Journal of Technology Management & Innovation

Received February 28, 2012 / Accepted June 9, 2012 J. Technol. Manag. Innov. 2012, Volume 7, Issue 2

Analysing Changes in Electricity Industries Against Actors and Technologies: Utility to Business Transformations in Denmark, Germany, Finland and Spain

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Abstract

Liberalization of electricity markets, governmental policies for renewable electricity and technology development are transforming national electricity industries. However, there are considerable national differences in how these industries have changed and which businesses have been developed. We propose a typology for comparing changes in electricity industry based on the changes in the actors and technologies. Wind power and solar photovoltaic are used here as technology examples. A qualitative analysis of the changes in electricity industries in four EU member states is presented. Based on the preliminary findings, we conclude that if the industry consists of many, small firms with relatively loose ties with the government the industry is more likely to change than if it consists of few large firms with strong relations with the government.

Keywords: electricity industry; liberalization; technology development; wind energy; solar photovoltaic

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ISSN: 0718-2724. (http://www.jotmi.org)

1. Introduction

National electricity industries are undergoing fundamental changes, which are brought about by three interlinked and overlapping factors: liberalization of electricity markets, technology development and energy policies.

In electricity industry free markets, market potentials, market niches or market demand do not exist the same way as, for example, in consumer goods. There are two main reasons for this. Electricity markets are mature and electricity industries remain under the jurisdiction of national governments. There is always more available production capacity than what is consumed at any given time because electricity cannot be stored in large quantities, and there are considerable daily and seasonal fluctuations in the consumption. For this reason, changes in electricity industry cannot be evaluated in terms of diffusion of innovations (Birkinshaw, Hamel, & Mol, 2008; Mol, 1995; Rogers, 1995). Nor can mainstream theories of technological change and development of new businesses be applied because they are based on assumptions of technological changes driven by technology development and market potentials (Anderson, Tushman 1990, Dosi, 1982; Murmann, Frenken 2006).

The national governments influence changes in the electricity industries. Liberalization has changed utilities and state controlled monopolies into many competing areas of businesses, such as generation, sales, metering and distribution (Künneke, 2008). Ideally, liberalization introduces a shift in the focus of governmental regulation from governmental preferences to assurance of competition in the industry. In this paper we use liberalisation instead of deregulation. Liberalization does not imply de-regulation in the sense that regulation would be reduced but as presented by Vogel (1996), liberalisation refers to an increase of it. Also, the European Union (hereafter EU) is pressuring to assure competition and to remove barriers to entry to markets to increase competition within the industry (European Commission, 2007).

However, extant research has discovered that the reality is quite far from the ideal situation. For example, liberalization has progressed quite differently in different countries (Green, 2007). And national governments (Blok, 2006) continue to influence the way national electricity industry changes and which technologies and businesses are developed (see for example, Campoccia, Dusonchet, Telaretti, & Zizzo, 2009; Johnstonea, Hascica, Clavelb, & Maricalb, 2008; Klaassen, Miketa, Larsen, & Sundqvist, 2005; Lewis & