Part I

Innovative Perspectives on Energy and Transportation in the Atlantic Basin

Chapter One

The Co-Transformation of Energy and Transport: Outlook for the Wider Atlantic

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The world is undergoing rapid transformations in several sectors. Chief and prominent among them is the energy sector, but there is also a new and welcome dynamism in transport. These transformations must succeed—and development towards sustainability be accelerated—for the planet to provide an acceptable environment for future generations. The Atlantic Lifestyle has driven human civilization to crash into planetary boundaries,[1] with Earth Overshoot Day coming earlier every year.[2]

Energy transformation (*Energiewende* as it is called in Germany)[3] is well established as a concept in our minds: it is a fundamental shift away from dangerous, dirty and expensive fossil energies and nuclear power towards energy efficiency and renewable energy supply with storage of various forms deployed and linked in smart energy management systems. It is happening now, sustaining itself economically; it has become self-accelerating and self-replicating. It is now a global phenomenon that began in the Atlantic.[4]

This chapter is based on a presentation given at the Jean Monnet Network on Atlantic Studies conference, "Energy and Transportation in the Atlantic Basin: Implications for the European Union and Other Atlantic Actors," held at Johns Hopkins University SAIS in Washington, D.C. on July 20, 2017.

1. Katriona McGlade, Lucy O. Smith, R. Andreas Kraemer and Elisabeth Tedsen, "Human Environmental Dynamics and Responses in the Atlantic Space," in Jordi Bacaria and Laia Tarragona (eds.), *Atlantic Future. Shaping a New Hemisphere for the 21st century: Africa, Europe and the Americas* (Barcelona: CIDOB, 2016), pp. 69-85.

2. See http://www.overshootday.org/newsroom/past-earth-overshoot-days/.

3. R. Andreas Kraemer, "Twins of 1713: Energy Security and Sustainability in Germany," in Robert Looney (ed.), *Handbook of Transitions to Energy and Climate Security* (Abingdon, UK, and New York, NY: Routledge, 2016), pp. 413-429.

4. Paul Isbell, *Energy and the Atlantic: The Shifting Energy Landscape of the Atlantic Basin*. (Washington DC: German Marshall Fund of the United States, 2012); Christoph Stefes and R. Andreas Kraemer, *Outlook for the Fossil Fuel and Renewable Energy Industries in the Wider Atlantic Space*, Atlantic Future Business Brief (Barcelona: CIDOB, 2015); R. Andreas Kraemer and Christoph Stefes, (2016). "The Changing Energy Landscape in the Atlantic Space," in Jordi Bacaria and Laia Tarragona (eds.), *Atlantic Future,* op. cit., pp. 87-102; IRENA, *Renewable Energy Statistics* (Abu Dhabi: International Renewable Energy Agency (IRENA), 2017); IRENA, *REthinking Energy 2017—Accelerating the Global Energy Transformation* (Abu Dhabi: IRENA, 2017).

In contrast, the idea of a transport transformation is still relatively new, often belittled, and generally not very well understood. It is often reduced to telling positive or negative stories about Tesla, and guessing about the future evolution of its stock market valuation. There is no agreement yet about the desirability, direction and speed of this transformation, or even whether it is heading for electric mobility or a transport system based on renewably-produced hydrogen or other alkanes (or their derivatives) in fuel cells. Even energy-efficient Diesel engines have their apologists.

There are very different and often contradictory visions about the future of transport systems around the Atlantic: the U.S. has Tesla with its clear focus on electric mobility, Brazil has alcohol as a bio-fuel derived from sugar cane, and Germany has efficient diesel engines that might run cleanly on biogenic fuels or synthetic fuels derived from renewable electricity. These are examples both of current technologies and of possible future evolutions of the transport sector.

This chapter starts from the assumption that a transport transformation is underway, that it exhibits a strong trend towards electric mobility, and that the energy transformation and the transport transformation are interlocking and mutually supportive. It is further assumed that there is an evolving co-transformation of the two systems—the most important infrastructure systems that underpin our industrialized and urbanized civilization with their generally unsustainable production, trade, consumption and wastage patterns.

The history of the world's dominant energy systems and most of its transport modes is Atlantic: all the old and dying energy industries are Atlantic in their origin and are still dominated by economic actors, regulatory philosophies and business models that have their origin and their history in the countries of the Atlantic. The same is true for the currently dominant transport technologies, even if innovation seems to be shifting somewhat to the Pacific, notably to China and Japan. The worldwide demand for energy, as well as transport, is driven by the wasteful Atlantic Lifestyle and its adoption outside its region of origin.

