same combination of factors as in southern Europe (increase of drier and warmer climate, decrease due to more efficient irrigation).

4.2.7.5 Future water stress

Estimating future water use does not necessarily lead to assumptions on future water stress. Water stress is a measure of the amount of pressure put on water resources and aquatic ecosystems by the users of these resources, including municipalities, industries, power stations and agricultural users. In order to get an indication on such future water quantity problems, water availability has to be assessed and compared to water uses. To estimate stress a conventional indicator, the ratio of withdrawals to availability was used. Figure 11 and Figure 12 show the areas with current water stress and potential stress in the future.

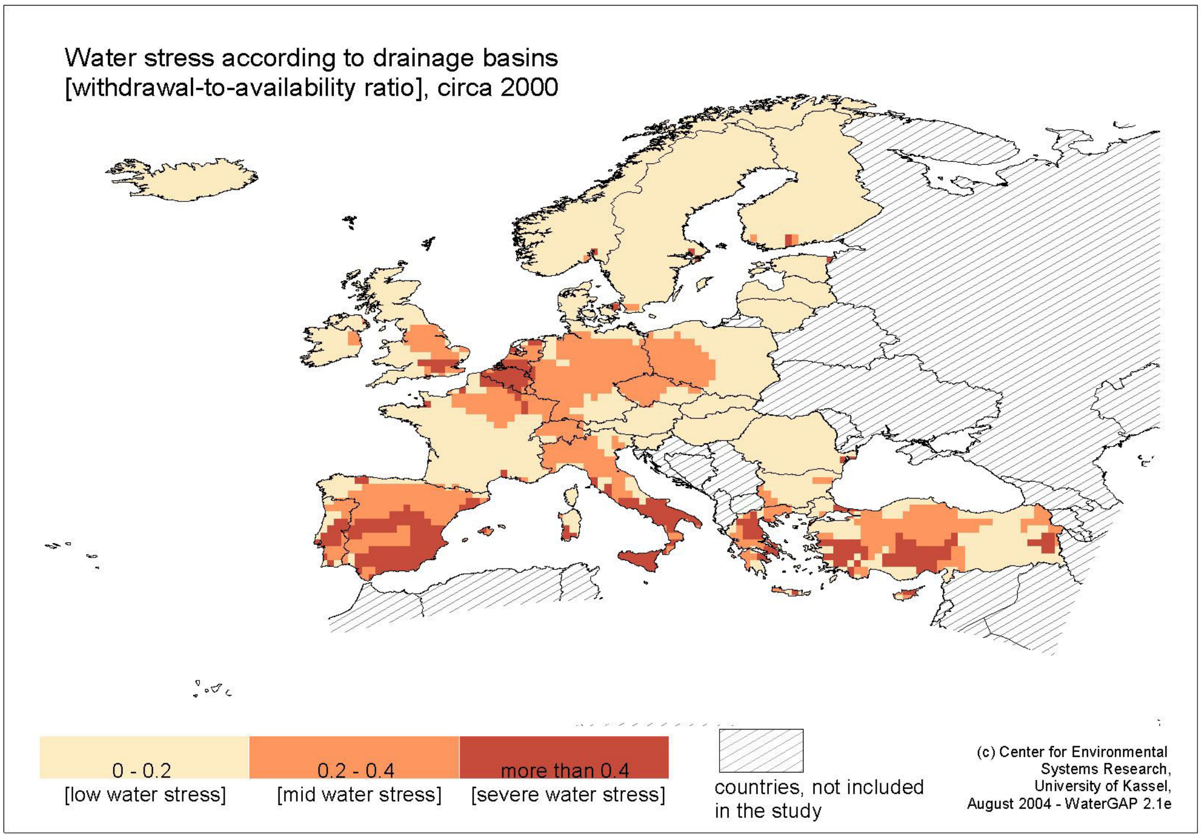


Figure 11: Current areas with water stress [45]

[45] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

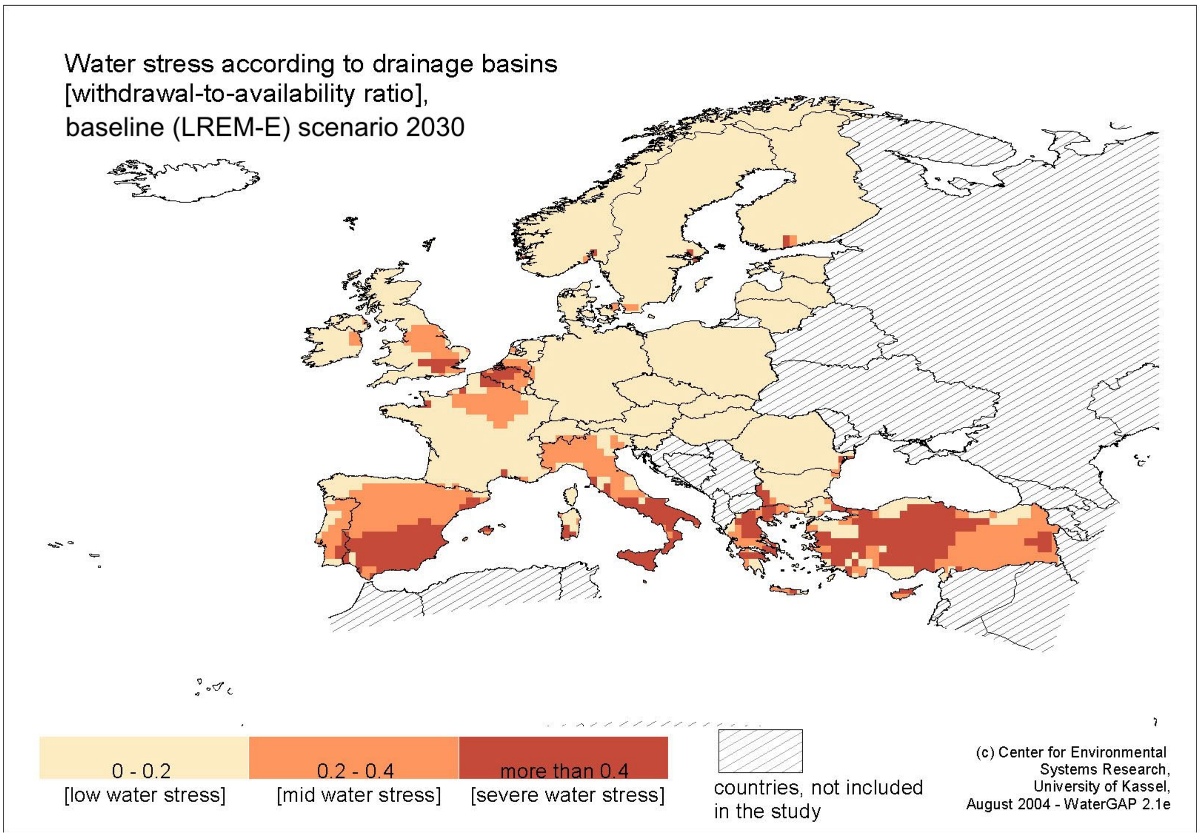
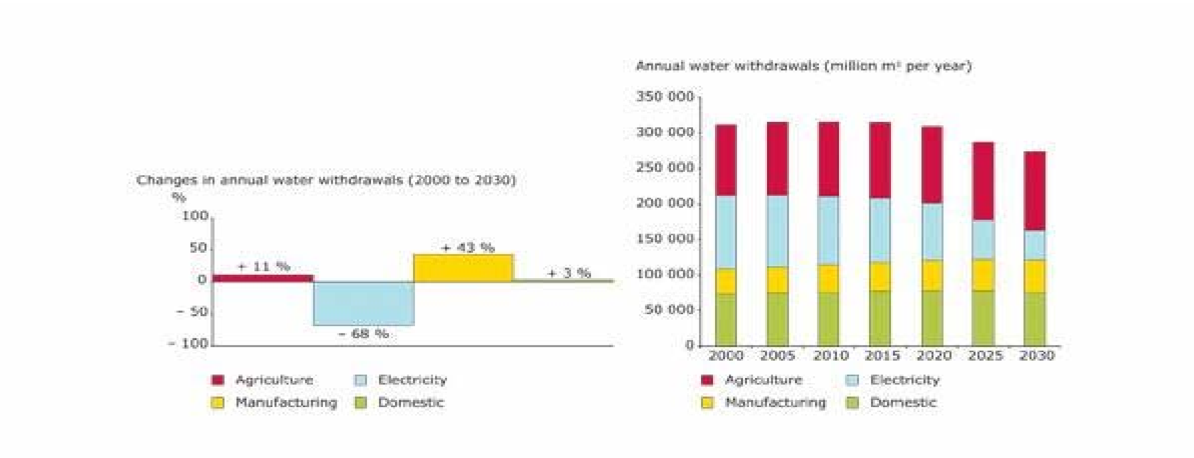


Figure 12: Future water stress[46]

4.2.8 Conclusions

As a result of the baseline scenario developed for the European Outlook on Water Use report, a negative trend of total European water withdrawals can be estimated. Total water withdrawals in the Europe-30 countries might decrease by approximately 11% between 2000 and 2030. However, it should be noted that this trend is different for different regions and different sectors. While agriculture, domestic and industry are increasing, the electricity sector is decreasing (see Figure 13). However, one must also consider that all these calculations are related to high uncertainties.



[46] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

Figure 13: Water abstraction in Europe in 2030[47]

[47] http://epaedia.eea.europa.eu/page.php?pid=518#galleryhere.

5 Detailed sector assessment of potential water savings – technical measures

5.1 Water saving for the agriculture sector

5.1.1 General issues

5.1.1.1 Water for the agriculture sector

Agriculture affects both the quality and quantity of water resources. Rain fed and irrigated agriculture together with livestock are considered the main contributors to diffuse pollution in Europe. In terms of water demand, irrigated agriculture is the largest water consumer, while water requirements for livestock-farming and fish-farming (excepting for some areas like Brittany in France[48]) are marginal. Because of the water saving focus of the present study, this chapter will only deal with quantitative issues.

The following Table 3 gives an overview of agricultural activities, volumes of water used and percentage of total water abstraction from the agriculture sector, combining elements from the national syntheses of the WFD Article 5 reports[49] submitted to the European Commission and results from the European Environment Agency (EEA) IRENA project[50], which dealt with water use intensity, regional water abstraction and water allocation to irrigation. This overview, however, is not complete, as the link between relative water consumption for agriculture and availability of water resources is not captured.

Table 3: Relative water consumption for agricultural activities (EU) [51]

Member State	List of agricultural activities	Volume of water used [M m^3/a]	Percentage of total volume abstracted
Austria	Small proportion of agriculture land is irrigated (south and south-east, only).	100 M m^3/a	6%
Belgium - Flanders	No differentiation between land drainage and irrigation (see information of Scheldt & Meuse RBDs)	No information [a)] (see information of Scheldt & Meuse RBDs)	No information [a)] (see information of Scheldt & Meuse RBDs)
Belgium - Wallonia	Livestock (Bovines, pigs), crops	6.5 M m³/a	3.98%
Cyprus	Irrigation, husbandry	182.4 M m³/a	69%
Czech Republic	No information [a)]	Elbe: 8.66 M m³/a Danube: 3.85 M m³/a	No information [a)]
Denmark	Drainage and irrigation	141 M m^3 /a	22%

48 European Environment Agency (EEA) (2001): Environmental issue report No 19, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

49 See http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_documents_1/wfd_reports/member_states&vm=detailed&sb=Title.

50 European Environment Agency (EEA) (2005): Agriculture and environment in EU-15 – the IRENA indicator report. EEA Report No 6/2005. Copenhagen; and European Environment Agency (EEA) (2005): IRENA Indicator Fact Sheet, IRENA 22 - Water abstraction. Copenhagen: EEA.

51 Herbke, N; Dworak, T.; Karaczun, Z. (2006): WFD and Agriculture – Analysis of the Pressures and Impacts Broaden the Problem's Scope, Interim Report, Version 6 – 18/10/2006.

	(especially in Jutland)	(mainly groundwater)	
Estonia	No detailed data available	0.19 M m^3/a	<1%
Finland	No information [a]	No information [a]	No information [a]
France	Irrigation (large variation across RBDs) (some data are available at the RBD level, see below)	No information [a] (some data are available at the RBD level, see below)	No information [a] (some data are available at the RBD level, see below)
Germany	No information [a] (but agriculture is significant water user)	No information [a]	No information [a]
Hungary	Irrigation (small proportion (ca. 2%) of agriculture land is irrigated) Aquaculture Animal husbandry and others	No information (11% surface water; 9% groundwater)	27% of water used by agriculture (irrigation) 68% of water used by agriculture (aquaculture) 5% of water used by agriculture (animal husbandry and others)
Ireland	Potatoes, cattle and cattle products, and sheep and sheep products (key water using sub-sectors for agriculture)	No information [a]	No information [a]
Latvia	No information [a]	No information [a]	No information [a]
Lithuania	No information [a]	7 M m^3/a	2%
Luxembourg	Irrigation not significant	No information [a] (see information of Mosel-Saar & Meuse RBDs)	
Malta	Irrigation Animal husbandry	Limited data exist on abstraction sources and their related abstracted volumes	5% (official data based on billed consumption) 43% (when crop irrigation is taken into account)
Poland	No information [a]	No information [a]	No information [a]
Portugal	No information [a]	No information [a] (see information on Vouga-Mondego-Lis, Tejo-Ribeiras do Oeste, Sado-Mira, Guadiana & Ribeiras do Algarve RBDs below)	No information [a]
Slovak Republic	Irrigation	1 063 M m^3/a	5.3%
Slovenia	Irrigation	606.1 M m^3/a 0.0043 M m^3/a (irrigation from public irrigation system)	No exact data available on total amount of abstracted water
Spain	Mainly irrigation and livestock farming	Information submitted at "RBD basin level" (see below)	Information submitted at "RBD basin level" (see below)
Sweden	Irrigation (low need)	No information [a]	1-4% total (0.4-12.3 relative% of total volume extracted)
UK, England & Wales	Irrigation (need varies across RBD)	6-50 M m^3/a (across RBD)	No information [a]
UK, Scotland	Irrigation (low need) Fish farming (need for high quality water)	56.5 M m^3/a (irrigation) 1 582 M m^3/a (fish farming)	No information [a]
UK, Northern Ireland	No information [a]	No information [a]	No information [a]
Italy*	Mainly irrigation and livestock farming	20 000 M m^3/a	49,6%
RBD/ Region /country	**List of agricultural activities**	**Volume of water used [M m^3/a]**	**Percentage of total volume abstracted**
Mediterranean	Irrigation	1 048 M m^3/a (irrigation)	75% (irrigation)

Andalusian District/Spain	Livestock farming	4 M m^3/a (livestock farming)	0.3% (livestock farming)
Baleares Island/Spain	Irrigation Livestock farming	105.6 M m^3/a (irrigation) 6.2 M m^3/a (livestock farming)	46% (irrigation) 3% (livestock farming)
Cataluna Internal basins/Spain	Irrigation Livestock farming	386.5 M m^3/a (irrigation) 29.7 M m^3/a (livestock farming)	32.6% (irrigation) 2.5% (livestock farming)
Cavado-Ave- Leça basin/Portugal	No information [a)]	No information [a)]	No information [a)]
Donava basin/ Slovenia	Irrigation	551.8 M m³/a (with 0.0022 M m³/a irrigation from public irrigation system)	No exact data available on total amount of abstracted water.
Douro basin/Portugal Duero basin/Spain	**PT**: no information [a)] **ES**: irrigation	**PT**: no information [a)] **ES**: 3 478 M m³/a	**PT**: no information [a)] **ES**: 76%
Ebro basin/Spain	Irrigation	6 310 M m³/a	13%
Garonne basin/France	645 000 ha of land irrigated (especially for maize, 70%)	1 000 M m^3/a	85%
Guadiana basin/ Spain- Portugal	No information [a)]	10.2 M m³/a (surface water) 9.0 M m³/a (total water abstracted)	13.9%
Jadran basin/Italy, Slovenia, Croatia, Albania	Irrigation	54.3 M m³/a (with 0.0043 M m³/a irrigation from public irrigation system)	No exact data available on total amount of abstracted water.
Júcar basin/Spain	Agriculture	3 657 M m³/a	76.3%
Loire basin/France	Irrigation (large variation across RBDs)	473 M m³/a	No information [a)]
Meuse basin/Belgium-France-Netherlands	**BE-FL**: agriculture **NL**: no information [a)]	**BE-FL**: 7.7 M m³/a (85% of water used for agriculture is groundwater) **NL**: no information [a)]	**BE-FL**: 14% **NL**: no information [a)]
Minho-Lima basin /Spain-Portugal	No information [a)]	No information [a)]	No information [a)]
Rhine basin/France-Netherlands	**High Rhine part**: no information [a)] **FR**: irrigation (large variation across RBDs) **NL**: no information [a)]	**High Rhine part**: 62-100 M m³/a **FR**: 100 M m³/a **NL**: no information [a)]	**High Rhine part**: 1-3% **FR**: no information [a)] **NL**: no information [a)]
Rhône basin/France	375 000 ha of land irrigated (especially for orchards and maize)	No information [a)]	At least 10% of groundwater abstracted
Ribeiras do Algarve basin/Portugal	No information [a)]	19.9 M m³/a (surface water) 115.3 M m³/a (total water abstracted)	48.3%
Sado-Mira basin/Portugal	No information [a)]	3.5 M m³/a (surface water)	17.2%
Sambre basin	No information [a)]	No information [a)]	No information [a)]
Scheldt basin/Belgium - France	**Roof report**: no information [a)] **BE-FL**: agriculture **FR**: irrigation (large variation across RBDs)	**Roof report**: no information **BE-FL**: 34 M m³/a (81% of water used by agriculture is groundwater) **FR**: no information [a)]	**Roof report**: 4% **BE-FL**: 5% **FR**: 4%
Segura basin/Spain	Agriculture	1 571 M m³/a	89%
Seine basin/France	**FR**: 140 000 ha of land irrigated (large cultivated surface areas, spring crops)	**FR**: at least 95 M m³/a (mainly from groundwater sources)	**FR**: 0.5%

Tejo-Ribeiras do Oeste basin/ Tajo basin/Sapin-Porugal	**PT**: no information a) **ES**: agriculture	**PT**: 2.1 M m³/a (surface water) 744.3 M m³/a (total water abstracted) **ES**: 1 785 M m³/a	**PT**: 31.9% **ES**: 37%
Vouga-Mondego-Lis/basin/Portugal	No information a)	75.1 M m³/a (total water abstracted)	No information a)

Note: a) "None" means that no significant pressure from the agricultural sector was reported in the Article 5 report; "no information" means that the Article 5 report does not specifically refer to agriculture as being the pressure behind the impact; and "no sectoral distinction" means that no distinction between households, industries and agriculture has been made in the Article 5 report.

It should be noted that the data presented is subject to high uncertainties because of significant data gaps regarding water use for agricultural purposes, including on the importance of "unregulated" water abstraction, which can be significant in certain river basins and regions[52].

5.1.1.2 Irrigation: the main water user of the European Union?

By world standards, Europe is a densely populated continent[53], and its river systems have been heavily modified to support economic activities. Agriculture uses, accounting for 44% of the EU territory, exhibits great variability along the north-south and west-east transects as a result of geographic and climate diversity, which ranges from the tempered climates of the north to the arid climates around the Mediterranean Sea. Thus, the importance of irrigation increases from north to south and is an indispensable input for agriculture in most of the arid and semiarid environments. In Mediterranean countries, irrigated farming accounts for a large share of total water withdrawals (83% in Greece, 68% in Spain, 57% in Italy, and 52% in Portugal), while it represents less than 10% in northern European countries.

The main agricultural driving force behind the use of water is irrigation water demand. The comparison between the total area equipped for irrigation (total irrigable area) and the utilised agricultural area (UAA) stresses that some regions might face unsustainable water balances. The irrigable area in EU-12 increased from 12.3 Million hectare to 13.8 Million hectare between 1990 and 2000 (increase by 12%). Irrigable areas in southern European countries (France, Greece, Portugal and Spain) increased during the same period by 5.8. Million ha (or + 29%[54]), as presented in Table 4:

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52 Water Research Centre (WRc) (2005): Review of the Article 5 Report for agricultural pressures, MS summary report, on behalf of the Environment Directorate General of the European Commission, draft report, April 2005.

53 Berbel, J Garrido A.; Calatrava, J. (2007): "Water pricing and irrigation: a review of the European Experience" in Molle, F.; Berkoff, J.J.; Barker, R. (eds) (2007 forthcoming): Irrigation Water pricing Policy in Context: exploring the Gap between Theory and Practice. Wallingford, UK.

54 European Environment Agency (EEA) (2005): Agriculture and environment in EU-15 – the IRENA indicator report. EEA Report No 6/2005. Copenhagen, available at: http://reports.eea.europa.eu.

Table 4: Area equipped for irrigation, irrigated land, utilised agricultural area and relative share of irrigated area and water abstracted for irrigation in the EU

Country	Area equipped for irrigation		Irrigated land (ha)[55]	Utilised agricultural area (UUA)(ha)[3]	Percentage of irrigated are compared to UUA a[3]	Water abstracted[56] Mio m^3/yr
	ha	Ref. Year				
Austria	97 480	2003	4 000	3 390 000	0,1	67,5
Belgium	35 170	2003	40 000	1 544 000	2,6	22,7
Bulgaria	545 160	2003	800 000	6 251 000	12,8	712,9
Cyprus	55 813	2003	40 000	117 000	34,2	122
Czech Republic	50 590	2005	24 000	4 278 000	0,6	11,3
Denmark	476 000	2003	447 000	2 676 000	16,7	156,4
Estonia	1 363	2005	4 000	890 000	0,4	36,4
Finland	103 800	2003	64 000	2 219 000	2,9	50
France	2 906 081	2003	2 600 000	29 631 000	8,8	3 120,1
Germany	496 871	2002	485 000	17 033 000	2,8	142,4
Greece	1 544 530	2003	1 431 000	8 502 000	16,8	7 600
Hungary	292 147	2004	230 000	5 865 000	3,9	173,7
Ireland	1 100	2000	-	-	-	130
Italy	3 892 202	2000	2 700 000	15 355 000	17,6	25 852
Latvia	1 150	2003	20 000	2 480 000	0,8	46,6
Lithuania	4 416	2005	7 000	3 487 000	0,2	6,6
Luxembourg	27	2002	-	-	-	0,2
Malta	2 300	2003	2 000	10 000	20	-
Netherlands	476 315	1997	565 000	1 931 000	29,3	76
Poland	134 050	2005	100 000	18392000	0,5	86,3
Portugal	792 008	1999	650 000	4 142 000	15,7	6 550,9
Romania	2 149 903	2003	3 081 000	14 852 000	20,7	912
Slovakia	225 310	2001	183 000	2 450 000	7,5	65
Slovenia	15 643	2005	3 000	510 000	0,6	6,7
Spain	3 020 458	2002	3 020 458	16 174 000	12,4	18 089,2
Sweden	188 470	2003	115 000	3 144 000	3,7	94
United Kingdom	228 950	2003	108 000	16 954 000	0,6	1896,2

The role of irrigation differs between countries and regions due to different climatic conditions. In several regions of Europe, irrigation is supplementary, meaning that (i) water

55 European Environment Agency (EEA) data base, based on Eurostat data of 2001 (data only available for EU25 excluding Ireland and Luxembourg).

56 European Environment Agency (EEA) data base, based on Eurostat data from the most recent year available for each country, in general 2000 and later.

comes first from rainfalls and (ii) only specific (high value) crops, such as vegetables, fruits or potatoes, are irrigated. In such cases, irrigation plays an insurance role against variability in climatic conditions.

The fraction of area equipped for irrigation that is actually being irrigated is highest for the more arid Mediterranean countries (e.g. Spain or Greece), with values between 80% and 95%. In northern European countries, values of 60% to 80% are recorded for Italy or France. Furthermore, countries like the Netherlands, Germany, the UK or Scandinavian countries record values between 30% and 80%. In contrast, year to year variations in irrigated areas are largest for the more humid western European countries (e.g. Netherlands)[57]. This variability will need to be considered when analysing water saving measures.

Within the IRENA assessment, regional water abstraction rates for agriculture were estimated based on the assumption that water requirements for irrigation are abstracted from local water supplies and results in regional pressures on water resources. In some cases, however, large-scale water works include the transfer of water across large distances[58]. Given the estimation method, it is not possible to draw direct conclusions on water use intensity per hectare of land in different regions from these figures. But they show the clear spatial distribution of potential abstraction pressures across the EU-15 (see Figure 14)[59].

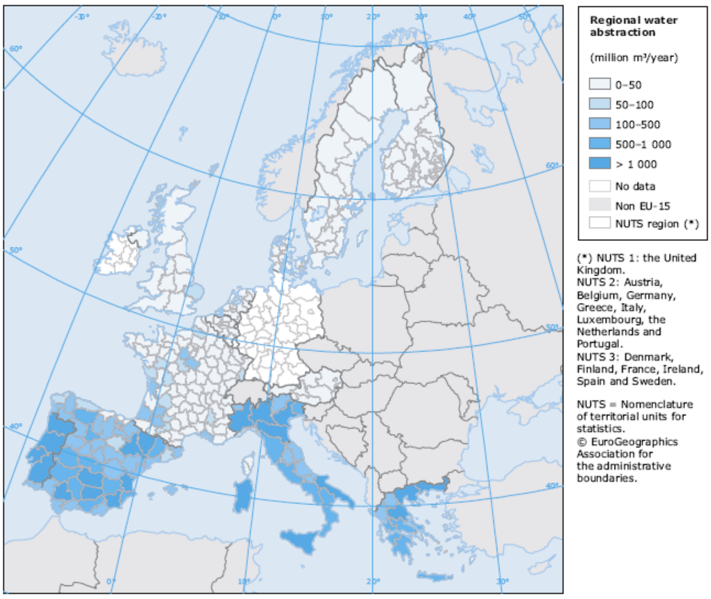

Figure 14: Regional water abstraction rates for agriculture in million m^3/a (2000)

Overall, the 41 regions with the highest use of water for agricultural purposes (more than 500 Million m^3 per year) are located in southern Europe, 21 of which are estimated to require more than 1 000 Million m^3 water per year for agriculture[60]. Conversely, in northern Member

[57] Siebert, S.; Hoogeveen, J.; Frenken, K. (2006): Irrigation in Africa, Europe and Latin America, Update of the Digital Global Map of Irrigation Areas to Version 4, available at: http://www.geo.uni-frankfurt.de/ipg/ag/dl/f_publikationen/2006/FHP_05_Siebert_et_al_2006.pdf.

[58] This was, for example, proposed in the Spanish National Hydrological Plan (SNPH). For further information see: http://www.mma.es/rec_hid/plan_hidro/plan_hidro_nacional_boe.pdf.

[59] Community Survey on the Structure of Agricultural Holdings (FSS), Eurostat combined with information from OECD/Eurostat questionnaire, in: European Environment Agency (EEA) (2005): Agriculture and environment in EU-15 – the IRENA indicator report. EEA Report No 6/2005. Copenhagen

[60] European Environment Agency (EEA) (2005): Agriculture and environment in EU-15 – the IRENA indicator report. EEA Report No 6/2005. Copenhagen, available at: http://reports.eea.europa.eu.

States, 90% of the regions are estimated to have abstraction rates of between 0 and 50 m^3 per year[61]. However, it should be noted that the water abstraction rate does not refer to water availability and thus no information can be derived in terms of water scarcity and drought issues in the respective region.[62]

Based on abstraction rates and irrigable area, the IRENA assessment estimated annual water allocation rates for irrigation. These were grouped into northern and southern EU-15 Member States[63]. In southern EU-15 MS, water allocation per hectare decreased slightly between 1990 and 2000 from 6 578 to 5 500 m^3 per hectare per year. During the same period, total water abstraction decreased from 69 103 to 66 424 Million m^3 per year, with irrigable area increasing, however, from 10.5 to 12.0 Million hectares. This reduction in water application rates per hectare of land irrigated is likely to be linked to both increase in water use efficiency and reduction in water allocation due to drought conditions (e.g. in 1995 farmers could not irrigate in the Guadalquivir rives basin (Spain) due to severe drought). In northern EU-15 MS, water allocation was halved from 757 to 349 m^3 per hectare per year between 1990 and 2000. During this period, both the water abstraction rate and the irrigable area decreased from 1 622 to 716 Million m^3 per year and from 2.1 to 2.0 Million hectare, respectively[64].

Table 5: Overview of types of irrigation and irrigated crop patterns in EU 15

Country	Technical	Water source	Timing	Crop types
Greece	Sprinklers dominant, with and without pressure, drip irrigation increasing slowly esp on tree crops, vines and horticulture	Mainly surface (85% nationally), often mixed, with regional variations	Support irrigation – from late spring to early autumn	E – tree crops, S- maize, I – cotton, beet, horticulture, vines (traditionally: trees and horticulture)
Spain	60% gravity (furrows and flooding) – widespread in many areas, traditional 24% sprinklers, esp in plateau/inland areas 17% drip irrigation, esp in Mediterranean coastal areas	71% surface, 28% aquifers 1% return flows <1% purified <1% desalinised seawater	Generally permanent or support in most regions. Where there is enough rainwater, irrigation is temporary, eg in Cantabria and Asturias	Continental areas – E/S/I: maize, beet, cereals Mediterranean – E/I/R: citrus, horticulture, rice South – all types: maize, tobacco, rice, horticulture, olives, fruit
Portugal – North/central Southern/ coastal	Mainly gravity Increasingly sprinklers and drip systems	Surface Surface and ground	Permanent Permanent	I Intensive S/I/R: Semi, Intensive, and rice
Italy	Sprinklers 33% Flooding 4% Gravity 51% Drip irrigation 10%	Ground 28% surface 72% Groundwater in north, surface in	Mainly permanent in South, support in north	Olives, vines, fruit trees, field crops, horticulture Cereals, maize, rice

61 European Environment Agency (EEA) (2005): IRENA Indicator Fact Sheet, IRENA 22 - Water abstraction. EEA, Copenhagen.

62 "Water scarcity" refers to long-term water imbalances, combining arid or semi-arid climate (low water availability) with a level of water demand exceeding the supply capacity of the natural system.

63 Northern EU-15 comprises AT, BE, DK, FIN, DE, IE, LUX, NL, SWE and UK; southern EU-15 comprises FR, GR, IT, PT and ES.

64 European Environment Agency (EEA) (2005): Agriculture and environment in EU-15 – the IRENA indicator report. EEA Report No 6/2005. Copenhagen, available at: http://reports.eea.europa.eu.

		south with some groundwater in coastal areas		
France	Sprinklers 85%(arable) Gravity 10% (rice, arable) Drip 5%(horticulture and tree fruit)	Ground 62% Surface 26% Mixed 12%	Mainly support, some temporary, some permanent in south	Grain maize 45% Forage crops 11% Other arable 18% Sugar beet 2% Potatoes 2% Horticulture 8% Vines 1% Tree fruit 9%
UK	Sprinklers/rainguns	Ground and Surface	Mainly temporary and support	Mainly potatoes, some beet
Germany	Mainly sprinklers, some drip in Rheinland and Hessen	Mainly ground, Surface in Rheinland and some in East	Support irrigation	Intensive cropping (horticulture, mainly) and some semi-intensive
Netherlands	West and north: gravity East, central and south: sprinklers Glasshouses: sprinklers and drip	Surface rivers/lakes Groundwater Mainly surface, some ground, long distance surface	Permanent Support Permanent	Grass and arable, some vegetables Arable, horticulture, grass Glasshouse horticulture, intensive
Belgium	Sprinklers	Ground Surface	Support and temporary	Mainly semi-intensive/intensive, eg Horticulture, maize
Austria	Sprinklers, some drip systems	Mainly ground Some surface	Support and temporary	Beet, horticulture, Vineyards, soft fruit
Denmark	Sprinklers and some drip	Ground 95% Surface 5%	Temporary, some support	Mainly semi-intensive and intensive – maize, horticulture, glasshouses
Luxembourg	Sprinklers	Ground	Temporary, some support	Not specified
Sweden	Sprinklers	Ground 25% Surface – lakes rivers and farm reservoirs 70% Treated waste 5%	Support	Extensive 20% Semi 20% Intensive 60%
Finland	Sprinklers	Surface – lakes and rivers	temporary	Some semi-intensive but mainly horticulture – potatoes, beet and vegetables
Ireland	Sprinklers	Surface – lakes and rivers	temporary	Some early potatoes and vegetables, soft fruit

Information on the relative share of irrigation technologies is not readily available for most countries. A rough picture on the relative share of these technologies for the EU 15 is given in Table 6[65]. Although the importance of water scarcity in explaining differences in adoption rates for different technologies is recognised, it is important to stress that the choice of

65 IEEP (2000): The Environmental Impacts of Irrigation. Available at: http://ec.europa.eu/environment/agriculture/pdf/irrigation.pdf.

technologies is also influenced by labour availability and productivity, access to financial resources and the existence of schemes for promoting the use of water saving technologies.

5.1.2 Water saving measures and economic implications

5.1.2.1 Technical measures and estimation of savings

In the irrigation sector, important water savings can be mainly achieved at two levels:

- At the resource side, except the construction of increased storage capacities. Increasing water resources can be achieved through recycling of treated wastewater;
- At the demand side, savings can be achieved at each level of the hydraulic system by reducing leakages in conveyance canals, applying more efficient irrigation practices at the field level, by selecting better agricultural practices reducing water stress/water demand or by changes crops and cropping pattern.

These different demand-based options are described in more detail in the following.

a) Recycling treated effluent

In areas where water is scarce, especially for irrigation, reuse of treated effluent provides an alternative source of irrigation water. Europe has so far not invested heavily in wastewater reuse. However, in areas with high water scarcity (Cyprus, France, Italy, Malta, Greece, Portugal, Spain), wastewater reuse is increasingly being used as a suitable alternative. Table 6 provides an overview of current practices in treated effluent reuse in selected European countries.

Table 6: Wastewater recycling and reuse in European countries[66]

Country	Current practices	Recycling and reuse
Austria	Limited to only few locations	Contribute to reduce pollution and/or costs
Belgium	38% of all sewage is currently treated	Limited to irrigation of crops and hydro culture
Denmark	Limited to industry sector	Re-circulate process and cooling water
Finland	No stated need	
France	Widely developed	crops and green spaces irrigation, cooling water and wash water
Germany	Little incentive because of low water losses	
Greece	1.30 M m^3/day wastewater capable at treating	mainly for crop irrigation
Italy	Amount for reuse 2400 Mm^3/yr	mainly for crop irrigation
Norway	Rarely considered	industrial companies are recirculating processing and cooling water
Luxembourg	Little incentive	recirculate process and cooling water, humidification in the compost industry
Portugal	Treated wastewater is a valuable potential resource	cover about 10% of the water needs for irrigation

[66] Angelakis, A.N.; Bontoux, L. (2001): “Wastewater reclamation and reuse in European countries”. Water Policy 3, 47-59.

Spain	Promotion for reuse of treated wastewater - limited	golf course irrigation, agricultural irrigation, groundwater recharge
Sweden	Widely developed	essentially for irrigation
Switzerland	Little incentive for water reuse	industrial processes
Netherlands	Is becoming increasingly interesting	maintenance of the water level, water for fire-fighting
UK	No consistent pattern of treated wastewater reuse	golf courses, parks, road verges

As illustrated in Figure 15 below, irrigation is the main outlet for reuse of treated effluent. In Spain, 88% of total recycled wastewater used is applied to irrigated crops. Levine et al (1997)[67] listed 6 main uses of treated waste water in agriculture: fodder, fibre and seed crops, edible crops, stock feed water, lawns and forests, nurseries and frost protection. Catalinas and Ortega[68] estimated that wastewater recycling could increase by 600% by 2012, from a recycled volume of 200 Million m^3/year today to 1 200 Million m^3/year in 2012.

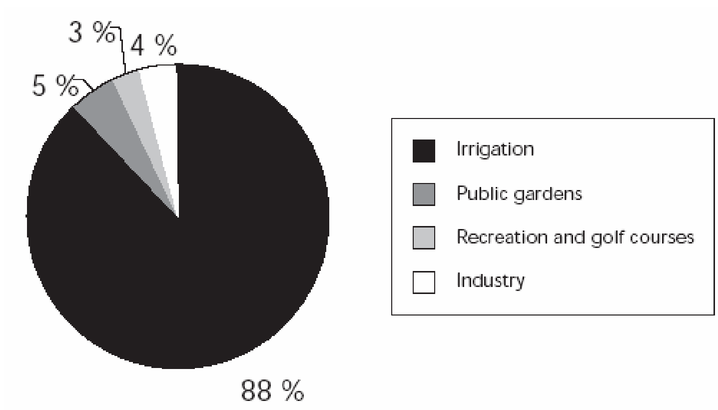

Figure 15: Water reuse by different sectors in Spain

The main limit for waste water reuse in irrigation are water quality standards. Waste water reuse regulation depends on the type of application, the regional context and the possible risk exposure. Two main regulatory guidelines for water reuse in irrigation have been followed world-wide: the State of California's wastewater reclamation criteria (1978) and the World Health Organisation guidelines. Guidelines at the European level do not exist yet. Moreover, there are wide differences between quality standards for treated effluent recycling between countries and regions in Europe. Table 7 illustrates the link between microbiological standards and the level of treatment required.

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67 Levine, B., Lazatova, V.; Manem, J. (1997): Wastewater reuse standards: goals, status and guidelines, Beneficial Reuse of Water and Biosolids Conference, Water Environment Federation, Malaga, Spain, April 1997.

68 Catalinas, P.; Ortega, E. (1999): Captacion, tratamiento, distribucion y depuracion del agua, y su impacto medioambiantal. Tecnologia del Agua, No 89, Year XIX, June 1999, p.48.

Table 7: Microbiological standards for water reuse and associated treatment in Cyprus[69]

Irrigation *	Faecal coliforms (number/100 ml)	Intestinal worms	Wastewater treatment required
Amenity areas of unlimited access	50 ** 100 ***	Nil	Secondary and tertiary followed by disinfection
Crops for human consumption	200 ** 1 000 ***	Nil	Secondary and storage for more than one week followed by disinfection, or tertiary followed by disinfection
Amenity areas of limited access	200 ** 1 000 ***	Nil	Stabilisation maturation ponds with total retention time > 30 days, or secondary and storage > 30 days
Fodder crops	1 000 ** 5 000 ***	Nil	Secondary and storage for more than one week, or tertiary followed by disinfection
Industrial crops	3 000 ** 10 000 ***		Secondary followed by disinfection, stabilisation maturation ponds with total retention time > 30 days, or secondary and storage >30 days

* Irrigation is not allowed for: vegetables, ornamentals for trade purposes; substances accumulating in the edible parts of crops and proved to be toxic to humans or animals are not allowed in effluent.
** Value must not be exceeded in 80 % of samples per month.
*** Maximum value allowed.

b) Improving irrigation efficiency

As irrigation constitutes the highest water consumption sector, technical measures for improving water use efficiency in irrigation systems are likely to entail large water savings opportunities. In a prospective study at the Mediterranean basin level[70], 65% of potential water savings are attributed to improvements in irrigation systems. Technical water saving measures can be classified depending on the parameter in the total irrigation system water requirement (***WR tot***). WR tot can be estimated as:

(1) WR tot = IN / (Ec x Ea)

With

Ec: Water conveyance efficiency:

Ea: Field application efficiency

IN: Irrigation needs (it depends upon crop water requirements, cropping patterns, soil type, agronomic practices and climatic conditions). Irrigation needs are the difference between total water requirements and effective rainfall.

Conveyance efficiency is generally a concern for irrigation districts that supply a group of farmers through a system of channels or pressurised networks. It refers to the percentage of diverted water from the source that is delivered to the field. There are large differences in conveyance efficiency depending on the irrigation network. In open channels networks, efficiency varies between 60 and 95% depending on the quality of maintenance, lining and length of channels. Average conveyance efficiency of an adequately maintained earthen channel of medium length (200- 2000m) is estimated at 75%. This efficiency reaches 95% for lined channels[71]. In Greece average conveyance efficiencies are estimated at 65% for

69 Angelakis, A. N., Salgot, M., Bahri, A., Marecos do Monte, M. H. F., Brissaud, F., Neis, U., Oron, G.; Asano, T. (1997): Wastewater reuse in Mediterranean regions: need for guidelines, Beneficial Reuse of Water and Biosolids Conference, Water Environment Federation, Málaga, Spain, April 1997.

70 Plan Bleu (2004): L'EAU DES MÉDITERRANÉENS: SITUATION ET PERSPECTIVES. MAP Technical Report Series No. 158. PNUE/PAM: Athens.

71 Rodríguez-Díaz, JA. (2004): Estudio de la gestión del agua de riego y aplicación de las técnicas de benchmarking a las zonas regables de Andalucía. PhD Thesis, University of Córdoba, Spain.

earthen channels, 80% for lined channels and 95% for pipes[72]. Thus, converting open channels into pressurised pipe network is indeed a potential water saving measure. Some countries are currently implementing renewal programs for irrigation infrastructure that aim at shifting from open channel to pressurised systems. In the Provence Alpes Cotes d'Azur region in France, modernisation plans of irrigated systems by converting gravity irrigation networks to pressurised systems have helped saving around 300 Million m^3 per year[73].

Field application efficiency is the ratio between water used by the crop and the total amount of water delivered to the fields. It informs how well an irrigation system performs in transporting water to the plant roots. Water application efficiency depends on the irrigation techniques implemented. Table 8 shows typical application efficiency values for several irrigation methods.

Table 8: Common values of field application efficiency[74]

Irrigation method	Field application efficiency
Surface irrigation (border, furrow, basin)	60%
Sprinkler irrigation	75%
Drip irrigation	90%

Additional values are presented in Table 9 from the case study on the Guadalquivir Basin (Southern Spain) [75], where field improvement is jointly considered with improvements in the distribution network.

Table 9: Irrigation efficiencies according to water delivery and irrigation systems

Distribution and irrigation system	Water conveyance efficiency	Field application efficiency	Global 'gross' efficiency
Open channel main network + furrow etc.	70%	55%	39%
Pressurized + Sprinkler	90%	75%	68%
Pressurized + Drip	90%	90%	81%

Table 9 stresses that improvement in total water efficiency can be close to 100% with changes in technology. The comparison between the "optimal" system (pressurised network and drip irrigation) with the "traditional" system (open channels and furrows), shows that irrigation water requirements per hectare can be reduced by 50%. Experiences from other regions in the world (e.g. India) show that a switch from flood irrigation to alternate furrow system can save half of the initial water requirements[76], with an estimated potential water savings of 35% as a result of a shift from gravity to sprinkler irrigation system for arable

[72] Karamanos,A.; Aggelides, S. Londra, P. (2005): Water use efficiency and water productivity in Greece. Powerpoint presentation made in Amman, septembre-octobre 2005.

[73] Personal exchange – Rhône Méditerranée Corse Water Agency.

[74] http://www.fao.org/docrep/T7202E/t7202e08.htm#TopOfPage.

[75] See the accompanying document to this report "Part II – Case studies"

[76] Sondhi, S.K. (no year): Irrigation water saving technologies for major agro-ecologies of the Indo-Gangetic Basin.

crops. In a European context, efficiency gains have been estimated for the UK[77], where water savings can be obtained from replacing a hose reel with rain gun (60-70% efficiency) to a central pivot (75%-90% efficiency). In southern Europe, drip irrigation may save up to 60% water compared to traditional surface irrigation.[78]

The level of implementation of these different irrigation technologies varies widely within Europe and depends on cropping patterns and national policies for modernisation of irrigation equipments (see Table 10). Overall, 60% of irrigation in Spain remains gravity-based (furrow and flooding), while France has already equipped 85% of irrigated areas with sprinkler systems.

Table 10: Split of the irrigated area between irrigation methods (%) in European countries[79]

Country	Area irrigated (ha)	Survey year	Irrigation method (%)		
			Surface flow (furrow, border)	Spray (sprinklers, hose - reels, centre pivot)	Trickle
Spain	3,453,000	1993	60	24	17
Italy	2,710,000	1993	55	33	10
France	1,468,000	1993	10	85	5
Greece	1,195,000	1993	Unknown	Dominant	Increasing
Portugal	791,000	1993	76	19	5
Netherlands	560,000	1993			
Germany	531,000	1994	0	95	5
Denmark	476,000	1997	0	95	5
Sweden	115,000	1993	0	99	<1
UK	150,000	2001	0	95	5
Bulgaria	50,000	1997	50	49	1
Czech Republic	14,000	1999	0.5	99	0.5
Hungary	100,000	1999	3	95	2
Poland	138,000	1997	97	3	0
Romania	319,000	1999	10	90	0
Slovak Republic	323,000	1999	0	100	0

Clearly, there are limits to the implementation of water saving irrigation technologies:

- There are agronomic limits that hinder the use of the most efficient devices. There can be crop incompatibility with irrigation techniques, as drip irrigation requires sarcled crops. While drip irrigation is well adapted to vegetables production, vineyards and orchards, it will not be possible to implement such techniques on cereals, such as maize, wheat or barley. Pivot and sprinklers are the most efficient irrigation systems for these crops.
- Soils constraints are also to be considered. In case of localised irrigation techniques (drip, micro sprinkler), lateral transfers of water might be insufficient (in particular for

77 Knox, J.W.; Weatherhead, E.K. (2003): Trickle Irrigation in England and Wales, R&D Technical Report W6-070/TR.

78 Massarutto A. (ed.) (2001): Water pricing, the Common Agricultural policy and irrigation water use, draft report, Udine, Italy.

79 Knox, J.W.; Weatherhead, E.K. (2003): Trickle Irrigation in England and Wales, R&D Technical Report W6-070/TR.

sand and sandy loam soils). Under such situations, micro-sprinklers are preferred over drip systems.

- In some farming systems, and as specified in the illustration below, increased water use efficiency does not impact total water consumption as saved water is used to expand irrigated areas.

Illustration 2

Negative effects of conversion to drip system in Spain

Investment in irrigation technologies can have ambiguous effects, as has been shown in policy evaluations. Negative effects result from the fact that changes in technology can induce new crop patterns and increase total water consumption. García Mollá (2002)[80] shows that drip irrigation technologies that were subsidised in the Valencia region (Spain) did not lead to reduced application rates, a behavior also observed in the Guadalquivir river basin. Indeed, the adoption of drip irrigation has encouraged the planting of new crops (orchards or vegetables) that can be more water-demanding than previous ones[81].

Another approach to water saving is by changing crops, adopting drought resistant varieties, changing cropping calendar or implementing agricultural practices preserving soil moisture.

When looking at the water saving potential in agriculture, there is a need to distinguish between savings that can be achieved due to technical measures, assuming that crop patterns remain stable or by changing crop patterns. Changing crop patterns has the highest potential in savings; for example, the production of high water consuming crops, such as maize, could be reduced to a certain level. Such a reduction can be achieved due to market incentives (water pricing), changes in consumption patterns or administrative restrictions. However, in all cases there are several uncertainties, and changes in production patterns are difficult to estimate, as these changes might also have side effects increasing water consumption in other areas.

Depending on their cropping calendar, their root system deepness, and crop tolerance to drought, some crops will be more affected by water deficit in term of yield. Therefore, switching from high water demanding crops to low water demanding crops is an option for reducing irrigation water requirements. A study lead by INRA in France[82] classified 9 major crops according to their drought resistance and water requirements parameters.

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[80] García, M. (2002): Análisis de la influencia de los costes en el consumo de agua en la agricultura valenciana. Caracterización de las entidades asociativas para riego. Tesis doctoral. Departamento de Economía y Ciencias Sociales. Universidad Politécnica de Valencia, Valencia.

[81] Berbel, J. (2005): Análisis económico del agua en la Directiva Marco. Su aplicación a la Cuenca del Guadalquivir. Conferencia ISR, Córdoba, Spain, 28/abril/2005. Available at: http://www.isrcer.org/jornadas.asp.

[82] INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise.

Table 11: Crop classification according to their tolerance to water scarcity

Crop	Climatic Threat			Water efficiency		Tolerance		Overall rating
	Cropping calendar	Root system	Adaptive capacity	Climatic efficiency	Intrinsic efficiency	Vegetal system robustness	Reproductive system robustness	
Rape	Autumn Spring	Deep	++++	+++	+	+	+	++++
Alfalfa	Perennial	Very deep	+++	++	+	+	+	++++
Vine	Perennial	Very deep	++++	+	++	+	+	++++
Wheat	Winter Spring	Deep	+++	+++	+	++	++	+++
Sunflower	Spring Summer	Deep	+	+	-	++	+++	++
Barley	Spring Summer	Medium	++	+	+	++	+++	+++
Sorghum	Summer	Medium	+	-	+++	++	+++	+++
Pea	Spring Summer	Low	-	+	+	+	+	-
Maize	Summer	Medium	+	-	+++	++	-	-

Based on Table 11 different types of crops can be distinguished:

- Some crops do not have specific tolerance to drought, but their cropping calendar is centred around the autumn and winter months when soil water reserves are high. Rape, winter wheat and winter barley are part of this category.
- Other crops do not indicated any particular water tolerance, but they have large and deep root systems that helps them to resist to water stress. These includes grapes and alfalfa.
- Some crops like sorghum and sunflower have a certain level of water stress tolerance.
- Finally, some crops are particularly sensitive to drought events and do not have deep root systems. This is the case of maize and pea. Maize flowering period (during the summer) is particularly sensitive to drought events and requires high amounts of irrigation. Maize has a high water use efficiency and the same water requirement as wheat (around 500l/m^2/year). But while wheat has a long cropping cycle, maize water demand is concentrated during the peak demand summer months.

Illustration 3

Irrigation needs of the 7 main crops in France[83]

As shown is the graph below, maize is the highest water consuming crop. Its high irrigation needs are mainly due to a high water efficiency and drought sensitivity. Volumes abstracted by this crop are 6 times higher than total water abstracted by others crops.

Table 12: Irrigation volume and water consumption of different crops

	Wheat	Rape	Pea	Maize	Sorghum	Soybean	Sunflower	Sugarbeat	Potatoes
Area (1000 ha)	5248	1176	429	1764	59	78	728	409	162
% of irrigation	0,5	0	14,5	44,5	3	40,5	2	7,5	36
Average irrigation volume (m3/ha)	400	0	650	1300	600	900	600	800	800
Irrigation consumption (Mm3)	10	0	40	1020	1	28	9	25	47

There are several solutions to decrease irrigation needs, particularly the possibility to switch from high water consuming crops (maize) to crops that are drought resistance and have low irrigation water needs (e.g. sorghum, sunflower etc. However, such changes of land use are highly dependent on market prices and opportunities.

Choosing crop varieties that are less water stress sensitive is another way to reduce the reliance on irrigation water. Crop selection in the past was mainly driven by yield increase and pest resistance. Some progress in terms of drought tolerance, however, has more recently been obtained for maize. Genetically modified varieties could also help fight against drought, although results indicate that this option is not yet ready to pass to the field use.

Changes in agriculture practices can also help decreasing irrigation needs. As explained above, the timing of the cropping calendar can be used as a technique to reduce water consumption. Early sowing, for example, can help captors winter rains so that the need for supplementary irrigation is reduced. Also, early sowing would help avoiding extreme evapotranspiration rates typical of Mediterranean summers. The use of no-tillage technology is another practice that is currently under investigation to reduce irrigation water demand. Deficit irrigation is also another technique aimed to reduce the amount of water below that of the ‘theoretical irrigation needs’. When this reduction is done in critical periods of the plant growth, it can have minimum impact on crop yield. Research results illustrate, for example, that a reduction by 40% of irrigation water supply on wheat induces only a decrease by 13% in yield[84]. Concerning potatoes, water savings of 20% can be achieved with a yield reduction of around 10%. For grapevines, reduction in water use ranging from 16.5% (rainy years) to 53% (dry years) have been demonstrated with no significant impact on the grape yield nor on the quality of the must[85]. For maize, limited reduction in yields due to water savings of up to

[83] INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise.

[84] Pereira, L.S., Cordery, I., Iacovides, I. (2002): “Coping with water scarcity”. Technical Documents in Hydrology, 58. UNESCO.

[85] Battilani, A. (2007): Application of the regulated deficit of irrigation to grapevines (Vitis vinifera) in a sub-humid area. III International Symposium on Irrigation of Horticultural Crops.

20% would be entirely compensated by reduced irrigation costs and reduced drying costs of maize[86].

Improving irrigation scheduling so that irrigation follows crop water requirements as closely as possible can also lead to significant water savings[87]. There are different tools to monitor a soil's moisture level (tensiometers in particular), and computer software has been developed to simulate crop water requirement depending on soils and climate conditions. Few results are available in term of volume of water saved. Farm surveys conducted in the Aquitaine region in France (see Table 13) show that in 2001 27% of farmers declared having irrigated "as usual". These farmers are responsible for 44% of total water consumption, with average irrigation water depth 30% higher than for farmers following technical advises, but were at the same time able to obtain the highest crop yields.

Table 13: Irrigation parameters depending on factors supporting farmers in their irrigation decision.

Source of decision for irrigation	Number of farmers	Area	Water volume	Average dose(mm)	Yield (100kg/ha)
Irrigation "as usual"	27%	33%	44%	203	94
Following simple observation	40%	31%	19%	94	93
Irrigation piloting tools	18%	18%	21%	183	96
Technical advise	15%	17%	16%	138	100

To summarise this section on technical measures, it is important to stress that information on estimated water savings in irrigation or changes in efficiency are based on "gross" or "dry" saving at the location where the technological change or new agricultural practice takes place. Thus, this information does not account for the hydrological functioning of a river basin and locations of uses:

- At a river basin scale, local improvements may not lead to "new water" or "wet savings" because of possible uses of return flows made downstream of irrigation systems. If an improvement in conveyance efficiency, for example, is implemented in the upper section of a river basin, it might only reduce return flows that might be used entirely downstream – thus not necessarily leaving saved water for the ecosystem and the environment.
- In other situations, increasing water use efficiency may not be desirable if return flows resulting from highly inefficient irrigation systems are providing base flows to sensitive ecosystems (e.g. wetlands), which may have developed over centuries as a result of inefficiencies in irrigation. This is the situation of the Camargue (South of France), whose ecosystems benefit from inefficiencies in irrigation in the Craue plain.

5.1.2.2 Investigating the costs of water saving measures in the agriculture sector

There are many illustrations of technical projects highlighting changes in irrigation efficiency at the irrigation system, sub-system, farm or field level as a result of changes in irrigation technologies or farm practices. Some of those have been presented above and are not

[86] INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise..

[87] INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise.

repeated here. However, information on costs are scarce, in particular in terms of changes in agricultural production and farm income that might result from the application of new farm practices aimed at reducing water use. Indeed, costs and benefits of technical measures can be divided in direct costs induced by the investments in irrigation devices and indirect impacts (positive or negative) on crop gross margin and farm revenue

Costs of improvements in conveyance infrastructure are highly dependent on local conditions (slope, length, roads to cross etc) of the irrigation system. The large modernisation plan conducted in the Provence Alpes Cotes d'Azur region in France[88] (conversion from gravity to pressure distribution networks) required a total investment of 15 Million Euro for water savings of 300 Millions m^3/year – equivalent to an investment of 0.05 Euro /m^3 of water saved. Other references give unitary costs for conversion from gravity to pressurised systems of around 10 000 Euro /ha.

Changes in irrigation technology will also change costs of irrigation for farmers, as illustrated in Table 14, which displays costs paid by farmers in the south-east of France depending on the source of water and the type of irrigation used. As a comparison, the share of the abstraction charge paid by farmers to the water agency in this region is very low between 2 to 8% of total water costs.

Table 14: Fixed and variable costs of irrigation depending on irrigation infrastructures[89]

Type of irrigation infrastructure	Tarif system			Cost	
	Fix costs per ha (assumption 4 m3/h/ha)		Volumetric cost	Total costs for 3000 m3/ha	
	Average	Variation		Per ha	Per m3
Gravity	183 eur/ha	76 eur/ha	0,00	183 eur	0,061 eur
Collective pressurized system	107 eur/ha	46 eur/ha	0,076 eur/m3	335 eur	0,111 eur
Individual pumping	122 eur/ha	21 eur/ha	0,009 eur/m3	149 eur	0,05 eur

It is important to note that the importance of irrigation costs in total production costs varies widely between regions, irrigation systems and main crop types grown by farmers. Values between 10 and 20% are cited for the costs presented in the previous table for the south-east of France[90]. In addition, the importance of water costs in farm gross margin and output is also highly variable, as indicated in Table 15 below. Thus, additional costs imposed by a change in irrigation technology may be problematic where water costs per unit of output are already high, while they might not be important for other farming systems with very low costs per unit of output.

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88 Personal exchange – Rhône Méditerranée Corse Water Agency.

89 CGGREF (2005), quoted by INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise.

90 CGGREF (2005), quoted by INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise.

Table 15: Water cost versus total farm output[91].

Crop/system	Location	River/Source	Output €/ha	Water cost cent/m^3	Water costs/ output (%)
Greenhouse	Netherlands	Underground	120 000	15	0.8
Strawberry	Chanza	Guadiana	48 193	15	1.6
Greenhouse	Almeria	Mediterranean Andalusia	90 361	25	1.7
Maize	France	Several	3 000	10	5.0
Olive	Jaen	CH Guadalquivir	4 000	15	6.0
Cotton	Seville	CH Guadalquivir	4 000	8	12.0
Sugar Beet	Palencia	CH Duero	3 000	6	12.0
Wheat	Cordoba	CH Guadalquivir	1 500	8	10.6

At the field level, investments induced by irrigation differs highly depending on the infrastructure implemented. The more efficient techniques are also the most expensive ones. For example[92], a siphon for surface irrigation (furrow) is estimated at 4 Euro /ha/year, while sprinkler irrigation ranges from 144 Euro /ha/year to 349 Euro /ha/year for rain gun and total sprinkler coverage, respectively. A pivot system is estimated at between 185 to 298 Euro /ha/year, values still significantly lower than drip irrigation costs that range from 2 470 to 5 146 Euro /ha/year.

With regards to reuse of treated effluents, investment costs for sand filtration can vary from 48 to 84 Euro /m^3 with additional 0.01-0.02 Euro /m^3 for operation and maintenance[93]. Reverse osmosis costs are higher, namely 151 to 193 Euro /m^3 for investments and 0.26-0.27 Euro /m^3 for operation and maintenance. Potential benefits of reuse of treated effluent include an increase of available water resource through substitution of fresh water, which can potentially be used for other uses (e.g. drinking water) or left in the river to support the functioning of the aquatic ecosystem. Additional benefits include a potential decrease of pollutants discharged into freshwater, a better use of the nutrient of waste water and a guarantee of regular water supply to farmers. It is interesting to note that reuse of treated effluent, while aimed at saving water, may have the opposite result; indeed, summer flows of some rivers in Mediterranean countries are highly supported by discharged treated wastewater. Diverting treated effluent to agriculture would then drastically decrease river flows[94].

Selected illustrations on changes in irrigation technology and costs are presented in the following illustrations.

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91 Berbel, J. (2005): Análisis económico del agua en la Directiva Marco. Su aplicación a la Cuenca del Guadalquivir. Conferencia ISR, Córdoba, Spain, 28/abril/2005. Available at: http://www.isrcer.org/jornadas.asp.

92 See: http://www.economie.eaufrance.fr:80/rubrique.php3?id_rubrique=44.

93 European Environment Agency (EEA) (2001): Environmental issue report No 19, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

94 Angelakis, A. N., Salgot, M., Bahri, A., Marecos do Monte, M. H. F., Brissaud, F., Neis, U., Oron, G.; Asano, T. (1997): Wastewater reuse in Mediterranean regions: need for guidelines, Beneficial Reuse of Water and Biosolids Conference, Water Environment Federation, Málaga, Spain, April 1997.

Illustration 4

Irrigation technology and costs in Cyprus[95]

The irrigation network in Cyprus consists of closed systems with an overall conveyance efficiency averaging 90–95%. Field application efficiency averages 80–90%. In parallel with the government's effort to increase the water available for agriculture, emphasis was placed on the optimum use of water through improved irrigation methods. To encourage farmers to use these methods, the government offered incentives to participating farmers in the form of subsidies and long-term low-interest loans for the purchase and installation of improved irrigation systems. In addition, through extensive demonstrations, the government convinced the farmers that improved irrigation methods, initially sprinklers for vegetables and the hose/basin method for tree crops, to be followed by micro-irrigation systems, not only saved water but also led to increased yields. As a result, the area irrigated by surface irrigation methods decreased from about 13 400 ha in 1974 to less than 2 000 ha in 1995, while the area equipped for micro-irrigation increased over the same period from about 2 700 ha to almost 35 600 ha. The areas irrigated by surface irrigation methods are mostly cropped with deciduous trees and are found in the hilly areas of the country. The cost of irrigation development varies and depends on a number of factors. The average cost of irrigation development using tube wells varies from about 3 890 Euro /ha for up to 1 ha, 2 237 Euro /ha for 2 ha to 1 683 Euro /ha for 3 ha. This includes the cost of on-farm micro-irrigation systems. Excluding the cost of the dam, the development of surface water varies from 1 544 Euro /ha to 2 584 Euro /ha including on-farm micro-irrigation systems. The average annual cost of maintenance varies from 297–347 Euro /ha for private schemes (tube wells) to 49–119 Euro /ha for public schemes.

Illustration 5

Drip irrigation in Israel[96]

Since the 1980s Israel has been using drip irrigation and micro-sprinkler techniques to expand crop output within the limits of existing water supplies. These techniques are mainly used for vegetables and fruit trees and are integrated into computerised systems that operate irrigation applications automatically based on information collected via plant moisture sensors. This technology, combined with the use of water-efficient crops, has resulted in an irrigation efficiency of 90%, as compared to the 64% efficiency of the traditional furrow irrigation system. As a result, average water requirements were reduced by 40% between 1975 and the end of the 1990s. At the same time, agricultural output increased twelve fold.

Illustration 6

Improving irrigation efficiency in New South Wales (Australia)[97]

As a result of government efforts to cement the environment's right to water and re-define water sharing arrangements among consumptive users, 5% to 12% of allocated irrigation water for New South Wales (NSW) was proposed to be returned to the environment. To offset the loss of irrigation water, the NSW government instituted an integrated package of measures between 1998 and 2005 to improve on-farm water use efficiency and increase crop yields. This programme, commonly known as WaterWise on the Farm, engaged more than 5 000 irrigators (out of a total of 12 000 for NSW) in

[95] European Environment Agency (EEA) (2001): Environmental issue report No 19, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

[96] http://www.damsreport.org/docs/kbase/contrib/opt159.pdf.

