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Green Shift to Sustainability: Co-benefits and Impacts of Energy Transformation

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Key Points

- Energy transformation toward 100 percent renewable energy is desirable and inevitable.
- New energy systems, based on efficiency, renewables, storage and smart management, are cheaper to build, run and maintain. They harvest free environmental flows, often for self-consumption.
- Fossil fuel extraction and commodity trade will end, as fossil asset values erode in a shrinking sector that loses its role in capital formation, international trade, economic activity and government revenue.
- Energy transformation is beneficial overall, and yet it may produce misleading signals in outdated statistics. International organizations and the Task Force on Climate-related Financial Disclosures (TFCD) should address this paradox in joint reports to the Group of Twenty (G20) leaders, ministers of finance and central bank governors.

Challenge

The current shift from fossil energy resources to "green" energy — renewable energy plus storage in smart grids, many with electric vehicles providing grid services — is now a global phenomenon (International Energy Agency 2016; International Renewable Energy Agency [IRENA] 2017b). For economic reasons, this energy transformation (or *Energiewende*[1]) has become self-sustaining and self-accelerating where it is under way, and self-replicating in an increasing number of countries and regions, including in poor areas and remote locations not yet served by a power grid.

The main reason for this boom in green energy is the decreasing cost of key energy technologies and equipment, especially wind turbines, solar panels, storage and smart energy management systems. Tom Randall (2016b) shows an impressive figure of the cost of solar panels falling by 26.3 percent every time the world's solar power doubles, in a stable technology learning curve from 1976 to 2016. Today, they are able to compete with heavily subsidized fossil and

1 "*Energiewende*" is the German word for the energy transformation away from nuclear and fossil energy and toward renewable energy supply and energy efficiency. The term became prominent after a book of the same title, published in 1980, sketched a national strategy for energy transformation (Krause, Bossel and Müller-Reißmann 1980). It is a typically German composite noun consisting of "energy" and "*Wende*," a tack in sailing or a U-turn in road driving. The suffix "*-wende*" has come to indicate corrective transformations of whole sectors, such as transport, agriculture and nutrition, so that they may become sustainable.

About the Author

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nuclear energy, and no longer need the subsidies that helped them mature in the past. The cost reductions are the result of technology learning (Rubin et al. 2015) that is projected to continue for years to come. The costs of fossil energy, by contrast, tend to rise, even before the true costs, including external costs, are calculated. The current low-to-medium world market prices for fossil energy commodities cannot hide the trend that with easy-to-access areas already exploited, these resources are getting ever more difficult and expensive to extract and bring to market: costs of extraction are rising while prices fall.

The urgency of climate change and its impacts — global overheating, melting glaciers, extreme weather events, desertification, ocean acidification and sea-level rise leading to flooding of coastal areas and low-land river plains — is increasing. The environmental and social costs of fossil energy use have moved from economics textbooks onto front pages and news channels.

Financial analysts at Trucost — a company based in London, England, which makes estimates about the hidden costs of the unsustainable use of natural resources by companies — conclude that the highest external damages (so-called externalities) are caused by coal-fired power in East Asia and North America and are estimated at US$453 billion and US$317 billion per annum, respectively. These consist of the impacts of greenhouse gas emissions, health costs and other damage due to air pollution: "in both instances, these social costs exceeded the production value of the sector" (Trucost 2013). An International Monetary Fund (IMF) study by David Coady et al. (2015) estimated global externalities (and subsidies) to be US$5.3 trillion.

Policy makers are already responding by removing subsidies and privileges for the fossil industries and by placing "a price on carbon" through taxes, emission trading in "carbon markets," changing liability regimes or (environmental and health) regulations (Burck et al. 2016; Roehrkasten, Thielges and Quitzow 2016). The overall objective, agreed to in the Paris Agreement, is to make "financial flows consistent with global long-term climate goals" (Obergassel et al. 2016; Hansen et al. 2017). Coordinated action by the G20 (or a majority group in the G20) on carbon pricing and subsidy reform would accelerate the energy transformation, which is, in any case, inevitable (Kraemer 2016a; Roehrkasten et al. 2016).

