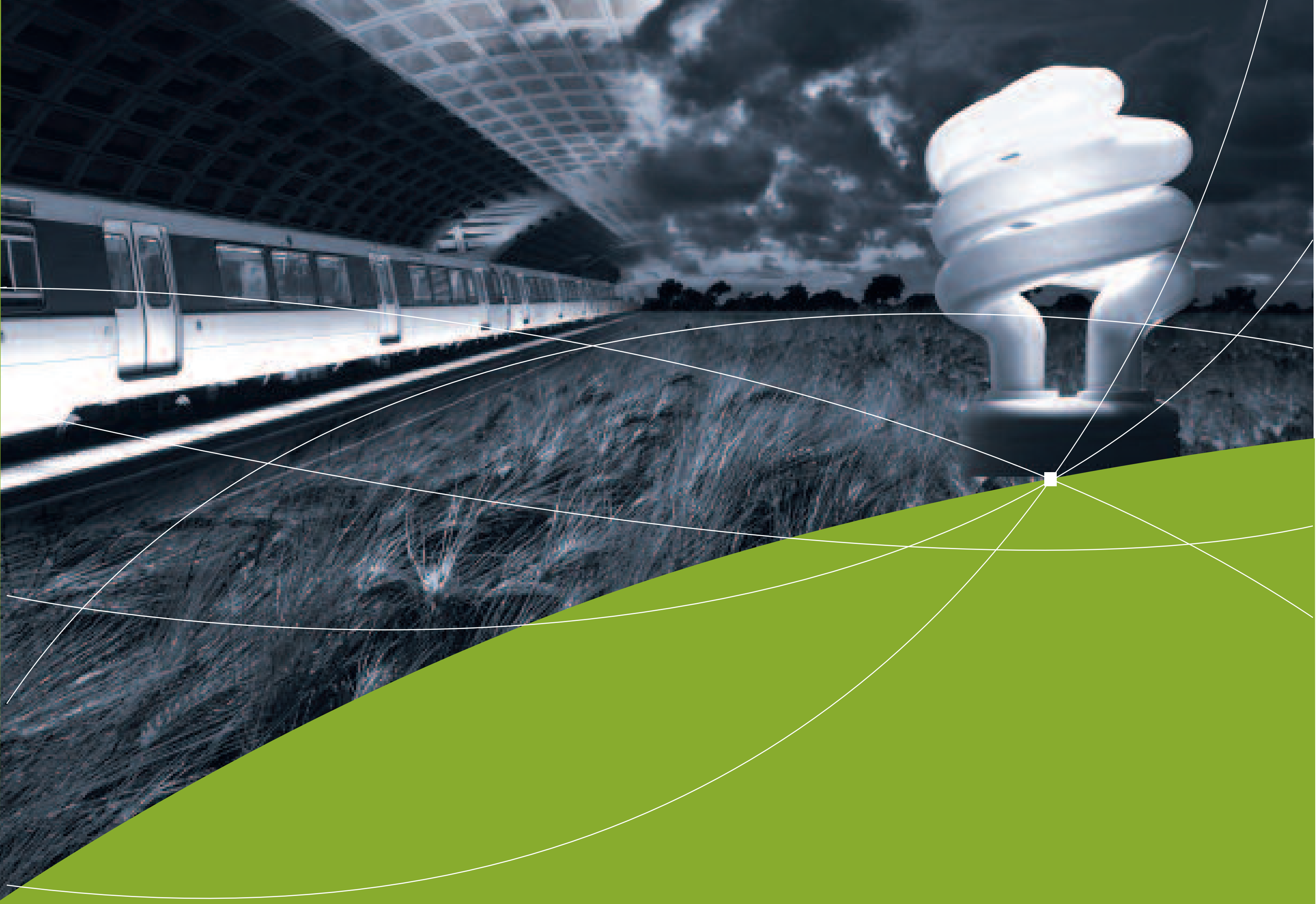

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AICGSPOLICYREPORT

THE FUTURE OF POWER IN A POST-CARBON SOCIETY

Max Gruenig
David Livingston

AMERICAN INSTITUTE FOR CONTEMPORARY GERMAN STUDIES THE JOHNS HOPKINS UNIVERSITY

American Institute for Contemporary German Studies

JOHNS HOPKINS UNIVERSITY

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The American Institute for Contemporary German Studies strengthens the German-American relationship in an evolving Europe and changing world. The Institute produces objective and original analyses of developments and trends in Germany, Europe, and the United States; creates new transatlantic networks; and facilitates dialogue among the business, political, and academic communities to manage differences and define and promote common interests.

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FOREWORD

The United States and Germany must both confront the global implications of a rising global population and increasing urbanization. Finding an approach to powering our societies that reduces our reliance on fossil fuels will be imperative, as the need for global transport and other energy-intensive uses will continue to increase in the coming decades. However, the prospects for alternatives to oil and electrification are far from certain. Despite the U.S.' abundant natural gas, the U.S. and Europe must continue to contend with an oil-based infrastructure.

Some cities and regions are already undertaking new initiatives and strategies to cope with these twenty-first century challenges. Smarter city planning and transportation networks, technological innovation, and the development of regional carbon markets are all important steps in determining how to create a post-carbon society.

AICGS' project on "The Geopolitics of Energy" addresses these and other issues pertaining to transatlantic energy security. This Policy Report offers German and American perspectives on the emerging fuel challenges in the transportation sector, and the potential for "post-carbon" cities. It is an example of AICGS' commitment to comparing and contrasting the interests and policies of Germany and the United States in an effort to identify common policy challenges, choices, and opportunities.

AICGS is grateful to the authors for sharing their expertise, to the Daimler-Fonds im Stifterverband für die Deutsche Wissenschaft for its generous support of this Policy Report, to Parke Nicholson and Kimberly Frank for their thoughtful contributions to and execution of the project, and to Jessica Riester Hart for her editorial efforts.

Jackson Janes
President, AICGS

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THE FUTURE OF FUEL SECURITY: TRANSATLANTIC CHALLENGES AND OPPORTUNITIES IN AN AGE OF UPHEAVAL

DAVID LIVINGSTON

Introduction

Fuel—broadly defined as the energy sources used to power our mobility and the oil system from which they are largely derived at the moment—must be a strategic priority for the United States and Germany. As both countries seek to anchor the transatlantic alliance against the backdrop of renewed insecurity along Europe's eastern border, there must be balanced attention paid not only to the crises of the present, but also to the possible demands of the future. Before any "optimal" policy path can be sketched, a stock-taking exercise is invaluable as a means of synthesizing the events and trends that have given birth to the current state of affairs, and of discerning the current set of options available to policymakers moving forward.

Given the changing economic structure of most societies, the fluctuations in oil price seen in the past decade, as well as the uncertainties implicit in the required transition to a low-carbon energy system in the decades ahead, the future of fuel use and fuel choice has never been more critical. It is widely agreed, at least in OECD states, that a global transition away from oil as the predominant transport fuel feedstock is desirable for various economic, geopolitical, and environmental reasons.

Studies have looked, for example, at the evolution of the American and German industrial sectors and their related factor costs in the midst of the oil price shocks of the 1970s, and found that such petroleum fuel price swings were able to push economic growth far out of line with neoclassical equilibrium.[1] The "weaponization" of oil and fuel is a perennial political challenge, from World War II to the 1970s energy crisis to the volatility and market share skirmish of today. From a climate perspective, approximately 40 percent of global greenhouse gas emissions are associated with transportation fuel,[2] and this number is even larger when taking into account the entire petroleum value chain.

However, there remains no silver-bullet commodity or technology to replace oil's role in the global economy. Challenges to a truly rapid and "disruptive" transition include the wide variety of vehicle types in operation; the operational diversity of oil-dependent business (e.g., long distance freight vs. urban delivery fleets); the capital intensity of fuel production and distribution; the political economy of a sector with powerful incumbent firms; the prospect of fully-functional infrastructure and other assets becoming "stranded" in such a transition; and the current technological and economic limitations of alternative fuels.

Meanwhile, a newfound abundance of unconventional oil resources, combined with the recent decline in global oil prices, is challenging conventional wisdom on resource scarcity and the costs and benefits of continued oil dependence. The "arc of instability" along Europe's frontier, stretching from North Africa to the Gulf and Levant all the way to the border with Russia, has served to sharpen the focus on how energy—and petroleum in particular—shapes the constraints and capabilities of various state and non-state actors. The paths to low-carbon fuel are dynamic and difficult to predict in such a world. Fuel and fuel feedstock (oil) markets are often highly liquid and global, yet at the same time lack transparency found in many other markets, making it difficult to compare the respective economic, environmental, and geopolitical implications of future fuel choices.

Policymakers will have to navigate a petroleum landscape of enduring complexity and volatility for the foreseeable future, whether they desire to or not. The inertia embedded in the current fossil fuel system should not be underestimated. As the "father" of complexity economics, W. Brian Arthur, has observed:

Technologies come into being only if there exists a "demand" for them. Most of this demand comes from the needs of technologies themselves. The automobile "demands" or calls forth the further technologies of oil exploration, oil drilling, oil refining, mass manufacture, gasoline distribution, and car maintenance. At any time then there is an open web of opportunities inviting further technologies and arrangements.[3]

This is not to say that disruptive transitions are not possible, but they must be precipitated by a timely imbrication of economic incentives, innovative capacity, and broader societal trends. Likewise, once a tipping point is reached that favors an emerging "web of opportunities" very different from the incumbent system, the collapse of the existing paradigm can move much more quickly from impossibility to improbability to inevitability than many experts would have ever predicted.

Mindful of this non-linearity, the challenge for policymakers today is perhaps best described not as one of discerning the future of fuels and fuel security in the United States and Europe, but instead one of lucidly understanding the forces acting on the incumbent system, as well as the alternative systems, still nascent, that could one day replace them. Only with this comprehensive view is one able to ascertain the strategic energy position of Germany, the U.S., and others in the twenty-first century.

The Unconventional Revolution and Oil Price Collapse

Any appraisal of fuel security in Europe and North America must take stock of the trends that have once again pushed oil and the upstream petroleum sector into the headlines, as it is oil that serves as the dominant feedstock for the world's fuels.[4] Fundamentally, this involves two separate but tightly interwoven phenomena: the rise of unconventional hydrocarbons and the recent collapse in oil prices.

UNCONVENTIONAL REVOLUTION

A number of drivers have led to the upsurge in unconventional hydrocarbon supply, overwhelmingly from North America, which has unfolded over the past half-decade. First among these has been the price of oil itself. Oil prices saw a sustained rise over the early to mid-2000s and reached an apogee in 2008 before briefly collapsing amid the 2008/2009 financial crisis. For the past five years, until late 2014, oil prices had maintained at a surprisingly stable level above $80 per barrel, with very little real or implied volatility.[5]

With even post-crisis economic growth forecasts for key oil consumption centers such as China suggesting continued tight supply and demand balance and concomitant high prices, oil companies began committing significant capital to more expensive, technically-challenging unconventional oil projects. These include oil located in arctic regions; extra heavy and bituminous oil such as that found in certain parts of Canada and Venezuela; ultra-deep-water drilling at depths of 1,500 meters or more; highly energy intensive kerogen (known commonly as "oil shale"), as well as tight oil produced from shale formations using hydraulic fracturing and horizontal drilling methods (known commonly as "shale oil").

Acting in concert with the economic incentive to drill has been technological progress. Nowhere has this been more transformational than in the case of shale oil, where hydraulic fracturing technologies, long in use in the industry, were joined by advances in horizontal drilling as well as new IT advances. Often overlooked is the significant contribution that well-monitoring technologies have had in enabling small firms to quickly ascertain the likely performance of individual oil wells and make early decisions as to the prudence of further investment in a well or specific play. Rather than one specific "game-changing" technology, a number of concurrent innovations have allowed unconventional shale formations to be accessed with a precision and professionalism that was unheard of even a decade ago.

Economic feasibility and technological capacity are necessary, but not sufficient, to explain the growth in unconventional oil exploration and production seen in the past half-decade. A third factor—the resource access imperative—connects these dots. Simply put, international oil companies hold an increasingly small share of the world's remaining conventional oil. In the 1960s, when resource nationalism was still embryonic, international oil companies (IOCs) enjoyed access to approximately 85 percent of global oil reserves. Today, this number has shrunk to only 6 percent.[6]

Many national oil companies (NOCs) have become competent—and in some cases globally competitive—players in the hydrocarbons sector. They enjoy privileged and largely unchallenged access to expansive domestic resources, as well as the resources of politically friendly countries lacking the capital or expertise to develop their resources independently. In a move to defend their market share, the private international oil majors have become what amounts to oil-specific project management firms, working in concert with large oil services companies to increase oil supply from some of the most expensive, complex, and—in some cases—environmentally challenged petroleum resources around the world.