[97] Elliot, S. (2005): Lessons from agriculture water saving initiatives and their impact on future programs. Paper presentation at the 4th National WaterWatch Conference.

training, farm planning and investment in water efficient technologies. Water use efficiency savings have been estimated at up to 25% with increases in crop yields of 20% being reported.

Illustration 7

Water savings and participatory irrigation management in Turkey[98]

Water scarcity in Turkey is of major concern since the 1960s. With agriculture accounting for 70% of Turkey's total water consumption, specific efforts have been made in this sector for enhancing the irrigation efficiency. In the context of a general move to transferring the management of some irrigation systems to water users, pilot projects aimed at improving water use efficiency were initiated, combining the implementation of new technologies (drip irrigation, sprinkler irrigation), better farm practices, awareness raising and training. Results from one pilot study indicated water savings of 34% between 1993 and 1998. At the same time, energy use for running the irrigation system was reduced by 30%. Because of water savings and better farm irrigation practices, environmental improvements were also recorded with a reduction by 2% and 5% of areas with salinity problems and high water tables, respectively.

Illustration 8

Cidacos river pilot study[99]

The 'pilot study' of Cicacos river (tributary to Ebro, North-Central Spain) proposes a ranking of measures to save water and therefore increase the river flow. The measures illustrated in below figure are ordered by unit cost (Euro /m^3 saved) by the blue line, and the impact on river flow (i.e. water saving) is plotted by the red line. We see that the most economically efficient measure is to invest in extension services for farmers skill building, starting with those farmers that irrigate with more than 5 000 m^3/ha, followed by changes in irrigation system and distribution network. As we can see the main measures (red) are targeted to irrigation and farmers followed by domestic users (black).

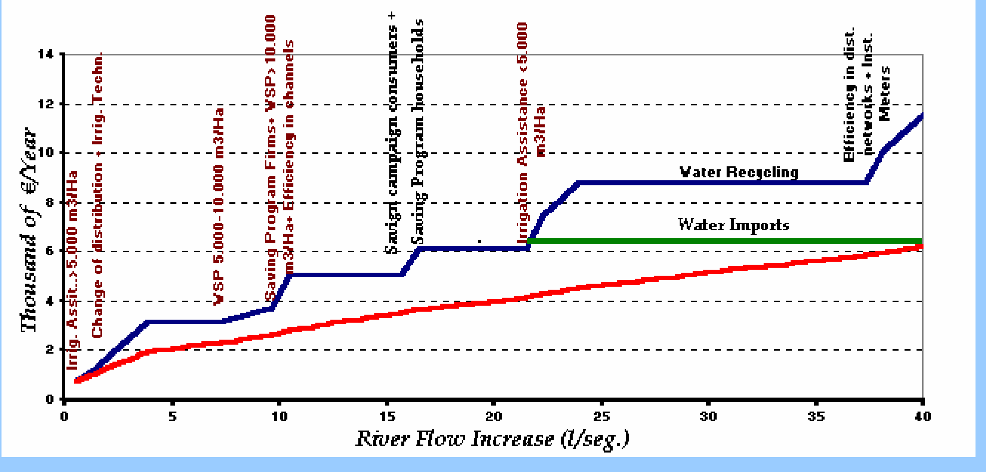

Figure 16: Various water saving measures and their impact on river flow increase

98 Burak, S. Vidal. A. (2000): Turkey success story: water savings in relation to participatory management. In: Water Conservation, GRID Issu 16, August 2000.

99 § Ministerio de Medio Ambiente y Gobierno de Navarra (MIMAM) (2002): Estudio Piloto de la Aplicación del Análisis Económico en la Cuenca del Cidacos.

Illustration 9

Changing irrigation technology and employment [100]

Changing agronomic practices for a reduction of irrigation needs and even a decrease of irrigated area would also have a social impact that one should take into account. A change in crop patterns might indeed lead to changes in incomes or even loss in jobs as indicated by information provided in the table below.

Basin		Person-day/ ha-year
Duero (North-Spain)	Rain-fed	0,7
	Irrigation	2,4
	Irrig/Rainfed(%)	360%
Guadalquivir (South-Spain)	Rain-fed	10,4
	Irrigated	14,6
	Irrig/Rainfed(%)	140%
Capitanata (CBC)-Italy	Rain-fed	0,5
	Irrigation	4,4
	Irrig/Rainfed(%)	862%

Table 16: Linkages between irrigation scheme and employment

The above mentioned table shows for three irrigated systems the impact of non-irrigation in employment as a basin average. The global average for each river basin increases from 140% (Guadalquivir-Spain) to 862% (Italy).

Illustration 10

Effect of subsidies for irrigation equipment.

Positive results come by increasing water productivity, which in turn would reduce the welfare windfall losses resulting from water price increases. Yet, Rainelli and Vermesch (1998)101 showed that one reason that explains the significant growth in French irrigated acreage was the subsidisation of irrigation equipment, which reinforced the CAP incentives mentioned above (as with Spain, cited earlier). The extent to which subsidisation of irrigation equipment should be taken into account in water subsidisation analysis is not clear. For one thing, a general belief is that these subsidies are redundant, as irrigators eventually invest in equipment with or without subsidies. Some of the reasons guiding their investment plans are labour cost reductions, lower input application costs through fertirrigation (simultaneous irrigation and fertilisation through the drip system) and upgrading product quality.

Illustration 11

Contingency plan for irrigation improvement in Spain

Plan de Choque para la Modernización de Regadíos was approved in February 2006 and introduced three new criteria in the National Irrigation Plans:

[100] Giannoccaro, G.; Zanni' G.; Berbel, J. (2007): La valutazione della multifunzionalita' dell'agricoltura irrigua negli ambienti mediterranei: un'applicazione di *benchmarking* Working Paper (Forthcoming).

[101] Rainelli, P.; Vermersch, D. (1998): Irrigation in France: Current Situation and Reasons for Its Development. Unpublished manuscript from a study submitted to OEDC Environment Directorate.

1. The co-ordination between the Ministry of Agriculture, in charge of promoting rural and agricultural development, and the Ministry of the Environment, oriented to the protection and improvement of water ecosystems.

2. The efficiency enhancement in order to effectively reduce the water demand and the abstractions required in the agricultural sector.

3. The promotion of technological innovations, in particular by improving the detailed control of water uses and to the automatic management of the irrigation networks.

With an overall investment of 2 344 Million Euro, the plan projects savings of 1.162 hm^3 on 866 898 ha mainly by improving water transport, distribution and application efficiency, by the selection of crops with low water requirements and by the use of non-conventional sources of water (treated effluent, water from desalinisation plants). The 291 024 farmers covered by the plan will commit to adopt an exigent program of environmental auditing to reduce pollution loads. To add transparency, all projects included in the plan are published online.

Illustration 12

Impact of water metering on irrigation water demand, Canada[102]

The Irrigation district of Kelowna (SEKID) in the south east of Canada covers 2 282 ha. Around 85% of total water consumption is for irrigation. Following drought events of the beginning of the 1990s, SEKID decided in 1994 to implement water meters and tensiometers at farm level to enhance farmers' awareness of their own irrigation practices. At the same time, an information campaign was implemented to increase awareness on more efficient irrigation water use. These measures have been supplemented in 2000 by the implementation of volumetric water pricing. Impacts of both policies on total water consumption were as follows:

1. The implementation of water meters and awareness campaign in 1994 was not followed by a direct decrease in agricultural water consumption.

2. Volumetric pricing has been followed by a rapid and significant decrease of volumes applied per hectare. Average savings between 2001 and 2003 vary from 1 000 m^3/ha to 2000 m^3/ha.

3. A long term decrease of water consumption had been observed before the programme began due to progressive renewal of irrigation infrastructure and conversion to lower water demanding crops.

Illustration 13

Irrigation water from an automatic teller machine (ATM).[103]

The Hanover Expo 2000 awarded a prize to Comunidad de Regantes de Mula (Segura basin). Each of the 1 700 members of the Comunidad covering 2 000 ha uses an 'ATM' with a personal card and secret code for ordering irrigation water. Users select the field and quantity to be applied each day and pays for it at the same time. Farmers have converted a traditional system with open channels, furrow irrigation and a water turn every 45 days to a new system with a daily turn of eight hours for drip irrigation. Average costs are 0.12 Euro /m^3, and a quota is defined for each farmer. If this quota is

[102] Government of Canada (2007): "La tarification de l'eau entraîne-t-elle une baisse de la demande dans le secteur agricole?, un cas en Colombie-Britannique", Note d'information, available at: www.recherchepolitique.gc.ca.

[103] http://www.todomula.com.

exceeded, an additional price premium of 50% is paid. Users saving water below their quotas get a 25% tariff reduction. Free transfer of water is allowed within the Comunidad but market transfers are forbidden. Total investments include 7 000 Euro /ha for the pressurised network plus 2 500 Euro /ha for drip systems at farm level.

5.1.3 Conclusions on water savings in agricultural sector

The following table summarises the results of the different case studies of agricultural water savings developed in the previous chapters. Overall, significant (freshwater) savings can be expected in the agriculture sector as a result of technological improvements, changes in farm practices, use of more drought-resistant crops or reuse of treated effluent. Potential water savings due to shifts in irrigation technologies are highest in countries where gravity/furrow irrigation is still important, in particular in southern European Member States. Improvements in irrigation scheduling, better agricultural and irrigation practices at farm and field levels or a wider use of deficit irrigation can potentially apply to all countries.

In some cases, the implementation of these measures will lead to reduced pressures on water resources and potentially a reduction in water supply uncertainty. Also, improvements in the overall “drought-resistance” of the agriculture sector would be expected – reducing to some extent risk and financial compensations to be paid to farmers because of production losses in case of droughts.

Table 17: Synthesis of measures for agricultural water savings and their impacts.

Measure	Details	Potential water saving	Place/ Level of the reference	Cost	Preliminary condition and limits	Source
Improving conveyance efficiency	open channels -> pipes	20%	Spain			University of Cordoba
	open channels -> pipes	300 Million m^3 per year	France	15 Million Euros (0.05 €/m^3)		Interviews with experts
	Earthen-> lined channels	10 to 25 %	Global, medium length channel (200 to 2000m)			FAO, irrigation manual 4.
Improving application efficiency	Surface -> sprinkler	15%	Global			FAO, irrigation manual 4.
	Surface -> drip	30%	Global		Crop compatible with drip system	FAO, irrigation manual 4.
	Drip irrigation	60%	Southern Europe		Crop compatible with drip system	Massarutto. 2001
	Sprinkler irrigation		France	+ 140-345 €/ha as compared to furrow irrigation		http://www.economie.eaufrance.fr/
	Pivot irrigation		France	+ 180-293 €/ha as compared to furrow irrigation		http://www.economie.eaufrance.fr/
	Drip irrigation		France	+ 2 465-5 142 €/ha as compared to furrow irrigation		http://www.economie.eaufrance.fr/
	From furrow to drip irrigation	40%	Israel		Agriculture output multiplied by 12	http://www.damsreport.org/docs/kbase/contrib/opt159.pdf
	From surface to micro-irrigation		Cyprus	between 1 544€ and 3 890 €/ha investments, O&M costs ranging from 50 €/ha to 347 €/ha		EEA. 2001
Improving irrigation scheduling	Use of tensiometers and advise	30%	Aquitaine region (France)			INRA. 2006
Decreasing crops irrigation needs	Replacement of high water consuming crops by crops with lower requirements	High variation depending on crops alternatives				INRA,2006
		50%	Maize -> sorghum France		Market outlets.	
	No tillage technology	Uncertain impact			Depending on current cropping calendar	
	Deficit irrigation	20%	Orchards, Guadalquivir Spain	Decrease of yield from 2 to 11%		See case study Spain
		16.5% (rainy year) to 53% (dry year)	grapevine (general)	No impact on yield and quality		
		20%	Maize (France)	Reduction in yield compensated by reduced irrigation and drying costs		INRA. 2006
		40%	Wheat, Tunisia	Decrease of yield of 13%		Pereira, and al 2002
		25%	Potato, Tunisia	Decrease of yield of 10%		Pereira, and al 2003
Wastewater reuse		10% of total water needs for	Portugal			A.N. Angelakisa and L. Bontoux, 2001
		12% of total water needs for	Italy			
	Treatment with sand filtration			48-84 €/m^3 for investments, 0.01-0.02 €/m^3 for O&M		EEA. 2001
	Treatment with reverse osmosis			151-193 €/m^3 for investments, 0.26-0.27 €/m^3 for O&M		EEA. 2001
Water saving programmes	Training, farm planning, new irrigation technology	25%	Australia		Increase in crop yields of 20% reported	Elliot.
	new technologies (drip, sprinkler), improved farm practices, awareness raising	34%	Turkey		Additional reduction in energy use by 30%, improvements in soil salinity and waterlogging	Burak et al. 2000
	New technology, automatic management of irrigation systems, efficiency enhancement measures, coordination.	1 162 hm^3 of water saved	Spain	2 344 Million Euros (2 €/m^3 of water saved)		
	Water metering, awareness and advise, volumetric pricing	Between 1 000 m^3/ha to 2 000 m^3/ha	Canada			http://www.recherchepolitique.gc.ca/
	ATM, new technologies & incentive pricing		Spain	Investments of 7 000 €/ha for the pressurized network + 2 500 €/ha for drip systems at frm level		http://www.todomula.com/

5.2 Potential Savings in the domestic sector

5.2.1 General figures

The domestic sector, which includes households, public utilities and small businesses but not manufacturing or electrical production facilities, accounted for about 24 percent of total water withdrawn in Europe[104] in 2000, which is about 73.2 km^3. As shown in chapter 4 there has been a negative trend over the past years.

The EEA[105] estimates that 80% of water used by the domestic sector is returned to the aquatic environment through leaks in the distribution network and through wastewater; only 20% is actually consumed (mainly by drinking and eating).

Households are normally the biggest users within the domestic sector. For instance, in Spain urban water consumption is apportioned as follows: 70% for household consumption, 24% for small industries and services, and 6% for public services[106]. Similar figures can be found for France. This means that although household water use represents most of the demand, some figures on “household” water use should be taken cautiously[107].

Across Europe water use in the household sector varies widely. These variations can mainly be explained as follows:

- The technical performance of the different supply system varies widely among different MS and urban areas, which results in different rates of leakages. Table 18 gives examples of leakage estimates for different countries show big differences, in particular due to the different network states.

[104] This are EU 27, Turkey, Iceland, Norway and Switzerland. See http://themes.eea.europa.eu/Specific_media/water/indicators/WQ02%2C2004.05/WQ2_WaterUseSectors_130504.pdf.

[105] European Environment Agency (EEA) (2005): The European Environment State and Outlook 2005.

[106] Ministerio de Medio Ambiente (MMA) (1998): White book about water in Spain, Madrid.

[107] Water use by tourism has an important influence on domestic water use. Tourism patterns are different among European countries and therefore accounts for a different share in the domestic use. Furthermore, there are also seasonal variations in population due to tourism that influence the amount of water used at a particular time. For example, the population of 27 municipalities on the Costa Brava in Spain grows from 150,000 in winter to 1.1 million in mid-August (Plan Bleu. (2000): Mediterranean Vision on water, population and the environment for the XXIst century. Jean Margat, Domitille Vallée. Contribution to the World Water Vision of the World Water Council and the Global Water Partnership prepared by the Blue Plan in the Framework of the MEDTAC/GWP).

Table 18: Leakage% for different countries

Country	% leakage	Reference
Bulgaria (Sofia)	30-40	[Ref 2]
Bulgaria (other than Sofia)	More than 60	[Ref 2]
Bulgaria (National)	50	[Ref 1]
Czech Republic	20-30	[Ref 2]
Czech Republic	32	[Ref 1]
Denmark	4-16	[Ref 2]
Denmark	10	[Ref 1]
Finland	15	[Ref 2, 1]
France (national average, 1990)	30	[Ref 2]
France	30	[Ref 1]
France (Paris)	15	Ref 2]
France (highly rural area)	32	[Ref 2]
Germany (former West Germany, 1991)	6.8	[Ref 2]
Germany (former East Germany, 1991)	15.9	[Ref 2]
Germany (average, 1991)	8.8	[Ref 2]
Germany	3	[Ref 1]
Hungary	30-40	[Ref 2]
Hungary	35	[Ref 1]
Italy (national average)	15	[Ref 2]
Italy (national average)	30	[Ref 1]
Italy (Rome)	31	[Ref 2]
Ireland	34	[Ref 1]
Romania	21-40	[Ref 2]
Romania	31	[Ref 1]
Slovakia	27	[Ref 2]
Slovakia	27	[Ref 1]
Slovenia	40	[Ref 2, 1]
Spain	24-34	[Ref 2]
Spain	22	[Ref 1]
Sweden	17	[Ref 1]
UK (England and Wales)	8.4 m^3/km mains pipe/day 243 l/property/day	[Ref 2]
United Kingdom	22	[Ref 1]

Note: The data is based on EEA (2001): EEA (2003), Indicator Fact Sheet (WQ06) Water use efficiency (in cities): leakage, version 01.10.2003 [Ref 1] and Environmental issue report No 19, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen, 2001 [ref 2].

- Water consumption per person and day varies widely across the EU as well. The following figures[108] provide estimates derived from volumes of distributed water from

[108] European Environment Agency (EEA) (1999): Environmental issue report No 19, Sustainable water use in

collective networks[109]. Average annual water consumption in the European Union in the 1990's was approximately 150 l/capita/day, whereas in the former Eastern Countries it was 105l/capita/day.

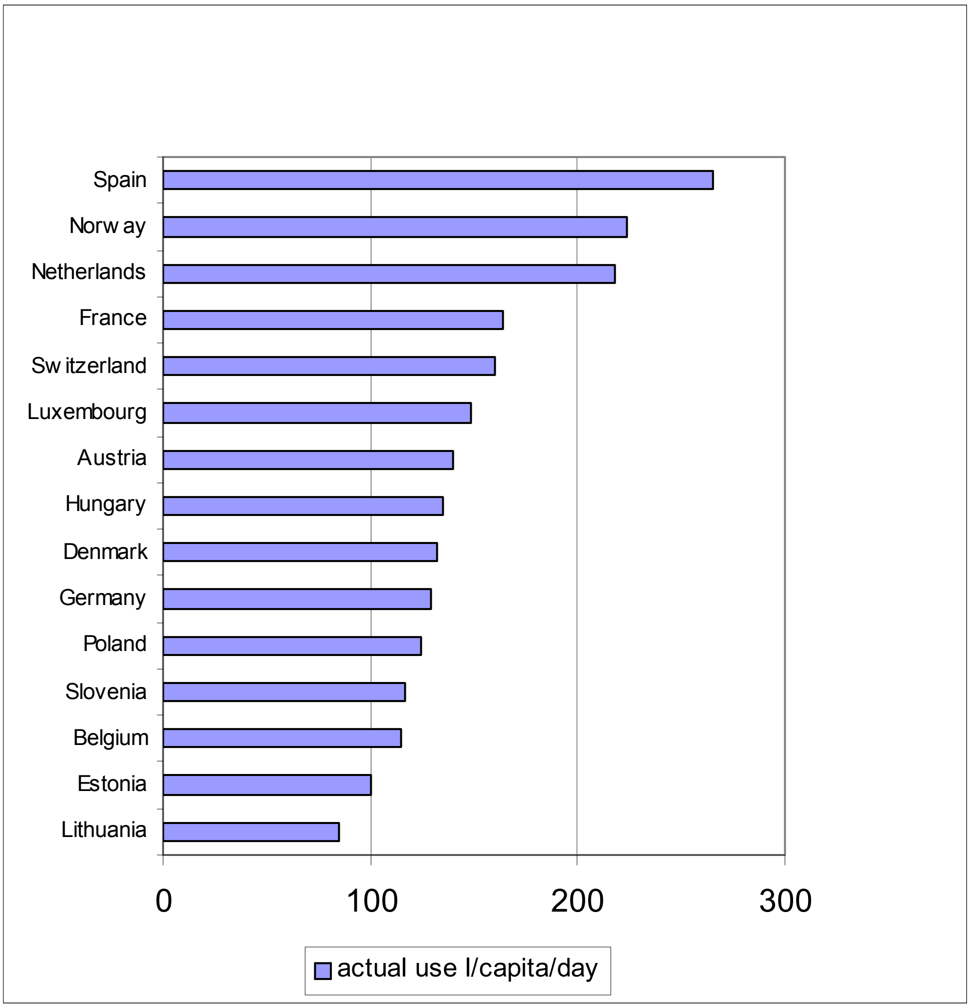

Figure 17: Household Consumption in Europe in 2000[110]

Water use per person may vary:

- with the way of life. Age, environmental education, income and living standards have a strong influence on how much water is used[111]. For instance, a 2-person household uses 300 litres of water per day, 2 single households use 210 litres each[112]. Population moving from a rural setting to an urban setting (urbanisation) can also

Europe. Part 1: Sectoral use of water. EEA, Copenhagen.

[109] Some differences can thus arise from a difference in the relative importance of self-supply by the domestic sector, more important in the Candidate Countries than in most EU countries at the time of the study.

[110] Data from NEWCRONOS, Eurostat, (2000)

[111] See Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use Final Report.

[112] European Commission (2005): Commission staff working document - Annex to the communication from the Commission to the Council and the European Parliament on Thematic Strategy on the Urban Environment - Impact Assessment {COM(2005) 718 final}.

change habits. Table 19 provides an overview of water use patterns by households in England and Wales, Finland and Switzerland[113]

- the application and efficiency of different technologies used in household varies between countries, as depicted in Table 20. A shower may use as much as 60l per shower in Finland, compared to 16l in France. Table 19 illustrates the range of technological performance across Europe and the great potential for water saving by improving water efficiency of common household appliances, such as toilets, taps and washing machines.

Table 19: Water use Patterns

Household uses	England and Wales (%)	Finland (%)	Switzerland (%)
Toilet flushing	33	14	33
Bathing and showering	20	29	32
Washing machines and dishwashing	14	30	16
Drinking and cooking	3	4	3
Miscellaneous	27	21	14
External use	3	2	2
Total	!Syntaxfehler,)	!Syntaxfehler,)	!Syntaxfehler,)

Table 20: Typical Domestic Water Consumption

Appliance	England and Wales	Finland	France	Germany
Toilet	9.5 l/flush	6 l/flush	9 l/flush	9 l/flush
Washing Machine	80 l/cycle	74-117 l/cycle	75 l/cycle	72-90 l/cycle
Dishwater	35 l/cycle	25 l/cycle	24 l/cycle	27-47 l/cycle
Shower	35 l/shower	60 l/shower	16 l/minute	30-50 l/shower
Bath	80 l/bath	-	-	-
Water Saving Appliances	No incentive for the majority of households to conserve water, but commerce and industry have invested in flush controllers for urinals, push operation taps, low-volume shower heads and devices to limit toilet flush volume	The amount of water per flush in toilets depends mainly on the construction year of the building: Prior to 1976, 9 l/flush; 1976-93, 6 l/flush; 1993-96, 4 l/flush; Since 1996, 2-4l/flush	Domestic water saving Appliances are not widespread	Some municipalities have invested heavily in installing water-saving devices and increasing public awareness

[113] European Environment Agency (EEA) (2001): Environmental issue report No 19, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

A reduction of freshwater abstraction in urban areas can be achieved by (i) changes of population habits, (ii) use of more efficient technologies and water saving devices and (iii) use of alternative sources of water (wastewater direct re-use). Measures can be implemented in several ways such as (i) legal (e.g. compulsory use of certain technologies, quota for water use), (ii) economic (e.g. tariff systems, progressive pricing, subsidies for small - large water saving investments);and (iii) informational (e.g. information campaigns, user education, programmes to increase environmental awareness due to metering or awareness campaigns, concern for public image).

5.2.2 Technical water saving options

There are several domestic water saving measures to reduce water use, which can basically divided into two parts: a) technical measures (changes in supply, network improvement, repair leaks, installation of water saving devices, etc.), and b) non-structural measures (information, education, pricing) that may change consumptive habits and/or lead to infrastructure improvements. The first one will be dealt in the following section, the later one please see chapter 6.3.

On the technical side there are many different water saving measures that can be considered:

5.2.2.1 Rainwater harvesting

Rainwater harvesting is one measure to reduce fresh water abstraction needs. It is used for water conservation and storm water management. Rainwater storage tanks can be connected to garden irrigation systems through filters. When connected to a toilet cistern or washing machine, use is maximized because, unlike garden watering, the tank is used even when it is raining. Some plumbing alterations to existing homes are required (e.g. up connections). For more technical details see Annex 1.

Legislation surrounding rainwater harvesting is strict. Many countries do not allow plumbing in houses to be altered in order to accommodate rainwater harvesting (for sanitary reasons). A double network should thus be installed in the house. In other countries, such as Germany, The Netherlands or Belgium, it is forbidden to use rainwater in specific devices, such as dishwashers. In France, new legislation allows for income rebate on the installation of rainwater harvesting devices. They are becoming very popular along the Mediterranean coast, where households are more and more affected by droughts and quotas during extreme events.

5.2.2.2 Reuse of wastewater

Treated wastewater from showers, baths, spas, hand basins, laundry tubs, washing machines, dishwashers and kitchen sinks, which accounts for at least 50% of the household consumption (so called greywater), is normally indirectly reused when it is discharged into a watercourse and used again downstream. However, it can also be directly reused in households, even if there are only a few examples and there is not widespread acceptability in Europe. Nevertheless, treated wastewater is reused in some Mediterranean countries, such as Cyprus, France, Greece, Italy, Malta, Portugal and Spain, particularly for irrigation. At present, the most important use of reused water in Europe is for irrigation for different purposes (e.g. crop cultivation, public gardens, parks and golf courses), followed by industrial use. Domestic use appears to be the least developed sector and only focused on in pilot studies.

Reuse regulations and guidelines differ from country to country. On the EU level, only Article 12 of the Urban Wastewater Treatment Directive[114] indicates that treated wastewater shall be

[114] Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

reused whenever appropriate. The amount of treated wastewater available for reuse has increased considerably in recent years, as the requirements of the directive are implemented across Europe. Usually tertiary treated wastewater can be readily used in agriculture (and sometimes secondary effluents), while industrial needs might be more case specific.

5.2.2.3 Reducing leakages

Losses of water in the distribution network can reach high percentages of the volume introduced (see Table 18)[115]. This water can not be used for any human activity. Leakage can be conceived variably as part of real losses: (i) leakage on transmission and (or) distribution mains, (ii) leakage at utility's storage tanks and (iii) leakage on service connections up to point of customer. When considering total water losses (according to IWA Standard Water Balance and Terminology), apparent water losses, such as unauthorized consumption and metering inaccuracies, can be added (cf. Table 21).

Table 21 IWA Standard Water Balance and Terminology

System Input Volume	Authorised Consumption	Billed Authorised Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorised Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

Water loss management consists of[116]:

- <u>A. Pipeline and Assets Management:</u> Infrastructure naturally ages and in most situations it is not being renewed/replaced at a rate which it should because of the high costs involved. Preventive maintenance and network renewal are the main factors affecting leakage of a network. The international survey for IWSA proposes an average of 0.6% of annual pipe replacement. The present situation can be characterised by very different replacement rates of between 0.1 and 2%. The need to replace service connections, irrespective of ownership, as well as mains is recognised in most countries. A proactive approach to assist customers to reduce leakage on their private pipes and plumbing systems has been identified as a rational and economically justifiable option

http://ec.europa.eu/environment/water/water-urbanwaste/index_en.html

[115] The figures introduces by the EEA do not allow calculations of savings in absolute terms, because if leakage figures are expressed in terms of a percentage of distribution input the information gained can be misleading. An increase in water use, for example because of a sustained hot, dry period, will appear to lead to an improvement in leakage levels when, in reality, the volume of water lost has not reduced. Likewise, a successful water efficiency campaign will reduce the amount of water put into supply and leakage will appear to increase. However the result of an intensive literature review have shown that there is a huge saving potential The most comprehensive study in this context was carried out by OFWAT. Ofwat (2007): International comparison of water and sewerage service 2007 report, covering the period 2004-05. Further investigations in this area are recommended in order to estimate the true saving potentials.

[116] IWA (2007): Water loss task force, Leak Location and Repair, Guidance notes, March 2007.

- B. Pressure Management: It has been recognised for many years that effective management of pressures is the essential foundation for an effective leakage management strategy. Probably the most important aspect of pressure management, in relation to leakage management, is the control of surges and rapidly fluctuating pressures. Successful pressure management projects have been implemented in Denmark, Cyprus, Malta, Spain, UK. Italy, Romania and Portugal.
- C. Speed and quality of repairs: A key component in water loss management is the speed and quality of reticulation repairs – the longer a leak runs the greater volume of water that is lost. The three key time factors are: awareness time (A), location time (L) and repair time (R). Leakage can occur due to corrosion (metallic pipes), cracks and splits.
- D. Active Leakage Control, to locate unreported leaks: Night flow data usually provides information that enables the prioritisation of the leak location effort. This effort is divided into two separate activities, leak localising and leak location. Leak localising is the 'narrowing down' of a leak or leaks to a section of a pipe network and can be undertaken in a routine survey of the network or part of the network every six months or annually. It can also be carried out in targeted areas (e.g. District Meter Areas(DMAs)) with high night flows. Leak location is the identification of the position of the leak and is often referred to as 'pinpointing'.

In the instance where flows are not measured or monitored, water loss can be controlled by undertaking regular or random leak detection surveys. There are several techniques to detect where leakage is occurring in a distribution system:

- The sub-division of DMAs into smaller areas by temporarily closing off valves or by installing sub-meters;
- A traditional step test (or a variation of this techniques);
- The use of acoustic loggers as a survey tool;
- Sounding surveys.

Illustration 14:

Tactical Leakage Management project based on Acoustic Noise logging and Correlation, Thessaloniki Greece.

The project was commissioned by the pertinent authority, EYATh, after the implementation of a 3-month pilot project. The anticipated project duration was one-year. The direct aim of this project was the reduction of leakage and consequent saving of water for the supply of the city. The acoustic leak location equipment employed for this project belonged to EYATH and consisted of:

200 last generation acoustic loggers

- 1 receiver unit, to download data from the loggers
- 1 communication unit, to set and deactivate loggers
- 1 analogue correlator with 2 sensor units
- 1 ground microphone
- 4 listening sticks

This was backed up by a series of assisting tools and instruments, the necessary software and supporting office infrastructure.

A total of 177 leaks were identified in the first six months of the project and were consequently repaired. There was only one dry hole, i.e. a case where no leak was discovered where expected. The overall performance of the method was remarkable with an almost 100% success achieved.

5.2.2.4 Reducing water use in buildings

Technical changes in buildings allow for reductions in water demand by being more efficient. The following table presents potential savings through specific technological changes:

Table 22: Typical Water Saving Devices

Equipment	Description	Water Saving
	TAPS	
Taps with air devices	Introduction of air bubbles into the water, increasing its volume Less flow and same effect	Flow reduction of around 50%
Taps with thermostats	They keep the selected temperature	Reduction of around 50% of water and energy
Taps with infrared sensors	Water is available when an object is underneath	Reduction of between 70 and 80%
Electronic taps, or taps with buttons for a timed length of flow	Water running for a limited time	-
	TOILETS	
Toilets	command for 6 l/flush	
Double-command toilets	command for 3 l/flush	
Waterless or vacuum toilets	No water used	Reduction of water use by 50l/cap/day
	WATER-SAVING DEVICES FOR OLD EQUIPMENT	
Device to mix water and air for taps	Increases the volume of water	Reduction of around 40%
Button to interrupt toilet flush	(reduction of flow)	Reduction of around 70%
Device to limit shower flow	(reduction of flow)	Reduction of between 10 and 40%
Dishwasher	Decreases the volume of water used from 20 lt per use to 15 lt per use	Reduction around 25%
	WASHING MASHINES	
Washing Machines (~7kg load)	Decreases the volume of water used from 80 lt per use to 45 lt per use	Reduction about 44%

5.2.2.5 Risks from reducing leakages and decreasing flows

It is important to mention that a strong reduction in flow rates can cause considerable problems for the functioning of water supply networks. In cases of large line diameter (large pipe volume) very low flow rates would be the results, leading to stagnation zones, sedimentation areas (precipitation), as well as long drinking water retention times in lines. This tends to increase the risk of bacterial after growth[117].

Depending on the sewage disposal system (separate sewerage system, combined sewer system), declining water consumption can in many places lead to a strong reduction in sewage volumes, falling below the required minimum flow rates. Failure to attain the

[117] Koziol M. (2004): The Consequences of Demographic Change for Municipal Infrastructure in German Journal of Urban Studies Vol. 44, No. 1.

minimum flow rate leads to sedimentation and, where flow times exceed ten hours and oxygen content is low, to the formation of H2S, HS-, S². Further, the sulphate reductions can corrode concrete elements of the sewer systems leading to a higher rate of leakage.

5.2.3 Potential water saving measures and costs – some illustrations

The potential savings linked to each of these technical saving measures are different as well as the cost. In the following some illustrations of potential savings and cost are given:

5.2.3.1 Rain water harvesting

About 600l per m^3 of roof of rainwater falls in France during rainfall events. In southern France, studies[118] have estimated that about 108 000 litres of rain can be harvested in a typical family house, and could meet about 80% of household needs. To meet the demand throughout the year, larger reservoirs are could help, but as the climate becomes drier the effects achieved by larger storages are limited.

Savings in the UK[119] ranges between 30 and 50% of a typical household water use. Since water price is low in the country, the payback time may be rather long for households. Shorter timescale may be possible for larger projects, such as for housing developments, the industry and agriculture.

The cost of rainwater harvesting device varies much when taking into consideration the type of reservoir, its capacity and the filtration process chosen. While there are estimates as low as 25 to 250Euro for a reservoirs of 200 to 800 l, costs can go up to several thousands euros for larger ones[120]. This is because they tend to be installed underground, needs heavy machinery, more sophisticated devices such as bigger pumps, etc..

Illustration 15

BPCL Housing Complex Rainwater Harvesting System, India[121]

The water requirement of the housing complex is met by one bore well located near the Plant room and is supplemented by municipal supply. On an average 238 000 litres of water is consumed daily for potable and non-potable purposes.

Total rooftop and surface area is 13 910 square metres (sq m) and annual rainfall is 792.4 millimetres (mm), a typical rainfall of Western Europe. The total volume of rainwater harvested throughout the year is 4 446 cubic metres or 4 450 000 litres.

The rooftop rainwater is collected in collection chambers and then, through a network of interconnecting pipes, diverted into different recharge wells. The recharge wells are 3 m x 2 m x 2 m in size and provided with recharge bores of 150 mm diameter and 16 m depth to facilitate the recharge. Layers of filtering material, such as boulders, pebbles and coarse sand, ensures efficient filtration. A surface runoff harvesting system supplements the roof top.

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118 Le Monde (2007): La récupération de l'eau de pluie, 30/05/2007.

119 http://www.environment-agency.gov.uk.

120 Source: 1) Le Monde (2007): La récupération de l'eau de pluie, 30/05/2007; 2) http://www.environment-agency.gov.uk.

121 http://www.waterharvesting.org.

Illustration 16

Estonia[122]

Tartu (Estonia) reported a 24% reduction in water use in the city between 1999 and 2002 and a 39% increase in recycling between 2001 and 2002 following the introduction of its environmental management plan in 2000.

5.2.3.2 Wastewater reuse

The large investment required for treatment may inhibit the development of direct domestic water use. It requires separate household pluming that must be foreseen during construction and is considered relatively difficult to apply to older buildings. An onsite treatment system will produce higher quality greywater to use in the garden and possibly the toilet or washing machine.

Illustration 17

Cyprus[123]

Currently, around 40 Million m^3 of wastewater is produced annually on the whole island of Cyprus. Only 16 Million m^3 of this amount is treated, mainly in the Lefkosia province where the city of Nicosia is located. About 11 Million m^3 is reused for irrigation purposes. Water demand for domestic and industrial purposes will continue to increase and receive priority over water demand for agriculture. This leaves the use of treated wastewater as one of the main sources for increasing water supply for agriculture in the foreseeable future.

Illustration 18

Australia[124]

Australia's largest residential recycled water scheme is in the Rouse Hill area in north-west Sydney. The scheme started in 2001, and about 16 500 homes are now using 1.9 billion litres of recycled water each year for flushing toilets, watering gardens, washing cars and other outdoor uses. Recycled water is treated wastewater - water that has been used in bathrooms, laundries and kitchens, and in businesses. It is treated to a high standard so it is ready to use again. On average the Rouse Hill scheme has reduced demand for drinking water by 35 per cent.

Eventually the scheme will serve 35 000 homes. The area includes parts of Acacia Gardens, Beaumont Hills, Castle Hill, Glenwood, Kellyville, Kellyville Ridge, Parklea, Quakers Hill, Stanhope Gardens and, of course, Rouse Hill.

Work started in early 2007 to expand the Rouse Hill Recycled Water Plant. The expansion will allow 4.7 billion litres of wastewater to be recycled each year for residential use.

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[122] See European Commission (2005): Commission staff working document - Annex to the communication from the Commission to the Council and the European Parliament on Thematic Strategy on the Urban Environment - Impact Assessment {COM(2005) 718 final}.

[123] European Environment Agency (EEA) (2001): No 19 Environmental issue report, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

[124] http://www.sydneywater.au.

Sydney Water provides homes in the area with two water supplies - recycled water and drinking water. This is known as dual reticulation. The recycled water taps, pipes and plumbing are coloured purple to make sure that recycled water is not confused with drinking water.

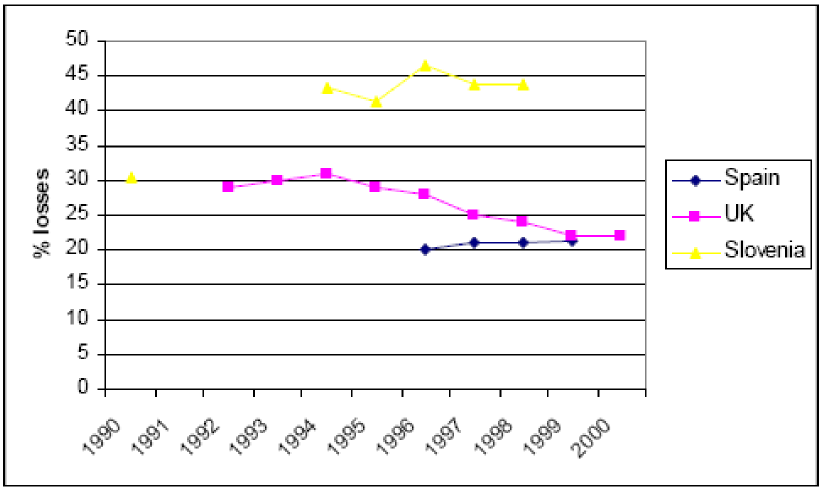
Recycled water is treated to a very high standard. It goes through a series of processes, including microfiltration and ultraviolet disinfection on top of the usual high level of wastewater treatment.

5.2.3.3 Leakage reduction in distribution networks

In Switzerland, network losses in some communities and small suppliers are estimated at around 30% of water introduced. Nevertheless, in cities like Zurich, where leakage control of 40–50% of the total distribution network length is carried out every year, losses have decreased from 10 to 5% over the last 10 years.

Progress is being made in some countries to reduce water leakage from urban distribution systems[125]. In England and Wales, an active programme of leakage reduction reduced network losses from 29 to 22% of the total distribution input between 1992/3 and 2000/1. In Spain average water losses in the distribution network increased from 20.0 to 21.4% between 1996 and 1999, with only 4 regions recording a reduction in water losses over this period. Network losses in Slovenia in 1985 and 1990 were 31.7 and 30.4% of total water urban supply, respectively, but increased to an average of 43.8% during the period 1994-1998.

Trends in urban leakage in Spain, UK and Slovenia



Sources:

Spain, INE 1999; UK, OFWAT; Slovenia, Statistical Yearbook of Rep. of Slovenia, 2000

Figure 18: Trends in urban Leakage

The following boxes provide some illustrations of specific effective actions.

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[125] European Environment Agency (EEA) (2003): Indicator Fact Sheet (WQ06) Water use efficiency (in cities): leakage, version 01.10.2003.

Illustration 19

Halifax's Leading Edge Practices Saves Millions[126]

Leakage is a serious problem across Canada, where between 10% and 50% of potable water is lost due to leaking pipes in the distribution system. In older cities, deteriorating municipal infrastructure causes potable water leakage as high as 30% to 50%.

The Halifax Regional Water Commission uses a holistic approach to reduce its leakage within the water distribution system. This approach centres around leak detection, metering, speed and quality of repairs, and asset management. This holistic approach, initially developed by the International Water Association, can be found in various InfraGuide best practices. Halifax was the first municipality not only in Canada but in North America to adopt an international best practice on water loss control in the distribution system and to revolutionise their leakage prevention programme.

As a result of adopting this best practice and previous efforts, the Halifax Regional Water Commission has managed to reduce the leakage of potable water from its distribution system by 6 Million gallons per day or almost 30 Million litres per day. This adds up to savings of half a Million dollars a year. "This is a huge impact," says Carl Yates because reducing leakage means there is less wear and tear on the system and its life cycle is extended. Other direct benefits associated with reduced leakage include deferral of capital investment, less disruption of service to customers, and a drastically reduced liability due to reduced risk of streets and adjacent property being damaged from aggravated leakage. In this way the Water Commission is being a good steward and is receiving very positive customer feedback.

Illustration 20

Italy Reggio Water Distribution Network[127]

One of the simplest uses of performance indicators to improve operations comes from a case study of the water distribution network in Reggio, Italy. It involves the use of performance indicators by AGAC, a private water authority, to reduce leakage rates. AGAC management believed that the distribution system was experiencing excessive leakage rates and implemented a performance improvement program to reduce the amount of water lost. Since the target audience for this effort was the system operators or management, the indicators selected focused strictly on reducing the system leakage, both in terms of total amounts and as a percentage of total water produced.

To calculate the values for the selected indicators, AGAC had to measure the water produced and the water delivered to the consumer, in total and for each district of the network. To collect the necessary data, AGAC divided the network into districts that were served by one or two water mains and installed flow meters on those pipes. With the meters in place, AGAC collected data on the volume of water flowing to a district, and collected billing data from consumer meter readings. To calculate the leakage amount for the system, AGAC compared flow measurements into each district with the consumer meter readings for each district.

Through the analysis of this data by district, AGAC was able to identify districts with high leakage or faulty point-of-use meters. Those districts with high leakage rates were then given priority for detailed pipe evaluations, through which operators identified specific leaking pipes. This effort resulted in an overall annual reduction of water losses of 52% in 1994, as compared to 1989.

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[126] Halifax Regional Water Commission – website: "Halifax's leading edge practices saves millions", http://www.infraguide.ca.

[127] Stone, S.; Dzuray, E.J.; Meisegeier, D.; Dahlborg, A.S.; Erickson, M. (no year), Decision-Support Tools for Predicting the Performance of Water Distribution and Wastewater Collection Systems, EPA/600/R-02/029, available at http://www.epa.gov/nrmrl/pubs/600r02029/600R02029.pdf.

AGAC realised an additional benefit from installing district meters: it created a long-term flow monitoring system that enabled it to continuously monitor leakage rates.

Water-saving equipment - water-saving devices in households

The following table and figure present some potential savings in different household technologies. Up to 25% savings can be obtained by improving the technological performance of household devices.

Table 23: Potential savings (litres per household per day) from water efficient appliances[128]

	Standard New		Water Efficient		% reduction
	litre/use	*litre/household/day* [(a)]	*litre /use*	*litre/household/day* [(a)]	
Toilet flush	9 6	87[(b)] 57 [(b)]	4	39[(b)]	55 32
Shower	54[(c)(d)] 45[(c)(e)]	77 [(f1)] 64 [(f1)]	30[(g)]	43 [(f1)]	44 33
Bath	88	71 [(f2)]	65 [(h)]	53 [(f2)]	26
Taps	0.6 [(i)]	10 [(j)]	0.5 [(k)]	8.5	15
Washing machine	60	26 [(l)]	40 45	17.4 19.6	33 25
Dish Washer	20	8.7 [(l)]	12 14	5.2 [(l)] 6.1 [(l)]	40 30
Total		**237 - 280**		**167-169**	**29-41**

Note:
(a) Assuming 2.38 persons/household
(b) Assuming 4 full flushes per person per day
(c) Assuming 5 minute shower
(d) Assuming 10.8 lt/min
(e) Assuming 9 lt/min (use of restrictor)
(f1) Assuming 1.43 showers per household per day
(f2) Assuming 0.34 bath per person per day
(g) Assuming a 6 lt/min "water saver" showerhead
(h) Assuming an undersized or corner bath
(i) Assuming 6.5 lt/min and an average 6 sec use
(j) Assuming 7.1 tap uses / day / person
(k) Assuming 5 lt/min flow
(l) Assuming 1 full load per day

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[128] Reproduced from: UK Environmental Agency (2007): Water Efficiency in South East of England Retrofiting Existing Homes; UK Environmental Agency (no year): Conserving Water in Buildings, Leaflet No10; UK Department of Communities and Local Government (2006): Code of Sustainable Homes, Technical Guide; UK Environmental Agency (2003): The Economics of Water Efficient Products in the Household; UK Environmental Agency (2007): Assessing the cost of compliance with the cost of sustainable homes; UK Environmental Agency, (no year): Conserving Water in Buildings, Leaflet No1.

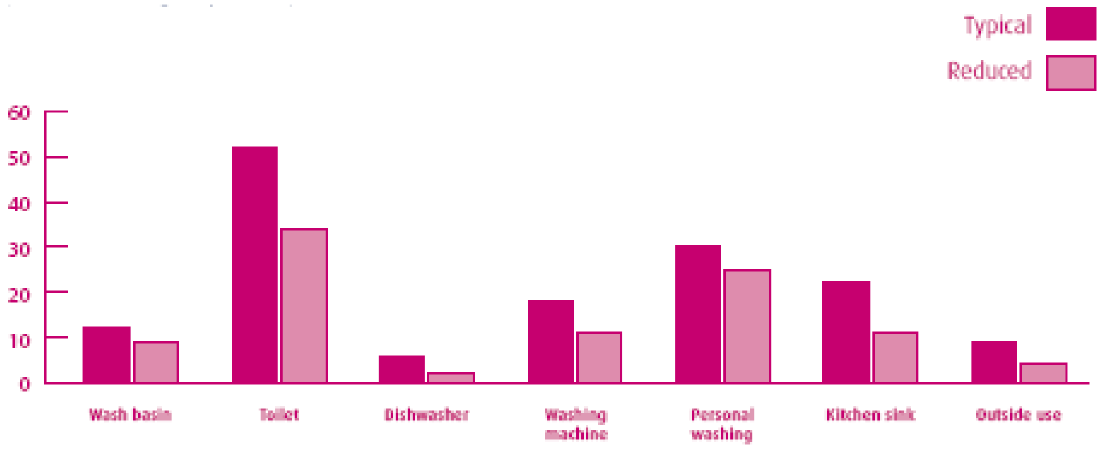

Figure 19: Potential savings (litres per household per day) from water efficient appliances[129]

The following boxes will illustrate how technological changes in buildings can save water as well as the impacts of such changes:

Illustration 21

The Biemer study

Biemeyer (2005) identified 6 scenarios in which water use can be reduced during showering. The most effective measure identified in this study is to counteract the trend of using multiple showerheads' body spas, which would lead to 25% savings in water consumed (when compared to the baseline). Reducing average showering time by 1 minute would reduce water use by 17%. Installing efficient showerheads below code and changing all showerheads that exceed code would reduce water use by 15% and 7% respectively. Reducing the number of showerheads tampered with (modified to increase the flow) and reducing tub spout leakage would only bring about 1% and >1%. Since toilet flushing uses around 50 litres per day, switching to ultra-low flow toilets would be a significant water saving measure. By replacing older models that typically use 9 litres per flush with a modern ultra-low flush toilet that has a double-command function, consumers can reduce water consumption to 3-6 litres per flush. Toilets with a stop function can also reduce water use up to 70%[130].

However, even if the potential savings for each technique are known, due top the lack of knowledge of market penetration of these devices the total saving is highly difficult to calculate.

[129] UK Sustainable Development Commission (2006): Stock Take: Delivering improvements in existing housing. Available at http://www.sd-commission.org.uk/publications/downloads/SDC%20Stock%20Take%20Report.pdf

[130] European Environment Agency (EEA) (2001): No 19 Environmental issue report, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

Illustration 22

The Hamburg Water Saving Demonstration Project [131]

Between 1986 and 1989, the city's local drinking water company, in co-operation with the city's environmental authority, conducted a test case study in a local area. Installation costs for the new equipment were covered by the municipal authority. Approximately 1 400 households participated in the research project. Nearly 50% of the households belong to a public housing company, whilst 32% of the targeted households are part of housing co-operatives and the remaining 18% are owned by various private owners. The aims of the project was to carry out consumption activities with water meters alone, and with water meters and water-saving devices, to demonstrate the bill for actual water consumption to the individual tenant, as well as to investigate the effects of water consumption with and without special water-saving advice and information.

After the three year period an evaluation was made for 967 households in tenant rented dwellings where consumption data prior to and after the installation of the water meters was available. 560 were equipped with water meters alone and 407 with water meters and water saving devices.

The results show an average saving rate of 25% in households with additional water saving techniques.

When setting up water saving devices, it is also important to look at the payback time. The payback period for a household strongly depends on the cost of the device, the water prices and sewer charges. Market costs for household saving devices and appliances vary among the different device or appliance brand names, for example:

- Toilets can run from 100-800 Euro ;
- Washers are usually found for more than 500 Euro ;
- Showerheads are cheaper and can be found even for 20 Euro ;

Differences are also observed in installation costs.

Illustration 23

Athens Metropolitan area household

The following assumptions are made:

- the cost of installing a water saving toilet is 150 Euro
- the number of people in the household is four
- the price per cubic meter of water used is 0.67 Euro
- the price per cubic meter of wastewater discharged is 65% on the price for consumption
- 11L/cap/day are saved from the use of the device
- a 6% financial rate is considered

The present values (PV) from costs and benefits (cost savings from reduced consumption and reduced wastewater discharged) are calculated in the table (differential costs are the only ones considered using current values).

[131] http://www.eaue.de/winuwd/132.htm.

As it is evident, a 12 year payback period can be expected for such a device. Similar payback periods have been illustrated elsewhere[132]. It is worth to mention that this payback period becomes almost 25 years for rural areas in Greece, with lower water prices and no wastewater discharge surcharge and 5 years for households in areas with double water prices per cubic meter. Payback periods for other devices, such as shower heads, may be shorter (e.g. 3.5 payback periods).

When considering water savings from household appliances, such as washers, benefits from energy savings should also be considered. It should be noted that calculated payback periods in the US have ranged from 1 to 3 years, and energy savings are three times as much as water and wastewater savings are.

Water saving devices and appliances also benefit the utility companies as a result of the reduced unaccounted water from leakage.

Other measures such rainwater harvesting and greywater reuse, especially when used in peak demand periods, can have a beneficial effect for utility companies. It is very common in areas with seasonal population to have oversized water and wastewater infrastructure. The infrastructure is there to cover peak demands for a two to three month period. Capital and operating costs saving for utilities (by downsizing water supply and wastewater management infrastructure and limiting maintenance costs) justify rebates in most cases.

[132] Aquacraft, Inc.; EBMUD; United States Environmental Protection Agency (EPA) (2003): Residential Indoor Water Conservation Study; Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area, July 2003.

Illustration 24

Kalymnos in southeast Greece

This illustration uses an island where 50% of the yearly portable water demand is in the summer period (due to increased consumption and seasonal population), for example the island of Kalymnos in southeast Greece, in order to examine water saving measures. A 20 year rebate program is considered, which covers 50 households for 1 500 Euro each year in order to retrofit greywater recycling plumbing. The following assumptions are made:

- Greywater recycling reduces consumption by 25% for each household
- The Utility Company has a reduced income of 0.30 Euro per m^3 not sold.
- The Utility Company avoids a capita cost of 1 000 000 Euro by downsizing infrastructure
- The Utility Company avoids (each year almost 2% of the capital cost) maintenance
- The Financial Rate is 6%
- Current prices are considered (no inflation)

Table 24: 20 year program for investments in domestic water saving techniques and associated benefits.

	Cost of Utility Supported Yearly Rebates €	Annual water saving m3	Reduced Net Income for the Utility	Avoided Capital Cost €	Avoided Maintenance cost €	Total Costs €	Total Benefits €	PV of Costs €	Accumulated PV of Costs €	PV of Benefits €	Accumulated PV of Benefits €
1	75.000	10.000	3.000	1.000.000	20.000	78.000	#######	78.000	78.000	1.020.000	1.020.000
2	75.000	20.000	6.000		20.000	81.000	20.000	76.415	154.415	18.868	1.038.868
3	75.000	30.000	9.000		20.000	84.000	20.000	74.760	229.175	17.800	1.056.668
4	75.000	40.000	12.000		20.000	87.000	20.000	73.047	302.222	16.792	1.073.460
5	75.000	50.000	15.000		20.000	90.000	20.000	71.288	373.510	15.842	1.089.302
6	75.000	60.000	18.000		20.000	93.000	20.000	69.495	443.005	14.945	1.104.247
7	75.000	70.000	21.000		20.000	96.000	20.000	67.676	510.681	14.099	1.118.346
8	75.000	80.000	24.000		20.000	99.000	20.000	65.841	576.522	13.301	1.131.648
9	75.000	90.000	27.000		20.000	102.000	20.000	63.996	640.518	12.548	1.144.196
10	75.000	100.000	30.000		20.000	105.000	20.000	62.149	702.667	11.838	1.156.034
11	75.000	110.000	33.000		20.000	108.000	20.000	60.307	762.974	11.168	1.167.202
12	75.000	120.000	36.000		20.000	111.000	20.000	58.473	821.447	10.536	1.177.737
13	75.000	130.000	39.000		20.000	114.000	20.000	56.655	878.102	9.939	1.187.677
14	75.000	140.000	42.000		20.000	117.000	20.000	54.854	932.956	9.377	1.197.054
15	75.000	150.000	45.000		20.000	120.000	20.000	53.076	986.032	8.846	1.205.900
16	75.000	160.000	48.000		20.000	123.000	20.000	51.324	1.037.356	8.345	1.214.245
17	75.000	170.000	51.000		20.000	126.000	20.000	49.599	1.086.955	7.873	1.222.118
18	75.000	180.000	54.000		20.000	129.000	20.000	47.906	1.134.861	7.427	1.229.545
19	75.000	190.000	57.000		20.000	132.000	20.000	46.245	1.181.107	7.007	1.236.552
20	75.000	200.000	60.000		20.000	135.000	20.000	44.619	1.225.726	6.610	1.243.162

As it is evident, a significant rebate program is feasible for the assumed Utility Company

5.2.4 The specific case of the public sector

Every year public authorities at all levels in the European Union spend several billions Euro on various purchases necessary for their day-to-day operations, representing some 15% of GNP (gross national product). This mainly includes a wide variety of goods and products, but also water. Water is used in public authorities for varies purposes:

- Sanitary use in public office buildings, museums, military buildings schools, etc. Water saving measures are the same as for households, including water saving devices, rainwater harvesting and water reuse.
- Irrigation of public parks and squares, sport fields, etc. Such urban irrigation is predominately concerned with irrigating plants ranging from grass for lawns and sporting facilities to flowers and different ornamental plants, shrubs and trees not generally meant for consumption or sale. This type of irrigation is often done to maintain aesthetics and pleasant environment in urban areas. Water savings can come from more efficient irrigation techniques, rain water harvesting and greywater use but also from using different plants with lower water requirements[133].
- Cleaning of roads and public vehicles (e.g. buses, trains). Water savings can come from reclaim systems (see Illustration below) and new cleaning technologies.
- Others, such as medical processes, cafeteria, laundry services, fire protection. In such cases specific water saving techniques and approaches are needed.

Even if the total costs for water paid by public authorities are often unknown, it can be assumed that cost associated with water use are an issues for several municipalities, as the following illustrations show.

Illustration 25

Water savings project in Australian public buildings

Several projects have recently received a grant from the Australian government water funds. Costs and estimated water savings for some public schools and administrative buildings were calculated:

- The city of Borondara decided to replace15 full flush toilets with dual flush toilets and 7 water flushing urinals with waterless urinals at four public facilities. Potential savings have been assessed at 789000 L per year with a cost of 38 315 $.
- Ballina shire Council has approved the installation of a reclaimed water irrigation system for the Saunders sport complex. Cost of the system and associated pump station for the reuse of effluent is estimated at 45 454 $. Estimated savings reach 30 000 000 litres per year.
- Alma public school has decided to install six tanks to store rainwater and runoff water from evaporative air coolers. Collected water will be used to irrigate the schools gardens. About 2 250 000 litres will be potentially saved with an investment of 39 239 $.
- The Newmarket State School expects to save more than 150 000 litres per year by installing 18 dual flush toilets, 2 waterless urinals, using rainwater collected in tanks to supplement toilet water supply and installing irrigation controllers for the garden with rainfall and soil moisture sensors. The cost of the total project is estimated at 45 454 $.

[133] Maheshwari, B.; Connellan, G. (Editors) (2005): Role of Irrigation in Urban Water Conservation: Opportunities and Challenges, Proceedings of the National Workshop, available at http://www.vl-irrigation.org/cms/fileadmin/content/irrig/urban/maheshwari_and_connellan_2005_role_of_irrigation_in_urban_water_conservation.pdf.

Illustration 26

Water saving potentials in public infrastructures of Loire Bretagne basin - France

The Loire Bretagne water agency conducted a study with the objectives to estimate current water consumptions and potential water savings in various types of public infrastructures: educative buildings, sport equipments, hospitals, administrative buildings, public gardens. Main results are summarised in the following table. Sources of the data are feedback from municipalities experiences, experts estimations, scientific papers or surveys.

Table 25: Saving potential of public buildings in the Loire Bretagne basin

	Consumption of reference	Savings potential	Source
Primary school	3m^3 / child/year	20%	Lorient, Pontivy, Brest, Douarnenez, Lannion, Perros, Guirrec
College	General : 3,6 m^3 /student/year Professional: 6,1m^3 /student/year	18%	Conseil régional de Bretagne
Student housing	46,7 m^3/ bed/year	30%	CROUS Aquitaine, Eco-Campus
Stadium (normal size)	1000m^3/year for equipment use 2000m^3/year for irrigation	20%	Surveys CNFPT Midi Pyrénées 2002, AIRES 1998, Report L. Cathala
Gymnasium (normal size)	800 m^3/an	15%	
Public swimming-pools	0,33 to 0,42 m^3/ visitor	no data	
Hospitals	100 m^3/ bed/year	0%	Water agency data, experts
Administrative buildings	14,3 m^3/ position/year	20%	Water agency data

Average potential water savings in public infrastructures appear to vary from 15% to 30% of the current consumption (hospitals excluded).

Illustration 27

Andorra experience[134]

In Andorra a large communication campaign for water saving was implemented in 2001. For the duration of one year, activities were developed to generalise saving devices and inform habitants on their potential to decrease consumption. Main results are:

- Installation of 250 saving kits (including showerheads, tap, toilets) for 650 habitants in a total population of 8 000 habitants. Potential saving have been estimated at 10 Millions litres per year.
- Reduction of water consumption in public buildings through audits, improvements of equipments, and leakages detection. With these measures, the town hall of Andorra has reduced its water use by 83% from 2001 to 2002. The Casa de la Cultura and the college Juan Ramon Alegre present savings of 31% and 47%, respectively.

[134] Catalogo aragones de buenas practicas ambiantes: http://portal.aragob.es/pls/portal30/docs/FOLDER/MEDIOAMBIENTE/EDUAMB/SENSIBILIZACION/CATALOGO/INDICE/8.PDF.

Illustration 28

Economic results of water saving initiatives in Canadian federal buildings[135]

In 1994 the government of Canada initiated a major program to incorporate water efficiency initiatives into government buildings. Implementation of water savings devices were promoted. Audits in three federal buildings have lead to the following economic results:

Illustration 29

Water saving in Vienna, Austria in public buildings[136]

Vienna public authorities started to introduce water saving devices in the late 1990s, which resulted in a reduction of water use by 30% in public buildings and a saving of one and a half Million euros a year.

Illustration 30

Water savings in public buildings – Gironde - France[137]

The Groundwater management plan of the Gironde region defined measures for promoting water savings in public equipments. Results of several experiences are listed below:

- The city of Merignac (65 000 hab) began a water saving plan in 2003 including: leakages detection in public buildings, implementation of water saving equipment in all new or renovated buildings, optimisation of public gardens irrigation through irrigation programs, creation of parks requiring no irrigation. Total investment was 45 000 Euro, which led to a 25% decrease in water consumption in 3 years (from 225 000 m^3 in 2003 to 160 000 m^3 in 2006). Decrease of the water bill was 100 000 euros.
- The Student housing complex of Talence (CROUS) lead a study aiming at evaluating efficacy of water savings devices. Equipments implemented were: water meters in each building and sanitary blocs, water savings taps, water savings showerheads, low water consuming toilets flush. Results in terms of water use per student bed were: 157 litres/day/bed in non equipped buildings, and 100 litres /day/bed in equipped area. It represents a 35% water saving for total water use and 45% for hot water. Equipments cost were 4 712 euros and the water cost avoided reached 11 000 eur/year. Pay back period was about 6 months.
- Implementation of meters in social housing complex. Statistical analysis on group of 15 000 social housing in Bordeaux has highlighted the impact of water metering and volumetric charging on consumption. Without metering, average water use is 150 to 170 m^3/apartement/year, but with cold water meters and volumetric pricing water use is 120 to 130 m^3/apartment/year, and with cold and hot water metering and volumetric pricing, consumption drops to 100 to 110 m^3/apartement/year.

[135] National Action Plan to encourage Municipal water use efficiency: http://www.ec.gc.ca/water/en/info/pubs/action/e_action.htm.

[136] http://www.tvlink.org/vnr.cfm?vidID=75.

[137] Jeudi de Grissac, B. (2007): L'expérience du département de la Gironde in Gestion de la demande en eau en Méditerranée, progrès et politiques – Saragoza 19-21/03/2007 - Communication: Les Economies d'eau et la Maitrisse des Consommations – Une alternative aux resources en eau conventionnelles.

Illustration 31

Water saving – Pilot study France

The impact of different water saving measures relevant to the urban public sector and pilot tested in different French cities was also investigated[138]. Table 26 illustrates the volumes of water saved for these measures, investment costs and reductions in water bills as a result of water savings and the payback period. Overall, payback periods were rather short with a maximum three years.