The fossil energy industries are reaching the end of their historical cycle and losing their social licence to operate (Carney 2015). Bankruptcies of major coal companies signal a trend that is spreading to the oil and gas industry, and increasing investor risk in an industry with low prospects for long-term recovery.

The result may be a denial of capital as institutional investors pull out of the industries, as they are being asked to do by activist investors and the growing divestment movement, and nudged to do by ever more stringent risk-disclosure requirements. The total value of the "fossil bubble" currently being deflated may be as high as US$33 trillion (Ryan 2016) — much of that is on paper only, and much is owned by governments or government-owned companies (Cust, Manley and Cecchinato 2017).

The shrinking of the fossil energy industry overshadows the parallel decline of the much smaller nuclear power industry. Devoid of economic justification, it cannot compete without massive subsidies and privileges, and these are increasingly difficult to hide. This industry will probably not die, but shrink to what it can be without being economically competitive: a military technology with marginal relevance to the energy economy.

In an economically rational world, the overall effect would be simple: in ever larger parts of the world, new investment would go into renewable smart energy and, progressively, capital would be withheld from the fossil and nuclear industries. Industry momentum and other factors explain why some investment is currently still flowing into old energy, but that is likely to be temporary. Since it is based on sound economics, this shift is not only unstoppable, but also transformational (Kraemer 2016b).

Energy sector and economic models will better reflect this transformational dynamic once the new realities are factored in (Pollitt and Mercure 2017). Perhaps one day, a new set of economic indicators will be accepted as a more suitable guide to policy evaluation and decision making (Stiglitz, Sen and Fitoussi 2009). At the end of a transformation, the winner takes all; essentially, the whole market will shift to renewable energy, similar to how motor cars replaced horses in transportation 100 years ago.

In the short to medium term, investment in the renewable energy sector is likely to increase rapidly, in part displacing investment no longer needed in the fossil and nuclear sectors, and in part to reach people in areas not currently served by a power grid (off-grid power). Because of the small investment volumes — with lots starting as low as US$500 — the latter might appear in economic statistics as consumptive expenditure by households, but should be regarded as capital investment in long-life energy conversion equipment.

Beneficial as it is, energy transformation may look bad through the lens of the statistics most commonly used to guide economic, fiscal, monetary and trade policy. Therein lies the risk of misguiding policy makers into protecting the incumbent industries, and their privileges and subsidies, and thus slowing down the energy transformation instead of accelerating it for maximum benefit.

Proposal

Implications of the Unstoppable Shift away from Fossil Energy Resources

Impact on Export, Trade and Import of Various Resources and Materials

This energy transformation will have significant and potentially disruptive impacts in other areas, notably capital formation and deployment, trade, finance and investment, growth and tax revenue and the ability of companies and countries to service debt. This disruption should be anticipated and prepared for, so that negative effects can be mitigated and risks of contagion can be contained. The disruptions are balanced by a range of obvious benefits (Jakob and Steckel 2016; Helgenberger and Jänicke 2017). Simply put, there is an ongoing shift from trading chemical energy commodities for consumption to trading durable equipment for the conversion of (kinetic) energy in free environmental flows into electricity.

The old fossil energy systems mine coal and extract oil and gas, which are stocks of preserved energy, from sites where they occur, and use an extensive and expensive global processing and long-distance transport infrastructure to bring derivative products to market for consumption. The energy itself is traded in chemical form as a commodity. Once a site is exhausted of its resources, the industry moves on, progressing from locations that are easy and less expensive to work on to those that are more difficult and expensive. Although technical innovation may obscure it at times, the operational costs of the fossil energy system increase over time (Lovins et al. 2005; summarized and updated in Lovins 2012).