The transformations of these two key industries and infrastructure systems is potentially disruptive not only for the businesses involved, which may find themselves with stranded assets, eroding balance sheets, plummeting market capitalization, and eventual bankruptcies. The transformations will also induce significant changes in resource trade, government revenue and expenditure and thus the fiscal and ultimately political stability of some countries. The wider economic implications of the end of the fossil age and the energy transformation,[5] along with the geopolitics of the shift towards renewable energies, have been the subject of reflection for over 40 years[6] but are not yet well understood.[7] The geopolitical consequences of a transport transformation are yet to be assessed.

The dynamics of the past are known; evaluations of the status quo and trends are subject to debate; and assessments of possible, probable, desirable or undesirable future evolutions of the energy and transport systems are controversial. The changes are fundamental and at least potentially disruptive, which creates hopes and fears, sometimes strong. This is fuel for an emotional energy in the discussion, in the public, among experts, investors, and policy-makers.

This chapter starts by assessing, separately, the outlook for the energy and transport sectors before exploring the combined effect and potential synergies of a co-transformation. The economic and geopolitical implications are discussed as a basis for further reflection on the trade and security policy implications in the Jean Monet Network on Atlantic Studies.

It should be noted that the current transformations are not the first. There have been previous transformations of energy systems[8] as well as transport systems, and especially the energy used in transport systems. However, the current transformation is unique as it is the first that is truly global: it is driven as much by changes in (globally available) technologies as by a motivation to fight global climate change. It was therefore also in part induced or promoted by public policy. The current transformation is focused on electricity as a relatively modern energy carrier and driven also by the digital disruption that allows for gains in dynamic efficiency of the energy system.

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5. R. Andreas Kraemer, *Green Shift to Sustainability: Co-Benefits and Impacts of Energy Transformation,* CIGI Policy Brief 109, (Waterloo, ON: Centre for International Governance Innovation (CIGI), 2017).

6. Amory B. Lovins, (1976). "Energy Strategy: The Road Not Taken," *Foreign Affairs* (October 1976). Available as a reprint (with an introduction) at www.rmi.org/Knowledge-Center/Library/E77–01_EnergyStrategyRoadNotTaken; Amory B. Lovins, "A Farewell to Fossil Fuels. Answering the Energy Challenge," *Foreign Affairs, 91*(2), 2012, pp. 134-146.

7. For example, see Meghan O'Sullivan, Indra Overland and David Sandalow, *The Geopolitics of Renewable Energy* (New York, NY, and Cambridge, MA: Columbia University, and Harvard University, 2017).

8. The history of energy transformations in Germany is sketched in Kraemer, 2016, op. cit.

Energy Transformation in the Atlantic

There can be arguments about the energy transformation's speed, its cost and benefits, its regional and distributive effects, and other issues, such as the outlook for using fossil methane gas—euphemistically called natural gas by some—as a bridge fuel until 100% renewable energy supply is achieved.[9]

Financial analysts agree that the shift towards green energy is now economically self-sustaining, self-accelerating, and self-replicating, such is the preponderance of (permanent) benefits over (temporary) drawbacks stemming from the energy transformation. Even detractors, such as those pushing for clean coal or carbon capture and storage (CCS), implicitly acknowledge the generally accepted understanding of the current great energy transformation with their rear-guard action to slow it down.

Priorities differ among countries and regions, but there are solutions for everyone, from the transformation of the old, well entrenched and overdeveloped energy systems mainly in the North of the Atlantic Space to the underserved, poor regions in the Atlantic South, notably Africa, where off-grid power is growing faster than any grid expansion could be imagined.

Transport—shipping, aviation, road and rail transport—was ignored in the early reflections on Atlanticism starting in 2010.[10] In contrast, energy was prominent among early discussions and publications, at a time when fossil energy trade was even more dominant than it is today and the outlook for the development of new fossil resources was positive for instance in Brazil, West Africa, and Angola, and fracking was becoming more widespread in the U.S. In the early years, the general themes were observed, along with anticipated changes in the fossil commodity trade patterns and the effects of such changes on economic and political interdependencies.