Table 26: Cost and effectiveness of different water saving measures

Pilot site	Measure	Investment (in Euro)	Water saving as % of total water use	Water saving (m^3/year)	Water saving (Euro/year)[1]	Pay back period (in years)[2]
Stadium Lorient	Leakage metering	68602	78	12500	*26250*	3
Swimming pool - Brest	Water recycling	20398	-	7140	15778	1,75
Swimming pool - Rennes	Flow regulator	183	28,5	1200	*2520*	0,1
Green spaces Brest	Drip irrigation	1677	62	2496	*5241,6*	1
Fontains of the city of Lorient	Optimum network closure	11128	-	*2468,10*	5183	2

[1] = water saving from reduction in domestic water bill for an average unitary tariff of 2.1 Euro/m^3

[2] = period when water savings equal investment costs

Illustration 32

Water saving in schools - UK[139]

The Department for Education and Skills (DFES) suggests that typical annual water consumption in schools is 4 cubic metres (m³) per pupil per year, and this can easily be reduced to 2.85 cubic metres (m³) per pupil per year.

Illustration 33

Reducing irrigation requirement of Park and athletic field[140]

7 days a week is a Canadian company providing water saving audit for municipalities' infrastructures. It concentrates on irrigation efficiency improvement, which represents the main potential savings in public water use. Potential water savings in park and athletic fields irrigation practices seems to vary from 25% to 75%, with an average of 45%. Such savings are reached through improvement of the distribution uniformity, limit over watering, increase irrigation techniques efficiency.

Recent irrigation audits of two Southern Ontario cities lead to the following conclusions:

- Average water savings per parks: 1158 m^3 over 3200 m^3 used per season (Golf courses excluded);
- Which represents a total of 99 072 m^3 savings for the 86 parks of the two cities;
- Water cost avoided: 121 858 $ (1,23$ per cubic meter);
- Audit cost: 2 200 $ per site.

[138] Institut Méditerranéen de l'Eau. 2001. Etude sur l'économie d'eau chez le consommateur. Etudes de cas: Espagne, France, Maroc et Tunisie.

[139] see http://www.environment-agency.gov.uk/subjects/waterres/287169/287864/?lang=_e.

[140] http://www.8daysaweek.net/whydoanirrigationaudit.html

Illustration 34

Water saving and reuse in public buildings and services for Madrid

Madrid City Water Management Plan 2005-2011 includes measures for water saving and efficiency in public buildings and services (28% of budget) and reuse in city services (59%) with a total budget of 103 Million euros. There is a small allocation to drought prevention (1%) with a continuous character.

Tool	**Thousand Euro**	**%**
Total education and participation	5 103	4,9%
Total saving and reuse non-municipal	5 807	5,6%
Efficiency in city buildings and services	29 750	28,7%
Reuse in city services	61 931	59,7%
Drought prevention	1 200	1,2%
Total	**103 791**	**100%**

The objectives for the plan are reduction of overall consumption by 12% for 2011, adapting the water quality and cost to the uses, coordinate urban planning and water management, socially fair distribution of cost between users and uses, maintaining financial and environmental sustainability in water services, increase efficiency in water management and prevention of water crisis (drought).

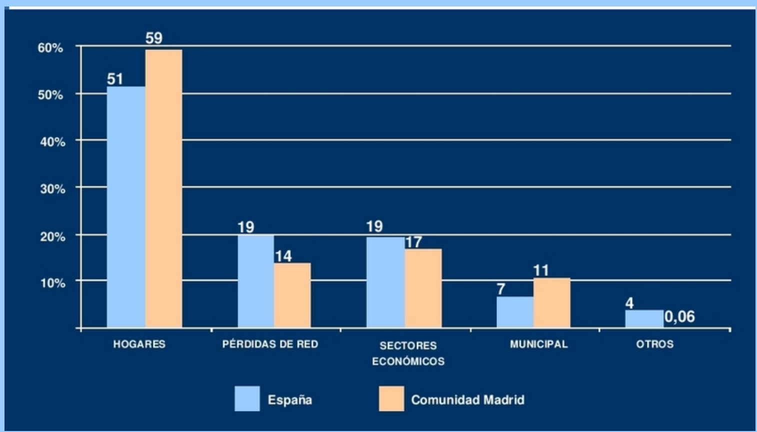

Figure 20: Use of Urban water

Illustration 35

Water savings in the professional car washing[141]

On a gallon-per-vehicle (gpv) basis, professional car washes use a minimal amount of water when conservation equipment, including reclaim systems, is installed. When no reclaim system is installed, water use can range from a low of 15 gpv for self-service car washes to a high of 85.3 gpv in a frictionless conveyor car wash for a basic wash using equipment and optimal operating parameters for water efficiency. For professional car washes using separation reclamation, the range varies from 30 gpv for in-bay automatics to 70 gpv for frictionless conveyor car washes. When a reclaim system with full filtration is used, the range is estimated from 8 gpv for in-bay automatics to 31.8 gpv for frictionless conveyor car washes.

[141] International Carwash Association (2000): Water Conservation in the Professional Car Wash Industry -A Report for the International Carwash Association, available at http://www.cuwcc.org/vehicle_washing/Car_Wash_Study_2000-Brown.pdf

Illustration 36

Norwood hospital- Metropolitan Boston Area, USA[142]

In hospitals, total water use can be divided among five major categories: sanitary, HVAC (heating, ventilation, and air-conditioning), medical processes, cafeteria and laundry services. In 1991 the Norwood hospital used 193.81Million litres of water. In order to reduce water use, a Water Management Plan was developed by facility staff:

- Elimination of seal and cooling water on medical air compressors and vacuum pumps. Water saved: 32.27 Million litre.
- Recirculating seal and cooling water for four vacuum pumps and one medical compressor as well as removing a vacuum pump, which was not needed, resulted in a net annual savings of 32.27 Million litre.
- Sanitary retrofits - aerators and flush valves. Water saved: 11.3 Million litre per year.
- Replacing the flush valves on toilets and urinals, and installing low-consumption aerators on all lavatory faucets resulted in a savings of 11.3 Million litre per year. This work was performed by an outside contractor.
- Refrigeration system retrofit. Water saved: 7.9 Million litre per year.
- Facility staff discovered the refrigeration system serving the morgue was cooled with once-through cooling water. In 1994 the system was replaced with an air-cooled unit, thereby eliminating 7.9 Million litre per year.

In total, the water use was reduced to 138.54 Million litre in 1994, which is a reduction of 29%. The total project cost was $5,500,resulting in an annual savings of $13,750 (Payback time: 0.40 years).

In order to enforce these water saving potential in the public sector, two main pieces of European legislation are available:

- The EU Eco-Management and Audit Scheme (EMAS) is a management tool for companies and other organisations to evaluate, report and improve their environmental performance. Since 2001 EMAS has been open to all economic sectors, including public and private services (Regulation (EC) No 761/2001 of the European Parliament and of the Council of 19 March 2001).
- Public procurement: In 2004, the Council and the European Parliament adopted two directives aimed at clarifying, simplifying and modernising existing European legislation on public procurement: Directive 2004/18 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts; and Directive 2004/17 on the coordination of procurement procedures of entities operating in the water, energy, transport and postal services sector set the main legal framework for public procurement.

[142] see http://www.mwra.state.ma.us/04water/html/bullet1.htm.

Illustration 37

Water savings in Commission buildings[143]

On 7 September 2001, the European Commission adopted a Decision (C (2001)/2591) whereby the Commission politically engaged in a process of applying the EMAS Regulation into its activities. By adopting this decision, the Commission emerged as an exemplary driving force towards better environmental management of its resources and processes, in agreement with the principles of sustainability and sustainable development powerfully endorsed at the Earth Summit in Rio in 1992. There is high expectation that the example set by the European Commission will result in a significant rise in EMAS uptake in other public and private organisations established in the Member States.

In 2002 a project entitled "EMAS in the European Commission – pilot phase" was set up as an important step towards fulfilling the Commission's commitment. The ultimate goal of full EMAS registration for the whole of the European Commission will be achieved in two phases. As a result of phase 1, four pilot services, namely the Secretariat General, the Environment Directorate General (DG), the Personnel and Administration DG, and the Office for Infrastructure and Logistics (OIB), registered in December 2005 as well as the European Environment Agency. Initial results reported that water consumption between 2003 and 2004 showed a slight downward trend.

5.2.5 In summary

The following table summarises the main elements of water saving measures for the domestic sector and saving potential information and data collected. Although the information collected is incomplete and pertains to different levels of intervention (a given measure, a range of measures or sub-sectors), some general conclusions can be drawn:

- Water savings for different measures are usually between 20 and 50%.
- Savings for individual measures can be as high as 50%.
- Significant savings in water bills can be expected. In some cases energy savings for utility companies are significant enough to justify rebates.
- Payback periods are very short for some water saving appliances.

The issue of water saving in the public sector is not deeply investigated at the moment, and therefore the water saving potential is difficult to estimate. However, it can be assumed that there is a huge saving potential in several municipalities, which would be beneficial not only because of cost savings also because of the show in leadership.

[143] European Commission (2006): European Commission recognised for its efforts to green its activities IP/06/563, Brussels, 03 May 2006.

Table 27: Overview of the main issues related to water saving in the household/domestic sector

General Measure	Specific measures	Expected water savings	Country	Costs	Benefits	Pay-back period (in years)	Reference
Rain water harvesting	Overall	80% of household needs	France	25 to 250€ for a reservoirs of 200 to 800 l			Le Monde (2007): La récupération de l'eau de pluie, 30/05/2007
	Overall	30-50%	UK				www.environment-agency.gov.uk
Waste Water reuse	Wastewater reuse for irrigation	25% of the wastewater produced	Cyprus				European Environment Agency (EEA) (2001): Environmental issue report No 19, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.
	Domestic Wastewater Reuse	35% of the drinking water consumption	Australia				www.sydneywater.au
Leakages	Leakage reduction program	Leaks reduced from 29% to 20%	England and Wales				EEA, Indicator Fact Sheet (WQ06) Water use efficiency (in cities): leakage, version 01.10.2003
	Leakage reduction program	30 Million litres per day	Canada		of half a Million dollars a year		www.infraguide.ca
	Leakage Control	52% reduction in water losses	Italy				Stone, S.; Dzuray, E.J.; Meisegeier, D.; Dahlborg, A.S.; Erickson, M. (no year), Decision-Support Tools for Predicting the Performance of Water Distribution and Wastewater Collection Systems, EPA/600/R-02/029.
Waster saving devices	Toilet	32-55%	UK				UK Environmental Agency (2007): Water Efficiency in South East of England Retrofiting Existing Homes; UK Environmental Agency (no year): Conserving Water in Buildings, Leaflet No10; UK Department of Communities and Local Government (2006): Code of Sustainable Homes, Technical Guide; UK Environmental Agency (2003): The Economics of Water Efficient Products in the Household; UK Environmental Agency (2007): Assessing the cost of compliance with the cost of sustainable homes; UK Environmental Agency, (no year): Conserving Water in Buildings, Leaflet No1.
			US	165-365		6-11 years	
	Shower	33-44%	UK				
			US	10$		3.5 years	
	Bath	26%	UK				
	Taps	15%	UK				
	Washing Machine	25-33%	UK				
			US	$550-$700		1-3 years	
	Dish Washer	30-40%	Europe				www.aquacraft.com
	Water saving devices Overall	25%	Germany				http://www.eaue.de/winuwd/132.htm

5.3 Industry

In long-industrialised countries, the share of industrial water use has been decreasing over the last 30 years, reflecting the decline of water –intensive heavy industry (e.g. mining, steel) and the introduction of cleaner technology. However, water use (mainly for cooling) has increased in the energy sector. The decrease of industrial activities in acceding countries during the transition process has also been significant – leading to a 70% reduction in water abstracted for industrial uses in most of central and eastern European countries. According to UNESCO, the annual water volume used by industry world-wide will rise from 752 km^3/year in 1995 to an estimated 1 170 km^3/year in 2025, with large differences between regions and countries in both the relative share of the industrial sector in total water abstraction (in 1995, this share was around 22%, 59% and 8% for the world, high-income countries and low-income countries, respectively) and the trend over time.

The following table provides information on the importance of industrial water use in the EU-15. Although the information is 10 year old needs updating, it stresses the large differences between countries. When water used for cooling of a power plant is disregarded, the share of industrial water consumption shrinks to a low 10.4%[144] of total water consumption in Europe. Larger industrial consumers are found in Finland, France, Germany, Sweden, Spain and Italy. In the larger consuming countries, one sector often induces most of the volume: the pulp and paper sector in Finland and Sweden (respectively 71% and 42% of total industrial water consumption) or the Chemical sector in Germany and Italy (respectively 38 and 36% of total industrial water consumption). Implementing water saving actions in these sectors has the potential to yield significant water savings.

Table 28: Share of industrial water use in total water abstraction

Country	Industrial water use (excluding cooling)		Country	Cooling for power generation and hydropower*	
	Million m³	%		Million m³	%
Austria	489	20.7	Austria	885	37.5
Belgium	210	3.0	Belgium	5 149	73.4
Denmark	82	9.0	Denmark	0	0
Finland	1 111	33.2	Finland	1 690	50.5
France	3 942	9.7	France	25 835	63.5
Germany	6 475	11.0	Germany	16 952	28.8
Greece	136	2.7	Greece	91	1.8
Ireland	250	20.6	Ireland	277	22.8
Italy	7 980	14.2	Italy	7 025	12.5
Luxembourg	14	24.5	Luxembourg	0	0
Netherlands	507	4.0	Netherlands	11 028	87.0
Portugal	241	3.3	Portugal	2 682	36.8
Spain	1 647	4.6	Spain	4 915	13.9
Sweden	1 479	54.6	Sweden	70	2.6
United Kingdom	848	7.0	United Kingdom	1 721	14.2
Total EU15	25 411	10.4 (average)	Total EU15	111 612	31.8 (average)

(Source: ETC/IW, 1997)

* Includes cooling water for power plants and hydroelectric power use. The water can be used again several times downstream

[144] ETC/IW (1997). Questionnaires to National Focal Points (Unpublished) – cited in: European Environment Agency (EEA) (1999): Sustainable water use in Europe. Part 1: Sectoral use of water. EEA, Copenhagen.

The emphasis given to the industrial sector in the water saving debate has diminished over time, partly due to past decreasing trends of consumption figures already indicated above. In many European countries, industrial water consumption decreased during the 1980s and 1990s. In France, withdrawals fell from 5 107 Million m³/year to 3 942 Million m³/year between 1985 and 1995[145]. Various factors explain this decrease:

- Shifts and restructuring of economic sectors, e.g. major closures of the coal and steel industries that were high water consumers;
- Stricter controls and charges on industrial pollution encourage industries to reduce volumes of effluents and water withdrawal;
- Water use legislation: since 1993 closed circuits are compulsory for all new factories in the plastic transformation industry;
- Policies of individual industries aiming to reduce water costs and to present an environmentally friendly image. Industrial users appear to be more sensitive to price increase than domestic consumers are;
- Availability of new water saving technologies and their take -up by innovative and competitive industrial actors.

At the same time, the European Environmental Agency observed that in some cases demand for better quality of products may induce higher water requirements. This has been particularly shown in the textile, paper and chemical industries. Denmark, Ireland and UK, for example, showed an increase in industrial water consumption during the 1980s and 1990s due to an accelerated industrial development.

5.3.1 Water in industrial processes

Fresh water in industry is used for cooling, heating, cleaning, transport, washing and is finally part of the final product (see Figure 21 below).

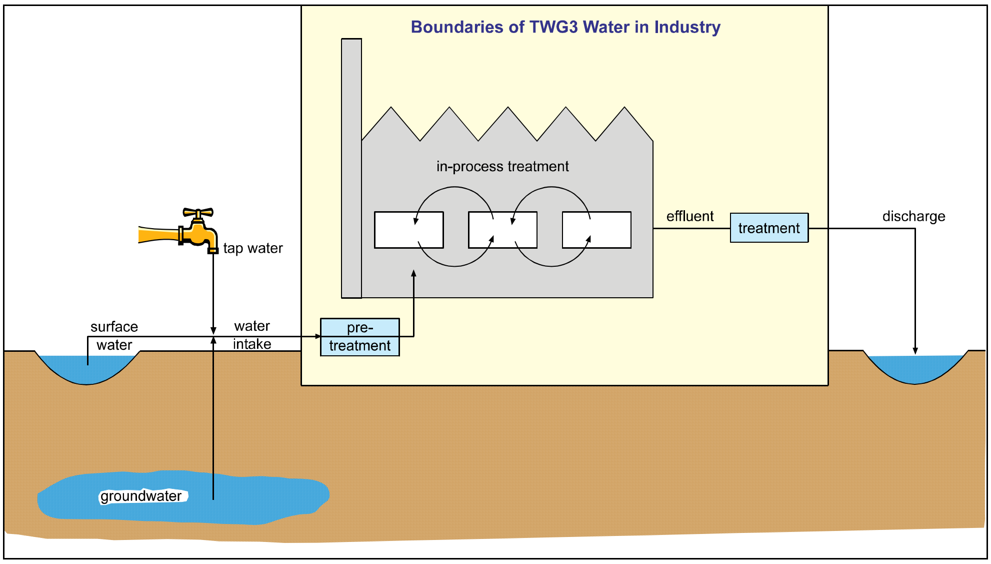

Figure 21: The different roles of water in the industrial sector[146]

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[145] European Environment Agency (EEA) (1999): Sustainable water use in Europe. Part 1: Sectoral use of water. EEA, Copenhagen.

[146] Water Supply and Sanitation Platform (WSSTP) Thematic Working Group (2006): Water in industry. Vision document & Strategic Research Agenda. (Draft version).

Water is of vital importance to many industrial sectors and is the most frequently used medium in industries. Industries that use large amounts of water include the paper & pulp, textile, leather (tanning), oil and gas, chemical, pharmaceutical, food, energy, metal and mining sub-sectors. To emphasise the importance of water for each of the major water using industrial sectors, the specific characteristics of the use of water are summarised below. Furthermore, important developments in the sector are given as far as they are relevant to water[147].

Paper & Pulp

In the paper and pulp industry, water is mainly used as a "carrying/transport/dilution" medium of the fibres. The major water related processes are washing, screening, bleaching and forming. Although much of the of water is re-used in this industrial sector, the water related costs are still high. The total water consumption of the sector is 2,000 M m^3 a year. Water related costs and the saving potentials are very high in the paper sector: water fees cover some 1– 2% of the entire production costs, energy 3-10%, additives 5-10%, fibres 4-8%. The product quality in relation to water is difficult to assess but is of course very important for the entire business.

Textile

The textile and clothing industry consist of different parts. Water is mostly used in the textile finishing stage, which gives the products their final physical, visual and aesthetic properties. In the textile finishing industry, water is mainly used as reaction medium (dyeing, finishing) for washing/rinsing, heating and cooling. The development towards "smart textiles" requires high water quality in the future.

Food

In food processing, large quantities of water are used for different functions, namely washing/rinsing, reaction medium, cleaning of equipment and heat transfer. Also water is used as raw material (e.g. as part of the product). Due to very stringent hygienic standards, water quality is important to ensure product quality and safety. Much attention is given to a good quality of intake water. Until now, only drinking water quality is applied. However, the European legislation is changing, which offers possibilities to use other sources than drinking water, provided that 'the competent authority is satisfied that the quality of the water cannot effect the wholesomeness of the food stuff in its finished form' (Regulation EC 853/2004). This makes closed loop systems feasible as well. The main point of attention is the micro-biological constitution of the water. Other critical compounds in the water system are cleaning agents, pesticides, colouring and smelling compounds. In relation to water costs, in addition to water treatment, also cooling and heating losses are of importance.

Leather (tanning)

The manufacture of leather follows many steps. The major steps are: curing - lime soaking – dehairing – deliming/bating – pickling – tanning- retanning /dyeing/ colouring. In these steps large quantities of water are used, mainly for soaking, washing/ rinsing and dyeing. The tanning industry is a potentially pollution-intensive industry; environmental costs – mainly on water – are estimated at about 5% of the turnover.

Metal (surface treatment)

[147] Note: the information presented for the different industrial sub-sectors is directly derived from WSSTP Thematic Working Group (2006): Water in industry. Vision document & Strategic Research Agenda. (Draft version).

Metal surface treatment includes a variety of processes and metals. Some of the processes are not based on wet processes and are not relevant in the context of TWG3. The major wet processes are electroplating/anodising, phosphating, conversion coatings, surface preparation steps (e.g. degreasing), passivating or pickling. Both types of treatment use large quantities of water, mainly for cleaning/rinsing and as "solvent" for metals to be precipitated on the metal surface. The wastewater streams contain high concentrations of the metals mentioned. Other pollutants are oil, fats, dyes, pigments, corrosion inhibitors, complexing agents and cyanides. In the last decade, much attention has been paid to reduce the environmental impact of the wastewater effluents. The major developments in this field include the separation and advanced treatment of concentrated waste streams, the monitoring of bath quality and/or increase of bath lifetime, the reduction of drag out of bath liquids and drag out recovery, process-integrated measures, and the use of alternative raw materials with less toxic components.

Chemical/Pharmaceutical

The chemical industry is a very diverse business. The IPPC BREF distinguishes between different main branches, namely Large Volume Organic Chemicals, Large Volume Inorganic Chemicals, Polymers, Organic Fine Chemicals and Speciality Inorganic Chemicals. This indicates that there are plants that produce very large volumes of a few chemicals and others which produce small volumes of many different types of chemicals. Even though the total amount of different chemicals produced in the chemical industry is large, the ways to produce them are more limited. Water is essential in most chemical production. For a specific production, the choice of unit process(es) and unit operation(s), together with the choice of raw material and process equipment, define the need and use of water. Typically the majority of water will be used in the unit operations. Waste water is also generated in the unit process due to water in the raw material produced during the reaction or used as reaction media and/or to control the conditions for the process. The distribution of water use and emissions to water between the unit processes and the unit operations can vary widely depending on the chemical produced and the unit process chosen. Water is mainly used for reaction medium/solvent, product washing, cleaning of equipment and heat transfer (cooling, heating). As mentioned above, the contaminant concentration is not evenly distributed in the waste water streams. As a rule of thumb, 20% of the total waste water flow contains 80% of the contaminant load.

Oil/Gas

Water in oil/gas exploitation is used in drilling activities and water comes out as product water originating from the oil/gas resources. Critical compounds are drilling agents, salts from the oil/gas deposits, bio-toxic organics (PAH, BTEX), heavy metals, and some times high concentrations of biologically degradable organics. Since in future more complex oil/gas fields will be taken into production and legislation on water discharges will become more stringent, the need for water treatment technologies will increase. If the oil and gas section includes the energy sector (power stations) as well, the critical compounds should include components from the flue gas scrubber liquids (salts, nitrogen, biologically non-degradable (or slowly degradable) organics), nitrogen and heavy metals.

Mining industry

Mineral extraction, which is usually connected with the necessity of draining a working pit, is carried out using two methods: an underground method and surface (open pit) method. To some extent, the drainage water is irretrievably used for internal circle of the facility or pressed back into the orogen. Most of the water, however, is discharged to surface waters. Working pit drainage always disturbs the natural water balance - in the area of groundwater depression cones which may often be degraded. In surface watercourses, the flows are changed (usually raised, which in rivers containing municipal sewage can be an advantageous change). Unfavourable changes include increased salinity with chloride and sulphate salts, contamination with heavy metals and natural radioactive elements contained in groundwater. The techniques used so far are insufficient to remove salt from water effectively. Very often, in order to reduce the effects of salted water discharge, controlled dosage systems correlated with flow in rivers are built; their impact on water environment, however, is not well recognised. Methods for balancing costs of environmental changes and costs of constructing installations for mine drainage water management (or costs that must be incurred) are not worked out, either.

Obtaining good information on water use in industry is very difficult. Many company reports provide some water data, but they often fail to put these figures in their context, which makes their use and interpretation difficult. For many companies and industrial sectors, the availability of reliable and clean water is vital for operations. Recognising this issue, an increasing number of companies are expanding their annual or periodic reports to include information on water. These reports, however, vary enormously in content, quality, detail, and format. A study based on the review of 121 non-financial corporate reports covering the period of 2005 to 2006[148] found that most of the reports reviewed (97%) provide some form of information on water performance or water management practices and policies. However, the examination of the reports revealed important gaps and inconsistencies in corporate water reporting.

Overall, it is important to stress the different productivity of water in different industrial processes. Producing specific goods requires very different quantities of water. For example, the production of a computer chip requires 32 litres of water, while the production of a car (including all its components) requires as much as 400 000 litres of water. As a result, the industry sector is characterised by highly diverse production and valued added per unit of water. Average productivity of industrial water use for Europe (EU-15) has been estimated at 101 US$ per m^3, ranging from a low 6 US$ per m^3 for Luxembourg to a high 828 US$ per m^3

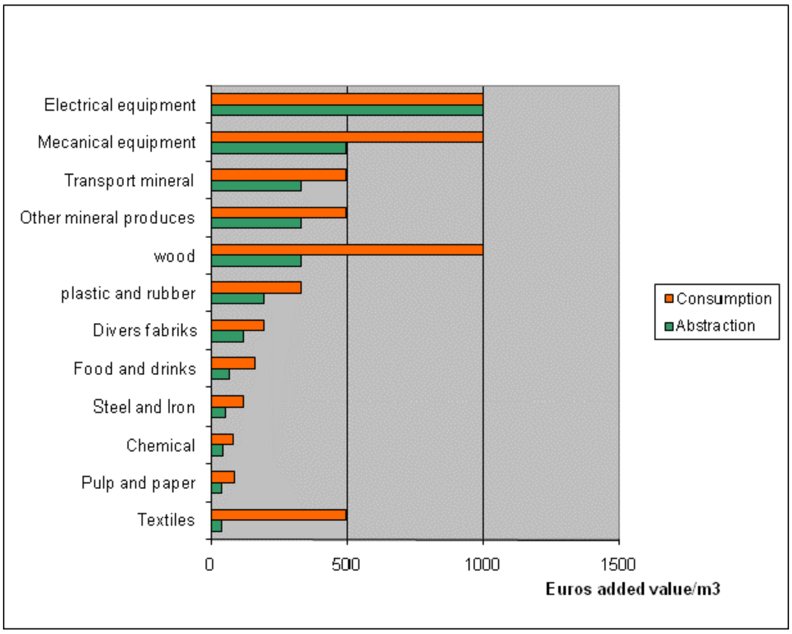

Figure 22: Value added per cubic meter of water consumed and abstracted in Spain[149]

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[148] Morikawa, M.; Morrison, J.; Gleick, P.H. (2007): Corporate reporting on water - A Review of Eleven Global Industries; Pacific Institute, California.

[149] Ministerio de Medio Ambiente (2007): El agua en la Economia Española: situacion y perspectivas. Documento de Trabajo, Ministeria de Medio Ambiante.

(differences between countries capturing the different types of industries present in each country)[150]. Very recent information for Spain on the value added per m^3 for the main industrial sub-sectors obtained from the Article 5 river basin characterisation reports[151] is presented in Figure 22 below.

5.3.2 Water saving technologies

A very wide range of water saving measures can be considered for the industrial sector – accounting for the large diversity in conditions and processes that has been summarised above. Different water saving measures include:

- Changes in production processes;
- Reduction in wastage and leakages;
- Recycling and re-use of water;
- Changes in cooling technology;
- On-site rainwater harvesting (leading to reduction in self-abstraction or water demand for the domestic network);
- Implementation of the classical water saving devices considered for the household sector – as part of the water used in industry is used as domestic water by workers in industrial plants;

In most cases, water auditing of specific individual plants will be the starting point for identifying the areas where water can be saved and the most appropriate strategy/range of actions to be put in place for reducing water demand and increasing industrial value added per unit of water consumed. In many cases, and because of the very characteristics of industrial processes and the potential role of recycling and reuse plan, water auditing needs to consider both water quantity and water quality aspects – the need to reduce polluting discharges to the aquatic environment or to sewage systems is often the key driver to water saving.

Industrial grant programmes can also be incentives to the industrial sectors to invest in water saving measures. Such financial incentives can be administered at the level of water companies or cities. As an example, the city of Tempe in the USA offers financial support up to $20 000 (depending on the size of the project and expected water savings), a minimum of 15% reduction in overall water use being set as minimum target[152].

Also, eco-labelling and the application of ISO 14001 certification provides incentive to review water use and identify potential water savings. In wider Europe (44 countries), around 23 316 companies had ISO 14001 certificates in 2002[153] – the largest group in the world far ahead of other regions. In the US, product certification is also applied and plays the role of incentive for industry to reduce water consumption.

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[150] European Environment Agency (EEA) (1999). Sustainable water use in Europe. Part 1: Sectoral use of water. European Environment Agency, Copenhagen. (based on: OECD 1996 & 1997).

[151] Ministerio de Medio Ambiente (2007): El agua en la Economia Española: situacion y perspectivas. Documento de Trabajo, Ministeria de Medio Ambiante.

[152] http:/www.tempe.gov/conservation/grants_industrial.htm.

[153] United Nation Industrial Development Organization (2005): Water: a shared responsibility – Water and industry (Chapter 8).

Illustration 38

The WaterSense product certification in the US[154]

WaterSense is a voluntary partnership program sponsored by the U.S. Environmental Protection Agency. Its mission is to promote and enhance the market for water-efficient products and services. WaterSense helps consumers identify water-efficient products and programs. Its will indicate that these products and programs meet water-efficiency and performance criteria. The program is partnering with irrigation professionals and irrigation certification programs to promote water-efficient landscape irrigation practices. It is also partnering with manufacturers, retailers and distributors, and utilities to bring WaterSense products to the marketplace and make it easy to purchase high-performing, water-efficient products.

5.3.3 Potential water saving measures and costs – some illustrations

Few studies are available for the industrial sector concerning the impact of water saving measures in terms of volumes of water saved and cost implications. A study carried out by ICAEN for the Catalonia region in Spain between 1992 and1997[155] shows potential water savings for different industrial sectors varying between 25 and 50% (See Figure 23).

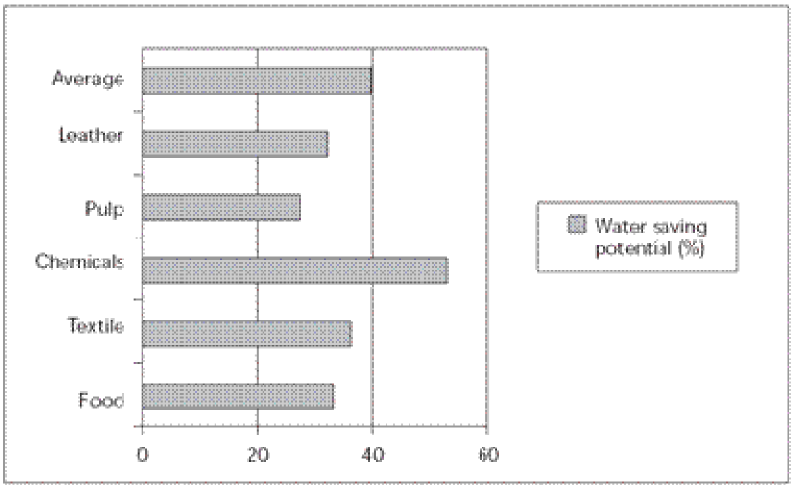

Figure 23: Potential water saving in different industrial sectors in Catalonia (1999) [156]

The same study stressed that around 35% of cost-saving measures were implemented in areas of management and control, 32% in the process and only 18% in the reuse of effluents (See Figure 24). Clearly, with the implementation of new legislation, such as the Integrated Product & Pollution Control (IPPC) Directive, some of these savings have already taken place today.

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[154] http://www.epa.gov/watersense/pubs/faq_cert-label.htm.

[155] Institut Català d’Energia. (1999): Gestió de l´aigua a la Indústria. Estalvi i Depuració.

[156] Institut Català d’Energia. (1999): Gestió de l´aigua a la Indústria. Estalvi i Depuració.

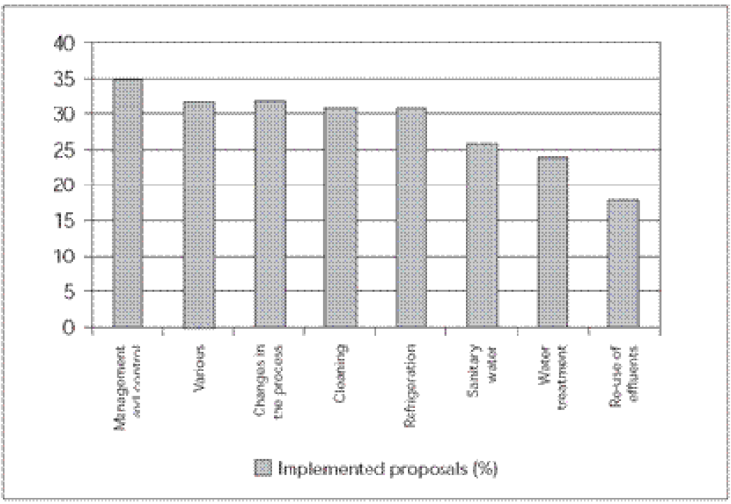

Figure 24. Water-saving measures already implemented in Catalonia (1999)[157]

Similar findings were obtained in surveys in the United Kingdom for different industry sub-sectors:

- A survey in the soft drinks industry[158], a sector using around 25 Million m^3 of water per year to produce 10 Million m^3 (10 billion litres) of soft drinks, showed that good practices in terms of cleaning-in-place equipment, control flow rates to washing & cooling processes, immediate leak repair policy or steam, condensate management, water use monitoring or boiler management policy were already in place in 44%, 30%, 41%, 33%, 30% and 26% of the industrial sites, respectively. Interestingly, the same survey stressed that 38% of the companies responding to the survey did not know exactly how much water was supplied to their sites.
- A survey in the paper and board mills[159] showed that many mills have introduced a range of measures to reduce water consumption. The percentage of interviewed mills who had already implemented water saving measures ranged from a high 81.5% and 78% for measures aimed at identifying water use and repairing leaks, to a low 19% and 22% for measures aimed at improving boiler management and washdown procedures. The average implementation rates of technical water saving measures amounted to around 30%.
- In the South-West Gironde basin in France, water savings already "internalised" in industry's today practices were estimated at 15% and 20% of total potential water savings in the industry sector for (1) water from the domestic drinking water network and (2) groundwater directly abstracted by industrial operators, respectively[160].

Possible water savings (average values) for different types of actions are presented in Table 29 below. Overall, these values stress the significant water saving potential one might obtained when applying these measures. This is in line with the results presented in Asano et

[157] Institut Català d'Energia. (1999): Gestió de l´aigua a la Indústria. Estalvi i Depuració

[158] Environmental Technology Best Practice Programme (1998): Water use in the soft drinks industry. EG126, United Kingdom and http:/www.etsu/com/etbpp/.

[159] Envirowise (2002): Reducing water costs in paper and board mills. Report BG348.

[160] Opinion from experts of the Syndicat mixte d'études pour la gestion de la ressource en eau du département de la Gironde (SMEGREG).

al. (2001), who stress that water savings between 40% to 90% can be expected on average (depending on industrial sub-sectors) if industry is given proper incentives.

Table 29: Potential water saving from measures applied in the industry sector[161]

Efficiency measure	Percentage of water saved
Closed loop recycling	90%
Closed loop recycling with treatment	60%
Automatic shut-off	15%
Counter current rinsing	40%
Spray/jet upgrades	20%
Reuse of wash water	50%
Scrapers	30%
Cleaning in place (CiP)	60%
Pressure Reduction	Variable
Cooling tower heat load reduction	Variable

The following illustration boxes provide some elements on the potential water savings and costs of water saving measures for the industrial sector:

Illustration 39

The tanning industry[162]

An average tannery uses 500 - 1 000m^3 of water/day; however, water consumption depends on what stage the product is in. Tanneries that manufacture finished leather goods from intermediate products use much less water than tanneries that manufacture the intermediate product do. Since it is not realistic to reduce water use in the tanning process, recycling waste water can significantly reduce the need for freshwater inputs. It is estimated that using membrane technology to ‘close the loop’ at manufacturing plants will allow up to 90% water recycling, thus reducing the need for ‘new’ water.

Illustration 40

The paper and pulp industry[163]

SCA, a consumer goods and paper company based in Sweden that produces personal care products, tissue, packaging solutions and solid wood products, has set a goal to reduce water consumption at all production plants by 15% between 2005-2010. Using 2005 as a baseline (water use in 2005 amounted to 237 Million m^3), this 15% goal will amount to savings of 35.5 Million m^3/year. In order to reach the intended target, the company will focus on:

1. increasing efficiency of water purification plants in order to increase water reuse;

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[161] Envirowise (2005): Cost-effective water saving devices and practices – for industrial sites. Good practice guidance, Envirowise, United-Kingdom.

[162] COTANCE (2002): The European Tanning Industry Sustainability Review. http://www.uneptie.org/outreach/wssd/docs/further_resources/related_initiatives/COTANCE/COTANCE.pdf.

[163] SCA (2006): Sustainability Report. Available at: http://www.sca.com/documents/en/Env_Reports/Sustainability_Report_2006_en.pdf.

2. optimising water consumption;

3. shifting from fresh water intake from well water to surface water.

SCA has already seen reductions in water consumption due to water saving measures the company has implemented. In 2006 SCA used 233 Million m^3 of water, a 4.7% reduction in water use from 2005.

Illustration 41

The dairy industry[164]

The European dairy industry produces more than 6 200 Million kg of cheese from around 55 800 Million litres of milk. Cheese consists of 42% water, in contrast with milk, which is 88% water. Traditional cheese factories, however, use 0.8 litres water to process 1 litre of milk and drain off 1.1 litres of wastewater. The water used can be divided into two types: internal process water and cooling water. In the Dutch dairy industry, however, a LIFE project has focused on reusing this waste water. At the end of the project, the following results were achieved with the first production line: a reduction in water intake of 550 Million litres per year (275 Million litres instead of 825 Million litres/year, which equals 67% reduction);and a reduction in wastewater from 800 to 545 Million litres/year. (32% reduction) was also recorded. The project beneficiary, however, stressed that financial gains may not be sufficient to make such investments.

Illustration 42

Reducing water use in the fish processing industry (UK)[165]

Water balances prepared by Marr Foods Ltd for its two fish processing sites in Hull led to the implementation of different water saving measures, such as leak repairs, installation of a new defroster, improved cleaning procedures and introduction of dry filleting. Significant water savings up to 58% per tonne of final product were achieved. Cost savings were estimated at £95 500/year.

Illustration 43

Investing in water saving in the transport industry in Hungary[166]

The Borsod Volan bus company, one of the largest bus company's in Borsod country in Hungary, installed in a new water-saving wastewater treatment facility in 1985 for wastewater resulting from the washing of vehicles. The commercial transportation system uses detergent-free, high pressure hot water to remove dirt and grim from both car bodies and engines. The wastewater produced is treated and then re-supplied to the washing system. The achieved efficiency of water recycling is 80%. Initial investment costs were around 80 000 US$, with an additional investment of 1 600 US$ required after 10 years of operation. The estimated period for recovery of the investments was 1.3 years, a typical figure for this type of water saving measures.

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[164] http://ec.europa.eu/environment/life/project/Projects/PDF/LIFE03_ENV_NL_000488_layman.pdf.

[165] http://www.envirowise.gov.uk/.

[166] http://www.unep.org.jp/ietc/publications/techpublications/.

Illustration 44

Water savings in the electronics manufacturing industry in the UK[167]

Artech Circuits Ltd designs and manufactures high technology multi-layer printed circuit boards in Littlehampton (UK). Because the company uses a large amount of water for manufacturing, it developed a proactive programme of monitoring to identify possible water savings. As a result, measures were put in place to reduce flow to both static rinse and counter flow rinse lines. Water demand was reduced from 46 000 m^3/year to 41 000 m^3/year (or a 12.5% reduction), leading to a £3 000 per year of cost savings. At the same time, water demand reduction led to effluent disposal reduction from 35 000 m^3/year to 32 000 m^3/year with an additional £2 700/year saving.

Illustration 45

Investing in water saving in the metal surfacing industry in the South-West of France[168]

Prodec Métal employs 60 employees and is specialised in surface treatment with nickel, chrome, precious metals etc for the aeronautic industry and for goldsmiths. In 2000, its activities increased with the production of 1, 2 & 5 Euro cent coins, and its annual water consumption amounted to 20 000 m^3 per year. To tackle problems of highly polluted wastewater in a cost-effective manner, the company decided in 2001 to invest in a close-circuit water system, which produces a small quantity of highly polluted water that is treated as externally. A system of rainwater harvesting (using the 5 000 m^2 of roof surface) was also put in place for supplying water to compensate for evaporation and other water losses. Today, the company uses only 2 000 m^3 per year for its internal domestic uses. It has reduced its water abstraction charges by 27 000 Euro per year (with other savings in wastewater treatment charges also). In addition, the system has led to improvements in working conditions and an optimisation of the tasks and processes. With total investment costs of 700 000 Euro , the payback period is estimated at 12 to 15 years.

Illustration 46

Saving water in the paper & wood industry in the South-West of France[169]

The company SMURFIT Cellulose du Pin is specialised, among other things, in the production of kraftliner paper using wood from the nearby Aquitaine forest. The plant abstracts water from the Le Lacanau River (1 100 m^3 per hour) and also from the groundwater aquifer (80 m^3 per hour). To reduce the volumes and temperature of its wastewater discharges, the company installed aero-cooling towers for recycling part of the water, combined with specific monitoring of flows and conductivity for optimising water use in each step of the production process. Overall, this action has led to significant water savings – from 52 to around 20 m^3 of water per ton of paper produced today. Accounting for the savings in water abstraction at 0.20 Euro per m^3, this has led to cost savings of 6 Euro per ton of paper produced. With total investments of 5 Million Euro, the payback period is slightly higher than 2 years.

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[167] http://www.envirowise.gov.uk/.

[168] http://www.jeconomiseleau.org/.

[169] http://www.jeconomiseleau.org/.

Illustration 47

Harvesting rainwater in the car industry in the North of France[170]

Rainwater harvesting represents an interesting alternative to reduce water consumption from industry in France. The Renault car factory of Maubeuge (North of France) currently consumers 2.5 m^3 per vehicle produced by the plant. Due to the rainfall level in the Maubeuge region and the large area covered by the plant, around 200 000 m^3 of rainwater is now collected every year – representing 35% of the annual water consumption of the company. At an average price for industrial water of 1.01 Euro per m^3[171], this saving represents a potential reduction in the company's water bill by 202 000 Euro per year.

Illustration 48

Water savings from improved process control at Welbeck Fabric Dyers (UK)[172]

As a result of rising costs for water supply and effluent disposal, Welback Fabric Dyers decided to put in place a systematic approach to process management, including the installation of meters to measure water and utility use. Water saving measures were then implemented in the preparation area after finding optimum sofcer valve settings and by water recycling. In addition, low-cost good housekeeping measures in the dyeing area and stenter room avoided water from being wasted from hoses and taps left running. Overall, the combined water saving measures have reduced water consumption by 37 200 m^3 in the first year (31% water savings, expected to increase to 40% over time), representing a cost saving (reduced water bill) of £29 000. In addition, energy savings as a result of heating less water for the sofcers amounted to £3 800/year. As no capital investment was needed to achieve the savings associated with the sofcers, there was an immediate payback on 90% of water savings.

Illustration 49

Water savings at Interface Fabrics Ltd (UK)[173]

Initiatives to reduce water and energy consumption have been implemented as part of the Environmental Management System (EMS) of Interface Fabrics Ltd between 1994 and 1998. The different measures implemented included: (1) installation of a hot water boiler for more efficient warm water scouring; and (2) the installation of a computer-controlled management system to perform routine metering and analysis of electricity, gas, water and effluent. In addition, measures were implemented to reduce the pollution load of the company's trade effluent. Cumulative cost savings were over £ 1 Million. The total costs for the computer-controlled management system was around £15 500 with an estimated pay-back period of 18-24 months.

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170 http://www.aquavalor.fr/experiences.htm.

171 Agence de l'Eau Seine-Normandie (2003): L'industrie et l'eau. Analyse économique des usages industriels de l'eau du bassin de la Seine et des fleuves côtiers normands.

172 http://www.etsu.com/etbpp/.

173 http://www.etsu.com/etbpp/.

Illustration 50

Water savings in the furniture manufacturing sector (UK)[174]

The Arenson group, which is involved in office furniture manufacturing, implemented a number of simple water saving measures in the non-manufacturing processes (installing passive infrared detectors in the urinals for example to prevent unnecessary flushes, on-going maintenance to maintain spring-loaded taps, check water meters to ensure no water being wasted from leaks, etc). As a result, water use in factory/office washroom environments was reduced by 45% from 3 800 m^3/year to 2 100 m^3/year, equivalent to cost savings of £3 000/year.

Illustration 51

Water savings in two industrial sub-sectors in the United States[175]

(1) Following a water audit, Graphic Sciences, a company that manufactures water-based inks, installed a cooling tower to re-circulate water. The company cut water use by 80% as well as sewage costs. The $5 800 project costs were recouped in about two months.

(2) Gangi Brothers Packing Co, a tomato processing and canning plant, undertook an audit to identify areas for water conservation. Water saving measures that were implemented lead to 60% water savings. The combined capital and operating costs of water saving measures were equal to $89 500 per year – as compared to savings from lower sewer and water costs of $130 000 per year. The pay-back period was 8 months.

5.3.4 In summary

Overall, there is significant water saving potential in the industry sector. It is interesting to note that sewage (compliance to effluent discharge requirements, sewage charges) is often the main driver explaining investments in water saving measures.

- Based on scant information for Spain, the UK and France, it can be assumed that around 30% to 40% of industrial plants have already implemented water saving measures for their processes or office water use.
- It is unclear, however, whether they have already captured all their water saving potential (i.e. implemented water saving measures in all their processes and office use).
- This rate could be applied rather conservatively for former EU15 Member States. Lower rates are expected in new EU Member States.
- Water savings documented in the literature stress the significant water saving potential in the industry sector. Reported water savings range from 15% to 90% of current water use, depending on the industrial sub-sector considered, the individual process investigated or the combination of water saving measures analysed. Most commonly found figures are within the 30-70% range.
- Information on costs and benefits remains rare, perhaps due to the fact that confidentiality aspects are important for the industry sector.

[174] http://www.etsu.com/etbpp/.

[175] http://www.grist.org/biz/tp/2006/04/25/makower//.

The following table summarises the information collated as part of the present study, including some of the basic economic information documented (although this information is rarely complete and does not provide a comprehensive assessment of the costs and payback periods for example).

Table 30: Overview of Industry water savings measures

Sub-sector	Specific measures	Expected water savings in% (quantities in brackets)	Country	Costs	Benefits	Pay-back period (in years)	Reference
All sectors	Closed loop recycling	90%	UK	-	-	-	Envirowise. 2005
	Closed loop recycling with treatment	60%	UK	-	-	-	Envirowise. 2005
	Automatic shut-off	15%	UK	-	-	-	Envirowise. 2005
	Countercurrent rinsing	40%	UK	-	-	-	Envirowise. 2005
	Spray/jet upgrades	20%	UK	-	-	-	Envirowise. 2005
	Reuse of wash water	50%	UK	-	-	-	Envirowise. 2005
	Scrapers	30%	UK	-	-	-	Envirowise. 2005
	Cleaning in place	60%	UK	-	-	-	Envirowise. 2005
Transport	Wastewater treatment and reuse	80%	Hungary	US$80 000 investment + US$1 600 after 10 years	Savings in water bill	1.3 years	http://www.unep/org.jp/ietc/publications/
Leather industry	Overall savings	30%	Catalonia	-	-	-	ICAEN. 1999
	Recycling wastewater (membrane technology)	90%	Sector-specific	-	-	-	COTANCE. 2002
Pulp & paper	Overall savings	28%	Catalonia	-	-	-	ICAEN. 1999
	Increased efficiency at water purification plant, optimise water consumption	15% (- 35.5 Million m^3/year)	Sweden	-	-	-	http://www.sca.com/
	Aero-cooling towers, monitoring	62% (- 32 m^3 per ton of paper)	France	5 Million € investments	Reduction in water abstraction costs of 6 €/ton of paper	2 years	http://www.jeconomiseleau.org/
Manufacturing	Monitoring programme, improved static rinse and counter flow rinse lines	12.5% (- 5 000 m^3 per year)	UK (electronics)	-	£3 000/year for water bill reduction, additional £2 700/year for effluent discharge reduction	-	http://www.envirowise.gov.uk/
	Close-circuit water system, rainwater harvesting	90% (- 18 000 m^3/year)	France (metal surfacing)	700 000 € investments	Reduction in water bill by 27 000 €/year	12-15 years	http://www.jeconomiseleau.org/
	Rainwater harvesting	35% (- 200 000 m^3/year)	France (car industry)	-	Estimated reduction in water bill by 202 000 €/year	-	http://www.aquavalor.fr/experiences.htm

Sub-sector	Specific measures	Expected water savings in% (quantities in brackets)	Country	Costs	Benefits	Pay-back period (in years)	Reference
	Water saving measures in offices and washrooms	45% (- 1 700 m^3/year)	UK (furniture)	-	Equivalent cost savings of £3 000/year	-	http://www.etsu.com/etbpp/
	Cooling tower to recirculate water	80%	US (water-based inks)	$5 800	Savings in water bills and sewage costs	0.15	http://www/grist/org/biz/tp/2006/04/25/makower/
Chemicals	Overall savings	53%	Catalonia	-	-	-	ICAEN. 1999
	Overall savings	37%	Catalonia	-	-	-	ICAEN. 1999
Textile	Optimum sofcers valve settings, water recycling	40% (- 48 000 m^3/year)	UK (dyeing industry)	No capital investments	Reduced water bill of £29 000/year, additional energy savings of £3 800/year	Immediate payback	http://www.etsu.com/etbpp/
	Efficient water boilers, computer controlled management system & routine monitoring	-	UK	£15 000 for computer-controlled management system	Over £1 Million/year for all measures	1.5-2 for man. system	http://www.etsu.com/etbpp/
	Overall savings	35%	Catalonia	-	-	-	ICAEN. 1999
	Reuse of wastewater	67% (- 0.55 Million m^3/year)	The Netherlands (dairy industry)	-	Reduction in water abstraction, additional reduction in discharged effluent	-	http/ec.europa.eu/environment/life/
Food	Leak repairs, installation of new defroster, improved cleaning, dry filleting	58%	UK (fish processing)		£95 500 per year	-	http;//www.envirowise.gov.uk/
	Water audit & different water saving measures	60%	US (tomato processing and canning)	$89 500/year (inv. + O&M)	Savings of $130 000/year for lower water and sewage costs	0.7	http://www/grist/org/biz/tp/2006/04/25/makower/

5.4 Water for energy production

5.4.1 General issues

Electricity production in the EU has been steadily increasing over the years and has become an integral part of daily life in European societies. Many forms of energy production depend on the availability of water (e.g. the production of electricity at hydropower sites in which the kinetic energy of falling water is converted to electricity). Thermal power plants, in which fossil, nuclear and biomass fuels are used to heat water to drive turbine-generators, require large quantities of water to cool their exhaust streams; the same is true of geothermal power plants. Water also plays an important role in fossil fuel production via injection into conventional oil wells to increase production and its use in production of oil from unconventional oil resources, such as oil shale and tar sands. In the future if we move towards a hydrogen economy, large quantities of water will be required to provide the needed hydrogen via electrolysis. Furthermore, the production of biomass requires large amounts of water to ensure sufficient crop yields.

Water abstracted for energy production is considered a non-consumptive use and it accounts for around 30% of all the uses in Europe. Western Central and western Accession countries are the largest users of water for energy production; in particular Belgium, Germany and Estonia where more than half of the abstracted water is used for energy production[176].

It is important to note the difference between water withdrawal and water consumption (consumed water is not returned to the source, mostly being lost to evaporation). This section only discusses water consumption in the energy sector. Therefore, specific attention will be given to the issue of evaporation, which occurs as a by-product of thermoelectric generation and, depending on the climate, also in large hydropower plants.

5.4.2 Water consumption of the energy sector

Fuel production

Except the for production of electricity from nuclear, hydropower, wind or solar plants, sufficient fuel to be burned is need in thermoelectric plants. This fuel normally comes from oil, gas coal and biomass and requires the withdrawal of water:

- Oil and gas: As long as the pressure in the reservoir remains high enough, no extra efforts are needed to abstract oil and gas. If the pressure decreases and it is economical feasible, enhanced recovery methods, such as water-flooding, steam flooding, or CO2 flooding, may be used to increase reservoir pressure and provide a "sweep" effect to push hydrocarbons out of the reservoir. This water can come from sea water but also can come from fresh water resources and is lost in deeper layers.

- Coal mining: The mining and preparation of coal for use in thermoelectric generation can impact the availability and quality of freshwater resources. The environmental impacts from these practices can range from physical effects on ecosystems (e.g. smothering of riverbeds), to pervasive acid drainage and leaching of heavy metals and other dangerous substances used for mineral processing into fresh water resources. Even if the water used for mining is not really consumed as it will remain in the river basin, it might increase water scarcity since it can not be used for any other purpose due to pollution.

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[176] http://themes.eea.europa.eu/Specific_media/water/indicators/WQ02,2004.05/WQ2_WaterUseSectors _130504.pdf.

- Biomass growth: This increasing source for energy production can have a huge impact on water use. On one hand, the areas irrigated could increase due to increased demand. On the other hand, biomass production might induce transfers of water uses between food crops and bio fuel crops[177]. Although biomass products are used for energy production, the main water saving effects have to be achieved in the agricultural sector where the crop is grown. Consequently, the same water saving measures applied to food crops apply to biomass crops as well. Water saving potential of biomass (technical and economical measures) is therefore covered in the section on agriculture.

Thermoelectric generation

As shown in Table 31, thermoelectric generation (in particular fossil fired nuclear and biomass) comprises more than 80% of the electricity production and is, therefore, the largest water consumer among the different production types.

Table 31: Gross Electricity Generation in 2004 (in TWh)[178]

	Total	Conventional Thermal:	Coal	Oil	Gas	Other	Nuclear	Pumped Storage	Renewables *
EU25	3179	1723	937	143	633	11	986	33	436
	100%	54.2%					31.0%	1.0%	13.7%

**Not including generation from hydro pumped storage*

Conventional cooling methods of thermal power plants are extremely water intensive. Once-through cooling needs large natural bodies of water (ocean, sea or major river) and disposing the waste heat into them causes thermal pollution. Evaporative (wet) cooling towers require significant amounts of make-up water, emit vapor plumes with the related drawbacks and meanwhile discharge concentrated cooling water blow-down, which may pollute the surroundings. Table 32 provides an overview on the different types of plant and cooling systems with respect to water withdrawal and typical water consumption in l/MWh.

Table 32: Water consumption and withdrawal of different thermoelectric power plant [179]

Plant and Cooling System Type	Water Withdrawal (l/MWh)	Typical Water Consumption (l/MWh)	Water consumption as% of withdrawal (average values)
Fossil/biomass/waste-fueled steam, once-through cooling	75 800 to 189 500	~1 137	1%
Fossil/biomass/waste-fueled steam, pond cooling	1 137 to 2 274	1 137-1 819	87%
Fossil/biomass/waste-fueled steam, cooling towers	1 895 to 2 274	~1 819	87%

[177] Importance of transfers in water use from food crops to fuel crops is dealt with in the last section of this report.

[178] Source: Eurostat 10.6.2007.

[179] Electric Power Research Institute (2002): Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production—The Next Half Century, Topical Report, March 2002. available at http://www.epriweb.com/public/000000000001006786.pdf

Nuclear steam, once-through cooling	94 750 to 227 400	~1 516	1%
Nuclear steam, pond cooling	1 819 to 4 169	1 516-2 729	71%
Nuclear steam, cooling towers	3 032 to 4 169	~2 729	76%
Natural gas/oil combined-cycle, once through cooling	28 425 to 75 800	~379	1%
Natural gas/oil combined-cycle, cooling towers	~872	~682	78%
Natural gas/oil combined-cycle, dry cooling	~0	~0	~0%
Coal/petroleum residuum–fuelled combined-cycle, cooling towers	~1 440*	~758	53%

** Iincludes gasification process water*

The use of dry cooling systems completely eliminates the need for cooling tower make-up water. Emitting only warm and clean air, these dry systems have no adverse environmental effects, while freeing power plants from dependence on water sources. This also allows for full power in cases of water shortages or water temperature fluctuations.

Hydropower generation

Evaporation of water is a natural process that takes place on every surface water. Dams for hydropower reduce the water flow of a river and often create artificial lakes, which have a larger surface than the former stream of the river had. This increase in surface area increases evaporation. Losses by evaporation associated with infiltration may significantly reduce the surface water flow after it leaves the mountainous part of the basin from where it originates.

Illustration 52

Importance of evaporation from lakes and reservoirs[180]

Average annual evaporation from lakes and reservoirs varies widely depending on climatic conditions. It can range from a low 200 mm per year for a lake above an altitude of 2 000 meters in the Alps to 600-700 mm for lakes in Germany, Poland and Sweden and up to a high 1 500 mm per year for lakes in the South of France and Spain. Extreme values of 2 400 mm are reported for the Dead Sea!

The share of evaporation losses among water stored in dams highly depends on the reservoir characteristics (its open surface and depth mainly). A simple calculation was made for the Serre Ponçon dam, the second largest hydropower dam in Europe. By applying the evaporation level available of the Geneva lake (650 mm per year) on the area of the Serre-Ponçon reservoir, we obtain an annual evaporation of 18 Million m^3, equivalent to 1.4% of the total dam capacity (1 272 Million m^3) and 1.7% of its effective capacity (1 030 Million m^3)[181]

Global warming is indicated by a long-term upward trend in temperature data, which increases trends in other characteristics such as evaporation, rainfall, and runoff. An increase in evaporation as a result of higher temperatures together with changes in precipitation patterns may alter the timing and magnitude of river flows. This would affect the

[180] Thébé,B.; L'Hôte,Y.; Morell, M. (1999): Acquisition et constitution d'une information hydrologique de base available at http://medhycos.mpl.ird.fr/en/data/hyd/Drobot/start3.htm

[181] http://afeid.montpellier.cemagref.fr/Mpl2003/Conf/Roux.pdf.

ability of hydropower stations to harness water resources and may result in reduced energy production, implying lower revenue and poorer financial returns.

5.4.3 Technical measures for water saving in the energy sector

Thermoelectric generation

The main focus of research and development regarding thermoelectric electricity generation lies on the improvement of energy efficiency, which is an important factor for water saving in the energy sector. Improved energy efficiency results in less water consumption per unit of energy produced. Moreover, there is separate research ongoing to reduce water use and consumption in thermoelectric electricity generation.

- Non-Traditional Sources of Process and Cooling Water: Water quality requirements for cooling systems can be less restrictive than many other applications, such as drinking water supplies or agricultural applications, so opportunities exist for the utilization of lower-quality, non-traditional water sources.

Illustration 53

Power plant using desalinised water for cooling in Florida

The University of Florida investigated an innovative diffusion-driven desalination process that allows a power plant using saline water for cooling to become a net producer of freshwater. Hot water from the condenser provides the thermal energy to drive the desalination process. Saline water cools and condenses the low pressure steam and the warmed water then passes through a diffusion tower to produce humidified air. The humidified air then goes to a direct contact condenser where fresh water is condensed out. This process is more advantageous than conventional desalination technology in that it may be driven by waste heat with very low thermodynamic availability. Cool air, a by-product of this process, can be used to cool nearby buildings.

- Increase water reuse and recovery: Advanced technologies that reuse power plant cooling water and associated waste heat or recover water from coal power plant flue gas could have the potential to reduce water withdrawal and consumption.
- Advanced cooling technology: Advanced cooling technology, such as dry cooling, evaporative cooling and hybrid cooling technologies, water use and consumption.
- Energy efficiency: New power plants, such as natural gas combined-cycle plants, decrease both the quantity of water withdrawn and the quantity consumed per MWh and can have an efficiency rate close to 60%182. With an increasing energy demand, more efficient plants might reduce the need for more plants up to a certain amount.

Hydropower generation

There are limited possibilities for reducing evapotranspiration from reservoirs linked to hydro-power generation.

- The first option is to reduce the area of the reservoir, for example building reservoirs for which the ratio total reservoir area divided by the total storage is very low. This is not, however, an option for dams already built.

[182] Electric Power Research Institute (2002): Water & Sustainability (Volume 3): U.S. Water Consumption for Power Production—The Next Half Century, Topical Report, March 2002

- The second option is to cover reservoirs and reduce evaporation. While such an option can be considered for small reservoirs, covering the reservoir surface for reducing or stopping evaporation is not an option for hydropower reservoirs due to their size. For example, the area of the Serre-Ponçon lake in France, the largest artificial water reservoir used for hydropower in this country, is 28 km2, clearly out of scope for imagining coverage solutions.

In both cases (hydropower and thermoelectric power plants), the planning and investment periods are quite long (more than 30 years).

5.4.4 Potential water saving measures and costs – some illustrations

There are not many examples in the EU of application of water saving measures and technology in the energy sector. More information can be found in the US. However, this information is rarely well documented. The following illustration box provides one example documented in the literature of water savings for the energy sector in Latvia.

Illustration 54

Recycling water in the power generation industry[183]

There are a number of water saving opportunities that can be applied to the power generation industry. In Riga, water cooling from Riga Thermal Power Plant Number 1 was upgraded with cooling water being biologically treated in ponds and recycled afterwards, as opposed to freshwater being discharged into the Lake Kisezers. The introduction of recycling of cooling water is expected to lead to a reduction of 9.5 times of water consumption, from 30 Million m^3 per year to 3.1 Million m^3 per year. Similar projects are, or were, under way in thermoelectric power plants in Poland, Ukraine and Hungary.

The relative simplicity and lower direct investment cost of wet cooling towers often result in power plant developers preferring evaporative cooling to dry cooling alternatives. The complex evaluation of investments as well as running costs relative to the cooling system may, however, prove that in many instances the low direct investment option of wet cooling is coupled with additional indirect investment costs or by increased operating costs, and the combination of these results in a total lifetime exceed that incurred with dry cooling. In order to avoid such “non-economical” decisions, a reliable analysis is needed in order to prevent a costly cooling system selection. This can be done by comparing the total costs of the different candidate cooling systems in the function of various economic parameters.

An example of such an assessment is given in Table 33, which summarises the results of the investigation for different cooling systems, assuming an annuity rate of 7.8% (i.e. annual depreciation rate), 3 US cent / kWh electricity cost and 60 US cent / m^3 water price[184]. As a result, wet cooling ranks behind the front-runner dry cooling when looking at the total annual costs. A different picture would have been gained if only the total investment cost and the electricity output had been considered.

