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Forecasting network transformation: A Delphi-based scenario approach

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Abstract

As the energy market network transforms – from large scale, centralized systems to smaller, agile networks with many actors and small-scale producer – the interest from both society and business to forecast and understand future scenarios increase. By using Delphi panel data with experts from industry, academia and government, the current study presents a future scenario for the Swedish electric utility market and relate it to the network transformation. Our findings reflect a range of different views of the future of the electric utility with different opinions from the expert panel when it comes to technological development, consumer behaviors, political ambitions and investments. One thing that unite the experts is the view of how the traditional electric utility's business network will be further integrated and connected into other systems through internet of things and digitalization. The study shows how network transformation can be forecasted by using a Delphi expert panel in combination with trend data for relevant parameters.

Keywords: Delphi Method, Qualitative Analysis, Scenarios, Network Transformation, Electric Utilities, Beyond 2020

Introduction

Using forecasting and scenarios to describe future development of a specific markets or a specific industry is a common method in research (Alizadeh *et al*., 2016; Bishop, Hines, & Collins, 2007; Durance & Godet, 2010) and is well suited to forecast complex and dynamic phenomena, in for example the management discourse (Bood & Postma, 1998). A scenario can best be described as a possible future representation – "scenario is not a future reality but rather a means to represent it with the aim of clarifying present action in light of possible and desirable futures" (Durance and Godet, 2010, p.1488). Hence, developing scenarios is a useful method when the environment is rapidly changing and future development uncertain as it allows multiple future representations – "from the expected to the wildcard" (Bishop *et al*., 2007, p. 5).

On area of high interest for scenario research is the changing electric market where a range of uncertainties encircle the present market network – climate change, rapid technological development, radical innovations, new consumer and producer patterns, political decisions at national level, European level, and global level. One example is how Swedish authority's decision to subsidies solar panel rapidly increased the demand for solar panels. Meanwhile, new solar cell technology and battery storage capacity have the potential to disrupt the market.

Accordingly, the 2020s is expected to be the most disruptive decade in the history of electric utilities, according to recent reports (e.g., PA Consulting, 2016; PwC Reports 2016). Such turmoil can potentially disrupt whole markets, bypass a specific position in a network structure, and turn conventional business models obsolete. Although, the above-mentioned uncertainties offer unprecedented opportunities to renew the network and bond with new actors. To navigate through opportunities and risks carefully, balanced scenarios can alleviate uncertainty and be managers' map of the future – hence using scenarios as a strategic tool (Shoemaker, 1995). Without guesstimates of what the future offers, decision makers fumble in the dark, hence scenario analysis can aid clarifying present strategies according to possible future (desired) scenarios.

The electric utility industry is at the brink of the most far-reaching disruptions since the industry emerged and formed its incumbent business models (Saba 2014; Sioshansi, 2014). These still-dominant business models are based on large-scale distant generation (e.g., nuclear power and hydropower) and grids that distribute electricity great distances to serve rate payers attached to meters. However, with a set of recent and impending innovations, the dominant way to operate is, in the near-term, challenged by a more decentralized, self-supporting and sharing economy-based way to operate what is expected to overturn the electric utilities' traditional roles, and drive them to revise their positions and business models (Brown *et al*., 2015). The anticipated challenge is made possible from megatrends including distributed generation, smart microgrids, and new methods of energy storage (Overholm, 2015).

On the one hand, we know from other sectors that industry-wide disruptions can decimate, or bypass, entire portions of an industry (a recent example is the digitalization of music consumption; see, e.g., Kask & Öberg, 2019), and consequentially ruin long-standing revenue streams. On the other hand, we also know that the disruptive stage in industries' developments offers windows of unprecedented new opportunities to developing radically new ventures (Kask & Linton, 2013; Murmann & Frenken, 2006). However, many companies that have been well-accustomed to pre-disruption orders have failed to revise their business models to fit with the post-disruption order (Kodak is a famous example). Danneels (2004, p. 247) points out that "disruptive technologies tend to be associated with the replacement of incumbents by entrants."

The aim of this paper is to identify and forecast a future scenario of network transformation in the electric utility industry by using a Delphi (Nowack, Endrikat & Guenther, 2011). Delphis has been used in a wide range of different academic disciplines such as supply change management (Ogden *et al*., 2005) and strategic management (Alizadeh *et al*., 2016). Our approach to scenario generation and forecasting is focused on pinpointing the game changers, enabler and obstacles – so that scenarios for network transformation of electric utilities in the 2020s, particularly highlighting transformation of the interfirm activities and network structures/practices, can be portrayed in a cogent way.

