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Some Reflections on the Global Energy Transition

"Energy transitions – be they from coal to oil, from oil to natural gas, or from coal-fired electricity generation to a system relying primarily on renewables – are inherently prolonged affairs. New energy sources and conversion techniques become commercially viable only after decades spent establishing often expensive infrastructure." Vaclav Smil, author of Energy Myths and Realities, 2010.

Is the world in the midst of a rapidly accelerating migration away from fossil fuels, toward a much greater reliance on carbon-free sources of energy? If one takes seriously the speeches of Environment Ministers or the content found on the web sites of many well-known environmental advocacy organizations, the temptation is to answer "yes." The reality, however, is more complex.

An energy transition of some kind is undoubtedly underway, but the magnitude and timing are less dramatic than many seem to believe. The existing global energy system is extensive in scope and is based on tens of trillions of dollars of embedded capital; it is not about to disappear, or to be superseded by something radically different, in the foreseeable future. Then too, one must recognize the very diverse mix of nations that make up the world's energy economy. The shifts occurring in energy production and use vary markedly among countries: what's happening in the United States or Denmark may tell us little about the salient trends in India or Indonesia.

That said, for the world as a whole, there is certainly evidence of an ***incremental*** move away from fossil fuels as a primary energy source,[1] in favour of low/no-carbon forms of energy. Looking out over the next two decades, the trend-lines point to a real, but far from revolutionary, energy transition, one that is unlikely to entail an absolute reduction in the quantity of fossil fuels produced and consumed globally by 2035 or 2040.

Global Supply and Demand Forecasts

Recent projections from three well-respected sources – the International Energy Agency (IEA), the United States Energy Information Administration (EIA), and British Petroleum (BP) – all paint a broadly similar picture of the global energy landscape over the next 25-30 years.[2]

- The world-wide demand for energy continues to increase, despite the diminishing "energy-intensity" of each dollar of GDP in the advanced economies. This reflects the growing global population plus higher energy consumption linked to ongoing economic and industrial development in the emerging economies which, collectively, are home to some 80% of the earth's population. In the IEA's baseline forecast, global energy demand rises by 37% to 2040.

[1] Primary energy is an energy form found in nature that has not been converted or transformed. It is the key input into the larger energy system. The main forms of primary energy are oil, natural gas, thermal coal, natural uranium, and renewable energy sources such as wind, solar, flowing water (hydro), and geothermal.

[2] IEA, World Energy Outlook 2014; US Energy Information Administration, International Energy Outlook, September 2014; BP Energy Outlook 2035.

- In the IEA's projections, by the late 2030s the global primary energy system consists of four roughly equal-sized components: oil, natural gas, coal and low/no carbon sources.[3] Renewables come to occupy a larger place in the supply mix. But even in 2040 fossil fuels still satisfy three-quarters of global energy demand.

- The regional distribution of energy demand changes significantly over time. Total energy use flat-lines or falls in many of the advanced economies,[4] while the volume of primary energy consumed continues to march ahead in the emerging world.

- In all of the projections, by 2035-40 Asia accounts for around three-fifths of world energy consumption.

- China eclipses the United States as the largest oil-consuming country by the early 2030s (or sooner).

A Look Back

An examination of the evolution of global energy demand and supply in the past 30-40 years may be instructive as we seek to understand the probable pace and sequencing of the current energy transition. The accompanying charts summarize some of the key developments since the early 1970s.

On the supply side (Figure 1), the amount of energy produced globally more than doubled from 1973 through 2012 (measured on a "millions of tons of oil equivalent," or Mote, basis). In terms of sources, the shares of coal and natural gas increased, while that of oil fell. Turning to renewable energy, hydro became more important, as did "other" renewables. However, added together, hydro, solar, wind and geothermal produced just 3.5% of the world's primary energy supply in 2012, albeit this was up from less than 2% in 1973. Of the 3.5% contribution made by all renewables in 2012, a majority came from hydro.

Switching to the demand side, Figure 2 shows the regional composition of global energy consumption in 1973 and 2012. Here, the main story is the shrinking footprint of the affluent economies that are members of the Organization for Economic Cooperation and Development (OECD), and the growing role of developing economies in driving world energy demand. The OECD was responsible for three-fifths of energy consumption in the early 1970s; by 2012, this had dropped to two-fifths. As the OECD countries have become less dominant in global energy use, the emerging economies have stepped forward as the preponderant engines of demand growth. And this trend is expected to persist, as depicted in Figure 3.