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[183] http://www.unep.org.jp/ietc/publications/techpublications/.

[184] Szabó, Z. (no year) The economics and the future of water conserving power plant cooling, available at http://www.worldenergy.org/wec-geis/publications/default/tech_papers/17th_congress/2_1_01.asp
.

Table 33: Annual Cost Comparison for Different Cooling Systems

Cost types	Heller System Natural draft	Mechanical Draft Dry Cooling Tower	Wet system
Total Investment	10 781 000	10 730 000	5 585 000
Annual Depreciation over Power Plant Lifetime ($/a)	843 000	839 000	437 000
Average Turbine Net Output (MW)	150	148	154
Annual Net Energy (GWh/a)	899	888	926
Annual Energy Loss (GWh/a)	27	38	basis
Cost of Annual Energy Loss ($/a)	806 000	1 143 000	0
Average Water Consumption (m^3/h)	-	-	385
Annual Water Consumption (m^3/a)	-	-	2 310 200
Annual Water Price ($/a)	-	-	1 386 100
TOTAL ANNUAL COST	1 649 000	1 982 000	1 823 100

Such calculations as made in the table above can be turned into a break-even water price analysis as shown in Figure 25. With such an economic assessment, the break even point for different cooling systems in relation to energy and water prices can be estimated.

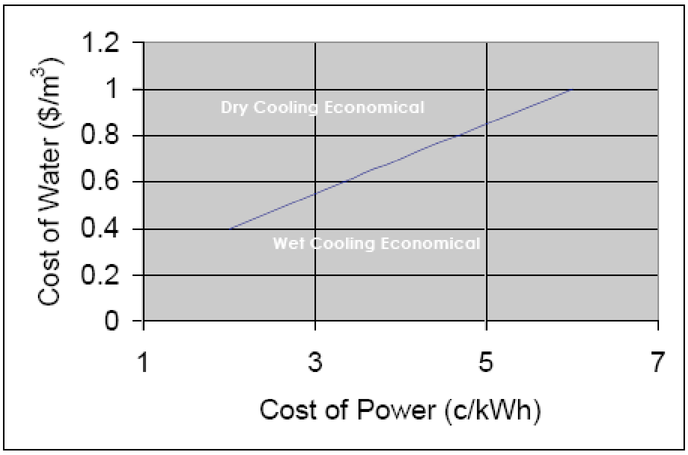

Figure 25: The relation between type of cooling, energy and water prices[185]

Figure 25 clearly shows that dry cooling becomes profitable if water is expensive and/or power is cheap. Considering the 30-year life-span of power plants and the growing problems with water availability, by estimating a more than proportional water price increase related to other cost items, the application of dry cooling can not only be justified because of water scarcity, it also can be justified economically.

5.4.5 Links between energy and water savings

Energy saving leads to water saving

As demonstrated above, water consumption and energy production are closely linked to each other, as the production of energy from fossil fuels (coal, oil, and natural gas) is

[185] http://esd.ans.org/presentations/shenoy-nov-06.pdf.

inextricably linked to the availability of adequate and sustainable supplies of water. Simple energy saving measures, such as avoiding the stand-by of multimedia equipment and house appliances, could readily reduce energy consumption in households. Less energy demand means less water consumed in the energy production processes.

Illustration 55

Energy savings leading to water savings?

According to studies conducted by the Joint Research Centre of the European Commission, 10% of household energy consumption is unnecessary and as a result of the number of household electrical products left on stand by[186]. The total energy consumption in households in 2004 was 1 516.993 GWh. A saving of 10% would mean an equivalent reduction in energy production of 151.699 GWh per year or close to a reduction by 300 Million m^3/year of water consumed via evaporation[187] - a volume of water that amounts to 25% of the storage capacity of the Serre-Ponçon dam mentioned above.

Water savings also leads to energy saving

Water demand also influences energy production and energy consumption. For example, hot water use in households for showers and baths as well as for washing clothes and dishes is a major driver of household energy consumption. Other household uses of water (such as irrigating landscaping) require additional energy in other sectors to transport and treat the water before use and to treat wastewater. With regards to the impact of water savings on energy savings, different elements have already been mentioned in the chapter on households and can be extrapolated to the different sectors and water users. Indeed, a reduction in water demand due to the application of water saving devices, for example, will lead to:

- A reduction in water abstraction and thus a reduction in pumping costs. A study by the University of Florida[188] estimates that a 15% improvement in water application efficiency when using drip irrigation leads to a cost saving of 16.6% in pumping system (electrical energy) use.
- A reduction in water use also means a reduction in hot water use leading to lower energy use for heating water and thus to lower carbon emissions in line with climate change challenges. For example, installing water-efficient showerheads is expected to lead to a reduction by half a tonne of greenhouse emissions per year if a house has an electric hot water system[189]. Similarly, fixing dripping hot taps saves up to 100 kg of greenhouse gas each year per tap[190].

Two illustrations on the link between water savings and energy savings are further detailed and presented below.

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186 http://ies.jrc.cec.eu.int/fileadmin/Documentation/Press%20Releases/MEMO-06-386_EN.pdf.

187 The calculation are based on the values Table 32 for a nuclear steam, once-through cooling.

188 Hodges, A.W.; Lynne, G.D.; Rahmani, M.; Franklin, C. (1994): Casey Adoption of Energy and Water-Conserving Irrigation Technologies in Florida, available http://edis.ifas.ufl.edu/pdffiles/EH/EH25000.pdf

189 http://www.greenhouse.gov.au/gwci/water.html. Clearly, these values vary depending on the type of water heating system in operation. Annual greenhouse gas emissions for hot water (assuming 140 litres hot water per day) range from a low 0.7 to 4.0 tonnes of greenhouse gas emissions per year for solar-gas heating systems to electric storage system respectively.

190 http://www.greenhouse.gov.au/gwci/water.html.

Illustration 56

Impacts of water savings on energy for the city of Liverpool[191]

United Utilities (UU), the local drinking water supply company, currently supplies Liverpool with 41 610 Ml of water per year. Using the data from UU, Liverpool homes consume 27,046.5 Ml of water, which is 65% of the total supplied. From this, toilets consume 8 925.34 Ml of water per year, which equals to 33% of total household consumption.

For the purpose of a scenario for reducing the water consumed by toilets, an assumption is made that all homes have one toilet, which is fitted with a 9 litre capacity cistern. In order to achieve a third reduction in toilet water consumption, all 9 litre capacity cisterns must be replaced with 6 litre capacity cisterns. This would mean that the present toilet consumption in Liverpool (8,925.34 Ml) would fall by 2 945.36 Ml per year by 2010. In addition, this reduction would save 736 340 kWh from water pumps and treatment processes. In summary, by 2010 these on-going savings would amount to 16 204 Million litres of water, over 4 GWh of energy and a reduction of 2 126.72 tonnes of CO_2 emissions.

Illustration 57

Ashland, Oregon, Small Town, Big Savings[192]

In 1991, the city council adopted a water efficiency program with four major components: system leak detection and repair, conservation-based water rates, a high-efficiency showerhead replacement program, and toilet retrofits and replacement. The city estimated that these programs would save 500 000 gallons of water per day at a cost of $825 875—approximately one-twelfth the cost of the proposed dam—and would delay the need for additional water-supply sources until 2021.

Implementation of the program began with a series of customer water audits, which in turn led to high-efficiency showerhead and toilet replacements and a $75 rebate program (later reduced to $60). Ashland also instituted an inverted block rate structure to encourage water conservation. Recently, Ashland began offering rebates for efficient clothes washers and dishwashers (including an energy rebate for customers with electric water heaters). The town provides a free review of irrigation and landscaping, as well.

Implementation of Ashland's Water Conservation Program began in July 1992. By 2001, almost 1 900 residences had received a water audit. Almost 85 percent of the audited homes participated in the showerhead and/or toilet replacement programs. Ashland has been able to reduce its water demand by 395 000 gallons per day (16 percent of winter use) and its wastewater flow by 159 000 gallons per day. An additional benefit of the program has been an estimated annual savings of 514 000 kilowatt-hours of electricity, primarily due to the use of efficient showerheads.

In conclusion, water consumption requires large amounts of energy for three main purposes: water supply, water heating, and wastewater disposal. Reductions in water consumption at the end-use level directly reduces energy consumption required for supplying and heating water and for disposing of wastewater, which could reduce the water needed for energy production.

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[191] Barett, J.; Scott, A. (2001): An Ecological Footprint of Liverpool: Developing Sustainable Scenario - A Detailed Examination of Ecological Sustainability, Stockholm Environment Institute & Sustainable Steps Consultants, February 2001.

[192] Environmental Protection Agency of the United States (2002): Cases in Water Conservation Available at: http://www.epa.gov/watersense/.

5.4.5.1 In Summary

Energy production in Europe is dominated by thermoelectric generation. This method infers high water use, which is linked to two main processes: the extraction of fossil fuels to run the power plant and cooling the exhaust water steam after it drove the turbine-generators. Therefore, the greatest water saving in the energy sector can be gained by saving energy, optimising the technical processes such as cooling, and – through the strong link to energy demand - by saving water itself. The following table summarises in brief the water saving options in the energy sector, which were presented in this chapter.

Table 34: Summary

Energy aspect	Specific water saving measure
Fuel production	▪ Energy savings could reduce also the water used when abstracting fuels (mining) for thermoelectric power plants ▪ Biomass production can lead to increased water use and consumption in some areas (see also section 4.2)
Thermoelectric power generation	▪ Thermoelectric power generation is far the most water user in electricity production. Most water is used for cooling purpose. ▪ Advanced cooling technology (dry cooling, evaporative cooling, hybrid cooling) do not need any water at all. ▪ General energy saving and improvement of energy efficiency helps to save water consumption. A saving of 10% energy throughout Europe would amount to 300 Million m^3 water less used per year ▪ Vice versa water saving measures reduce energy used for water supply, water heating and waste water disposal
Other ways of electricity production	▪ Solar panels and wind mills only need little water for cleaning purpose ▪ Hydropower uses water by interrupting the river continuum. Water consumption due to evaporation is strongly depending on local climate conditions. Increased evaporation, especially in southern European countries can become an issue with regards to climate change

5.5 Water saving potential in the Tourism sector

5.5.1 General issues

The tourism sector does not represent a key water use sector in Europe overall, but this can be the case in some regions and it might become a more important sector in the future. With an average growth rate of 2.2% between 2000-2005, tourism is a fast-growing sector; therefore, impacts to water resources in some areas (e.g. the Mediterranean) are significant. Out of the world's 25 top tourism destinations in 2004 (evaluated by number of tourist arrivals), 6 are European destinations located in the Mediterranean Region (France, Spain, Italy, Greece, Portugal and Croatia), thus accounting for 30% of total international tourist arrivals in the world[193].

However, this sector is important to look at since it is characterised by significant variability in water demand, namely temporal variability with significant peaks during the summer period when water availability is at its lowest; and spatial variability with the tourism industry being concentrated along the coasts, in particular the Mediterranean coast, which is already experience significant water imbalances. At the extreme, the population (residents and tourists) water demand of the Greek islands Cyclades can multiply by 5 to 10 during the summer. In the Provence Côte d'Azur region, water demands doubles during the summer vacation period[194].

The tourism sector is very diverse in terms of the level and components of water use. There are, for example, very large differences in water use depending on where tourists are staying (hotels of different standings, camping, holiday houses etc) and the type of activities they perform. For example:

- According to Hamele and Eckhardt (2006)[195], tourists use on average 174 litres/per night in a camping place, 281 litres/per night at a bed and breakfast and 294 litres/per night at a hotel. This results in average water consumption per year on a camping site of 14 200 m³, in a bed-and-breakfast 944 m³ and in a hotel 9 713 m³.[196] Within such establishments (includes all 3 categories), average water consumption at cafes or bars is around 35 litres per guest. In overnight establishments with swimming pools, guest use on average 60 litres more per overnight stay as compared to establishments without swimming pools.
- It is estimated that tourists visiting Mediterranean countries consume on average between 300 and 880 litres per day (depending on star rating), more than 100% more than local residents. In Malta, the tourism sector accounts for 8% of total water consumed.. In the Balearic Islands, water consumption during the month of July (peak tourist month) was equal to 20% (1999 figures) of what the local population used in one year. Where data on water consumption for the tourism sector is available, a clear increase has been detected in the past two decades. In Tunisia water demand for tourism more than doubled between 1977 and 1996; the Balearic Islands (Spain) have multiplied their water abstraction (primarily for the tourism sector) by 15 times between 1980 and 1995[197].
- Average daily water use per capita ranges from 140 l/night to 200 l/night in camping sites from the Loire-Bretagne river basin in France[198]. Larger differences exist between hotels in the same river basin; the average daily water use ranges from 170 l/night to 580 l/night for one-star hotels and four-star hotels respectively.

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193 See http://www.unwto.org/facts/eng/pdf/indicators/ITA_top25.pdf

194 De Dtefano, L. (2004): Freshwater and tourism in the Mediterranean. WWF Mediterranean programme.

195 Hamele. H.; Eckardt, S. (2006): Environmental initiatives by European tourism businesses – Instruments, indicators and practical examples. ECOTRANS, Germany.

196 Hotel stays are the most frequent, with 58% of tourists choosing to stay at a hotel, compared to 18% at a campsite and 12% in vacation apartments. The remaining tourists stay with family and friends or own a second home.

197 Plan Bleu (2004): L'eau des Méditerranées: Situation et perspectives. MAP Technical Report Series No. 158. PNUE/PAM: Athens.

198 Office International de l'Eau (2005): Office International de l'Eau. 2005. Consommation d'eau potable et potentiels d'économies. Rapport n°2, Etude « Economie d'Eau » pour le compte de l'agence de l'eau Loire-Bretagne.

- Until June 2006 about 600 data sets from 25 countries were entered into the database of TourBench[199]. As result it was found out that hotels and holiday houses consume far more water per overnight stay than camping sites or group accommodation services. The differences between the five main types of accommodation services are about 50 litre from one to the next. As guidance for average consumption of water per overnight stay in European it is suggested:
  - 300-350 l in hotels;
  - 250-300 l in holiday houses;
  - 200-250 l in bed & breakfast;
  - 150-200 l in camping sites;
  - 100-150 l in group accommodation services.
- Further, hotels and camping sites with swimming pool need ca. 60 l more water per overnight. This means for hotels ca. 20%, for camping sites ca. 40% more consumption and cost than in the businesses of their colleagues without pool.
- Golf increases the water consumption of tourists significantly. On average, a golf course needs between 10 000 and 15 000 m^3 of water per hectare, which is equivalent to the yearly consumption of a city of around 12 000 inhabitants if the size of a golf course is between 50 & 150 hectares[200]. In Spain, for example, the water demand of golf courses accounts for 125 Million m^3 per year (2004 data[201]), a figure expected to rise by around 65% by 2015. In France, more than 500 golf courses were already operational in 2002[202].

Overall, investigating water demand and water saving potential requires disaggregating the total demand of the tourism sector into individual components (i.e. one needs to examine the different areas of a hotel that use water). With respect to hotel water use, the following figure presents the share of different components in the total water demand of an average 3-star hotel in France[203].

[199] TourBench is a European monitoring and benchmarking initiative, that aims to reduce the environmental costs in tourist accommodation businesses. For more information see http://www.tourbench.info..

[200] De Dtefano, L. (2004): Freshwater and tourism in the Mediterranean. WWF Mediterranean programme.

[201] Ministerio de Medio Ambiante (2007): El Agua en la Economia Española: situacion y perspectivas. Documento de trabajo.

[202] Plan Bleu (2005): Dossier sur le tourisme et le développement durable en Méditerranée. PNUE. PAM MAP Technical Reports series n° 159.

[203] ADEME (2007): Mon hôtel & l'environnement. Guide produit par l'Agence de l'Environnement et de la Maîtrise de l'Energie, délégation régionale de la Région Aquitaine.

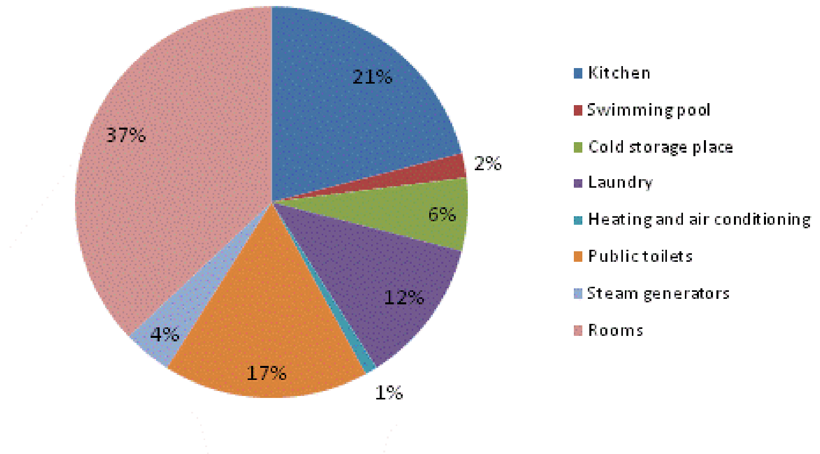

Figure 26: Example of the relative importance of different components of the total water demand for a 3 star hotel in France (irrigation of gardens excluded)

5.5.2 Technical water saving options

There are many different water saving measures to consider for the tourism sector, depending on the water demand component considered. Some of the measures are similar to those considered for the household/domestic sector (e.g. toilets, showers, but also those targeting the domestic water supply network), while others are closer to those relevant to the agriculture sector (irrigation of gardens, irrigation of golf courses).

5.5.2.1 Measures for reducing water demand:

Changing consumption habits of tourists can be a difficult task as customers do not have information on their consumption or its economic and environmental implications. Information and awareness raising to reduce the frequency of towel and bed sheet laundering, or in drastic cases reducing showering, are the type of actions most frequently put in place by the hotel industry to reduce water demand directly. It is estimated that 70% of the occupants of a hotel in France are sensitive to this type of information campaign and change their behaviour accordingly[204]. The installation of individual water meters for tourist infrastructure composed of a series of individual lodges/flats rented for longer time periods (minimum one week) can also be considered as a means for reducing water demand. Lallana estimates in 2001 that implementing metering can induce immediate reduction of water consumption by 10 to 25%.

5.5.2.2 Installation of water saving devices:

This is the main way to reduce water consumption in the tourism sector. Appliances are the same as those considered for households (specific technology for taps, toilets, pools, green area etc). The potential water saving amount is similar to the figure mentioned in household consumption chapter (see section 5.2.2)

5.5.2.3 Capturing alternative sources of water:

Significant efforts have been made in some countries to promote rainwater harvesting in hotels. Furthermore, larger hotels close to the sea are increasingly investing in their own desalination plants (e.g. reverse osmosis), in Malta and Cyprus for example. Moreover,

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[204] ADEME (2007): Mon hôtel & l'environnement. Guide produit par l'Agence de l'Environnement et de la Maîtrise de l'Energie, délégation régionale de la Région Aquitaine.

investments in dual water systems and the reuse of treated wastewater supplied from a hotel's own treatment plants is also now considered by the larger hotels that can afford such technology.

In some cases and for some of the tourism sub-sectors, eco-tourism labels and certification systems can be effective in ensuring the implementation of water saving measures in the tourism industry. Green certification programmes usually involve a combination of stakeholders (industry, consumers, NGOs, governments and local communities). Europe alone has more than 30 certification programmes for accommodation services – the most popular being ISO 14 001 used, for example, by Green Globe, Green Flags for Green Hotels or different individual chains and hotels[205]. Existing certification schemes can be divided into tourism certification, sustainable tourism certification and ecotourism certification. However, there is no evaluation system available today that specifically assesses an establishment on the role and effectiveness of water savings programmes.

5.5.3 Potential water saving measures and costs – some illustrations

A study of potential water savings in the tourism sector for the Loire-Bretagne river basin in France[206] identified camping sites and hotels as the main water use sub-sectors for this basin. While camping site are characterized by high seasonal variation with peak water demand during the summer season, hotels show lower variability in occupancy rates within the year because part of their customer base are professional salesmen and workers.

- The total water consumption is estimated at 5 Million m^3 and 6.7 Million m^3 for camping sites and hotels respectively. Saving potential is estimated at between 10% and 20% of current consumption.
- This low saving rate is explained by the fact that many hotel and camping owners have already invested in water saving appliances and techniques to reduce their water bill and enhance water use efficiency.
- For hotels, potential water savings between 14% and 37% have been estimated for water use attached to room occupancy. This is consistent with water saving estimates of 6% for a hotel in the United Kingdom[207] due to water saving devices in showers and toilets only – resulting in a 400 Euro saving per year from water bill reduction.

Using the information presented in Figure 26, an average water demand of 330 l/night obtained from the Loire-Bretagne river basin[208] and potential water savings for the different components of water demand[209], average water savings of 30%, 35%, 50% and 35% are estimated for kitchen use, laundry, public toilets and room use. This leads to an overall demand of 224 l/night, equivalent to a 32% reduction in total water demand.

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205 De Dtefano, L. (2004): Freshwater and tourism in the Mediterranean. WWF Mediterranean programme.

206 Office International de l'Eau (2005): Office International de l'Eau. 2005. Consommation d'eau potable et potentiels d'économies. Rapport n°2, Etude « Economie d'Eau » pour le compte de l'agence de l'eau Loire-Bretagne.

207 Based on data from: ADEME (2007): Mon hôtel & l'environnement. Guide produit par l'Agence de l'Environnement et de la Maîtrise de l'Energie, délégation régionale de la Région Aquitaine.

208 Office International de l'Eau (2005): Office International de l'Eau. 2005. Consommation d'eau potable et potentiels d'économies. Rapport n°2, Etude « Economie d'Eau » pour le compte de l'agence de l'eau Loire-Bretagne.

209 Including estimates derived from data provided in: ADEME (2007): Mon hôtel & l'environnement. Guide produit par l'Agence de l'Environnement et de la Maîtrise de l'Energie, délégation régionale de la Région Aquitaine.

Hamele and Eckhardt (2006)[210] also estimate the potential for water saving for different businesses in the tourism sector – building on a survey of 466 European businesses and comparing averages with benchmark values obtained from the "best" practices currently in place in the sector. Results are summarised in the following table.

Table 35: Potential water savings for the tourism sector based on current "best" practices

Type of business	Average water use (l/overnight stay)	Benchmark water use (l/overnight stay)	% water saving (as% of average)
Camping sites	174	96	-45%
Bed & breakfast	281	133	-52%
Hotels	394	213	-46%

Clearly, these averages hide the diversity of situations within each of the sub-sectors. The water saving potential, for example, is higher for 3 star and 5 star hotels (-50% and -48% respectively) as compare to 4 star hotels (-40% only). The study also identified potential water savings of 30% of total water use in kitchens of hotels/restaurants. It also stresses potential water savings in cafés, lounges and bars of nearly 70%; the average water consumption in a café is on average 35 litres per guest as compared to an exemplary value of only 11 litres per guest.

Investments in rainwater harvesting were also reported for an hotel in Saint-Emilion (South-West of France). The total investment of 1 550 Euros for the rainwater harvesting system was recuperated after only one year of operation; the water collected was primarily used to irrigate the garden of the hotel during the period April to September.

In Malta, information on costs and effects of water saving measures for the tourism sector was collected as part of the Twinning Project between the Ministry of Ecology and Sustainable Development of France and the Malta Resources Authority. The information collected as part of this project (not yet published) show that two 5-star hotels have already installed rainwater harvesting systems and their own in-house waste water treatment facility, combined with dual water supply systems to use gray water for toilet flushing and for irrigating garden areas.

- Decentralised waste water treatment and reuse systems could, in the long term, target 50% of the 4 & 5-star hotels constructed in sparsely populated and constructed areas on the island. Total investment costs for one system are estimated at 120 000 Euros or 3.03 Million Euros overall. The expected savings in groundwater abstraction (the main source of water to be protected in Malta) has been estimated at 4.8 m^3/year per bed or 46 000 m^3/year overall (30 hotels). The expected reduction in hotel water bills amount to 256 000 Euros per year.

- New investments in rainwater harvesting are also considered on the island. The construction of cisterns, double networks and the installation of a small pump is estimated at 35 000 Euros for an average 3 star hotel. It is expected that this measure could target around 20 hotels, with total investment costs of 700 000 Euros. Rainfall harvesting is estimated at 100 m^3 per hotel per year, leading to a reduction in water supplied by the public water network by 2 000 m^3. As a result, financial savings from reduced water bills are estimated at 5 100 Euros per year, with reduction in groundwater abstraction estimated at 920 m^3 per year (only 46% of water from the

[210] Hamele. H.; Eckardt, S. (2006): Environmental initiatives by European tourism businesses – Instruments, indicators and practical examples. ECOTRANS, Germany.

domestic network is abstracted from groundwater; remaining amount originates from desalination plants).

- The development of desalination plants (reverse osmosis) is also another option increasingly considered by hotels along the coast line to control their own water supply. Overall, this option can be considered by 3, 4 and 5-star hotels – in some cases sharing the plant for reducing costs. This would amount to total investments of 1.5 Million Euros, with relatively high running costs of 70 000 Euros per year. This would result in a reduction in hotel domestic water consumption and water bills of 74 000 m^3 and 190 000 Euros per year respectively. Due to the fact that only 46% of water from the domestic network is abstracted from groundwater, this would result in a reduction of 34 000 m^3/year in groundwater abstraction.

Part of the water savings in the tourism industry can originate from outdoor uses linked to irrigation of gardens and open spaces, golf courses etc. Savings of 30%[211], 45%[212], 76%[213] and 60 to 90%[214] are reported as a result of water auditing, irrigation scheduling that better accounts for water demands and rainfalls and shift to drip irrigation. Efforts have also been made to covert landscape, trees, turf, shrubs and grasses to ones that require less irrigation. With a payback period of 3 years for a change in landscape, savings of up to 70% of water have been estimated[215]. Attention is also increasingly put on reuse of treated effluent for golf courses. In addition to reducing pressures on water resources relevant to "green marketing", this solution ensures a safe water supply, as this source of water is not affected by drought measures that might be imposed in regions with high water scarcity/drought potential.

Illustrations mainly from the United Kingdom and Spain are provided in the following illustration boxes.

Illustration 58

London Coaches (Kent) Ltd (London Coaches (Kent) Ltd)[216]In an industry not commonly associated with environmental friendliness, London Coaches (Kent) Ltd has undergone a gradual, though significant review of its operations to minimise adverse impact on the environment.

Action: London Coaches recently introduced a state-of-the-art cleaning system for coaches, which recycles 80% of the water used.

Benefit: This was initially implemented to comply with restrictions on water consumption; but, as water use increasingly becomes metered, the firm is likely to see savings on its water bills.

211 http://www.rainbird.com/iuow/tips/tip_golf.htm.

212 http://www.8daysaweek.whydoanirrigationaudit.html.

213 http://www.etwater.com/public/market/prop_managers.html.

214 De Dtefano, L. (2004): Freshwater and tourism in the Mediterranean. WWF Mediterranean programme.

215 United States Environmental Protection Agency (EPA) (no year): GreenScapes. Resource Conserving Landscaping – Cost calculator, available at http://www.epa.gov/epaoswer/non-hw/green/tools/landscape.pdf

216 http://www.egeneration.co.uk/centre/services/cs/search.asp.

Illustration 59

Marina Developments Ltd, Marina Developments Ltd (Marina Developments Ltd)[217]Marina Developments Limited (MDL), a marina owner and operator with 18 sites around the UK, have taken measures to improve their water efficiency and quality.

Action: Generally, most of the water usage within a marina is through hose pipes located on pontoons, either when washing vessels or filling water tanks. Hoses are often left on and continue to run even when not in use. Water consumption can be considerably reduced by the installation of water guns on the hoses, which will stop the flow when not in use. The cost of the water guns, around £5 each, is offset against the savings achieved through the reduction in water consumption.

Benefit: The overall water use has been reduced in the last six months, so there is an immediate financial and environmental benefit. The measure is so recent that comparable cost data on water use is not yet available.

Action: The water used in the marinas is supplied on a meter system with the general presumption that 95% of volume is returned to sewer. This is reflected in the level of the water tariff. After careful monitoring, it was found that a considerably lower percentage of this water is actually returned to the sewer, as a substantial proportion is used to fill water tanks or to clean boats.

Benefit: In light of the reduced volume of water being returned to sewers, negotiations with water companies has lead to tariffs being reduced. This resulted in rebates in excess of £50,000.

Illustration 60

Renaissance Reading Hotel (Renaissance Reading Hotel)[218]

Renaissance Reading Hotel has introduced ways to help protect the environment while still achieving targets and standards set by Marriott policy. Environmental issues are embraced fully by the hotel and guided by a Health, Safety and Environmental Committee. Activities focus on saving resources and assisting the local community. Environmental improvement is seen as an ongoing issue, and the hotel is looking to expand environmental initiatives into all areas of its work.

Actions: Cistern ball cocks are adjusted to use 7 litres of water not 9 as standard.

Benefits: A reduction in water consumption through toilet flushing of 22%.

Actions: Economical showerheads that use air to pressurise the water are being used.

Benefits: Water savings.

[217] http://www.egeneration.co.uk/centre/services/cs/search.asp.

[218] http://www.egeneration.co.uk/centre/services/cs/search.asp.

Illustration 61

Saving water at Conference Centre [219]

The Wilton Park Conference Centre that employs 51 to 60 persons expects to save >£8k per year by improving waste management and energy efficiency. It has installed new urinals set to save 511 cubic metres of water each year.

Actions: Have purchased and will be installing five waterless urinals.

Benefits: The new urinals will reduce water use at Wilton Park by 511 m^3 per year. This will amount to an annual cost saving of £378. The urinals cost £1000 to install, which gives a payback period of approximately two and a half years.

Illustration 62

Worthing Guest House[220]

Worthing Guest House saves £300+ by improving energy & water efficiency (St Albans Guest House). Water efficiency measures lead to more than 18 000 litres of water each year being saved.

Action: Installed water saving Hogs into the guest house's toilet cisterns.

Benefit: With an average of around 50 flushes per day, use of the hogs will save around 18 250 litres of water per year.

Illustration 63

Energy and water efficiency at The Beech wood Hall Hotel[221]

Energy efficiency and recycling saves £4 000 per year for the Beech wood Hall Hotel. The Beechwood Hall Hotel is a hotel, bar and restaurant based in Worthing, West Sussex. They became involved in the programme via the Worthing Hospitality Association and have improved their environmental performance, saved money and hosted a Waste Minimisation for the Hospitality Sector workshop.

Actions: The Beechwood Hall Hotel has experimented with water saving 'Hogs' in lavatory cisterns. It plans to apply this to all twenty five toilets in the hotel.

Benefits: Water conservation is an increasingly important issue on the south coast. By installing Hogs into each toilet in the hotel, considerable savings in water consumption can be expected. Each Hog saves one litre of water per flush. Assuming each of the twenty five toilets is flushed an average of five times per day, savings of 125 litres per day (45 625 litres per year) can be expected, providing annual cost savings of £30.

Actions: Drainage water from the hotel roof is collected in a water butt. This is used to water the garden.

Benefits: Apart from financial benefits, The Beechwood Hall Hotel's water butt provides a water supply for the garden when hosepipe use is prohibited.

[219] http://www.egeneration.co.uk/centre/services/cs/search.asp.

[220] http://www.egeneration.co.uk/centre/services/cs/search.asp.

[221] http://www.egeneration.co.uk/centre/services/cs/search.asp.

Illustration 64

Water conservation in the Hotel Gran Rey in Spain[222]

Located in the Canary Island of La Gomera in Spain, the Hotel Gran Rey has a capacity of 198 beds with different swimming pools, conference rooms, a restaurant and a bar as well as a tennis court. It has replaced all traditional fittings and fixtures in the hotel's bathrooms with water saving devices such as dual-flush toilets and flow regulation in showers. Also, it has planted many regional plants adapted to the local climate with lower irrigation water requirements in its gardens. Due to these water saving measures, the hotel has been able to reduce its water consumption by 33% within one year.

Illustration 65

Reducing water consumption in restaurants – the example of the waterless wok stove[223]

Changes in kitchen equipment and appliances can directly impact on water consumption inof restaurants. In Chinese restaurants, for example, the wok stove is central to the kitchen equipment. However, many work stoves used today are not water efficient. Detailed studies have shown that the average daily water use of a work stove is around 5.5 m^3 to 8 m^3 per day Chinese restaurants, which represent the bulk of restaurants using this equipment. Installing a more water efficient wok stove can lead to water savings of 90% or equivalent to 1 800 m^3 per year or savings of up to $4 500 per year. The payback period has been estimated at one year.

Illustration 66

Illustration 9. Saving water in pubs, restaurants and bars[224]

Following an audit of water consumption in the different pubs and restaurants that the Spirit Group owns, a water efficiency improvement plan was implemented, including the repair of underground service pipes, repairs of internal leaks, the replacement or repair of defective water fittings and the installation of new water saving equipments, such as programmable flush controllers or toilet cisterns with reduced capacity. The company is now saving 725 000 m^3 of water per year. The total set-up costs of the improvement plan was £ 800 000 with recurrent costs of £ 50 000 per year. However, the payback period was less than nine months, and the annual savings for the company amount to £ 1.1 Million. This has also helped the company to reduce its energy demand, with an estimated saving in CO2 emissions of 293 tonnes a year.

Illustration 67

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[222] Hamele. H.; Eckardt, S. (2006): Environmental initiatives by European tourism businesses – Instruments, indicators and practical examples. ECOTRANS, Germany.

[223] http://www.sydneywater.com.au.

[224] http://www.egeneration.co.uk/centre/services/cs/search.asp.

Water conservation at the Malvern Hotel & the Blues Grill (UK)[225]

In addition to implementing many water saving measures aimed at reducing water consumption by residents, the Malvern Hotel & Blues Grill located in the South-East of England decided to make hotel consumers aware of the water supply problem in the region as a response to the regional water shortage in July 2005. They developed a small booklet asking consumers to help conserve water by reusing towels, have less frequent change of linen and make small changes, including not overfilling kettles and turning off taps while brushing teeth. For an investment of just £16 and a yearly expense of £ 15 to update guest bedrooms with new booklets, savings on metered water, energy and laundry products ad up to more than £ 840 a year.

Illustration 68

Use of treated wastewater effluent for irrigating golf courses in Spain[226]

As of 1997, there are 28 golf courses along the Costa del Sol in Spain, with additional golf courses expected to be constructed in the future. The average water used for irrigation of a golf course in this region is around 350 000 m^3/day. During peak times (especially during the high tourism season in the summer months), irrigation consumption can be as much as 1 500-2 400 m^3/day, depending on the grass variety and soils. In order to offset this high volume of water use, golf courses in the area began using treated wastewater effluent as early as 1989. In 1993, local authorities established a plan to ensure that every golf course in the area would use treated wastewater effluent for irrigation purposes. The plan aimed at using 14 Million m^3 of treated effluent per year. As of 1997, 70% of the golf courses in the area were already using treated wastewater effluent.

Illustration 69

Sustainable Golf Club management in the United Kingdom[227]

The High Post Golf Club located close to Salisbury (Wiltshire) has been involved for many years in sustainable golf course management with particular focus on reducing water consumption through spray irrigation and increasing the use of drought resistant grasses on the golf course. It has increased the use of fine bents and fescue grasses, which today cover 30% of the greens; the target is a 75% coverage. As these grass varieties are more drought resistant, they need less water. In addition, the club has introduced a £ 7 000 closed loop washdown system to clean machinery. This has led to water savings of 200 m^3 per year. More efficient hydrojets have also been installed to inject water at high-pressure below the surface of the grass and reduce evaporation as compared to spray irrigation. On the areas of the greens most in need of water, staff are irrigating with trickle irrigation carried out by hand and metered hoses. This is a labour intensive way of watering that has required increases in greenkeepers at a cost of £ 14 000 a year. Overall, through careful planning, the club has reduced its water abstraction by nearly half, from 6 138 m^3 per year in 2003 to around 3 261 m^3 in 2005.

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[225] http://www.environment-agency.gov.uk/subjects/waterres/.

[226] European Environment Agency (EEA) (2001). Sustainable water use in Europe. Part 2: Demand Management. EEA, Copenhagen.

[227] http://www.environment-agency.gov.uk/subjects/waterres/.

Illustration 70

Converting to Xeriscape for maximum water savings[228]

The City of Mesa is promoting the use of Xeriscape (from the Greek word xeros meaning "dry" and defined as creative landscaping for water and energy efficiency) as replacement to normal grasses that have higher crop water requirements. Xeriscape is a a combination of rocks and cactus and can include hundreds of low water use plants that can also attract wildlife and decorate the landscape the year round with different colours. Changing to Xeriscape clearly requires labour and efforts to remove the older grass and install Xeriscape. Potential water savings are expected to be high. Indeed, 35 000 gallons per year are required to properly water 1 000 square feet of turf, while low water use plants use only 15 000 gallons per year for the same amount of space – equivalent to a reduction by 57% in total water consumption. It is important to stress that maintenance of the land is also reduced with the new plant species, reducing labour requirements in the longer-term.

Illustration 71

Water saving in the Calvía tourist resort in the Balearic Islands (Spain)[229]

Calvià is the most important tourist municipality of the Balearic Islands (Spain). With 60 km of Mediterranean Sea coastline, it welcomes more than 1.2 Million tourists a year, with a residential population of 50 000 inhabitants. In 1995, the municipality of Calvià decided to implement Local Agenda 21, including actions for a wise use of freshwater. It set the target toconsume the amount of water it was consuming in 1997 (i.e. 10 Million m^3) by 2007. The achievement of the new water consumption goal required:

- A 7% and 10% reduction in water consumption per capita by 2001 (121 l/capita/day) and 2007, (117 l/capita/ day) respectively.
- A reduction by 10% and 15% of the water consumed per tourists by 2001 (141 l/ tourist/day) and 2007 (134 l/ tourist/day), respectively.
- Recycling of urban water to cover up to 8% of total water demand by 2001 and 11% by 2007.

The Municipality of Calvià has implemented a number of measures, for example improvement of the distribution network, production and distribution of treated effluent for reuse, installation of individual water meters and the creation of the Blue Brigades Programme. The Blue Brigades are two person teams (5 teams in 2001) that visit homes to inform citizens and tourists about opportunities for saving water, make demonstrations and install free water saving systems in taps, showers and toilets. The Blue Brigades work in the summer only when the tourist season is at its peak. Between 1999 and 2001, they installed 5,000 water saving devices free of costs.

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[228] http://www.cityofmesa.org/utilities/conservation/convert-to-xeriscape.htm.

[229] http://www.calvia.com.

Illustration 72

Water saving at Grecotel (Greece)[230]

Grecotel is one of the leading resort groups in Greece. Since the early 1990s, the company established an environmental department with water saving being a major aspect covered by their environmental policy. Specific water saving measures that were implemented between 1994 and 2001 included towels changed on guest's request, replacement of new technology washers, low flow water taps and toilet cisterns, wastewater reuse... Also, significant personal training was provided. Overall, a 30% reduction in total water consumption was recorded as a result of the implementation of these different water saving actions.

Illustration 73

Water saving in the Porto Carras Grand Resort, Halkidiki Peninsula (Greece)[231]

The Porto Carras resort covers an area of around 1 760 hectares including verdant forests, hills, vineyards and beaches. It includes hotels, villas, a marina, convention facilities and a golf course. It has built its own desalination and wastewater treatment facilities. Water demand is at its peak during the month of August with 1 500 to 1 700 m^3/day. A very wide range of water saving measures has been put in place in the resort. All the water comes from the desalination plant, the golf course being irrigated with treated effluent from the wastewater treatment facility. Water use scheduling is implemented and regularly revised to minimize peak demand. In total, 1 400 dual flush toilets have been installed in the resort and a towel and linen reuse program is implemented. Irrigation is happening during night time to reduce evaporation losses (30-35% is lost due to evaporation if irrigation is occurring daytime) and regular checks are made for leaks. In the marina, water guns have been installed in the hoses to stop flow when not in use. Because of evaporation from pools and lagoons that cover around 3 000 m^2, sea water is used to maintain their water level (evaporation during the summer period can be as high as 200 m^3 per day). And the golf course has been planted with paspallum on the 77 hectares of golf courses as this grass is saline tolerant (can be irrigated with treated effluent) and can tolerate high stress environments. Additionally it requires 50% less fertilizers than other grass varieties. The water used to irrigate the golf course comes from the on-site wastewater treatment plant, were it is directed to retention ponds of 36 000 m^3 capacity before it is used for irrigation. Water demand for the golf course is about 1 000 m^3 /day during the peak season that is entirely covered by treated effluent.

5.5.4 In summary

The following table summarises the main elements characterising the different water saving measures that have been identified for the tourism sector, saving potential information and data collected for this sector. Cost information for devices already described in the household sector are not repeated here. Although the information collected is incomplete and pertains to different levels of intervention (a given measure, a range of measures or sub-sectors), some general conclusions can be drawn:

- Total water savings for the different sub-sectors (camping sites, bed and breakfast, hotels) are between 30 and 50% when looking at these different sub-sectors in their entity. This would imply implementing a range of water saving measures in each sub-sector.

[230] http://http://www.ellinikietairia.gr/articles; http://www.grecotel.com.

[231] http://www.portocarras.gr/home.htm.

- Savings for individual measures can be as high as 80% to 90%; thus, identifying areas where such savings can take place is a priority.
- Savings in outdoor uses, which often represents a large share of the total uses of the hotel industry, can be around 50-60%. This estimate is conservative, as savings as high as 75% are found in various literature.
- Significant savings in water bills can be expected, in some cases combined with savings in energy bills when reduced water demand leads to reduced abstraction costs and reduced water heating costs.
- Payback periods are very short, always equal or lower to 3 years when reported. This would stress the significant advantages in installing water saving devices in the tourism sector.

Table 36: Overview of measures for tourism water savings and their impacts.

Sub-sector	Specific measures	Expected water savings in% (quantities in brackets)	Country	Costs	Benefits	Pay-back period (in years)	Reference
Camping site	Overall	10 to 20%	France (Loire-Bretagne)	-	-	-	Office International de l'Eau (2005)
	Overall	45%	Europe	-	-	-	Hamele and Eckhardt (2006)
Bed & Breakfast	Overall	52%	Europe	-		-	Hamele and Eckhardt (2006)
	Metering	10 to 25%	Europe	-	-	-	Lallana, 2001
	Improved toilet flushing	- (18 000 l of water saved per year for 50 flushes per day)	UK	-	£ 300 saved per annum (reduced energy and water bills)	-	http://www.egeneration.co.uk/
Holiday houses	Information & awareness raising, installation of (free) water saving devices in houses, reuse of treated effluent	15% for tourists (consumption reduced to 134 l/tourist/day)	Balearic Islands (Spain)	-	-	-	http://www.calvia.com
Hotels	Overall	10 to 20%	France (Loire-Bretagne)	-	-	-	Office International de l'Eau (2005)
	Overall	14% to 37%	France	-	-	-	Office International de l'Eau (2005)
	Water saving devices in toilets and showers	7%	United Kingdom	-	400 € per year (reduction in water bill)	-	ADEME (2007)
	Overall	32% (from 330 l/night to 224 l/night)	France	-	-	-	Own calculation based on Office International de l'Eau (2005) and ADEME (2007)
	Overall	46%	Europe	-	-	-	Hamele and Eckhardt (2006)
	Cistern ball cocks in toilet flushes	22%	UK	-	-	-	http://www.egeneration.co.uk/
	Improved toilet flushing	- (45 625 l per year for 100 toilet flushes per day)	UK	-	-	-	http://www.egeneration.co.uk/

Sub-sector	Specific measures	Expected water savings in% (quantities in brackets)	Country	Costs	Benefits	Pay-back period (in years)	Reference
	Water saving for appliances in rooms + plantation of local low water consuming plants	33%	Spain	-	-	-	Hamele and Eckhardt (2006)
	Raising awareness of hotel consumers	-	UK	Initial cost: £ 16 per room, Then £ 15 per year	£ 840 per year (reduction in water bill)	0.1	http://www.egeneration.co.uk/
	towels changed on guest's request, replacement of new technology washers, low flow water taps and toilet cisterns, wastewater reuse, training	31%	Greece	-	-	-	www.ellinikietairia.gr/articles & www.grecotel.com
	Comprehensive package of measures implemented	100% for maintaining pond water levels (seawater) & golf course irrigation (treated effluent)	Greece	-	-	-	http://www.portocarras.gr/home.htm
Restaurants & cafés	Cafés	70%	Europe	-	-	-	Hamele and Eckhardt (2006)
	Water saving measures in kitchen	30%	Europe	-	-	-	Hamele and Eckhardt (2006)
	Installation of waterless woks in Chinese restaurants	90% (1 800 m^3 per year per restaurant)	Australia	-	$ 4 500 per year (reduced water and energy bill)	1	http://www.sydneywater.com.au/
	Leak repairs, water saving toilet flushing & toilet cisterns	- (725 000 m^3 per year)	UK	Investments at £ 800 000, Recurring Costs at £ 50 000 per year	£ 1.1 Million per year	0.75	http://www.egeneration.co.uk/
Touristic infrastructure	Reduce leakage in stadium	78%	France	-	26 250 €/year (reduced water bill)	3	IME (2002), own calculation
	Water recycling in swimming pool	- (7 140 m^3 per year)	France	-	15 778 €/year (reduced water bill)	1.75	IME (2002), own calculation
	Flow regulation in swimming pool	28%	France	-	2 520 €/year (reduced water bill)	0.1	IME (2002), own calculation

Sub-sector	Specific measures	Expected water savings in% (quantities in brackets)	Country	Costs	Benefits	Pay-back period (in years)	Reference
	Optimum network closure for fountains	- (2 468 m^3 per year)	France	-	5 183 €/year (reduced water bill)	2	IME (2002), own calculation
	States of the art cleaning of buses	80%	UK	-	Reduction in water bill expected	-	http://www.egeneration.co.uk/
	Waterless urinals at conference center	- (511 m^3 per year)	UK	£ 1 000 per urinal => 5 000 £	£ 378 saved per year (reduced water bill)	2.5	
Outdoor uses	Drip irrigation for green spaces	62%	France	-	5 242 €/year (reduced water bill)	1	IME (2002), own calculation
	Water auditing, irrigation scheduling, shift to drip irrigation	From 30% to 76%	United States, Australia	-	-	-	Different sources presented in this report
	Change of grasses to water saving species	70%	UK	-	-	3	http://www.egeneration.co.uk/
	Range of measures including shift to low water consuming grasses	50% (2 870 m^3 per year)	UK	£ 7 000 (washdown system) + £ 14 000 per year (additional labour)	Expected saving in water bill	-	http://www.environment-agency.gov.uk/subjects/waterres/
	Conversion to Xeriscape	57%	US	Labour costs to be considered	Reduced water bill, reduced maintenance costs of gardens and public areas	-	http://www.cityofmesa.org/utilities/conservation/convert-to-xeriscape.htm

6 Horizontal issues - non technical water saving measures

6.1 Water pricing

6.1.1 General issues

Economic instruments for water demand management are promoted for various purposes. They can be used to provide financial resources to cover the costs of providing water; to promote an economically efficient allocation of water by moving water from lower to higher value uses; and to foster conservation and innovation. Last but not least they can provide signals to induce behavioural changes, changes in production patterns or the application of more efficient (water saving) techniques. The metering of water consumption is, however, a prerequisite for the application of efficient water pricing policies.

Economic instruments for environmental management can be classified according to the principal objectives they aim to fulfil. In the following, the main functions of economic instruments are classified based on a basic typology[232]:

- Incentive-based instruments with the primary purpose to create necessary incentives for behavioural changes
- Instruments with a fiscal and financial function aimed at raising revenues. A distinction has to be made between cases where the revenue is earmarked or simply added to the general government budget. If the purpose of a tax is merely to increase financial resources for the national budget, the economic instrument can be categorised as a fiscal environmental tax. A charge or tax fulfils a financing function if the revenue is earmarked and allocated to specific water-related actions or projects.
- Economic instruments can also have side results, such as awareness raising (ensuring users are aware of the value of water resources), capacity building and incentives in the implementation of (technical) measures.

With respect to water saving, the incentive function of water pricing is the main attribute of interest. Thus, the present section focuses on how pricing might foster the application of new technologies or induce changes in behaviour and production patterns in different sectors.

6.1.2 Water pricing in Europe

Water pricing and access to water resources have been issues in water management for several decades, even centuries in Europe, especially in water scarce areas. Consequently, a variety of approaches and solutions have been developed to reflect the

[232] Kraemer, R., A; Pielen, B.; Leipprand, A. (2003): Economic Instruments for Water Management: Extra-regional experiences and their applicability in Latin America and the Caribbean, In Economic Instruments for Water Management: Experiences from Europe and Implications for Latin America and the Caribbean.

diversity of local scarcity and pollution conditions as well as legal, administrative and socio-economic set ups (e.g. in terms of water rights, water management structure, market structure for water supply companies, etc.). In southern Europe, for example, although agriculture is the main water consumer, it pays a low preferential rates, which provide little incentive to save water, resulting from historical, cultural and socio-economic reasons[233]. Table 37 summarises water pricing and taxes related to water management for different European countries. The following sections of this chapter go into more details regarding economic instruments and water pricing for the main water users/economic sectors relevant to water saving.

[233] European Commission (2000): Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee: Pricing policies for enhancing the sustainability of water resources. COM (2000) 477 final. July 26. available at http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/com/2000/com2000_0477en01.pdf.

Table 37: Water Pricing systems[234]

Country	Year	Type	Level	Payer	Nature	Comments
Austria		Drinking water charge	Local administration		On a volumetric basis	
		Waste- water fee	Local administration			
		No pollution charges				For discharging into natural waters
		No resource costs to any user for taking surface- or groundwater		Any user		
		Sewerage and waste water charges	Local administration	User	Charges reflect the full capital and operational cost to the municipality of providing the water services	There is no nationally uniform method that occurs before charges (i.e. Salzburg charges are related to the area of the dwelling, hotels are charged per bed, restaurants per seat)
Belgium	1994, 1996	Abstraction charge	Flanders, Wallonia		BEF 3/m^3 for groundwater, for drinking water (passed on to consumers at BEF 4/m^3 to cover losses), for other purposes when abstraction > 100 000 m^3	
		Waste- water charge	Water companies, three regions		For households, based on water consumption (Brussels: BEF 14/m^3, Wallonia: BEF 16/m^3, Flanders: BEF 25/m^3). Industrial discharges pay per m^3 of effluent discharged, at a rate that varies with the pollution content	Used in all three regions to finance the construction of water treatment infrastructure

234 European Environment Agency (EEA) (2001): No 19 Environmental issue report, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

		Drinking water charge	Water companies, three regions	User		Flanders: price is a fixed charge, a zero charge for the first 15 m/person in the household and a volumetric charge ofBEF35-38/m^3(1997)
Finland	1995	Drinking Water charge Wastewater charge	Municipality	User	FM 4.94/m^3 (average)	The average annual investment in public water supply and sewage collection in the early 1990s was about FM 1.8 billion
			Municipality	User	FM7.84/m^3 (average)	The wastewater fee is directly connected to the water use even if the fee is a separate one
France	1964	Pollution levy	Water agencies	Municipality, industry	On measured or estimated quantity of substances discharged (decided by the Basin Committee)	Revenue: FRF 9.4 billion (1995), redistributed to industries, regional authorities and farmers
		Withdrawal levy	Water agencies	User	On net and raw volume withdrawn	
		Taxes on water used	State	User	On volume used	FRF 833 Million (1992) for FNDAE (Fonds National pour le Developpement des Adductions d'Eau, Ministere d'Agriculture et la Peche)
Germany	Differ ent	Groundwater abstraction charge	Federal states (Lander)	Public water works and industry	Volumetric basis PEM 0.03-1. 1/m^3)	There are big differences between charges in the federal states. Some states have not introduced these charges. A high amount of the charges is used for water protection measures
		Surface water abstraction charges	Federal states (Lander)	Every user	Volumetric basis PEM 0.01-0.07/m^3)	
		Wastewater charge	State: the charge shall belevied by the federal states (Lander)	Municipalities, industry (discharger)	The charge is based on the concentration of certain pollutants and on toxic units (noxious substances and groups of noxious substances	The charges increased in several steps (from 1981) up to DEM 70/unit (1997). They have to be used for water protection measures
Greece		Wastewater charge with sanitation fee	Local water and sewerage company	House hold	Based on volume in big properties or contractual price	Insufficient to finance wastewater treatment, cover operation costs in big towns

		Drinking water charges	Private water supply companies	User		Price rose from HUF 0.6 (1980) to HUF70 (1998)
Hungary						
		Water and sewerage charges				
		Waste- water tax	Local water company	User	On volume and water quality	Partially finance the collection and treatment
Italy		Tax on polluted discharges into the environment	Local water company	Polluting firm	On quantity of pollutants, weight	Partially finance the compensation of damages
Malta		Sanitation fee	Local administration		Based on volume	To cover the sanitation and treatment systems for wastewaters
Portugal		Drinking water charge				
	1995	Drinking water charge	Regional and local services	User	Different, depending of the regions and sectors	
Slovenia	1995	Water pollution fees	Municipalities		Based on quality and quantity of discharges. The tax is proportional to the pollution loads of the waste water	To cover investment and operating costs for technology and reducing pollution loads of effluents to permitted levels
		General tax for water pollution	State			A company offering a sanitation plan to reduce polluting discharges maybe exempted from the tax if it spends the money on the proposed activities
		Water pollution fee on discharges into rivers	Central	Municipality, industry	On polluting substances and tariff units for permit holders	Expected 1992 revenue: ESP 5.9 billion but collection is limited (42%)
		Wastewater charges	Regional (eight regions)	Municipality, industry	Based on estimated discharges into the natural waters	To cover wastewater treatment
Spain		Municipal sewage service charge	Household, industry		Charges may take into account pollutant concentrations, but are often based on volume only for both households and industry	To cover sewage and wastewater treatment
		Drinking water charge	Local water company	User	Charges per m^3 in a two-tier pricing system that covers pumping and treatment costs and part of capital costs	
Sweden		Tax for collection and treatment of	Local administration	User, industry		

wastewater

6.1.3 The role of economic instruments in reducing agricultural water abstraction

This section reviews current water pricing systems and rates in Europe, with specific focus on price elasticity of demand, which is relevant to the incentive power of water pricing. There are various means to charge water in agriculture. In some countries, it is understood that the distribution of water should not be charged. In other countries, water fees are applied to users using irrigation water. Water pricing mechanisms can account for water consumption (i.e. a fixed unitary rate is applied to each cubic meter of water used to calculate the total water bill). Water tariffs can also be based on the irrigated (or irrigable) area independently of the volumes of water used. In some cases, different rates can be applied to different crops (usually based on differences in crop water requirements between crops). Table 38 presents a typology of water pricing structures as identified by the OECD.

Table 38: Typology of structures of agricultural water tariff[235]

Water Pricing Method	Description
Pricing method by land area	Fee structure based on irrigated area. There are also cases in which fees are segmented by the crops that are irrigated, irrigation method or season.
Metered pricing method	A method in which usage volume or time is calculated and fees are charged accordingly.
Dual pricing method	Pricing method in which usage fee are charged by annual fixed facilities expenses and unit water usage.
Pricing method by use	A different pricing method applied for different uses. This is also known as block rate pricing.
Improved charged pricing method	Pricing method fees levied against agricultural land based on the increase in land value to the supply of irrigation water.
Incentive metered pricing method	Pricing method in which extra fees are charged for exceeding a given volume of water and incentives are provided for conserving a given volume
Passive water intake method	Pricing method in which pricing is proposed that permits a balance in overall water supply and demand in an irrigation district, and farming families use the water freely according to their needs. Average pricing per unit is charged for the total water usage rights per family and, if water is conserved, rebates are paid.
Water market pricing method	Pricing method in which pricing is set by voluntary payments for marginal water volume units of farming families.

6.1.3.1 Agricultural water pricing systems in Europe

Among the different water pricing mechanisms presented in Table 38, the most common one in Europe is the two part tariff (combining a flat rate and a unitary volumetric rate) and the tariff based on the irrigated area. There are, however, many experiments to apply more complex volumetric pricing system. Water pricing is often coupled with other water management instruments, e.g. quotas like in Italy, France, Spain, UK (see Table 39).

Table 39: Diversity of water pricing system in agriculture and associated economic instruments[236].

[235] OECD (1999): Agriculture Water Pricing in OECD Countries – Working Party on Economics and Environmental Policy Integration – 1999)

Country	Water rights	Water pricing	Other economic instruments
Austria	GW: licensed	Irrigation: GW free of charge.Livestock: from PWS at household rates.	
Belgium	SW: user rights	Agricultural water from PWS at household rates, from GW and SW a levy on declared volumes (from 1998).	Pollution charges
France	SW: user rights	Charges have a catchment component and a consumption component. The prices are established by the regional development companies.	Quotas depending on water availability
Germany	SW: user rights GW: licensed	Water prices are the responsibility of the Länder. Water tax (from 1998).	Tax exemptions for farmers
Greece	SW: user rights GW: licensed	Pricing from agreements between local land improvement boards and private suppliers. Water fees, in general, are dependent on extraction costs.	Agricultural policies; rural development policies
Italy	SW: licensed	Irrigation boards are responsible for irrigation projects.	Quotas; progressive pricing in the south
Netherlands	SW: user rights GW: licensed	Water control boards (66 in total) are in charge of water management; the costs are covered by water users. Farmers pay the full supply cost and the full drainage cost.	Pollution levies and flood control levies
Portugal	SW: public and private rights	Agricultural water prices are levied by user associations. From 1999, all licensed water has been subject to a water levy, depending on the amount of water used, returns generated by each type of user, and the region's relative scarcity of water.	Agricultural policies; rural development policies
Spain	SW: user rights GW: licensed	The irrigation water price has two components: the regulation levy (to cover capital investments for water works) and a tariff to cover the operational and maintenance cost of storage and transportation. The river basin agencies and the irrigation districts are in charge of the prices.	Quotas; occasional markets
Sweden	GW: permits when shortage of water in given regions (10 % of irrigation farmers)	Water for irrigation can be abstracted freely by farmers.	
UK	SW: licensed GW: licensed	National river authorities and water companies are in charge of water pricing. Only direct abstractions for spray irrigation require an abstraction licence. Licences are based on volume, nature of water resource, season in which abstraction is allowed and on the water returned directly to water resources; 25-50 % of the annual charge is based on actual recorded consumption. Where mains are used for agriculture, the tariff is fixed by the official regulator (OFWAT).	Quotas

NB: SW: surface water, GW: groundwater, PWS: public water supply.

The following table presents in more details current water pricing policies in the agriculture sector applied in different European countries.

[236] European Environment Agency (EEA) (2001): No 19 Environmental issue report, Sustainable water use in Europe - Part 2: Demand management, EEA, Copenhagen.

Table 40: Irrigation water charges in several European countries.[237]

Country	Pricing agency	Water supply fee/rate	Environmental water tax	Discharge levy/ Pollution tax	Costs subsidized?	Reference
Belgium	Regional governments	Volumetric, depending on source Same as urban users	n.a.	n.a.	n.a.	Nys, 1998; OEDC, 1997
Bulgaria	Irrigation companies and irrigation districts	Water abstraction fee Water use fee: Fixed (up to 5.00 €/ha) or volumetric (0.007-0.075€/m^3)	n.a.	n.a.	Part of O&M	OKO, 2001
Croatia	Government agencies	Volumetric, based on water quality Use fee: 0.01-0.04 €/m^3; Protection fee: 0.12 €/m^3.	Yes	Yes	Heavily, for O&M maintenance	Ostojic and Luksic, 2001
Czech Republic	Government privatization process	n.a.	n.a.	n.a.	O&M, until privatized	Raskin et al. 1996; OEDC, 1999
Denmark	Government	€0.55/m^3			Rate can be deduct from tax proceeds	OEDC, 1997
France	Basin agencies	Binomial (average 0.08.- 0.390 €/m^3) Catchment and consumption components	n.a.	For livestock	Yes	Duchein, 1997; Montginoul, 1998; OEDC, 2002
Germany	Landers	n.a.	Yes		Tax rebates	IISD, 1998
Greece	Governmental agencies	Volumetric in Crete: (42.00-€196.00/ha)	No	No	60% of total supply costs	Lekakis, 1998
Hungary	Basin authorities and users associations	Basin abstraction fee and water fee: Fixed (5.00-36.00 €/ha) or volumetric (0.004-0.034 €/m^3)	No	n.a.	Part of O&M	OKO, 2001
Italy	Public agencies	Concession fees and water rates (Flat, binomial and increasing block rates)	No	No	Part of capital costs	Destro, 1997; Xiloyannis and Dichio, 2001
Netherlands	Water control boards	Abstraction tax 1.04 €/m^3	Yes	Yes	None	OEDC, 1997

[237] Berbel, J Garrido A.; Calatrava, J. (2007): “Water pricing and irrigation: a review of the European Experience” in Molle, F.; Berkoff, J.J.; Barker, R. (eds) (2007 forthcoming): Irrigation Water pricing Policy in Context: exploring the Gap between Theory and Practice. Wallingford, UK.

Portugal	Public and private suppliers	Two-tier rate: Fixed: 12.00-211.00 €/ ha; Vol: 0. 012€/m^3	No	If applicable	O&M and part of capital	Castro, 1997; Bragança, 1998
Romania	Central government	0.4€/1000 m^3 for all regions	n.a.	n.a.	Part of supply costs Electricity costs	OKO, 2001
Slovakia	Basin authorities	Prices negotiated: Maximum at 0.046€m^3 and average at 0.031€/m^3 regardless of use	n.a.	n.a.	Part of supply and of irrigation costs	OKO, 2001
Spain	Basin authority and irrigation districts	Collected by district/users. Fixed, volumetric or both. Covers supply and district costs	No	No	O&M and part of capital	MAPA, 2001
Sweden	n.a.	Private abstraction costs	Yes	n.a.	None	Bergvall, 1998
Switzerland	Regional agencies	Yes	n.a.	Yes	None. Total prices: 0.025-1.56€/m^3	Siegrist, 1998
UK	Regions	Water abstraction fee: 0.08-0.023€/m^3	Yes	Including supply fee	None	OEDC, 1997; Knox and Weatherhead, 2003

6.1.3.2 *Lessons learned from current applications of water pricing*

The implementation of an effective pricing program is quite complex and requires consideration of physical modernisation, fee structure, enforcement procedures and the level of water delivery service. To increase the incentive power of water pricing and potential water saving in the agricultural sector, future water pricing systems can built on lessons learned from past and current practices. These are specified below:

- Per hectare water charges versus volumetric pricing: The efficiency of an irrigation system not only depends on its technical performance but also on the design of water tariffs. Rodríguez Díaz JA (2004)[238] show that irrigation districts with volumetric (i.e. two-apart tariff) systems in the Guadalquivir basin consume on average 10 to 20% less than irrigation districts with flat rate pricing, regardless of the level of the variable rate. Tsur and Dinar (1997)[239] compared the performance of volumetric pricing with per area pricing when implementation costs (of volumetric pricing) are proportional to water. Work done by Tsur and Dinar (1997) illustrate the efficiency gains will justify the costs of restructuring tariffs only when volumetric billing cost are lower than 7.5% of Agency water revenue.