Light, tight oil from shale formations throughout the United States and Canada has had the greatest impact on marginal oil supply just as the notion of "peak oil" was beginning to gain traction with many experts and industry observers.[7] Indeed, shale oil has proven to be not just additive, but fundamentally disruptive. Shale production has fewer up-front capital costs in exchange for relatively consistent operating expenses over the life of the well.[8] This also means that unconventional tight oil is more akin to a light manufacturing plant than a conventional large-scale oil project; individual unconventional wells can shut down and start back up in a matter of days, while conventional wells can take months or years to return to pre-closure levels.

Unconventional oil has, for the most part, emerged in the middle of the fuel supply cost curve, and has rapidly displaced or delayed the development of various alternatives, including biofuels and synthetic fuels generated from coal or natural gas (see Figure 1 on page 24).

OIL PRICE SHOCK

By 2014, growing North American unconventional production was adding far more to non-OPEC supply than analysts had previously forecast, and with negative economic news out of China in the middle of the year contributing to newly sanguine demand expectations, many had expected OPEC to follow past practice and adjust production quotas downward to balance the market and maintain high, stable prices.

Such a course would have largely fallen upon the Kingdom of Saudi Arabia which, as the world's primary holder of spare capacity, would have had to proactively surrender some of its relatively flat production to accommodate the upsurge in production from countries such as the United States (see Figure 2 on page 24). At a critical meeting of OPEC in November 2014, Saudi Arabia and its allies within the cartel balked, declaring that no quota change was necessary. In effect, the Kingdom had signaled that it would prioritize market share over profit margin, and in the process gain valuable information regarding the response of unconventional oil producers to low oil prices.

The prospect of a "new normal" of low oil prices, buttressed by recent indications that Saudi Arabia is prepared for a protracted battle over market share, threatens to fundamentally change not only the political and economic dynamics of upstream oil production, but also fuel markets as well. The global crude oil price fell by more than 50 percent in 2014 from its high earlier in the year, and has fallen further in the first month of 2015 in what some analysts are calling the largest supply shock to the market since the mid-1980s (see Figure 3 on page 25).

Upon closer inspection, however, some have posited that the ubiquitous narrative of a supply-driven shock to global oil prices, reduced in various media as a standoff between "sheikhs vs. shale,"[9] has unjustifiably reduced a highly complex system. One recent analysis, for example, has employed a sophisticated model aimed at disaggregating the multiple individual drivers of oil price movements.[10] It arrives at the heterodox conclusion that the current price decline is "more a market reaction to possible future imbalances than a sudden change in supply-demand fundamentals" (see Figure 4 on page 25).[11] While the merits and flaws of various models can be debated ad-infinitum, the costs and benefits of the recent oil price decline are real, complex, and of great consequence to Europe.

IMPACTS OF THE OIL PRICE SHOCK

Conventional wisdom holds that the late-2014 collapse in oil prices should be an economic boon for large net oil importers, including both Germany and the United States. While a debate has ensued regarding the extent of the benefit to the United States in the face of increasing domestic shale oil production, this benefit is by contrast touted rather unquestioningly in Germany. For the first time since January 2009, diesel prices in Germany fell to under €1 per liter. Bundesbank president Jens Weidmann commented in late 2014 that Europe had been "gifted a stimulus program" via cheaper oil prices, using the development to reinforce his opposition to the ECB's consideration of further stimulus via widespread purchases of euro zone government bonds.

However, high levels of transport fuel taxation in Europe will mask some of the effect seen by ordinary drivers, and implies a low oil price elasticity of fuel demand in the European Union (EU). This is not an altogether undesirable situation to be in, as it generates additional revenues that can be put toward crucial infrastructure investment; dissuades the purchase of large, inefficient vehicles with minimal benefits to the broader economy; and does a better job at capturing the full cost—including externalities—of fuel consumption (North America underprices transport fuel in this regard, as seen in Figure 5 on page 26).

Nevertheless, a number of European governments should expect lower government revenues from fuel taxation over the near- to mid-term. As German fuel taxes are a combination of fixed and percentage tariffs, for example, the dip in diesel prices seen in early 2015 will cause the government to concede approximately $0.66 per liter in foregone duties and VAT. For these reasons, as well as the growth in electric vehicles and private vehicle alternatives in much of the developed world (e.g., Uber, Zipcar, etc.), governments should appraise the feasibility of over time transitioning to taxation systems less linked to fuel use. This could include a distance-based fee, dynamic congestion pricing, or any other combination of innovative mechanisms. While Europe is generally more advanced in its consideration of these options, they have also been discussed in policy circles in the United States as a remedy for the country's perpetually under-funded Highway Trust Fund for infrastructure investments.

Furthermore, when trade linkages with key oil exporting nations are taken into account, the dividend for Germany may be far smaller than is often assumed. What is often overlooked is the fact that as a lower oil price reduces the oil-derived revenues of oil exporting countries, those countries' general imports (in value terms) of products and services also tend to decline in line with a weakening currency and consumer demand. For Russia and countries in OPEC, this correlation between imports and oil revenue is particularly strong, while it is weaker for other major oil exporters (e.g., Australia, Brazil, Canada, Mexico, or Norway).

As a result, those countries whose exports to OPEC and Russia account for an outsized share of GDP are likely to see these exports trend upward and downward with the global oil price. This is the case for Germany and Italy in particular, while other major oil importers (China, France, India, Japan, Spain, and the UK) do not demonstrate a strong linkage between oil price and general exports to oil-exporting nations. It can stand to reason, then, that Germany should temper its confidence in the strategic gains of low oil prices as long as it is dependent upon exports to oil-rich countries in the Middle East and Eurasia. The largest gainers are instead those whose oil imports are significant, but whose exports to oil-exporting nations are minimal as a share of GDP.

The impact of declining oil prices on other energy sources, namely alternative transport fuels, is mixed. Natural gas is a relevant fuel both as a feedstock in the power sector's generation of electric fuel for plug-in vehicles, and also as a fuel of its own right in the form of compressed natural gas (CNG) and liquefied natural gas (LNG) for commercial fleet and long-haul transport vehicles. In Europe, where natural gas is largely priced in accordance with oil-indexed contracts, natural gas prices can be expected to fall as low oil prices endure. In North America, a large proportion of recent natural gas supply can be attributed to "associated" shale gas co-produced with heretofore expensive oil, and would not have been necessarily produced if this gas resource were in isolation. Counter-intuitively, then, the fall in global oil prices may bring a modest increase in natural gas prices if overall drilling activity declines.

Low oil prices will theoretically render biofuels less competitive versus gasoline and diesel in relatively unregulated liquid fuels markets. However, there is not a single transatlantic fuel untouched by biofuel mandates, with a de-facto requirement in the United States for marketed gasoline to contain 10 percent ethanol, and a similar regulation in the EU, the Renewable Fuel Directive, carving out specific mandates for various categories of biofuels. In addition to these programs are supplementary regulations regulating the carbon intensity of various fuels, the most stringent of which are found in Europe (particularly Germany and Sweden) and in California.[12]

In any case, the environmental credentials of biofuels derived from food crops, once a key rationale behind the promulgation of policies to support biofuels, have come under increasing scrutiny. As the significant costs of biofuel subsidization becomes clearer to policymakers and the public, their rate of growth in the fuel mix of advanced economies is likely to slow, regardless of the future trajectory of global oil prices.

For electric vehicles, the ultimate impact is very difficult to discern. One well-respected analysis has estimated that electric vehicle penetration in the United States will reach approximately 6 percent by 2020 with gasoline prices just above $2, versus a much higher penetration of 9 percent with gasoline prices at $3.35 (penetration stands at less than 1 percent today).[13] On the other hand, much like biofuels, electric cars are largely being sold with the aid of very generous government incentives and subsidies, from rebates to tax credits to preferential road and parking access.

California has been a pioneer in this regard with its "Zero Emissions Vehicle" program, a market-based scheme that incentivizes car companies to produce, distribute, and aggressively market electric and hydrogen vehicles. The United States is today the world's largest market for electric vehicles, and 90 percent of these are sold in states with policies similar to California's.[14] These programs are more sustainable than many in Europe, such as those in the Netherlands and Norway, which have fueled an exponential increase in electric car adoption with direct government subsidies covering more than 50 percent of the sticker price of the vehicle.[15] While these programs represent ultimately unsustainable fiscal burdens, it is reasonably safe to bet that well-constructed incentive programs will prevent low oil prices from "killing the electric car." However, the rate of uptake in such vehicles may be tempered in regions with low fuel taxes, such as North America, where fuel prices tend to drop precipitously in response to a corresponding drop in oil prices.

In Germany, the government's first progress report for the Energiewende highlights electric vehicles as a key tool for achieving energy security and meeting the country's targets for reducing energy consumption in the transport sector (10 percent reduction by 2020 and 40 percent by 2050, against the 2005 baseline). While 6,024 new electric cars were registered in 2013, bringing the end-of-2013 total to 13,527 cars,[16] this remains far from the government's stated goal of having one million electric cars on German roads by 2020.

It remains to be seen whether German automakers, a key political force within Germany, will fully embrace a wholesale shift to electric vehicles or will continue to offer conspicuous, high-end models as a means of visibly complying with stringent CO_2 regulations while devoting the lion's share of resources to conventional internal combustion engine (ICE) vehicles. Low gasoline prices could strengthen the position of those within these firms who believe that the point at which the mass market is prepared to embrace electric vehicles is still far away. Much rides on expectations of future energy prices, consumer preferences, and government policy.

The Current Transatlantic Fuel Security Landscape

THE EVOLUTION OF EUROPE'S DOWNSTREAM SECTOR

Recovering oil demand after price spikes throughout the 1980s set the scene for healthy profits by a number of refiners, while the 1990s in many ways set the backdrop for the refining sector dynamics playing out today. The dissolution of the Soviet Union placed additional oil and petroleum product supplies onto global markets, with refineries sourcing an increasing number and diversity of global crudes and also sending finished products to consumers around the world. Infrastructure was often slow to catch up with this wave of globalization, and although European oil product markets benefitted from the commercial use of the NATO pipeline system, the linkage of this system with the pre-existing COMECON pipeline network was never realized.[17]

Trade protections sheltered the EU petrochemicals industry from foreign competition and encouraged the development of integrated energy-industrial complexes at key locations such as Rotterdam and Antwerp. Smaller refineries not associated with such complexes were increasingly acquired by non-vertically-integrated refining or trading firms (e.g., Agip, Petroplus, etc.), in a trend reminiscent of what is occurring in Europe today, only among different players (e.g., Gunvor, Klesch Group, Vitol, etc.).

The early to mid-2000s represented a golden period for Europe's refineries, as booming demand from China, the Middle East, and other developing countries was only slowly met with an increase in global refining capacity. Profit margins for Europe's refineries were high, and few worried about the specter of overcapacity on the continent.

In the years following the 2008 financial crisis, however, a number of European refineries have been closed, converted to oil storage facilities, sold to new owners, and/or had new stakes taken by Chinese, Indian, and Russian firms (see Figure 6 on page 26). This has occurred at the fastest pace since the 1980s, as the continent's demand for oil products has dropped for seven consecutive years and larger, more complex refineries coming on line globally has led to greater competition.[18] More than twenty European refineries have closed over the past six years, with over 150,000 barrels per day of capacity brought off line in 2014 alone.[19]

Refineries in Europe are likely to receive a temporary, but not lasting, reprieve as the most recent wave of closures on the continent has reduced oversupply. Many are also benefitting from the plunge in oil feedstock prices, although European refiners may still ultimately be relative losers within this global macro trend. The weakening of the euro from late 2014 into early 2015 has meant that these refiners have seen a proportionately smaller decline in input costs (see Figure 7 on page 27).

