



PERSPECTIVE

Long-term energy transitions and international business: Concepts, theory, methods, and a research agenda

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Abstract

International business and management (IB/IM) scholars are increasingly calling for more research attention to subject matter that incorporates global-scale issues (Buckley, Doh, & Benischke, 2017). These calls have frequently focused on societal “grand challenges” that transcend discrete geographical locations and well-defined (typically short) time periods. The present long-term energy transition (LTE), characterized by a shift away from hydrocarbons and towards renewables, represents an important example of a multi-level, multi-actor global challenge that unfolds at the interface of business and society, and requires employing multiple conceptual lenses to process and understand. Researchers addressing such multi-faceted complex problems face a range of challenges related to theorizing, framing, modeling, and ultimately conducting empirical studies. Based on our collective work as IB scholars and journal editors, in this Perspective article we identify some of the challenges long-term energy transitions pose, reflect on how those challenges can be conceptualized, offer potential responses, and propose a future research agenda.

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INTRODUCTION

We are now well into a long-term energy transition (LTE) in which renewable energy sources are slowly replacing fossil fuels. Since the 1970s, oil and gas have been associated with price volatility, and the declining cost of alternative energy sources has made these other options increasingly attractive (Gil-Alana, Gupta, Olubusoye, & Yaya, 2016; Ji & Guo, 2015). This period has been characterized by macro-economic volatility and political crises within some of the most advanced economies, conditions similar to the long-term energy transition of the early twentieth century (Wood, 2016; Wood, Finnegan, Allen, Allen, Cumming, Johan, Nicklich, Endo, Lim, & Tanaka, 2020; Newell, 2019). This raises questions on how these issues connect and what they could mean for international business and international management (IB/IM) studies.

Scholars have increasingly emphasized the role of context in defining how IB/IM is a unique business discipline (Buckley &

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Lessard, 2005). Specifically, environmental conditions are often the foundation of IB research questions and the source of variation in resulting studies (Kolk, 2016). Long-term energy transitions represent an important contextual variable with substantial implications for IB/IM theories and related phenomena. A frequent criticism of contemporary business and management research is that it focuses on narrow phenomena, neglecting our age's great issues (Abrahamson, Berkowitz, & Dumez, 2018). Hence, addressing such issues head on may extend the frontiers of IB research and help renew its relevance.

In this article, we identify some of the research challenges associated with long-term energy transitions and offer potential directions. We focus on conceptual/theoretical issues, the nature of the phenomenon itself, how it manifests in different contexts, and methodological challenges and opportunities with this research. We conclude our discussion with brief illustrations of broad alternative energy programs from actual organizations to demonstrate some of the principles we describe. Our goal is to stimulate dialogue and discussion around how IB/IM scholars can address research related to long-term energy transitions and other multi-level, multi-actor phenomena.

In order to capture and assess the key dimensions of this transition and the role and influence of its key actors, we adapt a framework developed by Verbeke & Fariborzi, (2019). They introduce a model that incorporates the timing and scale of governance adaptation in response to new resource combinations in MNEs, and argue that these adaptations can be narrow or more wholesale, and that the responses may be prompt or deferred. This framework provides a convenient structure and builds on other insights from IB scholars (Hennart, 2001) and the earlier Chandlerian tradition (Chandler, Hagström, & Sölvell, 1999), in that it describes how changes in resource allocations trigger changes in governance (Verbeke & Fariborzi, 2019). The resource dimensions of the firm encompass both the human and the physical–environmental ones; although the former are less tangible, and therefore more complex to analyze, the scale and scope of challenges posed by the latter are often underestimated (Hart & Dowell, 2011). Table 1 presents a modified and extended version of Verbeke and Fariborzi's (2019) conceptual model, which we apply in the discussion and case studies presented.

The table highlights that organizations can adopt a range of different paths in response to external

pressures and developments. However, the interrelationship between firms and the quality of ties between them and with their stakeholders also affects firm-level practices. In turn, these pathways will impact the behavior of energy suppliers, and, indeed, the interrelationships between them. The organizational examples noted in this article should be viewed in this context.

LONG-TERM ENERGY TRANSITIONS: CONTEXT AND KEY ACTORS

Fossil fuels are a limited resource and their consumption adversely affects the earth's climate. Most countries are considering or pursuing an "energy transition" (Lin & Omoju, 2017; Strunz, 2014) in which renewable sources of energy replace fossil fuels (York & Bell, 2019). Nearly 70% of global greenhouse gas emissions emerge from energy production and use, with 25 percent generated by electricity and heat production, 21 percent from industry, 14 percent from transportation, and 10 percent from miscellaneous energy such as heat production, for example, fuel extraction, refining, processing, and transportation of fuels (EPA, 2020). As such, the energy sector is squarely at the center of climate-change challenges. In this regard, the World Energy Council (an alliance of public- and private-sector leaders from more than 100 countries) proposes balancing three interwoven objectives under its "energy trilemma" concept: energy security, energy equity, and environmental sustainability (Planete-energies, 2015).

The world has seen two great energy transitions in the past 150 years, the first from coal to oil and gas (Yergin, 1991a) and the second from hydrocarbons to renewables. Although, in the first transition, oil offered a new source of cheap and easily transportable energy, it necessitated major reallocations of capital and fundamentally changed the basis of competitiveness of regions and firms (Wood, 2016; Wood et al., 2020; Yergin, 1991a). Those changes were accompanied by shifts in energy technologies and in the provision of energy services (Yergin, 1991a). They also generated dramatic realignment of countries and the reorganization of industries and companies. Although this change was disruptive for all economies, the two largest liberal market economies – the U.S. and the U.K., with well-developed financial systems and access to oil reserves – weathered the challenge better than many countries (Parra, 2004; Gillespie, 1995).

**Table 1** Timing and scale of organizational adaption in governance and strategy to the long-term energy transition

Scale of adaption	Timing	
	Swift	Delayed
Narrow	1 (Low coordination, firm-specific advantages, rational decision-making within organizational context; reliable decision-making)	3 (Uncoordinated panic, initial inaction reflecting institutional incentives making for bounded rationality in decisions and unreliable choices)
Broad/ organizational	2 (High coordination, institutional incentives on managers, decisions in line with institutional incentives)	4 (Changes in regulation and firm-level governance; catch up)

Adapted from Verbeke and Fariborzi (2019)

We are now in the throes of a second long-term energy transition; the relative proportion of oil and gas in the global energy mix has diminished, even as overall usage has increased (Verbong & Lorbach, 2012; Armaroli & Balzani, 2016; Wood et al., 2020). Solar and wind energy are beginning to compete with oil and gas in cost and price predictability, even without subsidies (Armaroli & Balzani, 2016). The present energy transition has been largely driven by the policies of specific governments, NGOs, and civil society (Yergin, 1991b), although private-sector actors and market forces are beginning to be felt throughout the shift.