  The comparison of water use levels of irrigators using surface water with those of farmers relying on groundwater also provides an indication of potential effects of flat rates. Hernández and Llamas (2001)[240] show that groundwater users who pay the full financial costs of abstractions that vary according to the volume abstracted tend to use between 25% to 35% less water than surface water users paying a flat land-based rate for irrigation water do. As it will be argued below, there are numerous obstacles that can hinder progress in replacing flat rates with volumetric rates. Among them is the fact that it may not be efficient to do so under a broad range of realistic situations. Tsur and Dinar (1997)[241] compared the performance of volumetric pricing with per area pricing when implementation costs (of volumetric pricing) are proportional to water. Work done by Tsur and Dinar (1997) illustrate the efficiency gains will justify the costs of restructuring tariffs only when volumetric billing cost are lower than 7.5% of Agency water

  Another relevant obstacle is the lack of appropriate water-metering devices in many European irrigation districts. However, this is changing rapidly in many countries, partly as a result of promotion campaigns led by governments and combining information and financial support. In the Adour-Garonne river basin in the south of France, for example, the number of water meters has drastically increased since the mid-1990s due to financial support from the water agency. As indicated in Figure 27 below, water metering was implemented for around 30% of total volumes abstracted by the agriculture sector in 1997 *versus* 94% of volumes metered in 2005[242], as indicated in Figure 27 below.

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[238] Rodríguez Díaz, JA. (2004): Estudio de la gestión del agua de riego y aplicación de las técnicas de benchmarking a las zonas regables de Andalucía. PhD Thesis. University of Córdoba. Spain

[239] Tsur, Y.; Dinar, A. (1997): The Relative Efficiency and Implementation Costs of Alternative Methods for Pricing Irrigation Water. The World Bank Economic Review 11, 2, 243-62.

[240] Hernández, N.; Llamas, M.R. (ed.) (2001): ‘La economía del agua subterránea y su gestión colectiva. Fundación Marcelino Botín y Ediciones Mundi-Prensa, Madrid, Spain.

[241] Tsur, Y.; Dinar, A. (1997): The Relative Efficiency and Implementation Costs of Alternative Methods for Pricing Irrigation Water. The World Bank Economic Review 11, 2, 243-62.

[242] http://www.eau-adour-garonne.fr/.

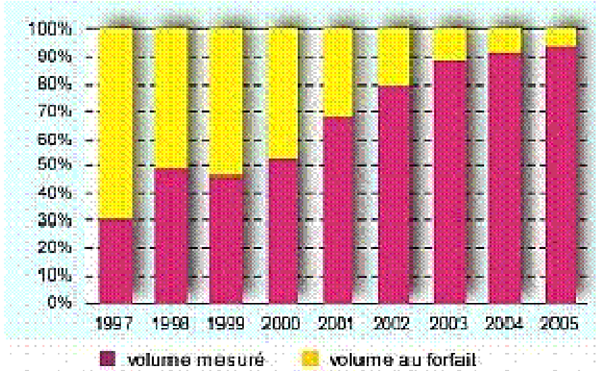

Figure 27: Percentage of metered volumes for the agriculture sector in the Adour-Garonne basin[243]

- Price (In-)elasticity of water demand: Increases in water prices will not always provide the right incentive for users to enhance water use efficiency. This is the case, for example, when water price elasticity of demand is close to zero, which can occur when the total water bill accounts for only a small proportion of farmers' total production costs or income; when alternatives crops or irrigation practices are not available due to technical, social or economic constraints; or when the bulk of total water charges consists of fixed costs.

As suggested by García (2002)[244], the price elasticity of demand will depend on three factors: a) the elasticity of substitution of water for other inputs, b) the price elasticity of demand for the good being produced and c) the share of irrigators' water costs in total production costs. If technology is fixed, water rights are not tradable and water allotments are fixed by water authorities in the form of entitlements or quotas. In such a case, water demand is likely to be inelastic.

Recent work by García (2002)[245] to explain water use differences across irrigation districts in the Valencia region showed that water use variability is largely explained by three factors, namely the type of institutional arrangement, the origin of the water used and the type of pricing scheme. Results of the econometric analysis, presented in Table 41 below, suggest that traditional districts supported by state projects combined with 'two-part tariff systems' exhibit the lowest consumption levels. Lastly, flat rates are directly associated with larger consumption, although causality is not properly established.

Bontemps *et al.* (2003)[246] show that water demand in southern France is inelastic for low available volumes and depends crucially on weather conditions. Rieu (2005)[247]

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243 http://www.eau-adour-garonne.fr/.

244 García, M. (2002): Análisis de la influencia de los costes en el consumo de agua en la agricultura valenciana. Caracterización de las entidades asociativas para riego. Tesis doctoral. Departamento de Economía y Ciencias Sociales. Universidad Politécnica de Valencia, Valencia.

245 García, M. (2002): Análisis de la influencia de los costes en el consumo de agua en la agricultura valenciana. Caracterización de las entidades asociativas para riego. Tesis doctoral. Departamento de Economía y Ciencias Sociales. Universidad Politécnica de Valencia, Valencia.

246 Bontemps, C.; Couture, S.; Favard P. (2003): 'Estimation de la demande en eau d'irrigation sous incertitude. (Irrigation Water Demand Estimation. With English summary).' Economie Rurale July-Aug:17-24.

247 Rieu, T. (2005): Water pricing for agriculture between cost recovery and water conservation: Where do we stand in France? OEDC Workshop on Agriculture and Water: Sustainability, Markets and Policies 14-18 November, 2005. Oral presentation. Adelaide, South Australia.

shows that although demand in Charente is elastic, local authorities have established quotas to limit potential negative effects on farm income that would result from increases in water charges. Overall, water charge policies in France seem to be driven primarily by cost recovery objectives and by the need to balance the budget of the water agencies, although this is achieved by a great variety of pricing mechanisms[248].

Dono and Severini (2001)[249] add further evidence from southern Italy to the inelasticity hypothesis. They suggest that water demand turns increasingly inelastic as water charges increase, as the crops that may be able to pay higher prices are mainly high-value vegetables and fruits, which can support high water price increases.

Finally, Massarutto (2003)[250] concludes that the demand inelasticity hypothesis should be framed in relation to the concept of 'exit price.' He claims that the effects on water demand are due to the fact that if water prices are below the exit threshold, they result in demand reductions caused by marginal adaptation of irrigation demand to price variations. Water demand elasticity is always very small, especially once the most obvious water saving techniques have already been implemented. Above the exit price, water demand is brought to zero because farmers do not cover input costs anymore and are better-off not using water.

It is often assumed that increases in water prices will lead to shifts to crops with the lowest water requirements or changes to extensive field crops. In the Duero region in Spain, as number of crops is limited, Gomez-Limon, Gutierrez and Berbel (2007)[251] show that a water price increase does not lead to significant decrease in water consumption. Spanish farmers' income could decrease by 25 to 40% before price increases have any impact on water consumption. In irrigation systems with already high water use efficiency, water demand elasticity is also expected to be low. Finally, for crops with relatively low weight of water cost compared to other inputs (e.g. fertilizer, pesticides), or crops with high added value, there are few incentives for farmer to decrease water consumption. Price elasticity of demand is expected to be low under such conditions.

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[248] Rieu, T. (2005): Water pricing for agriculture between cost recovery and water conservation: Where do we stand in France? OEDC Workshop on Agriculture and Water: Sustainability, Markets and Policies 14-18 November, 2005. Oral presentation. Adelaide, South Australia.

[249] Dono, G.; Severini, S. (2001): The Agenda 2000 CAP Reform and Its Impact on Irrigation Water Use: A Regional Programming Model for a Central Horticultural Area. Transnational Workshop on Managing Water in Agriculture through Pricing: Research Issues and Lessons Learned. CNR-ISPAIM, Ercolano, Italy, 24-26 May.

[250] Massarutto, A. (2003): Water pricing and irrigation water demand: efficiency vs. sustainability. European Environment 13/2003, 100-119.

[251] Gómez-Limón, J.A; Berbel, J.; Gutiérrez. C. (2007): "La Multifuncionalidad del regadío: Una Aproximacion empirica". Working paper.

Table 41: Differences in water consumption among irrigation districts in the Valencia region[252]

Type of organization and water type (S = surface water; G= groundwater)	Type of water rates			
	Two-part rate based on n°. of hours	*Two-part rate based on n°. of applications*	*Flat rates*	*Variable rate based on n°. of hours*
Traditional districts supported by state projects (S)	(-,-)	(-,+)	(-,+)	(-,-)
Traditional districts (S&G)	(+,-)	(+,+)	(+,+)	(+,-)
State projects (S&G)	(+,-)	(+,+)	(+,+)	(+,-)
Private associations (G)	(+,-)	(+,+)	(+,+)	(+,-)

Note: "+" = higher water consumption
"-" = means less consumption

It is important to stress the importance of possible side effects to water price increases. For example, price increases combined with increases in distribution efficiency can lead to increased total water consumption, as it can result in a reduction in the real price of water per unit of water received at the farm/field. Another side effect that is becoming a hot issue in many EU Member States is the shift to abstraction of other water sources such as groundwater, (when ground water abstraction costs are lower that surface water distribution costs) which is more difficult to control. The following boxes present results of studies on price elasticity carried out in different European regions.

Illustration 74

Institutional changes affect the elasticity of water demand[253]

As revealed by research on water demand in the Campiña Baja Irrigation District (Spain), water demand under Agenda 2000 conditions is price inelastic. Price elasticity varies depending on the degree to which subsidies are effectively de-coupled from crop production.

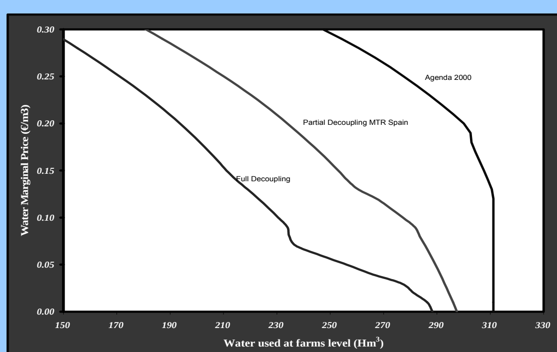

Figure 28: Price elasticity in the Campiña Baja Irrigation District as a function of subsidies

[252] García, M. (2002): Análisis de la influencia de los costes en el consumo de agua en la agricultura valenciana. Caracterización de las entidades asociativas para riego. Tesis doctoral. Departamento de Economía y Ciencias Sociales. Universidad Politécnica de Valencia, Valencia.

[253] Ministry of the Environment, Economic Analysis Group (2006): The MODERE: a micro-simulation model of farmers' decisions and its application to the WFD Implementation. Draft paper.

Illustration 75

Impact of water price increase on water consumption and farmer revenue – Charente river basin (France) [254]

In the Charente river basin (France), water pricing appears to be highly effective to regulate water consumption (according to economic model results). A water price increase will lower significantly agricultural water demand (see the water demand curve). However, local authorities and the water agency have abandoned the idea of imposing water price increases and now favour a quota system. This was explained by the high impact a change of water tariff would have on farmers' revenue (see the agricultural revenue curve), any reduction in farm revenue being considered as not acceptable.

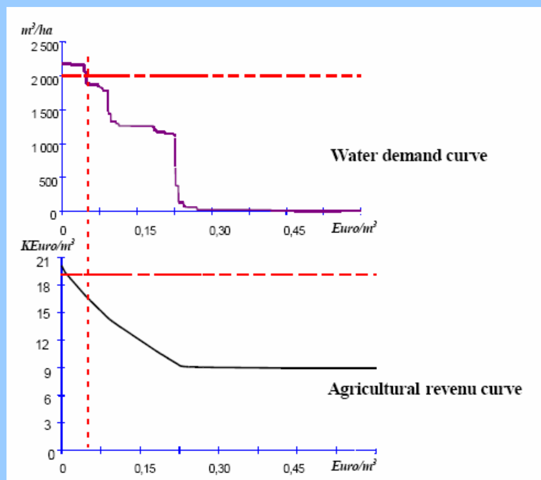

Figure 29: Change in agricultural water demand and farmer revenue in response to water price increase in the Charente river basin (France)

Illustration 76

Water demand functions in southern Europe

Water pricing will have different impacts depending upon specific characteristics of each farming type. Berbel and Gutierrez (2005)255 found differences in the water demand curves for three regions in Spain (two) and Italy (one) (see Figure 30). The Italian case, which was based on vegetable cultivation, shows a much lower level of water consumption and a much more rigid behaviour of the demand curve due to the high profitability of the crops cultivated. In the Foggia region (southern Italy), where excellent marketing channels for high- valued fruits and vegetables as well as drip technologies exist, there is almost no possibility of water saving. Furthermore, in the Italian case, increasing the price of water would have almost no effect in terms of diminishing water use and would merely deflate farmers' incomes.

[254] Chohin-Kuper, Anne, Rieu, Thierry, Montginoul, Marielle (2003): Water policy reforms: Pricing water, cost recovery, water demand and impact on agriculture. Lessons from Mediterranean experience.

[255] Berbel, J.; Gutierrez, C. (eds) (2005): "Sustainability of European Agriculture under Water Framework Directive and Agenda 2000". European Commission, Bruxelles.

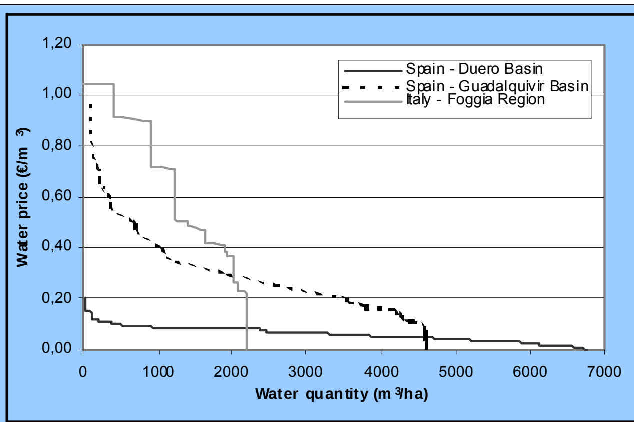

Figure 30: Water demand functions in three southern Europe basins[256].

On the other hand, in the Duero valley (northern Spain), where irrigation is mostly based on sugar beet, the impact of water price rise is that water demand collapses when price is above this crop's productivity and irrigation is abandoned.

The Guadalquivir case is somewhere in the middle, with some crops dependent on subsidies and others under market competition. In this area, water demand is approaching that of the Foggia case, as an increasing part of demand is already under drip irrigation (olive, citrus and other fruits, 44% of water consumption and 47% of area). Since drip irrigation is linked to high- value crops (fruits and vegetables), water demand becomes more 'structural' and 'rigid,' and the likely effect of water pricing is that the impact will go directly to decreasing farmers' income, as significant water saving is already in effect. Three examples of water demand characteristics are given in Table 42.

Duero (northern Spain)	Guadalquivir (southern Spain)	Foggia (Southeast Italy)
Demand disappears at €0.15 /cm	Demand varies from €0 to 1.00/cm	Demand varies from €0 to 1.00 /cm
Elastic demand	Inelastic up to €0.1. Then, elastic	Inelastic up to €0.23. Then, elastic
High response to water price	Low response to water price	Low response to water price

Table 42: Water demand characteristics[257]

[256] Berbel, J.; Gutierrez, C. (eds) (2005): "Sustainability of European Agriculture under Water Framework Directive and Agenda 2000". European Commission, Bruxelles.

[257] Berbel, J.; Gutierrez, C. (eds) (2005): "Sustainability of European Agriculture under Water Framework Directive and Agenda 2000". European Commission, Bruxelles.

These three cases show how specific characteristics of agricultural systems influence water price elasticity. For less favoured areas, such as the Duero River (Spain), any price increase will imply a substantial reduction in total irrigated areas, farm income and employment. On the other hand, high-value crops (Foggia, Italy) may bear price increases but with the consequence of transfers of income from farmers to water management agencies. More information on water price elasticity is presented in Table 43 below.

Table 43: Irrigation price elasticity of water demand[258]

Country/region	Water demand elasticity	Gross margin decrease	Estimated water savings	References
Spain/Andalusia	LP*: -0,06; MP*: -1,00			Garrido et al (1998) quoted in (Garrido, 1999)
Spain/ Andalusia	LP: -0,12; MP: -0,48			Garrido et al (1998) quoted in (Garrido, 1999)
Spain/Castille	LP: -0,09; MP: -0,26			Garrido et al (1998) quoted in (Garrido, 1999)
Spain/Castille	LP: -0,00; MP: -0,03			Garrido et al (1998) quoted in (Garrido, 1999)
Spain (Mid Guadalquivir and mid Duero valleys)	From 0.05 to 0.09 US$/$m^3$	25-40%		(Berbel and Gomez-Limon, 2000)
Spain (Mid Duero valley, Northern Spain) modern irrigation unit	0.014 to 0.04 US$/ m^3: -0.01 to -0.08 0.06US$/$m^3$: -1.5 Zero consumption for 0.4US$/$m^3$	7-20% 30%	9 ptas, 35%	(Gomez-Limon and Berbel, 2000)
Spain (Castille, Andalusia, Valence)	Andalusia: Elastic demand between 0.03-0.2US$/$m^3$ Castillo: Inelastic demand for price <0.1US$/$m^3$ Valencia: Inelastic demand for price <0.23US$/$m^3$ Less elastic demand in more modern districts	-1 to -14%(1) -17 to -57% -6 to -69%	10%	(Varela-Ortega, M. Sumpsi et al., 1998)
Espagne –Guadalquivir, Guadiana, Júcar,and Segura, Duero	Guadalquivir: 0-0.07 US$/$m^3$ Guadiana 0.07-0.17US$/$m^3$ Júcar & Segura inelastic up to 0.23US$/$m^3$ Duero: inelastic up to 0.03-0.1US$/$m^3$			Sumpsi, 1999 quoted in (Arrojo et Carles)
France Beauce	Elastic starting from 0.014 US$/$m^3$ (0.10F/m^3)			(Morardet et al., 2001)
France Charente	Elastic starting from 0.028 US$/$m^3$ (0.20F/m^3)			(Morardet, Rieu et al., 2001)

[258] CEMAGREF (2002): Synthèse sur la tarification de l’eau en méditerranée, série Irrigation “Rapports”, 2002-06.

France Adour	Elastic starting from 0.11 US$/m^3 (0.80F/m^3)			(Morardet, Rieu et al., 2001)
Israël	-0,18 to -0,49 for 0,20 US$/m^3 Zero consumption for 0.75$/m^3	42% (net revenue)		(Amir and Fisher, 1999)
Tunisia	North East: -0.03 North West: -0.27 Centre East: -0.14 Centre West: -0.07 South: -0.34		From 4 to 25% for a price increase of 50%	(Bechtel/Scet-Tunisie, 1999)
Turquie (Central Anatolie)	Inelastic for price< 0.005 US$/m^3 (77 TL) (1992)			(Eruygur, 2001)

(1) Income decrease induced by a water demand decrease of 10% - Range depending on Tariff structure and district
(*) LP, MP: Low, middle water price range

6.1.3.3 Costs and economic impacts of economic instruments on agriculture

Social costs

The potential negative impact of increased water pricing and the application of economic instruments to the agriculture sector is often used as argument against water pricing. The following sections clarify these notions and provide cost evaluations found in the literature and recent reports.

- In south-eastern Spain, where some trading of water occurs, especially for fruit, vegetables and greenhouse production, water cost is only around 2% of total cultivation costs. This implies that water demand will inevitably tend to go beyond sustainable renewable use, indicating that the private cost of water does not reflect the scarcity of the resource.

- Many authors have established a connection between farm subsidies and irrigation water demand in Spain[259]. Their results show that the elimination of farm subsidies has a larger impact on the farmers' welfare than the rise of water prices does. If EU farm subsidies become completely decoupled from production in the coming years, the economics of irrigation will be more guided by the relative productivity of crops and water accessibility than by relative farm subsidies granted to the crops.

- When the costs of water are low as compared to total agricultural output, water price increases are unlikely to lead to significant impacts. Table 44 presents some data on agricultural output and water costs. Overall, significant increases in water prices are likely to be problematic from an agricultural output/revenue point of view for irrigated maize, olive, cotton, sugar beet and wheat.

- Similar results are found when investigating the share of total water costs in total production costs. The loss in farm income resulting from an increase in water tariffs will be higher for crops with the highest share of water costs among total input costs. Illustration 77 below provides more detailed information obtained from five farming systems in France.

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[259] Sumpsi, J.M., Garrido, A., Blanco, M., Varela, C.; Iglesias, E. (1998): Economía y Política e Gestión del Agua en la Agricultura. MAPA y (ed.).Mundi-Prensa, Madrid.; Gómez-Limón, J. A., Arriaza, M.; Berbel, J. (2002): Conflicting implementation of agricultural and water policies in irrigated areas in the EU. Journal of Agricultural Economics 53, 2.; Arriaza, M., Gómez Limón J.A., Ruiz, P. (2003): Evaluación de alternativas de desacoplamiento total de ayudas COP: El caso de la agricultura de regadío del Valle del Guadalquivir. Economía Agraria y Recursos Naturales 6,129-153.; Iglesias. E., Sumpsi, J. M.; Blanco, M. (2004): Environmental and Socioeconomic Effects on Water Pricing Policies: Key Issue in the Implementation of the Water Framework Directive. 13th Annual Conference of the European Association of Environmental and Resource Economists,. Budapest, June 25-28. Unpublished.

Table 44: Water cost versus total agricultural output[260]

Crop/system	Location	River/Source	Output €/ha	Cost cent/m^3	Water/ output (%)
Greenhouse	Netherlands	Underground	120 000	15	0.8
Strawberry	Chanza	Guadiana	48 193	15	1.6
Greenhouse	Almeria	Mediterranean Andalusia	90 361	25	1.7
Maize	France	Several	3 000	10	5.0
Olive	Jaen	CH Guadalquivir	4 000	15	6.0
Cotton	Seville	CH Guadalquivir	4 000	8	12.0
Sugar Beet	Palencia	CH Duero	3 000	6	12.0
Wheat	Cordoba	CH Guadalquivir	1 500	8	10.6

Illustration 77

Impact of irrigation charge increase on incomes of 5 farming systems - France[261]

During discussions on the new water law in France, an increase in irrigation water charges was proposed and investigated. The potential economic effects of increasing water charges were studied for five representative irrigation systems with the following crops: orchards, potatoes, maize, cereals and vegetables. Different charge levels were proposed and their impact simulated using economic models. The study delivered two important messages:

1. The impact of water charge increases on farm income differs depending on main crops. The loss of revenue will be higher for crops with water costs representing a large share in total input costs. The relative importance of water costs in total input costs is presented below for the main crops.

[260] Berbel, J.; Gutierrez, C. (eds) (2005): "Sustainability of European Agriculture under Water Framework Directive and Agenda 2000". European Commission, Bruxelles.

[261] CEMAGREF (2001): Impact économique de la modification de la redevance prélèvement pour les irrigants - Rapport Final.

Crop	Abstraction methods	Share of water cost in total inputs costs
Orchards	Collective	4,1%
	pressurized	5,9%
Potatoes	Individual	1,2%
	Pumping	1,8%
Maize	Individual	3,5%
	Pumping	5,1%
	Collective	13,9%
	pressurized	19,1%
Cereals	Individual	4,1%
	Pumping	5,6%
	Collective	15,8%
	pressurized	20,8%
Vegetables	Collective	1,0%
	pressurized	2,0%

Table 45: Relative importance of water costs in total input costs for the main crops

2. For water charge increases between 0,02 to 0,25 FF/m^3, the decrease of revenue remains limited to the mechanical increase of input costs. For water charge increases between 0,02 and 0,4 FF/m^3 (i.e. between 0.003 and 0.06 Euro /m^3), the decrease in total revenue remains lower than 0.3%. The reduction in farm income reaches 0.1 to 1.4% for a charge of 0,08 FF/m^3 (0.012 Euro /m^3), and 2 to 5% for the highest charge increase investigated (0,16 to 0,25 FF/m^3, equivalent to 0.025 to 0.04 Euro /m^3).

Related environmental impacts

- Irrigated agriculture contributes to increasing nitrate contamination due to over-fertilisation. Examples of such direct effects have been found in the Adour-Garonne (France), in several Austrian regions, such as the Marchfeld, the Pandofer plateau, and the Welser Heide and Eferding Becken areas, in a number of Spanish regions, mostly located along the Mediterranean coast and main river valleys, and in various nitrate vulnerable Greek zones, such as Argolid, Kopas and the Thesaaly plain where large irrigated areas are located[262]. Nevertheless, in most river basins, the impact from livestock and rain-fed agriculture is higher than that from irrigation (e.g. in the Guadalquivir valley nitrate pressure generated by irrigated agriculture is around 22%, against 52% and 22% generated by rain-fed agriculture and livestock, respectively).
- Numerous studies have shown that more efficient water use reduces agricultural pollution (Dinar and Letey, 1991; Weinberg *et al.,* 1993; Calatrava and Garrido, 2001)[263].

[262] European Commission (2000): Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee: Pricing policies for enhancing the sustainability of water resources. COM (2000) 477 final. July 26. available at http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/com/2000/com2000_0477en01.pdf.

[263] Dinar, A.; Letey, J. (1991): Agricultural water marketing, allocative efficiency and drainage reduction. Journal of Environmental Economics and Management 20, 210-223.; Weinberg, M., Kling, C.L.; Wilen, J.E. (1993); Water markets and water quality. American Journal of Agricultural Economics 75, 278-291.; Calatrava, J.; Garrido, A. (2001): 'Agricultural subsidies, water pricing and farmers' response: Implications for water policy and CAP reform.' In: Dosi, C. (ed.) Agricultural Use of Groundwater: Towards Integration between Agricultural Policy and Water Resources Management. Kluwer Academic Publishers, Dordrecht. Pp 241-257.

6.1.4 The role of economic instruments in reducing domestic water abstraction

Domestic water prices are generally based on varying policies that usually evolve from the availability of water resources. Comparisons between areas and countries are very difficult. Figure 31 and Figure 32 show real prices for selected countries and the departure from average prices for 54 major cities in 20 countries. It is interesting to see that cities in areas facing water scarcity have prices below the average water price. In contrast, water prices are highest in northern European cities (about 75-100% higher than the average)[264].

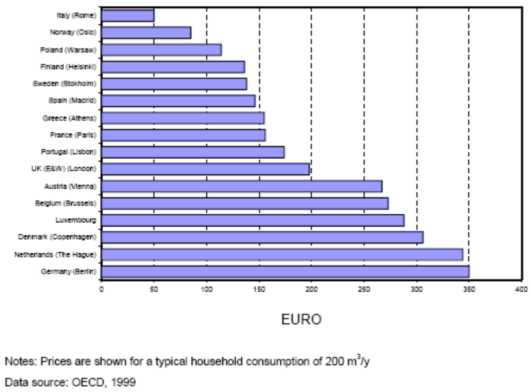

Figure 31: Water prices in some regions in the EU in 1998[265]

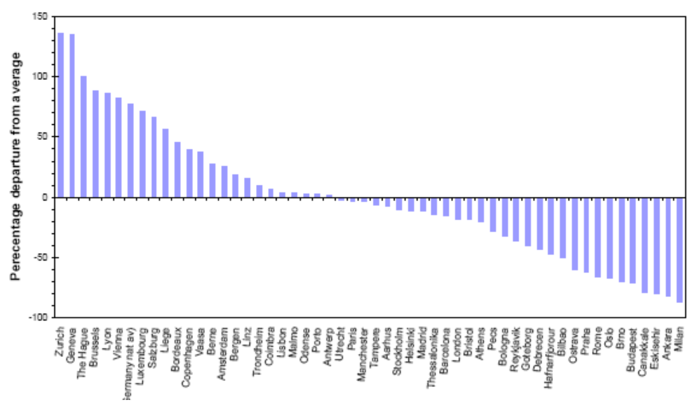

Figure 32 Percentages departure from average water prices (Euro/m^3) for major Cities in 1996[266]

Wide variations in real price increases have occurred between countries and within individual countries. In general, water bill composition over the last few years has been influenced by European directives, in particular on drinking water and wastewater treatment.

6.1.4.1 Tariff structure of public water supply

There is a huge variety in the types of metered tariff, namely (i) flat-rate tariff; (ii) uniform volumetric tariff, (iii) two-part or binomial tariff (sum of a flat rate tariff and a uniform volumetric tariff), and (iv) lock tariffs, which also usually incorporate a flat-rate charge, plus

[264] European Environment Agency (EEA) (2003): Indicator Fact Sheet (WQ05) Water prices, version 02.10.2003.

[265] European Environment Agency (EEA) (2003): Indicator Fact Sheet (WQ05) Water prices, version 02.10.2003.

[266] European Environment Agency (EEA) (2003): Indicator Fact Sheet (WQ05) Water prices, version 02.10.2003.

declining block tariffs and rising block tariffs. Two-part, rising block and declining block tariffs are widespread. There is a general shift to block tariffs. Seasonal tariffs (summer/winter) are uncommon, but are becoming more common as a response to water scarcity situations and droughts. Peak tariffs (hourly or daily) have only been tested in experiments.

Components of water bills usually include elements pertaining to water services (e.g. drinking water service, water treatment, and network maintenance) and elements related to specific institutional and financial arrangements (e.g. treatment tax, collection system and other taxes, VAT etc).

Water price elasticity of demand is usually moderate under European conditions. However, elasticity increases as water prices become high. The results of studies of price elasticity of household sector demand carried out in the EU and elsewhere show that price elasticity remains low. To increase the effect of water pricing policy, a combination of measures must be proposed that combine changes in water tariffs and other water saving measures. When addressing water tariffs, it will be important, however, to take into account vulnerable customers who might face difficulties in paying for their water services. The following boxes presents different illustrations on changes in water tariffs in the domestic sector and related price elasticity and changes in water demand.

Illustration 78

An example of changes in water tariffs for the household sector in Cyprus[267]

The effects of switching from the current regionally heterogeneous increasing block water pricing system to a regionally homogeneous uniform pricing one are investigated. The current pricing system is progressive but inefficient in the sense that it introduces significant price distortions. The regional differences, in particular, introduce a substantial price heterogeneity that cannot be justified on the basis of efficiency or equity criteria. It cannot be justified on efficiency grounds because it is difficult to imagine that in a small island like Cyprus such large regional differences in price can neglect differences in supply costs. The regional price heterogeneity also cannot be justified on equity grounds, because we found that users of large quantities of water pay substantially less per cubic meter of water than users consuming much smaller amounts of water do. Empirical analysis suggests that the price elasticity of water demand for households ranges from -0.4 to -0.8, depending on income levels (low income groups face higher price elasticity). This means that any major water price reform is bound to have effects on welfare of individual consumers in the bottom percentile of income distribution.

Illustration 79

An example of changes in water tariffs for the household sector in Canada[268]

Apart from the general statement that prices affect water use, it is difficult to assess the strength and even the shape of the price-demand relationship. Some studies show that household water demand is

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[267] Nauges, C. (no year): Estimating Residential Water Demand Under Block Rate Pricing: A Nonparametric Approach.

[268] Timberg Institute. (2001): Price and income elasticities of Residential Water Demand, Discussion Paper TI 2001 – 057/3.

relatively inelastic and will not change much when prices change (Espey et al., 1997[269]; Hanemann, 1998a[270]; Renzetti, 2002[271]). However, many studies stress that price elasticity increases in the long term – possibly because consumers replace inefficient fixtures and modify habits gradually rather than instantly (Carver and Boland, 1980[272]; Agthe and Billings, 1980[273]; Dandy et al., 1997[274]; Renzetti, 2002).

There are strong indications that volumetric pricing is associated with lower water use in Canada and elsewhere. A recent study shows that the choice of price structure (e.g., IBR, flat rate, or other) varies between municipalities as a consequence of local conditions (including water scarcity and pollution) (Reynaud and Renzetti, 2004[275]). The same study suggests that the price structure is important to explain the effect of price: Past a certain (variable) price threshold, water demand is more elastic; therefore, the price structure has a greater effect on water use than the price level has. (Reynaud and Renzetti, 2004).

Illustration 80

Impacts of increased water tariffs in California[276]

To assess the potential of price policy as a residential water resource management tool, an econometric model for residential water demand was developed and estimated. The analysis relies on agency level cross-section time series data for eight water agencies in California, which represent approximately 7.1 Million people or 24% of the total population of the State. The results suggest that price is a moderately effective instrument in reducing residential water demand within the observed range of prices. In addition, estimation results indicate that alternative demand management instruments, such as public information campaigns, retrofit subsidies, water use restrictions or rationing, reduce residential water usage more significantly – in some cases in combination with changes in water tariffs.

Illustration 81

Residential water demand in Slovakia[277]

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269 Espey, M.; Espey, J.; Shaw, W.D. (1997): “Price Elasticity of Residential Demand for Water: A Meta-Analysis.” Water Resources Research 33: 1369-1374.

270 Hanemann, W.M. (1998): “Determinants of Urban Water Use.” Urban Water Demand Management and Planning, New York: McGraw-Hill, pp. 31-75.

271 Renzetti, S. (2002): The Economics of Water Demands. Boston: Kluwer Academic Publishers.

272 Carver, P.; Boland, J. (1980): “Short- and Long-Run Effects of Price on Municipal Water Use.” Water Resources Research 16, no. 4: 609-616.

273 Agthe, D.; Billings, B. (1980): “Dynamic Models of Residential Water Demands.” Water Resources Research 16, no. 3: 476-480.

274 Dandy, G.; Nguyen, T.; Davies, C. (1997): “Estimating Residential Water Demand in the Presence of Free Allowances.” Land Economics 73, no.1: 125-139.

275 Reynaud, A., Renzetti, S. (2004): Micro-Economic Analysis of the Impact of Pricing Structures on Residential Water Demand in Canada. Report for Environment Canada.

276 Renwick, M.; Green R.; McCorkle, C. (1998): Measuring the price responsiveness of residential water demand in California, Ensuring the price responsiveness of residential water demand in California’s urban areas - A Report Prepared for the California Department of Water Resources.

This study investigates the residential water demand in the Slovak Republic. The demand model based a sample of 71 municipalities observed from 1999 to 2001. First, the residential water demand in the Slovak Republic appears to be inelastic but imperfectly with the three econometric specifications. First, the price sensitivity threshold using a Stone-Geary specification of the utility function is estimated at 31.5 cubic meters per person per year. This level is still significantly lower than the average water consumption per person observed in 2001, which was 41.5 cubic meters. This result has important policy implications. The average water consumption per person has decreased from 53.6 cubic meters in 1994 to 41.5 cubic meters in 2001. Given the price sensitivity threshold, the decreasing trend for residential water consumption may go on in the future. Second, using the Stone-Geary specification, a price elasticity of –0.35 to –0.50 has been obtained. Water demand is inelastic but not perfectly. Slovak consumers are price reactive, and changes in water tariffs can be used to convey current water scarcity to consumers.

Illustration 82

Residential water demand in Emilia-Romagna (Italy)[278]

A study undertaken for residential water demand in the region of Emilia-Romagna using municipal panel data estimated that price elasticity ranges from -0.99 to -1.33. The results of the study indicate that at least in regions associated with high per capita income and high water tariffs, where the water industry reform process is advanced in its development, the role of price-based policy instrument (regulated tariff) can be important as a demand-driver. The high elasticity is compatible with a rational profit maximising behaviour in monopolistic local water market. The study suggest that for areas that have already experienced a strong trend of tariff increases and currently face higher than average tariffs, water pricing can represent a feasible demand-oriented tool out of the mixed policy kit.

Illustration 83

Estimating short-run and long-run price elasticity in Spain[279]

An empirical study using monthly time-series observations from Sevilla (Spain) estimated price-elasticity of demand at around -0.1 in the short run and -0.5 in the long run. These results were in accordance to the economic theory that suggests that long-run price elasticity is greater in absolute value than short-run price elasticity is.

Illustration 84

Price elasticity of water demand in Portugal[280]

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[277] Dalmas, L.; Arnaud R. (2003): Residential Water Demand in the Slovak Republic, LERNA CEA-INRA-UT1.

[278] Mazzanti, M.; Montini, A. (2005): The Determinants of Residential Water Demand Empirical Evidence for a Panel of Italian Municipalities, Fonazione Eni, Enrico Matei, Notta di Lavoro 2005.

[279] Martins, R.; Fortunato, A. (2005): Residential water demand under block rates – a Portuguese case study, Faculdade de Economia da Universidade de Coimbra, ESTUDOS DO GEMF N.º 9 2005.

[280] Martinez. Espineira, R. (2000): Residential Water Demand in the Northwest of Spain Environment Department. University of York. Heslington, York.

A sample of panel data of 360 observations from 5 Portuguese local communities and 72 months were used to investigate price elasticity. The price elasticity value obtained falls within the range found in other case studies. Although price elasticity is currently low, changes in water tariffs will play an important role in water demand management. The expected influence of changes in water prices on residential water demand has not been confirmed. This result may be a consequence of the complexity of the Portuguese water tariffs and of confusing signs that come from the simultaneous use of fixed quotas and increasing block tariffs.

Illustration 85

Full cost-recovery in England & Wales [281]

In England and Wales, full-cost recovery has been applied since privatisation of the water industry in 1989. The annual average household water bill has risen by about one-third since privatisation, although today's water bill represents only 1% of average household income. Domestic water consumption, however, continued to rise but has remained at about 149 l/capita/day over the past few years. Water use by metered customers is about 10% less than non-metered customers, but meter penetration, whilst increasing, is still only about 13%. Water bills are expected to fall over the next two years.

Illustration 86

Changes in drinking water prices in Hungary[282]

The example of Hungary shows that drastic price increases in drinking water between 1980 - 1998 (prices rose from 0.6 to 70 HUF) were accompanied by significant reductions in water demand (by 30%). However, a large part of the reduction in water demand originated from the closing of industrial plants and buildings as a result of the drastic economic reforms that took place in these countries.

Illustration 87

Impact of economic instruments on water consumption in Athens[283]

In the following figure, the effect of water price increases on water consumption for the different sectors is given:

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[281] European Environment Agency (EEA) (2003): Indicator Fact Sheet (WQ05) Water prices, version 02.10.2003.

[282] European Environment Agency (EEA) (2003): Indicator Fact Sheet (WQ05) Water prices, version 02.10.2003.

[283] Malamos, N.; Nalbantis, I. (2005): Report No 15, "Integrated Water Management of Plastiras and Smokovo Reservoirs", NAMA SA, project ODYSSEUS, Athens.

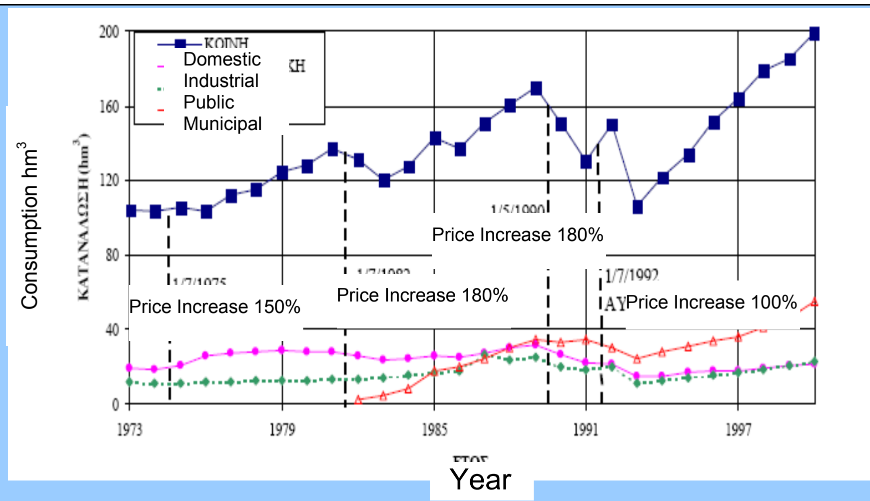

Figure 33: Water use in relation to price increases

The first important increase in 1975 did not lead to any reduction of the annual water consumption. However, the increases in 1982, 1990 and 1992 led to spectacular reductions in water demand. This reduction was achieved in combination with:

- An extensive water saving campaign
- Prohibition of use of potable water for swimming pools, irrigation of gardens, washing of cars
- Fines for exceeding previous year consumption by 70-100%.

6.1.4.2 Costs and economic impacts of economic instruments on households

In the Seine-Normandy basin, the household water bill of 377 Euro per household per year (for a consumption of 120 m^3/year, with 2.44 persons/household) is around 0.8% of a household's disposable income (2005 data). The following table provides the results for the sub-regions of the Artois-Picardie river basin:

Table 46: Comparison of the mean water invoice with mean available income per household in the Artois-Picardie river basin (France)[284]

Sub region	Mean available income per household (A)	Mean water invoice per household per year (B)	B/A
Aisne	23 499 €	455 €	1.94%
Nord	24 314 €	366 €	1.51%
Pas de Calais	23 194 €	428 €	1.85%
Somme	23 796 €	382 €	1.61%

6.1.5 Applying economic instruments to the tourism sector

Information on the potential application of economic instruments in the tourism sector is non-existent. Because tourists are never aware of the water they consume, have little room for

[284] Courtecuisse, A. (2005): Water Prices and Households' Available Income: Key Indicators for the Assessment of Potential Disproportionate Costs - Illustration from the Artois-Picardie Basin (France).

influencing it and do not benefit from any reduction in water use during their stay in camping sites or hotels, this instrument does not appear to be well adapted to influence water demand from tourists.

Abstraction and use charges applied to the tourism industry, on the other hand, could play an incentive role, combined with positive financial incentives for the installation of rain water harvesting systems, grey water reuse, optimum irrigation of lawns, gardens and golf courses. No specific taxes or charges are usually applied to the tourism sector, which usually faces the same water tariffs as the domestic sector (with some arrangements in block limits when block tariffs applies as it is the case in Malta). In some specific cases, regional differences in abstraction taxes are put in place to respond to very high tourism water demand. This is the case, for example, for the Artois Picardie river basin: abstraction and pollution charges applied to municipalities along the coast, where tourist activity of the basin is concentrated, are higher than for the rest of the river basin.

In parallel to abstraction charges, specific efforts could be made to develop the eco-labelling or eco-certification in the tourism sector. Such systems are already in place in some countries. In Malta, for example, an eco-certification system has been put in place and is managed by the Malta Tourism Authority. This eco-certification scheme promotes water conservation in hotels based on a detailed audit system. Actions to be put in place by hotels include the installation of rainwater harvesting systems, the monitoring of swimming pool water consumption or the use of water saving devices in showers and taps. Re-use of treated wastewater effluent is also promoted in the context of this scheme, although it is not compulsory. Today, 13 hotels (10% of the 2 to 5-star hotels but 25% of the bed capacity of the island) have applied to this eco-certification scheme.

6.1.6 The role of economic instruments in reducing industrial water abstraction

The industrial sector is characterised by two main sources of water supply: the public network and direct abstraction in surface/groundwater. For OECD countries, direct water abstractions represent roughly 75% of the total water consumption by industry – with significant differences among countries in the relative share between surface water and groundwater. While in Denmark, Italy, Portugal, France and the Netherlands, groundwater direct abstraction represent more than 60% of the total industrial use, groundwater source represents less than 30% in the United Kingdom, Belgium, Spain, Greece, Poland, Sweden, Finland.

6.1.6.1 Tariff structure of industrial public water supply

The most common pricing system for the industrial sector in OECD countries is a binomial tariff structure with a fix component depending on users characteristics and a variable component proportional to water consumption. In some countries, special contracts are proposed by water supply companies to large industrial consumers (e.g. in France, Germany, the Czech Republic, Finland), usually with significantly lower rates justified by economies of scales. Contrary to the domestic consumers, most industrial users are at least equipped with water meters for their share of water obtained from the domestic. A volumetric water pricing encouraging water saving can then be applied with respect to industrial consumption in the public water network.

6.1.6.2 Abstraction charges and taxes

Abstraction charges and taxes are applied in several EU countries In 1999, abstraction charges were applied in half of the OECD countries and particularly Spain, France, Hungary, Italy, Netherlands, Czech Republic, Belgium, Germany, United Kingdom[285]. Most of them were relatively recent. The situation has changed after the accession of the ten new EU members in 2004, with an increasing number of countries applying such taxes[286].

Abstraction charge can either take the form of a nominal licence fee linked to an abstraction permit regime (depending on industry size) or volumetric depending on effective water consumption. To implement volumetric abstraction charges, water metering is required, including for direct abstractions. This is, however, not always the case: in Malta, for example, direct abstraction from industry are not measured or monitored. In some cases, reduction or exemptions in abstraction taxes can be provided when the industries invest in water saving technologies. In Italy, a reduction of 50% of abstraction charge is proposed for industrial plants using water saving technologies. Even with abstraction taxes or charges applied, direct/self abstraction remains significantly cheaper than connection to the public water supply network is.

Although the main justification for establishing water abstraction taxes/charges (and environmental taxes/charges in general) is the environment, the review of current practices in Europe stresses that generating fiscal revenue is indeed the primary objective of these instruments[287]. Environmental consideration and efficiency issues are often marginalised in the design process.

6.1.6.3 Costs and economic impacts of economic instruments on the European industry

The potential negative impact of increased water pricing and the application of economic instruments to the industry sector is often used as argument against such changes; specific attention has been given to competitiveness issues.

Some rare studies have been lead to assess the impact of abstraction taxes on industrial economics[288]. One reason explaining such scarcity of studies is that obtaining consolidated data on direct abstraction and the existence of special tariff arrangements between water supply companies and industry remains a challenge. To illustrate the diversity and potential impact of such charges taxes, three examples are presented below:

- The Dutch groundwater tax - A groundwater tax was introduced in the Netherlands with the objectives to green the Dutch fiscal system and reduce groundwater use relative to surface water, which is more abundant. The groundwater tax applies to both public water supply and direct abstraction. When the tax was first introduced, small and medium size enterprises faced a price increase of about 40% in comparison to public water supply prices. The increase reached 113% for industry with self-abstraction[289]. However, further investigation[290] stressed that the

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[285] OECD (1999): Tarification de l'eau à usage industriel dans les pays de l'OCDE.

[286] Strosser, P.; Speck, S. (2004): Environmental taxes and charges in the water sector – A review of experience in Europe. A study undertaken for the water agency of Catalonia, ACT*eon*, Orbey.

[287] Strosser, P.; Speck, S. (2004): Environmental taxes and charges in the water sector – A review of experience in Europe. A study undertaken for the water agency of Catalonia, ACT*eon*, Orbey.

[288] Strosser, P.; Speck, S. (2004): Water abstraction taxes and the issue of competitiveness. Paper submitted at the symposium on Economic instruments for water demand management in an integrated resources management framework, Ottawa, June 2004.

[289] Strosser, P.; Speck, S. (2004): Environmental taxes and charges in the water sector – A review of experience in Europe. A study undertaken for the water agency of Catalonia, ACT*eon*, Orbey.

[290] ECOTEC. (2001): Study on the economic and environmental implications of the use of environmental taxes and charges in the European Union and Member States. Report for the European Union.

groundwater tax revenue collected amounted to only to 0.03% of total industrial turnover or 0.08% of the total added value of the sector. Thus, it is clear that the impact on industrial competitiveness can be considered as marginal.

- The French water abstraction and consumption taxes - In the Artois Picardie river basin, abstraction charges accounted for less than 5% of the total water tariff (water supply and wastewater services) to industry in the late 1990s[291]. Thus, it is unlikely that it impacts industrial competitiveness. In the Seine Normandy river basin, the abstraction charge is combined with a consumption charge, thus putting a higher charge burden on consumptive uses. The unitary rate of these charges vary between surface water (0.00071 Euro/m^3 abstracted and 0.04 Euro/m^3 consumed) and groundwater (0.024 Euro/m^3 abstracted, and 0.04 Euro/m^3 consumed). Different rates are also applied depending on local scarcity conditions and on current level of construction required for restoring water resource. However, the abstraction charge remains marginal and is unlikely to affect industry competitiveness.

- Abstraction charges in the United Kingdom - In the UK, abstraction charges are associated with the establishment of abstraction license and do not relate to volumes of water effectively abstracted. A report published by the department of Environment, Food and rural Affairs[292] concluded that the current abstraction charges are low (for example, 2p/m^3 compared to a mains water supply cost over 50p/m^3) and comprise only a small percentage of the total costs of abstracting water. Earlier research for the national Rivers Authority indicated that "80% of industrial abstractors would not consider increasing the efficiency of water use even when faced with a 50% increase in the price of water. Firms that were considering water saving measures were doing so as part of an environmental initiative or in response to increases in effluent treatment costs"[293].

Similar results were also found in the context of the policy discussions, which took place in Catalonia in 2003-2005, where the establishment of a new environmental charge for water was discussed. Studies showed that the proposed abstraction charge that was included in the overall environmental charge scheme would account for between 0.013% to 0.074% of total turnover of different industrial sectors, the most affected sector being the chemical sector[294]. This was clearly considered as marginal with no impact on the industrial sector competitiveness.

An additional study on the potential impact of cost-recovery of water services for the industry sector also suggested that economic instruments and water pricing have limited impact on the industry sector; this impact is reduced when more water saving measures are implemented. Ecotec (1996)[295] estimated the impact of full cost recovery of water on industry turnover in Greece, Spain, Portugal and Ireland. Introducing the full recovery principle would mostly impact the food and drinks sector (high water consuming sector), with total water cost

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[291] Courtecuisse, A. (2001): The observation centre of the price for water services in the Artois-Picardie basin. In: Proceedings of the Sintra Conference on Pricing Water: Economics, Environment and Society, European Commission, Bruxelles.

[292] DEFRA. (2000): Economic instruments in relation to water abstraction. A research report prepared by Risk Policy Analysis Ltd.

[293] DEFRA. (2000): Economic instruments in relation to water abstraction. A research report prepared by Risk Policy Analysis Ltd.

[294] Agenci Catalana de l'Aigua. (2005): Canon de disponibilitat, Contribucio dels diferents sectors, determinacio de tipus i impactes.

[295] ECOTEC. (1996): The application of the Polluter Pays Principle in Cohesion Fund countries. Birmingham.

in this sector increasing from 1.6% to 3,5% of total turnover. Increases would be lower in the pulp and paper sector (from 1.1% to 1.4%) and the chemical sector (from 0.3% to 0.4%). Thus, some economic impact would be expected for the food and drink sector, with potential water savings occurring in this sector as a result of increases in water pricing and application of the full cost recovery principle.

In general, water pricing and economic instruments will have low impact, in line with the UK study referred to above. Water service and abstraction charges will generally have limited impact on water savings in the industrial sector, partly because they represent a minimal part of industry production costs[296].

However, they might be relevant instruments when considered in combination with other tools and actions, in particular if the revenues collected from taxes and charges are used for providing positive financial incentives to support investments in water saving technology. In addition, fines for non-compliance with environmental standards – or significantly higher charges above certain well-defined abstraction thresholds – can still play a role as an incentive. In Singapore, for example, a 15% water abstraction tax is imposed on operations using more than a specific amount of water per month[297]. This instrument is seen as having an incentive function in promoting water saving technologies.

6.1.7 The role of economic instruments in reducing water use for electricity production

Most of European electricity comes from thermal power plants, with a lifetime of several centuries. As shown in section 5.4 there is a link between the price of water and the price of energy. However, water pricing in this sector is only an issue with respect to new investments. In the case of existing plants, higher water prices might increase the costs of electricity, but they are unlikely to have an impact on energy production from existing plants. Other factors such as a steady growing electricity demand or changes in fuel costs are much stronger drivers.

Even if water prices will not change water use in the short term, the revenue gained from a water pricing scheme in the sector could be used to cover the environmental and resource costs resulting from this sector.

6.1.8 Conclusions

Water pricing has different functions in an economy. With respect to water saving, its incentive function is the most important one, as an effective water pricing policy should lead to less water use by changing behaviour, shifting production patterns or fostering more efficient technologies.

Across Europe, water pricing has only in some specific cases an incentive function. In most cases, water prices are set to recover infrastructure and operational cost. Due to perceived political risks and concern that higher prices setting an incentive would hurt farmers and consumers, there have been few attempts to implement higher water prices to achieve water

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[296] Still, under specific situations, significant increases in water prices can influence industrial water demand. For example reduction of water use per unit output as a result of water price increases in Sao Paulo (Brazil) by 62%, 49% and 42% for the dairy, pharmaceutical and food processing industry, respectively. Nation Industrial Development Organization (2005): Water: a shared responsibility – Water and industry (Chapter 8). citing Kuylenstierna, J.; Najlis, P. (1998): The comprehensive assessment of the freshwater resources of the world - policy options for an integrated sustainable water future. Water International, Vol. 23, No.1, pp. 17–20.

[297] United Nation Industrial Development Organisation (2005): Water: a shared responsibility – Water and industry (Chapter 8).

savings in Europe. This trend might change in 2010 when incentive water pricing policies are required by the European Water Framework Directive.

6.2 Drought management plans (DMP):

Drought is a recurrent climate feature that is characterised by temporary water shortages relative to normal supply over an extended period of time, ranging from one season to several years. The term is relative, since droughts differ in extent, duration, and intensity.

Drought affects all components of the water cycle from a deficit in soil moisture, through reduced groundwater recharge and levels, and to low stream flows or dried up rivers. Drought should not be confused with water scarcity, which implies a long-term imbalance of available water resources and demands. Nevertheless, measures to mitigate or tackle water scarcity may also be useful to address droughts. The specific issue of droughts can be management by drought management plans (DMP) in two ways:

- As an emergency situation (crisis), which has to be tackled using extraordinary resources.
- Within the general planning framework taking the existing risk into account and introducing droughts in the general planning strategies.

Drought management plans are normally based on a hydrologic indicators system that will allow drought forecasting and aims to cope with gaps between water demand and supply by water rationing measures. Therefore, such plans are primarily aiming to minimise environmental, economic and social impacts of eventual drought situations in a given river basin by providing strategic mechanism for managing water supplies during drought periods or during emergency interruptions to supply. The specific goals addressed can be summarised as:

- Strategic objectives to address overall objectives for drought and emergency response (timely warning, ready response strategies, financial capacity to implement necessary infrastructure installation etc).
- Planning objectives to address future infrastructure and supply needs. (consumers have become aware of the DMP, identification of triggers that instigate implementation of management actions, monitoring and regular review of plan,, agreed level of service satisfies the requirements of the users at an acceptable cost, all feasible options of achieving a balance between supply and demand are evaluated in terms of impacts on users, etc)
- Operational objectives to translate the strategic objectives into specific responses and management actions. Such actions can act on duration of water supply and/or forbidden water uses.

Unfortunately, most Mediterranean countries, which suffer the most from droughts, only react to such an event when it is already occurring; such actions are often more costly and only respond to immediate needs. Current legislation on water and drought management shows different development stages for the Mediterranean countries that lead to important differences in the way droughts can be faced. While some of the countries have a stable legislative framework with functional river basin authorities and clearly defined responsibilities, others are still developing institutions and organisations that take care of water management issues[298]. In these countries, permanent structures and plans to cope

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[298] Iglesias, A.; Moneo, M.; Garrote, L. (no year): Drought Management Guidelines, Chapter 2. Defining the planning purpose, framework and concepts, available at:

proactively with drought are often lacking, compared to other countries such as U.S. or Australia[299].

The development of a DMP is similar to the development of a river basin management. Both require an active approach that takes into account changes in the river basin. However, mitigating and alleviating the impacts of droughts can also be addressed at national level and therefore the drought management plan can also include a national dimension. As technologies evolve, new water users occur or production patterns change, these plans have to be revised and updated; therefore, all components need to be dynamic. Figure 34 shows a possible approach to develop and update a DMP continuously.

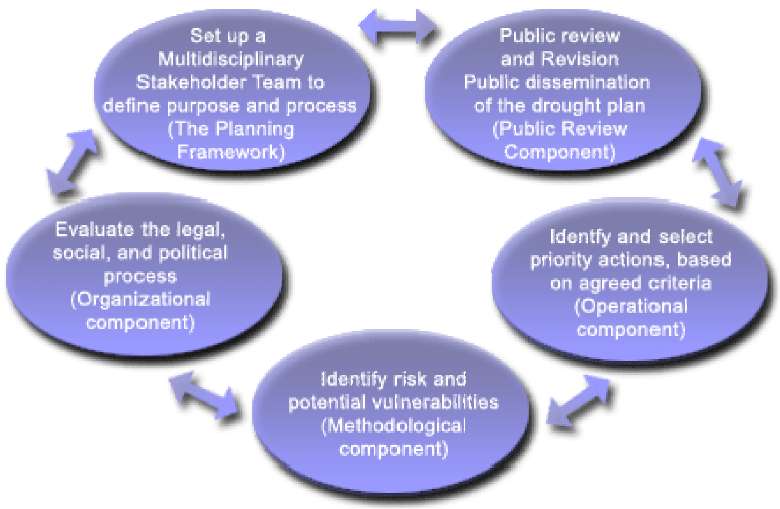

Figure 34: Development and revision of a drought management plan based on the MEDROPLAN guidelines[300]

According to this framework the following steps are needed[301]:

- As droughts have a wide range of effects on different sectors, social groups, or on the environment, it is necessary to establish the final purpose from the onset. The purpose determines the choice of methodologies for developing the plan.
- The successful management of a drought event requires integrative approaches and integrated management, based not only on the natural features, but also on socio-economic conditions of the area. The relations among organisations and institutions are the basis for understanding current drought management plans and for improving future actions that mitigate the effect of drought on agriculture, water supply systems and the economy. In order to avoid conflicts in the case of an drought event, the various institutions involved have to co-ordinate and set up clear responsibilities.
- A methodological component is needed to understand the system and its related risks and vulnerabilities. By understanding the causes of vulnerability of the systems,

http://www.iamz.ciheam.org/medroplan/guidelines/archivos/Guidelines_Chapter02.pdf.

299 A list of examples for DMP is given in Annex II to this document.

300 See http://www.iamz.ciheam.org/medroplan.

301 For further details on the proposed approach consult the web-pages of the MEDROPLAN-project http://www.iamz.ciheam.org/medroplan.

stakeholders can design proactive measures to decrease the potential impacts of drought, since the solution (management) depends on the problem (vulnerability).

- The operational component identifies both the long and short term activities and actions that can be implemented to prevent and mitigate drought impacts. It should be based on six aspects that need continuous feedback between them: (i) preparedness, early warning, monitoring systems, (ii) establishing priorities of water use, (iii) defining the conditions and the thresholds to declare drought levels (iv) establishing the management objectives in each drought level (v) defining the actions and (vi) implementation of actions.

  The measures are generally organised to protect water uses with different levels of priority. Normally the first priority is to ensure that adequate supplies of domestic water are available for public health, safety and welfare, with minimising adverse drought effects on the economy, environment, and social well-being a second priority. Based on the detailed assessment of priorities, the level of action is defined. In most cases DMPs follow a stepwise approach based on the magnitude of its impacts (Table 47).

  Voluntary measures under Level 1 formalise the need for all private diverters to carefully and responsibly manage their water requirements to ensure water is conserved and that environmental stream flows are maintained. In many cases (as demonstrated in the Case Study 6: San Diego County, California in Annex II), water authorities introduce rebate programs (e.g. rebates for the replacement of fixtures with new water efficient ones) in order to stimulate the users and enhance voluntary reductions, to reward low water consumption with favourable rates (as demonstrated in the Case study 5: City of Albury, New South Wales, Australia in Annex II) or to launch water saving promotion campaigns. The enhancement of voluntary reductions by any means has demonstrated to induce variable water reduction up to 30% or more in some cases, thus exploiting the water saving potential of the community without imposing restrictions.

  When the target consumption levels are not met and drought levels become more sever (level 2 or higher), mandatory restrictions are imposed by the DMPs. Those restrictions apply to all sectors and enforce the use of water saving technologies as well as water saving patterns for irrigation, outdoor uses, industries etc. by imposing, for example, watering patterns (bucket use, hand held hoses) and schedules (banning on watering during the day, on car-washing etc.). Such allocations of water can also be achieved due to water pricing (see section 6.1) or quotas. Quotas may be associated to water pricing in cases where water pricing may not have impact on water.

- Public review must play an important role throughout the plan development process since the social and environmental conditions may change and aspects of risk analysis and management improve and evolve. Furthermore, it creates awareness and may lead to a faster uptake of water saving measures and practices.

Table 47: Different levels of a drought management plan

Drought Severity Level	Characterisation	Introduced Restrictions
Level 1: Alert	Incipient	Voluntary Reductions
Level 2: Warning	Moderate	Low Level Restrictions
Level 3: Serious	Serious	Moderate Restrictions
Level 4: Emergency	Emergency	Severe Restrictions
Level 5: Disaster	Disaster	Emergency Restrictions

In **conclusion,** the establishment of a DMP is a demanding and highly complex exercise, but preparedness measures, particularly comprehensive drought planning and proactive mitigation measures, can lessen the impact droughts have on individuals, communities, and the environment (see also section 7.3.6 on benefits of drought management plans). Effective drought plans should have clearly identified objectives and priorities. They should be flexible to avoid a "one size fits all" approach, allow for social, cultural, and sector specific differences and should include an environmental dimension that addresses priority environmental impacts. Effective DMPs should consider the allocation of water to meet the need of environmental protection and to meet immediate human needs at the same time

6.3 Educational issues and consumer behaviour

A number of the environmental problems including water scarcity are to a greater or lesser extent caused by present consumer lifestyles. More sustainable lifestyles cannot be obtained without marked changes in consumer attitudes and consumer behaviour; therefore, it is necessary to examine current consumer behaviour with respect to environmental considerations, as well as the impact public awareness and education programs have on consumer habits.

6.3.1 Current Consumer behaviour

Within households there are number of habits that lead to high water consumption; some of these habits are easier to change than others. Running taps while cooking, washing dishes and brushing ones teeth can use up to 5 litres/minute. Moreover, leaky taps waste around 4 litres/day. Taking a 5-minute shower as opposed to a bath uses around 1/3 less water. A survey undertaken by a consumer magazine in the UK, indicated that the average person only puts around 2 kg of clothes in the washing machine per load, although most machines are designed to hold more than twice that amount[302]. Another household consumer issue is food choices and the related virtual water (see section 9).

