Energy Security and the Energy Transition

A Classic Framework for a New Challenge[1]

By **Mark Finley**

Series Introduction

The Covid-19 pandemic capped a series of events that made 2020 one of the most disruptive years in the annals of the energy industry, affecting markets, prices and livelihoods. The "Middle East, Asia and Energy Security in the Age of Covid-19" series of *Insights* looks at some of these developments and their impacts, including the astonishingly rapid emergence of the United States as the world's leading oil and gas producer, the increasingly dire outlook for the member countries of the Gulf Cooperation Council, the role of Asia in resuscitating global oil and gas demand and the increasingly important role of China, among the world's largest importers of oil and gas, in Middle East affairs

Abstract

Policymakers around the world are struggling to understand the security implications of an energy system in transition. New energy forms can help reduce vulnerability to oil supply disruptions, such as the one that arose from the September 2019 attacks on Saudi facilities. But they also have the potential to introduce new vulnerabilities and risks. Furthermore, the Covid-19 pandemic and the energy impact of government stimulus measures threaten to upend global energy systems and relationships. Many countries have built robust systems to mitigate risks to oil supplies, but little work has been done for other energy forms. This paper utilises a framework for assessing energy security based on evaluation of vulnerability, risk and offsets.

Concerns about access to oil supplies — a major consideration in global conflicts at least since the Second World War — were accentuated during the geopolitical shocks arising from the 1973 Arab oil embargo. Member countries of the International Energy Agency (IEA) have since built a cooperative system for dealing with oil supply disruptions.

While energy security considerations have historically been driven by consumers worried about access to uninterrupted supplies of oil, producer countries are equally concerned about shocks to — and the security of — demand, as they have emphasised amid the ongoing Covid-19 pandemic, which has caused a sharp collapse in global oil demand.

[1] This paper is based on a larger work by the author titled "Energy Security and the Energy Transition: A Classic Framework for a New Challenge". It was published on 25 November 2019 by Rice University's Baker Institute for Public Policy and can be found at https://www.bakerinstitute.org/media/files/files/844c4e55/bi-report-112519-ces-energytransition.pdf.

In addition to wars and geopolitical events, the reliability of energy supplies has recently been threatened by factors ranging from weather events (the frequency and intensity of which may be exacerbated by climate change) to terrorist activities, industrial accidents and cyberattacks.

In many countries, energy security is taken to mean self-sufficiency in energy supply. While self-sufficiency would alleviate some of the traditional concerns about energy security, the fact that many energy forms remain traded commodities means that global disturbances will continue to impact domestic markets. Rapid growth in the use of natural gas and renewable energy (and use of batteries for electric vehicles and power grid management), due in large part to climate change policies, may help mitigate conventional security concerns with regard to oil, but these new forms may also carry new risks. Unlike for oil, the domestic and international framework for dealing with risks arising from the growing use of other fuels is limited.

There are many approaches to appraising energy security. As an energy security specialist in the US government in the 1980s, I learnt an approach based on assessing vulnerability, risk and offsets. While originally applied to oil, this framework can also be useful for assessing the security of an energy system in transition towards greater reliance on natural gas and renewables. Although not intended to be an exhaustive review of all potential facets of the issue, this paper will illustrate how the framework can be applied to non-oil energy forms.

The Framework

The first element of the framework is **vulnerability**, which is how exposed the energy and economic system is to a shock. This could include the size of the energy input to the economy (in absolute terms and especially in financial value), the degree of substitutability, and its concentration in key sectors, such as the importance of oil in transport. Vulnerability has loomed in public perceptions as an economic consideration, experienced as either price spikes and/or physical shortages. Other dimensions of vulnerability can include diplomatic, strategic or military objectives — for example, fear of the adverse implications of a disruption may constrain an energy importer's diplomatic relations with its suppliers. In recent years, environmental considerations — especially climate change — have emerged as increasingly important to assessing vulnerability.

The second element, **risk**, assesses the chances of a shock. Considerations must include not only the probability of a disruption but also an assessment of its potential magnitude and duration. A large but brief shock (such as the one seen in September 2019 to Saudi oil supply) may be less disruptive than a small but long-lasting one.

