POLICY BRIEF

What can the EU learn from non-EU countries on its path to climate neutrality?

Main findings and recommendations:

1. **Integration** of different sectors is essential for managing an electricity grid with high shares of variable energy sources, especially wind and solar. This can be achieved by using the potential of prosumers and energy cooperatives to provide flexibility to the grid.

2. Mandating or rewarding utilities to develop **storage** to mitigate the impact of variable energy sources on the grid also helps to better integrate high shares of wind and solar and reduce the need for fossil back-up from peaking power plants.

3. Investment in low carbon technologies can be triggered by streamlining the **permitting process** of renewable energy projects. Concentrating permitting power in a single authority can facilitate this. At the same time, the permitting process needs to ensure acceptance among **local communities** by allowing them to benefit from the investment.

4. Mandates obligating car manufacturers to reduce the carbon intensity of their fuel facilitate investment shift towards low carbon modes of transport and the necessary **infrastructure**

5. Helping individual homeowners fund **thermal retrofits** without the need to finance the high upfront investments combined with policies aimed to end the use of oil for heating in existing buildings could increase renovation, thus accelerating decarbonisation of the buildings sector.

6. Better coordination between railway companies and national and regional governments in **infrastructure planning** and trains operation, combined with a significant increase in funding, could accelerate development of the infrastructure required to decarbonise the EU's transport sector.

7. Additional resources are needed to facilitate cooperation between research institutes and small and medium enterprises that could result in development and deployment of **innovation**. Large scale innovation could be accelerated through preferential loans for higher-risk projects developed in close cooperation with independent experts.

Introduction

With the adoption of the European Green Deal and the European Climate Law, the EU has set a target to cut its emissions by at least 55% by 2030 below 1990 levels and reaching "climate neutrality" by 2050. The existing regulatory framework is mostly geared at incremental progress but reaching this target will require transformative change.

When adapting its policy framework to meet the 2030 and 2050 emissions reduction goals, the EU can learn from the experiences of other countries that have already taken steps towards transformative change in energy, transport or building sectors. This is especially important against the background of the ongoing energy crisis, which requires the EU to wean itself off fossil fuels much faster than expected.

While the experiences of other countries cannot be directly transferred, the EU can nonetheless draw insights and inspiration from some good practice policy examples presented in this brief.

This policy brief summarises the results of 17 case studies of non-EU countries. We present the main lessons and takeaways for the EU along the four challenges that define the 4i-TRACTION project: facilitating integration across sectors, shifting investments, rolling out infrastructure and fostering innovation for a climate-neutral economy.

Facilitating integration across sectors: managing an electricity grid dominated by wind and solar

Most 1.5°C-compatible scenarios assume the electrification of many end-uses, combined with a rapid deployment of renewables to supply the needed electricity. Solar and wind alone are projected to provide 60-89% of electricity generation in 2030, and 82-99% in 2050 (Aboumahboub et al., 2022).

Consequently, renewables are rapidly increasing in importance in the EU. Ever higher penetration of renewable electricity requires a flexible electricity grid, which can be achieved through grid development, application of different storage technologies, and demand management. Such changes require getting all players on board, especially electricity utilities, prosumers, and energy communities.