6.3.2 Who are water savers?

There are a number of characteristics individuals who make concerted efforts to save water have in common with one another. Gilg and Barr (2005) examined these water saving behaviours in the context of other environmental actions, the frequency of water saving behaviour as well as assessing water saving behaviours in the context of different behavioural groups. By focussing on socio-demographic and attitudinal (psychological) factors, a trend emerges of the type of person most likely to reduce water consumption. Attitudinal factors identified and analysed were:

- Price and economic incentives: extent to which individuals believe price is a significant tool to affect water use behaviour
- Environmental threat: extent to which people feel that their inaction could lead to negative environmental consequences
- Social desirability: relating to actions people take that other people value and react positively towards
- Perceived water rights: right to access to water supply without restrictions

[302] http://www.environment-agency.gov.uk/subjects/waterres/287169/287245/?version=1&lang=_e.

- Intrinsic motivations and satisfactions: frugality, participation, luxury, altruism and competence.

Based on behavioural trends, such as turning taps off while doing dishes and brushing teeth to flushing the toilet less and taking fewer showers, people were categorised as committed environmentalists, mainstream environmentalists, occasional environmentalists and non-environmentalist. Committed environmentalists and mainstream environmentalists were most likely to engage in water saving activities, even with respect to the least popular measurers (e.g. taking fewer showers and reducing toilet flushes) with 50% of respondents in these two groups participating in such measures. On the other hand, only 18% of occasional environmentalists always turn off the tap when brushing teeth, and 69% of non-environmentalists do not turn of the tap when soaping up in the shower.

Within this categorisation, a number of demographic similarities emerged, namely "those most committed to water saving in the home were older, tended to own their home, lived in a terraced property, voted Green/Liberal Democrat[303] and were members of community groups. In contrast, those who were non-environmentalists tended to be younger, male, on low incomes, had received less formal education, were less involved in the community and were likely to be politically apathetic"[304]. By being able to identify the kind of person least likely to engage in water saving measures, policy makes can focus their public awareness campaigns more effectively.

6.3.3 Different Levels of changing behaviour

The ability to alter behaviour rests on how much personal sacrifice is involved. Gilg and Barr (2005)'s study[305] on behavioural attitudes towards water saving identified three groups in which these "changes in habits" can be categorised:

- behaviour modifications that require no degree of personal sacrifice, and result in no modifications that may alter a person's personal living standards. Such "common sense" behaviours, (e.g. turning the tap of when brushing teeth or washing dishes, showers as opposed to baths and using the washing machine only when full), are changes people are more willing to make.

- Limited personal sacrifice changes (i.e. turning off the water while soaping up in the shower, reducing the amount of toilet flushing, reducing the hot water temperature) are less popular.

- Activities such as reducing the number of baths and showers taken and using the sprinkler less frequently in the garden are the hardest to "sell", with only 20% of the respondents in the study participating in these behaviours modifications.

6.3.4 Water savings by raising awareness

Stakeholder consultations have shown that environmental technologies are not sufficiently used, partly due to the lack of clear information. There is a lack of accurate and easily accessible information on the potential of environmental technologies, preventing users from

[303] For reference for political parties, study was undertaken in England.

[304] Gilg, A.; Barr, S. (2006): Behavioural attitudes towards water saving? Evidence from a study of environmental actions. *Ecological Economics* 57, p.408.

[305] This study surveyed 1600 households in Devon, England regarding personal habits and choice and compared them with their respective lifestyles in order to identify current water savers and those who policy makers should target for water saving campaigns.

making informed decisions regarding investment in environmental technologies. Additionally, stakeholders have identified a lack of education and training in the area of environmental technologies.

Water conservation awareness (WCA) is, thus, a significant tool to reducing water consumption not only in the household, but also in all major economic sectors. UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific) identified steps for promoting high quality water conservation awareness, aimed at policy makers, water planners, and social marketers and educators, with the objective of increasing knowledge for these stakeholders so that they can further promote public education and information programmes.

Steps towards quality awareness programs are:

- Set up a managing committee of experts (marketing, public relations, education) to manage a campaign;
- Identify stakeholders;
- Analyse policy issues with respect to political commitment of a given area, institutional strengths and weaknesses, affordability;
- Review local factors to adapt campaigns to local and regional political, socio-economic, cultural and geographic factors;
- Identify target groups;
- Identify partners and sponsors, including government agencies, utility companies, NGOs;
- Agree on aims and key messages;
- Identify promotion activities: interpersonal communication tools, group media tools, traditional media tools, mass media tools and information and communication technologies tools;
- Set targets and timetables, budget and funding possibilities;
- Set up project teams to implement specific activities;

Information campaigns are considered to be an important part of initiatives such as promoting water-saving devices, raising prices to pay for leakage and encouraging more rational water use. They can include (i) general advice and information on conservation, (ii) tactical irrigation advice, (iii) advice on leakage.

Not only are household customers targeted for these programs, but also industrial and commercial consumers as well. Water saving in these economic sectors leads to cost savings, which can increase competitiveness. Water audits at industrial sites and at commercial properties can help these companies realise their water consumption, as well as steps to take to minimise their use. Many of the water saving technologies promoted for household use are also applicable to industry and commercial sectors. Waste minimisation is another key aspect; recycling waste water in closed loop systems has proven rather effective in reducing water consumption (see example from SCA, a paper and pulp manufacturing company).

Illustration 88

Sydney Water: Tips to Consumers[306]

"…Every day, there are many simple little things we can do around the house to save water, money and help the environment.

Take a look through the tips below for some clever shortcuts to savings:

- Checking for leaks in taps, pipes and dishwasher hoses is an easy way to reduce water wastage. Remember, one leaking tap can waste more than 2 000 litres a month.
- The most water efficient methods for cooking vegetables are microwaving, steaming or using a pressure cooker. You can also cut down on water loss by using tight lids on pots and simmering instead of boiling rapidly.
- Installing water efficient taps or tap aerators is a great, inexpensive way to cut your water usage without you even noticing.
- Put the plug in the sink when washing your hands instead of holding them under running water.
- Thaw frozen foods before you need them or use the microwave instead of placing them under running water.
- Prevent taps from leaking by turning taps off lightly and replace washers as soon as they begin to leak.
- Automatic dishwashers can use up to 40 litres of water per load. By using a dishwasher with at least a 3 star/AAA rating1, you can get this figure down to 18 litres per load and still get the kind of sparkling clean dishes you're used to.
- It's best to wait until you have a full load in your dishwasher before using it. This saves water and energy, and reduces the amount of detergent entering the sewerage system.
- Keep a container of water in the fridge so that you won't need to run the water down the sink until it's cool enough to drink.
- Washing fruit and vegies in a half-filled sink instead of under running water is a great way to cut back on water wastage.
- Rinsing your dishes in a plugged sink rather than under a running tap saves water and is just as easy and effective.
- Use a sink strainer.
- Try to use phosphate-free, eco-friendly detergents and cleaning products - there's a great range to choose from these days and they're much better for our environment.
- Remember to regularly clean the lint filter on your washing machine.
- Most washing machines have a load adjustment button or dial, so try to set this to match the amount of washing you're doing. If your machine doesn't have a load adjustment function, try to wait until you have enough washing for a full load.

[306] www.sydneywater.au.

- Installing one of the latest 3 star/AAA rating showerheads1 can give you a great shower and save you around 10 litres of water a minute. They also save you energy costs, as you'll use less hot water.

- To rinse your razor, run a little water into a plugged sink. Rinsing your razor under a running tap wastes lots of water.

- There's no need to leave the tap running while you brush your teeth. Simply wet your toothbrush before you begin and use a glass of water to rinse your mouth.

Illustration 89

Saragosa: a water Saving city[307]

The situation before the beginning

This misuse of water resources was part of a vicious circle: the lack of any regulations covering water-saving, government policies basedon increasing the supply,ignorance of the existence of water-saving technology enabling more efficient use of water in the home (a survey carried out in Zaragoza before the beginning of the campaign shows that about 60% of those questioned could not remember or were ignorant about water-saving strategies in the home), scant regard for this resource as far as the public was concerned, as well as wasteful water-consumption habits. The Fundación Ecología y Desarrollo aimed to demonstrate, with this project, that it was possible to solve water-shortage problems but using a cheaper, more ecological, faster and socially contentious-free approach: saving water by increasing efficiency in its use.

Preparing the information and marking priorities

In the planning stage of this project, various priorities were defined with the idea of establishing the bases of a new water-saving awareness:

- To promote the information about simple saving technologies.

- To create a collective challenge which would bring about the participation of all the agents involved in water-saving awareness.

- To create a water-saving city which would be an example to follow in the outside world.

- To save water without sacrificing comfort.

A systematic approach: all agents who are part of the problem would have to participate in the solving of that problem. The vicious circle would need to opposed by a virtuous circle which would create a synergy favourable to water-saving.

To carry out this project, the structure of participation was designed as follows: promotion partners, promotion businesses and collaborating concerns. The promotion partners were intended to include institutions whose role would require them to be actively involved in the campaign and would actively and financially contribute to its development. We also needed the support of the business sector connected with the manufacture of products which consumed and/or saved water. Finally, this campaign needed to be diffused among everybody in the city, and so concerns representing various collectives were required to take part in the project.

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[307] www.bestpractices.org.

Formulation of objectives and strategies and mobilisation of resources

The project's purpose is to promote a new water-saving awareness, with a rational management of this limited and life-giving natural resource. Between project activities one notices: The project activities are divided into six strategic measures for saving water:

Actions aimed at the general public.

A publicity campaign was launched, whose objective was to inform the public of the project. This campaign consisted of advertisements on TV, radio and the press, leaflets, posters, advertising hoardings, advertising on buses and on Municipal poster sites. A help-line has been set up to inform people of all the technological devices available for water-saving in the home, and where they can be acquired.

Actions aimed at children and young people

A specialised education programme has been developed. Resource packs for teachers to use with their students have been produced. Other schemes within the programme are: The Big Book of Water, a book with blank pages for the city's schoolchildren to write their ideas; the Water Card, on which each student thinks up an image and slogan to convince everyone of the need to use this natural resource correctly; and the Water Savings Book, where, by comparing monthly water bills, the savings obtained are entered.

Actions aimed at large-scale consumers.

Large-scale domestic water users (hotels, restaurants, bars, gymnasiums etc.) to inform them of the environmental and financial advantages to be gained from saving water.

Actions aimed at the business sector.

With the business sector (professionals linked to home water-consumption: manufacturers, distributors, retailers, plumbers), direct marketing activities have been realised.

One of these has been the "Mystery Shopper" campaign. This consists of giving prizes to professionals who use water-saving criteria as part of their sales pitch. The project was drawn up by the Fundación Ecología y Desarrollo -NGO- and presented to the European Union LIFE Programme in May, 1996. The project was approved in November, 1996. The project brought about a change in the cityAEs water-consumption habits. Some of the results obtained up to this moment, through the actions of the various social actors, are evidence of this:

General Public (Citizens, large consumers, collaborators

- There was a saving of 592 Million litres in domestic water consumption, representing 60% of the final objective.

- The existence of agreements and pacts has made it possible for over 2 450 establishments and/or buildings with public washroom facilities to be involved in the campaign.

- Collaboration agreements have been set up with 143 concerns, involving some 92 000 adult Zaragozans

The Educational Sector

- 168 educational establishments, 428 teachers and 70 000 students are directly participating in the campaign's Educational Programme

The Administrator

- The plenary meeting of the City Council of 31st October, 1997, with all-party consensus, decided to set up a water-saving plan in the city, in both domestic and other urban uses.
- The decision by the Mayoress' office not to raise the level of the Yesa reservoir, which was to have assured an alternative drinking water supply to that of the River Ebro.
- The Aragón Regional Government has urged all condominiums with central hot water supply, but without individual meters, to install them

The Business Sector

- Over 140 establishments selling products related to domestic water consumption are collaborating in the campaign. This figure means that 65% of bathroom, ironmongery, plumbing, electrical household appliance and meter installation outlets are actively participating in the project.
- Three of the cityAEs property developers have decided to install water-saving devices in their new homes.
- Over 128 large and small firms are collaborating in the campaign.
- Plumbing and bathroom retail outlets collaborating in the campaign have seen a 170% rise in sales of their water-saving products

The Media

90% of the media in Zaragoza are collaborating directly in the campaign.

Illustration 90

Copenhagen

98% of the Greater Copenhagen area is supplied by groundwater. Due to increasing problems associated with ground water pollution, which led to the closure of key wells, Copenhagen began in the late 1980's to look for ways to reduce water consumption.

Since 1989, Copenhagen Water, the city's principle water supplier, has worked to influence consumer water use through awareness programs and leak identification in the public distribution system. The awareness programs targeted individual property owners and housing co-operatives, as well as local industry. The following is a list of water saving initiatives implemented in the Greater Copenhagen area:

- Information campaign for domestic customers via advertising and pamphlet distribution in 1989, including identification of high consumption areas for more intense campaigning
- Establishment of a water saving consultancy division in 1994 to provide advice for companies and housing associations
- Competition with questions regarding water and consumption reduction in 1995 – 35 000 responses
- Training for workers in water and sanitation businesses regarding water saving measures
- Installation of water meters
- Extensive renovation of water pipeline, including periodic leakage testing

As a result of these water saving strategies, Copenhagen was able to reduce its total water consumption by 10 Million m^3/year. Domestic water use, in particular, has decreased from 168 litres/inhabitant/day in 1989 to 131 litres/inhabitant/day in 1997.

6.4 Water Labelling

As mentioned earlier in section (4.2), water-saving equipment and water-saving devices can contribute a recognisable part to domestic water saving efforts. Rising awareness and educating the public to save water in their daily life are further effective instruments. A tool that plays to the strength of both approaches is the labelling of water efficient products. It works by labelling certain products like washing machines or toilettes according to their water efficiency. In general a classification system is applied which ranks the products of a certain category like washing machines depending on their water consumption per use for example from 'A' to 'AAA' with 'AAA' being the most water efficient product. The advantages of water efficiency labelling are:

- It informs the customer about the water consumption level of the product and enables him to make a deliberate decision. If domestic water consumption is metered and paid for by volume, the incentive to purchase a product with a higher water efficiency is increased;
- Water efficiency labels create a pressure on the producers of the labelled products to incorporate available water saving techniques into the design of their products and to develop them further. This can only work if labelling for certain products is mandatory. If the system is voluntary producers will for obvious reasons only label their better products[308];

Illustration 91

Water Efficiency Labelling in Australia[309]

In Australia, the 'Water Efficiency Labelling and Standards Act' was passed in 2005 providing the basis for the 'Water Efficiency Labelling and Standards' scheme which became mandatory from 1 July 2006. A research study projected that labelling shower heads, toilets, clothes washers and dishwashers (accounting for over 80% of indoor water use in the domestic sector) would reduce the total national water consumption of these products by about 63 710 Million litres (ML) per annum below the business as usual (BAU) trend line by 2016. This would represent a water use saving of about 5.2% in total household indoor water consumption. The actual act includes also tab and urinal equipment to increase water saving beyond this projection.

Illustration 92

Influence of eco-labelling for energy use on consumer behaviour in Switzerland

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[308] Wilkenfeld, G.; Associates Pty Ltd; Artcraft Research (2003): A Mandatory Water Efficiency Labelling Scheme for Australia, prepared for Environment Australia, available at: http://www.waterrating.gov.au/publications/pubs/strategic-study.pdf.

[309] For further information please refer to: http://www.waterrating.gov.au/index.html.

Sammer and Wüstentragen (2006) examined the influence of eco-labelling for energy use on consumer behaviour through surveying Swiss customers in the process of buying washing machines. Results indicated that energy consumption is the second greatest priority when purchasing a machine after price. Interestingly, more customers stated that an energy label was more important in their decision than energy consumption itself, leading to the assumption that labelling products leads to customers choosing more environmentally friendly products. "The fact that this effect is particularly pronounced in the case of high, but not very high, importance of energy issues leads us to believe that the label is particularly meaningful for consumers outside the niche of highly energy-aware customers." Therefore, labelling products water efficient can also increase awareness for consumers who are not as aware of environmental issues as others are.

Specific types of labelling are eco-labels. Technically, an eco-label implies the endorsement of the good or service in question by an independent third party, after the third party has used a specific set of environment criteria to test it. The types of testing done on any product are specific to the product's life-cycle. When you look at the label, think of it as a pictorial representation of the environmental issues associated with its production.

Eco-labels started catching on with the public in the 1970s and the global community soon recognized that the different label criteria in use would be problematic. Consumers can easily be confused by the many different labels on the goods they buy, and there is no easy way to interpret a label without a handy reference guide. Further, consumer confidence in a labelling system required consistency in labelling practices.

The central elements of the eco-labels are:

- Limitations on emissions (waste water, air) and use of energy in production
- Environmental and health protection through restrictions on the use of chemicals and additives

In European the "European Eco-label"[310], is the only sign of environmental quality that is both certified by an independent organisation and valid throughout Europe, presents a unique opportunity to satisfy your customers' expectations. There are currently twenty-three different product groups, and already more than 250 licences have been awarded for several hundred products.

The issue of water saving is only covered explicitly in some of these groups. With respect to household appliances, dishwashers and washing machines are covered forcing low water consumption during use. Further the eco-label scheme for campsite services and tourist accommodation service contain criteria for water saving. For hotels the following criteria have to be fulfilled[311]: i) Water flow from tap or shower < 12L/minute; ii). No more than 5 urinals flushing at the same time, iii) Towels and sheets changed once or twice a week or on request. iv) Water plants and garden after sunset or before high sun. v) Waste water has to be treated, vi) Choice of low environmental impact water source (when applicable). A similar approach is chosen for camping sites[312].

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[310] For further information see http://ec.europa.eu/environment/ecolabel/index_en.htm.

[311] European Commission (2003): Decision of 14 April 2003 establishing the ecological criteria for the award of the Community eco-label to tourist accommodation service

[312] European Commission (2003): Decision of 14 April 2005 establishing the ecological criteria for the award of the Community eco-label to campsite service.

7 Investigating the potential benefits of water saving measures

This section investigates the potential benefits that may arise as a result of implementing water saving measures and drought mitigation measures in Europe. Different types of benefits that might be encountered are presented, as well as a brief review of methods and approaches that might be proposed for assessing benefits. Finally, results and illustrations of these different types of benefits are presented.

7.1 Which potential benefits?

Implementing measures and actions aimed at reducing water demand and managing drought situations can deliver a range of potential benefits, the importance of which will depend on the objective and focus of actions and the environmental and socio-economic conditions under which the actions are proposed:

- Sector-specific water saving measures (technical or economic incentives), but also incentives for sectors to shift from high to low water-intensive productions/products, lead to effective water savings, i.e. reduction in water consumption and volumes of water returned back into the natural environment. This contributes to restoring the quantitative balance of aquifers (in some cases limiting also sea water intrusion) and good water status for rivers, thus delivering **environmental benefits**. In some cases, water saving can also lead to reduced energy consumption and reduced air pollution coherent with climate change strategies to reduce emissions of greenhouse gases.
- Actions can also lead to direct **financial benefits**. Such savings can arise for individual water users and economic sectors when reductions in water bills resulting from water savings out-weigh the costs of water saving measures. In some cases, water savings might limit the need to capture new water sources. This can then also lead to significant financial savings. Indeed, capturing new water sources is often more expensive than even complex water saving measures are. Also, in the case of groundwater, water savings can lead to reduction in groundwater-table depth, which can reduce pumping costs of groundwater abstractors.
- It can deliver **economic benefits** – if part of the water saved is used by other economic sectors or new water users. This might be the case when water savings in one sector are used for supporting further development of the sector (e.g. volumes of water saved by applying new irrigation technologies being used to extend irrigated areas, modify cropping pattern and grow more profitable crops). However in accordance with the definitions in chapter 3 this is not a real “wet saving”. Economic benefits also results from water (re-)allocation mechanisms that do not change total water demand. Indeed, re-allocation of water between economic sectors or within sectors can help supporting the development of (new) economic sectors in situations where water availability is constrained (e.g. because of the need to protect the environment). If favouring highly productive economic sectors over less productive ones, drought management plans can also deliver economic benefits (i.e. minimising economic losses that might arise as a result of drought situations)
- **Social benefits** can also be obtained, in particular for quantitative restrictions and drought management plans that give priorities to health or social users as compared to water use in economic activities. Also, reductions in water supply uncertainty might provide opportunities for setting up industries and economic activities supporting rural development.

7.2 Methods and approaches to assess benefits

7.2.1 Assessing environmental benefits

The comparison between volumes saved, total volumes abstracted and minimum abstraction for ensuring a quantitative balance for an aquifer or minimum ecological river flows is the first step to estimate the importance of water savings as compared to environmental needs. In some cases, the effect of measures on river flows can be transformed into potential changes in ecosystems – including potential positive impacts on connected wetlands and terrestrial ecosystems.

Assessing the impact of water saving measures on river flows should build on a simple mass balance approach. To ensure that return flows and re-use aspects are well integrated, wider river basin modelling should be applied to assess effective impacts on the water environment.

Changes in river flows and ecosystems or changes in groundwater balance (including salt intrusion aspect) can also be assessed in monetary terms. For example, stated preference techniques capturing use and non-use values attached to ecosystems improvements can be applied and provide monetary estimates of improved river flows. It is important to note that valuation techniques are already often applied to complex changes in aquatic ecosystems without specifically differentiating between ecology, water quality and quantity aspects. In case of parallel savings in energy consumption, environmental benefits linked to the reduction of greenhouse gas emissions can also be estimated using monetary values available in the literature (for example, values of a ton of CO_2 emission).

7.2.2 Financial savings and avoided expenditures

Assessing reductions in water bills resulting from water savings is rather straightforward, as it requires multiplying volumes of water saved by water tariffs or by abstraction costs when direct abstraction by water users takes place (the majority of situations for the industrial sector and agriculture, an increasingly important situation for households). If abstraction charges or taxes are applied in a given country or river basin, reduction in charge/tax collection must also be considered.

In some cases, a reduction in water use can be accompanied by (i) reduction in wastewater discharge (a key factor driving water saving initiatives in the industry sector) and/or (ii) reduction in energy bills (as water savings lead to reduction in water quantities to be heated in houses, for example).

The analysis of potential financial savings, because water savings make investment in additional water sources redundant, requires first the identification of alternatives that exist in terms of additional water sources (e.g. abstracting from an aquifer that has sufficient recharge, installing new (deeper) wells and boreholes, building a new storage reservoir, desalinisation of sea water, water transfer from a different river basin or country). Investment, operation and maintenance costs of these alternatives can then be estimated (be it overall or in Euro per cubic meter of water saved) and considered as direct benefits from water saving measures.

7.2.3 Assessing economic benefits

Assessing economic benefits can build on the comparison between marginal values of water for different (productive) economic sectors, be it (i) between water uses (e.g. relevant to water re-allocation) and/or (ii) between different levels of water demand for the same users (e.g. restrictions and drought management plans, re-allocation of water). Such information can be obtained from modelling (e.g. linear programming), in particular for the agriculture sector. For industry, this information is more difficult to obtain and not readily available.

An alternative approach consists in estimating and comparing the average value added per unit of water produced by different economic sectors. Although this approach is very rough from an economic point of view, it has the advantage of being easier to implement, as data are more readily available (including as part of some of the Article 5 reports produced by Member States in the context of the implementation of the Water Framework Directive).

Finally, in the case of drought management plans, benefits can be estimated by assessing the total costs of past drought events. Implementing drought management plans is expected to limit or eliminated such costs, and these avoided costs can be counted as benefits of the plans.

Finally, existing water markets are quite limited but with growing importance. Although information on the economic impact of such markets is limited, their growing importance may in itself be an indication of economic gains where reallocation of water resources is permitted.

7.2.4 Assessing social benefits

Assessing social benefits can build on the assessment of the costs avoided by social groups and citizens resulting from the implementation measures, for example, reduction in illness costs if severe drought leads to reduction in water supply lower or close to minimum, the definition of which is based on health and hygiene standards. Very roughly, the number of citizens protected and their socio-economic characteristics already gives an order of magnitude of possible social benefits. Citizen surveys (including stated preference survey techniques) can also provide information on people's perception, acceptance and utility under different drought management scenarios (including the no-action scenario) – along with the importance they might attach to priorities given to water uses in drought management plans and restrictions.

7.3 Illustrations

7.3.1 Monetary values of river flow improvements

Improved flow conditions for rivers have been estimated in a limited number of studies.

- Four studies on the economic values of improved river flows are available from the United Kingdom. Hanley et al. (2006)[313] estimate that households are willing to pay between 4 and 5.7 Euro per household per reduced month of low-flow conditions and between 31 and 47 Euro per household per year for improvements in river ecology. Improving low-flow conditions in rivers in South-West of England was estimated at 68-71 Euro per household per year in a study by ERM (1997)[314]. In another study in Southern England[315], respondents valued their visits to river sites for recreational use for different flow regimes from 1.6 Euro and 4.5 Euro per visit for the low-flow regime conditions to 5.9 and 8.4 Euro per visit for improved flow conditions for the Wey River and Misbourne River, respectively – leading to a value for river flow improvements of

[313] Hanley, N;. Wright, R.E.; Alvarez-Farizo, B. (2006): Estimating the economic value of improvements in river ecology using choice experiments: an application to water framework directive. Journal of Environmental Management 78, 183-193.

[314] ERM. (1997): Economic Appraisal of the Environmental Costs and Benefits of Potential Solutions to Alleviate Low Flows in Rivers: Phase 2 Study, report produced for the Environment Agency, South West Region, March 1997.

[315] House et al. 1994. cited in: VITO. (2007 draft): (Cost Benefit Analysis on the implementation of the Water Framework Directive including a specific focus on agriculture. Draft final Report Draft.

2.9 Euro and 2.5 Euro per visit. Finally, the benefits from enhancing river flows were estimated at ranging from 12.7 to 24 Euros per household (1993 prices).

- A study in the Cidacos catchment in Spain also provides results on the values of river flow improvements[316]. An improvement by 12% in river flows resulting from the implementation of water saving measures in different sectors, combined with improvements in water quality, was assumed to be sufficient to bring the Cidacos river to good ecological status in line with the requirements of the WFD. Using a combination of choice modeling and participatory techniques similar to "citizens' jury", the study estimated the value of ecological improvements resulting from improvements in river flows at between 4.8 and 7.8 Euro per household per year. In addition, the improvements in water supply guarantees (for urban users and agriculture) were estimated at between 3.2 and 6.1 Euro per household per year.

- A recent study by Martin-Ortega et al (2007) gives an estimation for the Guadalquivir River ranging from 32 Euro to 39 Euro per household per year based on a contingent valuation survey[317].

7.3.2 Savings in water bills for the household sector

There are numerous examples of reductions in household water bills resulting from the implementation of water saving measures. In the Gironde region (South-West of France), for example, the impact of different water saving measures on household demand has been estimated at 60 m^3 per year (from 155 m^3 per year to 95 m^3). This would lead to a reduction in a household water bill by 240 Euro per year. The impact of different water saving measures for individual houses was also monitored for different actions effectively implemented in the Gironde region[318]. For example:

- Installing water saving devices for taps, showers and toilets in a holiday house close to the sea, occupied on average by 7 persons for 40 day per year, led to a 37% reduction in water demand (from 59 m^3/year to 37 m^3/year). This represented a reduction in the water bill of 140 Euro /year as compared to total costs of equipment of 296 Euro tax inclusive (pay-back period of around two years)

- Changes in the irrigation system of a 50 m^2 lawn (automatic operation of the irrigation system linked to a rain-gauge to adapt irrigation to crop irrigation requirements) led to a reduction of water quantities for irrigation from 38 m^3/year to 16 m^3/year. This has led to a reduction in water bill of 55 Euro /year for an investment of only 74 Euro (pay-back period of less than 2 years).

As mentioned above, water savings can lead to energy savings as well. It has been estimated, for example, that each household in the US could save around $132 per household/year or around 26% of its water and sewer bill[319]. Taken at the US level, this would save around $17 billion per year in water and sewer bills alone. As water supply and treatment facilities consume around 50 billion kWh per year, water savings will also entail

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[316] Álvarez-Farizo, B.; Hanley,N.; Barberán, R.; Lázaro, A. (2007): Choice modeling at the "market stall": Individual versus collective interest in environmental valuation. Journal of Ecological Economics.

[317] Martín-Ortega, J.; Berbel, J.; Brouwer, R. (2007): Beneficios y costes ambientales del uso del agua Una estimación en aplicación de la Directiva Marco del Agua al Guadalquivir. Working paper for the 2007 Spanish Agricultural Economist Congress. Albacete.

[318] http://www.jeconomiseleau.com/.

[319] http://www.epa.gov/watersense/water/benefits.htm.

energy savings. It is estimated that if 1% of American households retrofited their houses with water-efficient fixtures, the country would save 100 Million kWh of electricity per year (equivalent to removing 15 000 vehicles from the road for one year) and reduce its greenhouse gas emissions by 75 000 tons of greenhouse gases.

Illustration 93

Liverpool[320]

UU, the local drinking water supply company, currently supplies Liverpool with 41 610 Ml of water per year. Using the data from UU, Liverpool homes consume 27 046.5 Ml of water, which is 65% of the total supplied. Within the home, toilets consume 8 925.34 Ml of water per year, 33% of household consumption.

For the purpose of a scenario for reducing the water consumed by toilets, an assumption is made that all homes have one toilet, which is fitted with a 9 litre capacity cistern. In order to achieve a third reduction in toilet water consumption, all 9 litre capacity cisterns must be replaced with 6 litre capacity cisterns.

This would mean that the present toilet consumption in Liverpool (8 925.34 Ml) would fall by 2 945.36 Ml by 2010. In addition 736 340 kWh of energy would also be saved. Importantly, the on going savings by 2010 would be 16 204 Ml of water, over 4 GWh of energy, and a reduction of 2 126.72 tonnes of CO2 emissions.

Despite this potential to conserve water, save energy and reduce CO2 emissions, there is a major obstacle to achieving these targets – cost. At issue is whether UU should give away 'save-a-flush' devices (which save on average 8 litres of water per device) or whether the Liverpool Council or the government should take on cost responsibilities. For example, the Council could be proactive by undertaking a replacement programme on the properties currently under their ownership. Alternatively, the planning department within the Council could play a leading role by insisting that all new developments must be fitted with the smaller cistern.

Data analysed for the Aquitaine region[321] show that water savings of 45 m^3 per year could be achieved for a 2 member household. This would mean a reduction in water bill of 122 Euro /year. At the same time, reductions in the household energy consumption would be expected at around 1 013 kWh per year, equivalent to a reduction in water bill of 70 Euro per year. In total, this would mean cost savings of nearly 200 Euro /year for a two member household.

7.3.3 Savings in water bills for the industrial sector[322]

In general, the financial savings from water savings are higher for industries connected to the domestic water supply network than for industries having their own abstraction facility (the majority of industrial users and the bulk of industrial water demand); abstraction costs are lower than unitary water tariffs from the network. Examples of savings that took place in the Gironde region (South-West of Franc) help to assess the magnitude of water savings and reductions in water bills or abstraction costs[323].

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320 Barett J.; Scott A (2001): An Ecological Footprint of Liverpool: Developing Sustainable Scenario - A Detailed Examination of Ecological Sustainabiliy, Stockholm Environment Institute & Sustainable Steps Consultants.

321 Talpaert, I. (2005): Inventaire des matériels hydro-économes. Centre Régional d'Eco-énergétique d'Aquitaine.

322 The examples listed below are summarised in greater detail in section 5.3 Industry.

323 For both examples, see http://www.jeconomiseleau.com/.

- Prodec Métal specialises in surface treatment with nickel, chrome, precious metals etc for the aeronautic industry and for goldsmiths. Since 2000 the company has grown considerably and its annual water consumption amounts to 20 000 m^3 per year. Through water savings measures, such as investing in a close-circuit water system and rainwater harvesting the company now uses only 2 000 m^3 per year for its internal domestic uses. Additionally, water abstraction charges have decreased by 27 000 Euro per year With total investment costs of 700 000 Euro , the payback period is estimated at 12 to 15 years.

- SMURFIT Cellulose du Pin specialises in the production of kraftliner paper. By installing aero-cooling towers to recycle wastewater and monitoring flows to optimise water use, the company has reduced its water use per ton of paper produced from 52 m^3 to 20 m^3. This water savings has resulted in cost savings of 6Euro /ton of paper produced. With total investments of 5 Million Euro, the payback period is slightly higher than 2 years.

As illustrated in the industry sector sub-chapter, water saving measures have led to reductions in water bills sufficient enough to justify required investments. In many cases, short payback periods are reported, stressing the financial interest of companies in water saving investments. With water prices expected to continue to increase in most European Member States, this situation is likely to prevail in the future.

It is important to stress that the estimation of total financial gains resulting from investments in water saving technology is rather difficult for the industry sector. Indeed, financial implications cannot be accounted for many of the water saving investments significantly impacting wastewater discharges. As illustrated above, it is often the need to comply with wastewater discharge regulations that is the main driver explaining investments in water saving technology and (the often very significant) reduction in water abstraction from industrial operators. Finally, savings in energy bills are also expected for the industry sector similar to what has been illustrated for the household sector in the previous sub-section.

Using ETC/IW (1997)[324] and OECD (1999)[325] data on industrial water consumption in selected EU countries, and applying a 25% water saving factor (which seems very conservative based on the different data provided above in the industry sector sub-chapter), an attempt was made to estimate expected reduction in water costs (be it from reduction in water bills or direct abstraction costs) at larger scales. The main results are presented in Table 48. Overall, the implementation of water saving technology in the 7 countries selected would lead to a reduction in industrial water consumption of 4 770 Million m^3 per year – equivalent to a total reduction in water costs of 1 020 Million Euro. The largest share of these savings would accrue to the chemical sector.

[324] ETC/IW (1997): Questionnaires to National Focal Points (Unpublished) – cited in: European Environment Agency (EEA). 1999. Sustainable water use in Europe. Part 1: Sectoral use of water. EEA, Copenhagen.

[325] OECD (1999): Tarification de l'eau à usage industriel dans les pays de l'OCDE.

Table 48: Potential water saving (Million m³) and equivalent savings in water costs (in Million Euros) for the industrial sector in selected EU countries

	Current Industrial consumption (ETC/IW, 1997)	Potential water savings per sector													
		Chemical		Steel and Iron		Pulp and paper		Food and drinks		Mining		Oil and petroleum		Textiles	
		M m3	M Eur	M m3	M Eur	M m3	M Eur	M m3	M Eur	M m3	M Eur	M m3	M Eur	M m3	M Eur
Belgium	210	15	3	27	6	6	1	2	0	9	2	n.a	n.a	n.a	n.a
Finland	1111	79	17	27	6	160	34	3	1	3	1	3	1	0	0
Germany	6475	927	198	194	42	79	17	n.a	n.a	505	108	n.a	n.a	n.a	n.a
Italy	7980	1205	258	263	56	226	48	257	55	n.a	n.a	48	10	147	31
Netherlands	507	119	25	14	3	2	0	9	2	0	0	32	7	0	0
Portugal	241	5	1	5	1	13	3	4	1	2	0	n.a	n.a	28	6
Sweden	1479	141	30	84	18	126	27	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
	Total	2491	533	614	131	612	131	275	59	519	111	83	18	175	37

7.3.4 Avoided costs of alternative sources of water

There is large diversity in the total and unitary costs of new investments for capturing new sources of water.

- In coastal areas of Spain or on islands such as Malta or Cyprus, saving water can lead to reduction in operation of desalination plants or in avoiding building new plants. Costs per unit of water for new desalination plants are highly variable, for example in Malta costs are cited at 0.4 Euro per m^3. Thus, every cubic meter of water saved leads to a potential saving of 0.4 Euro per m^3. However, significantly higher costs are found in the literature, as high as US$2.5 per m^3 for desalination plants in Australia[326], which would imply that the avoided cost figure of 0.4 Euro / m^3 is a conservative estimate. At the same time, this measure has the potential to save energy and limit greenhouse gas emissions. Indeed, desalination plants are energy demanding; for typical reverse osmosis and large thermal distillation plants around 44% to 60% of their operating costs are associated with energy[327]. With seawater desalination energy demand ranging from 3 to 5 kWh per m^3, avoiding the production of one cubic meter of desalinised water implies saving between 1 to 5 kg of CO_2 per m^3 (depending on the energy mix for producing electricity). As an illustration, the 500 000 m^3/day reverse osmosis plant proposed for Sydney, Australia would have annual greenhouse gas emissions equivalent to putting an additional 220 000 cars on the road.
- In other regions of Europe, new storage is often considered as “the” alternative (or sometimes priority). The Charlas reservoir in the South of France or the Diga di Ravedis in the Province of Pordenone in Italy (already under construction) are illustrations of such options. The investment costs of these dams are 256 Million Euro and 150 Million Euro, respectively. Thus, not building these dams represents significant savings in financial resources – and potentially also reduces future financial burden on end-users. The case of Breña in Guadalquivir, probably the last large dam planned in Southern Spain, has a full cost recovery for financial cost of 0.06Euro /m^3 (including interest on capital), which also illustrates potential savings that would be obtained for not building the dam.

326 WWF (2007): Making water - Desalination: option or distraction for a thirsty world?

327 WWF (2007): Making water- Desalination: option or distraction for a thirsty world?

- Transferring water between river basins is another supply-based option for addressing water scarcity. Many discussions took place around the Ebro water transfer in Spain a few years ago. The synthesis of the costs of different alternatives made show that the water saving measures would cost around 0.12 to 0.21 Euro /m^3 of water saved. Costs of the Ebro transfer were estimated at between 0.3 to 0.7 Euro /m^3 (depending on different studies) – in any case higher than the costs of water savings[328].

- Re-use of wastewater can also be considered as alternative water source, – although limited to some uses and situations. Re-use of wastewater can require additional treatment costs and facilities for supplying re-use water to potential users (e.g. irrigation of golf courses and garden areas, irrigation of some crops in agriculture, supply to grey-water systems in hotels and public buildings, etc), leading to additional distribution costs. Average treatment costs of re-use water (without considering wastewater treatment costs charged to polluters) are highly variable depending on the wastewater use and the purpose of use. Costs between 1 and 20 US $ per m^3 (0.75 Euro to 15 Euro per m^3) for re-use in an office building can also be found in the literature[329].

- Rainwater harvesting is another alternative source of water that can be taped for enhancing water supply to water users. Average costs of rainwater harvesting systems have been estimated at 2 to 5 Australian dollars (1.3 to 3.3 Euro) per m^3.[330]

It is important to stress that the comparison between measures cannot be limited to cost per unit of water. Indeed, different alternatives have different levels of water supply reliability that is not accounted for here. Furthermore, re-use of treated effluent and rainwater harvesting are also measures that can reduce the pressure on natural water sources (rivers, aquifers) and help enhance their ecological and quantitative status. Finally, saving water also leads to reduced (avoided) costs for wastewater treatment infrastructure, which need to be accounted for as illustrated in the box below.

Illustration 94

Wastewater capital deferral in Barrie (Ontario, US)[331]

In 1994, the city of Barrie (Ontario) planned a new surface-water supply at a cost of $27 Million (Canadian dollars). As a result, wastewater flows began reaching existing sewage and treatment capacity and a $41 Million investment in sewer and treatment was envisaged. To help ease this water burden, the city developed a water saving partnership and offered rebates to citizens for replacing inefficient showerheads and toilets. Between 1995 and 1997, 15 000 high-efficiency toilets were distributed – leading to a 62 l/person/day reduction in water demand. Thanks to the water savings of the conservation programme, a 5 year deferral in the capital sewage and treatment expansion project was made possible. Furthermore, the costs of the upgrade were scaled back to $19.2 Million – for a net saving of $17.1 Million after accounting for the costs of the conservation programme.

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[328] WWF (no date): A synthesis of quantified alternatives for the Ebro water transfer.

[329] United Nations Environment Programme (2006): Water and wastewater reuse – An Environmentally Sound Approach for Sustainable Urban Water Management.

[330] MJA (2007): The economics of rainwater tanks and alternative water supply options. Prepared for the Australian Conservation Foundation, Nature Conservation Council and Environment Victoria, April 2007.

[331] United States Environmental Protection Agency (2002): Cases in water conservation: how efficiency programs help water utilities save water and avoid costs.

Illustration 95

Ashland, Oregon Small Town, Big Savings[332]

In 1991, the city council adopted a water efficiency program with four major components: system leak detection and repair, conservation-based water rates, a high-efficiency showerhead replacement program, and toilet retrofits and replacement. The city estimated that these programs would save 500 000 gallons of water per day at a cost of $825 875—approximately one-twelfth the cost of the proposed dam—and would delay the need for additional water-supply sources until 2021.

Implementation of the program began with a series of customer water audits, which in turn led to high-efficiency showerhead and toilet replacements and a $75 rebate program (later reduced to $60). Ashland also instituted an inverted block rate structure to encourage water conservation. Recently, Ashland began offering rebates for efficient clothes washers and dishwashers (including an energy rebate for customers with electric water heaters). The town provides a free review of irrigation and landscaping, as well.

Implementation of Ashland's Water Conservation Program began in July 1992. By 2001, almost 1 900 residences had received a water audit. Almost 85 percent of the audited homes participated in the showerhead and/or toilet replacement programs. Ashland has been able to reduce its water demand by 395 000 gallons per day (16 percent of winter use) and its wastewater flow by 159 000 gallons per day. An additional benefit of the program has been an estimated annual savings of 514 000 kilowatt-hours of electricity, primarily due to the use of efficient showerheads.

As indicated above, when presenting information on desalination, there are large differences in the energy efficiency of different options discussed here. Research in the Sydney area (Australia) stressed, for example, that average unitary costs per m^3 for rainwater harvesting and for desalination plants were of the same order of magnitude[333]. However, rainwater tanks were five times more energy efficient (1 MWh per Million m^3 of water produced for rainwater tanks versus 5 MWh per Million m^3 of water for desalination). Thus, in particular in the context of climate change, it is more important to assess the energy implications of different water management alternatives, in particular supply-based alternatives aiming at capturing new sources of water.

7.3.5 Economic benefits from water re-allocation

Water re-allocation can take place within the agriculture sector – between farmers from the same irrigation systems or between irrigation systems.

The comparison between the gross margin per unit of water consumed between different crops helps identifying potential benefits that would result from re-allocating water between farming systems specialised in different cropping patterns. Building on the information provided in the Article 5 reports for river basin districts in Spain[334], one can estimate that the re-allocation of one m^3 from low-value cereals to vineyards would lead to an increase net

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[332] United States Environmental Protection Agency (2002): Cases in Water conservation, How Efficiency Programs Help Utilities Save and Avoid Costs, available at: www.epa.gov/watersense/docs/utilityconservation_508.pdf.

[333] MJA (2007): The economics of rainwater tanks and alternative water supply options. Prepared for the Australian Conservation Foundation, Nature Conservation Council and Environment Victoria, April 2007.

[334] Ministerio de Medio Ambiente (2007): El agua en la Economia Española: situacion y perspectivas. Documento de Trabajo, Ministeria de Medio Ambiante.

margin for agriculture by 0.5 Euro /m^3. An additional 0.65 Euro /m^3 would be gained if the re-allocation takes place between cereals and vegetable production.

Overall, this stresses the significant economic gains that could be obtained if water allocation between crops is modified. Clearly, however, there are other farm and market constraints that would limit the possibility for such transfers and economic gains. To account for such farm constraints, economic modeling was performed to estimate the economic benefits that would arise from trading water quotas/water use rights in irrigation systems in Spain and Italy[335]. In situations with no transaction cost imposed on irrigators and average water availability of 1 000 m^3 per hectare, water trading would lead to increases in average gross margins from 8% (+ 95 Euro/ha) to 30% (+ 120 Euro/ha) for the Spanish and Italian irrigation schemes considered, respectively. These expected gains would be lower for higher transaction costs and water availability. Economic modeling has also been applied to the case of irrigation in the Charente River basin[336]. Increase in farm income resulting from water re-allocation among farm types has been estimated at 0.7% of total farm income of the area.

Two other examples of water markets in Spain can be referred to, both involving a transfer from extensive irrigation to coastal protected high-value horticulture: these are the Tajo to Segura basin (by using Tajo-Segura transfer system) and Guadalquivir-ALmeria (Negratin-Almanzora transfer system). Data for 2007 show a market price of around 0.18Euro /m^3 (that is the price at ‘source’ level in the exporting basin). To estimate the price in the receiving basin/irrigation systems, transfer cost of around 0.06Euro /m^3 should be added. The total price would still be below the above given estimate for desalination plants of 0.40Euro /m^3, therefore stressing the economic interest in water transfers compared to desalination.

Water re-allocation and water trading between water users and economic sectors has also been reported in the literature[337]. It has received little attention in Europe; water trading mainly takes place in the United States of America and in Australia. Net economic benefits of 10 US$ per m^3 are reported for trading in the Rio Grande Valley from agriculture to the urban sector[338]. Benefits ranging from 1.65 US$ to 285 US$ per m^3 (1995 values) have also been reported in the literature for Chile[339].

7.3.6 Economic benefits from a drought management plan

The DMP is a real time management tool for water authorities, and the costs of the plan itself involved are of administrative character. Obviously once the drought measure starts operating (according to the protocol alert), the cost are shared by all the users. Its aim is to re-allocate water according to water user priorities to minimize economic impacts.

The impacts (and costs) of drought can be classified into one of three principal types:

- Economic losses that range from direct losses in agricultural and agriculture related sectors (including forestry and fishing), to losses in the manufacturing-, energy-,

[335] Pujol J., Raggi, M. Viaggi, D. (2006): The potential impact of markets for irrigation water in Italy and Spain: a comparison of two study areas. Australian Journal of Agricultural and Resource Economics, 50, pp.361-380.

[336] Montginoul, M.; Strosser, P. (1999): Analyser l’impact des marches de l’eau. Economie Rurale 254/Novembre-Décembre 1999.

[337] Montginoul, M.; Strosser, P. (1999): Analyser l’impact des marches de l’eau. Economie Rurale 254/Novembre-Décembre 1999.

[338] Chang, C.; Griffin, R.C, (1992): Water marketing as a reallocative institution in Texas. Water Resources Research, 1992, 28(3), pp.879-890.

[339] Hearne, R. (1995): "The Market Allocation of Natural Resources: Transactions of Water-Use Rights in Chile." Phd. Dissertation. University of Minnesota. June, 1995.

transportation sector and recreation. Wider economic losses include added unemployment or loss of revenue to local, state, and federal government

- Environmental losses include damages to plant and animal species, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; and soil erosion. These losses are difficult to quantify, but growing public awareness and concern for environmental quality has forced public officials to focus greater attention on them.

Impacts on society mainly involve public safety, health, conflicts between different water users.

As with all other natural hazards, the economic impacts of drought are highly variable within and between economic sectors and geographic regions, producing a complex assortment of winners and losers with the occurrence of each disaster.

The main objectives of these Plans are to anticipate droughts, foresee solutions to satisfy priority demands and reduce socio-economic and environmental impacts.

In the case of Spain, the development of Drought Management Plans (DMPs) started in 2002 to enforce article 27 of the 2001 National Hydrological Plan law, which indicated that River Basin Authorities had to elaborate Special Action Plans for Alert Situations and Eventual Droughts. Works finalised through 2006, and the resulting DMPs were launched on March 2007 for all the river basins coordinated through the Ministry of Environment.

The definition and results of the drought management plan (DMP) in Spain include a theoretical implementation cost as of the Ministry´s general instructions. However, in the current DMPs do not have details on any costs of the plan as these are included in the general expenses of the Water Agency (e.g. Confederacion Hidrografica del Guadalquivir - CHG).

Analysis from 1996 of the last severe drought in Guadalquivir river basin in Southern Spain (1992-95) concluded that the urban (domestic and industrial) saving measures obtaining 30% reduction by supply reduction (daily interruptions of supply) plus increase in running cost because of decrease in quality for human consumption and need for new water sources (deeper wells, longer transport networks), estimations results indicates an 25% increase in cost for water utilities during the 3 years shortage. Furthermore, water for irrigation was on average 800 m^3/ha for years 1992 to 1995 (while average for 1981-91 was around 6,000 m^3/ha), which corresponds to 3,000 Million euros during this period. Environmental costs are difficult to estimate but the losses for fisheries and wetlands were quite severe and needed some years of normal rainfall to recover.

Consequently it can be concluded that the cost of ‘designing’ a DMP as a preventive tool is small (consultancy and own personnel time), specially in water scarce area where water use efficiency is high.

Illustration 96

Economic cost of the drought event 2003

The costs of the drought that hit Europe in 2003 and led to significant damages have been estimated by the Ministère de l'Ecologie et du Développement Durable in France[340]. The different costs estimated include costs linked to problems of access to water resources; increased use of mineral (bottled) water; additional investments to connect drinking water network and ensure minimum supplies to all; drying out of soils that impact on building structures; losses in agriculture production and income; negative impact on the sanitary conditions and biodiversity of forests.

Overall, the costs of the 2003 drought have been estimated at 2.8 billion Euro for France - as compared to average annual costs of 500 Million Euro for drought events between 1989 and 2003. These figures exclude the costs imposed on hydro-power, energy production and on the environment, thus total costs are expected to be significantly higher.

A particularly critical aspect for many sectors of the economy was the extremely low water level of numerous European rivers under the 2003 drought, in which the lowest values of all time were often measured. This meant that normal shipping was impossible for a long time and a numerous electricity-generating plants had to cut back on their output because there was either not enough "water power" or not enough cooling water to stay within the discharge temperature limits. Electrical power was therefore in short supply and the price rose; occasionally the power supply failed altogether. Even in sectors that usually benefit from nice summers like open-air entertainment and tourist attractions, there was a shortfall in daytime receipts because it was just too hot to make the effort and go. The owners of cafés, ice parlours, garden restaurants, beer gardens, and swimming baths did a roaring trade though. [341].

It is interesting to stress that the frequency of severe droughts is expected to increase in the coming years as a result of climate change, resulting in higher average annual costs of droughts and thus providing increasing rational for drought management plans.

With the implementation of drought management plans and a widespread application of water saving technologies, these costs would be (at least partly) avoided and represent the benefits of these plans. In case of restrictions of water use DMPs can be used also to minimize the losses by allocating water to the highest values minimizing the economic damages

Illustration 97

Effects of climate change on the economic situation of farmers

A simulation at the scale of the Midi-Pyrénées region, performed by INRA economists[342], has provided some indicators concerning the effects of climate change on the economic situation of farmers. In the short term (i.e. under a given cropping system) the economic cost generated by episodes of drought could be high for the farmer.

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340 Ministère de l'Ecologie et du Développement Durable (2007): Evaluation des coûts des sécheresses au niveau national. Evaluation Newsletter N°8, Février 2007, Direction des Etudes Economiques et de l'Evaluation Environnementale.

341 See Munich Re (2004): TOPICSgeo Annual Review. Natural catastrophes 2003.

342 INRA (2006): Sécheresse et agriculture Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau, available at http://www.inra.fr/les_partenariats/expertise/expertises_realisees/secheresse_et_agriculture_rapport_d_expertise.

For example, if the risk of having a dry year was multiplied by two (10 years of drought out of 33, instead of five initially), this resulted for the farmer in a 12% loss of profit. This loss will be even more marked if he is subject to water restrictions, but it will be more than halved in the longer term if the farmer can adjust his choice of crops In cases where the farmer could not anticipate bans on irrigation during a period with the lowest water levels during dry years, this loss could reach 54%. It thus seems important for the authorities to set up early warning systems for droughts.

7.3.7 Environmental benefits from a improved irrigation efficiency

The review analyses of twenty two irrigation efficiency (IE) studies carried out in the Ebro River Basin show that IE is low (average IEavg= 53%) in surface-irrigated areas with high-permeable and shallow soils inadequate for this irrigation system, high (IEavg= 79%) in surface irrigated areas with appropriate soils for this system, and very high (IEavg= 94%) in modern, automated and well managed sprinkler irrigated areas.

The unitary salt (total dissolved solids) and nitrate loads exported in the irrigation return flows (IRF) of seven districts vary depending on soil salinity and on irrigation and N fertilization management, between 3-16 Mg salt/ha*year and 23 195 kg NO3 N/ha*year, respectively.

The lower nitrate loads exported from high IE districts show that proper irrigation design and management is a key factor to reduce off site nitrogen pollution. Although high IE's also reduce off-site salt pollution, the presence of salts in the soil or subsoil may induce relatively high salt loads (14 Mg/ha*year) even in high IE districts[343].

7.4 Conclusion

This section presented a series of illustrations on the possible benefits that would be obtained by implementing water saving measures and drought management plans at the European level. The available information is rather patchy and incomplete, and there are many areas where further work is required. Any attempt to extrapolate this information to the EU scale would be considered unfeasible.

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[343] Causapé, J.; Quílez y R. Aragüés, D. (no year) Environmental impact of irrigated agriculture in the Ebro River Baisn (spain) A review available at www.encoreweb.org/downloads/Archive/FLAP/Water%20Bassin%20Management/Aragon%20WorkShop/Causape_etal.doc.

8 Today's EU water saving potential- first indications

The present chapter investigates potential water savings for Europe as a whole. The complexity of the task and the uncertainties behind results are clearly recognised – this task being out of the scope of a short study as the one that has led to this report. However, using existing data and information presented in the different sub-sector chapters (i.e. for domestic, industry, agriculture, tourism and energy) combined with general information available on current and future water abstraction, first estimates have been computed and are presented in this section.

8.1 Technical saving versus maximum saving potential

Beside the difference between wet and dry savings (see section 3.1) there is also a need to distinguish between the maximum saving potential and the technical saving potential. The maximum saving represent the level of saving that can be achieved if the best technologies would be applied and humans would change their behavior to a maximum. For examples, Gleick (1996) concluded that, on average, basic needs (for drinking water, water for human hygiene, water for sanitation services, and water for household needs to prepare food) can be met at 50 litres per person per day, without large-scale human misery[344]. About 50 litres per day and person are also the minimum water quantity needed for domestic use in emergencies according to the World Health Organization[345] However there is little doubt that a reduction of an average water use from 150 and more l /persona and day to the minimum amount of 50l /person and day which would represent the maximum saving potential would require drastic changes in daily lives of European citizens. Further it would also require also huge changes the drinking and waste water sector as it would need new infrastructure in waste water treatment.

There is little doubt that these maximum savings would change our way of live or production patterns in several cases dramatically and European society would not accept such changes. Within this study the baseline was set on the current level of living and without any changes in production patterns. In other words we focus only on the potential saving that comes from technical improvements (e.g. increasing efficiency) without or just negligible changes in human behaviour or production patterns (e.g. turn off water taps when brushing teeth).

Nevertheless in some areas the achievement resulting from technical savings will not be sufficient in mitigating water scarcity and additional measures are required. Such additional measures might need a change in human behaviour (e.g. reduction in showering time), production patterns (change of crop patterns) or service provision (e.g. reduction of gulf course in some areas). The saving potential from such non-technical measures is not included in the calculations

In the following only the **today's** technical water saving potential is estimated. In other words, only the savings that can be achieved with current technologies are calculated against the current water demand. It should be noted that the estimations made are based on highly inconsistence data including large uncertainties. So the results obtained have to be used with caution and in several cases more detailed investigations are needed. Nevertheless where possible estimations have been broken down to the larger European regions as the saving

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[344] Gleick, P.H. (1996): "Basic Water Requirements for Human Activities: Meeting Basic Needs." *Water International* 21: 83-92.

[345] WHO (2005): Technical Notes for Emergencies Technical Note No. 9 Draft revised: 7.1.05, available at http://wedc.lboro.ac.uk/WHO_Technical_Notes_for_Emergencies/9%20-%20Minimum%20water%20quantity.pdf.

potential differs widely. It is also important to mention that cross sector linkages on water use and consumption are also not considered.

Further the future water demand scenario developed by Flörke et al. (2004)[346] is used to estimate the savings that can by achieved by 2030[347]. It is important to recognise the assumptions made in baseline scenario (see section 4.2) where water savings are only taken into account without policy intervention. In this scenario just the natural rate of implementation of water saving devices in households or in industry which are partly driven by current legislation such as IPPC and partly driven by technological development that lowers water use is taken into account. This does not consider the maximum savings that can be achieved from a technical point of view and need policies helping to remove some constraints or making things obligatory for all. For example as part of baseline prepared by Flörke et al. (2004)[348], only IPPC related industries invest in water saving devices but the potential for saving is much wider if policy action requires that all industry will have to invest including small ones.

8.2 Water savings in the agriculture sector

When looking at the water saving potential in agriculture, there is a need to distinguish between savings that can be achieved due to technical measures assuming that crop pattern remain stable or by chancing crop patterns. Changing crop patterns has the highest potential in savings as for example the production of high water consuming crops such as maize could be reduced to a certain level. Such a reduction can be achieved due to market incentives (water pricing), changes in human behaviour (less food consumption or shift to other types of food) or restrictions. However, changes in production patterns are difficult to estimate as these changes might also have side effects increasing water consumption in other areas. In the following only the water saving potential due to technical measures is assessed, taking current crop patterns as a basis.

When water is applied to the fields only a part of it is used by the plant and evapotranspirates. The remaining water serves to leach salts from the field soils, leaks or evaporates unproductively from the irrigation canals, or runs off. This amount depends on irrigation technology and management. In order to calculate the potential savings it is assumed that the part of water used by the plants remains stable but the remaining water can be reduced by improving irrigation technologies and management. Putting this concept into practice the following formulas are used:

(2) $A_{saving} = A_{current} - A_{optimum}$

With

$A_{optimum}$ is the minimum water that needs to be abstracted for irrigation to ensure a optimum growth

$A_{current}$ is the current water abstraction for irrigation

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346 Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004

347 Please note that the data on water use for each sector might differ from the figures presented in Table 1. This can be explained by the fact that Flörke et al. (2004) used also national data and the inconstancy of the existing data depending on the source. See also Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004

348 Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004

A_{saving} is the potential water saving

$A_{current}$ can be calculated with the following formula:

(3) $A_{current} = IrA \times IWR_{current} / Ec_{current} \times (\% \text{ surf gravity}_{current} / Ea \text{ gravity} + \% \text{ surf sprinkler}_{current} + \% \text{sprinkler} + \% \text{ surf drip}_{current} / Ea \text{ drip})$

With

$A_{current}$ is the current water abstraction for irrigation based on Eurostat

$IWR_{current:}$ average Irrigation Water requirements of crops. This number is unknown for the irrigated area, as no detailed information on the current crop patterns is available. As the other variables in the equation are roughly know a theoretical value for IWR can be calculated by converting the equation.

IrA: Area equipped for irrigated based on the FAO database

Ea: Current Application efficiency

Ec: Current conveyance efficiency

% surf $X_{current}$: Percentage of the total irrigated area irrigated with a given method

To calculate $A_{optimum}$ a the following formula is used:

(4) $A_{optimim} = IrA \times IWR_{current} / Ec_{current} \times (\% \text{ surf gravity}_{current} / Ea \text{ gravity} + \% \text{ surf sprinkler}_{current} + \% \text{sprinkler} + \% \text{ surf drip}_{current} / Ea \text{ drip})$

With

$IWR_{current}$ From the calculations above (2)

IrA: Area equipped for irrigated based on the FAO database

Ea: Estimations on the potential maximum Ea that is possible for the crop pattern as indicated in Table XX. It has to me noted that drip irrigation with an application efficiency of 90% is currently the most efficient technology but for some crops, it is currently technically not possible to implement drip irrigation (cereals in particular). In that case sprinkler system is the most efficacy system available, and it has an application efficiency of 75%.

Ec: With the maximum conveyance efficiency that is technically possible

% surf $X_{current}$: Percentage of the total irrigated area irrigated with the method X based

Using data and information on area equipped for irrigation (reference year between 1999 & 2005 – see Table 10), combined with information on the share of irrigated areas for some countries (14 countries in total) presented in Table 4, an attempt has been made to estimate today's potential savings in the agriculture sector that would take place if different water saving measures would be implemented. To fill current gaps in the share of irrigation technologies, countries were split into three groups (Western and Northern Europe, Central and Eastern Europe and Southern Europe) – and averages for each group based on available information were then used for countries for which the information was missing. The following table summarizes how information has been used to fill these gaps. It is important to note that the information on the share of different irrigation technologies is 10 old, meaning that potential water savings calculated might be slightly over-estimated (indeed, additional shifts in irrigation technologies that would have taken place during the last 10 years are already accounted for in the water abstraction values obtained for more recent years.

Table 49: Methodology to close gaps in information

Groups	Countries included in the group	Countries with available data on share of irrigation technologies	Average share of irrigation technologies in the group based on available data			Countries for which average shares of the group have been used
			Gravity	*Sprinkler*	*Drip*	
Central & Eastern Europe	Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia	Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovak Republic,	26.7%	72.7%	0,6%	Estonia, Latvia, Lithuania, Slovenia
Western & Northern Europe	Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxembourg, Sweden, The Netherlands, United Kingdom	Denmark, Germany, Sweden, United Kingdom	0%	96%	4%	Austria, Belgium, Finland, Ireland, Luxembourg, The Netherlands,
Southern Europe	Cyprus, France, Greece, Italy, Malta, Portugal, Spain	France, Greece, Italy, Portugal, Spain	46.5%	41%	12.5%	Cyprus, Malta

Conveyance efficiencies were estimated based on information provided by the University of Cordoba and presented in the agriculture sub-chapter (see 5.1.2.1).

To assess the potential for water savings, the different assumptions were made:

- Improvements in conveyance efficiency can go up to a 90% level on average for all countries;
- Improvements in application efficiency will take place by shifting to more efficient irrigation systems (sprinkler, drip) based on existing share of different irrigation technologies, types of crops in current cropping pattern and potential for using the different technologies. The targets that were chosen for the assessments of water savings were:
- For countries from Central & Eastern Europe, 0%, 95% and 5% for gravity, sprinkler and drip irrigation, respectively – apart for Romania and Bulgaria with a large gravity irrigation today for which values of 5%, 90% and 5% are proposed for gravity, sprinkler and drip irrigation, respectively.
- For countries from Western & Northern Europe, 0%, 95% and 5% for gravity, sprinkler and drip irrigation, respectively;
- For countries from Southern Europe, 5%, 70% and 25% for gravity, sprinkler and drip irrigation, respectively (to account for the larger share of vegetables and orchards for which drip irrigation can apply) – apart for France for which the values of 5%, 85% and 10% are chosen for gravity, sprinkler and drip irrigation, respectively, to account for the Northern-*cum*-Southern character of this country and for Italy for which the values of 5%, 60% and 35% are chosen to account for the already large share of drip irrigation (26%) in this country today.