9. For a cautionary assessment, see H. McJeon, J. Edmonds, N. Bauer, L. Clarke, B. Fisher, B. P. Flannery, J. Hilaire, V. Krey, G. Marangoni, R. Mi, K. Riahi, H. Rogner and M. Tavoni, "Limited Impact on Decadal-scale Climate Change from Increased Use of Natural Gas," *Nature 514* (7523), 2014, pp. 482-485.

10. See the early and still defining publications on Atlanticism by Ian O. Lesser, (2010). *Southern Atlanticism: Geopolitics and Strategy for the other Half of the Atlantic Rim* (Washington DC, German Marshall Fund of the United States, 2010) pp 12ff; and Mark Aspinwall, (2011). *The Atlantic Geopolitical Space: Common Opportunities and Challenges—Synthesis Report of a Conference Jointly Organised by DG Research and Innovation and BEPA, European Commission, and Held on 1 July 2011* (Luxembourg, Publications Office of the European Union, 2011) pp. 11-14.

Later analyses changed the focus, in part because of the changing economic outlook for the fossil energy industries,[11] but also in part to reflect the policy dynamics behind climate protection and the expansion of renewable energy.[12]

Looking at the status of energy systems on the four continents around the Atlantic, the following general observations can be made:

- Energy systems in the North (North America and Europe) are well developed, in some cases overdeveloped, with significant overcapacities. At the same time, energy systems in the South are still underdeveloped, either because there is no access to modern energy (as in Africa) or because the systems are not able to provide the energy services likely to be demanded in fast-growing economies (South America). Generally, the Western Atlantic or the American hemisphere is better developed than the Eastern Atlantic. In fact, much of Africa is made up of outliers within the energy system's development for their simple lack of energy infrastructure.
- Since industrialization, all of the energy systems around the Atlantic have developed a high—and dangerous—dependency on fossil energy, with the exception of those parts of Africa that have no modern energy systems to speak of. The dependence on fossil energy is strong even in areas with high levels of renewable energy, such as parts of Canada, Brazil or some Member States of the European Union, because of the need for liquid, fossil-based fuels in the current transport systems.
- All of the energy systems also maintain a share of traditional energy sources, from dung and firewood to hydropower and wind-mills, and all of them also have a mixture of modern renewable energies, such as solar power and wind power turbines. The shares of traditional and modern renewable energy differ among the countries and continents, as do their combined shares within overall energy systems.[13]
- Nuclear power retains a foothold in the North (where all of the nuclear weapons states are located), while it is waning in the South of the Atlantic (where there are no nuclear weapons states). In fact, conflict over nuclear weapons controlled by North Atlantic states being present

11. See Paul Isbell, "The Shifting Flows of Global Energy and Trade: Implications for Latin America," in Felix Dane (ed): *The Politics of World Security* (Rio de Janeiro, Konrad Adenauer Stiftung (KAS), 2015); and Paul Isbell, "Modern Renewable Energy: Approaching the Tipping Point?" in Vicente Lopez-Ibor (ed.): *Green Law* (forthcoming), 2017, pp. 215-237.

12. R. Andreas Kraemer and Christoph Stefes , 2012, op. cit.

13. See Paul Isbell, "Modern Renewable Energy", op. cit.

in or passing through the South Atlantic is one of the recurring conflicts that define Northern vs. Southern geopolitical and security preferences.

- Each of the continents around the Atlantic also has some specificities:
  - South America has especially strong corporatist traditions in the energy and utility industry, which makes sector transformation particularly challenging. Brazil has developed a technology and value chain from sugar-cane to alcohol as a transport fuel, which is characterized by high energy conversion efficiency compared to other biofuels. The technology is exported, and the value chains replicated in Africa where similar conditions favor sugar cane production.
  - With hydrological fracturing of oil and gas fields (fracking), North America (and here mainly the U.S.) has a unique energy technology development that is not being replicated quickly and easily elsewhere. This is for reasons that are beyond the scope of this chapter. However, the fracking revolution, as a regional Atlantic phenomenon, continues to influence the trajectory of U.S. energy policy and emissions: it drives down coal and nuclear power, but also slows the growth of renewable energy, notably wind power.
  - Europe—and the European Union (EU) at its heart—has the most advanced, comprehensive and ambitious policies for climate protection and energy transformation. The frameworks established by policy and law, at the EU level and in the Member States, address many different technology options but particularly those which generally drive down carbon emissions when compared with fossil energy, along with the share of nuclear power, and promote renewable energy supply as well as energy efficiency.
  - Africa has perhaps the most varied energy economy environment of the continents around the Atlantic. There are energy superpowers, including South Africa (coal), Nigeria (oil), Algeria (gas) and Morocco (renewables). But there are also many countries and regions with extreme energy poverty. Interestingly, it is those underserved regions that may now be the most dynamic in adopting distributed renewable energy in off-grid solutions, and innovating business models around them.