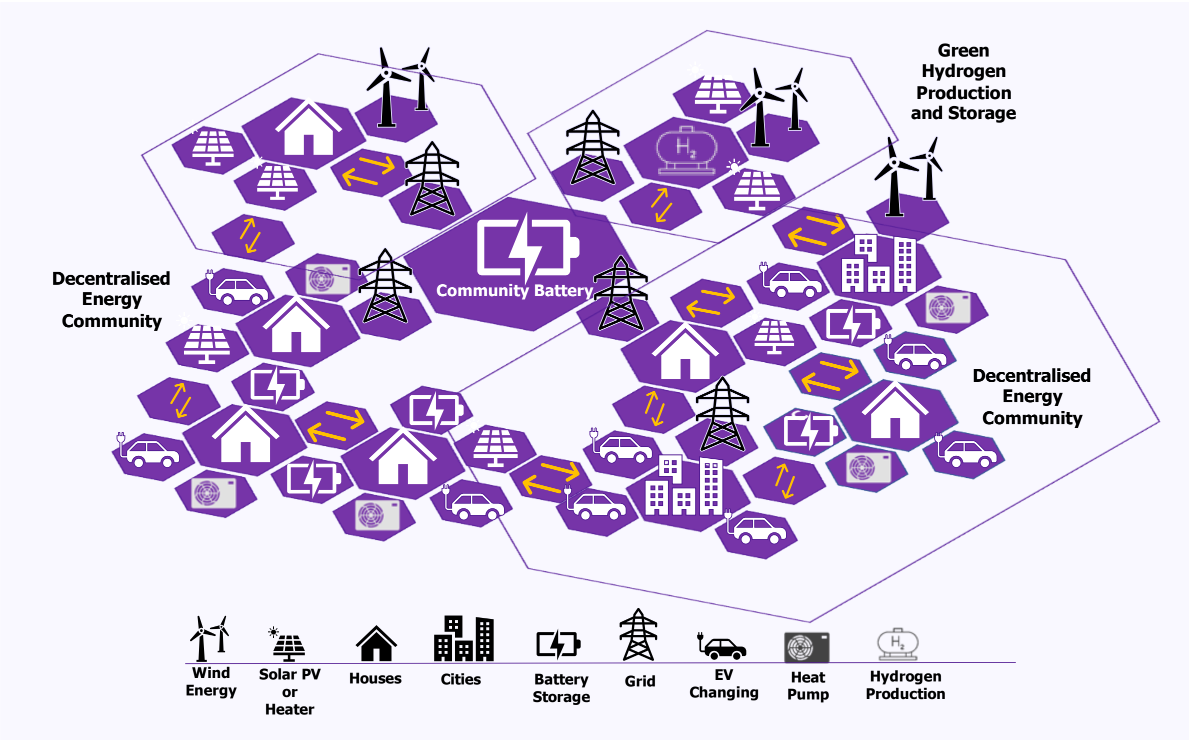
Harnessing the potential of prosumers and energy communities

The electricity market design in most EU member states restricts access to prosumers or unconventional actors. Moreover, charging schemes are complicated and hinder smart electrification of the transport and buildings sectors, especially using electricity generated and stored by prosumers or local communities (Lynch et al., 2021; PvC, 2019). The lack of suitable electricity tariffs and slow roll out of smart meters mean that the potentials of demand-side management remain untapped.

Australia's adoption of Virtual Power Plants and Community Batteries projects shows how reducing the barriers in electricity exchange between prosumers can address the challenges resulting from the high shares of variable renewables. Community Batteries are shared neighbourhood battery systems that are used to store solar energy locally. Sharing a battery at a local level decreases the costs compared with owning an individual battery and contributes to grid stabilisation. One of their main advantages is that consumers can access them for a monthly fee, with no upfront costs and a lifetime cost that is around 30% lower than that of individual storage solutions (Western Power, 2022). By mid-2022 the combined capacity of Virtual Power Plants in Australia amounted to 300 MW, helping to balance the increasing share of renewable electricity in the grid (Kuiper, 2022).

Energy communities are already well established in many parts of the EU. The EU can build on these as illustrated in the concept diagram in **Figure 1**. However, their non-commercial character limits their role in facilitating electricity exchange between participants and lowering their electricity bills. Their role in increasing the flexibility of the electricity grid has not been fully realised, nor recognised.

Figure 1: Concept diagram of the interconnected network of DERs.



Source: Illustration adaptation based on Enova Energy (2021).

With Virtual Power Plants and Community Batteries, Australia has demonstrated the financial viability of business models that not only create savings but may also generate new revenue streams. Key to this was allowing communities and collectives to participate in the electricity market. While there are some pilot projects in the EU that allow this, often based on temporary exemption from certain electricity fees and taxes, they are mostly exceptions. What is missing is a business model that would reward smaller actors for offering storage and flexibility without too much administrative effort, as is the case in Australia. Creating energy communities in the EU would be a win-win situation for their participants and the electricity grid, as it would allow for more flexibility and higher shares of variable renewables.

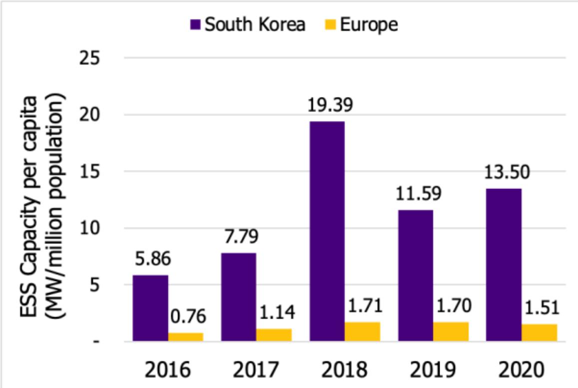
Developing storage by electricity utilities

Energy storage systems are another option to integrate more variable renewables. Electricity storage is important, especially as the EU tries to reduce the role of fossil gas power plants to balance the grid. California and South Korea created policy frameworks that made them leaders in installed battery storage capacity.