Finally, **offsets** involve the capacity and timeline to counter a shock. This could include the ability to increase production elsewhere, draw supply from inventories, switch to other energy sources, and/or reduce demand by conserving energy. The purpose of these interventions is to cushion the impact of the shock while giving markets and policymakers — in both producer and consumer countries — a chance to respond in a more orderly fashion, minimising the damage to the economy and other dimensions of vulnerability discussed above.

Importantly, energy security policy can aim to address any of these dimensions. For example, vulnerability can be reduced by diversifying the fuel mix, risk can be managed via diplomacy or military power, and a strategic stockpile can be used to offset lost supply.

Applying the Framework to a Future Energy System

While the energy future is highly uncertain, almost all forecasters expect oil and coal to decline in importance as a share of total energy consumption and relative to economic activity. Meanwhile, most forecasters expect natural gas and renewable energy to grow in importance (both as a share of total energy consumption and in absolute terms), with wind and solar energy expected to grow rapidly. For example, the "Stated Policies Scenario" in the IEA's 2020 World Energy Outlook sees oil's share of global energy use falling from 31 per cent to 28 per cent per cent by 2040 (albeit with oil remaining the largest fuel source), while gas and renewables gain market shares (from today's 23 per cent and 14 per cent per cent, respectively, to 25 per cent and 22 per cent by 2040).[2] More concerted action to address climate change would accelerate this transition. In the same report, the "Sustainable Development Scenario" (consistent with meeting the UN's sustainable development objectives, including limiting the impact of climate change to 1.5°C or less), has renewables playing a much greater role, accounting for 36 per cent of the global energy mix by 2040.[3]

Vulnerability

The displacement of oil by other energy sources would clearly reduce global vulnerability to oil shocks, but it could also introduce new vulnerabilities and risks to the energy system. Moreover, significant improvements in energy efficiency (another key feature of the IEA transition scenarios) reduce the amount of energy needed to produce a dollar of economic output, reducing the economy's vulnerability to energy shocks.

The rapid growth of new energy sources can introduce new vulnerabilities into global energy systems. Global markets are much less developed for new energy forms than for oil — today, only about one-third of global gas consumption is traded internationally, compared to about two-thirds of oil. In the case of natural gas, markets are less developed largely because of the extra cost of liquefying natural gas for sea-borne trade.[4] Nevertheless, gas trade is growing, with the rapid growth of liquefied natural gas (LNG) in particular helping to create a more global gas market.

Meanwhile, renewable energy is almost exclusively domestically produced, which is a significant security benefit. But inputs for these energy sources are frequently produced abroad, and — at least for now — are highly concentrated in a few countries. The expected growth in renewable energy and batteries will require an unprecedented increase in the mining and refining of ores and rare earth metals (an important component for batteries). This creates a risk of future supply shocks for countries like the United States, Japan and much of Europe, which are highly dependent on ores and rare earth metals that are mined and refined outside of their borders. For example, China dominates the global production of rare earth metals and is the largest producer of solar power panels and batteries for electric vehicles. Additionally, two-thirds of the world's cobalt production (another battery, solar panel, and wind turbine component) is concentrated in the Democratic Republic of Congo. In contrast, the United States, as the world's largest oil and natural gas supplier, accounts for just 18 per cent and 23 per cent of global oil and natural gas production, respectively.[5]

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[2] International Energy Agency, "World Energy Outlook 2020", Paris, 2020. Renewables here include hydro, bioenergy, wind, and solar energy.
[3] International Energy Agency, "World Energy Outlook 2020".
[4] While trade creates exposure to international risks, it also provides greater flexibility. For example, Japan increased imports of fossil fuels to maintain power availability after the Fukushima disaster caused a sharp reduction in nuclear power.
[5] BP, "Statistical Review of World Energy", 2020, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Many energy forecasts agree that in successful transition scenarios, electrification will accelerate, meaning that vulnerability to electrical supply outages will probably grow. The unique properties of power markets (with largely domestically produced electricity and substantial reserve margins to maintain supply availability, but with virtually no effective storage capability) stretch the application of our framework, but we still can find useful insights. For example, improved data gathering can lend insight into the economy's vulnerability to power outages as well as the frequency, duration and impact of such outages (which would be relevant to the assessment of risk).