The Impact of Technology

Technological innovation continues to influence energy markets and has proven to be especially disruptive over the past several years.[5] Since the latter part of the previous decade, two of the most consequential developments have been the shale oil and gas revolution and technical advances that have led to falling costs for solar power. In both cases, the result has been to alter the competitive landscape for certain forms of energy.

[3] IEA, World Energy Outlook 2014, central projection scenario.

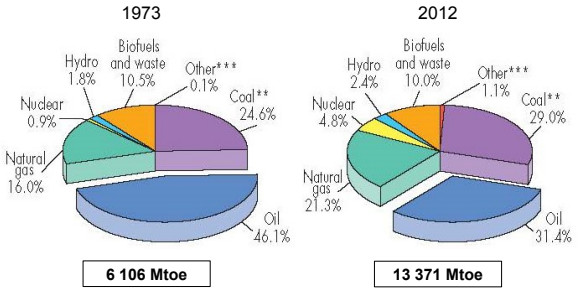
[4] But perhaps not all. Of interest, total energy use in Canada increased by 2.3% in 2013, on the heels of a smaller advance in 2012. Statistics Canada, "Physical flow accounts: Energy use and greenhouse gas emissions, 2013," The Daily, July 29, 2015.

[5] "Peering into energy's crystal ball," McKinsey Quarterly, July 2015.

Spurred by technological innovation, unconventional oil and gas production has skyrocketed – notably in the United States – boosting global supply, and pushing down fossil fuel costs. US unconventional oil output soared from essentially zero in 2007 to almost 4 million barrels per day by 2014, undercutting the market power of traditional oil exporting jurisdictions, dampening global prices, and converting the United States into the world's number one oil producer. Natural gas output has also increased

Figure 1

Total Primary World* Energy Supply



* World includes international aviation and international marine bunkers.
** In these graphs, peat and oil shale are aggregated with coal.
*** Includes geothermal, solar, wind, heat, etc.

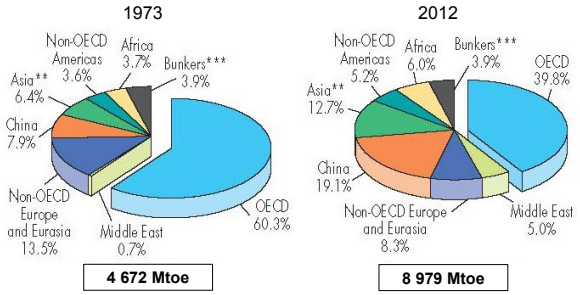
Source: IEA, Key World Energy Statistics, 2014.

significantly in North America and some other regions, owing to the deployment and refinement of innovative extraction technologies together with government policies that have encouraged fuel-switching in the electricity sector and/or put some kind of "price" on carbon emissions.

An often overlooked point is that if the prices for oil and natural gas remain low, as the futures markets suggest they will, this should ***stimulate demand***, offsetting some of the efforts being directed at reducing the use of carbon-based energy to help address concerns over climate change. The prospect of lower-for-longer fossil fuel prices also complicates the economics

Figure 2

Regional Shares of Total Final Energy Consumption



*Data for biofuels and waste final consumption have been estimated for a number of countries.
**Asia excludes China.
***Includes international aviation and international marine bunkers.

Source: IEA, Key World Energy Statistics, 2014.

surrounding some forms of carbon-free energy, such as nuclear, wind and bio-mass.

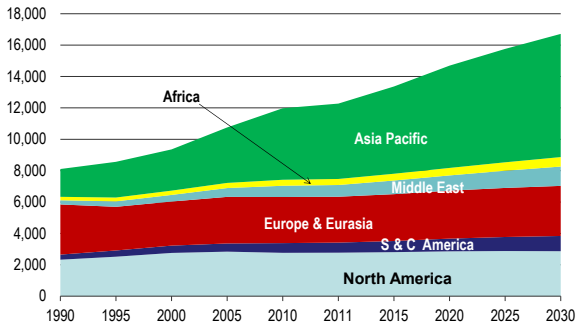
More generally, as cleaner forms of energy gain traction in the energy system, there can be unexpected consequences in terms of the economic attractiveness of different energy sources. As one expert recently observed, "The fundamental problem is that substantial initial success in displacing fossil fuels with zero-carbon energy will drive down the price of the remaining fossil fuel energy. [This] means that, absent policy, clean energy will face an ever tougher economic challenge."[6] Slumping oil and coal prices already seem to be fostering a rise in the use of these fuels in parts of Europe and in some emerging economies.

