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INCUMBENTS' DIVERSIFICATION AND CROSS-SECTORIAL ENERGY INDUSTRY DYNAMICS

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Abstract

Within the sustainability transitions literature, established, mature or incumbent firms have been stereotyped as 'locked-in' to socio-technical regimes. However, we believe regimes have been black-boxed, and few studies have explored incumbents' responses to transition processes. This article aims to achieve an improved understanding of incumbents in established energy sectors and their extent of involvement in other (niche) energy sectors. To this avail, we analyze data from a first-of-its-kind survey of 133 incumbent firms in Norway's two main energy sectors, namely oil/gas and hydropower. Providing inter-temporal dimensions, our data covers incumbents' diversification activities beyond their primary sector both in the past (cancelled activities), present (ongoing activity in secondary sectors) and future (ambitions of diversification), and also distinguishes between producers and product/service suppliers. By incorporating insights on firm diversification, our analysis sheds new light on the complex transformation processes associated with sustainability transitions. Empirical results show considerable heterogeneity in incumbents' responses to changing selection pressures, which can be explained by recognition that windows of opportunity are opening and some incumbents see potential to leverage their resources and capabilities to capture value in new niche energy sectors in both domestic and international markets.

Highlights

- Multidisciplinary analytical approach to explore cross-sectorial industry dynamics
- Novel quantitative study design with inter-temporal and cross-sectorial dimensions
- Empirical mapping also captures incumbents' various value chain positions
- Results show that energy incumbents are diversified into other (green) energy sectors
- Industrial change processes are underpinned through empirical explanatory factors

Keywords: Incumbent, diversification, sustainability transition, multi-level perspective, selection pressure, strategy

1 Introduction

Within the sustainability transitions (ST) literature, and the multi-level perspective (MLP) in particular, established, mature or incumbent firms have tended to be stereotyped as 'locked-in' to socio-technical regimes, i.e. supporting established technological trajectories (Geels et al., 2016). Firms that introduce innovations are important conveyors of change, and in this respect many researchers have contributed to the understanding of firm level roles and strategies amongst new entrants and niche actors (e.g. Konrad et al., 2012). However, regimes have been black-boxed, and few studies have explored incumbents' responses to transition processes (Hansen and Coenen, 2015, Karltorp and Sandén, 2012). Farla et al. (2012, p.996) stress that if *"we understand the struggles of actors with competing interests (…) we will better be able to assess the conditions for sustainability transitions to materialize."* Following this research call, this article seeks to complement other existing case based studies of incumbents in established sectors by investigating variation of incumbents in terms of diversification activities as they respond to changing selection pressures on their core activities as well opportunities associated with novel technologies and emerging industries.

Our point of departure is that a too narrow perspective on established firms and their innovation processes comes with the risk of relegating incumbents' innovative capacity and potentially positive role in the much-needed transformation of current unsustainable energy systems. Incumbents within their given sector possess the resources to steer future directions in their industry and influence regulatory matters in political decision making through lobbying, but are also capable of creating substantial changes beyond their industry through re-allocation of human and financial resources to develop or deploy new technologies (Geels and Schot, 2007). Incumbents that diversify into other (emerging) sectors may contribute with enhanced credibility of novel technologies, technological variety and innovation, important knowledge and resource transfer (Erlinghagen and Markard, 2012), the latter being of particular importance in terms of scaling up renewable energy technologies (Karltorp, 2014).

Most studies of incumbents in the ST literature have focused on 'lead firms' such as utilities, (major) car manufacturers and fossil fuel producers. These industries, however, encompass a broad range of firms such as suppliers of specialized and intermediate products and services. In the energy sectors, lead firms such as utilities or oil and gas producers are most often technology *deployers* or users, rather than technology *developers*, suggesting that considerable technological development and innovation (new products and services) occurs amongst suppliers, many of which must also be regarded as incumbents. We suggest that insufficient attention has been given to these 'non-lead' firms (various product/service suppliers/providers) that develop new solutions (often in collaboration with users) and provide a range of necessary inputs and complementary assets to lead firms. A more comprehensive view of understanding different types of incumbents (i.e. in different value chain positions) may provide valuable new insights into incumbents' involvement in the development of new technologies.

Against this background, this article contributes to understanding industrial transformation in energy industries through an analysis of incumbents' diversification activities within and across several energy sectors. To this avail, we analyze the results from a survey conducted in 2013 of both producers and product/service suppliers in Norwegian energy sectors, focusing on Norway's two dominant energy sectors: (large-scale) hydropower and (offshore) oil and gas (O&G). Both of these sectors have experienced forms of turbulence or stagnation (i.e. changing selection pressures) over the past two decades. In previous case studies we have studied how some firms in these industries have responded to altered business environments, and found that internationalization and diversification into emerging sectors such as offshore wind power has been an important strategy (Weaver, 2016, Steen, 2016). Our survey data allows us to expand on this previous qualitative work to explore the extent and direction of diversification into new energy technology fields by a range of incumbent firms and provide explanations for these trends. Our analysis thus has both inter-temporal (past, present and future) and cross-sectorial (multiple energy sectors) dimensions. The main research questions addressed in this paper are *what sectorial level historical, current and future diversification development patterns have been observed or are anticipated in Norwegian energy industries,* and *how can these development patterns be explained?*

Following several calls for more multidisciplinary research designs, our analytical framework seeks to contribute to the ST literature by drawing on perspectives on firm diversification and implications for industrial transformation. Our focus on diversification is (empirically) not geographically bounded within Norway, as internationalization components are incorporated into our research design. Having that said, cross-sectoral diversification rather than geographical (market) diversification is our main concern here, reflecting that our primary objective is to shed light on industrial transformation processes that may be associated with sustainability transitions. We must also note that it is beyond the scope of this article to discuss in-depth incumbents' 'non-market' responses to changes in their external business environment, such as strategies that seek to influence political, legal or social arrangements (Lauber and Sarasini, 2015).

The article proceeds as follows. In the following section we outline the theoretical framework. In section three we present our research setting, design and data. Section four presents the empirical results, which we discuss in section five. We then summarize, present ideas for further research and outline policy implications in the conclusion.

2 Theoretical framework

2.1 The multi-level perspective and the roles of incumbents

Seen broadly, global energy systems are currently undergoing a shift from large-scale centralized power production based on a limited number of energy sources (coal, gas, nuclear (and in some contexts) hydropower) to much more varied systems based on or incorporating many (renewable) energy production technologies (e.g. wind, solar, bioenergy, etc.). This 'greening' process of global energy systems, with the rise of intermittent decentralized production (e.g. rooftop PV), storage challenges, and demands for infrastructure innovation (smart grids etc.) imply that many energy industry incumbents are presently subjected to (potentially) disruptive change.

Following the terminology of the multi-level perspective (MLP) (Geels, 2002), these change processes affecting established socio-technical systems are a result of both changing 'landscape' pressure (e.g. emission reduction targets, fossil fuel resource depletion, citizen concern of climate change) and the emergence of various new and rapidly developing niche energy technologies (e.g. solar, wind). Radical change is seen to emerge in technological incubation spaces (niches), and "*are carried and developed by small networks of dedicated actors, often outsiders or fringe actors*" (Geels and Schot, 2007, p. 400). The 'socio-technical regime' concept in ST literature is based on evolutionary economists Nelson and Winter's (1982) seminal introduction of the notion of 'technological regimes', which refers to shared cognitive routines within a community of engineering practice and which explains why technological change tends to follow specific trajectories. Building further on this work, Hoogma et al. (2005, p. 211) defined a socio-technical regime as a "*whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, established user needs, regulatory requirements, institutions and infrastructures.*" As such, regimes form the institutional context for technological and economic practices, problem-solving and strategic decision making within an industry (Geels, 2010, Fuenfschilling and Truffer, 2014). Path dependence and the embeddedness of technology in routines, production practices, organizational structures, infrastructures, consumption patterns, cultural values and mental frameworks explains why innovation processes in regimes are mainly incremental and aimed at optimization rather than transformation. The sustainability challenge is thus aggravated by the path dependent co-evolution of institutions and technology leading to established socio-technical systems being "*locked in and stabilized on several dimensions*" (Geels, 2010, 495), making transitions long term processes often spanning several decades.

The MLP posits that socio-technical transitions come about due to interacting processes within and between three levels of heterogeneous configurations of increasing stability (niche, regime, landscape), whereby pressure from the landscape level destabilizes regimes and opens up windows of opportunity for niche technologies (Markard et al., 2012, Geels, 2010). Whilst seminal MLP articles (e.g. Geels, 2002) distinguished starkly between 'regimes' and 'niches', for instance in terms of actor involvement and roles, this interaction has more recently been recast as relatively porous, suggesting that regimes and niches form a continuum rather than dichotomies (Fuenfschilling and Truffer, 2014, Smith et al., 2010). This reconceptualization of regime-niche interaction also led Turnheim and Geels (2013) to argue that destabilization of regimes may result from reduction in flows of resources, decreasing legitimacy or eroding endogenous commitment, i.e. various exogenous and/or endogenous factors to a focal regime. Various 'transition pathways' or types of transitions have been identified, depending on nature and timing of selection pressures and the availability of resources (endogenous and exogenous to the regime in scope) to adapt to those pressures (Smith et al., 2005, Geels and Schot, 2007).

It is commonly inferred that incumbent firms form the backbone of regimes. Whereas regime actors also incorporate users, regulators, industry associations and so on, our focus is on the industry or production side of the regime. In so doing, we follow Karltorp and Sandén (2012), who suggest that changes in established sectors (such as hydropower or O&G) – for instance if incumbents diversify into other sectors - is indicative of regime change, or, in the words of Turnheim and Geels (2013, p. 1749) regimes losing "*their grip on firms-in-industries*". Incumbents in regimes have however been tended to be black-boxed (Hansen and Coenen, 2015), and few studies have explored incumbent firms' responses to transition processes (Geels, 2014a). Regarding incumbents, key questions of particular relevance to transition processes concerns their ability and willingness to innovate and explore niche technologies and also whether or not they contribute to creating an enabling environment for new technologies, for instance through influencing legal or political arrangements.