In contrast, the new renewable energy systems harvest environmental flow resources, which are near ubiquitous, so that the energy, often in the physical form of electricity, does not have to be transported over long distances. Many technologies are suitable for deployment at small scale, which creates the option of self-supply for many users, who then produce the energy they consume and become "prosumers." In such cases, the energy itself is no longer traded. Once a site has been developed for harvesting renewable energy flows, it can be used, theoretically, in perpetuity, even if, in practice, physical structures and equipment must be replaced from time to time. In consequence, the new energy systems tend to get cheaper over time, especially as equipment prices fall.

Overall, this results in lower trade volumes, both in total and in terms of international trade. The main fossil-energy-producing countries will have declining exports, and the importing countries will save on their fossil energy import bill. This overall phenomenon can be broken down into three components:

- Substitution effect: Import substitution can result from fracking for fossil oil and methane gas (in North America) or, more importantly, from the growth of renewables (everywhere), where new technologies reduce the market share of fossil fuels.
- Quantity effect: In consequence, the volume (or mass) of internationally traded fossil energy commodities declines.
- Price effect: With lower demand and thus increased competition in the fossil energy industries, the revenue per unit of volume or mass declines; the value of trade declines faster than the volume of trade. This combines with rising costs of extraction to erode profits even more quickly.

These three components will persist because they are underpinned by changes in the economics of energy systems, which have resulted in renewable energy being cheaper than fossil (or nuclear) energy (Randall 2016a, 2016b; Sussams and Leaton 2017). The old and the new energy systems still require large capital investment in infrastructure and equipment, but the composition of raw materials used is likely to change over time (see, for example, Angerer et al. 2016). Even if technologies evolve and the long-term evolution of the energy system is uncertain, one can surmise that there may be a shift from the ferrous metals that dominate the manufacturing of equipment for coal, oil and fossil methane industries, to more non-ferrous metals and other elements used in the manufacturing of renewable energy, storage and information and communication technology (ICT) equipment for smart energy systems.

The decline of the fossil energy industry will leave behind "stranded assets," economists' term for investments that have become worthless. Some of these are real assets that have been built by the industry, others are merely valuations of fossil energy stocks found in the ground that have made their way into balance sheets before being extracted. In the G20, the focus has been on stranded financial assets, the systemic risks to the world's financial system caused by the consequences of climate change, and contagion or "domino effects" that could rip through the global markets. The concerns about stranded assets should go beyond financial assets, which can be written off, and the resulting insolvencies, which can be managed with existing legal and regulatory instruments. Stranded assets also include the following:

- Stranded *industries*, which are a well-known consequence from earlier changes in technologies and industrial patterns. Industrial brownfield sites may look ugly, but in populated and, in particular, urban areas, imaginative policies can turn them into opportunities. Stranded industries present social, economic and fiscal challenges. When large companies close, unemployment rises, and tax revenue goes down when demand for social services goes up.
- Stranded *infrastructure*, some of it over long distances, is in a class of its own, especially in remote areas. Industrial installations, pipelines, ports, railroads and roads, off-shore platforms or transshipment terminals stay behind and the scrap value is often not enough to merit the dismantling of the infrastructure. The blights stay for decades, if not forever.
- Stranded *legacies* are the result of company insolvencies that, in effect, dump the long-term cost of decommissioning, dismantling, cleanup and reclamation on the state and future taxpayers. The experience in many industries — from mining to nuclear power

plants — shows that the accounting rules and the obligations to make provisions or accruals for legacy costs are not enforced, and that in too many cases the cleanup does not happen.

Some of the stranded assets are in the form of redundant equipment that can be recycled and, thus, provide materials that otherwise would come from the mining industry. They can be used in the wider economy, including in building the new energy industry, although there will also be a need for new resources in a changing composition to enter the technosphere (ibid.). The current overcapacity in the steel sector is already a concern for investors and even governments, to the point that the G20 leaders meeting in Hangzhou, China, in September 2016 addressed the issue in their final declaration (G20 Leaders 2016, paragraph 31).