Finally, in assessing vulnerability, there is an important distinction between fuel that is consumed (such as oil, natural gas or electricity) and equipment that produces energy (such as wind turbines and solar panels) or stores it (such as batteries and pumped-storage hydroelectricity). A disruption in the trade of the equipment that stores energy would not immediately disrupt energy availability and therefore economic activity, but it would have delayed impacts on investment and therefore future energy availability. In this sense, the potential disruption of fuels poses a much more substantial short-term vulnerability to the global energy system — a potentially significant finding for the energy security implications of the energy transition, but one which must be confirmed through additional research.

Risk

Assessing the risk of disruption for non-oil energy sources is still in its infancy and hindered by a lack of historical data. For example, while the US Department of Energy (DOE) tracks global oil supply disruptions, there is no corresponding effort for other energy forms.[6]

For natural gas, as with oil or coal, extreme weather events (such as hurricanes) have caused significant disruptions of production, processing and pipeline flows, most notably in the United States. (Hurricanes and storms also pose significant and potentially widespread risks to the power system.) Likewise, geopolitical factors also have caused disruptions several times over the past decade: for example, Russian gas exports to Europe, which account for one-third of the continent's gas consumption, have been disrupted as a result of disputes with Ukraine over pipeline transit. In addition, flows of LNG through the Strait of Hormuz or other chokepoints face risks similar to those frequently observed for oil.

Renewable energy forms and mineral inputs also have experienced threats of disruption arising from geopolitical considerations. For instance, the Chinese government has used its dominance of rare earth supplies as leverage in the past and has threatened to disrupt supplies in the face of growing trade tensions with the United States and other partners.[7] China's dominance of the global export of wind turbines, solar panels and batteries for electric vehicles could also put importing countries at risk under future conflict scenarios. Likewise, Indonesia proposed to ban nickel ore exports to stimulate domestic processing of the metal.[8]

While renewable energy that is wholly produced domestically may not be subject to geopolitically driven disruptions, all domestic energy supplies remain at risk of disruption owing to factors such as weather, industrial accidents and cyberattack. The digital revolution as applied to the energy system can mitigate risk by allowing system operators to quickly diagnose outages and find workarounds but it may also introduce new risks. For example, the software of a "smarter", more connected energy system could be significantly more

[6] In the United States and many developed economies, there is data on power supply disruptions, and these are held by grid operators, although such data is rarely aggregated to a national level for use in the type of studies envisioned here.
[7] See, for instance, "China ready to hit back at US with rare earths: Newspapers", Reuters, 29 May 2019, https://www.reuters.com/article/us-usa-trade-china-rareearth-idUSKCN1SZ07V.
[8] See "Indonesia releases nickel ore export ban decree", Reuters, 4 September 2019, https://reut.rs/36YScq0.

robust, reducing risks of disruptions, but it could also be more vulnerable to cyberattack. Power grids have come under cyberattack in Ukraine and elsewhere, and utilities have been subject to penetration attempts in many countries.[9] Greater reliance on distributed energy forms can reduce the risk of large-scale systemic outages but may lead to more frequent — albeit smaller and more localised — disruptions.

As with vulnerability, a lack of data availability impedes the assessment of risk to new energy forms; accordingly, a data-gathering exercise to understand the true risks to energy sources other than oil would be an appropriate first step to understanding the potential risks of an energy transition. In addition to data-gathering, other analytic tools can assist risk assessments. For example, in the United States, the DOE has in the past conducted expert workshops to gauge risks of oil supply disruptions.

Offsets

Because energy security assessments historically have been directed at oil supplies, the resulting domestic and multinational framework is heavily oriented towards managing oil supply risks. What can we say about offset mechanisms in a transitioning global energy system?

Large, efficient markets greatly assist in managing vulnerabilities and risks. While international trade of natural gas and critical metals needed for renewables and batteries is growing, the markets are much less deep and liquid than for oil — that is, the frequency and volume of trading is much less, as is the number of players. Furthermore, there are no viable futures markets for some metals, making it difficult for market participants to assess their vulnerabilities and impossible to manage them by hedging. Natural gas markets are becoming more globally integrated via rising LNG trade. Within the United States, the gas and power markets are large and efficient, although the power grid and marketplace are regional rather than national.

With regard to inventories, large US commercial inventories of natural gas help to manage what has traditionally been large seasonal variation in domestic demand. There is no government stockpile, however, and in many other regional markets, gas storage is much smaller relative to consumption. In terms of the metals needed for building renewable sources, such as solar panels, wind turbines and batteries, there is no reliable global data for commercial inventories, nor are there government strategic stockpiles. Note that electricity — unlike oil or gas — cannot currently be stored economically at scale; the future will depend on whether commercially viable large-scale, grid-connected batteries can be developed.