In the electricity sector, technological innovations have led to plunging prices for solar power and promising advances in distributed generation, which in turn are supporting the rapid adoption of photovoltaic (PV) installations in a number of jurisdictions. Analysts now expect PV "to capture by far the largest slice of the

[6] Michael Levi, "A Clean Energy Revolution is Tougher than You Think," Council on Foreign Relations, May 21, 2015.

Figure 3

Energy Consumption by Region, Mtoe*



*millions of tons of oil equivalent. Source: BP Energy Outlook 2030.

[growing] renewables pie," as renewable energy more broadly makes additional inroads in electricity markets.[7] However, when judged against the total quantum of primary energy produced and consumed world-wide, and after taking account of the continued growth in energy demand, further progress in solar and distributed power generation technologies is likely to have only a very modest impact on the overall global energy system in the next two decades. That said, these developments will have significant implications for some national and regional electricity markets.

Technological innovation is also influencing other parts of the energy system. Gains are being made in energy storage technologies, in vehicle electrification, and in wind turbine manufacturing, among other areas. Energy efficiency continues to improve across multiple domains (e.g., vehicle fuel economy, energy-efficient lighting and appliances, etc.). Over time, advances in technology will help to reduce per capita energy use – especially in more affluent economies – and facilitate market penetration by lower-carbon energy sources, including in areas like transport and agriculture.

The Role of Policy

Governments can speed the energy transition through smart policy. Rather than expensive subsidies, incentives directed at changing consumer behaviour, or heavy-handed intervention that favours particular forms of energy, the wisest course is to price the "environmental harm" from energy use via carbon taxes or emissions trading schemes. Compared to traditional, top-down government regulation, these kinds of policies produce fewer economic distortions and better leverage market forces and the innovative capacity of the private sector.

For small open economies, unilaterally pricing the environmental harm associated with energy production and use can be complicated, because of the need to consider the effects of higher energy costs on domestic competitiveness and the locus of industrial activity. That is why it makes sense for individual regions/countries to act in concert with like-minded trading partners to implement policy frameworks designed to support the shift to less carbon-intensive energy systems. The IEA foresees that future government policy measures – particularly directed at mitigating climate change – will contribute to a moderation in world primary energy demand to 2040, with the growth of global consumption decelerating to ~1% per year post-2025, compared to ~2% in the last two decades.

Conclusion

The global energy system is experiencing substantial turbulence, with the competitive landscape in flux across various energy sources, the pace of technological innovation and disruption accelerating, and some jurisdictions taking meaningful steps to reduce greenhouse gas emissions. In relative terms, natural gas and

[7] "Peering into energy's crystal ball," McKinsey Quarterly, July 2015, p. 5.

renewables are destined to loom larger in the global energy mix over the next 20-25 years, while the shares of oil and coal will diminish. The IEA expects global consumption of natural gas to double (in volume terms) by 2040, as the cleanest burning fossil fuel gains market share vis-a-vis other energy sources. In this scenario, liquefied natural gas (LNG) assumes a significantly greater role in global gas production and trade – a development which reinforces the argument for building an LNG sector here in Canada.

The growing importance of natural gas and renewables within the world energy system does not necessarily signal an absolute (as opposed to a relative) decline in the demand for traditional fossil fuels. In the IEA's baseline forecast, global coal consumption still increases by 15% to 2040, for example, even as most OECD countries continue to move away from coal in their electricity sectors. The main reason is that coal use continues to expand in many emerging economies. And while physical oil consumption in the OECD is projected to downshift, overall global demand rises by 15% through 2040, due to increased oil use in the transport and petrochemical sectors and further industrial development and economic growth in developing and emerging markets.

If these IEA projections turn out to be even approximately accurate, it is problematic to speak of a rapid world-wide "energy transition" – certainly if the term is taken to imply the near-replacement of an existing energy system with a different system, all within the short time span of two or three decades. Instead, it makes more sense to think of a world in which some fuel-switching occurs and a larger fraction of future demand growth is met through lower-carbon sources of energy. The latter statement aligns well with the medium-term energy supply and demand forecasts produced by the IEA and other leading authorities.

Within the global energy system, the most pronounced transformations are evident in the electricity sector. Technological innovation, policies to promote lower-carbon energy sources, and capital stock turnover are combining to push the share of renewables higher in the power sectors of many countries, including Canada (where renewables already supply more than half of all electricity consumed). This is the segment of the wider energy system where the notion of "transition" is perhaps most compelling.

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