There may also be significant growth in downstream trade in renewable energy, including fuels from (renewable) power-to-gas and power-to-liquid conversion processes. There is, furthermore, a potential for (small or incremental) increases in international trade in electricity and renewable-power-derived fuels, where interconnections exist and temporal, geographic differences in the availability of natural environmental energy flows make such trade advantageous (see, for example, Parikh et al. 2017). However, the overall impact of the shift from the old fossil energy to smart renewable systems will lead to the decline and cessation of (bulk) fossil energy commodity trade and a reduction in trade value and volume. These reductions will likely not be compensated by net increases in trade in other raw materials and manufactured goods in the energy sector, although other sectors may grow as a result of the energy transformation and the potential for innovation it provides.

Impact on Investment, the Economy, Tax Revenue and Subsidies

Furthermore, not only the "total cost of ownership" as the sum of capital costs and operational expenses over the lifetime, but also the total capital needs of the new energy system may well be significantly lower than those of the old energy system. "Every time the world's solar power doubles, the cost of panels falls by 26%" (Randall 2016b), far above the average effect of technology learning (Rubin et al. 2015). This resulted in the phenomenon that global solar investment in 2016 fell by 32 percent compared to the year before, while the capacity of new installations rose by 20 percent (Bloomberg New Energy Finance 2017). The corresponding effect for onshore wind is not as high, but at 19 percent is still above average. Technology learning in storage technology seems to replicate the downward cost trajectory of solar power (AECOM Australia 2015; Lazard 2016). Judging from the reports about new findings in material research laboratories, it can be assumed that the trend will continue for at least another five to seven years before technology learning may settle at a more average pace.

New configurations of equipment using low-voltage, direct-current technology are not only cheaper to build, but also much more energy efficient to run. They can provide low-cost modern and smart energy in areas that are not currently served by the power grid, at a technical complexity like that of motorcycle maintenance and smart-phone applications. With such installations mushrooming in rural areas with no grid or unreliable grids, large-scale investment for central power stations and regional or national grids may no longer be required. The investment needs of the new energy system can be shouldered by individual households and microcredit institutions (Vinci, Nagpal and Parajuli 2017).

In consequence, there is a reduced need for central coordination of the electricity system and, accordingly, a lower need for the deployment of large (aggregated) capital. Indeed, capital formation may shift, at least in part, from large aggregators (for example, stock markets, funds and governments) to individuals, households, microcredit institutions or mutual savings banks serving local communities (Morris and Jungjohann 2016). The lower overall capital needs of the new energy industry imply reduced opportunities for large capital accumulation and deployment. A ministerial round table at IRENA's seventh assembly in Abu Dhabi on January 17, 2017, discussed ways to improve access to electricity and gain substantial socio-economic benefits through off-grid renewable energy. The discussion highlighted "the importance of unlocking asset-based financing for rural consumers and levering on microcredit delivery" and "the importance of innovative financing tools, including provision of guarantees for de-risking private sector investments and local currency loans" (IRENA 2017a).

It follows that not only do international trade, overall trade, value of the energy system and capital needs decline, but business volume may also be greatly reduced, due to both the reduced cost of the industry and its products and services, and a rising share of self-supply that is neither a commercial business nor taxable. Economic activity (as measured by GDP) would be smaller compared to the business-as-usual scenario. The decline may or may not be masked by initial investment in new energy.

Tax bases are also likely to shrink, because of lower capital values employed and lower volumes and values of energy bought and sold. This effect should be roughly in line with the decline in GDP, except that the impact on public finance would be mitigated by phasing out subsidies for the fossil energy industries and a lower overall need for public funding to deal with the external environmental and social costs, the "externalities" imposed by the fossil energy industries on the public.