It is well established that incumbents will be more inclined to develop their existing products further than do something entirely new (Hoogma et al., 2005). New technological innovations that possess the potential to result in technological disruption (Christensen, 1997) will be seen as a threat to the existing line of business and therefore tend to be met with defensive responses from incumbents. For example, UK energy incumbents in coal, gas and nuclear have historically resisted a shift towards renewable energy sources (Geels, 2014b). Other studies have demonstrated how fossil energy incumbents resist more stringent environmental regulations (Penna and Geels, 2012, Kungl, 2015) or how utilities with vested interests in mature hydropower production assets have responded reactively to new policy instruments to support the deployment of new renewable energy technologies (Lauber and Sarasini, 2015). The literature provides various explanations for this resistance, such as the narrowing effects of established cognitive routines (Nelson and Winter, 1982), embeddedness in fairly rigid structures (user-producer relationships, supply chains, specific markets etc.), risk avoidance, and vested interests (e.g. sunk costs in manufacturing equipment, competencies and infrastructure). What several recent studies illustrate, however, is that the responses by incumbents is highly heterogeneous (e.g. Lauber and Sarasini, 2015, Geels et al., 2016, Berggren et al., 2015). This underscores the need for closer scrutiny of incumbents' (potential) roles in industry transformation processes associated with sustainability transitions.

2.2 INCUMBENTS AND DIVERSIFICATION

Before we proceed with our discussion of the role of incumbents in industry transformation processes we find it prudent to clarify the term 'incumbents', which is rarely (if ever) defined in the ST literature. We chose to use the Oxford Dictionary of Economics definition: "a firm which is already operating in a market." As such, we conceptualize incumbent firms as being profit-seeking actors that are 'established' and 'positioned' in markets. Incumbent firms have vested interests, historically accumulated capabilities, established supply chain linkages and institutionalized ways of operating.

Although incumbents muster a stock of historically accumulated resources, these can also constrain future strategic options (Teece et al., 1997). Whilst incremental innovations resulting in cumulative patterns of technological change (Breschi and Malerba, 1997) are part of the stabilizing factors of established paths, there are nonetheless many examples of incumbents developing radical innovations. Therefore, whilst new technologies can constitute threats to incumbent firms, they can also provide 'windows of opportunity' for new value creation (Novotny and Laestadius, 2014). It has been found that when some incumbents do invest in radical innovation they may keep them 'on a leash' (Smink et al., 2015) to avoid disrupting core product markets or hinder their deployment until the incumbent has built a position to benefit from their implementation into the market. Other times incumbents may develop radical innovations, yet not commercialize the technology due to various reasons (e.g. lack of market readiness or supporting infrastructure). Hesitation to develop a new technology further can also be the result of endogenous firm challenges to adjust or transform business models and organize strategies in order to reap the benefits (Stieglitz and Heine, 2007).

Contributions within different strands of literature suggest that incumbents may play important roles in the development, maturing and diffusion of niche technologies. For instance, previous theorizing on organizational path dependence has tended to assume that firms stick to one technological path (Unruh, 2000). However, some incumbent firms are capable of handling multiple technological paths (Bergek and Onufrey, 2014). Within the heavy vehicle transport sector Berggren et al. (2015)

illustrate how incumbents pursue contrasting technology strategies whereby both 'regime' and 'niche' technologies are developed simultaneously. Wesseling et al. (2015) finds the same contrasting technology strategies employed by electric passenger vehicle manufacturers, further showing the effects of being first movers or late comers. They additionally suggest that companies need both incentives (referring to aspirations to enhance competitiveness and increase market shares through innovation) and opportunities (referring to the investments companies can make in order to support innovation) in order to pursue radical and sustainable innovations. This distinction helps explain why some incumbents pursue niche technological innovations, and others do not. Lauber and Sarasini (2015) found that in the power generation sector, utility companies in Germany and Sweden differ in their responses to new renewable energy technologies according to differences in their perceived financial interests (depending e.g. on domestic natural assets) and thus sought various strategies to influence regulatory matters that either facilitate or hinder the deployment of (new) renewable energy.

There is considerable anecdotal evidence to support the more nuanced understanding that incumbents do in fact actively pursue niche technological innovations (both through technological *development* and *deployment*). To give but a few examples from the energy sector, DONG Energy (Denmark, O&G/multi-energy) is the current world leader in offshore wind deployment, whereas Siemens has the largest market share of offshore wind turbines installed. Statoil (Norway, O&G) developed and installed the world's first floating offshore wind substructure, whilst GE (US, electronics) and Caterpillar (US, heavy transport) are racing to develop more efficient locomotives to meet new emission standards for rail transport. These examples illustrate both incumbents developing novel solutions reactively because of exogenous pressures (e.g. regulations), and incumbents taking proactive steps to identifying new growth areas.

Geels (2014a) suggests a typology of linked response strategies to external pressure posed by competition from new technologies. In the first stage, incumbents will not perceive changing selection pressures as important (or misinterpret) and thus act in denial. In the second stage, increasing pressure will lead to small adjustments based on local search processes (incremental innovation). In stage three, external pressures gain enough strength that incumbents initiate more distant search and strategic reorientation processes with exploration into new technologies and development of new capabilities. Finally in stage four major external stress and continuing structural performance problems leads to strategic recreation where behavior, mindsets and missions are radically altered. As suggested by Karltorp and Sandén (2012) increasing firm divergence from a dominant technological path (or 'regime fragmentation') may indicate regime destabilization.

Taking these insights in tandem suggests that over time incumbents feeling the pressure to change and possess opportunities or recognize incentives will pursue alternative activities (e.g. in emerging sectors), and those without will act more defensively aiming to protect their market positions and corporate interests. Yet responses will also be contingent on the nature and scale of external pressures (Geels, 2014a) in addition to the resources, capabilities, and managerial mindsets within firms. Few ST studies have addressed the role of incumbents entering other sectors (Erlinghagen and Markard, 2012, Karltorp and Sandén, 2012) although some have argued that incumbent firms that diversify into other (new) sectors may play important roles in sectoral transformation (e.g. Dolata, 2009). Established firms that diversify into 'adjacent' or 'related' (emerging) sectors may transfer important knowledge and other assets, leading not only to expansion of technological variety, but also variety in business models, networks and innovation strategies (Erlinghagen and Markard, 2012, Poel, 2000, Raven and Verbong, 2007, Dolata, 2009). This is also acknowledged by Geels and Schot (2007), who suggest that incumbents that choose to adopt niche innovations can help propel them from niche status to full market economy, and thereby contribute to faster implementation of new solutions (see also Mignon and Bergek, 2016). An often-used incumbent strategy is to leverage complementary assets into new technology domains via cooperation (such as strategic alliances) with new entrants that tend to develop more radical innovations (Rothaermel, 2001). For example, large corporate firms that have invested into entrepreneurial firms in the marine renewable energy industry have contributed with important credibility to those technologies (and industries) in addition to increased network and market access (Bjørgum and Sørheim, 2014).

As stated in the introduction, most attention in the ST literature has been devoted to lead firms such as utilities. However, energy sectors are complex industries comprised of various firms and both vertical and horizontal value chain dimensions. Many energy sectors (and other sectors) have overlapping value chains and various forms of interaction (beyond competition) both in upstream and downstream phases (Sandén and Hillman, 2011). We argue that resources are needed from both suppliers and producers for the *development* and *deployment* of new technologies. Whereas suppliers are the main providers of new technologies in the energy sector, producers are largely responsible for deployment into the marketplace. One potential effect of lead firms' diversification into other (emerging) sectors is that their suppliers follow suit, provided suppliers have relevant capabilities. In this way, suppliers launching activities in new markets by following or 'piggy-backing' key customers (lead firms such as utilities or larger suppliers) may be an important mechanism of resource and knowledge transfer between sectors. Producers may however also invest into in-house technology development as well in external technology developers, e.g. through corporate venture funds (Bjørgum and Sørheim, 2014). Suppliers enable possibilities to leverage existing physical assets in manufacturing capacity, competence in design engineering, and supply chain networks in order to achieve innovation advancements and cost reductions. Producers bring knowledge of project management and crucial financial resources for deployment to achieve economies of scale and dynamic feedback effects that facilitate further diffusion.

Diversification and associated resource transfer from established to emerging sectors will be guided by incumbent firms’ historically developed assets and capabilities, as firms tend to diversify into sectors that are technologically related so that historically accumulated capabilities can be 'recycled' (Neffke et al., 2011, Breschi et al., 2003). Empirical studies suggest that firm level related diversification is more successful than unrelated diversification (Helfat and Lieberman, 2002, Shin and Jalajas, 2010). Diversification is motivationally impinged upon firm growth and survival (i.e. proactive and/or reactive strategies), often entailing future strategic orientations to either continue developing existing product lines (exploitation) or pursue new opportunities (exploration) (March, 1991). Exploitation emphasizes refining the firms' knowledge base through incremental steps with high degrees of control, certainty and risk minimization (Prange and Verdier, 2011). Exploration entails greater departure from routines (Barkema and Drogendijk, 2007), with discovery, experimentation, and innovation at its core. In tandem with literature on organizational ambidexterity (Raisch et al., 2009), Prange and Verdier (2011) argue that a combination of the two are necessary, as solely pursuing exploitation results in eventual obsolescence, whereas exclusive exploration does not allow for accumulated knowledge to be commercialized. Resource allocation between exploitative and exploratory activities characterizes the managerial challenge of pursuing multiple paths.

Diversification will be influenced by institutional environments and the perceived opportunities and barriers for growth in both established and emerging sectors. This may be linked both to visions and expectations of growth (or decline) of certain technologies and industries rather than others (van Lente, 2012), or more directly to policy interventions and the introduction of instruments to promote the development, diffusion or deployment of new niche technologies (Kivimaa and Kern, 2016). Incumbent power utilities are likely to strike an investment balance that contributes to reducing environmental impacts yet conforms to extant technological pathways tied to sunk costs in existing infrastructure (Lovio et al., 2011), whereas many product suppliers are bound by manufacturing infrastructures. Complicating managerial matters, energy sector incumbents seeking exploration into emerging energy sectors are often highly exposed to changes in the external environment outside their organizational scope and often national boundaries of operation. Institutional environments differ considerably between countries (and even on sub-national levels (Martin and Coenen, 2014)) and specific market segment opportunities (Dewald and Truffer, 2012) will thus often be found in other contexts than firms are accustomed to operating within.

3 RESEARCH SETTING, DESIGN AND DATA

Norway is an energy rich nation, with total primary energy production (fossil and non-fossil) exceeding the combined energy production of Denmark, Sweden and the UK (Hansen, 2013). Hydropower has always dominated power generation in Norway, with the majority of production capacity built out in the 1950-70s. This well-established renewable energy technology currently provides ~97% of Norway's electricity production with the sector accounting for 2,4% of GDP (NHO, 2012). Uncoupling of the vertically integrated utility began in 1991 (deregulation), whereas end consumers are now able to choose their provider suggesting a fully unbundled deregulated market dominated primarily by publically owned yet privately operated (profit driven) firms. Figure 1 reflects that of Norway’s total domestic hydropower resource base of 219 TWh, 61% has been developed and 24% is protected. A little less than half of what remains accessible (16%) is already in development phases (MoPE, 2016). Most of the remaining available hydropower potential is in small-scale distributed plants without regulating capabilities (no dam storage), making it of less strategic interest to incumbents of the sector.