To increase the average European refinery utilization rate (actual throughput vs. potential throughput) to the levels last seen before the 2008 financial crisis, additional refining capacity in excess of 2 million barrels a day would likely need to be closed.[20] Though a temporary reprieve for European refiners over the first half of 2015 is likely, the closure of two refineries in the UK[21] and Italy[22] in late 2014 has done little to alleviate the long-term pressure on less profitable refineries.[23] French oil company Total's agreement with labor unions to temporarily freeze any refinery closures expired at the start of 2015, and major upheavals in the western European market are in the medium term more likely to come from Germany's immediate neighbors than from Germany itself.[24]

Most European governments have taken surprisingly little interest thus far in the future of their refining sectors and concomitant implications for the economic, environmental, and security dynamics of Europe's future fuel mix. This is likely due to declining European fuel consumption, as well as a laudable focus on non-fossil alternative fuels. Though displaying impressive relative growth in recent years, alternative fuels remain a small contributor, in absolute terms, to the overall fuel mix in Europe. European governments will have to contend with a period of transition, then, in which declining refining capacity will mean a shift in the traditional security-of-supply paradigm: Europe's dependence on crude oil imports (in volumetric but not percentage terms) is likely to shrink, while its dependence on petroleum product imports is likely to grow in the years ahead.

While the shale revolution has had select negative impacts on the competitiveness of Europe's petrochemicals sector due to an inability to compete with lower feedstock prices on the other side of the Atlantic, there are also opportunities for Europe to secure inexpensive intermediate inputs (e.g., naphtha) from the United States, which may offer integrated energy/industrial complexes in Europe a newfound source of resilience. The petrochemical industry in Europe and Asia is primarily based on naphtha (crude oil derived), while in the United States and Middle East it is primarily based on ethane (natural gas derived). This presents select opportunities for complementarity, rather than competition, between the EU and the U.S. Industry has been active in exploring these opportunities, but policy circles have thus far been slow to examine possible future scenarios for the transatlantic petroleum product trade and its consequences.

FUEL SECURITY SITUATION IN GERMANY AND THE UNITED STATES

Oil is the single largest energy source in Germany, though its relative prominence has been mostly in decline since reunification. The transport sector is by far the largest consumer of oil in the country, and transport's share of total oil demand continues to grow in both the United States and Germany. On-road transport in Germany accounts for more than 50 percent of total oil demand, while in the United States this same share can be attributed to single petroleum product (gasoline), and the entire U.S. transport sector accounts for more than 70 percent of total oil demand.[25] The composition of German petroleum product consumption is comparatively more balanced, with diesel, gasoline, naphtha, and gasoil all taking relatively large shares.

U.S. petroleum consumption appears to have peaked in the mid-2000s at just above 20.8 million barrels per day, while Germany's consumption peaked in 1998 and has since been in gradual decline (see Figure 8 on page 27). Both countries have added refining capacity even as oil consumption growth has flattened off, such that in recent years the ratio of refining capacity to domestic oil consumption has approached 100 percent from ratios closer to 80 percent in the 1990s and early 2000s.

Germany possesses the second largest refining capacity in the Europe and Eurasia region (after Russia), with more than 2.19 million barrels per day of atmospheric distillation capacity spread across thirteen refineries at the start of 2015.[26] With only 100,000 barrels per day of coking capacity (4.5 percent of total refining capacity), Germany's refineries are optimized for a relatively light crude slate, and are not designed to handle more challenging heavy crudes such as those originating from the oil sands of Canada or Venezuela.[27]

German refineries are supplied almost completely by imports rather than domestic production,[28] as Germany has declining production, minimal future reserves, and uncertain future prospects for unconventional hydrocarbon resources due to local opposition and environmental concerns. Despite relying on Russia for approximately 40 percent of its oil imports, it is relatively diversified otherwise with other major suppliers including the United Kingdom (14 percent), Norway (10 percent), and Libya (9 percent) in 2012.[29] This structure largely mimics that of the EU as a whole, which maintains a balanced supply mix in which no single country apart from Russia accounts for more than approximately 10 percent of total oil demand.

Shell Deutschland Oil is the biggest refiner in the country, holding more than a quarter of the country's refinery capacity. Nevertheless, the German oil market is highly competitive and includes a large number of independents in the refining and retail sectors (e.g., Avia, Freie Tankstellen, and Westfalen).

In the United States, the refining market is an order of magnitude larger, though similarly deregulated competitive. The U.S. had 123 refineries with just over 18 million barrels per day of atmospheric distillation capacity at the outset of 2015.[30] This includes 2.7 million barrels per day of coking capacity, representing approximately 15 percent of total refining capacity. More than half of U.S. refining capacity is located in the Gulf Coast. Four-fifths of the region's fifty-three refineries include coking units, making it a desirable hub for processing heavier, more sulphurous crude (see Figure 9 on page 28).

Traditionally, refineries in the region have imported large quantities of heavy Mexican Maya crude, and in recent times rail-borne shipments of heavy Canadian oil sands crude have also made their way to the Gulf Coast. However, these refineries are also encountering challenges as they seek to accommodate growing volumes of light sweet U.S. shale oil production that is otherwise confined to the domestic U.S. (or Canadian) market due to export restrictions. At the same time, many refiners across the United States, and particularly those exposed to a crude supply glut in the mid-continent, are benefitting from the export ban in the form of depressed feedstock prices.[31] U.S. refineries continue to run at well above 90 percent of capacity, despite a reputed operable utilization rate of 88.7 percent.[32] Over time, this could impact the repair schedules of U.S. refineries and necessitate further investments in refinery retrofits and/or transport infrastructure to alleviate the situation.

Depressed feedstock prices, primarily in the form of natural gas but also via LPG, naphtha, as well as ethane and other NGLs, have also attracted new interest and investment from German heavy industry such as chemicals firm BASF. Given the new oil price environment and concomitant shift in competitiveness for ethane-based (gas) and naphtha-based (oil) petrochemical systems, the durability of these investment trends in the U.S. will largely depend upon the evolution of spreads between oil and natural gas prices and the credibility of futures markets as indicators of the likely direction of such spreads over time.

IN-FOCUS: GERMAN FUEL SECURITY VIS-À-VIS RUSSIA

With regard to import infrastructure, Germany maintains four crude oil pipelines across borders with Russia, the Netherlands, France, and Italy (see Figure 10 on page 29). The pipeline with Russia is in fact the northern leg of the world's longest oil pipeline—Druzhba ("friendship")—that carries crude to a number of eastern and central European states. Druzhba's northern route crosses Belarus and Poland to Schwedt in Germany, where it supplies one of the country's largest refineries and accounts for approximately 20 percent of German oil imports.[33] Germany is also connected to a single petroleum product pipeline, as well as four main sea ports. The country's sole deep water port at Wilhelmshaven handles a large portion of Germany's international oil trade.[34]

Refineries supplied by seaborne trade are rarely foci of concern over security of supply, as they can easily switch to new supply sources in a global and liquid market, within certain basic constraints.[35] Germany's pipeline imports, on the other hand, have fewer diversification options with Russia as a sole supplier. The EU is currently considering financing for seven prospective pipeline projects as part of its "Projects of Common Interest" infrastructure program, as it attempts to provide additional options to inland refineries currently supplied by Druzhba.[36] It should be noted, however, that the pipeline has been temporarily closed several times in the past, including in 2007 over a pricing dispute between Belarus and Russia, with little to no impact on German energy supply or on the oil price.[37]

The European refining industry continued to restructure in 2014, with a number of companies shedding downstream assets. In December, Russia's state-owned Rosneft agreed to buy French company Total's 16.67 percent share of the 240 kb/d Schwedt refinery in Germany,[38] which will give it a total controlling share of 55 percent.[39] Prior to this, in 2011, Rosneft had already purchased a 50 percent share of Ruhr Oel, which comprises shares in four German refineries (Gelsenkirchen, Bayernoil, Miro, and PCK). Foreign participation in the German oil sector, particularly by Russian firms, remains controversial.

After the German government approved the takeover of RWE's oil and gas subsidiary DEA, the British government in late 2014 intervened in an attempt to block the deal. Next to the BASF subsidiary Wintershall, DEA is the only larger German oil and gas exploration company and has numerous exploration and production licenses in Europe, including in UK-controlled areas of the North Sea. The purchasing party was a Luxembourg-domiciled investment company backed by Russian investor Mikhail Fridman, and disagreement had developed between the UK government and the buyer over contingencies in the case that energy sanctions against Russian firms were tightened further.[40] The deal finally went through in revised form in early 2015,[41] but not without garnering public criticism from a number of commentators within Germany and the UK.[42]

Beyond raising questions over the security of petroleum product supply, other geopolitical complications can arise when the strategic outlook of the refinery owner is incongruent with that of the German government. In mid-2014, for example, it was reported that Rosneft had been purchasing Kurdish oil for its Ruhr Oil refineries co-owned with BP, amid a protracted dispute between the Kurdish government and Baghdad over oil revenues that has already seen Austrian oil firm OMV blacklisted by Iraq for similar purchases.[43] While minimal public fallout from this particular report was generated, it raises the prospect for the German government, as well as European oil majors, to be put in an awkward position when Moscow's assessment of political risk is at odds with that of other government and corporate decision-makers.

While Germany and other European countries will long be dependent on significant crude supplies from Russia, and must remain vigilant over excess Russian control of the entire petroleum fuel supply chain, a number of factors are converging to push the oil power to the east, such that the supply relationship with Europe diminishes slowly in relative importance. For example, Rosneft has aggressively pursued a number of loans from China in exchange for guaranteed oil supplies, including $25 billion for the expansion of the Eastern Siberia-Pacific Ocean (ESPO) pipeline.

By 2020 the company is committed to shipping over 1 million barrels per day to China, making it Russia's largest customer, ahead of Germany.[44] In parallel, total Russian oil exports are expected to decline by at least 1 million barrels per day by 2035—and perhaps more precipitously, depending on the duration of sanctions on Russia's oil sector. Russia is counting on new supply from eastern Siberia and shale formations such as the Domanik and Bazhenov to offset declines in mature conventional fields, but its aggressive timeline has been impinged upon by both Western prohibitions on the transfer of relevant technology, as well as a declining global oil price. Russia has already found it necessary to re-direct western Siberian production originally intended for Europe in order to meet its commitments to the ESPO pipeline system.[45] Reports suggest that additional re-orientation away from Europe of Volga-Ural basin supply could soon follow.[46]

RUSSIA'S REFINERY RE-ORIENTATION

Putting further pressure on the European refining sector, in addition to new refinery capacity in Asia and the Middle East, are significant investments in Russian refineries to re-orient production away from low-value, bottom-of-the-barrel fuel oil toward higher value products such as diesel.

Fuel oil is projected to begin a steep decline in demand from most sectors, due to increasingly stringent environmental and performance regulations in both industry and shipping.[47] The International Energy Agency (IEA) projects that fuel oil demand will drop by just over 10 percent from 2012 to 2035.[48] Russia is a dominant player in the market, traditionally accounting for approximately 50 percent of global fuel oil exports.

Concurrently, diesel demand continues to rise in Europe and Eurasia even as EU oil consumption is in absolute decline. An increasing share of vehicles in Europe run on diesel rather than gasoline,[49] and with a mismatch also in the processing units available at European refineries, the continent has found itself in a persistent diesel shortage even as it has amassed significant surpluses of gasoline in recent years that are then exported.

On 22 November 2014, Russian President Vladimir Putin signed into law controversial amendments to the Russian oil taxation architecture. The new set of laws, known popularly as the "tax maneuver," came into force in January 2015 and simultaneously reduces crude oil export duties while increasing the mineral extraction tax from current levels. It will also align export duties for fuel oil (currently set at 66 percent of crude oil export duties) at par with those for crude oil, while keeping light products at a discount (see Figure 11 on page 30).

In line with this favorable shift for diesel production in the fiscal regime, Russian fuel standards are evolving in a complementary manner, with Russia expected to join Europe as a major source of demand for ultra low-sulfur diesel (ULSD). Russia prohibited the use of Euro-3 fuels[50] starting in January 2015, and Euro-4 fuels will be prohibited starting in January 2016, meaning that only relatively high-quality Euro-5 fuels will be available from 2016 onward.[51]

In practice, the reforms are likely to encourage Russian refiners to maximize their yield of light oil products, first and foremost diesel, and in many cases this requires refinery retrofits or the addition of new refining units to minimize bottom of the barrel products and maximize diesel yield. Thus far, proactive steps on the part of Russian refinery owners to comply with the reforms have been mixed, with some Russian firms investing in more complex refining assets, and others (notably Rosneft) having to embark on a large capital spending program in the downstream sector over the past two years (see Figure 12 on page 30).[52]

The IEA estimated that as a result of the reforms, Russian fuel oil, used mostly as bunker fuel or as refinery feedstock in Europe or Asia, could plummet to just over 0.6 mb/d by 2019 from 1.6 mb/d in 2013.[53] On the flip side, the IEA estimates that exports of middle distillates (diesel) could rise to almost 1.2 mb/d in 2019 from 0.9 mb/d in 2013. Independent analyses by industry observers further corroborate this outlook.