Research design

In the present era, characterized by uncertainty, innovation and change, increasing emphasis is being placed on the use of scenario techniques because of its usefulness in times of uncertainty and complexity (Amer, Daim & Jetter, 2013) Scenarios can be defined as descriptions of possible future situations, including paths of development leading to these situations. It is often described as hypothetical constructs that are useful to highlight central elements of possible futures (Kosow & Gabner, 2008).

In this paper, an explorative scenario analysis is used, since it is important to generate knowledge about the present and the future, but also to identify the limitations of that knowledge to be able to answer the research questions proposed. Scenarios address blind spots by challenging assumptions, expanding vision and combining information from many different sources. There is no single approach to scenario analysis, instead, literature reviews on the subject (Amer *et al*. 2013; Keough & Shanahan, 2008) reveals several methodologies for generating scenarios. However, the methodologies presented have many common characteristics. Kosow and Gabner (2008) presents a general scenario process in five phases, i.e. scenario field identification, key factor identification, key factor analysis, scenario generation and scenario transfer.

Since this paper is part of an ongoing research project regarding the future transformation of the electric utility industry, the identification of the scenario field was given from start. The required information to identify key factors have been collected by using both primary and secondary data. One case study based on a network of five companies within the electric utility industry has been used as one way to include important information in identifying key factors. The case study consists of a mix of in-depth interviews, internship days, round table discussions as well as observations of work meetings between the companies. Interviews were conducted with CEOs, business area managers, sales managers, marketing and communications manager as well as partner manager. The interviewees had qualified knowledge on the overall, strategic, market and operational parts of the businesses. The questions were of an open-ended nature and covered areas of industry change, market trends, offerings, current business models, transformations processes, strengths, weaknesses, opportunities and threats as perceived by the companies, ongoing collaboration projects etc. The interviews lasted around 60-90 minutes. All interviews were recorded using a digital voice recorder. Besides the interviews made, the researchers have also spent one whole day at each company (5 in total) as an internship to learn more about the market, the companies, offerings and customers. Impressions and lessons learned were written down and compiled in company reports. Notes have been taken during round table discussions and firm meetings. Secondary data have also been collected which includes presentations and reports provided by the companies, annual reports, press releases and newspaper items. Hence, the secondary data included both company internal material as well as official material. Desk research has also been conducted by collecting and analyzing secondary data like trend statistics, development reports, policy documents etc.

A third method used to identify key factors – and the central data collection for this paper – have been through a three-round, web-based Delphi panel (Dalkey & Helmer, 1963; Linstone & Turoff, 1975; Okoli & Pawlowski, 2004; Schmidt, 1997), where experts participated and shared their views of the directions and speed of the utilities' network transformation toward 2030. Selecting knowledgeable experts is an important part of the Delphi process. Experts from three different fields were invited, that is academia, industry and government representatives. The industry experts were working both within the electric utility industry as well as in related industries. The panel of experts were asked to anonymously and independently estimate how certain developments could turn out in the future, through a structured method of information transfer and reflection in three repeated cycles of questions and answers (see, Czaplicka-Kolarz *et al.*, 2009 for a recent Delphi study in an energy sector). In this way, the degree of consensus and/or dissent within the panel, and thus the degree of uncertainty of the knowledge at issue, was determined over the course of multiple cycles. Thus, the case study, the desk research conducted and the Delphi study were all used as an input in the scenario generation process. In this particular paper, we report the forecasted scenario primely based on the Delphi study.

28 theses were formulated by the researchers (see Table 1) and grouped under adjusted headings. An online Delphi survey was applied, where the first page on the survey consisted of an introduction, including a short description of the research project with the aim to develop future scenarios for the Swedish electric utility industry in 2030. It also included instructions for the participants to fill out their views on the theses. Following the introduction, the 28 theses were introduced, one per page. For each thesis, the experts had to answer the following:

- Probability of occurrence, 0-100%
- Impact on industry (in case of occurrence), Very low - very high, 1-5 Likert scale

- Desirability of occurrence, Very low - very high, 1-5 Likert scale
- Year of occurrence, all years between 2020 and 2030 were available as options as well as after 2030 and never.