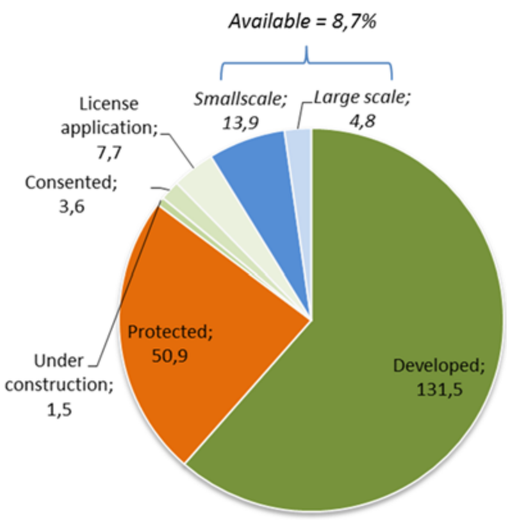

Figure 1 Hydropower resources in Norway (TWh) (MoPE, 2016)

Norway's commitments under the European Economic Area Agreement with the EU have resulted in a commitment to increase its share of primary renewable energy consumption from 60,1% in the 2005 baseline year to 67,5% in 2020. The strategic plan of implementation has resulted in a joint 'tradable green certificate' (TGC) scheme for renewable energy (RE) in the power sector with Sweden, with both countries jointly responsible for adding 26,4 TWh (recently expanded to 28,4

TWh) of new clean power to the common grid. The estimated production trajectory of RE share of electricity for Norway is anticipated to be 113,6% in 2020 (MoPE, 2012), reflecting Norwegian ambitions to become a clean power exporter ('green battery') in offering balancing services needed for planned expansion of European intermittent RE resources (Gullberg, 2013). The TGC scheme is technology neutral, suggesting new RE technologies have to economically compete with more established RE technologies with lower costs. So far the TGC scheme in Norway has resulted in deployment of onshore power wind and the construction of many small hydropower plants. Outside of the scheme many biomass based district heating plants have fulfilled local needs for heat. It is also important to note that Norway, unlike most other countries, does not have fossil fuel based electricity production as a key component in its energy mix.

Norway is however a major producer and exporter of oil and natural gas (O&G), with most of the gas being exported to Europe where it is used for electricity generation and household consumption. The extraction of fossil fuels on the Norwegian continental shelf (NCS) currently generates tax revenues amounting to ~25% of GDP, and represent ~50% of total exports, making the petroleum sector Norway's largest industry (MoPE, 2016). Figure 2 reflects Norway's speedy rise as an O&G producer since the early 1970s to 2000, the subsequent (moderate) decline in production levels thereafter, and future prognosis. Peak oil occurred already in the early 2000's in Norway, and while production of natural gas has expanded overall available petroleum resources[1], they are ultimately on the decline. However, the Norwegian O&G industry (both producers and suppliers) is highly internationalized.

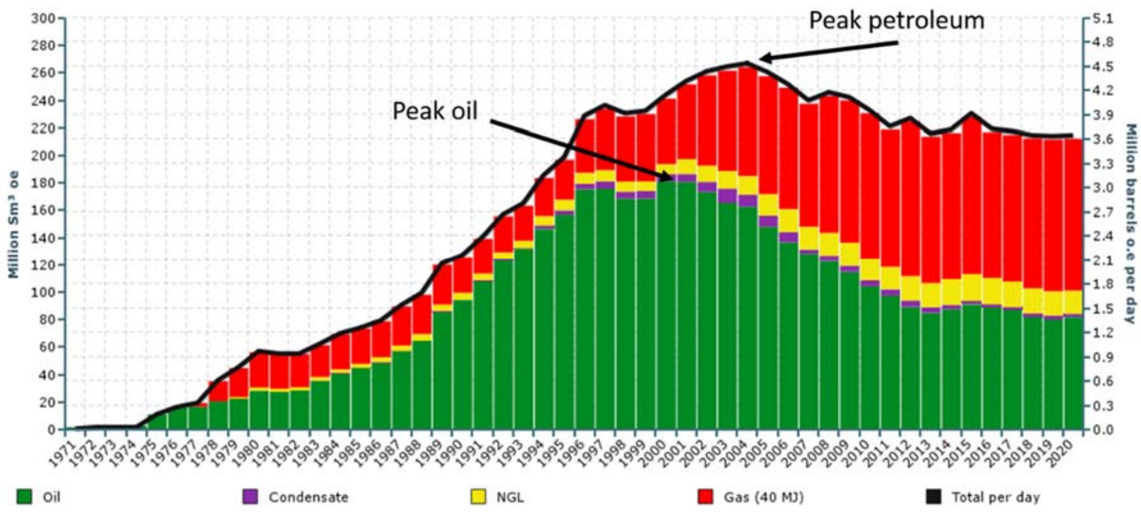

Figure 2 Historical oil and gas production and prognosis for coming years (MoPE, 2016)

[1] Based upon proven reserves.

Norwegian O&G firms have maneuvered in an uncertain environment since the early 2000s. This was a result of resource depletion on the NCS, uncertainty regarding access to new resource areas, high cost levels compared to other countries (both resource regions and manufacturing sites), lack of access to skilled engineering talent, and considerable unpredictability regarding long-term (global) price levels. The latter is linked to uncertain demand growth levels in emerging economies, the rise of unconventional O&G extraction methods (e.g. shale gas and tar sand resources), and increasing competition from renewable energy.

The period after the 2008 financial crisis up until early 2011 was particularly characterized by widespread pessimism in the Norwegian O&G industry (Hansen and Steen, 2015). Optimism was renewed in 2011 following several large resource discoveries in mature production areas on the NCS. Global oil prices rose, leading to unprecedented high investments levels. This optimism was also connected to expectations of future access to new resource extraction areas in the High North latitudes.

The institutional context governing domestic activity in this sector is characterized by setting stringent environmental, health and safety requirements, high taxation, and a dominant state owned firm (Statoil) to maintain control over operations. The original frameworks for regulating the sector were drawn up based upon hydropower resource management. In line with the Nordic social democratic model, primary goals of regulating both O&G and hydropower have historically been to maximize societal welfare value capture for the extraction of natural resources (seen as a common good).

Given Norway's strong industrial foundations built around these two core energy industries (hydropower and offshore O&G) with limited opportunities and significant future uncertainties in the mid to late 2000s, we were motivated to investigate the response of incumbents in these sectors to changing selection pressures and the emergence of new potential growth areas. In addition, it is important to note these industries transcend national borders through export cables and undersea pipeline networks, as 2013 export sales account for 24% of total revenues in the renewable energy industries (Multiconsult, 2014). This international orientation is (naturally) strongest in sectors that have little to no home market. For instance, although Norway does not have a domestic offshore wind market, the Norwegian offshore supplier industry is located in close proximity to the rapidly growing offshore wind markets in Northern Europe. This also presents interesting trading opportunities for the power sector should large-scale offshore wind farms be interlinked to both Norway and the UK.

3.1 Analytical model

Our analytical model displayed in Figure 3 reflects how our survey aimed to map incumbents' activities in their main or primary sector (O&G and hydropower) as well as their (potential) activities in secondary sectors in the (near) past, present and (near) future. For example, a firm in hydropower (main sector) may have electricity production as its main activity, but also be involved in one or more secondary sectors such as bioenergy. The firm may have previously been involved in other secondary sectors (past), and also have ambitions of entering yet other new (to the firm) sectors in the future.

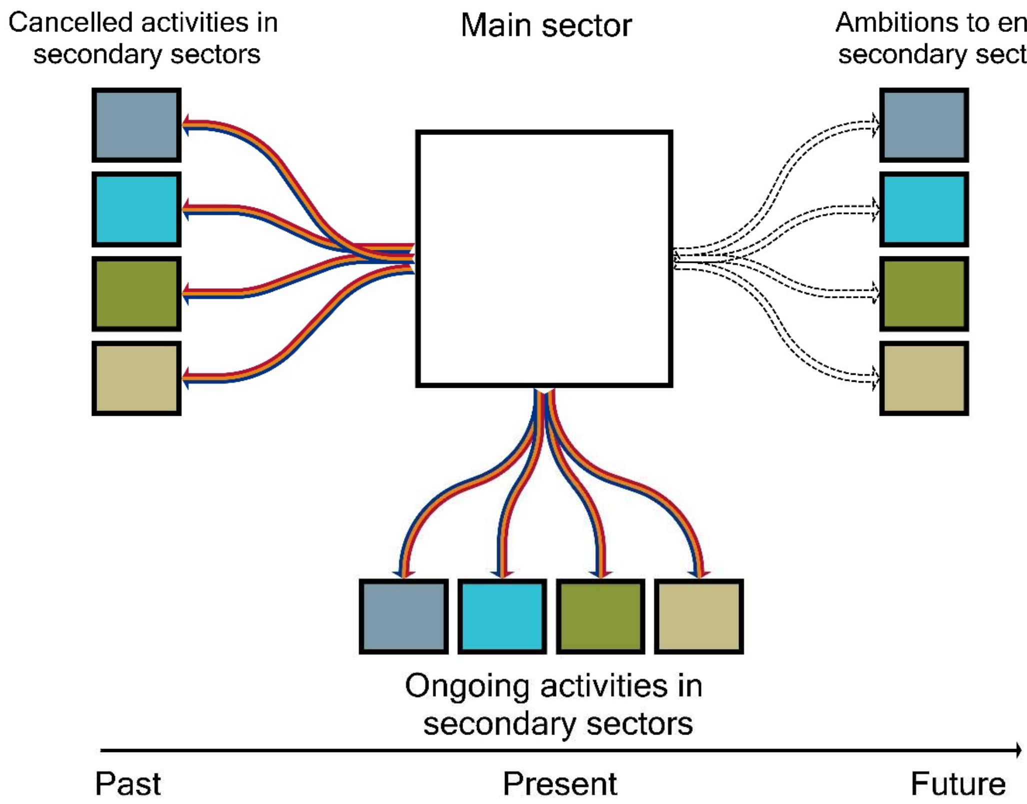

Figure 3 Analytical model

After mapping out these overall trends we provide explanations to these observed processes of industry transformation. Guided by strategic management and organization theory,[2] we created a set of explanatory variables (see appendix) that comprise the foundation for understanding how selection pressures are shaping business dynamics (namely motivations and barriers) for diversification.