California's three major electricity utilities were mandated to procure over 1.3 GW of energy storage by 2020, with installations to be completed no later than by the end of 2024. The other electricity providers were expected to install an equivalent of 1% of their 2020 annual peak load by no later than 2024. The goal was significantly overachieved: as of May 2022, the three major electricity utilities have procured over 7.2 GW energy storage (California Energy Storage Alliance, 2022).

South Korea's storage development was embedded in its Renewable Portfolio Standard (RPS) and the connected renewable energy certificates. The RPS requires utilities to generate a certain share of their electricity from renewables. If they cannot meet their goal, they can purchase certificates from utilities that overachieve their goals.

Figure 2: Additional energy storage capacity per capita installed annually in South Korea and Europe.



Source: Hwang & Jung (2020); IEA (2021). Note: These values were calculated using ESS capacity data from IEA and population data from the World Bank. As the countries in Europe were not defined the IEA data, it was assumed that Europe encompasses the EU, Norway, Switzerland, and the UK.

Renewable energy projects also equipped with battery storage benefitted from a multiplier effect and could generate more certificates than projects without storage. As a result of the policy, the additional storage capacity installed annually in South Korea increased significantly, competing with Europe as a whole, as shown in **Figure 2**. (IEA, 2021; Korea Energy Agency, 2016).

The EU and most of its member states individually lag behind California and South Korea in storage development. With a population 11 times that of California, the EU has only 10 GW of combined battery storage, just a third more than California (Taylor, 2022). While the European Commission expects this to increase to around 57 GW by 2030, other estimates see a need for up to 200 GW storage capacity to accommodate the rapidly growing renewable energy (European Commission, 2022d; Moore, 2022).

Increasing storage capacity could allow EU member states to reduce the role of fossil fuels in their power mixes and thus fossil gas import costs. In addition, storage brings important benefits to the grid, including flexibility, load shifting, and adjusting power frequency. It is therefore necessary for the EU's clean energy transition. However, deploying the required capacity necessitates the creation of an enabling policy environment. Both, South Korea and California demonstrate how targeted policy interventions could accelerate deployment of storage systems and achieve these goals. The fact that California's utilities continued to procure storage well in excess of what they were required to by law, showing that storage is already financially viable within a well-adjusted regulatory framework.

Shifting investment: accelerating investment flow towards renewables, low-carbon transport, and buildings

Facilitating permitting

Permitting is considered to be one of the biggest barriers to accelerating the roll-out of renewables in the EU. While technology costs have come down and capital is abundant, permit lead times for onshore wind power plants still take between 30 months in Romania and 120 months in Croatia (Fox et al., 2022). To scale up the deployment of renewables, permitting issues need to be resolved.

One suggested solution is to concentrate decisions on permitting in a single authority to streamline processes and operate independently of political influence in the decision-making process. Norway's permitting system is an interesting test case for such a proposal. Its permitting system is substantially centralised, with authority concentrated in the Norwegian Water Resources and Energy Directorate (NVE). The streamlining of processes and concentration of decision-making in a largely insulated agency is believed to have benefitted the rapid deployment of onshore wind power in Norway in the past decade. Political discretion, moreover, allows the NVE to prioritise energy over other public interests. However, centralising decision-making and removing formal veto powers from municipalities has resulted in dissatisfaction among local stakeholders and widespread protest against the system, resulting in the halting of all permitting decisions in 2020.

There are important lessons to learn from Norway. Firstly, permitting systems need to ensure long-term social acceptance especially among local communities. This is especially relevant with regards to the EU Commission's latest proposal for 'Renewable Go-To Areas'. Secondly, local communities need to benefit from the hosting of wind power projects, either by becoming shareholders or through financial compensation schemes. Lastly, institutional capacity is imperative to process permits efficiently and effectively.

Incentives for low-carbon road transport

Although transport emissions across Europe continued to rise, the number of electric vehicles increased significantly. In the first half of 2022, almost 19% of all new passenger cars sold in the EU were electric – an increase from 10% in 2020 and 3% in 2019 (ACEA, 2022).