However, Russia's own evolving fuel standards, and the increase in Russian diesel demand that they imply, make it very difficult to discern the likely breakdown of Russian supply between domestic and export markets. At least some Russian middle distillate (diesel) exports will seek markets in Europe, but are likely to find limited receptivity as long as economic performance in the euro zone remains weak and U.S. petroleum product exports—buoyed by the current de facto ban on American crude oil exports—continue to flood the Atlantic basin. A precipitous outlook for the broader Russian economy in light of sanctions and a depressed oil price will only add to this uncertainty, with the fate of similar diesel-oriented retrofit projects at European refineries at stake.[54]

Emerging Areas for Concerted Transatlantic Effort

In the short term, Germany and Europe have few good options for increasing the security and dynamism of the fuels sector. A limited number of actions are available within the petroleum sector given current political and technical constraints. In terms of oil displacement strategies, innovation in alternative fuels and transport models offers reason for optimism, though the resilience of these alternatives through a prolonged period of low oil prices remains to be seen.

STRATEGIC OIL STOCKPILES

IEA member states are legally required to hold emergency oil stocks equivalent to ninety days of net imports or sixty-one days of consumption, whichever is higher. The EU imposes a similar mandate on its own member states, though they are permitted to utilize different stockholding management regimes to need the mandate, including direct government stocks, compulsory industry stocks, or the establishment of a non-profit "central stockholding entity" (CSE).[55] While many countries have initially planned for a hybrid stock management approach, a number of countries have committed to (Italy and Slovakia) or expressed interest in (Greece, Luxembourg, and the UK) moving closer to the German approach of managing exclusively through a CSE or comparable semi-autonomous agency (see Figure 13 on page 31).

Germany's central stockholding entity, the EBV, has held sole responsibility over the country's strategic oil stockpile since 1998. EBV's stocks are distributed across four cavern facilities with a total of 58 caverns,[56] 130 above-ground storage facilities, as well as through contracts for storage with third-party caverns. As there is no minimum stockholding obligation on industry, industry-held commercial stocks are supplementary to the EBV stocks, though they cannot be considered "strategic" supplies for the purpose of meeting EU-reserve mandates.

Germany's total oil storage capacity is around 414 million barrels, which includes around 174 million barrels of storage in underground caverns. When filled, the country's oil storage capacity covers more than half a year of oil consumption at current levels, with a roughly analogous coverage of the country's oil imports.[57]

Article 9(5) of the Directive requires at least one-third of the stocks to be comprised of petroleum products, and despite the fact that few member states have transcribed this requirement explicitly into law, finished products currently comprise more than half of European stocks.[58] Additionally, the Directive also lays out how countries should handle biofuels and additives when calculating obligations and inventories, though this remains an area where transposition into respective national legal systems is currently under development, and where consistent, comprehensive reporting is rare.

As biofuels take up a growing share of the European fuel mix in the years ahead, European leaders will likely have to revisit this issue and identify whether biofuel and additive stock requirements are congruent with ever-changing technical and market realities. Moreover, the composition of petroleum product stocks should roughly track domestic demand trends, and that of crude oil should roughly track Europe's refinery profile.

Going forward, this could mean establishing explicit guidance for member states on minimum benchmarks for the volume and quality of diesel and gasoline stocks, as well as virtual "stress tests" to better understand what current crude oil stocks could be "stranded" in the event of an emergency due to incompatible configurations of nearby refineries or insufficient intra-European transport infrastructure. The present low oil price environment provides an opportune time to adjust stockpile composition and engage in additional market purchases, should they prove necessary.

The United States is already preparing to engage in such an exercise. A recent report from the U.S. Government Accountability Office (GAO) reiterated that growing American oil production will likely require a re-think of the size and configuration of the U.S. Strategic Petroleum Reserve (SPR), and has indicated that further study will be conducted in recognition of the SPR's need for "modernization."[59] Were the U.S. to conclude that a smaller stockpile is optimal, a strategically-oriented crude oil swap with the European Union could possibly be explored. There are a number of potential legal obstacles to such a swap under current U.S. crude export restrictions, but a one-time exchange supported by a presidential national security finding may be sufficient to rationalize the strategic stockpiles of both the U.S. and Europe without necessitating a full renovation of the current American petroleum export policy architecture.

THE U.S. CRUDE OIL EXPORT BAN

While there is broad tacit agreement on the part of most analysts that U.S. crude oil export controls are not fully compliant with World Trade Organization (WTO) rules,[60] there has yet to be a formal legal challenge. This is in large part due to the paradox that those with a desire to access U.S. crude oil supplies are typically friendly states that have avoided offensive measures on the issue for fear of retribution in other sectors, and that those with the possible motivation to launch offensive measures do not wish to see U.S. crude oil supplies enter the global market in large volumes by virtue of their own status as an incumbent exporter that has enjoyed some degree of market power (e.g., Russia).

This means that U.S. crude oil export controls will likely be amended through either a voluntary policy reversal or on an ad-hoc basis through trade agreements and/or targeted loosening of the export controls. The latter is already being witnessed, most recently through the Commerce Department's clarifications on the minimal processing necessary to qualify crude oil and/or condensate as a legally exportable product, as well as through the exploitation of a loophole that allows crude swaps with "adjacent" states.[61] The Obama administration is currently exploring the possibility of swapping light tight oil from U.S. shale basins for additional Mexican heavy Maya crude that is better-suited for the U.S. Gulf Coast refining complex.[62]

Whether a targeted loosening of the oil export ban would ever be facilitated through a trade agreement such as the Transatlantic Trade and Investment Partnership (TTIP) is unknown, but the prospects for an occurrence are doubtful. Despite the leak of a public document[63] that indicated the European Union's interest in access to U.S. hydrocarbon resources via an energy chapter in TTIP, both negotiating teams recognize that a wholesale policy change via TTIP is unlikely, and early attempts at drafting the conceptual contours of an energy chapter have been focused more on common principles and third-party access issues than on the oil export ban.[64]

In any case, the U.S. benefits from a European perception that the oil export ban is a metaphorical "third-rail," even if in reality the ban were to be proactively amended in only a few years' time. Compromises in large trade negotiations are often inter-sectoral rather than intra-sectoral, meaning that the significant leverage that the United States currently enjoys in the energy sector could be used to possibly extract further concessions from the EU in other areas. Only a serious deterioration of the security situation in Europe, or the explicit manipulation of heretofore uninterrupted oil supply by the Russian government as a geopolitical tool, could change the broad political outlines of this discussion.

Though still mostly proscribed by law, U.S. crude oil exports nevertheless reached a record 520,000 barrels per day in November 2014[65] as certain loopholes in the legal structure of the ban continue to be exploited.[66] Regardless of how these trends evolve, it is important to note that U.S. policy is limited in its ability to direct shipments of specific products to specific countries or regions, apart from the oil and fuels under its control in the Strategic Petroleum Reserve. In the long run, these trade patterns will be dictated by markets and arbitrage opportunities more so than geopolitical circumstances.

INNOVATION, REGULATION, AND OIL EMANCIPATION

Despite the rise of unconventional hydrocarbons, oil remains a long-term structural risk to transatlantic economic and political stability, not to mention a key challenge for meeting climate goals over coming decades. The way in which oil dependence is mitigated matters greatly, however, as there are a number of avenues to the same destination. It is critical that the United States, Germany, and the European Union as a whole seize this moment of upheaval in oil markets to re-think the synergies between environmental and energy security objectives.

For Germany, the need for additional policy action in the transport sector is clear. Transport's share of total German primary energy consumption, at 29 percent, equals that of industry and is larger than the other two major energy consumption sectors (households and commerce/trade/service). Oil is overwhelmingly the primary energy source for the transport sector, and is coincidentally the country's largest source of energy (33 percent of primary energy supply, and growing).[67] Two recent analyses have concluded that circumscribing the focus of the *Energiewende* to the power sector, even with the implementation of a partial coal phase-out, would still leave Germany short of its 2020 carbon targets (not to mention those in later years).

The new "Action Program on Climate Protection 2020" adopted by the German government in late 2014 provides additional support for electric vehicles, including new tax reductions and new mandates for the number of electric cars in public fleets. From a strategic perspective, however, it may behoove the German government (along with other EU member states) to quietly sacrifice the symbolism of headline electric vehicle deployment targets and instead adopt different transport sector benchmarks—such as hard targets for the reduction of oil consumption.

Such benchmarks, if well designed, would be technology-agnostic and better align with national security objectives in light of the Crimean crisis. When coupled with a robust domestic emissions intensity standard[68] (such as the EU Fuel Quality Directive), energy security performance benchmarks would provide the market with the maximum flexibility in rapidly decreasing the oil intensity and carbon intensity of the German economy.

Europe and the United States have long avoided the difficult work of establishing a comprehensive oil policy that reconciles oft-conflicting environmental and security objectives. A compelling example of this tension exists in the debate over the Canadian oil sands, which some argue is a critical component of strengthening European energy security and expanding EU policy options, while others condemn the import of oil sands as incompatible with the EU's fundamental climate targets.

The Fuel Quality Directive (FQD) has thus far been a victim of this debate. The goal of the policy is to advantage lower-carbon crude oils in the EU market while disadvantaging higher-carbon oils, but it has been both poorly conceived in its design and poorly managed in its attempted implementation. Most recently, the European Parliament voted to weaken the measure significantly in the face of opposition from both heavy oil producers such as Canada as well as domestic industry.[69]

There is a better way forward. The European Union should institutionalize a working group including policymakers, the oil industry, and alternative fuel suppliers in both the EU and California, the U.S. state most successful in pioneering an FQD-like policy. As the EU moves to integrate successful features of California's Low Carbon Fuel Standard (LCFS) into its own FQD, it will gain not only environmental credibility, but also increase the compatibility of the FQD with WTO and other trade obligations.

The inclusion of not only environmental regulators, but also foreign policy hands, would be critical to this process. Hard security goals need not necessarily be in conflict with domestic regulatory goals, and indeed EU regulatory policy has in recent times proven to be a potent foreign policy tool (e.g., the antitrust case against Gazprom). In the oil sector, both the United States and the European Union require more data on the various risks—including climate risks—of various global oils before they can construct policy on this basis.

In other areas, it may be less—or at least more flexible—regulation that is called for. Increasingly, oil displacement strategies must contend not only with the question of what alternative fuel(s) to support, but with a broader, more structural question of what mobility strategy to pursue: individual, atomized transport or pooled, service-oriented transport approaches? This question is particularly compelling for countries such as Germany and the United States with strong, historically-rooted "automotive cultures."

The case for a new approach is clear. By 2050, 85 percent of the global population will live in cities. Today, 90 percent of all driving distance in cities account for less than 6 km.[70] Many fear that in countries which know only the hammer of highways, every mobility challenge will appear as a nail. There is a danger of locking in a high-cost, oil-dependent, inefficient transport infrastructure and in turn suffering the geopolitical and economic consequences of continued mobility monoculture. As former Munich mayor Hans-Jochen Vogel once said, "The one who sows roads reaps traffic."

Recently, businesses that combine the characteristics of firms and markets—often called "platform" companies—are becoming more prevalent. In the transport sector this is exemplified by ride-sharing companies such as Uber, Lyft, and Sidecar as well as car-sharing companies such as Car2Go and Zipcar. Not only do these companies challenge conventional wisdom as to the boundaries of the firm, but they are also poised to redefine the relationship between regulator, provider, and consumer in the market for mobility goods and services.

Car-sharing models in Europe can be traced back as far as 1948, when the "Sefage" cooperative was established in Zurich to provide access to automobiles to those who were unable to afford private vehicles in the economic aftermath of WWII.[71] Publicly subsidized initiatives were also introduced in Montpellier and Amsterdam in the early 1970s, but quickly petered out.[72] Germany´s first car-sharing organization "StattAuto Berlin," was born out of a university research project in in 1988, with other schemes quickly following in the cities of Aachen, Bremen, and Freiburg. Germany's largest car-sharing network today is Flinkster, an offering of the German railroad company Deutsche Bahn. As of January 2014, there were over 750,000 users registered in Germany with approximately 150 different car-sharing providers. This includes approximately 320,000 participants registered in fixed, station-based programs, and another 440,000 in station-independent ("free-floating") programs.[73] Extrapolating from recent trends, there were likely more than 1 million participants at the outset of 2015.