The experts used the year 2030 as a starting point. The experts were also able to provide comments to explain their answers. The final page of the survey consisted of a text thanking them for their participation.

Table 1: Theses with headings

Renewables plus batteries is the new norm	
T1	Variable renewable electricity is the mainstream source.
T2	Battery storage have replaced disposable power generation as the principal provider of grid stability.
T3	Decentralized, on-site production and storage dominates over utility-scale production and long-distance transmission.
More actors	
T4	A more diversified set of stakeholders are active in the market.
T5	It is harder for a single party to outline the market.
Glocalization	
T6	Capacity mechanisms in the European wholesale markets are heavily strengthened to solve bottlenecks.
T7	A clear majority of households, businesses, and communities are producing and storing their own electricity locally.
T8	A significant proportion of the customers have gone "off-grid," trusting local micro grids disconnected from the large national networks.
Disruptive technologies	
T9	The electricity system is based on smart, "flexible" infrastructure.
T10	Technological advances and distributed resources at the "grid edge" (an Internet-of-Things) unlock significant economic value for the industry and improve power delivery.
T11	To track and trace distributed resources, Blockchain is widely used and accepted as an integrated technology.
Higher demands for electricity	
T12	With the breakthrough of electromobility and a rapid electrification of the industry, the overall electricity consumption took a big leap.
T13	Electric vehicles are widely used as rolling energy storages to provide grid stability.
Sustainability and the new attitudes	
T14	Among companies in the industry there is a marked shift to focus socially and environmentally sustainable solutions, taking care of all resources used.
T15	The vast majority of Swedes has invested in renewable energy, either individually or cooperatively.
T16	Electricity and its generation has become a high-interest product that people often are talking about and use to express belonging and personality.
A mindset shift and separated forms of business	
T17	Successful electricity retailers are all customer centric, taking a relevant part in peoples' and business' lives by offering services that matter.

T18 Utilities, grid operators, and electricity retailers are clearly separated to own businesses.

A smaller but smarter grid

T19 The need for a high peak-load capacity of the grid infrastructure is significantly reduced.

T20 Across Sweden, local flexibility markets are the established solution to alleviate regional grid bottlenecks.

New consumer preferences and bundled services

T21 Electricity is offered as part of a bundled package of smart, home services.

T22 Peer-to-peer (e.g. prosumer-to-prosumer) services based on the idea of the sharing economy is the dominant business model.

T23 The former electricity retailer's main business is to act as a platform for brokering peer-to-peer transactions, and to offer a wide range of complementary services.

Pricing strategies

T24 Electrical energy (kilowatt-hours) is free of cost for the end-use consumer if the electricity retailer is allowed to control the customer's load, production and storage, and take advantage of the flexibility.

T25 Most consumers pay flat rate fees for grid electricity based on supply security needs (peak load).

The new supply chains

T26 Plug-and-play solar PV panels are widely sold in regular retail chains.

T27 As thin-film solar cells are integrated in roof tiles, windows and facade materials, the building-material retailers and construction companies have become main channels for supplying production means.

T28 Since user data has a high value for businesses in other industries, sales of data have become a main source of income for electricity retailers.

In most business settings, there are many different issues that compete, combine and interact with one another to characterize the future. Generating scenarios according to themes is a way to capture this, and will be used in this paper as a guiding principle. The chosen themes will highlight different important aspects of the future industry and provide a helpful framework for structuring the narratives when describing the different scenarios. The emphasis at this stage will be on clarifying the scenarios and making them relevant for the next step of the process, i.e. scenario transfer. The prime reason for initiating scenario analysis is to aid companies, investors and policymakers with the basis for decision-making regarding how to plan and manage business model transformation, while allowing the real-time study of knowledge insights and awareness among incumbent actors, and the ability to link between these and business model transformations.

Toward a scenario of the Swedish electricity market in 2030

The following section will elaborate on the future scenarios of electric utility industry using Delphi-based data and trend statistics, for instance, price-decline curves for solar panels and Li-ion batteries.

The awakening of prosumerism and decentralized electricity generation

In 2030, the share of renewable generation in Sweden has increased significantly. The environmental and climate awareness will be high among both B2C and B2B customers. The future customers want to buy electricity from renewable sources to make their carbon footprint and environmental footprint as small as possible. The environment in general and the idea of a sustainable lifestyle in particular will continue to change values and behaviors of the customers which in turn also affects the network configurations. Most of the customers feel proud and happy about the fact that they are contributing to a sustainable development by supporting the energy transition to renewable generation. The wear and tear economy are gone by 2030, and as a consequence, both consumers and businesses will look for electricity suppliers that take real responsibility, not just in the energy source but also more widely.