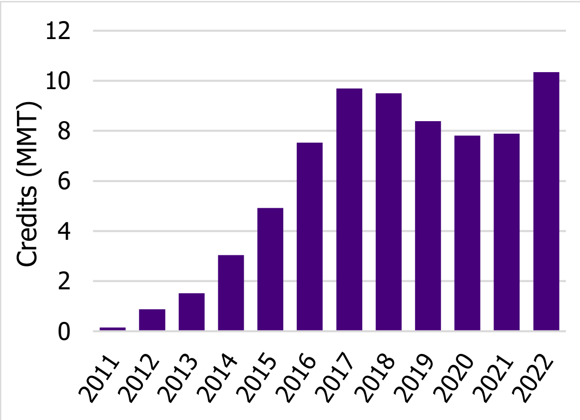
Much of this increase was due to substantial financial incentives offered by several EU member states. There are, however, examples of policies that support the expansion of electric vehicles at significantly lower cost to the public budget: Low Carbon Fuel Standards (LCFS) adopted in California.

California's Low Carbon Fuel Standard aims to reduce greenhouse gas emissions by reducing the carbon intensity of transportation fuel, taking into consideration the fuel's full life cycle GHG emissions (California Air Resources Board, 2022). Fuel producers are obliged to fulfil increasingly stringent carbon intensity requirements by either increasing the low carbon fuel share in their portfolio or by purchasing credits from other entities. Such credits can be generated in numerous ways, e.g., selling electric vehicles, installing charging stations or developing e-fuels for heavy-duty transport. **Figure 3** shows the cumulative volume carbon in million metric tonnes of credits generated through the LCFS, crediting scheme, illustrating its success.

The LCFS creates an incentive for fuel producers to reduce their emission intensity and to invest in low-carbon mobility infrastructure. Moreover, it has the added benefit of shifting the financial burden of producing this infrastructure from public entities to private players.

The LCFS opens the possibility of including other actors who could contribute to the development of low-carbon transport infrastructure. By shifting the funding from pubic to private sources, it also reduces the risk of the funding running out e.g., due to a change in government policy or budget cuts. Finally, by increasing the costs of fossil fuels it increases the competitiveness of low-carbon modes of transport.

Figure 3: Cumulative million tonnes (MMT) of credits generated through the LCFS from 2011 to 2022.



Source: California Air Resources Board (2022).

Introducing such an instrument could facilitate harmonising the coordination of efforts and thus the speed of decarbonisation in different countries. This would result from investors moving to regions with less saturated markets, for instance, with fewer charging stations, but with significant potential for their development.

Finance for decarbonising buildings

The buildings sector is responsible for 36% of the EU's emissions and 40% of the energy consumed. The major barriers to decarbonising this sector are complexity, diversity, and the number of actors involved. High upfront investment cost of renovations is another fundamental challenge. Homeowners often lack the necessary resources, or they are not willing to take the risk of upfront costs, without certainty about energy cost reductions in the future.

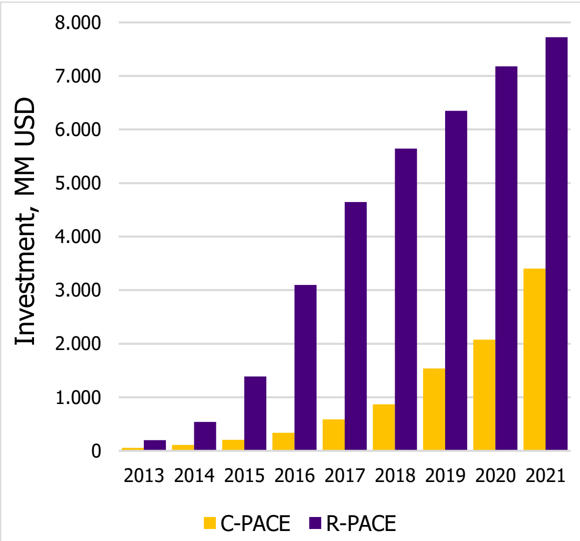
The US Property Assessed Clean Energy (PACE) programme aimed at helping individual homeowners fund energy renovations offers interesting insights about dealing with high upfront investments. It allows homeowners to invest in energy efficiency, renewable energy improvements, or water savings without upfront payment and according to harmonised rules. It targets renovation of both residential (R-PACE), and commercial (C-PACE) buildings (see **Figure 4** for an overview of cumulative annual investments by programme).