The disruptive potential of car-sharing schemes is immense, particularly in terms of efficiency and sustainability. The German Carsharing Association has found that more than 70 percent of all German car-sharing vehicles are compact or smaller cars that emit 15 percent to 20 percent less carbon dioxide than the average new automobile in Germany. It estimates that ten private vehicles are displaced by every car-sharing vehicle.[74] More boldly, the firm that helped General Motors out of bankruptcy has estimated that every vehicle in a car-sharing scheme in the United States represents the avoided purchase of approximately thirty-two private automobiles.[75] A separate study by Zipcar found that nearly 50 percent of its users had avoided an otherwise-necessary vehicle purchase by using the service.[76] Globally, one consultancy estimates that ride-sharing services have eliminated 500,000 sales of new cars already, with the potential to eliminate a total of 1.2 million new cars by 2021.[77]

Illustrative calculations show that, accounting for the increased utilization rate, each vehicle in a car-sharing scheme can be expected to reduce national fuel consumption by up to 11,620 gallons (44,000 liters) of gasoline equivalent per year, or anywhere up to 1,050 barrels of oil per year.[78] Though often regarded as a niche trend among young urbanites, this is in reality a powerful, organically emerging energy security tool.

With German car-sharing schemes at an aggregate fleet size of approximately 15,000 vehicles at the start of 2015, this implies existing national oil savings of as much as 15.75 million barrels per year (43,000 barrels per day) for the country. If the entire EU were to embrace car-sharing at a level comparable to that of Germany, even in this very nascent stage of the industry, the savings could amount to more than 250,000 barrels per day—more than the total demand reduction expected to result from private vehicle efficiency improvements in Europe from 2011 through to 2020.[79]

But the trajectory of the sharing economy, despite portending the Schumpeterian gale of often painful creative destruction in the transport industry, also brings with it the promise of national economic efficiency and productivity gains. After all, ride-sharing companies are fundamentally premised on a simple thesis: the personal automobile, a longtime symbol of middle class achievement and autonomy, is increasingly in danger of becoming a potential "stranded asset" in parts of the developed world.

It is not difficult to see why. The average price of a new car in the United States, along with maintenance, has continued to rise over time and yet personal vehicles are utilized on average only 4 percent of any given day.[80] Average annual miles per driver peaked in 2005 and have declined 8.8 percent since then.[81] This represents a significant discontinuity; from 1900 until the mid-2000s, the average had increased every single year except for one in the midst of the Great Depression.

In Europe, this peak and decline is even more pronounced, and indeed more than 25 million vehicle owners in Europe plan to forego vehicle ownership in the next five years.[82] These trends are not lost on traditional automakers and rental firms, many of which have sought to participate in the growing car-sharing sector. Avis purchased American firm Zipcar for $500 million in 2013,[83] while BMW, Daimler, and Volkswagen are among the German automakers that have designed proprietary offerings of their own in select cities throughout Europe and North America.

The key to harvesting the full potential of car-sharing, ride-sharing, and other promising system efficiency tools such as autonomous vehicles may lie in a rethinking of the regulatory apparatus rather than targeted support through subsidies, as has been so ubiquitous for alternative fuels in the past. For example, even in innovation-embracing Germany, U.S. ride-sharing service Uber has faced bans in at least two major cities (Berlin and Hamburg) as it encounters stiff resistance from entrenched taxi union interests and an instinctually conservative regulatory ethos.[84] This resistance is prevalent not only throughout Europe, but in the United States as well, and it underscores two under-recognized phenomena.

The first is that cultural attitudes toward such innovative offerings are often more complex and nuanced than many assume. Interestingly, in an extensive survey of consumer attitudes across six countries, while Germans were the second most likely to prefer basic automation of vehicles, they were the least likely to prefer full, self-driving automation. One cannot simply assume that the benefits of greater efficiency and optimization at the city or national level will always be recognized by individual citizens. At the very least, a further exploration of the risks and vulnerabilities of any new system—whether premised upon asset pooling, automation, or another concept entirely—will likely need to be debated and deliberated in a transparent, public manner.

At the moment, the power to enable or stymie many of these transformative mobility and energy consumption trends lies in cities across Europe and North America. Mayors are increasingly receiving long-overdue attention as key actors in not only local, but also global governance, and the infrastructure decisions of urban areas are increasingly recognized as impacting the strategic direction of national and supranational entities.

It is in this latter area that the European Union can take immediate steps to offer a more dynamic and empowering energy security strategy for member states. In addition to conventional notions of security of supply, strategic stocks, and domestic market integration, U.S. and EU infrastructure policies should evolve to better account for the robust economic, environmental, and energy security dividends of investments that avoid vehicle ownership and/or vehicle use altogether. Just as experts in the electricity sector have begun to tout the benefits of the "negawatt" (avoided electricity usage), so should those in the transport sector recognize the value of a "negajoule" of avoided transport fuel.

One place to begin could be the EU's recent mandate for member states to develop national clean transport infrastructure plans.[85] Rather than focusing on specific fuels and hard goods, a forward-thinking approach would provide member states with a framework for estimating the economic, environmental, and energy security value of avoided petroleum fuel consumption, whether such savings are delivered by innovative vehicles, fuels, or new service offerings. Moreover, as the level of electrification and IT sophistication grows in the world's vehicle fleets, it would be wise for policymakers to institutionalize regular engagement and consultation with utilities, network providers, and other key industries that will play a growing and unavoidable role in enabling the fuel security strategies of tomorrow.

Conclusion

In sum, it would be advisable for the transatlantic partnership to focus on, in order of immediacy, a comprehensive evaluation of potential synergies in strategic liquid fuel stock rebalancing, earnest and frank discussion of the opportunities and limitations for policy to promote further transatlantic energy trade in the context of TTIP, and a concerted effort to quantify the strategic foreign policy value of domestic oil displacement strategies, and to catalyze the most promising strategies with the proper application of fair and intelligent (but not necessarily more) regulation.

The analyses and recommendations laid out in this analysis seek to strike a balance between the realities of the present and the latent opportunities of the future. Strategic decisions do not benefit from an excessive focus on either end of this spectrum. A dour preoccupation with the constraints of history can distract from very real undercurrents of technological and societal change, just as a Pollyannaish focus on the frontier of innovation may omit crucial structural constraints in the present system.

This is abundantly true as the U.S., Germany, and all of those invested in the transatlantic relationship seek to ascertain the state of fuel security fifteen years into the twenty-first century, with old challenges—including an intransigent Russia—refusing to dissipate and new challenges emerging in parallel. But through and throughout, an orientation toward the future is essential. The American inventor Charles Kettering—father of the electric starting motor and leaded gasoline—captured this idea with an enduringly perspicacious observation: "We should all be concerned about the future—we will be spending the rest of our lives there."

Notes

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2 BSR, “Transitioning to Low-Carbon Fuel: A Business Guide for Sustainable Trucking in North America,” 2014.

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4 At present, global transport fuels are overwhelmingly comprised of either gasoline or diesel (distillate). In addition to these are a small but growing share of alternative fuels, including liquefied natural gas, compressed natural gas, hydrogen, biofuels, and electricity.

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17 NATO, “NATO Pipeline System,” 7 June 2012, <http://www.nato.int/cps/en/natolive/topics_56600.htm>.

18 For example, a new 400,000 barrel per day refinery in Jubail, Saudi Arabia, reached full capacity in August 2014, with up to 6% of output targeted at the European market.

19 International Energy Agency (IEA).

20 Based on author calculations informed by discussions with industry and analysts.

21 Murphy Oil’s 130,000 barrel per day Milford Haven refinery.

22 Eni’s 105,000 barrel per day Gela refinery in Sicily.

23 Platts, “Outlook: Temporary Reprieve for European Refiners,” 29 December 2014.

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25 U.S. Energy Information Administration (EIA).

26 Oil & Gas Journal, Worldwide Refining Survey 2015.

27 Spain is one of the European countries with the greatest capacity to handle heavier crudes due to its sizable share of coking units at refinery sites (coking capacity is 15% of total distillation capacity in the country). A Spanish refinery was also the recipient of the first publicly reported shipment of Canadian oil sands to Europe, in late May 2014.

28 Germany produced just over 50,000 barrels per day in 2013, the majority of which came from Schleswig-Holstein (55%) and Lower Saxony (34%). Data from EIA and German government sources.

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32 IEA, Energy Supply Security 2014.

33 UpstreamOnline, “Belarus steps back from the brink,” *Upstream Oil & Gas Newspaper*, 1 January 2015.

34 EIA, Germany Country Analysis Note, <http://www.eia.gov/countries/country-data.cfm?fips=GM>.

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46 Vladimir Soldatkin, “Transneft aims to ship Central Russian oil to Asia by 2020,” *Reuters*, 11 April 2014.

47 Ships operating in Emission Control Areas (ECA) will have to use bunkers with a sulphur content of 0.1pc or less from 2015, which could reduce fuel oil market prospects for a number of refiners.

48 See “New Policies Scenario” in: IEA, World Energy Outlook, 2013.

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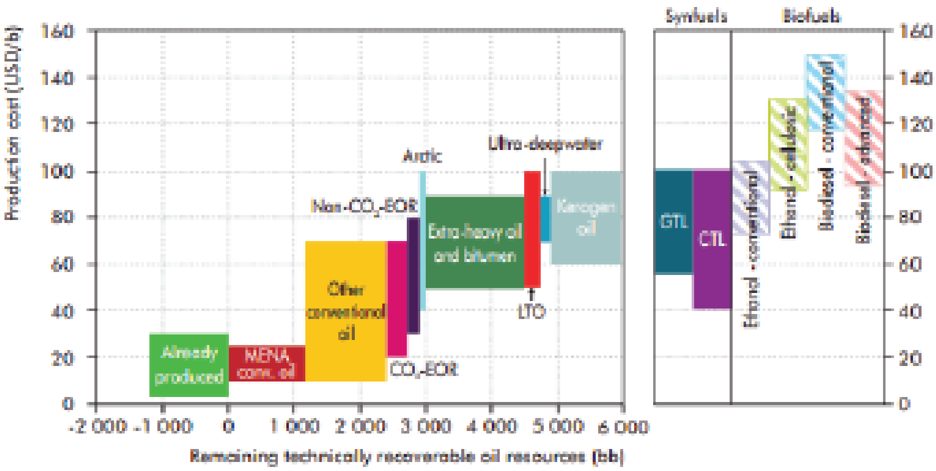
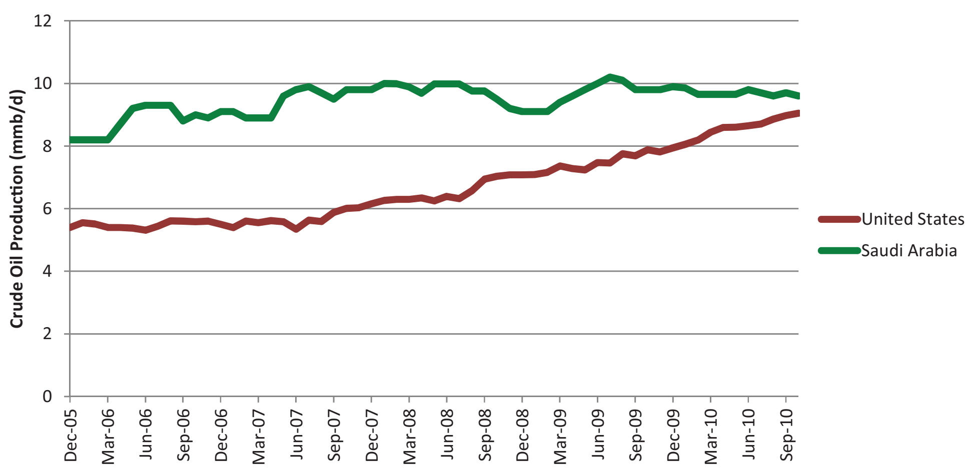
Figure 1: Production Costs for Select Conventional and Unconventional Resources
(LTO = Light Tight [Shale] Oil)