The value of subsidies (in 2012) was estimated to be €57 billion per annum for Germany, of which 90 percent is linked to the energy system and climate damage (Köder and Burger 2017). The Organisation for Economic Co-Operation and Development (OECD) (2015) estimates that direct subsidies to the energy sector account for hundreds of billions of US dollars per year. Including "external costs" as an expression of social and environmental damage to current and future generations caused by the fossil energy sector, "the total value of global subsidies," has been estimated by the IMF to be US$5.3 trillion (Coady et al. 2015). G20 countries provide roughly US$444 billion per year in subsidies for the production of fossil fuels (Bast et al. 2015). The phasing out of subsidies for the fossil energy sector is also called for by institutional investors.[2]

Co-benefits of Energy Transformation, Value Creation from Electrification and an Economic Paradox

Despite the reductions in cost, value, trade, economic activity and tax revenue from the energy sector that can be expected, the energy transformation is likely to be beneficial for the wider economy and society in ways that are often difficult to quantify and are not reflected in economic statistics (Helgenberger and Jänicke 2017). This is not only because the money saved on energy supply can go to other and potentially better uses, but also for the following reasons:

- the total value of damages caused by the industry will diminish — the external cost (in the form of, for example, an overheated planet and a legacy of radioactive waste that needs to be kept safe and managed for thousands of future generations) will stop rising;
- there are many co-benefits of the energy transformation aside from climate change mitigation (for example, in the areas of pollution control and environment, conservation and protection of habitats, economic and fiscal, social, ethics and governance, foreign affairs and security policy); and
- the shift toward electricity as the main energy carrier will help in the creation of additional value beyond what was possible with the chemical and thermal energy from fossil resources.

Electricity is a noble, physical form of energy, more physically valuable than the equivalent chemical energy contained in fossil fuels, and more versatile and suitable for use in advanced systems. The physical value of electricity, its *exergy*, translates into properties that increase its economic value for end-users. It can be transformed quite easily into other forms of energy — movement, light and heat. Electricity also enables modern ICT, which is at the heart of the transformations or "digital disruptions" (Khare, Schatz and Steward 2017) that improve efficiencies at many levels.

The cost of extracting, processing and bringing fossil energies to market, plus profits, determine the lower bounds of prices consumers pay (absent consumer subsidies). Those prices tend to rise as fossil fuels become more difficult to extract. Renewable energies, in particular solar and wind energy, rely on the harvest of free environmental flows; their costs are determined largely by the capital expenditure for photovoltaic equipment and wind turbines (plus grid investment in some areas), divided by the respective lifetime output of electricity (in kilowatt hours). These costs tend to come down over time. Paradoxically, the energy with lower physical value has higher costs and prices, and the physically superior electricity is getting cheaper.

The demise of fossil fuels and the rise of renewable electricity produce an apparent paradox in economic development, to the benefit of end-users. In return for lower total energy costs, they obtain a more valuable form of energy that allows them to create additional value in manifold ways. There is a very

2 See www.actiam.nl/nl/verantwoord/Documents/Klimaat/170214_Statement_G20_governments_must_lead_in_phasing_out_subsidies_and_public.pdf.

large additional “consumer rent” they can enjoy. The value of this rent is difficult to estimate, and it is likely that a large part of it will be enjoyed in ways that are not captured by economic statistics or subject to taxation. Well-being (and perhaps happiness) may rise, but not be reflected in GDP growth or an increase in tax revenue.

Summary and Recommendations

The energy transformation is building an energy economy that serves the needs of the population — both current and future — and the planet much better than the old energy system. Some — perhaps even many — of the benefits are not reflected in traditional economic indicators and statistics, which, therefore, give false signals to policy evaluators and decision makers.

With the TFCD of the Financial Stability Board (FSB), the ministers of finance and central bank governors of G20 countries already have a mechanism in place to investigate the implications of the energy transformation for the wider economy, including:

- → the impact on the extractive sectors, both fossil (coal, oil and gas) and minerals and metals, including companies and underground assets in government-owned and privately held companies;
- → commodity trade patterns and financial flows, and balances of trade and payment;
- → investment needs and time horizons, including for small smart-energy systems that constitute durable investments but may look like “consumption” because of their small lot size;
- → changes in the level and distribution of economic activity, including the likely growth of energy self-supply, peer-to-peer trading in the platform economy;
- → resulting changes in the statistics covering trade, investment, capital stock, GDP, and so on; and
- → resulting changes in the tax bases and future government revenue streams.