The current transition has been influenced by – and will result in – substantial change, including dramatic increases in demand for renewables, the depletion of finite traditional energy sources, and resistance against fossil fuel extraction and usage (e.g., Tarim, Finke, & Liu, 2019). These overarching trends, however, have important implications for – and are shaped by – economic and political forces; the relative competitiveness of firms, industries, and nations, and by large-scale capital allocation programs. Specifically, the speed of the transition remains uncertain as different countries and regions pursue transition policies at a different pace. As Fouquet (2010) notes, historical evidence alerts us that energy transitions are very protracted affairs. Proactive action by governments and firms can significantly accelerate or hamper this process (Hoppe, Graf, Warbroek, Lammers, & Lepping, 2015). At present, it is also hard to predict which renewable energy technologies will win and what might be a “final” energy mix (Fattouh, 2018; Sovacool, 2016).

Importantly, both the public and private sectors are driving this transition, and their contributions and positions vary across space and time (e.g., Valentine & Sovacool, 2019). Significantly, the 1997 Kyoto Protocol – a treaty between nations that took full effect in 2005 – failed, owing to many

participants’ lack of active buy-in. In contrast, the 2016 Paris Agreement assigns a much greater role to civil society and NGOs in monitoring and promoting increased usage of renewables; the process is not exclusively “owned” by governments (Falkner, 2016). Unsurprisingly, skepticism about a shift to renewables has often been led by organizations with the most to lose from the transition: large hydrocarbon companies and allied stakeholders (Hess, 2014). This divide has become highly polarized, as seen in the resurgence of both green and center-left political parties that call for a “green new deal” in the U.S. and a “green recovery” in Europe, as well as right-wing populist governments such as in Brazil that advance the agenda of traditional energy firms (Inglehart & Norris, 2017).

EMERGING ISSUES AND RESEARCH AGENDAS

Energy transitions require inter- and multi-disciplinary approaches, as they involve a range of actors and interests in both the public and private sectors, and require technological development, economic trade-offs, political compromises, and social-impact mitigation (Araujo, 2014; Demski, Thomas, Becker, Eevensen, & Pidgeon, 2019). For example, an economics perspective can analyze costs and risks of different asset portfolios, while a social science perspective may highlight societal challenges of large-scale energy transitions (Zaunbrecher, Bexten, Specht, Wirsum, Madlener, & Zeifle, 2019).

Viewing long-term energy transitions as complex transformation processes, Moallemi and Malekpour (2018) suggest that traditional planning and modeling approaches tend to be inadequate because they simplify the qualitative aspects of transitions and fail to internalize the realities of high uncertainty and complexity. They propose a combination of qualitative participatory and quantitative modeling approaches as a practical way forward for long-term planning for energy transitions. They

expect such an approach to “enable energy decision-makers to test various policy interventions under numerous possibilities with a computational model and in a participatory process”. 2018: 205).

IB has often employed a variant of a corporate finance perspective, focused on the impact of financial actors on the global firm (e.g., Bower, Filatotchev, & Marshall 2020). In exploring the effects of long-term energy transitions, however, it may be necessary to take into account the complexities and dynamics of relevant trends in commodity markets and the pricing of relevant assets. This would entail drawing on some of the other subdisciplines of finance, such as asset pricing. For example, the hydraulic fracturing (commonly known as the fracking industry) has relied extensively on highly leveraged speculation that assumed high prices into the future, which has recently rendered fracking in high-cost locations uneconomic. More broadly, large traditional fossil fuel-based energy producers have found their share value depressed in comparison to utilities that have diversified into renewables. As of late 2020, NextEra, the world’s top generator of solar and wind power, with a market cap of US\$147 billion surpassed Exxon Mobil as America’s largest energy company (The Economist, 2020).

While this approach may be valuable in identifying issues and variables traditionally outside the realm of extant IB/IM research, scholarship on long-term energy transitions should also integrate traditional IB theorizing or devise new proposition-oriented theoretical frameworks. Hence, in drawing out the implications of shifts in commodity prices and technological assets, IB scholarship will need to integrate insights of relevant statistical and mathematical modeling as well as socio-economic theorizing from the allied social sciences. Policymakers within the domain of IB then have an opportunity to pursue research to effectively channel the transition to deliver future energy systems that are environmentally sustainable. A strong enabling framework such as the World Economic Forum’s “Energy Transition Index,” which incorporates elements of a country’s readiness for energy transition, provides a valuable and comprehensive mechanism for benchmarking (WEF, 2020; see below).

The phenomenon of long-term energy transition and the associated analytical challenges will require the development of a comparative understanding of current conditions, and of the opportunities and constraints they place on the firm in different

geographic settings, each with varying approaches and policies. This will be a much more demanding process than previous IB excursions into cognate fields. At the same time, it presents a unique opportunity to draw in other research communities and to respond to the great questions of our age and the analytical base of the field.

Alternative energy sources do not suffer from hydrocarbon exhaustion, and, although they have high set-up costs, they are also associated with more stable revenue flows and low running costs (Khare, Nema, & Baredar, 2016; Wood, 2016; Wood et al., 2020). As such, alternate energy investments are more conducive to patient capital and provide opportunities for long-term investors (Wood et al., 2020). Highly mobile capital shifts towards new opportunities and space during any long economic crisis; however, the evidence shows that to date investments have been disproportionately focused on hydrocarbons (cf. Bunn, Chevallier, Le Pen, & Sevi, 2017). There is then a correlation between national institutional regimes and the relative receptiveness to alternative energy sources (Wood, 2016; Wood et al., 2020). This linkage between national institutions and energy policies is reflected in several contributions to the *JIBS/BJM* Special Joint Initiative on this topic. As one example of an opportunity, the tax incentives extended to electric vehicles (EVs) purchases in the U.S. and elsewhere helped jump-start Tesla. Tesla’s holistic approach to the EV market, which includes the development of increasingly powerful batteries, in turn attracted capital investment that valued Tesla at multiples of traditional automotive assemblers.

Energy usage trajectories – and, indeed, relative propensity to act on climate change – represents an important distinguishing feature between different national institutional archetypes. Incorporating this into the identification of national institutional archetypes, and the comparison of firm-level and socio-economic outcomes between them, could provide the basis for a major extension of theory, broadening the basis through which we compare different forms of capitalism.

Within the conceptual framework presented in Table 1, the scale and scope of organizational-level adaption is connected to the bounded reliability of managerial decision-making and bounded rationality (Verbeke & Fariborzi, 2019). First, the literature suggests that individuals and collectives may make “wrong” or unreliable decisions due to imperfect knowledge, but also by weighting the status quo more heavily than high-probability future events



(Diamond, 2005). Senior decision-makers favoring the status quo at the expense of long-term positive outcomes for the firm or nation reflects bounded reliability vis-à-vis their shareholders and citizens, respectively. This could reflect an inherent human aversion to challenging pathways and a tendency to fall back on familiar past experiences, even if this means abrogating commitments to organizational stakeholders or the wider society.