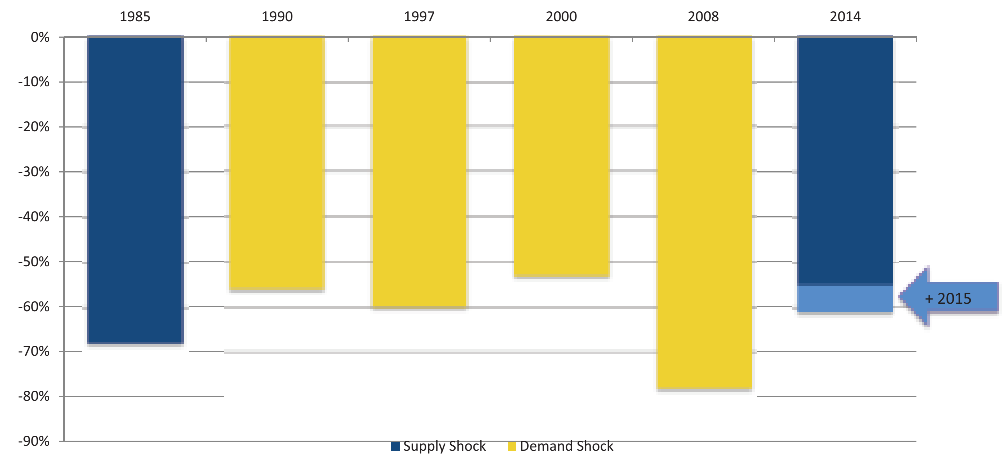
Source: International Energy Agency

Figure 2: U.S. & Saudi Arabia Crude Oil Production, 2010 Onward



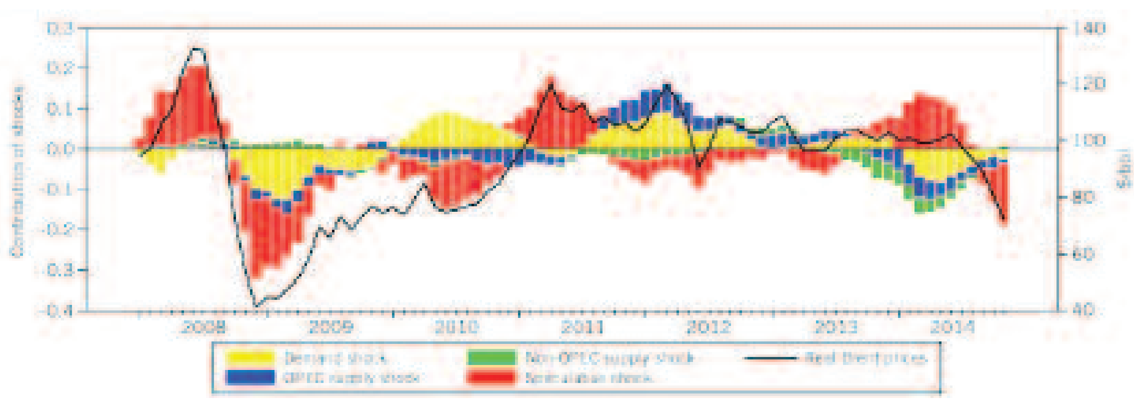
Source: U.S. Energy Information Administration (2014)

Figure 3: Supply-Driven and Demand-Driven Oil Price Declines Over the Past Twenty Years



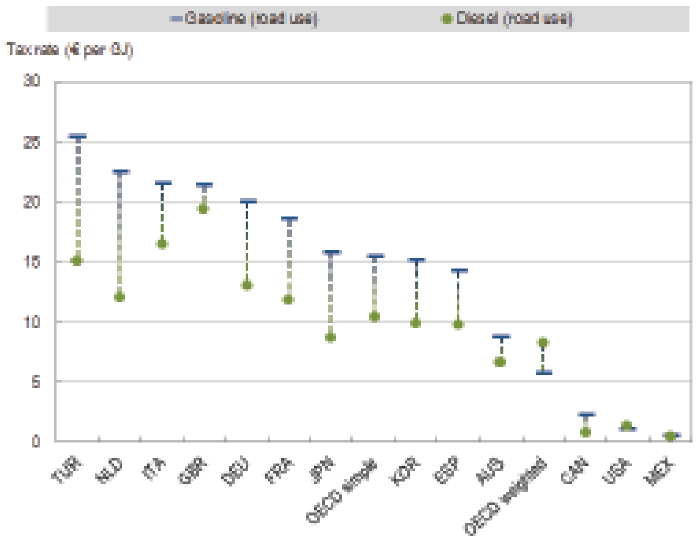
Sources: Bloomberg, Guggenheim Investments, U.S. Energy Information Administration

Figure 4: Historical Decomposition of Real Brent Crude Prices



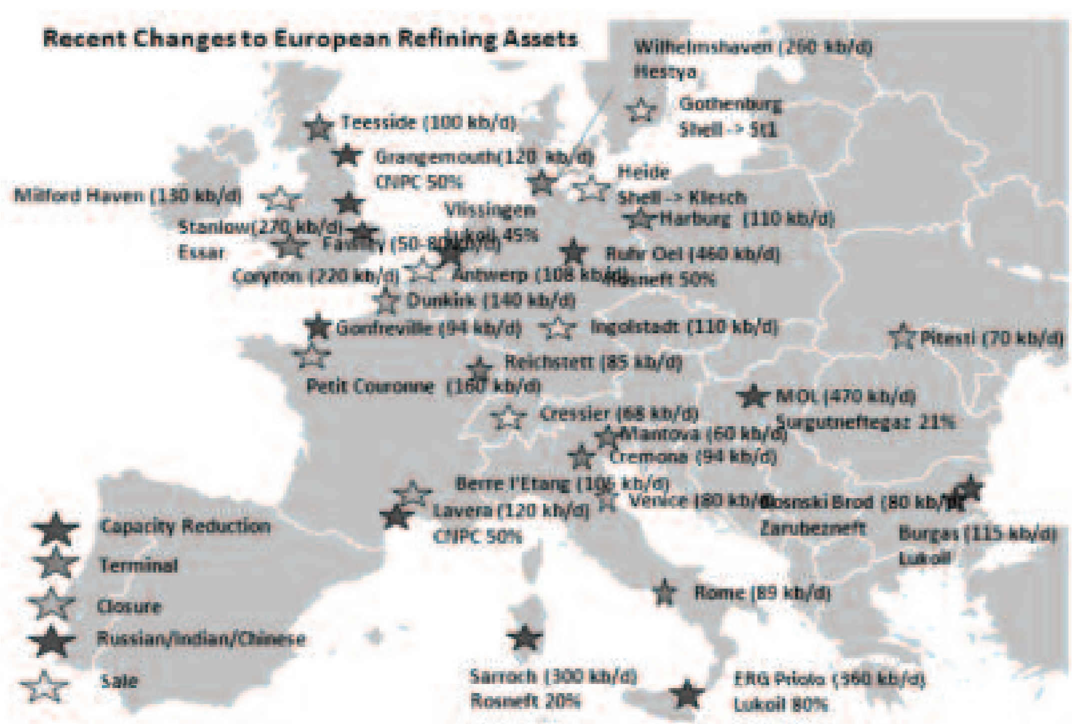
Source: Counglin Xu, “Decomposing Shocks to Oil Prices,” Oil & Gas Journal, 5 January 2015.

Figure 5: Effective Fuel Tax Rates (Per Unit of Energy) in Select Countries



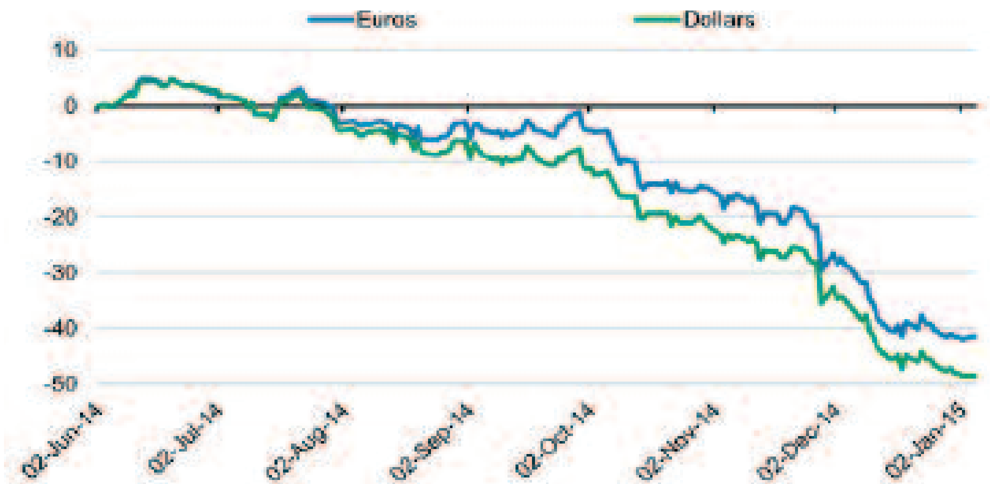
Source: "Taxing Energy Use: A Graphical Analysis," OECD, 28 January 2013.

Figure 6: Recent Refinery Changes in Europe, as of Mid-2014



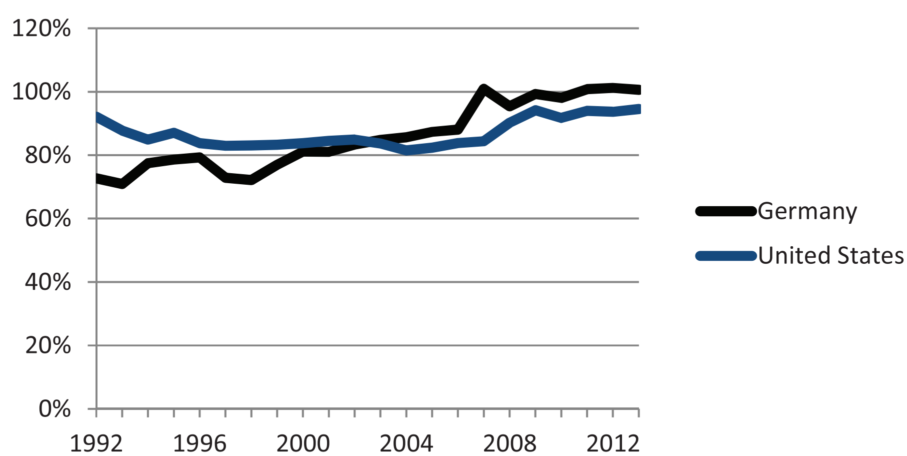
Source: International Energy Agency (2014)

Figure 7: Percentage Change in Euro- and Dollar-Denominated Oil Prices since Mid-2014



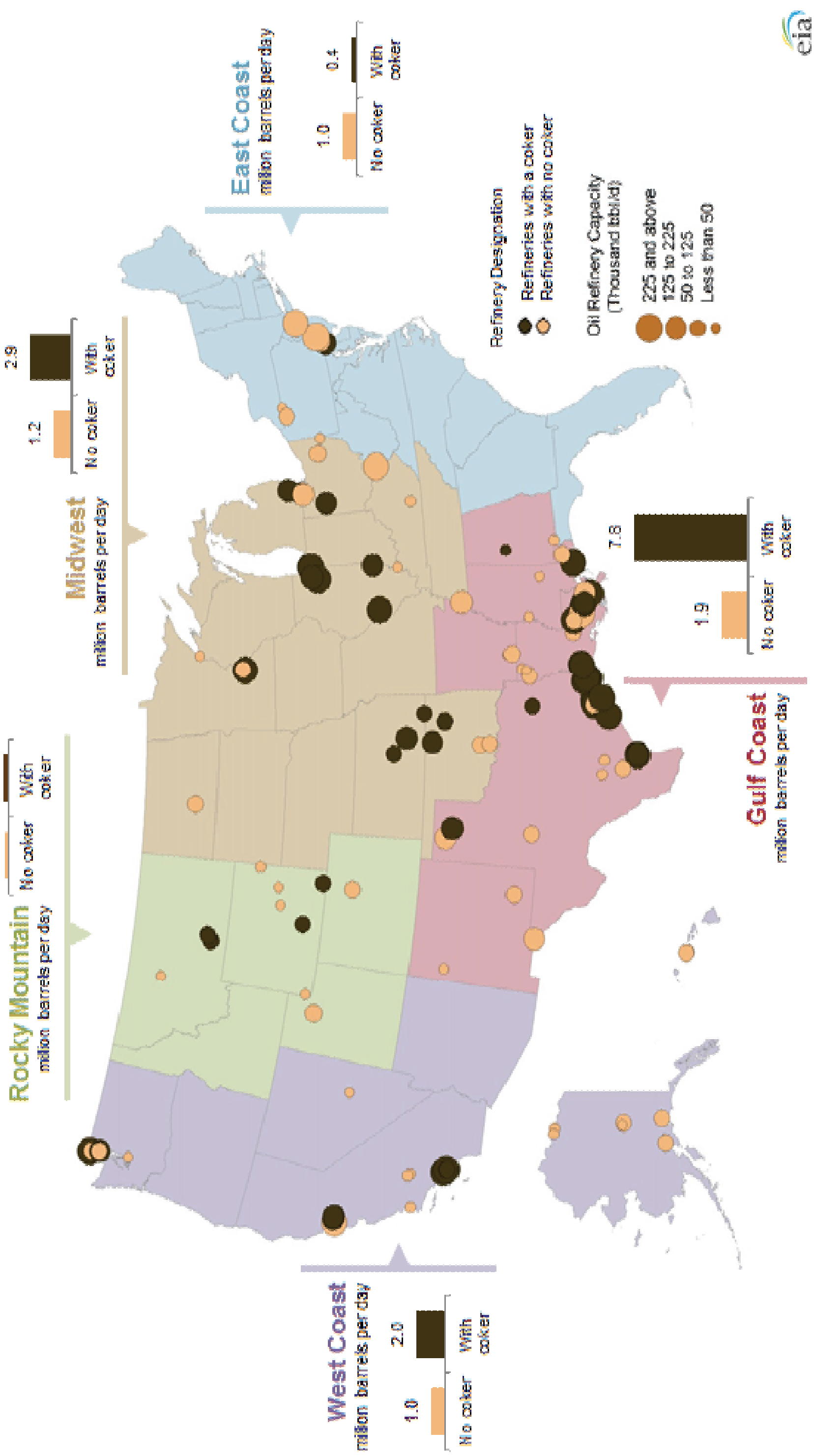
Source: Wall Street Journal (2015)