Moreover, the electric power sector will during the 2020s truly and genuinely make the move from technology centric to customer centric. The mindset of electric utilities that survive this transformation are those that change from viewing customers as "grid-load points" to enabling an easier everyday life of customers. The surviving electric utilities are genuine in this change, and has by 2030 start playing a relevant role in the customers' lives; that is, to solve an actual problem and fulfil an actual need in a relevant, gratifying and sustainable way. If one utility cannot meet these new demands, the next one will. In this transformation process, it is the companies that succeed in taking a relevant role in individual customers' and businesses' lives that prosper.

Swedish citizens are already much more used to see solar panels and windmills in their everyday life compared to few years ago, and in the 2020s investments in solar and wind power are made by many different actors of society (individual citizens, communities, municipalities, companies etc.) and not just the traditional actors. There might also be ideas of being, partly or fully, self-sufficient and providing your own electricity, and, in so sense, dissolve or transform the current business network ties. In some communities, small scale renewables are getting more popular and satisfy their energy demand by acting as prosumers (producing consumers; see, Toffler, 1980; Kask & Klézl, 2019) in smart microgrid systems of single households or together with neighbors. However, this might actually cause higher costs and environmental footprints than to use the grid as a sharing platform. On the other hand, sharing solutions will probably increase in all sectors, making new sharing solutions for electricity attractive as well, where the grid in 2030 is used as a gigantic sharing platform where all the different actors of society that, at time, over-produce (under-produce) electricity can sell to (buy from) one another.

New actors joining the network

In 2030, electricity is the biggest source of energy for mobility, the transportation sector. The game changer being a combination of climate awareness and reduced prices making all but electric (and renewable) cars unacceptable to buy already in the early years of the 2020's. The car industry will be disrupted as soon as self-driving cars and electric vehicles are the new norm. Moreover, the impetus to build electric vehicles is driving the Li-ion battery price decrease. That, in turn, has during the 2020s an effect on new actors in the network as well as for the development of energy storage and grid infrastructure: In 2030, the self-driving cars are an integrated part of the mobility services, and the cars are also seen, when not in operations, as movable electric storages for grid flexibility to deal with peak load hours: They charge when they are not in use, thereby transporting electricity from one location to another, and while not in use during peak load periods they can feed back excess electricity to the grid if the situation requires. In other words, battery and car manufacturers and their likes are integrated partners in the business network in the electricity sector in 2030.

For the heavy traffic and the industry as a whole, electrification is an important way to reduce carbon emissions and to phase out the use of fossil fuels; although, here combined with hydrogen, bioenergy and energy efficiency. As a consequence, new actors had by 2030 joined the business network, for example real estate companies that own and operate charging facilities and small solar power plants, and car fleet operators that offers "transport-as-a-service" to the masses and rolling electric storages.

Obstacles for network transformation

We let the informants of the Delphi panel answer the question "For your visualization of 2030 to become reality, what obstacles need to be mastered?" This resulted in both long-term and short-term obstacles that conserve the current network configuration and mitigate the network transformation process. Those transformation obstacles can be grouped into three different themes: political, commercial and technological.

First, the political obstacles appear since electricity in the 2020s is heavily dependent on cross-national collaboration. With more inward-looking governments in Europe, nevertheless, there is a risk that cross-national electrical integration obtrudes, and hence, mitigate a technological and social change. Second, there are many commercial issues that arise in the changing network configuration of electric utility. A central question raised by a Delphi-panel informant is who will pay for the necessary new infrastructure:

> *"Will it be more of the ratepayers or the utility companies that bear the burden. How much will public entities and governments invest in the infrastructure necessary to ensure this transition and to what extent will existing political interests delay the process."*

Moreover, another conserving commercial obstacle is the customers inhabited unwillingness to change behavior as the electric utility is a non-prioritized area for the customer yet in the 2020s. This is a bit contradictory among the Delphi panel members – in one way, the customers are seen as driver for change, based on new more sustainable way of living. On the other hand, customers are seen as resistant to change and unwilling to change behavior towards more active and informed consumers.