When confronted with overwhelming evidence to the contrary, this may result in panicked remedial action (cf. Dupont, 2009). Accordingly, what constitutes rational decision-making is bound up with wider institutional realities; a defining feature of national institutional regimes is which sets of managerial choices are incentivized (Wood et al., 2020). By the same measure, if institutional incentives are uneven or incoherent, then autonomous managerial choices assume much greater importance. These choices may manifest as ad hoc local initiatives by managers or by focused strategic experiments that may be extended or abandoned without necessarily undermining existing organizational priorities, such as oil and gas majors' tentative forays into renewables (Table 1, quadrant 1). Alternatively, organizations may decide to fundamentally change their core technologies and/or business model, like the growing number of automotive manufacturers transitioning rapidly from the internal combustion engine to EVs (Table 1, quadrant 2). Another response is for organizations to postpone change and implement narrow measures (Table 1, quadrant 3); for example, GM has dipped its toe in the electric automotive market while becoming ever more reliant on the profits from traditional consumer trucks. Finally, organizations may be latecomers to the renewables game, yet then radically shift direction, such as the Norwegian oil firm, Equinor. Such a late conversion may run the risk of missing the proverbial boat, but, at the same time, such firms may avoid the costs and risks that come from being a first mover.

ENERGY TRANSITIONS AND UNEVEN PROSPERITY: IMPLICATIONS FOR ECONOMIES, FIRMS, AND INDIVIDUALS

The scope of the current energy transition to renewables will require massive investment in new technologies and a new, complex energy landscape that will require robust interactions between energy producers and users. A key component of this is the "energy internet", which is a

complex array of interconnected devices that, for example, enable updates of the existing smart grids and eventually contribute to optimum utilization of energy (Sun, Han, Zhang, Zhou, & Guerrero, 2015). Also, providing energy access to the estimated one billion people who lack it, and meeting the demand of a possible additional two billion by 2050, while reigning in carbon emissions will undoubtedly be challenging (World Economic Forum, 2018). However, there have been a number of encouraging new initiatives, even in contexts where the policy environment is relatively hostile to renewables. For example, the Australian State of Queensland is witnessing a renewables boom, with more than 1.6 billion AUD invested in new large-scale solar projects in 2018.

In addition, billionaire Sanjeev Gupta has launched a \$1 billion AUD, one-gigawatt renewable energy plan in Whyalla, South Australia, as an initial stimulus to Australian industry's transition to renewable power (Say et al., 2019). The project is expected to produce 280 megawatts of power, featuring 780,000 solar panels to generate sufficient solar energy for 96,000 homes, which is equal to around 1% of Australia's annual power needs (for details, see Reuters, 2018). Solar technology has shifted from a niche product for the wealthy to one accessible to the poor within many emerging markets (Goodall, 2016). The average cost of solar panels has plummeted, and relatively compact panel configurations are now in widespread use across many developing nations (Sivaram, 2018). As with mobile phones, solar electricity is particularly attractive in institutionally weak countries in that it reduces reliance on often failing physical infrastructures. Although some countries have more favorable weather systems to generate significant electricity than others, solar is commercially viable even in some northerly and cooler climates (Mussard, 2017; Awad & Gul, 2018), suggesting that conflicts around resource access would be less likely than the resource wars for access to oil and gas reserves.

The long-term energy transition opens up at least two new research agendas. Although comparative institutional analysis has made strong inroads into IB scholarship, very little analysis has drawn in variations in energy mixes and the linkages between regulation, policy, firms, and other actors. In essence, responding to this research challenge would entail adding a much wider range of variables to be considered in comparing nations, firm ecosystems and practices, cross-country and cross-

firm networks, and how MNEs respond to different national policy environments. This will become all the more significant considering that it is unlikely that private actors will make necessary behavior changes swiftly to reduce greenhouse gas emissions without appropriate inducements; hence, national governments are required to implement policies to facilitate the aspired transition.

Alternative investors are playing an increasingly important role within the global investment system, many being explicitly international (Goergen, O'Sullivan, Wood, & Baric, 2018). Different types of alternative investors are likely to respond very differently to the opportunities presented by the long-term energy transition. For example, more transparent sovereign wealth funds (SWFs) from democracies may come under public pressure to reduce their hydrocarbon portfolios. More opaque ones from undemocratic countries may be somewhat immune to such pressures, instead following the interests of ruling elites (Cumming, Wood, Filatotchev, & Reinecke, 2017). Within the private equity ecosystem, funds geared towards debt financing may have very different approaches to fracking than institutional, buy-out-oriented funds. This would create new opportunities for comparative analysis both within and between different types of investors, opening avenues for novel research across core IB subdisciplines.

Further, some types of alternative investors have received scant attention in IB/IM (see Cetkovic & Buzogany 2016 for an exception). A large proportion of SWFs owe their resources to oil and gas windfalls. Yet Norway – the largest of them all – has shifted its investment focus away from hydrocarbons (Wirth, 2018). The long-term time horizons of renewables could lend themselves to SWF activity, whose *raison d'être* is to serve as an intergenerational savings device (Cumming et al., 2017). This would open up research opportunities in comparing the scale and scope of SWF investment flows, the relative effects of SWFs' country of origin on which countries they invest in, and the impact of those investments. IB scholars are well positioned to explore the multiple roles of governments as they seek to advance both economic and social objectives through the international operations of state-owned enterprises and directed companies, a phenomenon analogous to SWFs (Cuervo-Cazurra, Inkpen, Musacchio, & Ramaswamy, 2014).

Impact investors would likely be particularly interested in alternative energy sources; a key question remains as to how impact investors

respond to different national policy regimes (Mitchell, 2016). Impact investors work to combine financial returns with making a real difference through promoting more sustainable practices, and have raised awareness of these issues among other investors. This has led to a number of larger, more conventional investors divesting from hydrocarbons, a process accelerated by concerns as to the capacity of unconventional oil and gas to generate real returns in the future (see Saha & Muro, 2016).

The relationship between crowd-funding and renewable energy start-ups in different national contexts would also merit closer investigation. Crowd-funding allows relatively small investors to club together, typically to support innovative start-ups that would otherwise battle to secure funding (Ahlers, Cumming, Günther, & Schweizer, 2015). Finally, the hedge fund ecosystem seeks to diversify against risk while maximizing returns (Stowell, 2017). In practice, hedge funds appear agnostic towards renewables versus hydrocarbons, and have taken advantage of both in the hopes of new opportunities in the former (Krupa & Harvey, 2017) and volatility in the latter (Peach & Adkisson, 2017).

A comparative understanding of the patient-capital ecosystem and different types of agendas would help inform why certain national contexts have made much faster progress in moving away from hydrocarbons than others. Patient investors' goals are better aligned with renewables' longer time horizons and more stable revenue flows (Wood et al., 2020). In contrast, the financial ecosystem remains dominated by highly mobile investors that are oriented towards short-term returns. Price volatility and the very short-term time horizons of individual unconventional oil and gas projects are particularly attractive to hyper-mobile investors who may be unconcerned about medium-term revenue flows, or even the absence of significant returns other than via debt distribution (cf, Zwick, 2018). A more developed understanding of the trans-border activities of patient capital, major countries of origin, and coveted countries of domicile would advance understanding of the transnational investment ecosystem and variations in national-level outcomes.