The trends and outlooks on the four continents around the Atlantic can be summarized in a similar way. Overall, they are relatively similar. Because of technology changes and economic forces, there is likely to be a convergence of end points or landing zones of the current energy transformations. Table 1 offers a cursory summary of status, trends and outlook around the Atlantic.

Table 1. Overview of Energy Status, Trends and Outlook around the Atlantic

North America

Status: Very high energy consumption. Largely grid-supplied, weak interconnections, many distribution lines over-ground and vulnerable, mid-level supply security; high levels of renewable energy (including wood for heating); the region is an innovator and technology supplier with the power (by business but also government) to direct technology development and make informed technology choices

Trend: Nuclear down, coal out, oil declining, fossil methane gas holding up (for a while), renewables up, especially solar and onshore wind; driven by states and municipalities; grid defection in some areas; growth of smart-energy applications and business models

Outlook: Accelerating green power shift, with rear-guard action by powerful coal lobby and nuclear military-industrial complex, persistence of fracking for oil and gas; disruption by technical, material and business model innovation in a conservative political environment

South America

Status: Mid-level energy consumption (with great variation). Mix of grid-supplied areas and off-grid or micro-grids, weak interconnections, many distributions lines over-ground, mid- and low levels of supply security; partly caught up in unreformed corporatism (and collateral corruption, e.g. Brazil, Mexico); Venezuela as first petro-state in collapse; the region has a weak innovation system (with Brazil being a possible exception) and is generally a technology follower with the power to chose

Trend: No entry or growth for nuclear; persistence of fossil structures in corporatist utilities, but autonomous electrification in unserved or underserved areas based on renewables (mainly solar); persistence of sugar-cane-to-alcohol in car engines in Brazil

Outlook: Falling cost of renewables will shift private investment their way, including LVDC systems; potential for conflict with incumbent utilities (and the unions behind them); utility-scale renewables may accelerate in some areas

Europe

Status: High energy consumption. Largely grid-supplied, mainly strong interconnections, most distribution lines underground, mid-to-high supply security; high and rising levels of renewables, with variations; the region is an innovator and technology supplier with largely governmental power to direct technology development and make informed technology choices

Trend: Nuclear down, and out everywhere except France, Russia and UK as nuclear weapons states; coal out, oil and fossil methane gas declining (maybe except in Russia); renewables up, especially onshore and off-shore wind, along with solar; even more interconnections, including with North Africa, growth of renewable technologies

Outlook: Continuing green power shift, spreading to the East and South-East, rear-guard action by retrograde regimes in some countries (e.g. Poland, potentially Germany prolonging the life of lignite coal), disruption is partly policy induced

Africa

Status: Low energy consumption. Large areas unserved, weak or non-existent interconnections, mostly no distribution lines, no supply security; the region can innovate in business models but is a technology taker without the power to choose in all other respects; political power often trumps economic sense

Trend: Patchy growth of utility-scale renewable energy in some countries (e.g. Morocco) but futile focus on coal in others (e.g. South Africa); some interest in nuclear driven by corruption (e.g. South Africa)

Outlook: No entry or growth of nuclear; stagnation in areas already served by grids, due to political and economic power of incumbent utilities and associated interests; first access to modern energy accelerating in areas not served by a grid, based on increasingly inexpensive, smart low-voltage direct-current energy systems; potential conflict over energy supply visions (e.g. Tanzania, where kerosene lobby fights solar power)

Source: own elaboration.

Transport Transformation in the Atlantic

All the modern forms of transport—automobiles, trains, modern ships, and aircraft—are equally of Atlantic origin and still dominated by businesses that have their origin and headquarters in the Atlantic Basin. The names of the relevant inventors are all European or of European origin, with North America being a main driver of developments in the past 100–150 years. James Watt's steam engine comes to mind, and the British engineers that first built a transport infrastructure based on coal and for coal. Rail transport is still associated with coal engines in many minds even if current technologies are electric or hybrid.