A special assessment of the real estate owner's property tax bill is used instead of traditional mortgage or debt repayment schemes. Since the responsibilities remain linked to the property where the improvements were made and not to the owner, the upfront investment comes at much smaller interest rates. In this way, owners can forego the high initial capital costs of investments. The investments are to be repaid through energy savings generated by the building upgrades, usually over a 10 to 20-year period.

While there are numerous sources of funding for home renovation in different EU member states, they differ significantly in scope, bureaucratic effort, and the level of support.

One of the main advantages of the PACE scheme is its recognisability: property owners in the US states where it has been implemented mostly know what to expect and how to apply to benefit from the program.

Figure 4: Cumulative annual investment (in USD millions) of C-PACE and R-PACE.



Source: PACENation (2022)

A support scheme for home renovation that could function according to similar criteria, use similar application processes, but with some differences regarding the balance between grants and loans, could reduce the bureaucratic effort of property owners and construction companies in the EU.

Infrastructure: experiences from rail networks

Decarbonising transport requires much more than just lowering emissions from passenger cars: new mobility solutions also include shifting towards lower-carbon modes of transport, especially rail. In this context, the Japanese and Swiss railway policies offer relevant insights for the EU – in terms of governance structure, infrastructure planning, and funding.

Japanese railways exhibit remarkable performance levels by international standards, in terms of profitability, punctuality and track capacity usage, or customer orientation. The main driver of this – in addition to significant funding for infrastructure and research – was the governance structure where after the privatisation in 1987, the government played an important role in ensuring that railways remain an important element of the country's transport sector. This resulted in future-oriented investments in new infrastructure and modern trains. The cooperation between rail companies and the national and regional governments ensures availability of train connections even on less profitable connections. This governance structure is complemented by a vertically integrated market that allows faster connections through train services across regional boundaries.

For its part, Swiss rail policy has succeeded in shifting more of its overall transportation from roadways onto railways since the 1990s, thereby reducing emissions. The ample funding of rail operations has contributed to this success: Switzerland spends five times more per capita on railways than its neighbour, Germany (Wüpper, 2021). Funding has been aimed toward both small and large infrastructure investments as well as research and planning. The Swiss government provides a framework that ensures infrastructure investments support a country-wide modal shift from road to rail.

These case studies imply that a more coordinated, possibly more centralised governance of railways across Europe could strengthen their role and help to accelerate decarbonisation of the EU transport sector, especially in Eastern Europe. One way to achieve this would be to significantly expand the competencies of the European Railway Agency, which currently plays a largely technical role. Alternatively, it could be incorporated into a new European Railways Research, Investments, and Information agency. Its remit could include coordination of planning railway infrastructure, co-funding development of transboundary connections, ensuring better coordination between timetables for intercity connections across Europe, and developing a pan-European booking system that would allow seamless journeys across Europe.

Furthermore, investments in rail infrastructure need to increase significantly. Meeting the EU's climate neutrality goal requires a modal shift from aviation and road transport to rail. This will not be possible without significant investments into expanding and upgrading rail infrastructure. These investments must be steady and covered largely from public funds. Switzerland, for instance, uses tax revenue from road freight transport to fund some of its railway infrastructure.

Fostering innovation and managing exnovation

To bring about the necessary breakthrough innovations for climate neutrality requires a better alignment of the innovation policy mix with climate goals, developing and identifying breakthrough technologies that drastically reduce GHG emissions, leading them to market maturity and deploying them at the necessary scale. Blending private and public innovation support is vital – and the following cases demonstrate how this can be done.

Yet innovation is only one side of the story – increasingly, managing technologies also includes exnovation policies, i.e., the managed phase-out of fossil-based technologies and associated value chains.

Large-scale innovation

The US Department of Energy Loan Program (DoE Loan Program) was very successful in targeting large-scale innovation, e.g., development of manufacturing lines for electric vehicles or development of geothermal energy projects. It was introduced with the Energy Policy Act of 2005. The guaranteed loans cover 80-90% of eligible costs, with fixed interest rates. The DoE Loan Program Office's team of experts, who review the submitted proposals comprehensively, can strongly influence the content of the projects and weigh in on how they are executed. This opens the door to venture capital to invest in projects that receive strong financial and expert support from the government.

