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The Transformation of Energy Markets and the Role of Innovation in Reshaping National Energy Mixes

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EXECUTIVE SUMMARY

This paper considers the transformation of energy markets that is now under way as the world seeks to move to the decarbonized energy market that will be required to meet the targets set in the Paris Agreement, and assesses the implications of recent innovations in renewable energy technology.

Main Argument

While there has been much talk about the need to move toward a decarbonized energy market in order to mitigate the impact of global climate change, and policy incentives have resulted in significant investment in renewable energy in a number of countries, the impact on the structure of the world's energy supply has to date been rather limited. This has led many commentators, unsurprisingly including those heavily vested in the current structure, to suggest that while the energy transition will proceed, it will do so at a leisurely pace, with fossil fuels being the overwhelmingly dominant energy source for a long time to come. However, this view is partly based on a perception of renewables as a "luxury" energy source requiring substantial subsidization and does not fully reflect dramatic improvements to the cost structure of wind and solar power, which have added cost-competitiveness to their existing environmental and security of supply attributes. While significant challenges still exist, such as the intermittency of renewable energy, policymakers have yet to take full account of these changes.

Policy Implications

- The new cost-competitiveness of renewable energy creates an opportunity to develop policy that no longer requires compromises between different goals, such as lowering energy costs and improving environmental friendliness.
- To take full advantage of this opportunity will require awareness of, and openness to, the possibility of creating a new energy model, including a policy framework that encourages innovation and the active participation of new players;
- A new model that moves toward a more decentralized supply structure could also offer a more cost-effective means of addressing energy poverty than traditional approaches.

A transition is supposedly now underway from a carbon-heavy, fossil fuel–dependent model to a decarbonized one in which renewable energy is increasingly the driving force. There has been much talk about the need to move toward a decarbonized energy market in order to mitigate the impact of global climate change, and policy incentives have resulted in significant investment in renewable energy in a number of countries. However, the impact on the structure of the world's energy supply has to date been rather limited; in particular, the impact of this transformation on the global balance of energy supply and demand has thus far been somewhat muted, at least statistically.

This has led many commentators to suggest that while the energy transition will proceed, fossil fuels will remain the overwhelmingly dominant energy source for a long time to come. However, this view, based partly on a perception of renewables as a "luxury" energy source requiring substantial subsidization, does not fully reflect dramatic improvements to the cost structure of wind and solar power that have added cost-competitiveness to their existing environmental and security of supply attributes. While significant challenges still exist, such as the intermittency of renewable energy, policymakers have yet to take full account of these changes.

This essay will first explore the status of global renewable energy deployment today. The next section will then assess the specific components of supply and demand that have been most influential in shaping the utilization of renewable sources in energy mixes and corresponding policy challenges. Finally, the essay will outline four recommendations for maximizing the potential of this low-carbon transition and achieving both energy security and environmental targets.

The Global Energy Market Today

The Indo-Pacific is currently on the front line when it comes to the need to address the goals of reducing harmful emissions and increasing access to energy that were outlined at the 2015 United Nations Climate Change Conference (COP21) in Paris. The region is estimated to account for two-thirds of global demand growth and half of total energy consumption by 2035. However, while major demand centers like China, in particular, and India have certainly recognized the challenge and have begun to act accordingly, the fact remains that they remain heavily reliant on inefficient coal consumption, threatening the environmental sustainability of the region at large.

From a policy perspective, renewable energy ticks three vital boxes, namely (1) security of supply, given that it is a domestic supply source whose resource base is unlimited, (2) environmental friendliness, and (3) cost-competitiveness. Given these persuasive attributes, it is perhaps surprising that the renewable agenda is not being embraced with more enthusiasm by policymakers in the Indo-Pacific. In the early stages, the growth of new sources of renewable energy, namely wind and solar, occurred simultaneously with a substantial drop in the costs of traditional energy sources and therefore relied on significant policy support and subsidization to underpin investment. However, that very same policy/subsidy support served to create the initial demand that enabled learning curve effects (encompassing technological improvements, economies of scale in production, etc.) to kick in to an extent that nobody anticipated.

However, during a period when there has been huge policy support for and massive investment in wind and solar in some of the world's major energy markets, renewable energy has only been able to modestly increase its share of primary energy demand. From 2012 to 2017, the share of primary energy consumption accounted for by renewable energy (not including hydroelectric) only increased from 1.3% to 3.1% in the Indo-Pacific and from 1.9% to 3.6% in the world at large (see **Table 1**). If the market penetration of renewable energy were simply to continue at this rate, then the global share of renewables would reach a respectable, but still relatively modest, 15% of world primary energy demand in around 2050. This of course would leave the world a very long way short of fulfilling the objectives signed up to in the Paris Agreement, a message that has just been reinforced by the recent "progress" report from the UN Intergovernmental Panel on Climate Change.