[2] Key perspectives were drawn from e.g. Schumpeter, Penrose, Ansoff, Porter, Barney, Teece, on firm growth, resources, dynamic capabilities, absorptive capacity, complementary assets, etc.

3.2 RESEARCH DESIGN AND DATA

To achieve these analytical aims we deployed an online survey in 2013 directed at both upstream producers and suppliers. The survey sought to open the 'black box of regime dynamics' by uncovering firm perceptions of sectorial development, variation in firms' product and market diversification activities and their motivational and constraining factors. The survey was designed based upon the authors' previous qualitative research in the same context, thus survey findings are supplemented with formerly acquired empirical insights (Hansen and Steen, 2015, Weaver, 2016, Steen, 2016).

The survey target population was firms in all Norwegian energy sectors[3]. Our list of respondents was developed by collecting private emailing lists from nine member based energy interest organizations. Three of these had contact information details whilst six were made accessible to us. The member lists generated a total of just over 1,100 firms (producers and suppliers). Removal of duplicates and firms outside of our empirical scope (e.g. attorneys, regional growth agencies, banks) generated a final sample of 650 firms. We launched the internet based survey in May 2013, with three reminders sent two weeks apart. After data cleansing (excluding duplicate and incomplete responses) we were left with 213 responses. This 33% response rate is slightly higher than other surveys of this kind (Sauermann and Roach, 2013), which we attribute to direct access to email addresses. CEOs and senior managers represent 61% of our responses, whereas 59% had been within their respective firm for 6 years or more. The survey was anonymous, which intended to open up respondents' willingness to answer strategically sensitive questions, yet this restricts opportunities to combine survey results with other quantitative data sources.

As stated in the introduction our analysis only utilizes responses from hydropower and O&G incumbents (102 O&G, 31 hydropower). The 'incumbent' category here is based on firms' own reporting on firm life cycle phase as shown in Table 1. Based upon our definition of incumbents (section 2.2), we deemed the latter three life cycle categories as such given they 'possess a stake in the market'.

Table 1 Incumbents by phase, sector and main activity

	Oil and gas		Hydropower	
	Producers	Suppliers	Producers	Suppliers

[3] Regarding the overall energy sector population, there were approx. 2465 O&G sector firms in 2008 (ca. 180 operators, the remaining different types of specialized suppliers or sub-contractors). In renewables and infrastructure there were approx. 1240 firms in 2009 (Reve and Sasson, 2012). Nuclear energy does not constitute a sector as such in Norway.

Early growth	2	27	1	1
Mature	3	67	19	10
Stagnation/decline	0	3	0	0
Total	5	97	20	11

Table 1 reflects the number of incumbents within the O&G and hydropower industries that responded to our survey, based upon firm type and organizational maturity. The O&G and hydropower industries are similar in terms of being well established and capitally intensive, but also differ considerably in many ways. They are opposites in terms of the structural composition, with O&G having few producers and many suppliers, whilst hydropower suppliers are few compared to producers. The (offshore) O&G industry has a highly complex value chain, comprised of a wide variety of Tier 1-3 product and service suppliers. The Norwegian O&G industry is prone to varying activity levels largely as a result of international petroleum prices, whereas the hydropower industry has to a large degree enjoyed a very long period of domestic price stability. These two industries are furthermore subject to different rules and regulations, and also subject to different societal expectations with (large-scale) hydropower regarded as the gold standard for electricity production and the O&G industry as the gold standard for money making (Hansen, 2013). These two dominant energy sectors thus constitute distinct socio-technical systems; however there is to some extent overlap in value chains with for instance several large consultancy firms playing important roles in both sectors.

It is important to note that the survey did not capture any precise measurements of resource transfer across sectors, such as capital investments or percentages of human resource allocation to different activities. Our primary aim was to map the landscape of former, ongoing, and potential future activities that could shed light on cross-sectorial dynamics, and to provide some explanatory power to observed trends. However, we do incorporate questions pertaining to the perceived importance of secondary activities for incumbents, which provides insights to their levels of commitment.

One challenge in utilizing a survey as the basis for empirical evidence on diversification and development processes that occur over time is that surveys tend to provide 'snapshot' accounts rather than longitudinal perspectives. We sought to address this methodological challenge by incorporating temporal dimensions of the past, present and future in our survey design. As such the survey covered present time ongoing activities in primary and secondary sectors (the latter being diversification activities), cancelled activities in secondary sectors (diversification) in the past, and ambitions for sectorial diversification in the future. In sum, this allows us to present a broad inter-temporal empirical description of cross-sectorial industry dynamics stemming from diversification activities by incumbents in Norway's two main energy sectors.

There are two distinct limitations to our data. First, the survey only covered diversification across different energy sectors, but it is likely that some firms (especially suppliers) are active in other sectors of the economy (e.g. transport, buildings, process industries). Second, there may be a selection bias in our data in that firms with no diversification activities saw little reason to respond to the survey. Whilst the first limitation does not have any substantial effect on our results or their implications, the second implies that we do not aim at statistical generalization.

We illustrate our descriptive empirical findings on diversification patterns through Sankey diagrams, a well-known engineering tool to depict process flows. Process flows are represented in absolute terms, where the size of flow corresponds to the frequency. Our motivation for presenting our data this way lies in simplification: by combining several questions (i.e. in which sectors are firms diversified?) into a single illustration we are able to visualize aggregate patterns of inter-temporal cross-sectorial dynamics in the Norwegian energy sectors.

4 Results

In the subsections that follow we present our mapping of inter-temporal cross-sectorial dynamics, focusing first on hydropower followed by O&G and discuss these in light of explanatory variables (provided in the appendix) on the meso- (or industry) level. We also draw on our previous qualitative research in the same research setting as well as secondary sources to provide complementary explanation to the dynamics captured in the survey. The section ends with an overall comparison of O&G and hydropower.

4.1 Inter-temporal cross-sectorial dynamics – hydropower

Figure 4 reflects that 11 of 31 hydropower incumbents formerly had a total of 32 activities in secondary sectors.[4] This observation shows a rather wide dispersion of former exploratory diversification activities across all the various energy sectors. Of the 20 hydropower producers, nine (45%) have (unsuccessfully) attempted diversification into other energy related sectors.

[4] The reader must understand that one firm cannot have more than one activity in a single secondary activity at a time. Thus the 11 firms that pursued and ultimately mothballed the 32 diversification initiatives does not equally mean each firm tried to diversify into two activities, but rather that some firms tried a wide variety of new technological areas, whereas others may have only pursued a single diversification strategy.

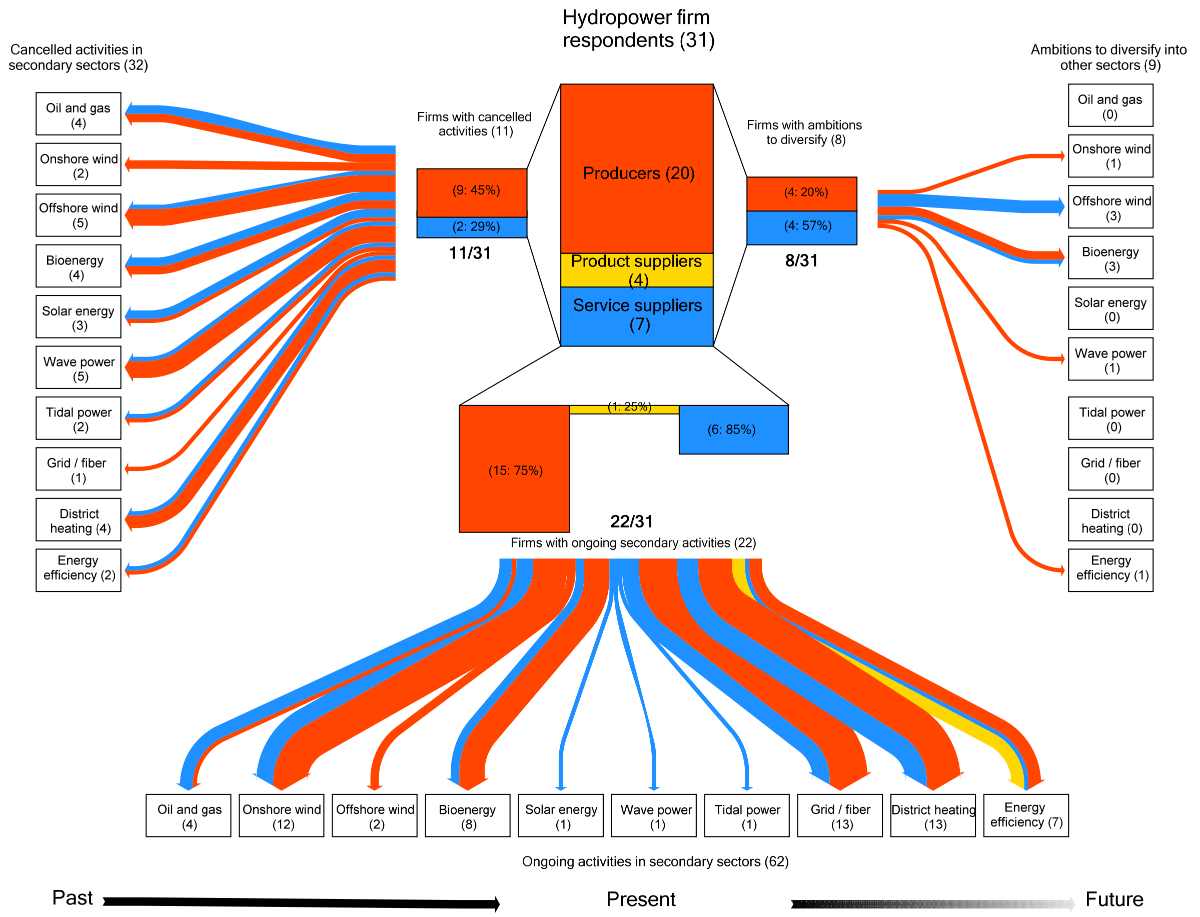

Figure 4 Hydropower diversification past, present and future

Past exploration attempts into various secondary sectors (niches) suggest that many incumbents have surveyed viable new business areas to invest into, yet for various rational retreated (Table A.2). To a larger degree, diversification efforts from 75% of the incumbent producers resulted in positive outcomes, as they retained ongoing operations in secondary sectors. Given the high degrees of current diversification into a variety of other energy sectors, it is not surprising to see lower future ambitions amongst the producers.