Finally, any series of complex and interconnected technological, social, and economic developments undoubtedly bring with them unintended consequences, including political extremism, seen today in the U.K. and U.S., and the displacement of some economic interests over others. The



interconnectedness of unexpected socio-economic developments, national institutional configurations, and the material world is poorly understood, whether in theoretical and empirical terms. However, it is generally acknowledged that the oil price shock of the early 1970s – and subsequent volatility – coincided with a period of recession interposed with similarly volatile growth. In turn, this led to an unwinding of the post-WW2 Keynesian settlement, and the ascendancy of neo-liberalism (Schmidt, 2016). In turn, jobs, incomes, occupations, and retirements became precarious. Traditional approaches to theorizing the linkage between context, policy, and managerial choices have depicted the process as confined to the social, economic, and psychological worlds (Coleman, 1986; Giddens, 1984). The physical environment and resource availability and exploitation should also be included; human civilizations have always faced finite natural resources and human-made environmental challenges, yet this is often neglected in socio-economic theorizing (Sutton, 2017).

In methodological terms, pursuit of these agendas would entail the use of a wider range of data sources and methodological techniques than those that IB research traditionally encompasses. This would include the combination of bespoke datasets and firm-level survey and interview data, and also macroeconomic data from the asset pricing community of financial studies. In other words, scholarship would be of value in developing analytical models to enhance our understanding of the relationship between variations in monetary policy and hedge fund or private equity activity, asset pricing, and microstructures. Finally, research related to climate change can be highly controversial. This places pressures on the researcher as, while global warming represents the consensus among the overwhelming majority of scientists, there is much less certainty as to what should be done about it and how, making it difficult to assume a dispassionate neutrality.

LONG-DISTANCE TRADE AND COMMUNICATIONS

Although the IB literature has encompassed studies of trade and commodity flows, it has often taken transport as a given (Hamilton & Webster, 2015). Yet, shipping and aircraft dominate long-distance global flows of goods, both of which are highly carbon-intensive and polluting industries (Lister, Poulsen, & Ponte, 2015). Although globally

orientated proposals for massive improvements in transportation via renewable energy systems and large electric shipping engines are starting to make an appearance (e.g., see Garcia-Olivares, Sole, & Osychenko, 2018), in the medium term, higher fuel costs and regulatory pressures may primarily drive reform (Kock & Osterkamp, 2019).

With regard to shipping, the uncertainties of the global economy are likely to pose further challenges to – and changes in – regulation and input costs (Vander Hoorn & Knapp, 2015; Lister et al., 2015). Here, IB could draw on transport economics and salient strands of the engineering literature to gain deeper insights into technological enablers and constraints. If shipping costs are likely to rise, the extended nature of global value chains may come under increasing pressure, which would exacerbate trends towards nearshoring, possibly accelerated through increased protectionism and exits from established trading blocs. This might entail drawing on economic geography to more fully understand any processes of de-internationalization or constrained regionalization (Fratocchi, Di Mauro, Barbieri, Nassimbeni, & Zanoni, 2014). Other pressures driving nearshoring range from technological advances like robotics that allow for more efficient automation to concerns about supply chain dependencies that the COVID-19 pandemic has exposed, prompting governments and firms to promote alternate domestic or nearby production of critical medical products. However, the interaction among these factors may result in more rapid progress than scrutiny of each individual factor might suggest.

There are recognized counter-tendencies in shipping. Whatever the limits of diesel-based propulsion, the traditionally powered container sector has considerable room for growth centering on larger ships (Slack, 2017). Land-based transport is subject to closer regulatory scrutiny. Nonetheless, the development of long-distance freight rail between China and Europe is starting to make inroads into long-distance shipping and has the potential to make considerable gains (Jiang, Sheu, Peng, & Yu, 2018). However, moves that may facilitate renewable energy are uneven and at times contradictory.

Finally, impending challenges facing air and shipping would vest ongoing efforts at land-route renewal with even greater significance. Although there is an emerging body of scholarship on this subject (Huang, 2016), future IB research would have to draw on both international trade and

international political economy for a fuller understanding of such initiatives.

VARIETIES OF SUSTAINABLE DEVELOPMENT: INSTITUTIONAL, SECTORAL AND FIRM-LEVEL ISSUES

A central theme of IB literature is the structural distinctions between developed and emerging markets and the role of energy aid donors. However, long-term energy transition and the associated economic adjustments come with long-term shifts that could erode these distinctions. On the one hand, a number of emerging markets, most notably China, have seen very rapid growth and have helped lead the shift to renewables (Xinhua, 2018). Although it is presently the world's largest producer of greenhouse gas emissions, China is also one of the biggest sources of low-carbon initiatives, as its major cities suffer from very high air pollution (Guan, Zheng, Chung, & Zhong and Bazilian, 2016), and it recently pledged to become carbon neutral by 2060. At the same time, Chinese energy policy continues to rely on traditional fuel sources (Alkon et al., 2019), and its fracking industry continues to push ahead, even in the face of local concerns and visible downstream environmental costs (Tan et al., 2019).

China's recent espousal of renewables has included a historic bet on electric autos: the country has already gained a technological and production lead in the area and is well equipped to flood export markets with a new generation of cheap and practical electric cars (Teece, 2019). Chinese automakers have been able to ramp up volumes partially due to restrictions on foreign imports (Kenworthy, Newman, & Gao, 2015), placing other countries with nascent national automotive industries but without the similar domestic markets and international political power at a great disadvantage. India is also taking a lead in global renewable energy transition (see UNCC, 2017), in particular via institutional entrepreneurship (see Jolly, Spondnaik, & Raven, 2016).

Meanwhile, the U.S. and the U.K. have followed sometimes contradictory policies that respond to their respective political contexts by continuing support for traditional carbon-based energy sources while also providing some incentives for solar and wind (Stokes & Breetz, 2018; Partridge et al., 2017; Williams, Macnaghten, Davies, & Curtis, 2017). In some cases, national and local governments have even erected roadblocks to renewable production

such as implementing regulations that make it difficult to secure planning permission for land-based windfarms (Muthoora & Fischer, 2019; Harper, Anderson, James, & Bahaj, 2019). Yet, in the case of fracking, many U.S. states have provided generous access to public lands and the U.K. government has proven willing to override local opposition (Short & Szolucha, 2019; Muncie, 2020)¹. It should be noted that the U.K. has also erected substantial offshore wind capacity, because it is both economically attractive and avoids some of the disruptions of onshore alternatives. In the U.S., there have also been renewed commitments to traditional sources, such as the Trump administration's continued support for coal, even as markets have definitively judged that it is neither economically nor environmentally viable (Selby, 2019). However, renewable investments in the U.S. have grown rapidly, especially in the southeast (Michaelides, 2019).