Table 1 *Primary energy consumption by fuel (mtoe)*

	2007		**2012**		**2017**	
	Total	Renewables	Total	Renewables	Total	Renewables
Indo-Pacific	4,195	22 (0.5%)	4,992	64 (1.3%)	5,744	175 (3.1%)
Total World	11,588	107 (0.9%)	12,477	237 (1.9%)	13,511	487 (3.6%)

Source: BP, "BP Statistical Review of World Energy." Renewables do not include hydroelectric power.

There is one notable exception to this rule, namely China, where the penetration of renewable energy has taken many by surprise. For a number of years now, China has accounted for a significant proportion of the world's overall investment in wind and solar. As noted by Bloomberg New Energy Finance, China invested $132.6 billion across all clean energy technologies in 2017, a figure more than twice what the United States invested in that year.[1]

There are signs that things are changing elsewhere. A prime example is India's increasingly bullish plans for solar, including reported consideration of a vastly ambitious tender for 100 gigawatts (GW) of capacity to be linked to manufacturing plans. These positive signs suggest that policymakers are beginning to understand that they can seek to provide both affordable energy supply and broader societal benefits such as clean air, without making compromises. Nevertheless, renewables in general have yet to become the focus of energy policy planning, and it is useful to consider the possible reasons.

Transformations Shaping the Renewable Energy Industry

Supply Side

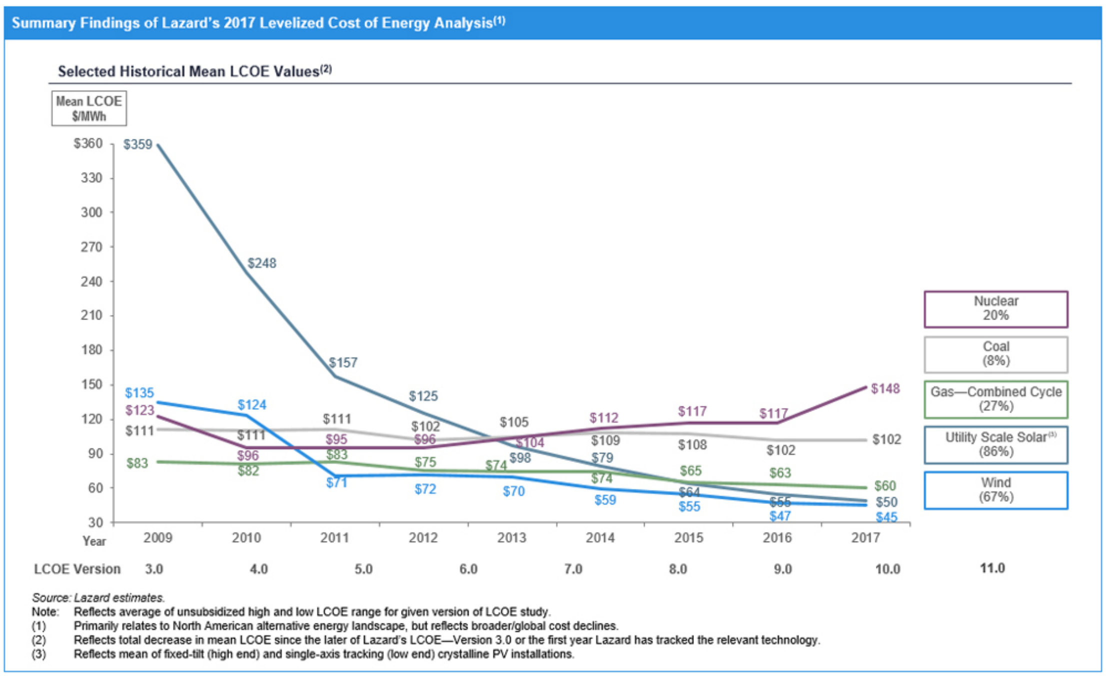
Cost structure. One of the most notable changes on the supply side of the energy sector has been the radical improvement in the cost structure of renewables. Where energy policymaking and associated investment planning are concerned, the important point is that the transformation that has taken place to date has not been in the structure of energy supply but rather in the cost structure of the energy supply options now available to the market—in particular, electricity. This development has major forward-looking implications. Cost-competitiveness, however, is not the only factor. In an increasing number of cases, renewable energy not only offers the most cost-competitive energy supply options but also ticks the vital socioeconomic policy boxes of security of supply and environmental responsibility.