The names tell the story: MacAdam for asphalt or tar on the road, Goodyear for tires, Otto and Diesel as the dominant engine types, Ford for the production mode—Fordism—that is still at the heart of the automobile industry, even if the Toyota model of co-location of suppliers and just-in-time delivery has been superimposed in a large part on the mobility industry. This industry focuses on putting few people at a time into cars that run on fossil oil derivatives and roll on galvanized fossil oil over gelled fossil tar on the ground. That industry is now in decline—at least with respect to drive-train technologies—and is likely to erode faster than most people anticipate.

The automobile industry is on the cusp of a radical transformation which will be based on electrification, with pure electric vehicles dominating the passenger transportation matrix, along with some hybrid vehicles. Self-charging at home will increasingly become structurally dominant for private individual mobility, including commuting. This trend is starting in the Northern Atlantic (notably Norway and California—on the outer edge of the Atlantic and bordering on the Pacific) but will spread fast in the North and then from the North to the South Atlantic. The costs of the key components are coming down fast: electric motors, batteries and super-capacitators as well as light-weight materials for the car structure and body are getting cheaper faster than the amortization of the existing car fleet. Technological and economic disruption are beginning to work together and reinforce one another.

In parallel, there is a separate but also reinforcing dynamic of change in the transport sector associated with the platform and sharing economy. New, internet-enabled platforms like Uber or car sharing apps empower owners and users of cars as well as intermediaries, aggregators and transport service providers to innovate new approaches to satisfying mobility needs. Vehicle mileage is higher, with fewer cars needed for each unit of transport demand. We are beginning to witness a digital disruption of the current transport systems with an efficiency gain of potentially enormous proportions.

Autonomous driving and other cross-functionalities with internet and cyberspace will increasingly favor electric cars. Here Tesla shows the way not just with its electric drive-train but with the (remote) updates of car operating systems that allow additional functionalities to be added to cars after delivery at very low cost and without the need for visits to car workshops or dealerships. The mobility innovation system is shifting from engineering to programming, and the innovation cycle is become ever shorter as a result.

This development is about to be economically self-sustaining. In some situations, the total cost of ownership (TCO) even of an expensive Tesla Model S is already below that of similarly-sized cars with combustion engines. The cost advantage of electric mobility will become clearer with each generation of electric vehicles. Indeed, this is the major future cost assumption underpinning the study of Basque and European passenger car mobility that forms the foundation of Chapter Three of this book and the basis for its conclusion that the best alternative for replacing gasoline and Diesel cars in Europe would be the battery electric vehicle, in combination with conventional hybrid vehicles.

As in the case of energy transformation, the shift from combustion to electric engines will soon be self-accelerating, and the enabling policy frameworks will be adopted in ever more countries. No country will want or be able to stop the spread of electric vehicles as a superior and soon dominant technology configuration.

For each class, future vehicles will be simpler and much cheaper to build, with simple design, fewer parts, especially fewer moving parts. Without gear-boxes and clutches, and much simpler transmission of motor energy to the wheels, the cars will be lighter, simpler, and more versatile. With engine servicing intervals of 100,000 miles or 150,000 km for electric motors, without motor oil and spark-plugs to change, and with the most short-lived part perhaps being the wiper blades, there will be a significant reduction in the volume and value of after-sale services. This will release many qualified technicians to perform more important and valuable tasks.

Public and commercial freight transport is on a similar trajectory. New fuels, and drive or propulsion technologies, are also increasingly available for railroads, ships and aircraft. Some of these are still based on liquid fuels (like LNG or LPGs), but the quantities likely to be required for uses where electricity is not a viable option can be supplied from biological sources or synthesized using abundant and cheap renewable electricity in power-to-gas and power-to-liquid applications.

This all started in the far western reaches of the Atlantic world, notably in California, which, although on the Pacific coast, is economically and culturally part of the Atlantic and even epitomizes the Atlantic lifestyle. The iconic leader is Tesla, and while the founder Elon Musk hails from South Africa, the innovation style of the company is typical of the U.S. Pacific Coast. In fact, the company is a disrupting force not only in transport but also in solar power concepts, products and business models as well as storage and smart home development. Most innovation is undertaken by new entrants, and disruption of the incumbents is itself a defining trait of the Atlantic innovation system, notably in North America.

Atlantic leadership in transport innovation may be lost to Asia-Pacific (mainly China, but also Japan, South Korea and Taiwan). The leader in hybrid drive-train technology is Toyota, with other automakers belatedly catching up. The concept cars developed by the company are an indication that Toyota may also be able to lead in the next generation of electric cars, with small motors in each wheel and similar car concepts that can be highly efficient, very light, and easy to manufacture. The leader in market penetration and total numbers is China, where on-the-road operational experience is speeding up innovation.