In the power system (as opposed to oil and natural gas production), the concept of reserve margins to manage unexpected swings in demand and variability of supply is well established. The importance of these reserves will grow as more and more consumers switch to intermittent renewables — that is, renewables such as wind and solar, which, unlike fossil fuels or nuclear power, cannot generate electricity "on demand". But for the broader energy system, such practices are not institutionalised.

Moreover, there is no global or domestic supplier that invests in maintaining a buffer of spare production capacity for non-oil energy sources or mineral inputs to help manage disruptions, as Saudi Arabia does for oil. As with oil, US shale gas production can respond more quickly to price signals than other gas resources can, but not quickly enough to be a first responder in a shock.[10]

[9] See Robert M Lee, Michael J Assante and Tim Conway, "Analysis of the Cyber Attack on the Ukrainian Power Grid", Electricity Information Sharing and Analysis Center, Washington, DC, 2016, http://bit.ly/2qJfhMK; and Blake Sobczak, "First-of-a-kind US grid cyberattack hit wind, solar", *E&E News*, 31 October 2019, http://bit.ly/2KeSmjg.

[10] See Richard G Newell and Brian C Prest, "Is the US the New Swing Producer? The Price Responsiveness of Tight Oil", Resources for the Future Working Paper, June 2017, http://bit.ly/2O0CToa.

The IEA has begun to expand discussions of emergency preparedness to include other forms of energy. Some European countries, such as Spain,[11] have begun to impose natural gas storage obligations on companies. Unlike in the case of oil, there are no formal, binding multinational agreements laying out obligations for holding and releasing inventories or sharing supplies. Furthermore, there is no organised system to hold strategic stockpiles for non-oil energy forms or mineral inputs, nor a cooperative multinational effort to govern the use of such stockpiles and coordinate policy responses in the event of a disruption.

The Uncertainties Brought About by the Covid-19 Pandemic

The global pandemic has caused sharp declines in global economic activity and energy consumption. While the crisis is in its early stages and the long-term implications are highly uncertain, the course of the pandemic — and government policy responses — has the potential to durably reshape both global energy markets and energy security considerations. The future path of global energy supply and demand will impact assessments of vulnerability, risk and offsets as laid out in this paper.

- The most obvious potential impact is on future economic growth and therefore on future energy demand. Will the global economy stage a strong, V-shaped recovery? Or will economic activity — and energy demand — be durably depressed?
- Another key question is the impact of government policy responses. Will "green" stimulus accelerate the energy transition, or will more conventional stimulus extend the current fossil fuel–based energy economy?
- A final dimension of uncertainty is the potential for long-term changes in consumer behaviour. Will "work at home" policies grow, reducing commuting and therefore oil demand? Will consumers be more reluctant to fly, which could reduce oil demand? Or will they prefer to use their personal vehicles rather than mass transit, which could boost oil demand?

In addition to impacting future energy supply and demand, the pandemic may shift risk perceptions and therefore the future focus of energy and security policy. Will the crisis act as an accelerant to an already developing backlash against globalisation? Is there a risk of greater emphasis on domestic energy production and domestic supply chains?

These uncertainties make it all the more important that energy security policies evolve along with the growing reliance on natural gas and renewable energy. These new energy forms might help mitigate vulnerability to future oil supply disruptions but they also raise the prospect of new vulnerabilities and risks that must be understood and managed. A robust set of capabilities and institutions has been built over the past 50 years for managing oil supply risks — both within key countries and cooperatively between them — but such capabilities are limited for other energy forms. Assessing the security of these new energy forms by analysing vulnerability, risk and offsets — and building domestic and international policies accordingly — can be a useful approach in tackling the emerging energy security challenges and advancing the energy transition. Data collection is always a good place to start but cooperative efforts to systematically gather information on the relevant indicators for new energy forms are still in their infancy. Collecting data is especially important in the case of natural gas, which is growing in importance in the global energy system and is the second most widely traded energy form.

[11] See "Natural Gas", CORES, Spain, nd, accessed 1 November 2019, http://bit.ly/2CAf6px.

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