The adoption of new technologies may entail wasteful usage of resources, and some forms of green energy impose environmental costs of their own. Nonetheless, there is little doubt that a number of continental European coordinated market economies, most notably Germany and Scandinavia, have made much better progress in using alternative energy. Such variations have long-term consequences for their future within the community of developed nations and their future basis of national competitiveness. It also raises the challenges of pro-renewable governance as a political agenda (Laes, Gorissen, & Nevens, 2014). These institutional issues have direct impacts on industries and firms, prompting the emergence of different sectoral characteristics and business models in different countries and regions. This would suggest the need for further interdisciplinary work drawing on economic geography, engineering, logistics, and policy studies. Examples would encompass better spatial mapping of alternative energy use in relation to regions and proximity to other industries; more comprehensive comparative analyses of national energy policies; and the relationship between logistics infrastructures, transport costs, and proclivity to use alternative energy sources.

METHODOLOGICAL AND THEORETICAL CHALLENGES AND OPPORTUNITIES

Research on long-term energy transitions could benefit from insights from allied social sciences and other business disciplines, but identifying



suitable conceptual and theoretical frameworks is challenging. Determining the relevant time horizon within which to examine these transitions, identifying and incorporating the range of relevant stakeholders, and specifying appropriate levels of analysis all present challenges for both theory and method.

First, while long-term energy transitions and similar phenomena may lend themselves to longitudinal panel data, researchers should also consider other methodological approaches. For example, Bayesian methods are well suited to long-term energy transitions in that they “permit the engineering and updating of more realistic, complex models” (Hahn & Doh, 2006: 783). Specifically, Bayesian approaches allow for the continuous updating of predictive models as additional information becomes available. Given that research in long-term energy transitions unfolds over long time periods, Bayesian methods may be useful for factoring in the dynamic substitution effects among energy sources and the effects of firm–state interactions on their penetration.

Qualitative methods, especially those that employ discursive and dialectical approaches to account for the individual firm’s embeddedness in unique social, political, and historical contexts (Vaara & Tienari, 2011), are also warranted. Indeed, research on the global diffusion of LTE (long-term energy transition) must explore both its content and process (Barnett & Carroll, 1995; Treviño & Doh, 2020). For example, the “story” of the emergence and global diffusion of carbon markets lends itself to rigorous historical narrative that could help explain current patterns and anticipate future trajectories (Verbeke & Fariborzi, 2019).

Relatedly, long-term energy transitions and similar phenomena suggest a wider range of evidence that goes beyond the scope of traditional IB. For example, tools from economic and environmental geography may be appropriate and insightful alternatives to traditional IB/IM approaches. Doh and Hahn (2008) argue that researchers can use spatial and geographic constructs and techniques in international strategy research to improve upon more traditional methods, especially in research involving the multi-level phenomena and geographic variables that may be part of a local or global network. For example, geospatial identification and modeling of access to decentralized energy sources could be a substantial predictor of foreign direct-investment location choices.

Third, LTE naturally involves multiple actors and levels of analysis. Actors include governmental institutions at the supranational, national, and subcentral level; the range of private actors; and NGOs. While this complexity poses challenges, advances in statistical tools and in the modeling process itself make such approaches more feasible than in the past (Peterson, Arregle, & Martin, 2012). As Buckley, Doh, and Benischke (2017) point out, multi-level research is especially appropriate for “grand challenges” such as climate change where macro-, meso-, and microphenomena interact. For example, as most energy transition demand comes from global urban settings, Arrizabalaga, Hernandez, and Portillo-Valdes (2018) propose a multi-criteria ex-ante impact methodology for such a planned transition, combining energy modeling and life-cycle analysis along with regional macro-economic analysis through the supply-chain evaluation. The emerging consensus suggests that long-term energy transition must contend with multiple overlapping uncertainties (Pye, Sabio, & Strachan, 2015) due to the complex nature of systems involved, their multi-dimensionality, the serious consequences of the decisions, and frameworks and models to be utilized. Here, the “Energy Transition Index” (by the World Economic Forum) can help benchmark a given country’s readiness for energy transition and get a global comparative analysis. The outcomes of both of these multi-level methodologies can help global majors to develop their strategies for specific geographies.

There are more specific methodological issues and challenges we believe deserve attention. Given the global scope of long-term energy transitions and related phenomena, we expect increased use of data from different national contexts; however, this raises questions of data reliability and transparency and whether data from different contexts can be compared with sufficient checks for robustness and reliability. Some of this data may be subject to political sensitivities, raising issues of research ethics, particularly given the role of vested interests in challenging de-carbonization drives. Yet, despite these issues, other relevant data sources include those the asset pricing sub-community of finance commonly deploy, and those relevant to understanding the micro-structures of stock markets, variations in the relative ability of sectors and firms with differing orientations towards renewables to attract specific classes of investors, and how investors behave to the firms they invest in.

We believe the emerging practices of making data available in conjunction with article publication is especially important in this research area. Research organizations aggregating data – and that data's public availability – is important as groups of researchers tackle this research together. There are excellent proprietary databases on specific categories of investors and those aspects of their strategies that are directly salient to exploring policies and practices on renewables.

Finally, we encourage the collection and use of new or underutilized data sources that could be leveraged for research on long-term energy transitions, including those deployed in the natural and engineering sciences. For example, in natural-sciences literature, multi-dimensional simulation models have brought together climate and macro-economic data to understand likely changes in fossil fuel production and value (cf, Mercure et al., 2018). Data on the linkages between earthquake frequency and fracking (Schultz, 2013) might be tied to shifting industry-investor attitudes. Finally, data on relative strategic mineral versus hydrocarbons endowments might help understand varieties of regulatory, investor, and firm-level responses (cf, Hao, Liu, Zhao, Geng, & Sarkis, 2017).

There are a wide range of potential conceptual and theoretical approaches drawn from IB/IM and related disciplines that could and should be applied to LTEs, including transaction costs, institutional, and internationalization. Here, we focus on two lesser-known theoretical traditions: *comparative capitalism/national business systems* and *first-mover/entry order and real options*.

Institutional theory's versatility provides helpful structure to research LTEs. New institutional economics as in the work of North (1990) and Williamson (2000) provides one variant of institutional perspectives, and neo-institutionalism may also provide insights into LTEs (DiMaggio & Powell, 1983). However, the third variant of institutional theory, "comparative capitalism" (or "national business systems") approach (Whitley, 1999, 2007), may provide the most relevant institutional perspective on LTEs. This perspective focuses on the persistence of differences between national economic systems and why some international economic and social patterns persist (Hall & Soskice, 2001).

Jackson and Deeg (2008) argue that the comparative capitalisms approach to international business variation rests on three core theoretical tenets: (1) distinct institutional configurations characterize

national economies; (2) these configurations are a source of comparative institutional advantage; and (3) institutional path dependence stabilizes the configurations. Given the differing political philosophies and approaches to regulating and taxing existing energy sources and the role of distinct political economies in overseeing LTEs, this approach is well suited to generating theory regarding why some political jurisdictions exhibit a more interventionist approach to stimulating LTEs while others adopt a more hands-off, *laissez-faire* stance. As such, studies seeking to reveal differences in the pace and extent of LTEs would be well framed using this perspective.