The traditional U.S. motor industry, epitomized by Detroit, may try to match the innovation and dynamism of the Pacific Coast innovation system. The Chevy Volt and the admission by Cummins, the U.S. technology leader in diesel and gas engines, that their old engines may be phased out by 2040 to be replaced by electric and hybrid systems are signs that not all is lost in the world of the fossil-energy combustion engine, and that some leading companies are likely to invent their way into the electric mobility future.[14]

On the European side of the North Atlantic, the challenge of technological change and disruption is now understood, and yet the question is open if any of the European producers can catch up with the innovators in the North-West Atlantic and the Pacific. A recent phenomenon in Germany—the home of Diesel, Otto, and Wankel—is that car and truck manufacturers find that both their key suppliers and their largest customers are beginning to compete

14. Joann Muller, "Cummins Beats Tesla to the Punch, Unveiling Heavy Duty Electric Truck," in *Forbes*, August 29, 2017. https://www.forbes.com/sites/joannmuller/2017/08/29/take-that-tesla-diesel-engine-giant-cummins-unveils-heavy-duty-truck-powered-by-electricity/.

with them. The barriers to entry into the car-making business seem to have fallen to the point that no single company is now safe from being disrupted to the core.

The exception may be BMW with early and continuous investments in electric mobility, including the development of new car designs using modern materials, and clear market positioning: their i3 and i8 models are like concept cars that escaped from bays in the research and development unit and found their way onto the road. They make a strong statement that BMW has the capacity and the will to design the electric and hybrid cars of the future.

When it comes to future rail transport systems, Europe is still the technology leader. Again, the industry is Atlantic in origin, with Siemens, Alstom and ABB being leaders in Europe and Bombardier in North America.

In this process of technological and economic disruption, much of Latin America and all of Africa is a technology taker; they are dependent on the products and drive-train (or jet engine) technologies developed elsewhere. They will be forced to follow where the technology leaders take them. The battle over innovation and future dominance of the transport sector is fought among California, Southern Germany (with Stuttgart and Munich) in the Atlantic and China and Japan in the Pacific.

Energy & Transport Co-Transformation and Resource Implications

Economic forces are on the side of these parallel and mutually reinforcing transformations of the energy and transport systems around the Atlantic. Still, fossil subsidies, although declining in recent years, continue to be arrayed against them and uphold the fossil (and nuclear) energy system, and provide for continuing support for fossil-based combustion engines.

The energy and transportation transformations are mutually reinforcing. More electric vehicles connected to the grid for charging also means more storage capacity on balance, allowing the grid to incorporate progressively higher levels of electricity from fluctuating renewable sources more readily and reliably. On the other hand, a higher penetration rate of renewable energies in the generation mix will lead to a smaller carbon footprint from the transport sector. Given that new systems will provide a range of services far beyond that possible under the old fossil energy system, this co-transformation will extend to buildings (including the use of solar roof tiles and other smart home possibilities).

Both transformations have strong environmental and social value propositions. They stem from the imperative to protect the Earth's climate systems—an imperative that gains political urgency with every natural disaster that is connected to the overheating of the planet from the burning of fossil fuels. The increase in hurricanes and typhoon activity in recent years is beginning to make the stakes clearer to many who previously preferred to ignore the threat. While the economics are already driving the co-transformation of the energy and transportation systems, the question remains if the transformation will be quick enough to help avoid the worst consequences of what could already be run-away climate change. Small island states and many coastal and low-river communities are already being faced with existential crises.

Innovations in policy frameworks and international policy coordination may well be required, especially around the Atlantic.[15] Chief among those would be a coordinated push to stop, perhaps by 2020, all subsidies as well as tax and other privileges for the fossil energy industry. Concerning nuclear energy, the abolition of international agreements that protect the builders, owners, operators, and regulators of nuclear power plants from liability for damages in other countries might be put on the agenda.

Because of excessive air pollution in cities, there is pressure to removed two-stroke and Diesel engines, which might be done through "cash for clunkers" programs that reward drivers that buy electric vehicles and scrap their old and dirty fossil-energy driven ones. Cities may well find that banning dirty engines during episodes of high air pollution is the only way to ensure that pollution stays within legal limits. The more cities resort to banning Diesels, the faster the change-over in the car fleet is likely to be. In addition, cities can help the transformation of the energy and the transport system by establishing the necessary infrastructure for charging electric vehicles, and keeping parked vehicles connected to the grid so that they can provide power grid stabilization services. Existing infrastructure for street lighting can be used for the purpose at a fraction of the cost of building an additional new infrastructure of vehicle charging stations.