Both hydropower producers and suppliers are highly active in a number of other sectors within the energy system. Of the 31 hydropower incumbents, 22 firms have an accumulated total of 62 ongoing activities in secondary sectors. This fact underscores the depth and complexity of cross-sectorial energy industry interactions. Currently 75% of the hydropower producers and 85% of the service providers are active in multiple energy sectors. To some extent this is natural for producers as investments in supporting grid infrastructure support existing power supply operations. However, high activity levels in onshore wind, bioenergy and district heating suggest that a number of niches are being pursued as well. Several service suppliers are also present in these niches, reflecting that many suppliers are motivated to diversify by following their customers (Table A.3).

Respondents indicated that primary motivations for sectorial diversification are reusing existing competence and resources, and positioning for the future to capture more attractive business opportunities (Table A.3). Increased optimism (Table A.1) amongst suppliers in the hydropower sector is connected with the anticipated deployment demand as a result of the TGC scheme. The introduction of an additional 28,4 TWh of production capacity is likely to negatively influence energy prices as demand is relatively stable, which helps to explain less optimistic future outlooks on behalf of hydropower producers. Similarly to many other countries, the arrival of new subsidy mechanisms that promote RE technologies provides both opportunities and threats to incumbent power producers (e.g. Lauber and Sarasini, 2015). Whilst hydropower incumbents recognize the value capture opportunities offered by deploying new power technologies into the market (hydro or otherwise), the accrued effect of doing so puts downward pressure on their existing portfolios of income generating assets. Investing into new production capacity with marginal revenues thus comes at the expense of negative effects on core business activities, implying that the impetus to invest may be of more strategic (gaining knowledge, building supplier relationships, etc.) rather than pure economic intent.

There are two notable differences between producers and suppliers regarding barriers to (positive) developments in the hydropower sector. First, producers, who make the strategic choices of new production capacity investments, consider uncertain framework conditions and unpredictable policies to be the main barriers (Table A.3). Second, suppliers consider Norwegian cost levels to be more of a challenge than producers, reflecting higher international competition facing the supplier side of the hydropower industry. Perceived barriers to secondary activities for hydropower incumbents reflects that a lack of access to labor is not just something the petroleum industry must adhere to (Hansen and Steen, 2015), but is rather the case for several Norwegian firms competing for engineers and skilled workers.

Given these cross sectorial diversification moves and their underlying explanations, it is worthwhile to ask: how important are secondary sector activities to incumbents? Figure 5 reflects the diversification activities' current level of importance to the incumbents. We see that supporting infrastructure (grid) plays the most crucial role (likely for the producers), followed by onshore wind power parks and district heating.

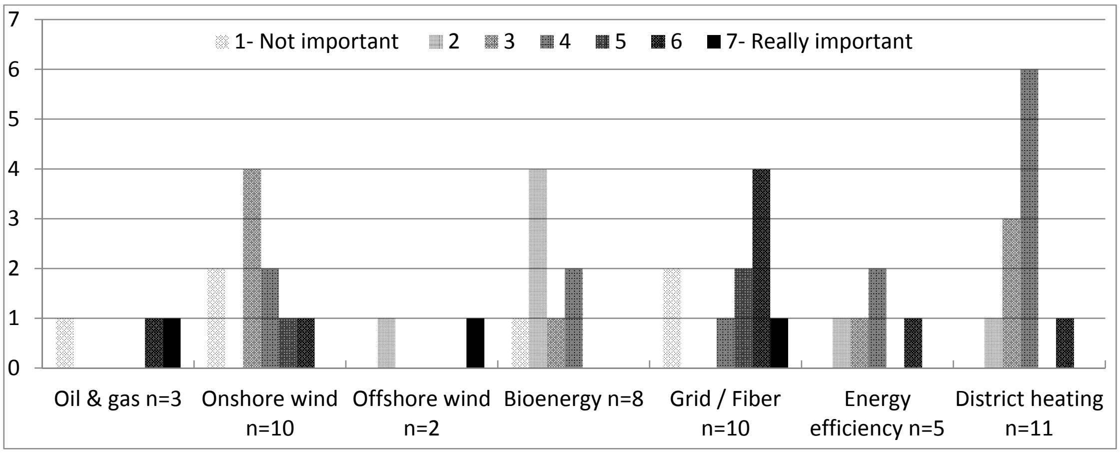

Figure 5: Hydropower incumbents' diversification activity current level of importance to firm

Moving forward we found it equally insightful to ask whether incumbents believed these diversification activities would play a greater role in firm growth and survival in the coming years. Figure 6 reflects high growing importance for grid (in our belief reflecting anticipated implementation of smart grids), as well as higher expectations for onshore wind, bioenergy and district heating. Providing new anecdotal evidence to this data, two hydropower producers in a consortium recently committed to building Europe’s largest onshore wind farm, totaling 1 GW of new capacity at a cost of $1,2 billion (Hovland, 2016).

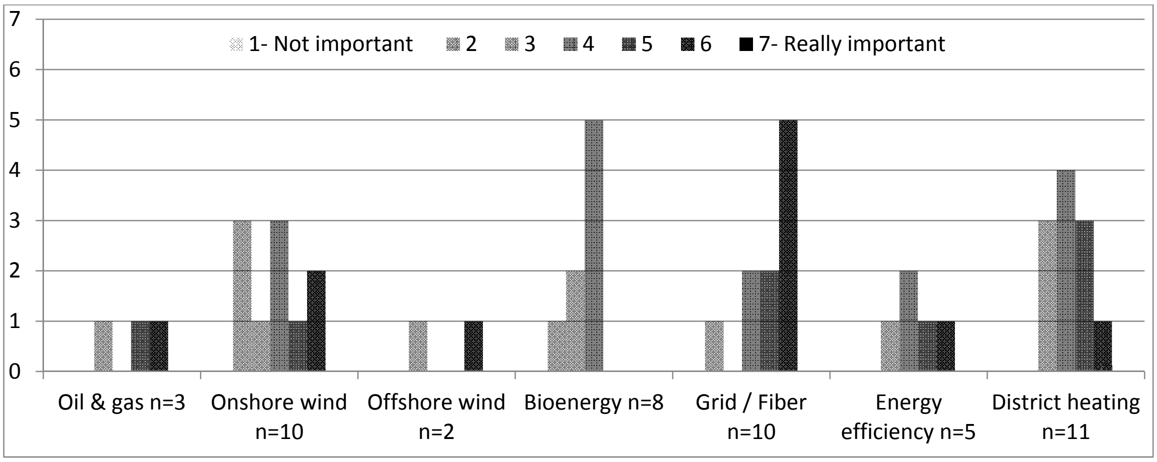

Figure 6: Hydropower incumbents' perceptions of how the diversification activity will develop for the firm in the next 5 years

In light of all the various diversification activities hydropower incumbents are currently involved with, the results reveal that not only is the regime susceptible to change, but more that significant industrial transformation already took place. These cross- sectorial business activities suggest that resources are being reallocated from core business activities into a wider set of activities within the energy system.

4.2 INTER-TEMPORAL CROSS-SECTORIAL DYNAMICS FOR OIL AND GAS FIRMS

Survey respondents in O&G were fairly content with market development the last five years, and both producers and suppliers were optimistic regarding anticipated development of the O&G market in the 5 years post 2013[5] (Table A.4). Considering barriers to development of the O&G industry, there are only marginal differences between producers and suppliers in terms of how they consider various selection pressures that may pose risks to firm operations. Norwegian labor cost levels, which are high by international standards, is seen as the most important barrier to primary activities, reflecting the producers' challenge of keeping costs per barrel down when competing in global markets for sales, and suppliers challenge of keeping labor costs down in what is a fiercely competitive and highly internationalized industry (Reve and Sasson, 2012).

Figure 7 shows that 24 out of 102 O&G sector incumbents have previously been involved in various secondary activities (54 in total), mainly in RE. In particular, several firms have been involved in maritime RE (offshore wind, wave, tidal), reflecting that Norwegian offshore O&G incumbents pursue related industries in which they may apply their specialized capabilities. Despite levels of engagement into these emerging industries, a general lack of domestic deployment has been observed, which in large can be explained by the absence of support schemes for new (and especially immature, niche-type) RE technologies in Norway (Hansen, 2013, Løvdal and Neumann, 2011). As suggested previously, the TGC scheme is technology neutral and thus does not provide sufficient subsidies for more immature RE technologies. These former findings are consistent with our empirical results, whereas survey respondents indicated amongst several other causalities, their primary rationales for abandoning diversification initiatives in these new energy sectors laid in the exogenous political environment (Table A.5). In particular, unmet expectations (Alkemade and Suurs, 2012) of domestic market formation resulted in some firms abandoning these niches.

[5] It must be noted that global oil prices plummeted from mid-summer 2014 up until this write-up (mid-2015/6). We place ourselves at survey launch time (May 2013) when writing our empirical analysis.