Another approach drawn from strategy and finance – the first-mover advantage theory – can help identify and reveal the organizational winners and losers from LTEs, especially when integrated with a real-options approach. First-mover theory, as described by Lieberman and Montgomery (1988), outlines the benefits for early entrants into geographic, industry, or product markets, including first-movers' ability to master technical knowledge and limit access to scarce assets by building an early customer base. Given the potential for early entrants to establish broad, global industry standards for solar photovoltaic technology, large-scale battery storage systems, and other various aspects of LTEs, the theoretical and empirical research on first-mover and early entrance may be especially meaningful in determining industry and competitive dynamics.

Real options may offer an additional perspective relevant to industry- and firm-specific responses to LTEs. A real option is a right, free of any obligation, to take a specific future action at some cost with regard to a tangible or intangible asset (Trigeorgis, 1996). Facing uncertainty about the future value of an asset, the option allows a decision-maker to delay a more definitive commitment to gather new information and pursue action only if it is beneficial. Examples in IB/IM include expanding an existing production facility or acquiring a partner's ownership share (Tong & Reuer, 2007).

Developing and commercializing renewable energy requires substantial investment and uncertainty. A core uncertainty is the future price of traditional petrochemical-derived energy, which has direct implications for the cost competitiveness of alternate energy and therefore the overall energy mix within a geographic region. Issues related to which technologies will emerge as dominant and the level and directions of tax and subsidies are also

ambiguous. Relatedly, overall environmental policies generally and carbon-pricing schemes in particular also create uncertainties.

As one tangible example of several of these uncertainties, the government of Spain provided generous subsidies to the wind-generation industry from 2006 to 2010. The country expanded its renewable base rapidly and helped establish a domestic industry in both wind turbine and solar energy. However, support was drastically cut back following the global financial crisis and a Conservative government taking power in 2013. As such, new installations stagnated, many alternate energy generators and investors became insolvent, and some foreign investors sued the government for renegeing on their commitments. More recently, the solar industry has proven to be more resilient and cost-effective, shifting the overall mix in Spain from wind to solar.

Real options provides a research context for IB/IM scholars to explore and test the historical experience with LTE and to engage in future scenario planning to identify multiple pathways. More practically, the real-options approach offers a strategy for investors to make a series of “small” bets on a range of different technologies and, in so doing, preserve alternatives in the future, given the high uncertainties surrounding the pace and extent of LTEs.

A somewhat fraught point is the interconnection between different planes of analysis. For example, comparative institutional analysis claims to be a firm-centered account, and yet, at times, the firm is treated as something that merely responds to contextual stimuli (Wood & Brewster, 2016). On the one hand, there is a growing body of evidence that, in certain contexts, and in response to rules and incentives, firms are more likely to use renewable technologies. On the other hand, no national institutional environment is perfectly coherent, and many firms will choose alternative paths. Again, many organizations may adopt hybrid strategies, alternating investing in renewable technologies and in their established business models. This would highlight the need for more detailed accounts exploring the relationship between context and the range of firm-level choices, and why specific patterns are more likely to be encountered in some settings than in others. Again, if national institutional orders periodically experience crises of efficacy, then there may be more room in both scale and scope for innovative or organization-specific practices at the firm level.

ILLUSTRATIONS OF ORGANIZATIONS COPING WITH LONG-TERM ENERGY TRANSITIONS

What do these systemic issues and methodological challenges mean for organizations, and how have they responded? In this section, we provide three brief illustrations of institutions and organizations that have developed various policies, programs, and initiatives related to long-term energy transitions, focusing specifically on those organizations whose remit, scale, and scope transcend national boundaries. We explore how these players have responded to the opportunities and pressures to move towards renewable sources, and what this tells us about sectoral and contextual dynamics and diversity.

Energy Storage

One critical dimension of a more sustainable energy mix is to increase the efficiency and duration of energy storage, namely in the form of electricity. Both solar and wind, the two largest sources of truly renewable energy, are intermittent and non-dispatchable without an energy-storage system because of daily and seasonal weather variability (Arbabzadeh et al. 2019). Further, electricity grids require a perfect balance of supply and demand such that the precise amount of energy provided is in equilibrium with the requirements. Energy storage, then, is critical to the expansion of renewables as a primary source of electricity. Although much of the current investment in batteries – the primary means for energy storage – relates to electric vehicles, new investment for industrial, commercial, and household use has been growing dramatically (Baldinelli et al., 2020).

Electricity storage can manage or even overcome intermittency, allowing solar and wind sources to store their electricity for later use (Cao et al., 2020). Tesla is already mass-producing such energy-storage devices for home and commercial use. These “Powerpacks” connect to solar panels, allowing homeowners, utilities, and businesses to use their solar power at otherwise unusable hours (Li et al., 2020). Owners avoid paying peak-time prices for electricity and have a reliable source of electricity even in the event of a power outage. In the future, these storage systems may allow energy consumers to completely de-couple from traditional grid-based systems.

Investment in energy storage has been growing exponentially in the U.S., Europe, and China. In the U.S., roughly US\$12 billion was dedicated to

energy-storage technologies from 2010 to 2018, with nearly \$2 billion invested in 2018 alone (Wood McKenzie, 2019). Among the top specialty energy-storage companies are EENOTECH, Instant On, and Bloom Energy. In addition, many established energy and technology companies, such as ABB, GE, Johnson Controls, Samsung, and LG, have aggressively entered the energy-storage solutions space (List Solar, 2020).

According to Mercom Capital Group, in 2019, venture capital investment in battery-storage firms increased to \$1.7 billion from \$850 million raised in 2018. Total corporate funding, including debt and public market financing, increased to \$2.8 billion in 2019 compared to \$1.3 billion in 2018. Lithium-ion-based battery technology companies received the most funding in 2019, with \$1.4 billion (Hall, 2020). Other categories that received funding included gravity storage, flow batteries, CAES, and zinc–air batteries. Shell and several venture capital firms acquired the German home-battery storage company, Sonnen (Hall, 2020), and QuantumScape, a start-up producer of solid-state batteries backed by Volkswagen and Bill Gates with no revenue, reached a market value of \$44 billion in late 2020. Solid-state batteries have the potential of greater performance in relation to weight and bulk, longer storage, and avoid the fire hazard of typical lithium-ion batteries which carry a liquid electrolyte (Wilmot, 2021).

In September 2018, the World Bank Group committed to a \$1 billion battery-storage investment program to increase support to battery-storage projects in developing countries. In May of 2019, World Bank Group agencies and 29 other organizations established the Energy Storage Partnership (ESP), a new international partnership helping to expand energy-storage deployment and bring new technologies to developing countries' power systems (World Bank, 2019). ESP helps tailor energy-storage solutions to these countries' needs, as most mainstream technologies cannot provide long-duration storage or withstand harsh climatic conditions and low maintenance capacity. In September 2018, the World Bank Group had previously committed to a \$1 billion battery-storage investment program announced to substantially increase support to battery-storage projects in developing countries through the addition of \$1 billion in concessional finance.