Figure 8: Select Petroleum Indicators for Germany and the United States (thousands of barrels of oil per day)



Source: U.S. Energy Information Administration

Figure 9: U.S. Regional Refinery Capacity and Complexity



Source: U.S. Energy Information Administration

Figure 10: Oil Infrastructure in Germany

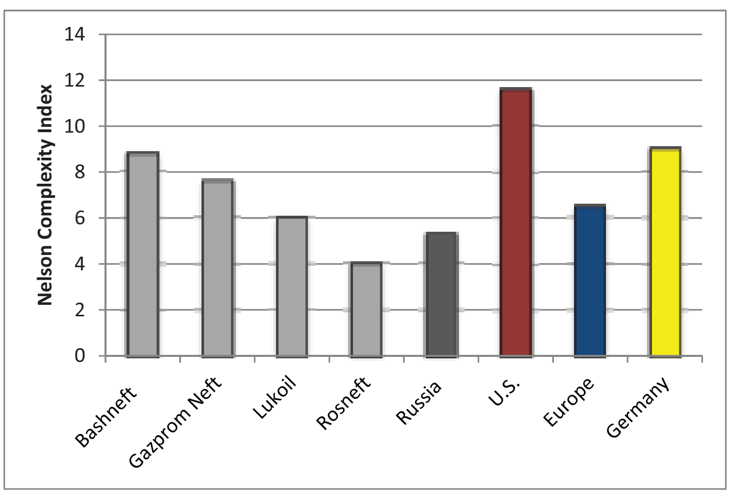
Source: International Energy Agency

Figure 11: Changes in Russian Petroleum Taxes and Duties

	2014	2015	2016	2017
Extraction Taxes, rubles per ton				
Crude Oil - Mineral Extraction Tax (MET)	493	765	856	918
Excise Taxes, rubles per ton				
Gasoline, Euro 4 Standard	9916	7300	7530	5830
Gasoline, Euro 5 Standard	6450	5530	7530	5830
Diesel	5427	3450	4150	3950
Export Duty Rates as % of Crude Oil Duty				
Gasoline	90%	78%	61%	30%
Diesel	65%	58%	40%	30%
Fuel Oil	66%	76%	82%	100%
Naphtha	90%	85%	71%	55%

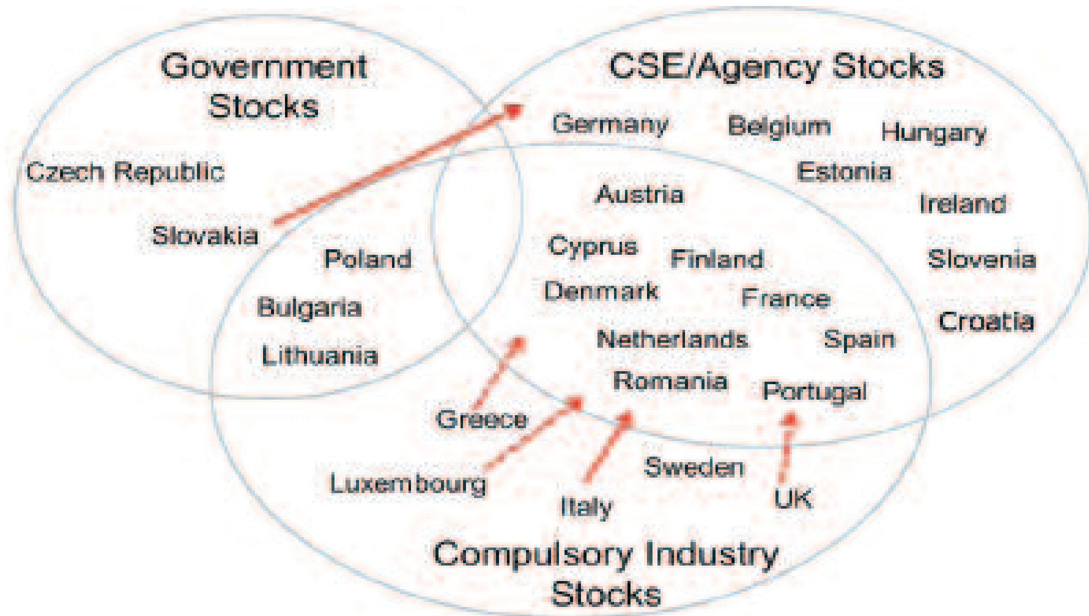
Source: Russian Parliament (2014)

Figure 12: Estimated 2013 Average Nelson Complexity of Select Company and Country Refineries



Source: Company data, PBF Energy, Roland Berger Strategy Consultants, Russian Ministry of Energy

Figure 13: Strategic Petroleum Stockholding Regimes in Europe



Source: European Commission (2014)

02

BREAKING THE CARBON CARTEL: HOW CITIES ARE LEADING THE WAY TO A POST-CARBON TOMORROW

MAX GRUENIG

Cities are at the forefront of the global carbon revolution, breaking established structures and creating new models for integrated systems. This essay will investigate those cities leading the way to innovative advancements and show how integrated urban networks are spreading successful strategies of low-carbon development to communities of every size across the globe. Further, we will discover how cities, serving as hubs of knowledge and learning, are essential catalysts in the global transformation to a post-carbon society. Both German and American cities are among the leaders in the global transition and significant initiatives originate in both the U.S. and Germany. The success of the global post-carbon transformation of cities relies heavily on continued support and commitment in both nations. As we can learn from the post-World War II economic miracle (*Wirtschaftswunder*) in Germany and the parallel rise of the American middle class, progressive social changes radiate from urban centers outward. American and German cities will continue to serve as springboards for both local and international efforts that will define success in the global post-carbon transformation.

Post-Carbon Cities in the Global Energy Transition

Today, urban environments are home to 50 percent of the world's population. Within fifteen years, that level is expected to increase to more than 75 percent.[1] Developing countries will see 95 percent of the increase of global urban population.[2] Europe, where already three-fourths of citizens reside in cities, will see its urban population rate continue to rise to 80 percent by 2030.[3] And in the United States, where the rate of urbanization is already at 81 percent, the 263 million urban dwellers will be joined by another 50 million by the year 2050.[4]

Not only are urban settings places where people live, learn, and engage in services, they are also centers for innovation and manufacturing.[5] Per-capita gross domestic product is often significantly higher in urban agglomerations compared to the averages of their respective nations.[6] Thus, cities are unequivocally at the core of global economic activity, but this concentration exerts increasing demands on water supplies, sewage, public health, and human well being.[7]

Many of the these demands would seem to primarily lead to local impacts—such as noise and local air pollution—but many other consequences such as water abstraction, water pollution, greenhouse gas emissions, and resource depletion are manifest globally. Estimates are relatively confident that cities contribute approximately 70 percent of global anthropogenic greenhouse gas emissions today.[8] Demographic projections indicate that this rate will only continue to grow. Improving the efficiency of cities and the health of the urban metabolism is therefore imperative to ameliorating living conditions for urban populations and beyond in both the near and distant future.[9]

Though certainly not the only concern of urban development, energy systems and related impacts on humans and interdependent ecosystems are a central aspect linking many other sub-systems. For example, water provisioning and treatment require energy and generate greenhouse gas emissions. Similarly, waste treatment and recycling, the food system, mobility, and communications are directly linked to energy consumption and greenhouse gas emissions. In light of this interlinked urban metabolism, a new conceptualization of the post-carbon city has recently emerged.[10]

In the continued absence of a global climate agreement, the ability of cities to act and react to climate realities will be of critical importance. This was evidenced in the past, when the U.S. could not ratify the Kyoto Protocol, but over 500 U.S. mayors stepped in and have signed the Protocol.[11] Similarly, German cities are at the forefront of climate change mitigation. As political powers they will be agenda-setters in a bottom-up climate architecture. On the other hand, if a global agreement can be minted in Paris in December 2015, cities will still be paramount in transforming the global energy regime by breaking the carbon cartel and establishing the way toward a post-carbon tomorrow.

From the Carbon Cartel to Post-Carbon Cities of Tomorrow

Understanding the modern urban system is tantamount to understanding the carbon cartel. Urban planners have readily adopted Corbusier's Athens Charta and implemented a strict compartmentalization of life, work, and leisure functions through zoning.[12] This planning approach inevitably led to an increase in transport demand and thus increased energy intensity of the urban agglomeration. While being advantageous in terms of reduced conflict between uses and an initial increase in convenience due to individual motorized transport, the car-oriented city soon began showing its side effects, such as lost time due to traffic congestion or health impacts linked to air quality deterioration and traffic accidents.[13] Addressing these issues by promoting compact development, walkable communities, and transit-oriented development are among the first steps toward delegitimizing the carbon cartel.

Yet, the carbon cartel's hold on society expands far beyond transport and mobility and encompasses all other forms of energy generation and use such as heating buildings, lighting homes and streets, and generating electricity. Therefore, a comprehensive approach is needed to challenge the existing urban structure at its foundations: Post-Carbon Cities. This concept "signifies a rupture in the carbon-dependent urban system, which has led to high levels of anthropogenic greenhouse gases, and the establishment of new types of cities that are low-carbon as well as environmentally, socially, and economically sustainable. The term post-carbon emphasizes the process of transformation, a shift in paradigm, which is necessary to respond to the multiple challenges of climate change, ecosystem degradation, social equity, and economic pressures. Through their adaptive capacity, post-carbon cities use the threat of climate change 'as an opportunity to reduce vulnerability as they restructure human-ecological and human-human relationships toward ecosystem health and a clean energy economy.'"[14]

This description reinforces the idea of a holistic approach, combining economic, social, and environmental sustainability. The definition also stipulates that a post-carbon city is not a state or end-goal, but rather a fluid, continuous process, characterized by attempting significant change in the urban metabolism. But then, of course, one has to start somewhere.

Cities in Action

Cities on every continent around the world have taken the initiative and become laboratories for innovation, leading the transition away from the fossil fuel-dependent system and toward a sustainable, post-carbon future. Among those are some very promising experiments taking place in the following cities that could serve as examples and inspiration for other locations around the globe:

- Frankfurt am Main, Germany
- Munich, Germany
- Lisbon, Portugal
- Guangzhou, China
- Sao Paulo, Brazil
- Nice, France
- Houston, Texas, USA

INTEGRATED CLIMATE PLANNING: FRANKFURT AM MAIN

Frankfurt am Main, Germany's fifth largest city with 650,000 inhabitants, is a leader in sustainability efforts and outcomes. From 1987 to 2008, the city's population increased more than 9 percent, yet at the same time, total greenhouse gas emissions decreased by 8 percent; it also scored first in the 2015 Arcadis Sustainable Cities Index, ahead of London and Copenhagen.[15] Frankfurt is one of the 1,700 members of the Climate Alliance, a twenty-five year old network of European cities and indigenous people in the Amazon committed to protecting the climate, as well as one of nineteen German municipalities to receive the title "Master Plan Climate Change Mitigation Community." It has established a complete strategy plan to combat climate change and has implemented concrete measures and programs to actually reach the target of climate neutrality by 2050. Sub-goals include reducing absolute energy demand by 50 percent and achieving 100 percent renewable energy sourcing for the remainder. Initiatives are publicly deliberated and formed in close collaboration with citizens and stakeholders via a climate advisory board, with a concerted effort aimed at increasing participation.