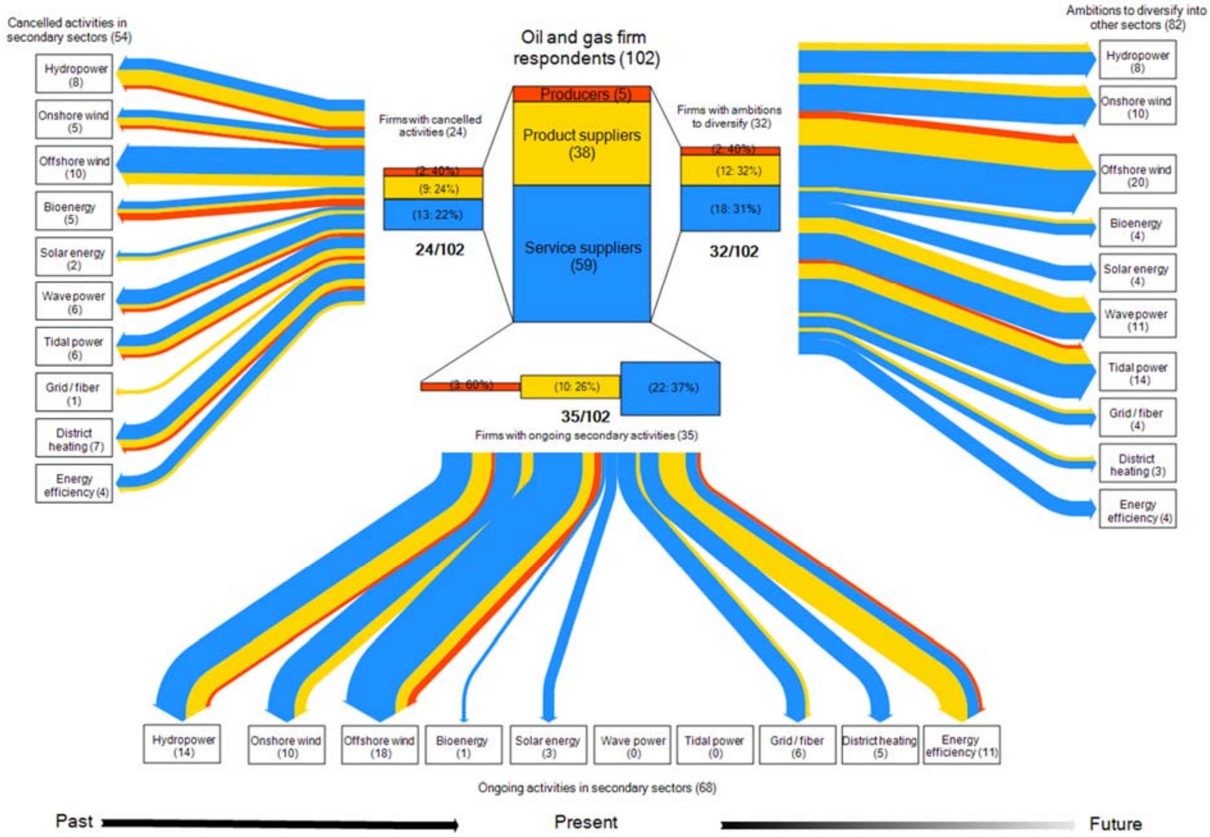

Figure 7 Oil and gas diversification past, present and future

Roughly one third (35) of the 102 O&G industry incumbents are currently diversified. These 35 firms have a combined total of 68 ongoing activities in secondary sectors. Offshore wind constitutes the largest secondary sector for O&G sector firms, but several firms have activities in the hydropower sector, indicating interaction between Norway's two main energy sectors. Offshore wind is the clear sectorial target amongst O&G sector firms in the past, present, and future, suggesting that O&G incumbents believe they have the requisite knowledge and resources to create and capture value in this rapidly evolving niche (Steen, 2016). Several suppliers also have activity in energy efficiency, the clean tech sector in Norway experiencing the fastest growth in recent years (Reve and Sasson, 2012). Whilst there are few producers among our respondents, which is reflective of the structure of this industry, we see that a higher share of producers than suppliers have ongoing secondary activities within other energy sectors. Service providers appear to have the most diverse portfolio of diversification activities, probably reflecting their 'multi-sector' relevance and embeddedness in overlapping value chains (Sandén and Hillman, 2011) rather than these firms having a variety of products tailor-made for different sectors.

What is perhaps most striking about Figure 6 is the relatively high number of firms that have ambitions to diversify in the coming years, notably into maritime RE, and that several firms have ambitions of diversifying into several secondary sectors. The 32 firms that have future ambitions to diversify into a total of 82 activities in secondary sectors indicates a potential shift of attention from O&G activities to a portfolio of activities in other (clean) energy sectors.

Given that the future market outlook is fairly positive amongst O&G sector firms, and that there are few perceived risks that strongly stand out (Table A.4), what motivates these firms to diversify into other sectors? O&G producers and supplier incumbents alike state they are motivated to diversify to position themselves for the future, reuse resources and capabilities, and lastly follow their customers.[6] Motivations to diversify into other sectors also reflect uncertainties associated with future O&G sector developments, hence the relatively high importance of 'reduce dependence on main sector'. Whilst the future developments of new RE sectors are also highly uncertain, the overall expectation is that these will grow. This growth provides opportunities to supplement cyclical and uneven demand in the O&G industry with new market activities in other sectors (Hansen and Steen, 2015), hence the highly cited rationale to position themselves for the future.

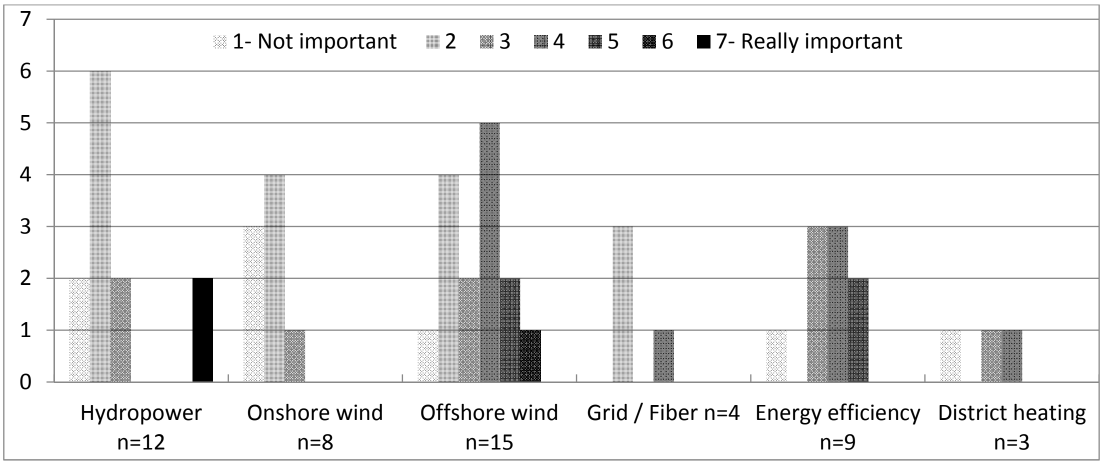

Figure 8: Oil and gas incumbents' diversification activity current level of importance to firm

Figures 8 and 9 reflect these growth expectations, as seen from the view of incumbents that have positioned themselves to capture value in secondary sectors. Figure 7 shows that these secondary activities are modestly important to O&G incumbents at the current time. Normann and Hanson (2015) found that revenues from offshore wind power constituted less than 5% of total revenue for more than half of all Norwegian firms involved in that industry. Knowing that many Norwegian firms operating in the offshore wind sector are O&G diversifiers, this suggests that the magnitude of investments into this niche is fairly limited amongst many incumbent (O&G) firms. Figure 8 however

[6] We treat the high score on producers on the 'following customers' variable with some caution. Customers may in this regard be seen as the overall market, which increasingly calls for energy based on new technologies (i.e. biofuels, electricity from wind turbines).

reflects growing reliance on these diversification activities for firm growth and survival, particularly in offshore wind and energy efficiency.

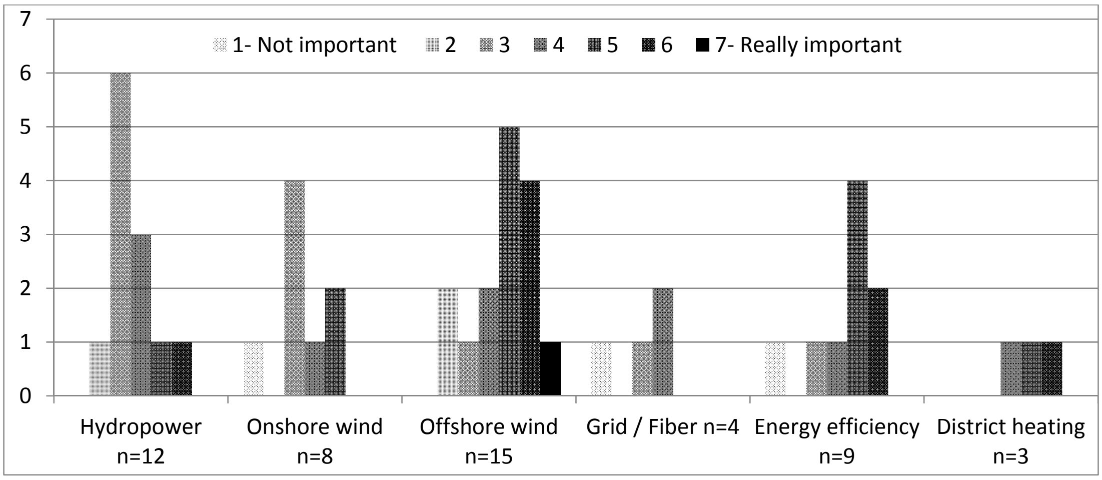

Figure 9: Oil and gas incumbents' perceptions of how the diversification activity will develop for the firm in the next 5 years

Whilst increased importance is also placed on hydropower and onshore wind, all together this empirical data suggests that for the incumbents that are pursuing multiple paths, the current and future transfer of resources into secondary activities is perceived to become more important in the years ahead.

4.3 COMPARING O&G AND HYDROPOWER SECTORIAL DIVERSIFICATION

Table 3 summarizes number of diversification activities by incumbents in the hydropower and O&G sectors respectively. Historical processes of testing opportunities with trial and error through learning investments has resulted in established positions within several niches. What we can learn from the hydropower sector where 77% of incumbents in our sample are well diversified is that these exploration processes do not always result in favorable outcomes for these firms (mothballed projects), whereas others gain traction and momentum within firms for future investments and resource allocations. Given their resources and efforts are already spread over a variety of exploration efforts, that hydropower incumbents possess slightly lower overall ambition levels for future diversification is not surprising. We venture to suggest that hydropower incumbents will be more focused on developing these existing secondary business lines rather than exploring even more technological options. In stark contrast, O&G sector incumbents are currently far less diversified, yet almost a third of all firms have ambitions of future diversification.

Table 3 Number of firms pursuing diversification in hydropower vs. O&G

Firms/activities in secondary sectors		**Hydro (n = 31)**			**O&G (n = 102)**		
		Producers (n=20)	Suppliers (n=11)	Total	Producers (n=5)	Suppliers (n=97)	Total
Cancelled	Firms	9 : 45%	2 : 18%	11 : 35,5%	2 : 40%	22 : 23%	24 : 23,5%
	Activities	21	11	32	7	47	54
Ongoing	Firms	15 : 75%	7 : 64%	22 : 77%	3 : 60%	32 : 33%	35 : 34,3%
	Activities	37	25	62	4	64	68
Ambitions	Firms	4 : 36%	4 : 20%	8 : 25,8%	2 : 40%	30 : 31%	32 : 31,4%
	Activities	5	4	9	3	79	82

These empirical results reflect large degrees of heterogeneity amongst incumbents in these two energy regimes. That suppliers in both O&G and hydropower follow customers (Tables A.3 and A.6) points to the importance of piggy-backing (suppliers follow producers, or sub-suppliers follow (larger) suppliers) inherent in sectorial diversification, given that energy producers and/or large suppliers venture into new technological terrains.