In the past, the DoE Loan Program has been used not only to fund development of large innovative projects, such as solar and wind projects, but also to support car companies affected by the 2008/2009 economic crisis. This support was granted under the condition of meeting stringent emissions standards. While the program funding included some failures – e.g., funding for solar panel start-up Solyndra, which went bankrupt after receiving a federal loan guarantee – it also gave rise to companies that went on to become commercially successful, such as Tesla.

The DoE Loan Program offers several elements that could help trigger radical large-scale innovation in the EU. Firstly, the existing support for innovation could be complemented by support for 'high risk' programmes, particularly those that do not qualify for the Innovation Fund. Broadening the criteria would increase the number of projects eligible for funding. However, already the first round of calls for proposals for the Innovation Fund was significantly oversubscribed.

The oversubscription indicates that the demand for innovation support is there. However, much more funding is needed to fund transformative technologies, also those at a less mature stage of development. The value of large-scale proposals totalled almost EUR 22 billion, while the available budget is 1 billion (European Commission, 2022a). The total amount to be distributed, estimated at EUR 38 billion for the period 2020-2030, assuming a carbon price at EUR 75 EUR/tCO_2 (European Commission, 2022c), is roughly equivalent to the USD 64 billion of additional funding for the DoE Loan Program, which arose from the August 2022 Inflation Reduction Act. This indicates that the

EU lags behind the US in funding for large scale innovation.

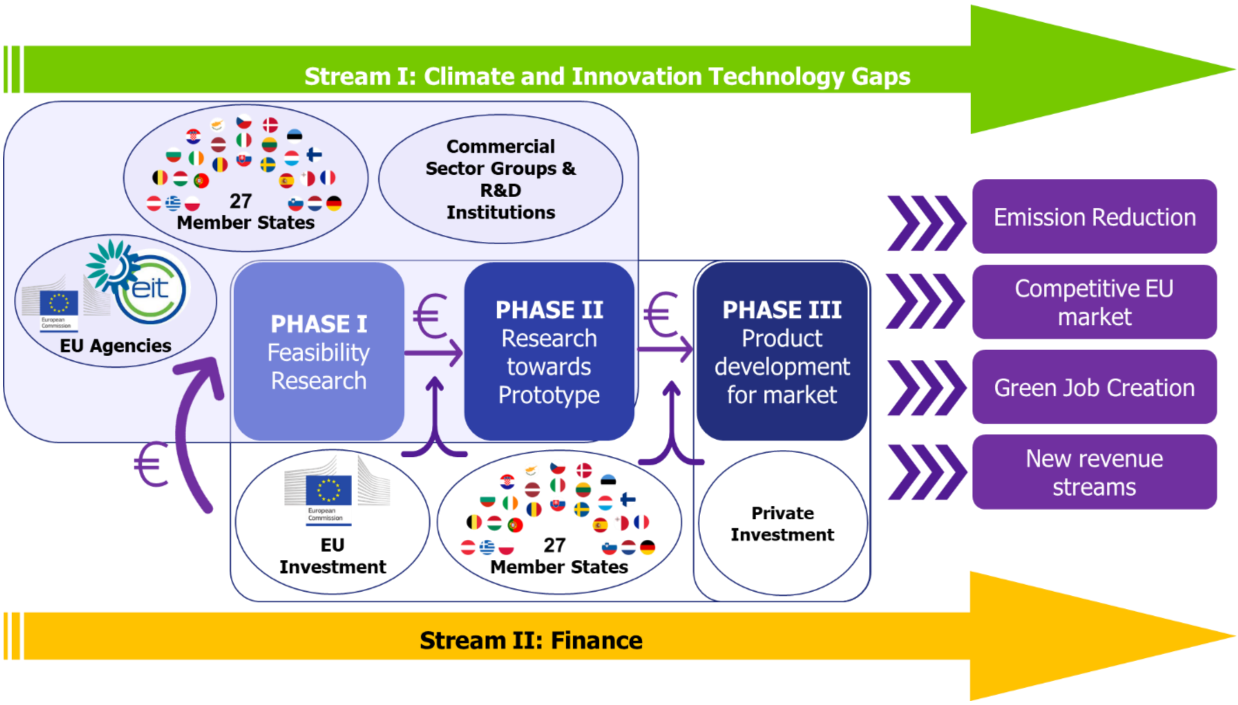
Finally, the role of the experts assessing proposals should move from merely evaluators to co-creators. This task is partly fulfilled by the Project Development Assistance provided by the European Investment Bank for selected projects (European Commission, 2022b). This practice should be expanded and mainstreamed. A permanent group of experts should not only review the submitted proposals but actively engage in their improvement.