The third and final aspect is related to technological obstacles and relates to issues of technological change. One issue raised by the Delphi member concern the risk of reduced electricity security with a much more decentralized production where many actors contributes. Trustworthiness of the electric system and electric reliability, has become major questions in many European countries. For many years, the existing energy paradigm has ensured the countries with fossils energy from central production plants – securing this system has been possible through rigorous control mechanism. How the future, decentralized system, could be secured according to reliability is big challenge.

Enablers for network transformation

On the contrary, there are factors that facilitate and potentially speed up the network transformation. We let the informants of the Delphi panel answer the question "for your visualization of 2030 to become reality, what are the important key factors to enable this development?"

Several members of the Delphi panel comment on how important it is for the network actors to intensify exchange and resource-interaction activities in order to enable the clean energy transition. Coordination and collaboration between society and companies is seen as a key in order to develop and apply new offerings, while interactions and new ties between incumbent companies and startups with fresh thinking is an important enabler for the transformation of the business network. More dynamic grid tariffs are used in 2030 to steer towards smoother grid load. This creates business opportunities for smart-homes entrants who help control machines and chargers to be used in the "right" hours. This movement will speed up the transformation by interacting more recourses and data with, for instance, the utility, the grid operator and the households; and, hence, add to the transformation of the business network. Moreover, the customers are also important players to color change by demanding new types of products and services that are more in line with a sustainable way of living.

Summary of Scenario 2030

According to this scenario, the energy sector, and in some senses the society at large, will move from an individualistic/centralistic to a neo-collectivistic network model as an effect of the sharing economy, where energy will be shared among households and other small producers, using blockchain or similar solutions that will allow these prosumers to produce energy and sell the energy they don't use themselves to others in need of more energy. Blockchain solution will offer the possibility to create smart contracts between different parties. Technical advances, for example, cheaper solar panels, much cheaper and more effective batteries for storing large amounts of electricity as well as new ways of harboring and producing energy, will reach the market. This will increase competition and enable both households and businesses to be (partly) self-sufficient and electricity providers themselves.

To conclude, the incumbent electric utility's role is largely transformed in 2030, from a traditional electricity generator, grid owner/operator and electricity retailer, to a customer-centric service provider that offers a platform solution and additional services for the trading of excess electricity, an investor and partner that builds and runs, for instance, cooperatively-owned, utility-scale photovoltaic parks and wind farms, and an network integrator that offers know-how and smarter energy solutions. Still, in a country like Sweden some parts will remain the same: as wind and solar are intermittent forms of electricity production and investing in so much Li-ion battery storage capacity that it, in a worst case, can support the whole society for days or even weeks is a big waste of resources, and economically unjustifiable (even if the price continue to decrease at the current experience curve), it is likely that Sweden to a large degree still trust the hydro power plants to maintain grid balance beyond 2030. Because, like utility-scale batteries, the energy potential in hydropower dams serve as energy storages; when there is a sudden demand spike or a supply shortage due to variation in the weather, the old hydropower plants are still needed to balancing the grid as they can be switched on and off at short notice regardless of insolation or wind.

Concluding remarks

The forecasted business network transformation in this paper offers electric utilities guidance for decision making in the coming years regarding business network strategies and partnership/network development. The traditional utilities' challenge lies in figuring out how to best use a century of accumulated resources and investments to capture these new opportunities to accommodate a good fit with a transformed business network. This topic addresses concerns about how an actor currently positioned in an industry that is at a disruptive stage can adapt the way it organizes its business to prosperously build ties and interact resources with new entrants in order to not to be fully replaced in a post-disruption era.

A guiding principle for the managers of electric utilities would be not only to look at technical innovations and how they can utilize new technologies to become more efficient, but also to look much wider, considering new business models with the customer at the center; for instance, to become a service provider that helps household to become a prosumer or to be more of a resource integrator or platform owner that facilitate sharing solutions of excess electricity.

The dissensus within the Delphi panel on potential enablers and obstacles to make this scenario a reality, makes it possible to explore divergent ideas about the futures. Even if the goal was a convergent future scenario, the divergent ideas can enrich the study with a plethora of ideas and potential future scenarios – addressing a dynamic, complex and unreliable future. One potential explanation to the very diverging views of the future of the electric power sector is that several technological regimes changes at the same time, creating a complex system difficult to foreseen. One other aspect might be due to that 2030 is too far in the future in order to reach consensus among the respondents.

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