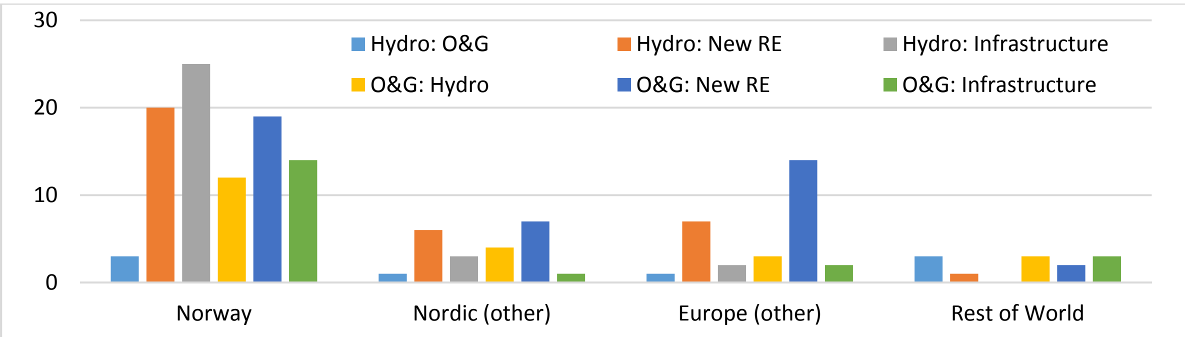

Figure 10: International footprint of energy incumbents' secondary sector activities[7]

Lastly we must underscore that these diversification activities are not transpiring solely within the boundaries of the domestic market but rather on a broader geographic scale. Figure 10 shows a crude geographic dispersion of where diversification is transpiring. Given limited domestic market opportunities for RE, both hydropower and O&G incumbents' involvement in new RE (e.g. offshore wind power, solar) is particularly taking place in proximate Nordic and European markets. Obfuscating the figure, suppliers' customers may be in Norway, but the latter deploys in another market. Taken together, these implications of industrial change in the Norwegian energy sectors reach beyond national borders.

[7] New RE comprises onshore and offshore wind, bioenergy, solar energy, wave power and tidal power. Infrastructure comprises grid/fiber, district heating and energy efficiency.

5 DISCUSSION

The preceding explanatory analysis of inter-temporal diversification processes from the vantage points of incumbent firms in Norway's two main energy sectors provide support for certain core notions in the sustainability transitions (ST) literature. Although some incumbents appear to enter niches in their very early phases of development, perceptions of growth beyond an early formative phase and sustained future market demand for new (green) technologies must exist for most incumbents to pursue them. Notably, the lack of stable institutional environments to facilitate investment and growth in new RE sectors provides some of the explanation why incumbents from O&G and hydropower have been cautious in diversifying into these sectors, and more generally also explains why new energy sector deployment has been lagging in Norway (Hansen, 2013, Normann, 2015), despite the fact that the industries are developing. In addition, our empirical results show that 'growth in main sector' was an important reason why incumbents cancelled niche activities, reflecting path-dependent commitment to core activities. Nonetheless, and despite a number of cancelled diversification activities, the relatively high share of incumbents involved in other (often niche renewable) sectors not only lends support to the argument that incumbents are capable of pursuing multiple technological paths (Bergek and Onufrey, 2014), but also that more variety exists within 'regimes' than often assumed in the ST literature. Echoing Berggren et al. (2015), we therefore question validity in the assumption that incumbents by 'default' rarely stray off the beaten path.

Incumbents' diversification reflect altered selection pressures on their primary sectors. These exogenous factors shaping the business environment are broad, pointing towards the importance of stable and sufficient regulatory frameworks, market readiness, access to labor pools and swings in energy prices that drive or hinder new investment. Thus the business dynamics at play are highly complex, as managers must make sense of all these simultaneous factors at play to determine strategies to pursue.

Our results also suggest that increased interest in new sectors corresponds with uncertainties in the future development of primary sector activities. Using the variable 'level of importance' as a proxy, we observe that the (anticipated) increased reliance on diversification efforts into niche energy sectors suggests that the more broad-scale change processes underway in global energy systems are also making their impact on Norway's dominant energy sectors. For O&G incumbents, the importance of positioning for the future is clearly seen to correspond to collective expectations (Konrad, 2006) that a 'green shift' is underway (Steen, 2016), despite the expectation that hydrocarbons will form the backbone of global energy provisions for decades to come (IEA, 2012).

Following Geels (2014a), our results indicate that incumbents in both hydropower and O&G have come under sufficient external pressure to initiate more distant search and strategic reorientation processes with exploration into various new technologies that offer novel value creation opportunities. The fact that incumbents are developing in different directions suggests that 'regime fragmentation' (Karltorp and Sandén, 2012) has already occurred in the hydropower sector and appears to be underway in O&G. Whereas the hydropower sector previously had relatively well-defined boundaries in terms of actors and activities, the picture is now considerably more nuanced in terms of the production technologies that traditional hydropower actors are currently involved in. A similar shift (towards greater heterogeneity in terms of involvement in various energy sectors) is observed in O&G, however in Norway this sector has from its onset been comprised of firms from a diverse range of industries (Engen, 2009).

We venture to suggest that these 'regime fragmentation' processes are indicative of broader trends (more complex energy systems, more variety in production technologies etc.) that are both cause and effect of producers and suppliers originating in more established energy sectors becoming multi-sectoral. However, in this case (Norway) we do not interpret this regime fragmentation as a 'substitution pathway' (Geels and Schot, 2007) whereby currently dominant energy sectors are replaced by new technological solutions and energy sources. Rather, incumbents' diversification indicates that these firms are initiating new market activities that in the short-term can supplement their core activities and possibly sustain firm growth and survival in the long-term. This indicates a transformation pathway (Geels and Schot, 2007) for Norway's two main energy industries. As largely recognized in the ST literature, transformation of capitally intensive industries is a drawn out process. In the evolution of any industry, it is natural that firms initiate new and different paths of exploration in the search for carving out their niches in the marketplace based upon their competitive advantages (often in resource bases).

Thus, combined driving forces suggest that the macroeconomic business environment is undergoing a shift in which various emerging energy sectors offer new business opportunities. That hydropower producers are motivated to pursue other niches is driven by declining available hydro resources and recognition of other future opportunities, yet this is impinged upon evolution of the institutional context. Prior to the introduction of the TGC scheme, many hydropower incumbent producers placed institutional pressures on opposing the measure, as they expressed concerns of oversupply in the market (for more insights on incumbent institutional strategies, see Smink et al. (2015), Bolton et al. (2016)). The policy compromise was to offer certificates for the marginal production increases achieved through refurbishing old existing hydropower plants. Beyond the TGC scheme in 2020, the Norwegian policy agenda on renewable energy and new energy technology is highly oriented towards R&D and innovation for new export-based industrial value creation rather than domestic market formation (Hansen, 2013). This may explain why many incumbents cited ‘positioning for the future’ as a key motivation for diversification.

One obvious difference between producers in hydropower and O&G is that given the renewable status of the former, future (continued) exploitation is a viable long-term business option, whereas the latter’s resource base is (ultimately) on the decline. As pointed out by several O&G sector managers in interviews regarding corporate investments into RE sectors, exploration into energy system niches is based on expectations of future value creation more than short-term profit-making (Steen, 2016). Thus, in both hydropower and O&G industries, profits from core business lines that pay well today subsidize activities in niche sectors that may become (more) lucrative later, underscoring the importance of 'positioning for the future' (Tables A.3 and A.6).

These empirical findings highlight the underexplored strategic management dimensions of firms in the context of sustainability transitions (Karltorp and Sandén, 2012), especially as seen from incumbents’ perspectives. This is further supported by our endogenous explanatory factors, which point towards proactive motivations (such as reusing resources or future positioning) as more important than reactive motivations (following competitors) for firm diversification, but this issue demands closer analysis on the actor or micro level.

Our results support claims regarding the importance of historically accumulated resources as a platform from which to leverage capabilities into new areas (Helfat and Lieberman, 2002, Neffke and Henning, 2013), as evidenced by the importance of 'recycling' resources and capabilities as a motivational factor for diversification. For instance, relatedness in terms of capabilities is a key explanation as to why O&G incumbents have targeted diversification into maritime REs such as offshore wind power. In short, cross-sectorial dynamics diverge largely based upon established hard (manufacturing capacity, existing infrastructure, financial assets, etc.) and soft (knowledge, networks, capabilities, etc.) firm resource bases.

Our analytical research design and corresponding empirical results suggest the importance of resource flows from both suppliers and producers from established to emerging sectors. Our results indicated that 'following customers' is an important driver of diversification for incumbent suppliers in both O&G and hydropower. This suggests that lead (producer) firms' diversification can have more profound effects both on resource transfer and regime fragmentation processes throughout the value chain than has been recognized thus far in the sustainability transitions literature.

6 CONCLUSIONS

This article set out to achieve an improved understanding of incumbents in established energy sectors and their extent of involvement in other (niche) energy sectors. By drawing on perspectives on firm diversification, our theoretical discussion suggested that incumbents in established sectors can play important roles in industrial transformation associated with sustainability transitions. Notwithstanding the potential selection bias issues in our data (section 3.1.), our extensive study of both producers and suppliers in Norway's two main energy sectors (hydropower and offshore oil and gas (O&G) lend support to the argument (e.g. Berggren et al., 2015) that there is considerably more heterogeneity amongst 'regime actors' than often assumed in the ST literature in terms of incumbents' responses to changing selection pressures on core activities, and strategic response to opening windows of opportunity. Our results offer support to Karltorp and Sandén's (2012) suggestion that the combination of different types of landscape pressure, multiple new technological options with early market formation and heterogeneity amongst incumbents can help explain how regime fragmentation unfolds.

Our findings demonstrate that incumbents' diversification appear to be motivated more by proactive rather than reactive factors. One could venture to argue that energy industry incumbents are realizing that substantial transformations are underway, and that strategic adaptive responses are therefore needed to keep pace with change. We encourage further empirical investigation to better understand whether this holds true in other industries and countries. A limitation to our data is that we cannot say anything specific about the consequences of incumbent diversification into niche sectors in terms of enhanced technological variety, actual resource flows, or (more rapid) upscaling. However, we must assume that the observed diversification processes contribute with various types of resource and knowledge transfers, ranging from financial investments to business models, networks and technologies (Poel, 2000, Raven and Verbong, 2007, Dolata, 2009). Further research is needed to underpin the magnitude of incumbents' investments into other (emerging) sectors and implications for their further development and diffusion.

Given our data is not appropriate for statistical testing, and Norway's unique situation as a large hydropower producer and O&G exporter, we are cautious to generalize our findings to other contexts. However, other countries well-endowed with natural (energy) resource bases and strong industry sectors linked to those assets, such as Australia, Canada, Finland, Sweden or Brazil, may experience similar resource transfers between established (dominant) and emerging industries.