Small-scale innovation

Two smaller-scale federal programmes – Small Business Innovation Research Program (SBIR) and Small Business Technology Transfer Program (STTR), established in 1982 and 1992, respectively, complement the DoE Loan Program. They focus on facilitating innovation by small and medium companies and research institutes. The STTR offers a solution to the problem of the separation between the academia and the private sector, especially for small companies. The SBIR offers a significant potential to facilitate targeted innovation to address gaps in the technological solutions needed to transfer to a low-carbon economy. While none of these programmes focuses specifically on energy and climate, they offer interesting lessons that could be applied to facilitating innovation needed to meet the EU's emissions reduction goals.

When implementing an innovation stream of funding for small businesses, the EU could deal with some of the programme's weaknesses. While the amount of funding available could be determined by the research needs of agencies and private actors, it should have a permanent

Figure 5: Concept of the SBIR system applied to an EU context.



Source: Illustration adaptation based on concept from National Research Council (U.S.) (2008).

character in the framework of the Horizon Europe programme to increase familiarity with the programme across the EU. It could also focus on testing solutions developed by research institutes in practice. The implementation of solicitations announced by private actors could be funded jointly by the private organisations and public funding, with the shares of funding depending on the risks and benefits for the actors involved. **Figure 5** demonstrates how such a framework can exist in the EU context, with agencies, member states and commercial sector playing roles in identifying technology gaps complemented by a stream to finance different phases of the process.

Policies to phase out fossil technologies

The final step in the decarbonisation process is to phase out fossil-based technologies and the infrastructure and value chains that support them. This process can be observed above all in space heating (fossil fuel boilers), and increasingly in mobility (internal combustion engines). Norway and Vancouver, Canada were among the first jurisdictions to ban fossil heating systems. Their experiences show how such a ban can be supplemented with a combination of economic incentives, skills creation, infrastructure roll-out and targeted assistance to mitigate the distributional impacts associated with the transition.

Norway has been a global pioneer: in 2020 it was the first country to end the use of oil for heating in existing buildings and is set to phase out fossil fuel cars by 2025 (see **Figure 6** for overview of ICEV phase-out targets across the globe). Vancouver has imposed stringent performance standards, which implicitly ended the use of fossil-based heating systems in new buildings since 2022.

The Norway and Vancouver examples show that to gather sufficient support for such a policy-driven phase-out, adoption of the alternative, younger technology must become economically attractive. Both countries used a mix of taxation incentives and subsidies to penalise fossil-based technology and to incentivise cleaner alternatives (i.e., heat pumps and thermal retrofitting). In the EU context, it highlights the importance of aligning energy taxation and carbon prices with climate goals.

Figure 6: Overview of phase out targets for ICEVs across different countries.

2025	2030	2035	2040
Norway	Netherlands	Denmark	France
	Ireland	EU (proposed)	Spain
	Slovenia	California	Canada
	Sweden	Quebec	
	UK		
	Iceland		

With moderate electricity prices, the total cost of heat pump ownership will be below that of fossil-based heating systems. Yet they also come with greater upfront costs. Households need to be able to access finance for these upfront costs. The Vancouver experience demonstrates how revenues from carbon taxation can help address upfront costs, but also provide zero-interest loans for building retrofits. Yet the successful roll-out of a new technology is not only a matter of creating economic incentives but requires a whole array of supporting interventions – building up the domestic (installation) industry and skill base, adjusting the infrastructure where necessary, as well as ongoing communication efforts.

Phase-out plans provide long-term clarity and enable actors to adjust. The best practices presented here demonstrate that once the necessary conditions are in place, change can happen relatively quickly – and more rapidly than expected.

Conclusions

Learning from the experiences of other countries can accelerate the speed and broaden the scope of the transformation to climate neutrality in the EU.

The EU already has policies aimed at the development of renewables, advanced over more than three decades of climate action. It could consider carefully incorporating some of the aspects of good practices identified in other countries and regions into the European climate policy framework. In those cases, it must be ensured that any change does not undermine the trust of stakeholders who adapted to the existing framework – companies, energy cooperatives, prosumers, research institutes, and national agencies.

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