Renewables inherently allow for more “distributed” energy systems, meaning that countries, regions, and individual companies may become less

reliant on national grids and energy sources from other countries. The growth in decentralized battery storage further reinforces this shift. One interesting implication for IB/IM research is that this future energy ecosystem will require fewer (inter-)dependencies between countries and less trade in fuel sources, meaning that energy markets will be less globally integrated and more regionally, nationally, and locally based in comparison to the globally integrated markets that characterize fossil fuels. As such, global energy MNEs and their customers and suppliers may be much less important as a subject of study, while those that manufacture technologies – both in capturing energy and storing – it will be relatively more central.

NGOs: WWF/World Wildlife Fund and World Economic Forum

Two prominent global non-profit organizations, WWF/World Wildlife Fund and World Economic Forum (WEF), are at the center of advancing transitions toward renewable energy futures.

WWF International and its U.S. affiliate, the World Wildlife Fund, constitute the largest global network of conservation organizations, working in more than 100 countries. WWF works closely with governments to push for policies that favor climate-resilient, low-carbon development, energy efficiency, and clean renewable energy. WWF also works with financial institutions to redirect fossil-fuel investments to climate solutions, promotes climate adaptation in agriculture, forests, and water, and engages with companies on energy transitions (WWF, 2019a).

WWF has undertaken a range of programs to advance energy transitions in particular. The Renewable Energy Buyers Alliance (REBA) is an umbrella program consisting of five initiatives with a collective goal to help businesses voluntarily purchase 60 GW of additional renewable energy in the U.S. by 2025. REBA brings together customers, suppliers, and policymakers to identify barriers to buying renewable energy, developing solutions, and rapidly scaling them to meet REBA's ambitious goal. REBA's engine is the enormous demand for renewable energy from more than 100 large participating buyers, including companies in energy and resources (Exxon Mobil, Shell), defense (Lockheed Martin), technology (Apple, Alphabet, Bloomberg, Cisco, Microsoft, Salesforce), retail (Home Depot, Walmart, Target), banking and insurance (JP Morgan, Wells Fargo, Swiss Re), manufacturing (GM, Johnson Controls), and



consumer products (Danone, Johnson & Johnson, 3M), and many others (Reba, 2020).

A core REBA initiative, the Buyers' Principles, conveys to utilities and other suppliers what industry-leading multinational companies are looking for when buying renewable energy. This includes greater choice in procurement options, longer- and variable-term contracts, access to new projects that reduce emissions, and standardized and simplified processes. To date, more than 80 companies representing over 70 million MWh of energy demand have signed up to the principles. One of the best-known signatories, Facebook, has committed to deriving 100% of its energy from renewable sources by 2020 (Buyer's Principles, 2019).

The World Economic Forum, an international organization for public-private cooperation, has also been advancing an alternate-energy initiative among its governmental and private members. The Fostering Effective Energy Transition project is part of the WEF System Initiative on Shaping the Future of Energy. The "Energy Transition Index" (ETI) benchmarks 115 countries on their energy system's current performance and their macroenvironment's readiness for transition to a secure, sustainable, affordable, and inclusive future energy system. The fact-based framework and rankings are intended to enable policymakers and businesses to identify the destination for energy transition, identify imperatives, and align policy and market enablers accordingly (WEF, 2020).

The ETI provides benchmarks across a country's energy-system performance, based on energy security and access, environmental sustainability, and economic development and growth – dubbed the "energy triangle." The ETI also assesses countries on their transition readiness, which measures their energy system's future preparedness. Figure 1 shows the readiness scores for the G-20 economies and the share of global energy output emanating from each (WEF, 2020).

Consulting

Due to factors such as the finite nature of fossil fuels, pressure for more sustainable sources of energy, and global agreements, there is a dire need for the global economy to proactively pursue serious energy-transition initiatives. There are regular calls for initiatives like "zero net emissions" and a move towards a blended energy mix (KPMG, 2019a, b) in order to decarbonize the existing energy system to meet the 2016 Paris Agreement requirements (Poyry, 2019), reduce the "net carbon

footprint" of energy products (Shell, 2018), and transform the global energy system (Financial Times, 2019).

The current need is therefore not only to move away from fossil fuels and toward renewable sources of energy but to also seriously consider overall approaches to various aspects of energy transition. This requires a shift towards a new economy, including changing systems of production, storage, distribution, and regulation, better integration within the energy industry and its supply chains, and truthful communication and robust review processes (e.g., Deloitte, 2019). On these critical questions, Shell CEO Ben van Beurden has stated: "Understanding what climate change means for our company is one of the biggest strategic questions on my mind today" (Shell, 2018). At the same time, critics have charged that Shell's activities amount to little more than "greenwashing" (Scanlan, 2017).

The energy transition poses challenges for the dominant energy sector's existence, and there is uncertainty about both intended and unintended consequences that will follow (KPMG, 2018). This is further complicated by the fact that the renewables sector is fragmented, without commitment from concerned stakeholders for sustained, global, long-term investments. In contrast, the demand for fossil fuel is and will stay strong, and the governments of major countries remain divided against a backdrop of growing populism and signs of a rising carbon backlash (Financial Times, 2019). Nevertheless, there is now reliable evidence that such a transition is actually happening and is picking up momentum. Emerging evidence suggests that the resultant changes are creating opportunities to develop new connections, engaging in surprising discoveries and significant new value creation (e.g., PwC, 2019).

Major consulting companies have created dedicated services to help both the producers and receivers of traditional energy transform to cleaner and sustainable solutions. For example, A.T. Kearney launched its not-for-profit Energy Transition Institute in 2017 to better inform businesses about the effects that energy transition may have on their operations and those of their wider value chains (A.T. Kearney, 2017). Similarly, KPMG's International Global Renewable Network is helping clients with energy transition by offering an integrated portfolio including financial, strategic, and regulatory advice, as well as taxation and auditing related support to enable government bodies, developers,

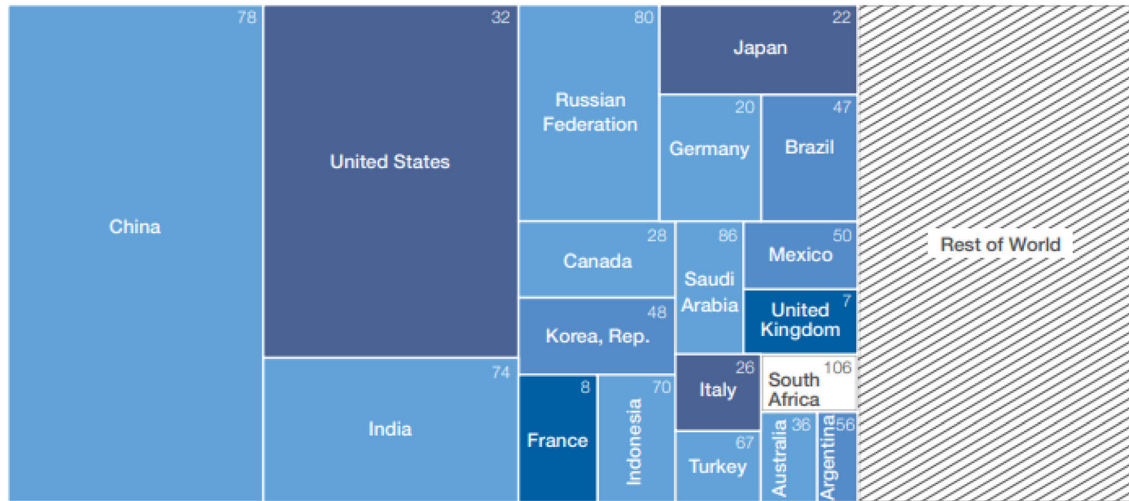


Figure 1 G20 countries' Energy Transition Index (ETI) 2020 ranking and share of global total energy supply, 2017 (Source: World Economic Forum). Areas represent countries' share of global total energy supply (%). Figures in the top right corner indicate country ranking on the ETI 2020. The ETI is a composite score of 40 indicators across three broad areas, energy access and security, environmental sustainability, and economic development and growth. WEF benchmarks 115 countries on the current performance of their energy system and their readiness for transition to a secure, sustainable, affordable, and inclusive future energy system.

generators, and investors to achieve effective results (KPMG, 2018).