The results of these calculations are presented in the following table. The main lessons that can be derived from these data are as follows:

- Today's potential water savings that would result from improvements in conveyance efficiency (e.g. via lining of earthern canals) and shifts to more efficient irrigation technologies (sprinkler and drip) are estimated at 14 520 Million m^3 per year for the irrigation sector in the EU-27. This is equivalent to 22% of total water abstraction;

- As expected, the largest share of water savings are obtained for Southern European countries where irrigation is clearly the largest abstractor. Overall, 98% of the estimated savings would come from this group of countries – with Italy and Spain alone accounting for two third of the total savings of this group/EU-27.
- Potential water savings in Northern & Western Europe are limited both in absolute (9 Million m^3 per year only) and relative (0.3% of today's water abstraction in this region) terms;
- Potential water savings in Central & Eastern Europe are mainly found in Bulgaria (542 Million m^3 per year or 23.9% of today's abstraction) and Romania (869 Million m^3 per year or a bit less than 5% of total abstractions)

Table 50: Today's water saving potential in the agricultural sector for European countries (base year: 2000)

Country	Area equiped for irrigation 1000 ha	Current water abstraction (2000) in Million m³	Current share of irrigation technologies (in % of irri. Area)			Today's conveyance efficiency (estimated based on Cordoba)	Average plant requirements m/m2	Optimum share of irrigation technologies (in % or irr. area)			Max. conveyance efficiency (target)	Water abstraction with water saving measures (in Million m³)	Relative share of water saving in % (2000)	Water savings Million m³ (2000)
			Gravity	Sprinkler	Drip			Gravity	Sprinkler	Drip				
Bulgaria	545	713	50	49	1	80	0,066479271	5	90	5	90	542	23,9%	170,7
Czech Republic	41	11	1	99	1	89,9	0,018747608	0	95	5	90	11	1,0%	0,1
Estonia	1	36	27	73	1	84,65	1,505677497	0	95	5	90	31	14,9%	5,4
Hungary	292	25	3	95	2	89,4	0,005695469	3	95	5	90	25	0,0%	0,0
Latvia	1	47	27	73	1	84,65	2,346641182	0	95	5	90	40	14,9%	7,0
Lithuania	4	7	27	73	1	84,65	0,086866009	0	95	5	90	6	14,9%	1,0
Poland	134	86	97	3	0	70,6	0,025209354	5	95	5	90	53	38,5%	33,3
Romania	2150	912	10	90	0	88	0,02701521	5	90	5	90	869	4,7%	43,1
Slovak Republic	225	65	0	100	0	90	0,0195	0	95	5	90	64	0,8%	0,5
Slovenia	16	7	27	73	1	84,65	0,024871892	0	95	5	90	6	14,9%	1,0
Central & Eastern Europe	**3409**	**1909**										**1642**		**261**
Austria	98	68	0	96	4	90	0,047044399	0	95	5	90	67	0,2%	0,1
Belgium	35	23	0	96	4	90	0,043821976	0	95	5	90	23	0,2%	0,0
Denmark	476	156	0	95	5	90	0,022364946	0	95	5	90	156	0,0%	0,0
Finland	104	50	0	96	4	90	0,032732669	0	95	5	90	50	0,2%	0,1
Germany	497	142	0	95	5	90	0,019506486	0	95	5	90	142	0,0%	0,0
Ireland	1,1	130	0	96	4	90	8,03081147	0	95	5	90	130	0,2%	0,2
Luxembourg	0,03	0,20	0	96	4	90	0,453020134	0	95	5	90	0,20	0,2%	0,0
Sweden	189	94	0	99	1	90	0,033716672	0	95	5	90	93	0,7%	0,6
The Netherlands	476	76	0	96	4	90	0,010842808	0	85	5	90	68	10,2%	7,8
United Kingdom	229	1896	0	95	5	90	0,563620418	0	95	5	90	1896	0,0%	0,0
Western & Northern Europe	**2104**	**2635**										**2627**		**9**
Cyprus	56	122	46	41	13	80,9	0,11538267	5	70	25	90	93	23,7%	29
France	2417	3120	10	85	5	88	0,08287621	5	85	10	90	2972	4,7%	148
Greece	1545	7600	53	37	10	79,4	0,249159667	5	70	25	90	5567	26,7%	2033
Italy	3892	25852	33	41	26	83,4	0,385873581	5	60	35	90	21357	17,4%	4495
Malta	1,6	20	46	41	13	80,9	0,659667312	5	70	25	90	15	23,7%	5
Portugal	792	6551	76	19	5	74,8	0,36593927	5	70	25	90	4193	36,0%	2358
Spain	3020	18089	60	24	17	78,9	0,295409377	5	70	25	90	12906	28,7%	5183
Southern Europe	**11723**	**61354**										**47104**		**14250**
Total	**17237**	**65898**										**51372**		**14520**

In addition to water savings because of investments in increasing conveyance efficiency and shifting to better technologies that are accounted for in the table calculations already proposed, some savings can be expected because of:

- Improvements in irrigation scheduling – the only illustration presented in the sub-chapter on agriculture refers to water savings of up to 30%. It is assumed that improved scheduling is already accounted for in water saving potential for drip and sprinkler, and that there is only 10% water savings additional that can be obtained from improved scheduling.
- Water savings can also take place because of reducing water supply to crops and apply deficit irrigation. Based on results presented in the agriculture sub-chapter, average water savings of around 20% are proposed. To compensate for an estimated yield decrease of 10% (a rather high yield reduction if we see the literature), we take the assumption that additional irrigated area is put in place to obtain the same total production. This means that deficit irrigation with no loss of production implies an increase by 11% of the irrigated area, leading to overall net water saving of around 10%.
- Reuse of treated effluent/wastewater is assumed to replace 10% of total agriculture water need – reducing freshwater abstraction by the same amount although not changing total water demand and crop water requirements.

Implementing these measures would lead to additional savings in the irrigation sector of 13 900 Million m^3 per year. Added to the 14 520 Million m^3 per year that would be obtained from improvements in conveyance efficiency and application efficiency presented above, we obtain total today's potential water savings in the irrigation sector of 28 420 Million m^3 per year or 43% of todays' total water abstraction from the irrigated agriculture sector.

Potential water savings for 2030 have been estimated building on results and data provided in Flörke et al. (2004)[349].

- This report uses for EU-30 figures of 119 902 km^2 of irrigated land and 99 593 Million m^3 per year for 2000, and 146 000 km^2 of irrigated land and 110 920 Million m^3 per year for 2030 (the abstraction data are coherent with the data used above for EU-27 as EU-30 includes Turkey with estimated abstraction for the agriculture sector estimated at 33 034 Million m^3 per year, Switzerland and Norway having marginal water abstraction for irrigation). The values for 2030 account for both structural and water use efficiency changes in the irrigated agriculture sector – and are equivalent to a +11.4% increase in total water abstraction for the sector;
- Limited improvements in water use efficiency (+0.4-0.5% per year depending on countries) are included in this baseline scenario of this study to account for changes of technologies and investments to reduce leakages. Total water use in 2030 without water use efficiency improvements can then be estimated at 122 190 Million m^3 per year.
- This implies that water savings that are part of the baseline for 2030 are equal to 11 270 Million m^3 or a bit less than 10% (9.22%) of estimated total water demand for the irrigated agriculture sector in 2030.
- Applying the same value of 43% of potential water savings due to improvements in conveyance efficiency, application efficiency, irrigation scheduling, application of

[349] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004

deficit irrigation and reuse of treated effluent, we can estimate 2030 potential water savings at 52 740 Million m^3 per year.

- As a bit less than 10% of potential savings will take place as part of the baseline scenario, this leaves 41 470 Million m^3 per year as potential savings that will require additional specific policy action.

It should be noted that the data used in this calculations on the relative importance of different irrigation technologies is several years old while improvements in irrigation systems would have taken place in several Member States. While this does not change the calculations for total water savings in 2030, it changes the share of water savings that are computed for today's situation.

The range of results from the calculations fits with estimations from other studies. Some authors (Causape et al. (2004)[350], and Luquet et al. (2005)[351], cited in Garrido (2005), p. 8[352]) estimate potential of approximately 35-40% reduction in water consumption in case a comprehensive pricing scheme would be introduced (that would clearly lead to investments in the different technological changes described above). They assume that these savings would be achieved without even changing cropping patterns or production method but just by increasing efficiency and avoiding leakage.

8.3 Water savings in the domestic and household sectors

As mentioned earlier there is a need to distinguish between household water consumption and domestic consumptions. The following section will assess the both sectors – domestic and household in different ways, considering the information available for each sector.

8.3.1 Water savings in households

The approach chosen is following two lines. Firstly we looked at different standards for water use in sustainable housing and compared this to the actual use and secondly we looked at the issues of leakage.

Water quantity targets for housing are not very common in Europe and recommendations for minimum water supply needs are not easily to find. However, some examples exist. In the UK the Code for Sustainable Homes has been introduced to drive a step-change in sustainable home building practice. It is a standard for key elements of design and construction which affect the sustainability of a new home. It will become the single national standard for sustainable homes, used by home designers and builders as a guide. It proposes standards for sustainable houses in terms of potable water use between 120l/p/d and 80l/P/d[353]. The UK Sustainable Development Commission has calculated a similar rate between 122 l/p/d and 92 l/p/d (see section 5.2.2 for detailed calculations). 100 l/p/d are also mentioned as an achievable value by the EU Environmental Technology Action Plan (ETAP) Water Issue Group[354]

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[350] Causape, J.; Quilez,D.; Aragues, R. (2004): Assessment of irrigation and environmental quality at the hydrological basin level - I. Irrigation quality. Agricultural Water Management 70: 195-209.

[351] Luquet, D.; Vidal, A.; Smith, M.; Dauzat, J. (2005): More crop per drop: how to make it acceptable for farmers? Agricultural Water Management 76:108-19.

[352] Garrido, A. (2005): Using good economic principles to make irrigators become true partners of water and environmental policies. OECD Workshop on Agriculture and Water Sustainability, Markets and Policies. November. Available at: http://www.oecd.org/agr/meet/water/ (restricted access).

[353] http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf.

[354] ETAP Water issue group (2003): Water issue group report, available at:

Comparing this to the average EU consumption of (150 l/p/d) the average for Europe water saving potential can be estimated between 18% (122 l/p/d) and 47% (80 l/p/d). From the data presented in Table 51 it comes clear that the water saving potential varies strongly among the EU Member.

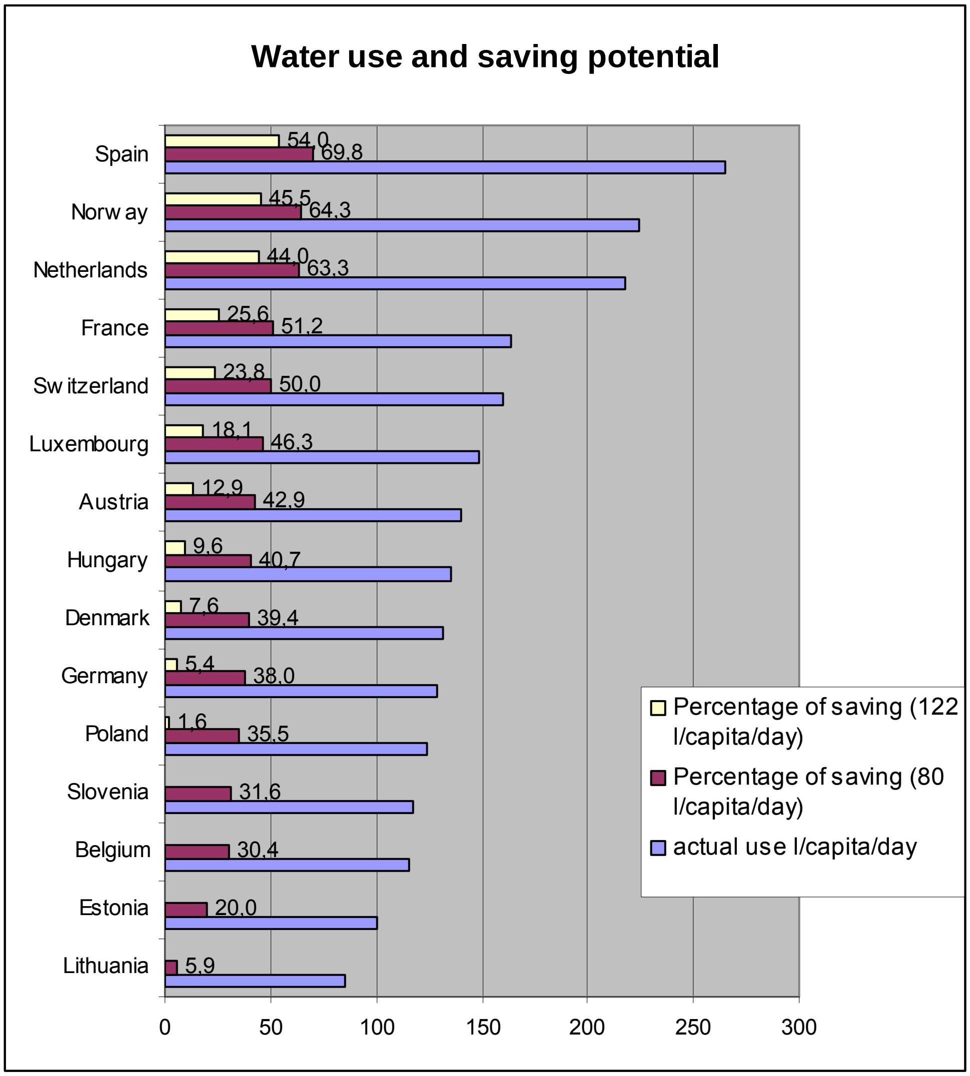

Table 51: Water saving potential for households in EU-MS (Own calculations based on Eurostat data[355])

8.3.2 Calculations of water savings for the domestic sector

The approach chosen for estimating the potential for water savings in 2030 builds on the report by Flörke et al. (2004)[356]. There a total population of 563 Million inhabitants for EU-30 in 2000 for a total water abstraction of 73 222 Million m^3 equivalent to an average of 130 m^3 per person per year is assumed. Values for 2030 are estimated at 587 Million inhabitants and 75 616 Million m^3 of water abstracted by the domestic sector or 128 m^3 per inhabitant and year. It is important to note here that values for the domestic sector used in this study do include domestic water demand as analysed above but also complementary uses from

http://daywater.enpc.fr/www.daywater.org/CityNetCluster/ETAP-Water-Issue-Group-Final-Report-22-08-03.doc.

355 Data from NEWCRONOS, Eurostat, (2000)

356 Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

offices, urban management, small businesses – this explain the higher figure used in this report.

Based on the estimated saving in households made in the section before a threshold/target representing maximum water savings of 87 m^3 per year per inhabitant[357] can be set. This allows to estimate 24 430 Million m^3 or 33% today's water savings.

For estimating water savings for 2030, we need to go back to the assumptions chosen by Flörke et al. (2004)[358] in building their 2030 baseline. Indeed, they assume changes in income and different future structural changes of water demand depending on the maturity of the water economy. At the same time, they assume that measures aimed at improving water efficiency will take place at a pace equivalent to a 2% decrease in water demand for old MS and by 1% for new MS and candidate countries. Combined, the increase in income leading to changes in water demand and the application of water efficiency measures lead to a total water demand of 75 616 Million m^3 in 2030.

- If only the estimated water use efficiency gains would have taken place (with no change in income and structural water demand), total water use of 48 721 Million m^3 would have been reached by 2030 – thus 26 885 Million m^3 lower than what has been estimated in the 2030 baseline scenario.
- We can then assume that these 26 885 Million m^3 are due to structural changes and income changes. Assuming that both structural changes and water efficiency changes are not correlated, we can estimate that total water demand without water use efficiency gains but with income/structural changes would be equal to 75 616 plus 26 885 Million m^3 which is around 102 500 Million m^3 per year.
- Minimum water use for 2030 is estimated at 87 m^3 (the same relative reduction in water demand that the one used for domestic uses multiplied by 587 Million inhabitants which is equal to 48 800 Million m^3 per year.
- Thus, total water savings by 2030 would be equal to 53 700 Million m^3 per year or 52% of total water use by the domestic sector.
- Out of these total water savings, 26 885 Million m^3 of water savings (equivalent to 26% of the total water demand) are part of the baseline scenario.
- This leaves 26 815 Million m^3 or 26% of total water demand for additional policy action.

8.4 Potential water savings in the industry sector

The current water saving potential in the industry section is highly different for the various sub-sectors. The review of information collected in the report provides the following numbers:

- In Catalonia, saving potential for different industrial sectors varies between 25 and 50%. The highest saving potential is seen in the chemical industry (around 50%) as presented in the industry sector sub-chapter.
- Based on scant information for Spain, the UK and France that is presented in the same sub-chapter, it can be assumed that around 30% to 40% of industrial plants

[357] This minimum value is equivalent to a reduction in water use similar than the one estimated for households above, i.e. -50% (from 150 l/person/day to 100 l/person/day). The estimated water use in households is set at 36,5m^3/inhabitant and year.

[358] Flörke, M. Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

have already implemented water saving measures for their processes or office water use.

- From the different illustration provided in the report, savings ranging from a low 15% to high 90% can be expected. Most commonly found figures are within the 30-70% range. However it should be noted, that these potential savings are based on a case study level and do not reflect the overall saving potential of the sub-sector. In some cases the true potential might be lower, as most of the companies have already in implemented part of the measures reported in the illustrations.

Due to the lack of information on the current level of water savings in industry, the following calculation on the water saving potential has been used with caution. Today's potential water saving is calculated based on the following formula:

(5) Savings in Million $m^3 = (I_s * T_r * T_{iwu})/(I_s + I_0 * T_r)$

With

I_s Industry without any water saving technology currently applied.

I_0 Industry with currently no further water saving potential. As a result from the information collected several industrial companies have already implemented the current maximum water saving measures and there is currently no room for improvement. This has to be taken into account. This value was estimated at 25%.

T_r as the potential saving. Based on the information collected an average saving potential of 50% for each and every industry can be assumed

T_{iwu} Total industrial water use. According to the latest information in Eurostat the EU 31 abstracted in 2001 around 34 194 Million m^3 of water

Using the formula above and based on a total industrial water abstraction for EU-30 of 34 194 Million m^3 per year, total water savings amount to 14 655 Million m^3 per year. Implementing all water saving measures in the industrial sector today would then lead to a reduction in industrial water abstraction by 43%.

To assess potential water savings for 2030, data from the Flörke et al. (2004)[359] are used. The report estimates for today and for 2030 (baseline) total water use for the manufacturing sector for the EU-30 at 39 737 Million m^3/year and 56 943 Million m^3/year, respectively. However, calculations for the baseline scenario account for some improvements in water use efficiency (the ratio of total production by water use) of 1% per year. Using estimated Gross Value Added (GVA) for the manufacture sector for 2000 and 2030 provided in the report (1 092*10^9 Euros and 2 131*10^9 Euros, respectively), total water use for the manufacturing sector that would be necessary to deliver the 2030 GVA with no improvement in water use efficiency is computed and estimated at 77 545 Million m^3 (+95% as compared to the 2000 figure and +26% as compared to the 2030 baseline figure). This implies water savings of around 26% are already accounted for in the baseline scenario.

Applying these percentages to the 34 194 Million m^3 per year of EU-31, this leads to the following results:

- Today's water savings are estimated at 43% of total water use or 14 360 Million m^3 per year;

- Using the relative increases in total water use presented in Flörke et al. (2004)[360], the 2030 water use in the industry sector is estimated at 66 680 Million m^3 per year

[359] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

[360] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

(increase by 95%). And total water savings in 2030 are estimated at 28 580 Million m^3 (43% of total);

- Out of the total savings for 2030, 17 340 Million m^3 (26% of total water use) will take place as part of baseline independently on any policy action;
- The remaining 17% or 11 240 Million m^3 will require additional specific policy action.

8.5 Potential water saving in the electricity production

As shown in section 5.4.5 water consumption and energy production are closely related and savings in one sector can result in savings in the other sector. To estimate the total water saving potential two approaches are chosen. The first approach is technology driven and requires changes in power plants; the second one is based on the Europe's energy saving policy.

Technical Approach

When looking at the different production ways of electricity it comes clear that water use and consumption of a thermoelectric plants is much higher as compared to others ways of production. The generation of electricity from wind and solar requires only little water for cleaning, and the evaporation that results from artificial lakes for hydropower seems to be negligible small in most cases, depending on the local climate conditions. Further, as shown in Table 31 most of the current electricity is produced by power plants making this way of energy generation to the largest water consumer also in absolute terms. However modern oil and gas thermoelectric plants do not require any cooling water From the figures set out in Table 32 a theoretical technical saving potential of almost 100% can be achieved, as modern oil and gas thermoelectric power plants do not need water at all and some Member Sates have decided to withdraw from nuclear power plants. A more realistic saving ranges around 68% and 88% depending on the water consumption of new plant technologies (e.g. to convert biomass) and the replacement of nuclear power plants by more modern plants or the degree of change towards non-nuclear thermoelectric plants.

To assess potential water savings in the electricity sector for 2030, again the data from the Flörke et al. (2004)[361] are used. The report estimates for EU 30 a water use for today of 94 973 Million m^3/year and for 2030 (baseline) 30 816 Million m^3/year. The calculations for the baseline scenario account for large improvements in cooling systems of thermoelectric power plants. A water saving of 68% is estimated up to 2030. This leaves a saving potential for policy action for around 20%, assuming that the technical optimum of almost zero water use can not fully achieved.

Energy saving approach

In 2006 the Commission released a communication on energy saving. This communication set out an energy saving target for 2020 of 20%. This target was set as a cross sector target applied for all different types of energy. According to a report from the JRC on the electricity efficiency the saving potential of 20% is possible with current technologies[362].

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[361] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

[362] One of the aims of this report is to show the present status of electricity consumption for the main appliances and equipments, and on the base of the best available data estimate the saving potential for electricity in buildings in EU Member States and Candidate Countries. Bertoldi, P.; Atanasiu, B. (2006): Electricity Consumption and Efficiency Trends in the Enlarged European Union - Status report 2006, available at http://re.jrc.ec.europa.eu/energyefficiency/publications1.htm.

Applying the 20% saving potential to the current electricity consumption of 3 179 TWh would result in a saving of 635.8 TWh per year.

Estimating that these savings would lead to a reduction of energy inefficient plants (plants without a combined cycle) with an average water consumption rate between 1 300l per MWh and 2 000l per MWh the amount of water saved would be between 826.54 mio m^3 and 1 271.6 mio m^3 per year.

8.6 Potential water savings for tourism

Water saving in tourism is more and more becoming an issue. In 2005 in the EU 25 a total of 2 214 323 000 night have been spent in hotels and other accommodations (see Table 52).

Table 52: Overview of nights spent in hotels and other accommodations (EU 25)

	Hotel	Accommodation collective[363]
Nights spent by non residents	657 220 000	238 366 000
Nights spent by non residents	791 375 000	527 362 000
Total	**2043**	**1493**

According to the sections section 0 an average water consumption of 180 l/night on a camping site and 300 l/night for hotels can be assumed. These numbers to not account for the water used by golf course or water parks. Based on the numbers above a total water consumption of 490 Million m^3 can be assumed.

The benchmarks set by TourBench, which is an is European monitoring and benchmarking initiative, that aims to reduce the environmental costs in tourist accommodation businesses has set the following for different accommodations:[364]

- 96l/night for camping;
- 133/l night for bed and breakfast and
- 213l/night for hotels

In the following calculations we have taken the value of 213l/night for all accommodations which are not grouped under "accommodation collective" as it can be assumed that higher ranked hotels need more water to satisfy consumer needs. Putting this numbers into place a water saving potential of 188 Million m^3 litres can be identified.

The future demand in tourism is hardly to estimate as changes in the tourism sector. There is little doubt that tourism is one of the fastest running industries in the global economy fostering economic development worldwide and so in Europe. However the future development of the sector is currently quite unclear and several factors are influencing the its development (see also section 4.2.4). This uncertainties needs also to be addressed by improved tourism statistics as is envisaged by the amendment of the current tourism statistics Directive[365].

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[363] In accordance to the EU Council Directive 95/57/EC of 23 November 1995 on the collection of statistical information in the field of tourism these term covers (i) tourist campsites (ii) holiday dwellings other (iii) collective accommodation.

[364] See http://www.tourbench.info/index.pl/home.

[365] European Council (1995): Directive 95/57/EC of 23 November 1995 on the collection of statistical information

8.7 Conclusions

The following table gives an overview of the potential water savings today and in 2030 distinguishing between water savings that would take place as part of the baseline scenario (i.e. without any specific policy intervention) and water savings that would need specific and targeted policy action to take place.

in the field of tourism.

Table 53: Summary of the water saving potential in all sectors

Sector	Todays' water use	Todays' saving potential	Water use in 2030 (baseline scenario)	Water savings as part of the baseline	Additional water savings in 2030 for policy action	Comments
Agriculture (EU-30)	Around 65 898 Million m^3 for 11.7 Million hectares equipped for irrigation	Estimated at 28 420 Million m^3 or 43% of today's total water abstraction – Most of the water savings (98%) take place in Southern Europe	73 608 Million m^3 per year (based on +11.3% increase for the period 2000-2030)	7 235 Million m^3 per year (or 9.22% of total water abstraction with only structural changes for 2030)	27 125 Million m^3 per year (or 33% of total water abstraction with only structural changes)	If only structural changes would be accounted for, total water demand in 2030 would be equal to 80 840 Million m^3. Thus, water savings that are part of baseline are equal to 7 235 Million m^3 per year.
Households (selected countries)	Between 265l/p/d (Spain) and 85l/p/d (Lithuania) with an average of 150 l/p/d	Between 18% and 47% assuming an average consumption of 122 l/p/d (UN Sustainable Development Commission) and 80 l/p/d (UK Code for sustainable planning) respectively.				For household use no baseline scenario was found in literature, nor calculated because of lack of information. Flörke, et al. (2004) consider households as part of the domestic sector
Domestic (EU 30)	73 222 Million m^3 for EU 30 (563 Milllion inhabitants in 2000). Based ón Flörke, et al. (2004)	24 430 Million m^3 or 33% based on 87 m^3 /year (own calculations)	75 616 Million m^3 20 for EU 30 (587 Million inhabitants) Based ón Flörke, et al. (2004)	Water savings of 26 885 Million m^3 per year (26% of the total water demand) are part of the baseline scenario	Remaining water savings of 26 815 Million m^3 or 26% of total water demand for additional policy action.	If only the estimated water use efficiency gains would have taken place, total water use in 2030 would be 48 721 Million m^3 – 26 885 Million m^3 lower than what has been estimated in the 2030 baseline scenario. These 26 885 Million m^3 are due to structural changes and income changes. Assuming that both structural changes and water efficiency changes are not correlated, we can estimate that total water demand without water use efficiency gains but with income/structural changes would be equal to 75 616 + 26 885 Million m^3 = around 102 500 Million m^3 per year.
Industry (EU 30)	39 737 Million m^3/year Based on Flörke, et al.. (2004)	43% of total water use (14 360 Million m^3) Based on the assumption that the sector has a average technical saving potential 50% but 25% of the sector	56 943 Million m^3/year (95% increase) Based on Flörke, et al. (2004)	17 340 Million m^3 (26% of total water use)	17% or 11 240 Million m^3	It is highly recommended that an in-dept assessment of the water saving potential in industry is carried out, as the information used is highly related to uncertainties.

		have already achieved the maximum saving				
Electricity	94 973 Million m^3/year Based 0n Flörke, et al.(2004)	Almost 100% according to the technical specifications provided in Electric Power Research Institute (2002):	30 816 Million m^3/year Based on Flörke, et al. (2004)	68% Based on Flörke, et al. (2004)	20%	A remaining use of 12% of today's use is estimated to in order to account for situations where dry cooling is not possible
Tourism (EU 25)	490 Million m^3/year (own calculations)	38% or 188 Million m^3litres/year				Watch out! The water use of several tourism facilities is also accounted in the domestic and agricultural sector. No suture scenario was calculated.

9 Virtual Water in the context of water saving

9.1 Definitions

Virtual water refers to the amount of water required to produce a good. While it is commonly said that an average Western European uses about 0.140 m^3 of water per day, this estimate does not include water embodied in food or industrial products and water used to produce them (See Table 54). Cars, for example, need about 400 m^3[366] of water to produce its components[367]. Water consumption figures rise to 3 400 l a day for an average Britton when including these volumes. There are two different ways to calculate the virtual water of a product[368]:

- One way is to calculate the virtual water content of a product based on the water that would have been used in the importing country. This approach can help to illustrate the consequence of production of national resources, for example in light of national food security (what would be necessary to become self-sufficient?).
- The other way is to calculate the virtual water content of a product based on the water that is used in the exporting country, which helps to demonstrate the impact trading policies have on countries abroad. This approach is the most relevant to the issue of water saving.

Table 54: Virtual water in a single portion, excluding most processing and packaging[369].

Portion	Litres	Portion	Litres	Portion	Litres
Pint of beer, 568 ml	170	Cup of coffee, 125 ml	140	Glass of orange juice, 200 ml	170
Glass of milk, 200 ml	200	Cup of instant coffee, 125 ml	80	Glass of apple juice, 200 ml	190
Cup of tea, 250 ml	35	Glass of wine, 125 ml	120	Orange, 100 g	50
Slice of bread, 30 g	40	Bread with cheese, 30 g + 10 g	90	Bag of potato crisps, 200 g	185
Egg, 40 g	135	Tomato, 70 g	13	Hamburger, 150 g	2400
Potato, 100 g	25	Apple, 100 g	70	Bovine leather shoes	8000
Sheet of A4, 80 g/m^2	10	Cotton tee, Medium 500 g	4100	Microchip, 2 g	32

366 Water content is highly dependent on the car model.

367 Waterwise (2007): Hidden Waters, A Waterwise Briefing, available at www.waterwise.org.uk.

368 Fernandez, S. (2007): Gestion de la demande en eau en Méditerranée, progrès et politique. L'eau virtuelle dans les pays Méditerranéen: un indicateur pour contribuer à l'analyse des questions de gestion et de répartition de l'eau en situation de pénurie ?.

369 Waterwise (2007): Hidden Waters, A Waterwise Briefing, available at www.waterwise.org.uk.

Depending on the production system (i.e.. its efficiency in using water, capacity of the country to manage its water resources etc) and environmental conditions (evapo-transpiration, soil type etc). Table 2 presents some examples of agriculture products of different virtual water content depending on the country of production.

“Blue” and “green” water are commonly used to illustrate how agricultural practices can influence water use. Green water represents the water that is held in soil, and that most cultures use in order to grow. Blue water represents water that is abstracted from surface and groundwater resources. In the case of irrigation, blue water represents the water sprayed onto the field. In South-East Asia, rice production[370] is based on green water during the monsoon season because there is enough water to meet rice demand and fill paddies. In the dry season, rain and water held into the soil are insufficient to meet crop water demand. Water, “blue water”, is abstracted in order to irrigate the fields. The volumes of water to grow rice between the monsoon and the dry season are not the same. In the monsoon season rice grows on rainwater-fed soils. In the dry season, one should also consider water that is evaporated during irrigation. Most fields in Europe are based on soil-based “green” water, although the use of “blue” water for irrigation has increased a lot in the second half of the century.

Table 55:Virtual water in food products for different countries[371].

	USA	China	India	Russia	Indonesia	Australia	Brazil	Japan	Mexico	Italy	Netherlands	World average*
Rice (paddy)	1275	1321	2850	2401	2150	1022	3082	1221	2182	1679		2291
Rice (husked)	1656	1716	3702	3118	2793	1327	4003	1586	2834	2180		2975
Rice (broken)	1903	1972	4254	3584	3209	1525	4600	1822	3257	2506		3419
Wheat	849	690	1654	2375		1588	1616	734	1066	2421	619	1334
Maize	489	801	1937	1397	1285	744	1180	1493	1744	530	408	909
Soybeans	1869	2617	4124	3933	2030	2106	1076	2326	3177	1506		1789
Sugar cane	103	117	159		164	141	155	120	171			175
Cotton seed	2535	1419	8264		4453	1887	2777		2127			3644
Cotton lint	5733	3210	18694		10072	4268	6281		4812			8242
Barley	702	848	1966	2359		1425	1373	697	2120	1822	718	1388
Sorghum	782	863	4053	2382		1081	1609		1212	582		2853
Coconuts		749	2255		2071		1590		1954			2545
Millet	2143	1863	3269	2892		1951		3100	4534			4596
Coffee (green)	4864	6290	12180		17665		13972		28119			17373
Coffee (roasted)	5790	7488	14500		21030		16633		33475			20682
Tea (made)		11110	7002	3002	9474		6592	4940				9205
Beef	13193	12560	16482	21028	14818	17112	16961	11019	37762	21167	11681	15497
Pork	3946	2211	4397	6947	3938	5909	4818	4962	6559	6377	3790	4856
Goat meat	3082	3994	5187	5290	4543	3839	4175	2560	10252	4180	2791	4043
Sheep meat	5977	5202	6692	7621	5956	6947	6267	3571	16878	7572	5298	6143
Chicken meat	2389	3652	7736	5763	5549	2914	3913	2977	5013	2198	2222	3918
Eggs	1510	3550	7531	4919	5400	1844	3337	1884	4277	1389	1404	3340
Milk	695	1000	1369	1345	1143	915	1001	812	2382	861	641	990
Milk powder	3234	4648	6368	6253	5317	4255	4654	3774	11077	4005	2982	4602
Cheese	3457	4963	6793	6671	5675	4544	4969	4032	11805	4278	3190	4914
Leather (bovine)	14190	13513	17710	22575	15929	18384	18222	11864	40482	22724	12572	16656

* For the primary crops, world averages have been calculated as the ratio of the global water use for the production of a crop to the global production volume. For processed products, the global averages have been calculated as the ratio of the global virtual water trade volume to the global product trade volume.

[370] Taken from § Waterwise (2007): Hidden Waters, A Waterwise Briefing, available at www.waterwise.org.uk.

[371] Hoekstra, A.Y.; Chapagain, A.K.; Water Footprint Nations (2007): Water use per person as a function of their consumption pattern, Water Resource Management, 21, 35-48.

9.1.1 Imports, exports and national footprints

Virtual water can help to visualise the impact of European demand in food and industrial products around the world using a single indicator. Similarly to an ecological footprint, "a water footprint" can be derived. Water footprints should include (i) internal use of national water for internal consumption, and (ii) water use in other countries for internal consumption.

Figure 35 presents estimates of the World average for the share of agriculture, industrial and domestic water use in the internal and external footprint. Globally 70% of water abstraction is for agriculture production, 20% for industrial production, and 10% for domestic purposes External footprints represent on average 18% of the total footprint of a given country. For some countries, such as the UK, import volumes (external footprints) represent 71% of the total national footprint[372]. The table in the annex II presents detailed import and export volumes of virtual water for each country.

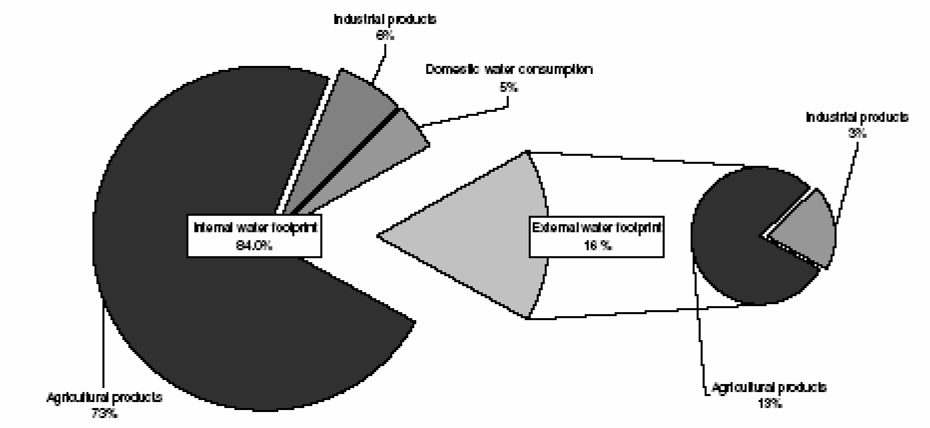

Figure 35: Internal and external national water footprint by type of water use. [373]

Virtual water trade has increased in the last 40 years, and today about 15% of water use in the world, about 695 km^3 of water per year[374], is exported through trade in agriculture products. Between 1995-1999, 90% of global virtual water is associated with agriculture goods, including crops (67%[375]), livestock and livestock products (23%). Only 10% of global virtual water is related to the trade of industrial products.

National import and exports are presented in Table 56. Although some countries in the EU are considered major virtual water importers, other countries, such as France, Hungary, the United Kingdom and Sweden, are considered major virtual water exporters. France, for example, exported 88.4 billion m^3 between 1995 and 1999. On the other hand, the Netherlands was the

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[372] Hoekstra, A.Y.; Chapagain, A.K.; Water Footprint Nations (2007): Water use per person as a function of their consumption pattern, Water Resource Management, 21, 35-48.

[373] Hoekstra, A.Y.; Chapagain, A.K.; Water Footprint Nations (2007): Water use per person as a function of their consumption pattern, Water Resource Management, 21, 35-48.

[374] Fernandez, S. (2007): Gestion de la demande en eau en Méditerranée, progrès et politique. L'eau virtuelle dans les pays Méditerranéen: un indicateur pour contribuer à l'analyse des questions de gestion et de répartition de l'eau en situation de pénurie ?

[375] Wheat represents 30%, soybean 17% and rice 15%.

world's third greatest net importer of virtual water[376], importing 147.7 billion m^3 of water (1995-1999). Additional top 10 countries include Spain, who imported 82.5 billion m^3 of water during that time, as well as Germany (67.9 billion m^3) and Italy (64.3 billion m^3).

Table 56: National export and imports of virtual water[377]

Table 5.1. Top-30 of virtual water export countries and top-30 of virtual water import countries (over 1995-1999).

Country	Net export volume (10^9 m^3)		Country	Net import volume (10^9 m^3)
United States	758.3	1	Sri Lanka	428.5
Canada	272.5	2	Japan	297.4
Thailand	233.3	3	Netherlands	147.7
Argentina	226.3	4	Korea Rep.	112.6
India	161.1	5	China	101.9
Australia	145.6	6	Indonesia	101.7
Vietnam	90.2	7	Spain	82.5
France	88.4	8	Egypt	80.2
Guatemala	71.7	9	Germany	67.9
Brazil	45.0	10	Italy	64.3
Paraguay	42.1	11	Belgium	59.6
Kazakhstan	39.2	12	Saudi Arabia	54.4
Ukraine	31.8	13	Malaysia	51.3
Syria	21.5	14	Algeria	49.0
Hungary	19.8	15	Mexico	44.9
Myanmar	17.4	16	Taiwan	35.2
Uruguay	12.1	17	Colombia	33.4
Greece	9.8	18	Portugal	31.1
Dominican Republic	9.7	19	Iran	29.1
Romania	9.1	20	Bangladesh	28.7
Sudan	5.8	21	Morocco	27.7
Bolivia	5.3	22	Peru	27.1
Saint Lucia	5.2	23	Venezuela	24.6
United Kingdom	4.8	24	Nigeria	24.0
Burkina Faso	4.5	25	Israel	23.0
Sweden	4.2	26	Jordan	22.4
Malawi	3.8	27	South Africa	21.8
Dominica	3.1	28	Tunisia	19.3
Benin	3.0	29	Poland	18.8
Slovakia	3.0	30	Singapore	16.9

For the most part, imports and exports of national virtual water occur between countries the European Union. Western Europe exchanges imports most virtual water from America (Figure 36). Eastern European countries most exchange with Western Europe. Gross water import for all of Western Europe (1995-1999) was 523 billion m^3, while gross water import for Eastern Europe (1995-199) was 60 billion m^3, which can be seen as water savings *for Europe*. Gross water

[376] Hoekstra, A.H.; Hung, H.Q.A (2002): Quantification of virtual water flows in relation to international crop trade, IHE Delft.

[377]: Hoekstra, A.H.; Hung, H.Q.A (2002) Virtual Water Trade. A Quantification of Virtual Water flows between Nations in relation to International Crop Trade.

export for Western Europe during the same timeframe was 143 billion m^3 and for Eastern Europe 65 billion m^3.

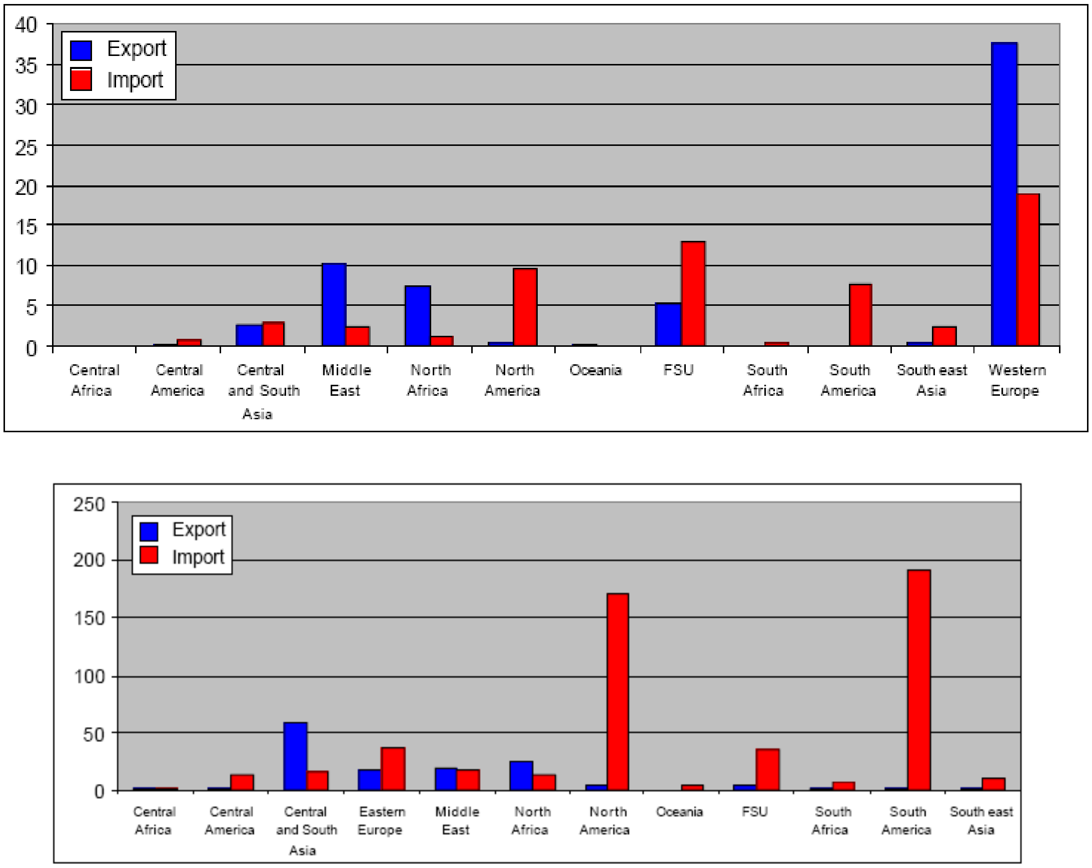

Figure 5.36a. Gross virtual water import and export of Western Europe in the period 1995-1999 (Gm^3).

Figure 36: Virtual water trade (import and export) between (i) Eastern Europe and the rest of the world, and (ii) Western Europe and the rest of the world[378].

9.1.2 Advantages and disadvantages in using virtual water for water saving strategies

Virtual water can first help in thinking of water use along the whole production process. Since the virtual content of a product will depend on a mixture of physical conditions (climatic, topography, soil type, etc.), and of managerial and technical capacities (human, technology, economic, institutional)[379], virtual water can provide a single indicator from which the influence of these different variables of water use can be judged.

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[378] Hoekstra, A.H.; Hung, H.Q.A (2002): A quantification of virtual water flows in relation to international crop trade, IHE Delft.

[379] Fernandez, S. (2007): Gestion de la demande en eau en Méditerranée, progrès et politique. L’eau virtuelle dans les pays Méditerranéen: un indicateur pour contribuer à l’analyse des questions de gestion et de répartition de l’eau en situation de pénurie ?

Secondly, virtual water can help in reflecting on the likely impact of European water saving policies. For example using pricing policies to promote water savings may lead to more efficient technologies, but it may also lead to a shift in the location of the production to places where water is cheaper. This shift does not lead always to water savings, for example in places where production system is less efficient, but man power cheaper. Virtual water can help in visualising these "real" volumes of used water, and assess whether a given policy leads to "real" savings".

Thus, virtual water trade has the potential to[380]:

- Support global water use efficiency: based on trust and co-operation, countries can optimise the use of their internal without worrying about food and water security. Water savings can be achieved by shifting activities towards regions of higher productivity. In the industrial sector, or in irrigation, this could be for example shifting production towards places where technical efficiency is higher. Another mean to achieve water savings in agriculture could imply a re-allocation of culture patterns in places where their production mostly requires "green" water, lowering the global demand for water.
- Lessen environmental damage resulting from over-abstraction of local and regional water resources by adapting local economic activities to the environment and favour imports of water intensive products if necessary.

A study from the IWMI points out several issues with using virtual water trade as a water saving tool[381]:

- Global irrigation water savings may be coming at the price of natural environments in rain-fed countries.
- Some studies estimated that productivity improvements in irrigated and rain-fed areas may have a more prominent role in water conservation than trade with a potential saving of 1205km^3 between 1995 and 2025 with productivity improvements, and 355km^3 with trade.

There are also several other points to note:

- The concept of virtual water helped to explain some trade policies in the Middle East[382], showing that water-intensive products were imported. Further studies showed the difficulty to generalise such causal relationship. Trade is not only governed by environmental conditions, but also on deliberate policies (ex. food security scheme to be self-sufficient), on the structure of the workforce, on international market. Policies promoting water savings by influencing agricultural practices towards less water intensive cultures may thus face obstacles on the basis of national security or economic principles[383].

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[380] § Waterwise (2007): Hidden Waters, A Waterwise Briefing, available at www.waterwise.org.uk..

[381] Rosegrant, M.; Molden, D. (2004): Does international cereal trade save water ? The impact of virtual water trade on global water use, Ximing Cai, Upali Amarasinghe. International Warez Management Institute.

[382] Fernandez, S. (2007): Gestion de la demande en eau en Méditerranée, progrès et politique. L'eau virtuelle dans les pays Méditerranéen: un indicateur pour contribuer à l'analyse des questions de gestion et de répartition de l'eau en situation de pénurie ?

[383] Waterwise (2007): Hidden Waters, A Waterwise Briefing, available at www.waterwise.org.uk.

- By showing dependency" situations (ex. a country lacking water resources importing most virtual water from a single country), virtual water may be used as political tools
- Virtual water is a limited indicator. Virtual water may provide a negative vision of irrigation. However irrigation still increases food production, and still helps farmers to control climatic risks, and secure some production year-by-year. An efficient use of water in irrigation (as well as in animal breeding) can increase very efficiently the calorific composition of food

10 Conclusions

Water is a precondition for human, animal and plant life and is an indispensable resource for the economy. Water resources are production factors for most economic sectors in the European Union (EU). Manufacturing plants, agriculture farms or tourism rely on a reliable supply of water often of a pre-determined quality. As drought events and water scarcity situations are becoming more common, in particular in southern Member States, there is an urgent need for policy action to tackle this issue and ensure a clear sustainable future for water resources and management in Europe. This will be a challenging task as climate change is further exacerbating the debate and driving to ever-increasing unstable weather patterns and unreliable water resources.

The European Commission therefore commissioned a study to estimate the EU water saving potential. This report presents the main results of this study that analysed the most promising water saving measures that could be implemented to reduce the pressure on water resources. The study addresses savings that can by achieved by implementing mainly technical measures with no major change in human standard of living and living patterns. It also considers instruments that can foster the implementation of these water saving measures (e.g. regulatory approaches or economic instruments). The assessment focuses on four priority sectors, namely agriculture, the domestic sector (with special attention given to households), industry (including energy production) and tourism.

What is today's water demand in Europe…..

Total water abstraction in the European Union (EU 27) amounts to about 247 000 million m³/year. With regards to water abstraction, the energy sector is the largest water user followed by for agriculture and public water supply (see Table 1). The situation is different when looking at water consumption, with agriculture being then by far the most demanding sector. However, it should be noted that there are several regional differences across Europe. For example in Northern Europe and most of the New EU Member States the most important water using sector is now the electricity production sector while water withdrawals in Southern Europe and in the EU Candidate States are currently dominated by agricultural water use.

…and how is water demand going to develop?

According to Flörke et al. (2004)[384], total water withdrawals in Europe-30 is expected to decrease by approximately 11% between 2000 and 2030, with 18 of these 30 countries presenting a decreasing trend in water withdrawals. The largest decreasing trend is expected for the electricity sector (minus 68%), while all other sectors will increase (industry 43%, agriculture 11% and domestic 3%). In this context it should be mentioned that the total share of each sector in water used has to be considered. For example even if a 43% increase will take place in industry the sector will remain the smallest water user compared to agriculture and domestic use (see section 4.2.5). This is even more important as water for industry or energy production is mainly recharged to the environment, while the water used in agriculture is consumed.

Further it is important to consider the regional differences in future water use across Europe. Thereby three main trends have to be considered:

- According to Figure 11and Figure 12 Southern Europe will face even more water stress not only because of climate change, also because of growing water demand in the

[384] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

agricultural sector. On the one hand, gross irrigation water requirements increase by 14% because of a somewhat warmer and drier climate and the further development of the total area irrigated. It is expected that the irrigated area increases by 27% and the irrigation water requirements increase by 14% between 2000 and 2030. Considering the steady progress in improving the efficiency of irrigation water the net result of these changes is an increase in irrigation water withdrawals of 32%. The picture can be same applies to Turkey

- The New Members States will increase there domestic water use mainly because due to the economic developments in this region. The domestic water withdrawals are expected to increase from 5 025 Million m³ to 8 753 Million m³ (+74%) between 2000 and 2030 in the EU Member States since 2004.
- All of Europe tends to use more water for industry production.

How to achieve water savings?

Water savings can be achieved by two ways: i) by implementing technical measures that induce more efficient water use, and/or ii) by chancing water users' behaviours and production patterns. Both can be fostered by economic instruments, institutional changes, information campaigns or regulatory changes. Potential measures are considerably inter-linked and their combination need to be designed with care.. For example, water saving in agriculture is possible through the implementation of new irrigation technologies that increase the efficiency of water applications to crops. This implementation can be fostered by applying economic instruments such as water pricing and volumetric billing that would then lead to farmers implementing more water efficient technologies and changing farm practices.

What is the magnitude of potential water savings?

T**oday's** technical water saving potential that can be achieved with current technologies have been estimated against current water demand. Building on future water demand scenarios developed by Flörke et al. (2004)[385], potential water savings that could be achieved by 2030 have also been estimated. These estimates did not consider cross-sector linkages and the side-effects water saving in one sector would have on production, water use and water savings in other sectors.

With respect to **agriculture** (see section 5.1), potential large (freshwater) savings could be obtained in many countries by improving infrastructure for irrigation. Potential water savings for EU 30 when improving conveyance efficiency in irrigation ranges between 10 and 25%, while potential water savings from improving application efficiency are between 15 and 60% depending on regions and current irrigation technologies. Potential water savings due to shifts in irrigation technologies are highest in countries where gravity/furrow irrigation is still important, in particular in southern European Member States. Additionally, significant savings can be expected from changes in irrigation practices (30%), use of more drought-resistant crops (up to 50%) or reuse of treated sewage effluent (around 10%).

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[385] Flörke, M.; Alcamo, J. (2004): European Outlook on Water Use, Final Report, 1 October 2004.

Based on the information on the current water use practice in agriculture and the assumptions made in section 5.1, implementation of these measures would lead to potential total water savings in the irrigation sector of 28 420 Million m^3 per year (43% of today's withdrawals) and potential water savings of 52 740 Million m^3 per year in 2030

There is a wide range of technical measures to save water in the **domestic sector** (including households, public sector organisations and small businesses). Leakage reduction of the water supply system, water saving devices or more efficient household appliances allow large savings up to 50% (for details see Table 27). Many of these water saving technologies can be easily introduced and have short payback periods, which make water saving also economically feasible for private households and public administrations. In comparison, rain water harvesting infrastructure, which has the highest saving potential (up to 80%) is rather expensive, this option ranking low amongst all water savings for the domestic sector from a financial/economic point of view. With an average EU water consumption of 150 l/person/day, applying the technical measures mentioned above would help reducing water consumption to 120 l/person/day and 80l/person/day resulting in water savings ranging from 18% to 47% of today's water consumption. Clearly, water saving potential varies widely among EU Member States with values as high as 70% being estimated for potential water savings.

Based on the estimated saving in households made in section 5.2, a threshold/target representing maximum water savings of 87 m^3 per year per inhabitant[386] can be set for the domestic sector. This leads to total water savings of 24 430 Million m^3 or 33% of today's water consumption. Water savings in 2030 would be equal to 53 700 Million m^3 per year or 52% of total water consumption by the domestic sector.

There was even less information available for the industry section, which is very diverse. Industries that use large amounts of water include the paper & pulp, textile, leather (tanning), oil and gas, chemical, pharmaceutical, food, energy, metal and mining sub-sectors. Technical measures mainly focus on changes in production leading to less water demand, higher recycling rates or the use of rainwater. Depending on technologies, water savings range from 15% to 90%.

There are only a few indications on current applications of water saving technologies and future potential water savings. Based on examples and illustrations collected in this report, it is assumed that around 30% to 40% of industrial plants within the former EU15 Member States have already implemented water saving measures for their processes or office water use. Lower rates are expected in new EU Member States. It still remains unclear whether those who already embarked on water saving strategies have already captured all their water saving potential. Closing these gaps by making assumptions as set out in section 8.4, total water savings amount to 14 655 Million m^3 per year today, leading to total water savings of 28 580 Million m^3 (43% of total) in 2030.

A particular sub-sector of industry is electricity production. Electricity production abstracts large quantities of water for abstracting fuel and for cooling purposes in thermoelectric power plants. Depending on the type of plant, the water demand is between zero and 227 400 l/MWh and the water evaporated (water consumption) is up to 2 729 l/MWh ((see Table 30). From these figures, it is clear that the theoretical technical saving potential is up to 100%, as modern oil and

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[386] This minimum value is equivalent to a reduction in water use similar than the one estimated for households above, i.e. -50% (from 150 l/person/day to 100 l/person/day). The estimated water use in households is set at 36,5m^3/inhabitant and year.

gas thermoelectric power plants do not need water at all and some Member Sates have decided to withdraw from nuclear power plants. A more realistic saving ranges between 68% and 88% depending on the water consumption of new plant technologies (e.g. to convert biomass) and the replacement of nuclear power plants by more modern plants or the degree of change towards non-nuclear thermoelectric plants.

The **tourism sector** does not represent a key water use sector in Europe overall. However, regional differences make tourism a key sector in some regions (e.g. the Mediterranean region) accounting for significant water use. With an average growth rate of 2.2% between 2000-2005, this fast growing sector can significantly impact on water resources in the Mediterranean. Technical water saving measures that can be considered for the tourism sector are similar to those presented for households. The sector has the potential to increasing water use efficiency significantly by installing newer appliances in guest rooms, cafe areas, and kitchens. Since some of the measures identified in the report show a potential for a maximum of 80-90% savings, tourist accommodations could considerably reduce costs by buying more efficient appliances with payback periods of 3 years or less. In the case of irrigation of golf courses and sporting areas, more efficient irrigation techniques, reuse of treated sewage effluent or rain water harvesting could provide additional water savings up to 70% (see Table 35).

Calculating the water savings for the tourism sector remains the most difficult part, as little information is available and the future development of this sector is not clear. Data gaps here particularly refer to future trends for destination hot spots as well as changes in vacation durations. However, based on the limited information available, a saving potential of 188 million m^3 per year has been estimated for today's situation (see section 8.6).

Measures to foster the implementation of technical measures

In many cases, technical water saving measures are readily available but not yet applied. In order to foster their application, additional instruments need to be applied to provide the right institutional environment, incentives and awareness. Within this study, three main approaches have been reviewed: i) water pricing, ii) information campaigns, and iii) drought management plans.

Section 6.1 assessed the different situations, challenges and opportunities for **water pricing** to promote water savings in different sectors. The leads to a very heterogeneous picture in what can or cannot be achieved with water pricing. The main function of currently existing water pricing schemes is to recover infrastructure and operational costs. This results from perceived political risks and concerns that higher prices would hurt farmers, producers and consumers. This might change in the future since incentive water pricing policies are required by the European Water Framework Directive by 2010.

Drought management plans aim at minimising environmental, economic and social impacts of eventual drought situations. They provide strategic mechanisms for managing water supplies during drought periods, for implementing water rationing measures to cope with gaps between water demand and supply and by proposing measures aimed at enhancing reliability of supplies and reducing risk.

Measures set up by such plans can be voluntary in cases of low risk, but are mainly mandatory in cases of higher risk. The type of measures included in such plans can range from technical measures up to limitations in water use. Currently, drought management plans are not widely applied in Europe, but they might become more recognised in the future when draughts become more frequent.

Water use is mainly influenced by present consumer lifestyles. **Information campaigns** are considered to be an important part of initiatives, such as promoting water-saving devices, raising prices to pay for leakage and encouraging more rational water use. Not only are household customers targeted for these programs, but also industrial and commercial consumers as well. Such campaigns should informs the target audience about the water consumption level in order to enable them to make a deliberate decision.

What are the benefits from saving water?

The benefits of water saving can be addressed in different ways. Financial and economic benefits of water conservation include delayed or avoided procurement of new supplies, reduced water (including sewage) bills, and reduced volume of effluent to sewage treatment facilities. Environmental benefits can include reduced stress on river basins and wetlands and benefits associated with more progressive irrigation and growing practices, such as reduced fertiliser use, reduce soil erosion and leaching. Also, social benefits may occur, such as reduction in illness costs that occur when health and hygiene standards in the supply system are reduced due to water stress.

Total benefits from water saving in Europe are, however, hard to assess. The benefits achieved vary strongly depending on the measure applied or region examined. Further research in this area would be required to better support decision making processes in cases where water saving measures are implemented. This additional research would minimise the risk of applying measures that are costly but bring only a few benefits. Last but not least, reducing water use also brings significant ancillary benefits. Reducing energy consumption, electricity bills and thus CO_2 emissions is one of these benefits that would contribute and re-inforce to climate change strategies and policy actions in this policy field.

Concluding remarks

Overall, Europeans can choose among a wide range of technical possibilities to save water without changing their lifestyle or behaviour drastically. Water saving potentials differ among sectors and different regions. However, “net” water savings and environmental improvements in the aquatic ecosystems will only be achieved if water saved by specific sectors is not used elsewhere in the same or another sector or downstream.

More attention should be given to potential water savings that might come from changes in life styles, standards of living and our society. This would require that different visions are proposed for Europe’s future that are different than today’s system and consumption society. Some elements that could support such thinking are scattered in this report (e.g. the notion of virtual water and its implications). But the complexity of this task left this investigation clearly out of the scope of the present study.

The study has revealed high data gaps and data uncertainty. Data that are available on Member States’ water abstraction and consumption originate from a variety of sources. They are collected using different approaches and are often incomplete. Furthermore, data on current applications of water saving technologies in different sectors, a key element to estimating today’s (remaining) water saving potential, are not widely available. Finally, information on future trends in water use and development of economic sectors/water uses is limited. These gaps and uncertainties make comparisons between Member States difficult and renders the task of estimating today’s and future water saving potential at the EU scale very complex and uncertain. Thus, figures presented in this report should be used with caution and mainly relatively to each others. In-depth assessments would be required to better grasp the situation in each of the sectors investigated in this study.

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Annex I: Rain water Harvesting: Definition- Benefits – Uses - Calculations

Definition

Rainwater harvesting is the process of collecting, diverting and storing rainwater from an area (usually roofs or another surface catchment area) for direct or future use. The captured water is either directly applied to a cropping area and stored in the soil profile for immediate use (i.e. runoff framing, landscape irrigation) or stored in a on-site reservoir for future productive uses (i.e. domestic use, livestock watering, aquaculture irrigation).The collected water can also be used for groundwater recharge and storage into the aquifer (i.e. recharge enhancement).

Benefits

Rainwater harvesting can lead to a number of benefits, the most important is the reduction in mains water consumption. Through the utilisation of this alternative water source, demand on the mains water supply is lowered. Thus, municipal water supply is more secure and there is less chance that a municipality has to temporarily curtail water use. Furthermore, by reducing demand, the construction of new or bigger regional catchment storage facilities(e.g. dams) can be avoided, leading to cost savings. With respect to costs, additional savings can be achieved with rainwater harvesting, as infrastructure costs (e.g. pipes, lakes, constructed wetlands, gross pollutants traps) will need less maintenance due to less abstraction. Cost savings also translate to households and commercial businesses by reducing water bills. Rainwater harvesting also has the additional benefit of reducing total storm water volume and peak discharges, which can help to ease the risk of flooding events. Stormwater quality can also be improved through this water saving measure, as the impacts associated with stormwater, such as erosion, contamination of surface water with sediments, fertilisers and pesticides in rainfall run-off, can be minimised. Other water sensitive urban design measures can also be improved due to rainwater use as well. Another benefit is that commercial sites before thought to be incompatible for development due to the lack of available water nearby could be potentially be utilised through rainwater harvesting, as the reliance on a main water source is mitigated.

A study conducted at the University of Newcastle analysed the impact of collecting roof runoff in rainwater tanks with volumes 1 000 – 5 000 litres in Bisbane, western Sydney, Melbourne and Adelaide. The use of rainwater tanks resulted in considerable main water savings and a marked reduction in stormwater runoff in each city, as illustrated in the following graphs.