As **Figure 1** illustrates, the dramatic improvements in the cost structure of renewable energy have resulted in a situation today where solar and wind power are often cost-competitive, on a subsidy-free basis, with the conventional options for new electricity supply capacity. This is of course a generalization and will certainly be dependent to a degree on local conditions, but there is an increasing number of such successful projects. In May 2017, for example, a tender for offshore wind in Germany was won by the Danish company DONG Energy (which has built more

[1] Bloomberg New Energy Finance, "State of Clean Energy Investment," https://about.bnef.com/clean-energy-investment.

than a quarter of the offshore wind capacity in operation globally) at a price of €c6 per kilowatt hour (kWh) (or around USc7/kWh). This price compares with the price of UKp9.25/kWh (or around USc12/kWh) that in 2016 the UK government guaranteed to pay for 30 years or more, with prices even indexed to inflation, for the power that will be generated from new nuclear capacity that may, or may not, come online in the mid-2020s.

Figure 1 *Levelized Cost of Renewable Energy*



Source: Lazard, "Levelized Cost of Energy 2017," November 2, 2017, https://www.lazard.com/media/450436/rehcd3.jpg.

Intermittency and storage. Even if headline prices have reduced to levels where they appear to be reaching, or even bettering, grid parity, critics argue that this is misleading because such prices do not factor in the extra costs of grid support that derive from the intermittency and unpredictability of renewables. There is undoubtedly truth in this, but it still does not detract from the fundamental message of Figure 1, not least because the learning curve effects seem unlikely to have reached their limits and are thus likely to increase. What it does do is highlight probably the biggest challenge and opportunity for the energy business today, namely the development of low-cost energy storage at scale that can translate the low commodity cost of renewable energy into uninterrupted, zero-carbon power supply to the market.

Other low-carbon sources. Another significant change on the supply side of the energy sector has been the significant increase in the cost of nuclear energy. Contrary to what we have seen happen with renewables, Figure 1 illustrates a steady upward trend in the cost of nuclear power over the course of the current decade. Responsibility for this trend can largely be ascribed to the greater focus on safety and risk prevention that followed the tragic incident at the Fukushima Daiichi plant in March 2011 and the resultant increase in construction cost. But the fact remains that the overall cost of nuclear power has risen at a time when the costs of other sources of energy have been falling. As a result, it is currently impossible to conceive of any project going ahead on the basis of private-sector investment alone.

Demand Side

Efficiency. There has been significant progress in energy efficiency, but much more is on the horizon. The old adage remains true: the most effective and cheapest way to address the challenge posed by growing energy demand is to prevent as much of that growth as possible through the promotion of energy efficiency and associated improvement of the energy intensity of national economies. Much progress has already been made in this respect, with the global economy having witnessed an annual improvement of just under 2% per annum during 2006–16 period, according to BP. However, this rate of improvement fell back in 2017. Policymakers everywhere must renew their focus on this vital component of energy policy in the coming years. The good news is that the scope for further, technology-driven improvement would appear to be huge, as will be discussed later in this paper.

Digitalization. While there has been no lack of talk about the potential impact of the digital economy on the energy industry, the key word remains "potential." The impact to date can only be described as muted, at least on the demand side. The digital economy has already made itself felt to a greater extent on the supply side—for example, in the oil and gas exploration and production sector via concepts such as the "digital oil field." Looking forward, however, the application of new digital technologies will undoubtedly be a key factor in determining the extent and pace of the energy transition. This in turn will be an area where new, nontraditional players will have a huge role to play. Technology companies such as Google and Amazon have already made their presence felt on the demand side through their insistence on sourcing sustainable energy, but they can also be expected to be major factors in bringing digitalization to bear on the supply side of the industry, as will be discussed further later.

What Impact Have These Changes Had on Energy Policymaking?