Frankfurt is an example of how businesses, such as the flourishing finance sector, and citizen groups can work together to support climate change mitigation. The city has adopted energy-efficient combined heat-and-power as the main generation source. The heat generated serves major energy consumers in the area, including the Frankfurt airport, the city's trade fair, and the Commerzbank tower.[16] Solar rooftops are another important element of Frankfurt's sustainability strategy. A city-owned housing association offers its tenants the opportunity to participate and invest in the rooftop solar installations and thus benefit from the revenues of the feed-in tariff.

PARTICIPATORY CITY DEVELOPMENT: MUNICH

Munich, Germany's third largest city with 1.4 million inhabitants, is one of the leading cities in the Siemens German Green Cities Index.[17] Munich is currently aiming for a 50 percent reduction in its greenhouse gas emissions by the year 2030 and, as a member of the Climate Alliance, is committed to reducing its CO2 emissions 10 percent every five years. Climate strategies are integrated across the various municipal departments and are an integral part of the city's general master plan. Per-capita CO2 emissions decreased 33 percent from 1990 to 2012, to 7.6 tons CO2 per resident,[18] and CO2 emissions per euro GDP were the lowest in Germany in 2010: 147g CO2.[19] In 2012, Munich conducted a city-wide participatory process with all groups of the population under the slogan "think Munich" to develop a new urban development strategy.[20] This process continued with an interactive "think inner city" exhibition in 2014-2015 in the city's town hall. These processes are both a result of and a reason for the very actively engaged civil society in Munich. One such civil society actor is Green City,[21] an association-cum-corporation supporting the re-environmentalization of the city and climate change mitigation via projects on environmental education, city development, energy, and mobility, and also offering energy services and financial solutions. The association fully owns the energy and finance company and thus brings a twenty-first century mindset to the roles in the consumption/production dichotomy: the "prosumer." Citizens in Munich can now participate in the energy transition regardless of their financial means.

CONNECTED SUSTAINABILITY: LISBON

Lisbon, with a population of about 2 million in its metropolitan area, is the westernmost capital in Europe. Apart from multiple local initiatives aiming at cleaner air and a more sustainable city, Lisbon is also a member of the Connected Urban Development (CUD)[22] program, a five-year initiative centered on the power of information and communication technology (ICT) to leverage leaps in system efficiency and thus reduce absolute resource use and emissions of pollutants. The total emissions reduction potential of ICT is estimated at 7.8 gigatons (Gt) of CO2 equivalent greenhouse gas emissions in 2020, or 15 percent of business-as-usual emissions.[23] The initiative is a public-private partnership involving the Clinton Foundation, Cisco Systems, the MIT Mobile Experience Lab, and a range of cities across the globe under the coordination of The Climate Group, an independent NGO. The initiative is bringing businesses, cities, and NGOs together to implement ICT solutions for sustainable cities. This approach is of particular relevance due to the business potential and the potential positive impulses for jobs and growth in the participating cities, which also include San Francisco, Amsterdam, Seoul, Birmingham, Hamburg, and Madrid. CUD is a technology-driven, business-oriented take on the "Post-Carbon City of Tomorrow."

CITY FOR PEOPLE: LIUYUN XIAOQU

The neighborhood of Liuyun Xiaoqu in Guangzhou, China, is an example of a "City for People in Practice,"[24] i.e., a place where changes in urban planning transformed the neighborhood from a car-oriented city of the carbon cartel into a city for people. The residential area was developed in the mid-1980s as single-use gated apartment blocks with limited interconnectivity and resulting long commutes for the inhabitants. In 2000, the local government gave residents property rights to their apartments and soon after that, ground-level units started to transform into commercial use. The removal of separating gates between blocks and investments in the streetscape further improved the livability of the area. It is now considered a prime example of the "eight principles of sustainable urban development":[25]

- Develop neighborhoods that promote walking;
- Prioritize bicycle networks;
- Create dense networks of streets and paths;
- Support high-quality transit;
- Zone for mixed-use neighborhoods;
- Match density to transit capacity;
- Create compact regions with short commutes; and
- Increase mobility by regulation parking and road use.

While there are other examples of such successful urban planning, such as prominent neighborhoods of Vauban in Freiburg and Hammarby in Stockholm, the case of Liuyun Xiaoqu shows how cities in developing countries are able to be cutting edge in terms of their transformational potential and commitment to change. Observed benefits are not only improved air quality, increased social interaction, and a more vibrant cultural life, but also improved local economic development with greater participation. The case also highlights the important role of local planning decisions for sustainable development.

MOBILITY PLANNING: SAO PAULO

Sao Paulo, Brazil's most populous city with over 11 million inhabitants, is not a straightforward pick to demonstrate cities transitioning into a post-carbon tomorrow. Paulistas drive 8.5 million motorized vehicles and thus create one of the most congested urban agglomerations on the planet—but the city is making strides in shifting its residents from carbon dependence. Together with the World Bank and a range of NGOs, the city implemented a pilot project in the Berrini Avenue business district, in which local businesses would encourage employees and visitors to refrain from using cars, to increase car-pooling, to shift commute time to off-peak hours, and to enable telework options.[26] The city of Sao Paulo has recognized the need for further action and created the MobiLab as an integrated innovation agency for urban mobility and a public-private partnership. MobiLab won the 2014 Enterprising City/State MobiPrize[27] and the 2015 Sustainable Transport Award.[28]

While the city is still highly congested and transport infrastructure operates at its conceivable limit, the pilot points toward cost-effective solutions that are attainable without prohibitive financial investments. Thus, Sao Paulo's efforts can be seen as an example of a socially-engaged public-private partnership with low investment needs on both sides and high returns for all involved.

SOLAR SMART GRID: CARROS

Carros is a municipality of just 11,000 inhabitants in the Nice metro region in France. The project NICE GRID consists of a smart solar district with full integration of a high share of distributed energy resources through demand response combined with the islanding of the solar smart grid, i.e., a full separation of the pilot grid from the surrounding energy system.[29] The pilot project involves 1,500 customers, 200 solar rooftops, 2 MWh of storage capacity, and 3 MW of demand response dispersed load.[30] The project is part of the six Grid4EU demonstrators across Europe but is unique in the degree of solar integration and demand management. Lessons from NICE GRID can be scaled-up and transposed to urban agglomerations with medium-high solar potential across the world. Households and local businesses can directly participate in the project not only as adaptive consumers, but also as "prosumers."

WEATHERIZING BUILDINGS: HOUSTON

Houston, with 2 million residents, is the largest city in Texas and fourth largest in the U.S. It is the leading American city in building retrofit programs. In large cities, emissions linked to buildings can correspond to up to 80 percent of total greenhouse gas emissions.[31] Houston started its weatherization program in 2006 with simple measures with short payback periods, reaching some 4,000 houses per year. In 2007, Houston joined the C40 cities network which, together with the Clinton Climate Initiative,[32] created an Energy Efficiency Building Retrofit Program with major buy-in from the financial sector and leading energy technology companies. Houston soon faced difficulties reaching its self-imposed goal of energy upgrades and, thus, created an energy services performance contracting model, i.e., a public-private partnership. The measure covers all 271 non-enterprise city-owned buildings, a total of 11 million square feet. By applying a life-cycle cost perspective and allowing payback periods of up to twenty years, the city could access energy savings beyond the business as usual development. In addition, Houston took unconventional approaches to financing the measures via tax-exempt commercial papers and unsecured short-term loans with tax benefits for the holders.

Phase 2 covered 1,934,035 square feet in fifteen buildings for a total of $23,148,472 and savings of 7,218 tons in annual CO_2 emissions and almost $2 million in annual energy costs.[33] Houston aims to transform itself from the "energy capital" to America's "energy conservation capital."

Exchanging Information

The impressive success stories in the seven cities presented in the previous section cover a wide range of issues confronting post-carbon cities. Information dissemination becomes a critical part of the global energy transformation: local and regional representatives from cities across the globe need to be able to exchange experiences and lessons learned. Therefore, networks at all levels become increasingly important for sharing knowledge between urban researchers, urban planners, governments, and citizens.

These networks exist at the regional and national levels, but also on specific topics. Energy-Cities,[34] for example, is an association of over 1,000 European towns and cities in over thirty countries focusing specifically on energy-related issues.

At the same time, there are fully global networks to support emerging Post-Carbon Cities of Tomorrow:

ICLEI, Local Governments for Sustainability,[35] is a network for sustainability with over 1,000 member cities, covering over 20 percent of the global population. With thirteen offices around the world, covering a broad range of sustainability issues, ICLEI is able to connect many different facets of the urban transformation. In 1990, 200 local governments from forty-three nations founded ICLEI in the context of the World Congress of Local Governments for a Sustainable Future at the United Nations in New York. ICLEI started its work in 1991 with the global secretariat in Toronto, Canada, and the European Secretariat in Freiburg, Germany. Today, the World Secretariat has moved to Bonn, Germany, thus making Germany the global and European headquarters for ICLEI.

C40, Global Leadership on Climate Change,[36] is a network of large cities taking an active role in climate change mitigation. C40 is supported by significant donors such as the Clinton Climate Initiative—with which it is aligned—as well as Bloomberg Philanthropies and others. Currently, C40 has seventy-five affiliated cities, representing 25 percent of global GDP and 8 percent of the global population, with over 8,000 individual actions to combat climate change. On the occasion of the September 2014 Climate Summit in New York, over 2,000 cities pledged to reduce greenhouse gas emissions by 454 megatons by 2020 as part of the Compact of Mayors commitment.[37] The Compact brings together ICLEI, C40, and United Cities and Local Governments (UCLG), as well as individual cities and other networks, to set concrete targets, agree on reporting, and establish compliance standards. The "Carbonn Climate Registry"[38] collects city climate data.[39] The Compact benefits from support by former New York mayor and now UN Special Envoy for Cities and Climate Change Michael Bloomberg, who is integrating the existing key networks such as C40 and ICLEI into the UN Compact of Mayors.[40]

The Compact of Mayors is still very young. Details about targets as well as reporting and compliance standards will evolve in the near term. However, it is clear that cities have already taken a leading role in the global ambition for climate change mitigation. It is also clearly visible how both American and German actors are accelerating the learning and knowledge exchange on climate change mitigation and adaptation between cities around the world. However, German and American cities have been productive laboratories for decades, experimenting with initiatives ranging from regulatory and legal frameworks, such as New York City's Green Codes Task Force for developing sustainable building codes, to incentivized consumer and citizen campaigns, like Berlin's fledgling food-sharing networks. The best practices gleaned from these experiences will inform the next steps taken by municipalities within the network.

Hub and Spoke

Leading climate cities or aspiring post-carbon cities are still a severe minority in the global cityscape and, as positive as the advances are in the cities and regions discussed in this essay, it is of paramount importance to go beyond these early movers and reach each and every city.

Moreover, it will not be enough to reach cities alone; it is essential to also reach out to the more rural communities, to reach the extra-urban space. Cities are not islands in the sea but exist within a peri-urban, sub-urban, and rural environment that supports the urban agglomeration with energy, food, and other resources, but also serves as a sink for waste and other emissions.

Post-Carbon Cities of Tomorrow cannot develop as isolated monuments to the environmental movement of the time, but need to be inspiration for neighboring cities, towns, and everywhere in-between. This concept of radiating ideas and concepts can build on the logistics system of "Hub and Spoke," conceptualized by John Foster Dulles and introduced to the global business community in the 1970s by FedEx, then a fledgling shipping company and now a world leader in logistics management. Applying the hub and spoke approach to the world of ideas implies continued exchange between the leading cities at the level of the global networks, but supplementary learning between the leading cities (hubs) and the surrounding regions (spokes). This horizontal-vertical exchange and learning system will generate faster dissemination of ideas and solutions and encourage accelerated uptake of post-carbon visions, while simultaneously allowing for local adaptations pursuant to area needs and conditions.

Finally, re-integrating urban centers into the broader geographic community has many benefits beyond climate change mitigation, as it improves regional resiliency and regional sustainable economic development. More regionally-integrated approaches to planning will leverage considerable benefits in terms of social, environmental, and economic sustainability.

Given the leading role that German and American cities play in the ongoing global transformation of cities to post-carbon cities; the pivotal influence of U.S. and German actors in creating networks of learning; and the significant potential for expanding these networks horizontally and vertically, applying a hub and spoke approach across political, linguistic, and geographic borders, it is pivotal that U.S. and German mayors, regional governments, and urban stakeholders take the lead in developing a sustainable future.

Notes

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