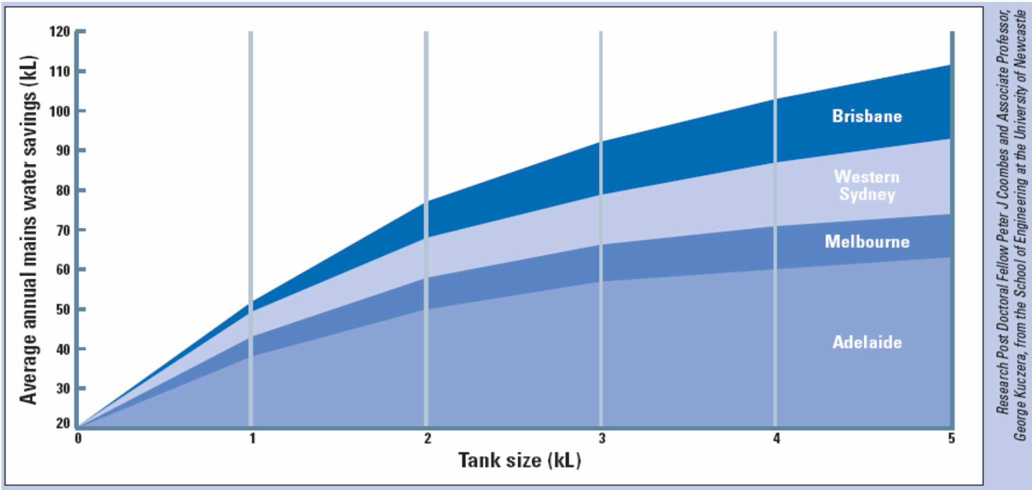

Figure 37: Savings in mains water supply due to rainwater harvesting[387]

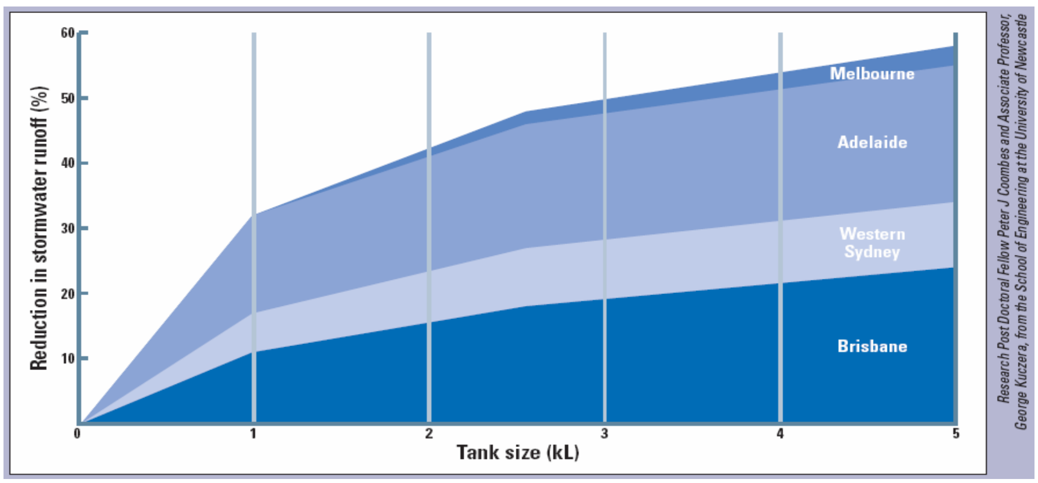

Figure 38: Reduction in stormwater runoff due to rainwater harvesting[388]

Sources and type of uses - Classification

Rainwater harvesting can be categorised according to the type of catchment surface used and by the scale of activity:

[387] Coombes, P.J.; Kuczera, G. (2003) Analysis of the Performance of Rainwater Tanks in Australian Capital Cities, prepared for the 28th International Hydrology and Water Resources Symposium

[388] Coombes, P.J.; Kuczera, G. (2003) Analysis of the Performance of Rainwater Tanks in Australian Capital Cities, prepared for the 28th International Hydrology and Water Resources Symposium

Figure 39: Types of catchment systems[389]

Rainwater systems can further be classified into four categories according to their reliability:

- Occasional - water is stored for only a few days in a small container. This is suitable when there is a uniform rainfall pattern with very few days without rain and there is a reliable alternative water source nearby.
- Intermittent - in regions with one long rainy season when all water demands are met by rainwater; however, during the dry season, water is collected from non-rainwater sources.
- Partial - rainwater is used throughout the year but the 'harvest' is not sufficient for all domestic demands. For instance, rainwater is used for drinking and cooking, (while for other domestic uses (e.g. bathing and laundry) water from other sources is used.
- Full – throughout the whole year, all water used for domestic purposes comes from rainwater. In such cases, there is usually no alternative water source other than rainwater, thus the water harvested should be well managed, with enough storage to bridge a dry period.

The type of user regime to be adopted depends on many variables including rainfall quantity, rainfall pattern (length of the rainy periods, the intensity of the rains), available surface area, available or affordable storage capacity, daily consumption rate, number of users, cost and affordability, presence of alternative water sources and the water management strategy.

Rooftop rainwater harvesting is commonly used for domestic purposes, because the rainwater is easy to collect and the water source is convenient. An added advantage is that users uniquely own, maintain and control their system. Rainwater harvesting is also promoted for commercial and agriculture use, such as small scale irrigation for domestic food production, watering small stock, watering tree nurseries, brick-making etc. For these purposes, the quality of runoff water harvested from other surfaces, such as a slope, does not create a problem. The runoff is stored in ponds (with the disadvantage of evaporation) or small underground storage tanks. Different materials can be used for optimal catchment efficiency. Plastic sheeting and cemented surfaces are commonly used. Although puddled (clay) surfaces reduce the infiltration of runoff, they can result in poor water quality. Rainwater from rock surfaces can be diverted to storage tanks using

[389] Coombes, P.J.; Kuczera, G. (1999): University of Newcastle, School of Civil Engineering.

bunds and gutters. In runoff gardening, rainwater is directly applied to agricultural land by techniques that retain the water in the soil, such as bunds and swales (shallow, level depressions to accumulate runoff and allow infiltration and storage in the soil).

Designing a rainwater system - Calculations

In order to properly assess the type of rainwater system to be utilised, rainfall data is required, preferably for a period of at least 10 years. The more reliable and specific the data is for a given location the better the design will be. Average rainfall data can normally be found at offices of the Dept. of Agriculture or Water Resources, at airports and in the national atlas used in schools.

Domestic water consumption and demand varies substantially by country. Socio-economic conditions and different uses of domestic water are among the influencing factors. Where water is very scarce, people may use as little as a few litres per day. 20 lcd2 is a commonly accepted minimum. An estimate of the amount of water required for economic and productive uses should be added. In general, roof rainwater harvesting is only able to provide sufficient water for a small vegetable plot.

Water demand = 20 x n x 365 litres/year, with n=number of people in the household; if there are five people in the household, then the annual water demand is 36 500 litres or about 3 000 l/month. For a dry period of four months, the required minimum storage capacity is 12 000 litres; this is, however, a rough estimate.

Rainwater supply depends on the annual rainfall, the roof surface and the runoff coefficient.

Supply = rainfall (mm/year) x area (m2) x runoff coefficient

for instance: metal sheet roof of 80m2: S=800 x 80 x 0.8 = 51 200 litres/year.

Figure 40: Graphical method to determine required storage volume[390]).

The graph above indicates the cumulative roof runoff (m^3) over a one-year period, along with cumulative water use (m^3), in order to determine the storage volume (m^3) required. The greatest distance between these two lines shows the storage volume need to minimise the loss of rainwater.

[390] Adopted from Gould, J.; Nissen-Petersen E. (1999): Rainwater Catchment Systems For Domestic Supply.

Annex II: Examples on Drought Management Plans

In the following some examples and lessons learned from drought management plans are given in order to support the ongoing discussion on drought management plans across Europe.

Example 1: Experience on volumetric water management in Charente region

To adapt irrigation water allocation to annual water stored in dams a double system has been implemented in the Charente river basin in 2000: a pricing system coupled with a volumetric management (VM) system[391].

Why a volumetric management system?

The volumetric mechanism has been implemented as result of the main following observation: Double pricing of surface and ground water for irrigation uses is only effective in the basin beyond a price per cubic meter above 0.09 Euro. However in the Charente river, the users fee negotiated with irrigators representatives is composed of a fixed rate of 12.2 Euro/ha and variable rate of 0.003 to 0.006 Euro/m^3. This price does permit to balance budget for dam management but is not enough high to promote water savings. Therefore the VM system has been settled to tackle water scarcity.

Major principles of volumetric management:

- For each farm is allocated a maximal volume of water based on theoretical water requirements for corn cultivation (75% of irrigated area) on 3 types of soil. This reference volume can be reduce in dry years.
- The irrigation season is divided in 10 periods (mid-June to mid-September). The state organism communicates to irrigator a weekly bulletin indicating volumes they are advised not to exceed.
- In case of water scarcity, 4 levels of water restrictions are implemented depending on water flow at a measure point downstream of the Charentes river: Level 1: when flow is lower than 4m^3/sec farmers are forbid to pump 1day/period, level 2: 2days, Level 3, 50% reduction of withdrawals, level 4: no irrigation allowed.
- Volumes abstracted are metered. Monitoring is managed and controlled by local organism in charge of water policy. In case of over consumption, price per cubic meter is maximized and the over consumption can be deducted from the following year allocation.

Technical support to implement VM measures:

[391] The following case study is based Loubier, S., Aubry, N., Christin, F., Giry, E., Garin, P., Malaterre, P.-O. (2005): How to deal with Irrigation Demand in a Context of Water Scarcity and Water Uncertainty: an Example of combining Tools in the Charente River Basin in France.

Two categories of actions are lead to support farmers in a more stringent water management at field level:

- advisory tools for piloting irrigation: this is the role of the weekly bulletin "irrig'info" based on observations on 30 parcels representative of the watershed.
- equipment improvement: Subsidies are allocated to water saving irrigation equipment such as electronic regulation, automated supply systems, hose reels, swivels…

Conclusions and improvement of the drought management system:

Main conclusions after 4 years of implementation of the system are:

- Farmers current consumption is lower (40%) than authorized volumes. 3 reasons have been advanced to explain such difference: volume restrictions induced during dry years, overestimation of reference volume and overestimation of the irrigated area.
- Restriction level 1 and 2 are inequitable and ineffective: Farmers with the largest pumping and irrigation equipment could compensate technically and economically effects of 1 or 2 days of water cut-off without decreasing their total consumption. Therefore daily cut off has been replaced by volumetric restrictions (15% and 30% of water allocation)
- Hydraulic efficiency of the system can be improved through tools for real time regulation of irrigation system supplied by dams (potential gain of 25% of hydraulic efficiency – Litrico, 1999)
- Advisory and training activities (through diagnosis) can contribute to significant water savings. Nevertheless they are not often implemented by farmers as an irrigation diagnosis cost 0.15 eur/m^3 saved while storage costs in hillside reservoir amounts at 0.082 Euro/year.
- Volumetric management relevance discussions has entailed a deeper debate on increase of irrigated crops not sustainable without CAP subsidies.

Case study 2: Drought management plan for Melbourne City[392].

Estimation of water saving induced by drought management plan are available in the case of Melbourne city water use. 4 stages of restrictions have been defined depending on annual water unbalance drought level. 4 stages are including gradual measures on residential or commercial and public Garden or Law, sports ground, pond or lake, fountain or water feature, residential or commercial pool or spa, municipal pool, mobile spa, water toy, dam or tank, water tanker, commercial market garden or commercial or council plant nursery, car wash, surface cleaning, construction, animal husbandry, commercial poultry farm.

[392] Dawson-Waldron, B. (2006): Drought response plan for South East Water, Australia, available at: http://www.sewl.com.au/SiteCollectionDocuments/Corporate%20reports/SouthEastWaterDroughtResponsePlan.pdf.

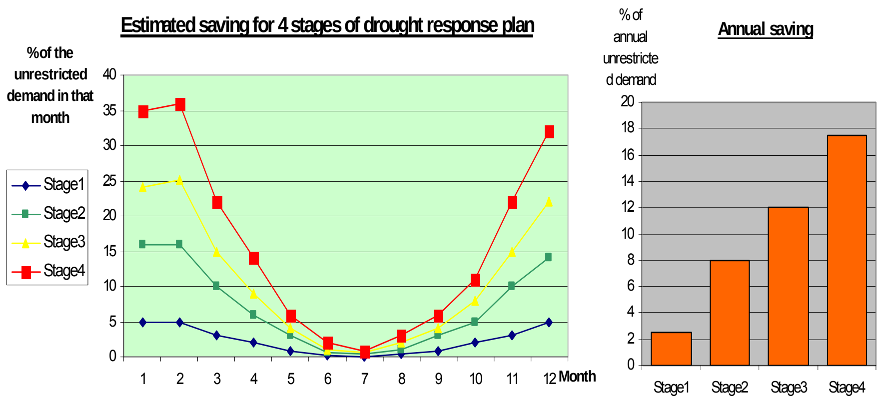

Figure 41: Estimated water savings depending on the level of DMP applied

Case Study 3: City of Louisville, Colorado[393]

This drought management plan is a guide for the City of Louisville for the varying degrees of drought experienced in the normal variations of weather patterns. The purpose is to identify the conditions which place the City in a designated level of drought and predetermine the general responses appropriate for given drought conditions.

Drought Response Strategies:

There are two primary approaches for responding to a drought

- **Increase water supply:** Limited option; it is possible to lease surplus water from other communities or agricultural users in order to meet short-term deficiencies in supply, however, this option will be fairly expensive and may not materially improve water supply in a time of diminished yields
- **Reduce water demand:** The focus of the Drought Management Plan is on how to reduce water usage consistent with the drought event being experienced. To quantify drought events a relationship between water reduction and the severity of the drought event has been developed along with a response plan

Table 57: Defined Drought Stages based on the Water Supply Index (WSI = Supply/Demand) and associated Conservation Goal (%), Drought Response Plan Summary.

Drought Severity and Conservation Goal				Drought Response Summary Plan	
Drought Severity Stage	Trigger	WSI	Conserva-tion Goal*	Main Focus – Private citizens & business	Main Focus – City agencies
Stage 1	Projected streamflow and reservoir yields are	0.85-0.95	10%	Voluntary conservation	Provide water wise

[393] City of Louisville, Colorado (2004): Drought Management Plan, Prepared by: City of Louisville Public Works Department, March 2004.

Moderate	less than 95% of normal demand			measures	information and education
Stage 2 Serious	Projected streamflow and reservoir yields are less than 85% of normal demand	0.75-0.85	20%	Keep the following vegetation alive: - Trees - Shrubs - Vegetable Gardens - Flower Gardens - Lawns	Keep the following vegetation alive: - Trees - Shrubs - Flower Gardens - Turf (Prioritize playing fields for use and watering, keep unused playing fields alive) Open all public pools
Stage 3 Severe	Projected streamflow and reservoir yields are less than 70% of normal demand	0.65-0.75	30%	Keep the following vegetation alive: - Trees - Shrubs - Vegetable Gardens	Keep the following vegetation alive: - Trees - Shrubs - Turf (playing fields and other where possible) Determine on case-by-case basis if public pools will open
Stage 4 Extreme	Projected streamflow and reservoir yields are less than 50% of normal demand	<0.65	50%	Sustain some mature trees, but recognize there may be a major die-off of lawns, trees, and shrubs.	Sustain some mature trees, but recognize there may be a major die-off of turf, trees, and shrubs.

** annual reduction target*

Drought Water Rate Surcharge Plan:

The approach is that the cost of water should be established during the various drought events to generate reductions in water usage necessary to balance supply and demand. In other words, the City's water saving plans are rate based and are not dependent on an extensive list of do's and don'ts associated with water usage. This plan is also based on the premise that more water can be saved during the summer months than the winter months given the winter months reflect a non-irrigation usage necessary for public health and safety. Historic consumption information is contained in the appendix. The calculation of the rate surcharge needed in order to induce water conservation was based on historic consumption information.

For Residential accounts, each single-family account will be allocated 5 000 gallons per month usage at the base rate (currently 1.70$ per 1 000 gallons). Water consumed beyond the 5 000 gallons will be billed according to Table 58.

Table 58: Residential Surcharge Rates

EXISTING RATES		STAGE 1 - MODERATE		STAGE 2 – SERIOUS		STAGE 3 – SEVERE		STAGE 4 - EXTREME	
Consumption	*Rate*	*Consumption*	*Surcharge **	*Consumption*	*Surcharge **	*Consumption*	*Surcharge **	*Consumption*	*Surcharge **
5 001-20 000	$2.50	5 001-20 000	None	5 001-12 000	2	5 001-10 000	2.50	5 001-15 000	5
20 001-30 000	$6.00	20 001-30 000	None	12 001-20 000	5	10 001-20 000	6	15 001-20 000	10
30 001-40 000	$6.50	30 001-40 000	None	20 001-30 000	6	20 001-30 000	12	20 001 & over	20
40 001-50 000	$7.00	40 001-50 000	None	30 001 & over	8	30 001 & over	18	N/A	N/A
50 001 & over	$7.50	50 001 & over	None	N/A	N/A	N/A	N/A	N/A	N/A

* *Surcharge is a multiple of the base rate, currently $1.70 per 1,000 gallons of water used*

Table 59: Non-Residential Surcharge Rates

STAGE 1 - MODERATE		STAGE 2 – SERIOUS		STAGE 3 – SEVERE		STAGE 4 - EXTREME	
Consumption	*Surcharge**	*Consumption*	*Surcharge **	*Consumption*	*Surcharge **	*Consumption*	*Surcharge **
20 001-40 000	None	20 001-40 000	2	20 001-40 000	3	20 001-40 000	5
40 001-60 000	None	40 001-60 000	4	40 001-60 000	6	40 001-60 000	10
60 001-80 000	None	60 001-80 000	6	60 001-80 000	9	60 001-80 000	15
80 001-100 000	None	80 001-100 000	8	80 001-100 000	12	80 001-100 000	20
100 001-200 000	None	100 001-200 000	10	100 001-200 000	15	100 001 and over	25
200 001 & over	None	200 001 & over	20	200 001 & over	20	N/A	

Table 60: Drought Response Plan. Water savings (%) for each drought stage and proposed activities to be implemented in order to achieve them.

Drought Stage	Use Reduction Target / Water Savings	Steps to reduce water usage
1 - moderate	0-10%	Primarily focus on voluntary programs to reduce water usage. At this level of drought it is not expected that noticeable impacts to landscaping would result from voluntary reductions in water usage. Water saving activities: o Eliminate wasted water from sloppy irrigation practices, leakage, and other marginal outdoor water use o Discourage changes in landscaping to higher water use landscapes o Internally, City departments would establish a ways to reduce water usage o Reinforce incentives for converting plumbing fixtures and irrigated areas to low water usage and high efficient devices. o Work with large water users to identify possible areas where their water usage could be reduced.
2 - serious	20%	Requirement of more than eliminating waste and voluntary water saving activities. Moderate changes to normal water use. Surcharges to emphasize the need for conservation in a drought rate structure. Watering restrictions limited to time of day. Water saving activities: o Identify water reductions. Outdoor turf irrigation could be limited to specific hours o Sidewalk, driveway washing or street cleaning through hosing, car washing by bucket only (no hoses), and other water intensive methods would be discouraged o Street sweeping, which utilizes nominal amounts of water for dust suppression would continue as normal o Postpone new landscaping associated with development and discourage landscape modifications that result in higher water usage o Implement the surcharge on water usage previously referenced for the purpose of encouraging water conservation and maintaining revenue for the water utility
3 - severe	30%	Effectively eliminate most outdoor water usage, except for targeted community uses. Most residential and commercial accounts would receive little irrigation water, and therefore see a totally dormant of turf depending on the type. Tree, shrub, and garden watering would follow established guidelines. Water saving activities: o Restrict turf irrigation including parks, golf courses, and other public facilities unless irrigated with reuse water, and only to the extent that utilization of reuse water will not result in additional demand on raw water resources o Implement the drought surcharge in water rates to strongly encourage water conservation through pricing mechanisms and stabilize water revenue o Through city ordinance provide incentives for significant water users such as hotels, motels, etc. to install low flow plumbing fixtures and reward same with significant pricing incentives for water reduction
4-extreme	50%	All outdoor water usage to be prohibited. The drought surcharge implemented to emphasize water saving needs through pricing mechanisms. A special water rate structure such as a water budget based rate structure could be implemented. Given the likely duration of this event, it is probable that all turf would be lost and there would be significant die off of trees, shrubs, and associated landscaping. Water saving activities: o Prohibit use of all outdoor watering o Close public swimming pools and other water using facilities such as the Recreation Centre. Prohibit filling of private swimming pools, hot tubs, ornamental fountains and other optional water features o Implement a moratorium on new water taps until minimum reservoir levels are seen or drought is over o Establish a high profile indoor water conservation program for the purpose of eliminating waste through leak detection and incentives for converting plumbing fixtures to low water usage fixtures

** Surcharge is a multiple of the base rate, currently $2.50 per 1 000 gallons of water used*

For Non-Residential accounts (multifamily, commercial, and industrial) rates will be allocated water based on the tap size. Tap size is proportional to tap fee, which means the larger the tap the more one pays for water resources. As an example each 1 ½-inch account will be allocated 20 000 gallons per month usage at base rate (currently at $2.50 per 1 000 gallons). Water consumed beyond the 5 000 gallons will be billed according to Table 59

The drought response plan is described in Table 61.

Variable Reduction required to produce a given Water Supply Index (WSI):

Table 61: Required water savings (%) to achieve sustainable WSI for different droughts stages under current and future conditions.

A. Current Conditions

Drought Severity	WSI (Supply/Total Demand)	Variable Reduction (%)	Supply (AF/yr)	Total Demand (AF)
NORMAL	156%	0.00%	7,776	5 000
STAGE 1	90%	36.50%	4 938	5 456
STAGE 2	80%	43.00%	4 432	5 538
STAGE 3	70%	49.50%	3 927	5 619
STAGE 4	50%	63.00%	2 877	5 788

B. Future Conditions

Drought Severity	WSI (Supply/Total Demand)	Variable Reduction (%)	Supply (AF/yr)	Total Demand (AF)
NORMAL	119%	0.00%	8 455	7 120
STAGE 1	90%	21.00%	6 679	7 383
STAGE 2	80%	29.00%	6 003	7 483
STAGE 3	70%	37.00%	5 326	7 583
STAGE 4	50%	53.50%	3 931	7 789

Case study 4: Richmond Valley, Colorado[394]

Drought Management Plan (August 2006)

The drought management plan (DMP) establishes how Richmond Valley Council (RVC) will manage its water supply scheme during periods of drought. The service areas included are the Mid and Lower Richmond River (MLRR) area and the Casino area.

The Drought Management Action Plan (DMP) is summarised below:

394 Richmond Valley Council (2006):, Drought Management Plan, Final, August 2006.

Table 62: Richmond Valley Drought Management Action Plan (DMP)

Component	Role	Objective
Strategic Objectives	Overall purpose of the DMP	• Ensure a robust, timely, efficient and affordable response to drought to reduce the water consumption to meet specific targets • Ensure the security of the water supply and the sustainability (economic, social and environmental) of the options to reduce the risk of water supply failure • Ensure consistency with the strategic frameworks of the local bulk supplier • Ensure consistency with the strategic frameworks
Planning Objectives	System requirements necessary to deliver the strategic objectives	• Ensure the viability of the water supply system by providing appropriate operation and maintenance of the infrastructure • Develop drought management strategies to minimise the risk of water supply failure • Define levels of water restrictions and trigger points • Develop procedures to effectively monitor and review the drought management strategies developed
Operational Objectives	Implementation of restrictions and drought response measures	• Educate the community about water conservation and reducing water consumption • Ensure that operating and managerial staff have a clear understanding and knowledge of the steps to implement this plan and their roles and responsibilities • Ensure water users are aware of this DMP prior to and during operation • Ensure clear communication to the public (including visitors) of water restrictions, enforcement policies and the actual impact of such restrictions while implemented • Ensure water quality meet all relevant health standards and guidelines at all levels of restrictions • Ensure the provision of a minimum water supply during emergencies for basic sanitation and health requirements • Ensure the plan is monitored during drought and adjusted over time as necessary

To plan a drought management plan it is necessary to understand the minimum water supply (health and sanitation) requirements of the RVC area, and those are demonstrated below:

Table 63: Richmond Valley customers' drought requirements and associated water savings

Consumer Category	Water Consumption (L/account/d)				Minimum Current Water Requirements (L/account/d)			Water Saving Potential (Current-Minimum) %
	Current (year 2005)		*Expected (year 2011)*[3]					
	Potable[1]	Potentially Non-Potable[2]	Potable	Potentially Non-Potable	Potable[4]	Potentially Non-Potable[6]	Total	
Multi Business[5]	8 184	2 046	8 028	1 900	2 250	6 750	9, 000	12%
Single Business	3 979	995	3 899	920	Unknown			N/A
Vacant Business	111	28	109	26	0	0	0	100%
Parks	537	60	526	55	0	0	0	100%
Multi Residential	362	195	337	156	27	81	108	81%
Single	276	276	224	210	34	101	135	76%

Residential								
Vacant Residential	14	14	14	13	0	0	0	100%
Rural	618	618	606	571	34	101	135	89%
Others[7]	Unknown		Unknown		34	101	135	N/A
Fire Fighting Requirements	Unknown		Unknown		Unknown			N/A

Notes:

1. As there is no mechanism at the customer level for separately providing non-potable water inside most premises (with the exception of those customers who have installed and plumbed rainwater tank to the laundry or toilet), current potable requirements have been defined as all internal water use.

2. Drawing from the definition in note 1, the current non-potable requirements have been defined as all external water use.

3. Based on the definitions in notes 1 and 2 and on the implementation of water efficiency program 2 identified in the RVC demand management modelling carried out for RVC IWCM concept study (JWP, 2006).

4. Minimum potable water requirements based on 15 L/person/day assuming an average occupancy ratio of 2.25 per single residence and 1.8 per multi-residence. 15 L/person/day minimum potable allowance for drinking, cooking and personal hygiene (pers. comm. P. Byleveld NSW Health).

5. Assumed that the category of Multi Business is institutional accounts. Assume an average occupancy of 150 persons per institutional account. There may be some double counting in these assumptions as, for instance, the water requirements of school children and staff would be accommodated in the assessment of the needs of homes. However, allowance has to be made for residential facilities such as hospitals and aged care.

6. Additional allowance of 45 L/person/day for flushing toilets and washing clothes by bucket (pers. comm. P. Byleveld NSW Health). This water may not necessarily be of a potable standard but would need to meet secondary contact requirements as a minimum.

7. This category includes residential rural areas that are not connected to the RVC water supply systems and that are supplied by rainwater tanks and/or groundwater. It is assumed that in severe drought, the non-reticulated supplies may also fail.

Table 64: Water Restriction Levels and Water Saving Measures

Customer	Sensible water use order	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Target Demand		32.5 ML/day	30 ML/day	26 ML/day	24 ML/day	23 ML/day	22 ML/day
Residential (single and multi residential dwellings)							
Outdoor Usage	o Sprinklers and fixed hoses not to be used from 8am-4pm o All hoses must be fitted with an on/off nozzle o Essential garden watering only o Washing of vehicles should be done on grassed rather than paved surfaces o No hosing of hard surfaces unless for health reasons	Sprinklers and fixed hoses not to be used from 8am-4pm	o Sprinklers and fixed hoses are totally banned. Hand held doses allowed for 2hrs/day and micro-sprays for 15min/day outside hours from 8am-4pm on alternative days. o Households w/an even street number can water on even numbered calendar days, same practice for the odd numbers	o Sprinklers and fixed hoses are totally banned. Hand held doses allowed for 2hrs/day and micro-sprays for 15min/day outside hours from 8am-4pm on alternative days. o Households w/an even street number can water on even numbered calendar days, same practice for the odd numbers	o Sprinklers and fixed hoses are totally banned. Hand held doses allowed for 2hrs/day and micro-sprays for 15min/day outside hours from 3pm-10pm on alternative days. o Households w/an even street number can water on even numbered calendar days, same practice for the odd numbers	Sprinklers, micro-sprays. Fixed and hand held hoses are banned. Buckets or watering cans only	All external use of town water is banned
Internal Use	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines	o Installation of water efficient fittings and minimizing shower times o Full load for dishwashers and clothes washing machines
Swimming Pools-Private	No restrictions apply	No restrictions apply	No restrictions apply	o Filling of new pool allowed o Topping up of pools allowed by hand held hose 1hr/day outside the hours 8am-4pm on alternate days matching house numbering	o Topping up of pools to 300mm below skimmer box by hand held hose only for ½ hr/week on Wednesdays o New pools to be filled only to 300mm below skimmer box	o Topping up of pools to 300mm below skimmer box by hand held hose only for ½ hr/week on Wednesdays o New pools to be filled only to 300mm below	Emptying, filling and topping up of pools banned

				o Emptying and filling of existing pools banned	o Emptying and filling of existing pools banned	skimmer box o Emptying and filling of existing pools banned	
Business & Commercial							
Public gardens/ Sports grounds/ Community facilities	o Sprinklers and fixed hoses not to be used from 8am-4pm o All hoses must be fitted with an on/off nozzle o Exceptions for sprinkler use (up to 2hr/day) allowed for essential businesses e.g. nurseries, or where business hours dictate water use e.g. schools, public gardens, sport grounds o Washing of vehicles should be done on grassed rather than paved surfaces o Installation of water efficient fittings and minimizing shower times o No hosing done of hard surfaces unless for health reasons	o Sprinklers and fixed hoses not to be used from 8am-4pm o Exceptions for sprinkler use (up to 2hr/day) allowed for essential businesses e.g. nurseries, or where business hours dictate water use e.g. schools, public gardens, sport grounds	o For level 2 restrictions (as above) o Exceptions for sprinkler use (up to 2hr/day) allowed for essential businesses e.g. nurseries, or where business hours dictate water use e.g. schools, public gardens, sport grounds	Hand held hoses allowed for 1 hour every second day outside the hours of 8am and 4pm	Buckets or watering cans only	Buckets or watering cans only	Use of town water is banned
Public Pools				Topping up allowed	Topping up allowed	Topping up allowed	Closed
Schools				Hand held hoses allowed for 1 hour every second day. Apply for times	Buckets or watering cans only	Buckets or watering cans only	Buckets or watering cans – eating areas for health rasons only
Nurseries				Sprinklers and hand held hoses allowed for 2 hrs/day. Apply for times	Sprinklers/Hand held hoses 1 hr/day – apply for times	Sprinklers/Hand held hoses 1 hr/day – apply for times	Buckets or watering cans allowable at all times
WASHING Motor Vehicles-cars, taxis, food transport, commercial, etc.				Buckets only-exemptions for essential purposes by application only	Buckets only-exemptions for essential purposes by application only	Buckets only-exemptions for essential purposes by application only	Use of town water is banned
Bowling Greens				Hand held hoses allowed for 2 hrs/day. Apply for times	Hand held hoses allowed for 1 hr/day from 6pm-7pm	Buckets or watering cans only	Use of town water is banned
Building Construction				No restriction on essential business use	No restriction on essential business use	Restricted to essential business use	Restricted-application for times
New Turf/Landscaping				Hand held hoses 1 hr/day – eating areas for health reasons only	Once only 1 hr water in by hand held hose and then bucket or watering can only	Buckets and watering cans only	Use of town water is banned

Paved public areas, where food is prepared or consumed, or for health reasons				Hand held hoses 1hr/day – eating areas for health reasons only	Buckets and watering cans only	Buckets and watering cans - eating areas for health reasons only	Buckets and watering cans - eating areas for health reasons only
Water Cartage-Potable Supply				No Restriction-private carriers must be registered. Approved filling locations only	No Restriction-private carriers must be registered. Approved filling locations only	Filling of domestic tanks only–private carriers must be registered. Approved filling locations only	Filling of domestic tanks only–private carriers must be registered. Approved filling locations only
Auto Flush Urinals/Public toilets				On Timers – Banned On Demand - OK	On Timers – Banned On Demand - OK	On Timers – Banned On Demand - OK	On Timers – Banned On Demand - OK
Industrial							
Meatworks/Hide Traders, Norco Ready Mix Concrete & Others	Implementation of water savings and demand management measures	o Implementation of water savings and demand management measures o No restrictions on water usage for essential business activities	o Implementation of water savings and demand management measures o No restrictions on water usage for essential business activities	No restrictions on water usage for essential business activities – close consultation with Council	No restrictions on water usage for essential business activities – close consultation with Council	No restrictions on water usage for essential business activities – close consultation with Council	Business usage restricted – close consultation with Council. Application to be made for business operating hours.
Rural							
Stock Watering	No restrictions apply	No restrictions apply	No restrictions apply	No restrictions apply	No restrictions apply	No restrictions apply	Restricted – approval from Council only

Case study 5: City of Albury, New South Wales, Australia[395]

Albury has a secure water treatment, distribution and reticulation system, with a capacity of 140 ML/day which is approximately twice the capacity of the highest recorded peak day consumption to date. The City's Service Reservoirs have a storage capacity of 97.4 ML, enough to cater for most emergency distributions to supply. The Albury Drought Contingency and Emergency Response Plan is based on Demand and Supply Management. Demand Management focuses on community awareness and cooperation in maximizing water conservation backed up by a charging policy which effectively rewards consumers using 300 kilolitres per year or less.

The following targets for water consumption have been identified:

Annual Consumption = 10 925 ML

Peak Day Demand = 75 ML/day

Growth in Demand (based on 2001/02 usage rates) ≤ 0.5% p.a.

Water Supply

Table 65: Water Supply Services

Water Supply	
Filtration Plant Capacity	140 ML/day
Reservoirs' Storage Capacity	97.4 ML
Entitlement	12, 274 ML
Annual consumption (2001/02)	10 022 ML
Population Supplied	46, 000 approx.
Customer Service Connections	18 326

Table 66: Trends in Water Consumption

Period	Consumption
20 year average consumption	9 924 ML/year
10 year period (1982/83-1991/92) average consumption	10 038 ML/year
10 year period (1992/93-2001/02) average consumption	9 810 ML/year
5 year period (1997/97-2001/02) average consumption	10 316 ML/year
Entitlement	12 274 ML/year
Peak Day consumption (1997)	76.5 ML
Peak Day consumption (1998)	71.6 ML
Peak Day consumption (1999)	74.2 ML
Peak Day consumption (2000)	66.9 ML
Peak Day consumption (2001)	69.0 ML

[395] Albury Water (2002): Drought Contingency and Emergency Response Plan, November 2002, Amendment No.2.

The rates and charges which apply to customers (based on 09/2002) are

Water Rate:	$153 per assessment ($102 for flats and units)
Sales:	12c per kl up to 300 kl/annum
	45c per kl thereafter

Water Conservation Strategy

Multiple campaigns promoting voluntary water conservation and water saving tips, backed up by a two-tier charging policy which effectively rewards consumers who use 300 kilolitres or less per year. The two-tier charges are:

Consumption 0-300 kl/year @ 12 cents per kl

Consumption > 300 kl/year @ 45 cents per kl

The penalty charge for usage over 300 kl/year relates to a multiplier of 3.75

Demand Reduction during Drought

There may be occasions when restrictions need to be imposed to cater for drought conditions. The probability that restrictions will occur is 4% (i.e. 4 years out of every 100 years). The Stages that will be applied under declared drought conditions are as follows:

Table 67: Restriction towards Water saving for the different Drought Severity Sta

Drought Severity Stage	Imposed Restrictions for Water Saving
Stage 1: Voluntary Reductions	To be implemented when consumption approaches target trigger levels. Public awareness campaign targeting on voluntary restrictions in garden watering, use of fixed sprinklers
Stage 2: Low Level Restrictions	To be implemented when requested by the DLWC, may or not be tied to forecast temperature. Trigger: consumption reaches or exceeds benchmark consumption trend line. Restrictions: ban on sprinkler use from 7am-9pm, only hand held hoses during those hours
Stage 3: Moderate Restrictions	To be implemented when requested by the DLWC and/or demand is predicted to approach available capacity to supply. Trigger: consumption reaches or exceeds benchmark consumption trend line for 4 weeks. Restrictions: total ban on use of sprinklers, garden watering restricted to hand held hoses from 9pm-12pm, introduction of roster system for gardens based on odd/even home may be introduced
Stage 4: Severe Restrictions	To be implemented when requested by the DLWC and/or demand is likely to approach to exceed capacity to supply. Trigger: consumption exceeds benchmark consumption trend line by more than 10% for 6 weeks or longer. Restrictions: total ban on garden & loan watering, domestic car washing 7 other forms of external use, restricted standpipe use, agreed reductions in industrial & commercial use
Stage 5: Emergency Restrictions	To be implemented in extreme conditions of water shortage, when river flows approach cease-to-flow condition. Supply restricted to 60 lt/person/day

Water Saving Facts:

The average consumption over the last 10 years (9 810 ML/year) is 2.3% lower (water saving) than the average consumption for the previous 10 years, 1982/83-1991/91 (10 083 ML/year). This reduction in consumption is noteworthy given that the population growth in the 20-year period has averaged 0.82% per year. There are two explanations for this reduction in consumption:

- The City has annually conducted a water conservation campaign since 1994/95;
- The 2 part tariff system for water consumption has been applied (12c/kl for the first 300 kl/year and 45c/kl thereafter);
- The "threshold" of 300 kl/year was reduced from 450 kl/year in 2000/01.

As a conclusion, without any mandatory restrictions water saving has been achieved.

Case Study 6: San Diego County, California[396]

In planning and managing Drought, water conservation plays a critical role in long-term supply reliability for the region. The San Diego County Water Authority (CWA) and its member agencies are implementing an aggressive conservation program to use water more efficiently. The total reduction in water demand attributable to projected conservation savings over the next 25 years is identified in the following table:

Table 68: Water Supply and Demand assessment, and projected Water Saving

CWA Single Dry Water Supply and Demand Assessment (AF/yr), and associated Water Saving					
Year	2010	2015	2020	2025	2030
Total Projected Supplies	767 650	795 970	825 560	848 610	883 030
Total Estimated Demands w/Conservation	767 650	795 970	825 560	848 610	883 030
Total Projected Conservation Savings (normal year)	79 960	87 306	94 174	101 954	108 396
% Conservation Saving	10%	11%	11%	12%	12%

CWA Conservation Activities: The San Diego CWA has underway programs which will reduce water use. Most of those programs are efforts designed to improve the efficiency of water use in the long run, focusing on physical system changes (retrofitting older plumbing fixtures, educate users etc, large turf irrigators etc.) Additionally, water saving programs intended strictly to short-term drought response will be implemented.

Table 69: CWA Conservation Programs and associated costs

Long Term Demand Management Programs implemented by the CWA affecting Drought		
Program	*Description/Target*	*CWA Cost*
Agricultural and Turf Audit	Funding 4 ongoing teams of irrigation experts who provide audits for large users (urban irrigators: parks, cemeteries, golf courses, multi-residential, agricultural irrigators)	$98,000
Toll free CIMIS (California Irrigarion Management System) information	Information to irrigators in determining optimal irrig.schedules through a toll free number updated every 24hrs	$5,000
Multi-family Plumbing Replacement	Replacement of 500 non0conserving toilets and showerheads	$25,000

[396] San Diego Water County Authority (1991): MWD's Incremental Interruption and Conservation Plan, November 1990 and San Diego Water County Authority, Drought Response Plan, February 1991.

	w/new water saving fixtures	
SDG&E Showerhead Project	Replacement of 40,000 non-conserving residential showerheads w/conserving heads	$58 000
Toilet Rebates	Over 13,000 rebates for up to $100 rebate each toward the cost of a new toilet using up to 1.6 gal/flush (over 13	$125 000
Single Family Surveys	The home survey includes showerhead replacement, examin. Of toilets for leaks, distribution of faucet aerators and analysis of outdoor water use	$70 000
Industrial Audits	Targeted to about 100 industrial users for water efficiency surveys. Contract to a consultant to review process water uses, and assist them in developing methods to increase water use efficiency	$140 000
Total Number of Programs: 7		*$521 000*
Short Term Drought related Programs implemented by the CWA		
Showerheads for Member Agencies	Apply approx. 10,000 showerheads kits to the member agencies for distribution within their service areas	$30 000
Enforcement Training	Assist member agencies in providing training for personnel charged with the responsibilities of water restrictions enforcement	$15 000
Assistance to Public Institutions	Assistance in repairing and increasing the efficiency of irrigation systems, installing water saving devices, manpower to repair minor plumbing leaks and low flow showerheads, etc. A plumbing and irrigation contractor would be hired at a basic hourly rate. Letters to be send to candidate institutions publicizing the program. Check audits to be performed by the CWA	$100 000
Total Number of Programs: 3		*$145 000*

The above mentioned water conservation activities were implemented according to the 1991 San Diego Water County Authority Drought Response Plan. In the same Plan the CWA used the following guidelines in administering the Plan:

Table 70: CWA guidelines in administering the 1991 Drought Response Plan

Drought Severity Level	Municipal Water Districts (MWD) Reductions		Estimated CWA Reductions
	In Non-Firm Deliveries	In Firm Deliveries	
Phase I (Voluntary)	5%	5%	5.0%
Phase II	20%	5%	7.8%
Phase III	30%	10%	14.7%
Phase IV	40%	15%	21.6%
Phase V	50%	20%	28.5%

Case Study 7: Bourke Shire of New South Wales, Australia[397]

To define the DMP the water supply requirements for the different water uses were carefully evaluated and measures to be taken in order to achieve reductions in the water use for the different drought severity levels have been proposed. In the case where the water

[397] Bourke Shire Council (2002): Draft Drought Management Plan, 24/10/2002.

conservation measures are not efficiently covering the problem, emergency supply sources can be activated, were the associated cost per km (truck transfer) was calculated. The results are summarized in the following tables.

Water Supply and Requirements:

Table 71: Community Water Services

EXISTING POTABLE WATER SUPPLIES					
Community	Population	No. Houses	Water Source	Provider	Storage Vol.
Bourke	3 000	1 150	Darling R Weir Pool	Council	4 470 ML
North Bourke	46	25	Darling R Weir Pool	Council	4 470 ML
Louth	32	25	Rainwater Tanks	Private	Average 10kL/house
All other communities & properties	823	537	Rainwater Tanks	Private	Average 10kL/house
EXISTING NON-POTABLE WATER SUPPLIES					
Bourke	3 000	1 150	Darling R Weir Pool	Council	4 470 ML
North Bourke	46	25	Darling R Weir Pool	Council	4 470 ML
Louth	32	25	Darling R Weir Pool & Bore	Council	4 000 ML WP Bore NK
All other communities & properties	823	537	Artesian Bore	Council	Various or NK

Table 72: Community Water Requirements

Community	Population	# Houses	Human Consumption Requirements (9L/person/d) kL/day	Potable Minimum Requirements (100L/person/d) kL/day	Non-Potable Basic Requirements (715L/person/d) kL/day
Bourke	3 000	1 150	27	300	822.3
North Bourke	46	25	0.4	4.6	17.9
Louth	32	25	0.3	3.2	17.9
All other communities & properties	823	537	7.5	82.3	389.9

Table 73: Industry dependant services

Horticulture Operators Dependant on the Bourke Weir Pool			
Property	***Crop***	***Area (ha)***	***Average Weekly Requirement (kL)***
Lodebar	Citrus	45	9 000
Rivergum	Table Grapes	30	6 000
Darling Farms	Citrus	40	8 000

Darling Farms	Jojoba	80	15 000
Mansell's	Table Grapes	160	31 000
Mansell's	Citrus	140	27 000
Mansell's	Stone Fruits	10	2 000
Pitches	Citrus	6	1 000
Parkdale	Table Grapes	5	1 000
Joaquin	Table Grapes	5	1 000
Ferguson Farms	Wine Grapes	3	1 000
TOTALS		**524**	**101 000**

Water Restrictions:

Based on the DMP the following restrictions apply for each category of water users:

Table 74: Water Restrictions for different levels

Restriction level	1	2	3	4	5	6
At River Gauge Level	3.9 m	3.5 m	2.7 m	2.1 m	1.6 m	1.1 m
Weir Poll Volume	100% (4 470 ML)	75% (3 350 ML)	50% (2 230 ML)	35% (1 560 ML)	25% (1 120ML)	15% (670 ML)
DOMESTIC						
Household Use	No restrictions	No restrictions	No restrictions	No restrictions	No restrictions	100L/person/day
Evaporative Airconditioners [1]	No restrictions	No restrictions	No restrictions	No restrictions	No bleed-off allowed	No water allowed
Garden Watering	Sprinklers 2hrs/d	Sprinklers banned	Hand held hoses 2hrs/day	Hand held hoses 1hr/day	Buckets only	Reused water only
Swimming Polls Private	Filling of pools prohibited	Filling of pools prohibited	Filling and topping of pools prohibited	Filling and topping of pools prohibited	Filling and topping of pools prohibited	Filling and topping of pools prohibited
Wash paved areas and roof	No restrictions	Buckets only except as required by law	Buckets only except as required by law	Buckets only except as required by law	Banned except as required by law	Banned except as required by law
PUBLIC / COMMERCIAL						
Public Gardens	Sprinklers 2hrs/d	Sprinklers 1hr/d	Hand held hoses 2hrs/day	Hand held hoses 1hr/day	Reused water only	Reused water only
Sports Gardens	Sprinklers 2hrs/d	Sprinklers 1hr/d	Hand held hoses 2hrs/day	Hand held hoses 1hr/day	Reused water only	Reused water only
Market Gardens and	Sprinklers	Sprinklers	Sprinklers	Sprinklers	Sprinklers	With

Orchards	6hrs/d	6hr/d	4hr/d	4hr/d	2hrs/d	Council license only
Nurseries and Commercial Flower Gardens	Sprinklers 2hrs/d	Sprinklers 1hr/d	Hand held hoses 4hrs/day	Hand held hoses 2hrs/day	With Council license only	With Council license only
Washing Motor Vehicles	No restrictions	No restrictions	Manual buckets only	Manual buckets only	Banned except as required by law	Banned except as required by law
Bowling greens	Sprinklers 2hrs/d	Sprinklers 1hr/d	Hand held hoses 2hrs/day	Hand held hoses 1hr/day	Reused water only	Reused water only
Fountains	No restrictions	Topping up prohibited	Banned	Banned	Banned	Banned
Water Cartage from Town Supply	No restrictions	No restrictions	With Council license only	With Council license only	With Council license only	With Council license only
Automatic flush toilets	No restrictions	No restrictions	Banned	Banned	Banned	Banned
INDUSTRIAL						
Soft Drink Manufacturer	No restrictions	No restrictions	No restrictions	8hrs/day operation only	With Council license only	Banned
Ready Mixed Concrete	No restrictions	No restrictions	No restrictions	8hrs/day operation only	With Council license only	Banned
Others	No restrictions	No restrictions	No restrictions	8hrs/day operation only	With Council license only	Banned
HORTICULTURE						
Horticulture	Under Review	Under Review	Under Review	Under Review	Under Review	Banned

Note: [1] Evaporative Airconditioners Bleed-off average is 18L/hr. For 24hr operation, consumption is 423L/day. 1,000 houses x say 80% with evap cooling total Town use = 345kL/day

Table 75: Horticulture Operators Water Restrictions

Property	Crop	Area (ha)	0% Restrictions ML/Wk	25% Restrictions ML/Wk	50% Restrictions ML/Wk	75% Restrictions ML/Wk
Lodebar	Citrus	45	9	6.5	4.3	2.2
Rivergum	Table Grapes	30	6	4.3	2.9	1.4
Darling Farms	Citrus	40	8	5.8	3.8	1.9
Darling Farms	Jojoba	80	15	11.5	7.7	3.8
Mansell's	Table Grapes	160	31	23.1	15.4	7.7
Mansell's	Citrus	140	27	20.2	13.5	6.7
Mansell's	Stone Fruits	10	2	1.4	1.0	0.5
Pitches	Citrus	6	1	0.9	0.6	0.3

Parkdale	Table Grapes	5	1	0.7	0.5	0.2
Joaquin	Table Grapes	5	1	0.7	0.5	0.2
Ferguson Farms	Wine Grapes	3	1	0.4	0.3	0.1
TOTALS		**524**	**101**	**76**	**50**	**25**

Note: Horticulture Needs based on 10 ML/ha/yr which is an industry standard

Irrigation extraction is not guaranteed at any point, and may be suspended at any time. Horticulturalists should be aware of the risk of continuing with a crop without guaranteed access to water

In case that emergency water supply needs to be found by alternative sources, there are several nearby abstraction points (0-200 km) that can be utilized as alternative resources. The associated cost to truck water to Bourke is $88.80 per km per day or $621.60 per km per week (7 days). This cost is based on the minimum supply level of 100 L/person/day.

Case Study 8: Yarra Catchment, Melbourne Area, Australia[398]

Melbourne Water has an obligation under the State Environment Protection Policy for Waters of the Yarra River and tributaries, to attempt to maintain a flow rate of 245 ML/d in the Yarra River at Warrandyte. This DRP applies to all Melbourne Water managed private river water diversions within the Yarra catchment or on other unregulated waterways if considered appropriate. The DRP enhances voluntary water savings or introduces water reductions (30-80%) according to the associated restriction level as summarized bellow:

[398] Drought Response Plan (Yarra Catchment)(2001): Private Diversions, Melbourne Water, DRP Final Version, November 2001

Table 76: Drought Response Plan

<table>
<tr><th>Licence type</th><th>Restriction level 1
Yarra flow 375 ml/d</th><th>Restriction level 2
Yarra flow 300 ml/d</th><th>Restriction level 3
Yarra flow 200 ml/d</th></tr>
<tr><td>Direct diverters - general & annual crop</td><td rowspan="5">All private diverters to carefully and responsibly manage their water requirements to ensure water is conserved and that environmental streamflows are maintained.

Individual drought contingency plans should be implemented</td><td>Pumping permitted 8 hours between 6am-10am and 6pm-10pm on allotted days. Commercial flower growers and similar pump 4 hours between 6am-8am and 6pm-8pm each day.</td><td>Pumping permitted 2 hours between 8am-10am or 7pm-9pm on allotted days. Commercial flower growers and similar pump 1 hour between 9am-10am or 7pm-8pm each day as agreed with mwc</td></tr>
<tr><td>Direct diverters - perennial crop</td><td>Pumping restrictions apply as per direct diverters.</td><td>Pumping permitted 4 hours between 6am-10am or 7pm-11pm on allotted days.</td></tr>
<tr><td>Direct diverters - onstream dam</td><td colspan="2">No restrictions provided diverters share of dam storage is at least 50% of licensed entitlement and all water used is drawn from reserves of stored water. If share is between 20% - 50% stored water may be used but licence holder must collaborate with other affected diverters. If share is less than 20% of licensed entitlement normal direct diverter restrictions apply.</td></tr>
<tr><td>Direct diverters - golf courses</td><td>Volume diverted to be reduced by 30%. Records to be kept of actual use for audit purposes</td><td>Volume diverted to be reduced by 80%. Records to be kept of actual use for audit purposes.</td></tr>
<tr><td>Domestic and stock</td><td>Pumping banned if alternative supply available. Otherwise no restrictions except hand held hoses or watering cans to be used on gardens, cars to be washed by bucket.</td><td>Pumping banned if alternative supply available. Otherwise no restrictions except as follows: • watering of home gardens is banned unless required for legitimate fire prevention reasons • washing of vehicles using stream water is banned</td></tr>
<tr><td>Domestic and stock - town water supply</td><td rowspan="6">All private diverters to carefully and responsibly manage their water requirements to ensure water is conserved and that environmental streamflows are maintained.

Individual drought contingency plans should be implemented</td><td>Mwc approved local drought response plan to be implemented.</td><td>Mwc approved local drought response plan to be implemented</td></tr>
<tr><td>Onstream dam - winterfill</td><td>No restrictions provided water supply is drawn from reserves of stored water, but conditions apply</td><td>No restrictions provided water supply is drawn from reserves of stored water, but conditions apply</td></tr>
<tr><td>Off-stream dam winterfill</td><td>No restrictions provided water supply is drawn from reserves of stored water, but conditions apply</td><td>No restrictions provided water supply is drawn from reserves of stored water, but conditions apply</td></tr>
<tr><td>Fish farms, cooling and electricity generation</td><td>No restrictions provided 100% of water is returned in accordance with epa licence.</td><td>Provided 100% of water is returned in accordance with epa licence no more than the lesser of 25% of the assessed streamflow or 75% of the daily flow as indicated on the licence may be diverted.</td></tr>
<tr><td>Industrial</td><td>Volume diverted to be reduced by 30%. Records to be kept of actual use for audit purposes.</td><td>Volume diverted to be reduced by 70%. Records to be kept of actual use for audit purposes.</td></tr>
<tr><td>Temporary authorities</td><td>All current tas to be cancelled, no new ones issued.</td><td>All current tas to be cancelled, no new ones issued.</td></tr>
</table>

Annex III: Water footprint for selected countries[399]

Country	Population	Use of domestic water resources					Use of foreign water resources			Water footprint		Water footprint by consumption category				
			Crop evapotranspiration*		Industrial water withdrawal		For national consumption					Domestic water	Agricultural goods		Industrial goods	
		Domestic water withdrawal	For national consumption	For export	For national consumption	For export	Agricultural goods	Industrial goods	For re-export of imported products	Total	Per capita	Internal water footprint	Internal water footprint	External water footprint	Internal water footprint	External water footprint
		Gm³/yr	Gm³/yr	Gm³/yr	Gm³/yr	Gm³/yr	Gm³/yr	Gm³/yr	Gm³/yr	Gm³/yr	m³/cap/yr	m³/cap/yr	m³/cap/yr	m³/cap/yr	m³/cap/yr	m³/cap/yr
Afghanistan	26179398	0.34	16.47	0.19	0.001		0.45	0.03	0.01	17.29	660	13	629	17	0	1
Algeria	30169250	1.23	22.77	0.32	0.494	0.25	11.91	0.29	0.31	36.69	1216	41	755	395	16	10
Argentina	36806250	4.68	41.31	48.03	2.328	0.30	1.81	1.53	2.30	51.66	1404	127	1122	49	63	42
Australia	19071705	6.51	14.03	68.67	1.229	0.12	0.78	4.02	4.21	26.56	1393	341	736	41	64	211
Austria	8103235	0.76	2.98	1.89	1.070	0.29	4.66	3.55	3.91	13.02	1607	94	368	575	132	438
Bangladesh	129942975	2.12	109.98	1.38	0.344	0.08	3.71	0.34	0.13	116.49	896	16	846	29	3	3
Belgium-Lux.	10659200	1.09	2.29	3.26	0.382	7.29	14.90	0.54	31.66	19.21	1802	103	215	1398	36	51
Brazil	169109675	11.76	195.29	61.01	8.666	1.63	14.76	3.11	5.20	233.59	1381	70	1155	87	51	18
Bulgaria	8125750	0.37	9.50	1.92	0.048	9.27	1.42	0.00	0.66	11.33	1395	45	1169	174	6	0
Canada	30649675	8.55	30.22	52.34	11.211	20.36	7.74	5.07	22.62	62.80	2049	279	986	252	366	166
China	1257521250	33.32	711.10	21.55	81.531	45.73	49.99	7.45	5.69	883.39	702	26	565	40	65	6
Colombia	41919368	5.31	23.08	9.40	0.358	0.04	4.60	0.70	1.96	34.05	812	127	551	110	9	17
Congo, DR	50264530	0.20	36.16	0.79	0.058		0.39	0.08	0.01	36.89	734	4	719	8	1	2
Côte d'Ivoire	15792145	0.19	26.71	33.83	0.077	0.02	0.96	0.13	1.24	28.06	1777	12	1692	61	5	8
Denmark	5329750	0.38	2.36	6.31	0.296	0.03	2.18	2.46	6.08	7.68	1440	72	442	409	56	461
Egypt	63375735	4.16	45.78	1.55	6.423	0.66	12.49	0.64	0.49	69.50	1097	66	722	197	101	10
Ethiopia	63540513	0.13	42.22	2.22	0.104	0.00	0.33	0.09	0.02	42.88	675	2	664	5	2	1
France	58775400	6.16	47.84	34.63	15.094	12.80	30.40	10.69	31.07	110.19	1875	105	814	517	257	182
Germany	82169250	5.45	35.64	18.84	18.771	13.15	49.59	17.50	38.48	126.95	1545	66	434	604	228	213
Ghana	19082858	0.15	23.44	18.81	0.054	0.00	0.86	0.16	0.70	24.67	1293	8	1229	45	3	8
Greece	10550968	0.83	14.80	3.35	0.775	0.08	7.18	1.62	1.79	25.21	2389	79	1403	680	73	154
India	1007369125	38.62	913.70	35.29	19.065	6.04	13.75	2.24	1.24	987.38	980	38	907	14	19	2
Indonesia	204920450	5.67	236.22	22.62	0.404	0.06	26.09	1.58	2.74	269.96	1317	28	1153	127	2	8
Iran	63201525	4.68	78.58	3.18	0.984	0.60	17.90	0.51	1.03	102.65	1624	74	1243	283	16	8
Iraq	23034540	1.32	23.86	0.63	2.055		3.10	0.58	0.08	30.92	1342	57	1036	135	89	25
Israel	6166040	0.47	1.63	0.20	0.112	0.00	4.28	2.09	0.59	8.58	1391	75	264	694	18	339
Italy	57718000	7.97	47.82	12.35	10.133	5.60	59.97	8.69	20.29	134.59	2332	138	829	1039	176	151
Japan	126741225	17.20	20.97	0.40	13.702	2.10	77.84	16.38	4.01	146.09	1153	136	165	614	108	129
Jordan	4813708	0.21	1.45	0.07	0.035	0.00	4.37	0.21	0.22	6.27	1303	44	301	908	7	43
Kazakhstan	15191620	0.59	24.87	7.92	1.147	4.58	0.29	0.06	0.33	26.96	1774	39	1637	19	76	4
Kenya	29742440	0.44	18.63	4.35	0.079	0.01	1.92	0.16	0.47	21.23	714	15	626	65	3	5
Korea, DPR	22213458	1.68	12.76	0.04	2.268		1.97	0.10	0.01	18.78	845	75	574	89	102	4
Korea, Rep	46813750	6.42	12.34	1.53	2.256	0.56	27.50	6.69	5.06	55.20	1179	137	264	587	48	143
Malaysia	22990590	1.43	36.58	18.47	0.867	0.90	12.73	2.28	8.81	53.89	2344	62	1591	554	38	99
Mexico	97291745	13.55	81.48	12.26	2.998	1.13	35.09	7.05	7.94	140.16	1441	139	837	361	31	72
Morocco	28472000	0.81	35.99	1.33	0.224	0.04	6.07	0.51	0.31	43.60	1531	28	1264	213	8	18
Myanmar	47451298	0.34	73.89	1.53	0.149		0.94	0.17	0.02	75.49	1591	7	1557	20	3	4
Nepal	22772793	0.27	18.35	0.19	0.031	0.00	0.60	0.08	0.01	19.33	849	12	806	26	1	4
Netherlands	15865250	0.44	0.50	2.51	2.562	2.20	9.30	6.61	52.84	19.40	1223	28	31	586	161	417
Nigeria	125374700	1.41	240.38	8.54	0.383	0.30	5.59	0.31	0.43	248.07	1979	11	1917	45	3	2
Norway	4474000	0.45	1.09	0.17	1.032	0.43	2.42	1.57	1.02	6.56	1467	101	244	541	231	350
Pakistan	136475525	2.88	152.75	7.57	1.706	1.28	8.55	0.33	0.67	166.22	1218	21	1119	63	12	2
Peru	25752968	1.47	12.59	1.82	1.379	0.32	4.21	0.37	0.69	20.02	777	57	489	163	54	14
Philippines	75749645	4.50	99.09	7.61	0.805	1.69	11.74	0.71	2.40	116.85	1543	59	1308	155	11	9
Poland	38653288	1.85	21.62	2.78	6.890	4.15	10.41	1.85	2.45	42.62	1103	48	559	269	178	48
Portugal	9997250	1.09	8.00	1.47	1.411	0.62	10.55	1.59	2.64	22.63	2264	109	800	1055	141	159
Romania	22450998	2.04	29.03	2.51	3.527	4.75	3.99	0.34	0.80	38.92	1734	91	1293	178	157	15
Russia	145878750	14.34	201.26	8.96	13.251	34.83	41.33	0.80	3.94	270.98	1858	98	1380	283	91	5
Saudi Arabia	20503670	1.61	10.42	0.42	0.181	0.01	12.11	1.58	0.62	25.90	1263	78	508	591	9	77
South Africa	42387403	2.43	27.32	6.05	1.123	0.40	7.18	1.42	2.10	39.47	931	57	644	169	26	33
Spain	40417948	4.24	50.57	17.44	5.567	1.73	27.11	6.50	11.37	93.98	2325	105	1251	671	138	161
Sri Lanka	18335500	0.25	21.72	2.29	0.165	0.09	1.32	0.24	0.26	23.69	1292	14	1185	72	9	13
Sudan	30832808	0.89	66.62	7.47	0.189	0.04	0.48	0.07	0.07	68.25	2214	29	2161	15	6	2
Sweden	8868050	1.07	4.49	1.42	1.166	0.45	4.52	3.12	2.62	14.37	1621	121	507	509	132	352
Switzerland	7165250	0.45	0.97	0.23	1.057	0.33	5.59	3.98	2.56	12.05	1682	63	136	780	148	555
Tanzania	33299168	0.11	36.39	3.15	0.024	0.00	0.90	0.08	0.08	37.51	1127	3	1093	27	1	3
Thailand	60487800	1.83	120.17	38.49	1.239	0.55	8.73	2.49	3.90	134.46	2223	30	1987	144	20	41
Turkey	66849750	5.38	84.05	9.81	2.731	1.07	13.68	2.11	2.43	107.95	1615	80	1257	205	41	32
Turkmenistan	5184250	0.38	8.39	1.07	0.118	0.05	0.18	0.07	0.05	9.14	1764	74	1619	36	23	13
Ukraine	49700750	4.60	54.14	10.09	3.673	9.71	2.72	0.26	1.21	65.40	1316	93	1089	55	74	5
United Kingdom	58669403	2.21	12.79	3.38	6.673	1.46	34.73	16.67	12.83	73.07	1245	38	218	592	114	284
USA	280343325	60.80	334.24	138.96	170.777	44.72	74.91	55.29	45.62	696.01	2483	217	1192	267	609	197
Uzbekistan	24567500	2.68	18.93	6.24	1.151		1.06	0.23	0.35	24.04	979	109	771	43	47	9
Venezuela	23937750	2.80	12.42	1.28	0.360	0.13	4.86	0.70	0.76	21.14	883	117	519	203	15	29
Viet Nam	78020938	3.77	85.16	11.00	11.280		2.27	0.85	0.29	103.33	1324	48	1091	29	145	11
Global total/average	5994251631	344	5434	957	476	240	957	240	427	7452	1243	57	907	160	79	40

[399] Hoekstra, A.Y.; Chapagain, A.K. (2007): Water footprint of nations: Water use by people as a function of their consumption pattern. Water Resource Management, 21, 35-48.