Supply security. A major preoccupation of energy planners, not to mention politicians, is to provide reliable and continuous energy supply to their markets to meet the expectations of consumers and to underpin sustained economic growth. The intermittent nature of renewable energy introduces a degree of complexity in terms of meeting this primary objective. Thus, if renewables are to play an increasingly important role in overall supply, a holistic policy is needed that explicitly incorporates supply options that are complementary to renewables in terms of addressing the intermittency issue. The degree of complexity involved, which extends to issues of grid management, may simply seem too great, especially if the perception lingers that renewable energy is essentially an indulgence of wealthy nations, requiring significant subsidization to deliver environmental benefits. In this respect, in terms of considering the social value of energy supply, a higher value may be placed on the provision of continuous supply from polluting sources than on the environmental benefits of renewable energy, especially if, as mentioned, those benefits are perceived as incurring a cost premium. This points in turn to another frequently observed feature of energy policymaking.

Policy time lag. When things are changing fast, it is sometimes difficult for policymakers to keep abreast of recent developments and adapt policy accordingly. In the absence of compelling evidence, including observed examples in practice, perceptions can remain deeply rooted (such as the one mentioned above that renewables are a "luxury" energy source that poorer economies simply cannot afford), and policymakers can remain wedded to tried and trusted approaches to the issues they face. This is all the more the case when taking maximum advantage of new technology would involve a fundamental reassessment of familiar industry models, such as a move to a less centralized approach. The sheer scale of the challenge can seem intimidating. All these factors can, and often do, result in a policy time lag. Policy appears to remain rooted in the past, failing to adapt to, and benefit from, the opportunities opened up by innovation and new technology.

Vested interests. The potential for radical change to the status quo, while generating opportunity for the purveyors of the innovative models and new technologies that offer the prospect of change, also threatens the interests vested in the status quo. In most cases, these interests can be expected to fight to defend their advantageous positions. That being said, there are instances of vested interests accepting the inevitability of change and actively seeking to adapt to it rather than preventing change from happening. But this tends to be the exception rather than the rule. Although vested interests exist in multiple guises, it may be helpful to think about them in terms of two broad categories:

The incumbents—that is, the entities that own and/or operate the existing energy infrastructure—will almost invariably take a very jaundiced view of change that they cannot control. The perception of threat will relate not just to the viability of their existing asset base but also to the business model associated with that asset base and the culture/mindset associated with the model—put more simply, a "way of doing things" that will have developed over a long period of time and that will constitute their comfort zone.[2] Incumbents will furthermore be very well placed to oppose the change in question, not least through the links that they will have with a policymaking establishment that can itself be heavily vested in the status quo by virtue of being, or seeing itself as, the author of that status quo. This nexus can represent a significant obstacle to change offering broader societal benefits.

The political establishment is another major vested interest. One of the great institutional barriers to the creation of coherent energy policy in many countries is the disconnect between the timeline of democratic politics, where the next election is never far away, and the life cycle of the energy business, where a ten-year time horizon is relatively short. The fact is that change, however beneficial in the longer term, is almost always disruptive in the near term. There will always be certain constituencies on the receiving end of that disruption, which can make risk-averse politicians very focused on short-term, not to mention narrow, considerations.

To provide just one example close to home, the protection of jobs and communities is cited as one of the reasons for the current political push in the United States to promote a renewal of the coal sector. Placing things in perspective, the coal industry employed around 50,000 miners at the end of 2016 (compared with more than 800,000 at the industry's employment peak in the early

[2] Interestingly, this will tend to apply equally whether the incumbents in question are state-owned or privately owned. State-owned enterprises, cushioned from the effects of competition, will often be characterized by an engineering-led culture, whereas privately owned companies will be more commercially focused. However, in both cases this will tend to generate a strong protectiveness of the technologies, assets, and structures in which so much has been vested.

1920s). Even if one applies a multiple to this number to account for employment in related activities, one is likely to fall far short of the roughly 800,000 people that are now employed in the renewable energy sector in the United States, according to the International Renewable Energy Agency.

What Can Be Done to Enable Innovation to Unleash Its Full Potential?

The opportunities and challenges outlined above raise questions about the pace and extent of this lower-carbon transition. The answers will derive from the degree to which policymakers recognize the opportunities that recent technology- and innovation-inspired changes have created to move to a new model that combines reliable and low-cost supply with environmental responsibility and seek to incorporate them in policymaking that looks forward rather than backward. To help this happen, the following actions and measures should be considered.

The first measure is ensuring that policymaking is based on the best and most recent information available. Forums could be organized to encourage the sharing of knowledge and best practices, such as by raising awareness of the changes that have taken place and their policy implications.