In 2017, major oil companies started to restructure their operations for a low-carbon future. Analyses by institutes like the OIES (Oxford Institute of Energy Studies, 2018) and consultants Wood Mackenzie (2018) provide useful examples. For instance, many major oil companies are building portfolios around upstream positions, suitable for renewable energy. Equinor (formerly Statoil) is investing primarily in offshore wind, aiming to leverage its infrastructure and technical capability in the North Sea. Similarly, Total is actively building its new energy portfolio concentrating in U.S. solar, but also progressing quickly down the value chain by pursuing battery-storage acquisitions in Europe. Total aims to have 20% of its assets in renewables by 2035. New energies are high on Shell's agenda, aiming to cut its carbon footprint in half by 2035 (Shell, 2018).

Critics have charged that progress has been mixed and that most of the oil and gas majors continue to invest in controversial projects such as arctic drilling and fracking (Ivanova, 2016). However, such investments may end up as "stranded assets" as a growing number of investors shun the sector, prompted by ethical or commercial concerns. The hydrocarbon industry is increasingly associated with very high debt leverage, while the costs of renewable energy have reduced (Dietz, Bowen, Dixon, & Gradwell, 2016). The shifting of

the pendulum is now clearly visible, and the major players in conventional energy production are expected to commit a higher proportion of both capital expenditures and strategic change efforts to support energy transition.

FUTURE CHALLENGES AND A WAY FORWARD

The long-term energy transition is clearly underway, but, while some firms and national governments eagerly support the change, others actively seek to impede it. However, as with any long historical process, the latter may simply postpone the inevitable. An ideal way forward would be to enable firms to identify ways of optimizing financial and social performance during the expected change, helping to accelerate the move to a lower-carbon footprint and achieving a zero-carbon profile in the transition.

Asset management companies are a key stakeholder group in the energy transition. Jacquier-Laforge and Kiernan provide a useful analysis about the potential impact of climate change on investment decisions and how to reduce exposure to large carbon footprints (IPE, 2015). They highlight the growing significance of socially responsible investing and the consideration of environmental, social, and governance criteria leading to strategically aware investing. Impact investors' activities have become mainstream, leading to growing concerns that investments in oil and

**Table 2** Examples of timing and scale of organizational adaption

Scale of adaption	Timing	
	Swift	Delayed
Narrow	KPMG	Shell
Broad/organizational	WWF	Equinor

(Based on Verbeke & Fariborzi, 2019)

gas might become stranded and effectively worthless (Sovacool & Scarpaci, 2016; Mercure et al., 2018). In January 2020, Blackrock announced that its active funds would divest from firms that generate more than 25% of sales from coal. Such moves underscore the risk that fossil fuel investments could end up as unsaleable assets. This, in turn, would fundamentally challenge the viability of large firms dependent on hydrocarbons, especially coal. Although advances in automated open-cast mining and the use of robotics in fracking have meant that the job consequences are more limited than they would have been a decade ago, this will nonetheless disrupt existing patterns of intra- and inter-firm relationships. Changes in regulation to encourage the usage of renewables will further accelerate such changes, as will socially-responsible auditing. The hydrocarbon industry has been associated with the extensive use of non-market strategies (especially lobbying and political donations), and this is likely to accelerate with efforts to halt or reverse industrial decline. Challenging this is the rise of new environmental movements, as well as the fact that the renewable energy sector's influence is increasing in scale, scope, and moral terms.

Highlighting the limitations of the linear approach to address energy-transition challenges, Anne Huibrechtse of Deloitte (2018) recommends a strong emphasis on the principles of the "circular economy." This entails technological, social, and financial innovations that enable the reduction, reuse, recycling, and recovery of materials and energy. Given that the global energy demand is expected to grow by another 48% by 2040 (Deloitte, 2018), incremental changes to achieve energy transition are not likely to work; hence, drastic steps are needed, among them an emphasis on circular economy.

Again, a key challenge is storage. Amelang (2018) calls the storage of intermittent renewable power "energy's next big thing" and the "holy grail" for energy transition. Other critical issues include an agile regulation system, as it usually takes years for regulators to catch up with new technological

developments (Deloitte, 2018). Also, the present approach to energy auditing will need serious amending to suit the energy-transition systems. Lastly, with the increasing push for renewable energy, a recent Deloitte (2019) analysis highlights that close to one-third of the world's publicly traded oil companies are at risk of bankruptcy. Given that environmental uncertainties are expected to increase in the oil and gas sector, firms need to have appropriate mechanisms to both identify and manage risk.

A modified version of our original concept, Table 2, helps to locate the different firm-level cases. Here, we have positioned organizations discussed in the four quadrants to represent how they are responding to the challenge of LTEs.

CONCLUSION

As in the first half of the twentieth century, the present long-term energy transition has coincided with economic and political turbulence, technological change, and shifts in the investment ecosystem. Within this mix, unambiguous causal relationships among core drivers may be difficult to identify, but it is clear that these forces are interconnected. Adapting and preparing for this transition will require new theoretical perspectives, drawing upon a wider range of methodological tools and data sources. At the same time, individual and organizational agency does matter. In some instances, a focus on renewables has become an integral part of the firm's broad organizational mission, whereas in other companies it has even become the center-point of an ambitious organizational strategy. However, acting upon the long-term energy transition has also led to ambivalence and inconsistency.

To add to this is uncertainty over outcomes: global warming may overwhelm all nations and firms, without distinguishing between those that moved away from carbon-based energy and those that did not. This may challenge the existing basis of hypothesis and proposition formulation. The hypothesis formulation rests on an existing body of evidence, suggesting that future developments can

be understood based on the past, which increasingly may no longer be the case. The proposition formulation rests on a familiar corpus of theory; new theorizing to better approximate and predict emerging socio-economic realities is likely to result in more novel sets of propositions, again requiring novel analytical tools and data sources.

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NOTES

¹The U.S. and U.K. are not the only countries with mixed and sometimes contradictory policies; in Spain, which is a world leader in *onshore* wind farms, often with strong local support, it has become very challenging to expand the industry *offshore* despite very promising weather conditions, in part because of vested interests in support of the onshore alternatives (Salvador et al., 2018).



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