The resource sectors will change in response to the co-transformation of energy and transport. Demand for oil, steel and welding is weakening, and

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15. R. Andreas Kraemer and Camilla Bausch, "Koordinierte Weltinnenpolitik: Zusammendenken im atlantischen Raum," in Wolfgang Ischinger and Dirk Messner (eds), *Deutschlands Neue Verantwortung*. (Econ, 2017) pp. 286-287; English as "Joining up in the Wider Atlantic," *IASS Blog* http://blog.iass-potsdam.de/2017/03/joining-wider-atlantic/.

will continue to do so, but demand for carbon fibers and plastics (including adhesives) will rise. Overall, fossil and ferrous metal industries will lose out to companies that supply a wider selection of elements in the Mendeleev periodic table. Current patterns of mining and metals trade will give way to a wider range of elements: demand for non-ferrous metals, metalloids and rare earth elements will continue to rise; demand for trade in ferrous metals, on the other hand, will remain flat or even decline.

The energy and transportation co-transformation will lead to shifts in trade flows and volumes. Trade in chemical energy in the form of energy commodities for one-off consumption will be displaced by trade in durable equipment for the continuous long-term harvesting of ubiquitous, free environmental flows.

There will be impacts on maritime transport. The current fleet of oil (and LNG) tankers can be retired, and the terminal infrastructure for handling fossil energies can be dismantled, freeing up space in port areas. Shipment of durable energy equipment will be largely in containers, but may require specialized transport infrastructure in some cases, e.g. the long blades for off-shore wind turbines. The minerals and other raw materials that will be in higher demand, are likely to be processed close to the mines, especially if cheap renewable energy is available in the region. Not so much of those raw materials will be transported in bulk maritime transport, but the partly refined intermediate products are most likely to be traded internationally, reducing the volume while increasing the value of shipments.

Overall, this co-transformation will be accompanied by a decline in the trade of fossil energy commodities, in both value and volume. At the same time, the revenues of petro-states will collapse, as new business opportunities simply will not compensate for the decline and loss of trade in fossil energy commodities. In the Atlantic, Venezuela provides an example of the dynamics that shape a society and a country when the resource curse is lifted and a regime can no longer count on oil revenue to stay in power. On the other hand, the total cost and capital needs for energy and transportation will fall, while the services provided expand and the related environmental and social values will rise.

Discussion and Outlook: Geopolitical Implications

The geopolitical implications of the co-transformation of the energy and transport systems are not yet fully understood. The implications for the shrinking and dying industries are clear enough: there will be capital write-offs, bankruptcies and job losses in the fossil and nuclear industries as well as among combustion-engine makers. The implications are less clear for the manufacturers of cars, trucks, buses, trams, trains, ships and aircraft. Some of them may be out-innovated and disappear, while others may thrive.

The anticipated shifts may be so dynamic that they result in social and political disruption. In fact, there are already discernible links and commonalities in North America and Europe, among populist advocates of economic nationalism, nativism and protectionism, and climate-change denial. On both continents, there are strong attachments to fossil fuels and defense of the Diesel engine, epitomized by "rolling coal," the eco-terrorist practice of smoking the environment by producing massive black-carbon plumes from the exhausts of Diesel-engine trucks. The contrasting attitudes may lead to conflicts over trade, regulation, state-aid and competition, and other areas.

The distributional effects of the necessary—and therefore welcomed, but also economically beneficial and ultimately unstoppable—co-transformation of the energy and transport sectors in each country are already proving difficult to manage. The economic and political power of the incumbent industries is strong, as is their hold over the identities and cultural values of key constituencies. There will be larger distributional effects to come among countries and continents around the Atlantic, but also beyond.

Many resource extracting and exporting countries are afflicted by the resource curse when conflicts over resource control and its economic benefits result in ever more corruption and repression, and ultimately in an oppressive autocratic regime. When the resource curse is lifted, the regime does not go away voluntarily to allow for a peaceful transition to a more liberal order, as the example of Venezuela shows. Nevertheless, the lifting of the resource curse should be good in the medium to longer term.