Second is promoting and incentivizing further technology development. On the supply side, the issue of intermittency, and the related need for backup and storage, is undoubtedly the biggest single obstacle to renewable energy fulfilling the potential that it undoubtedly offers to provide low-cost, secure, and clean energy to all, including the world's poorest who currently lack access to electric power. Technology already offers numerous possible solutions to this problem, from batteries to "power to gas," but cost-effectiveness remains the challenge.

On the demand side, a priority aim must be to promote and exploit the "low-hanging fruit" of energy efficiency. This could include, for example, the generalized use of "smart lighting" for street lighting, air conditioning efficiency, and district cooling networks. Smart lighting, including the use of LED bulb street lamps, offers the potential to reduce energy consumption by 75%. As for air conditioning, it has in recent years been one of the biggest single contributors to the growth in global energy demand. This is a problem that will only worsen as global warming continues to make itself felt and disposable income in the cities of the developing world, many of which are found in tropical climates, continues to rise. The Lawrence Berkeley National Laboratory in

California has calculated that if all air-conditioning units were as efficient as the best ones available (and if hydrofluorocarbons were phased out), the world could be spared 1,000 average-sized (500 MW capacity) power stations by the year 2030. Furthermore, district cooling networks in dense urban areas would be twice as efficient as air conditioning in terms of energy consumption per unit of cold produced.

Third, give full consideration to the broader implications of the opportunities afforded by new technology, including those deriving from the "digital economy." In a recent report entitled "Digitalization & Energy," the International Energy Agency identified a number of ways in which the digital economy can be applied to the benefit of the energy sector:

- Smart demand response could provide 185 GW of system flexibility globally, potentially saving some $270 billion of investment in new electricity infrastructure that would otherwise have been needed.
- The rolling out of smart charging technologies for electric vehicles would help both promote the electrification of transportation demand and shift charging to periods when electricity demand is low and supply abundant.
- The integration of variable renewables would enable grids to better match energy demand to times when the sun is shining and the wind is blowing.

More generally, energy policy that takes full account of the opportunities provided by the particular attributes of renewable energy, combined with the digital economy, could also consider the scope for a broader move away from the traditional centralized, network-based structure of energy supply toward new decentralized, distributed models. Among a number of potential benefits of such a move would be the possibility to bring reliable supply to dispersed areas where relatively low demand would make the extension of existing grids prohibitively expensive. Another benefit would be the reduction of dependence on often vulnerable transmission infrastructure, thereby generating greater resilience in the overall energy supply system. Such an approach could also, importantly, offer a more cost-effective means of addressing energy poverty.

The last measure is providing the right signals to both energy suppliers and consumers. Policymakers must ensure that prices at least reflect the true cost of supply, preferably including externalities such as the cost of damage to the environment, in order to generate a coherent demand response. The subsidies saved by doing so can best be deployed in direct income support to those more vulnerable to higher energy costs, whereas existing subsidy structures tend to favor the better off. In line with the above, leaders should implement carbon pricing to promote the environmental agenda (but via the market, not by picking winners). Furthermore, it is important to remove barriers to participation by new industry players, in particular by creating the appropriate regulatory structures. Nontraditional players, such as tech giants as well as the small and medium-sized enterprises that are so often the source of innovation, could play a vital role in accelerating the energy transformation, if afforded the opportunity to do so.

Conclusion

All of the above measures will involve taking on entrenched interests and ideas, and success will depend on providing the arguments and information to give policymakers the confidence to promote change. The stakes are high—namely the pace of the transition to a model that can meet the world's growing need for affordable energy while enhancing the chances of meeting the ambitious targets set in the Paris Agreement. The extent to which renewable energy's potential can be realized in the future, and, correspondingly, the pace of the energy transition, will depend on a number of factors, of which two can be identified as of crucial significance:

- The development of cost-effective solutions to the intermittency inherent to renewable energy, which remains a limiting factor in terms of the share of renewable energy that can be supplied to demand sectors requiring a continuous supply of energy.
- The continuation and acceleration of the global trend in which electricity is accounting for an ever-increasing share of the world's final energy demand.

The sceptics may yet be proved right, and those targets accordingly proved unreachable. However, further technological innovation, building on the recent dramatic improvements to renewable energy and promoted and supported by the appropriate policy and regulatory structures, will be key to successfully addressing these issues and providing the means to accelerate the energy transition. I am reminded of the McKinsey study written in 1980 that predicted that by the year 2000 there might be a total of 900,000 mobile-phone subscribers worldwide. In reality, there were 109 million. Perhaps we will be able to look back in twenty years on a transformation of the energy business that will have proved equally surprising.