In addition, the G20 should request a report from a group of international organizations, notably IRENA, the IMF, the OECD and the World Bank, on the wider economic implication and the true costs and benefits of the energy transformation.

Implementation Overview

The TFCD of the FSB is given a broader mandate to investigate and report on the wider implications of energy transformation, and to make recommendations for additions and changes in international statistics.

In 2018, IRENA, the IMF, the OECD and the World Bank submit to the G20 leaders, the G20 ministers of finance and central bank governors, and the G20 ministers of climate and energy their joint report on the wider economic implications and the true costs and benefits of the energy transformation.

From 2019, the TFCD reports annually through the G20 Finance Track as well as G20 ministers of climate and energy. Energy sector transformation becomes a standard item on the agenda of future G20 summits.

Author’s Note

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Appendix

Existing Policies and Monitoring

- FSB TFCD
- Sustainable Development Goals (SDGs):
  - Goal 7 — "Ensure access to affordable, reliable, sustainable and modern energy for all"
  - Goal 9 — "Building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"
  - Goal 12 — "Ensure sustainable consumption and production patterns" (including material consumption and resource husbandry)

Progress toward the SDGs is reviewed by the High-Level Political Forum on Sustainable Development in annual conferences.

Resources

Beyond GDP — Measuring Progress, True Wealth, and Well-Being: The European Commission maintains a website with a repository of relevant news, studies and policy papers: http://ec.europa.eu/environment/beyond_gdp/index_en.html.

The NetGreen Network for Green Economy Indicators maintains a blog with opinions and information about current developments: http://netgreen-project.eu/blog.

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About the Global Economy Program

Addressing limitations in the ways nations tackle shared economic challenges, the Global Economy Program at CIGI strives to inform and guide policy debates through world-leading research and sustained stakeholder engagement.

With experts from academia, national agencies, international institutions and the private sector, the Global Economy Program supports research in the following areas: management of severe sovereign debt crises; central banking and international financial regulation; China's role in the global economy; governance and policies of the Bretton Woods institutions; the Group of Twenty; global, plurilateral and regional trade agreements; and financing sustainable development. Each year, the Global Economy Program hosts, co-hosts and participates in many events worldwide, working with trusted international partners, which allows the program to disseminate policy recommendations to an international audience of policy makers.

Through its research, collaboration and publications, the Global Economy Program informs decision makers, fosters dialogue and debate on policy-relevant ideas and strengthens multilateral responses to the most pressing international governance issues.

About CIGI

We are the Centre for International Governance Innovation: an independent, non-partisan think tank with an objective and uniquely global perspective. Our research, opinions and public voice make a difference in today's world by bringing clarity and innovative thinking to global policy making. By working across disciplines and in partnership with the best peers and experts, we are the benchmark for influential research and trusted analysis.

Our research programs focus on governance of the global economy, global security and politics, and international law in collaboration with a range of strategic partners and support from the Government of Canada, the Government of Ontario, as well as founder Jim Balsillie.

À propos du CIGI

Au Centre pour l'innovation dans la gouvernance internationale (CIGI), nous formons un groupe de réflexion indépendant et non partisan qui formule des points de vue objectifs dont la portée est notamment mondiale. Nos recherches, nos avis et l'opinion publique ont des effets réels sur le monde d'aujourd'hui en apportant autant de la clarté qu'une réflexion novatrice dans l'élaboration des politiques à l'échelle internationale. En raison des travaux accomplis en collaboration et en partenariat avec des pairs et des spécialistes interdisciplinaires des plus compétents, nous sommes devenus une référence grâce à l'influence de nos recherches et à la fiabilité de nos analyses.

Nos programmes de recherche ont trait à la gouvernance dans les domaines suivants : l'économie mondiale, la sécurité et les politiques mondiales, et le droit international, et nous les exécutons avec la collaboration de nombreux partenaires stratégiques et le soutien des gouvernements du Canada et de l'Ontario ainsi que du fondateur du CIGI, Jim Balsillie.

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