Because incumbents possess various capabilities and resources to engage in transformations not only within their core industry but also in other sectors, their roles in energy system transformation should not be understated (both in positive and negative lights). Since we have not come across previous research with which we could compare our empirical findings, we encourage more comprehensive studies that examine variation within regimes, and the contributing factors which lead to this heterogeneity. Focusing less on the typical lead firms of industries (e.g. utilities) and more also on (specialized) suppliers would in our view probably also lead to more nuanced understandings of the development trajectories of industries with overlapping actors networks and value chains, potentially showing how firms from (adjacent) sectors can contribute to niche technology development and diffusion.

The issue of timing in diversification and investments into new market opportunities outside of the boundaries of firms' primary sectors seems to be a continually moving and elusive target to empirically underpin. Our inter-temporal research design should be seen as an attempt to overcome this issue. We encourage other researchers to contribute to developing more innovative and robust methodological designs to provide a better sense of the timing issue (Geels and Schot, 2007; Geels, 2014a) in the relationship between macro-level societal changes, regime dynamics and niche level technological maturity and momentum.

Because our findings suggest that when energy producers seek to invest into new niches, suppliers may follow suit (bringing various types of knowledge and resources), a policy implication is that lead firms should be encouraged and incentivized to diversify into emerging 'green' energy sectors on which the realization of sustainable energy systems critically depend. Given the importance of relatedness for cross-sectorial interaction, policy makers and other stakeholders should attempt to identify industry interlinkages wherein trading zones between established and emerging sectors could be nurtured. Finally, accepting that sustainability transition processes are slow, deliberate 'destabilization' or decline of fossil fuel based industries such as evidenced in Germany's 'Energiewende' could be positive also in a context such as in Norway, because it could provide space and 'un-lock' resources (Smith et al., 2005) and incentivize incumbents to invest into emerging (clean) energy sectors.

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APPENDIX

Table A.1 Hydropower incumbents: core sector barriers & market outlooks

	Mean			Median		Mode		S. D.			n (31)			Likert scale measure
	P*	S*	T*	P	S	P	S	P	S	T	P	S	T	
Barriers – main sector														1 (strongly disagree) – 7 (strongly agree)
Uncertain framework conditions	5,35	3,89	4,9	6	4	6	4[a]	1,268	1,054	1,372	20	9	29	
Norwegian cost levels	3,89	4,56	4,11	4	5	3	4[a]	1,15	1,59	1,315	19	9	28	
Lack of access to competent labour	4,53	4,33	4,46	5	4	5	4	0,905	1,581	1,138	19	9	28	
Lack of access to new resource areas	3,21	3,25	3,22	3	3	1[a]	3	1,782	1,753	1,739	19	8	27	
Market development/outlook – main sector														1 (very bad) – 7 (very good)
Past 5 years	4,95	4,25	4,74	5	4	5	4	1,58	1,035	1,457	19	8	27	
Next 5 years	4,11	5,33	4,5	4	6	4	6	1,049	1,118	1,202	19	9	28	

*P = producers, S = suppliers, T = total
[a]Multiple modes exist, lowest value is shown

Table A.2 Hydropower incumbents' cited causalities for cancelling diversification initiatives in the past

	Hydropower - aggregate means of Likert scale 1-7		
Reasons for cancelled	OG*	NR*	I*
Market didn't develop as expected	-	3,29	2,84
The company's results weren't as expected	-	1,95	2,0
The company lacked the right competence	-	2,0	1,34
Uncertain framework conditions	-	4,4	3,67
Inadequate support mechanisms	-	3,95	2,67
Growth in main sector	-	4,02	3,17
Lack of internal resources	-	2,15	1,84
Share of respondents of cancelled activities	0/4	21/30	6/7

*OG = oil and gas, NR = new renewable (onshore & offshore wind, bio/solar/tidal/wave energy),
I = infrastructure (grid and fiber, district heating, energy efficiency)

Table A.3 Hydropower incumbents' motivations and barriers in pursuing energy sectoral diversification

	Mean			Median		Mode		S. D.			n (31)			Likert scale measure
	P*	S*	T*	P	S	P	S	P	S	T	P	S	T	
Motivations for diversification														1 (unimportant) – 7 (highly important) + don't know/ not relevant
Low profitability in main sector	2,47	3,14	2,67	2	2	2	2	1,007	1,864	1,308	17	7	24	
Reduce dependence on main sector	3,13	4,14	3,43	2,5	4	2	3[a]	1,668	1,574	1,674	16	7	23	
Opportunities for 'recycling' of competence/resources	4,59	5,43	4,83	4	5	4	5	1,121	0,787	1,09	17	7	24	
Create a more attractive place to work	4,06	5,14	4,36	4	5	4[a]	4	1,589	1,215	1,551	18	7	25	
Positioning for the future	5,11	5,86	5,32	5	6	6	6	1,079	0,69	1,03	18	7	25	
Follow competitors	2,92	4,29	3,4	3	4	3	4	1,32	0,951	1,353	13	7	20	
Follow customers	3,5	5,88	4,36	3,5	6	1[a]	5[a]	1,99	0,835	2,013	14	8	22	
More attractive business opportunities	4,19	5,57	4,61	4	6	4	6	1,471	0,787	1,438	16	7	23	

Stagnation or decline in main sector	3,75	4,14	3,87	3,5	4	3	2[a]	1,571	1,676	1,576	16	7	23	
Barriers to secondary sector activities														1 (very low risk) – 7 (very high risk) + don't know/ not relevant
Lack of access to competent labour	4	4,75	4,24	4	5,5	2[a]	6	1,458	1,982	1,64	17	8	25	
Lack of internal knowledge resources	3,82	3,43	3,71	4	3	3	3	1,185	1,512	1,268	17	7	24	
Lack of financial capacity	4	3,33	3,83	4	3	3	3	1,369	2,066	1,557	17	6	23	
Unpredictable policies	5,65	2,83	4,91	6	3	5	3	0,862	0,983	1,535	17	6	23	
Unpredictable subsidy/tax schemes	5,06	3,67	4,7	6	3,5	6	3	1,713	1,751	1,795		6	23	
Lack of access to new resource areas	3,18	2,4	3	3	2	2	2	1,468	1,14	1,414	17	5	22	

*P = producers, S = suppliers, T = total
[a]Multiple modes exist, lowest value is shown

Table A.4 Oil and gas incumbents' core sector barriers & market outlooks

	Mean			Median		Mode		S. D.			n (102)			Likert scale measure
	P*	S*	T*	P	S	P	S	P	S	T	P	S	T	
Barriers – main sector														1 (strongly disagree) – 7 (strongly agree)
Uncertain framework conditions	4	4,04	4,04	4	4	4	5	1,871	1,532	1,539	5	93	98	
Norwegian cost levels	4,8	5,14	5,12	5	5	4[a]	6	0,837	1,29	1,27	5	93	98	
Lack of access to competent labour	4	4,75	4,71	5	5	2[a]	6	1,871	1,411	1,436	5	92	97	
Lack of access to new resource areas	3,5	3,67	3,66	3,5	4	2[a]	2	1,291	1,535	1,52	4	93	97	
Market development/outlook – main sector														1 (very bad) – 7 (very good)
Past 5 years	5,2	5,48	5,47	5	6	5	6	1,483	1,291	1,294	5	93	98	
Next 5 years	5,2	5,57	5,55	5	6	4	6	1,304	1,076	1,084	5	91	96	

*P = producers, S = suppliers, T = total
[a]Multiple modes exist, lowest value is shown

Table A.5 Oil and gas incumbents' cited causalities for cancelling diversification initiatives in the past

	Oil and gas - aggregate means of Likert scale 1-7		
Reasons for cancelled activities	H*	NR*	I*
Market didn't develop as expected	3,75	4,97	3,79
The company's results weren't as expected	2,88	3,81	3,25
The company lacked the right competence	2,75	3,78	3,05
Uncertain framework conditions	2,57	4,78	2,89
Inadequate support mechanisms	2,75	4,60	2,64
Growth in main sector	3,13	5,11	5,86
Lack of internal resources	3,13	3,97	3,75
Share of respondents of cancelled activities	8/8	32/48	11/12

*H = Hydro, NR = new renewable (onshore & offshore wind, bio/solar/tidal/wave energy), I = infrastructure (grid and fiber, district heating, energy efficiency)

Table A.6 Oil and gas incumbents' motivations and barriers in pursuing energy sectoral diversification

	Mean			Median		Mode		S. D.			n (102)			Likert scale measure
	P*	S*	T*	P	S	P	S	P	S	T	P	S	T	
Motivations for diversification														1 (unimportant) – 7 (highly important) + don't know/ not relevant
Low profitability in main sector	3,67	3,9	3,89	4	4	1[a]	5	2,517	1,852	1,861	3	67	70	
Reduce dependence on main sector	4,25	4,75	4,72	4,5	5	1[a]	6	2,754	1,636	1,689	4	71	75	
Opportunities for 'recycling' of competence/resources	4,67	5,04	5,03	6	5	1[a]	6	3,215	1,331	1,405	3	76	79	
Create a more attractive place to work	3,5	4,97	4,9	3,5	5	1[a]	6	2,38	1,537	1,599	4	78	82	
Positioning for the future	4,8	5,85	5,79	6	6	6	6[a]	2,168	1,282	1,354	5	79	78	
Follow competitors	3,5	3,41	3,41	3,5	3	1[a]	5	2,082	1,687	1,694	4	74	78	
Follow customers	5,2	5,54	5,52	6	6	7	7	2,49	1,598	1,648	5	74	79	
More attractive business opportunities	4,2	5,2	5,14	5	6	5	6	1,924	1,539	1,569	5	79	84	
Stagnation or decline in main sector	3,75	4,68	4,15	4	5	1[a]	5	2,217	1,606	1,914	4	70	74	
Barriers to secondary sector activities														1 (very low risk) – 7 (very high risk) + don't know/ not relevant
Lack of access to competent labour	5,75	4,68	4,74	6	5	6	5	0,5	1,606	1,584	4	73	77	
Lack of internal knowledge resources	4,25	4,31	4,3	4,5	5	1[a]	5	2,5	1,411	1,461	4	72	76	
Lack of financial capacity	3,75	3,76	3,76	4	4	5	2	1,5	1,801	1,777	4	71	75	
Unpredictable policies	4,75	4,15	4,19	5	4	6	2[a]	1,5	1,786	1,768	4	71	75	
Unpredictable subsidy/tax schemes	4,33	3,85	3,87	4	4	3[a]	2	1,528	1,869	1,849	3	67	70	
Lack of access to new resource areas	5	3,37	3,46	5,5	3	6	3	1,414	1,704	1,722	4	67	71	

*P = producers, S = suppliers, T = total

[a]Multiple modes exist, lowest value is shown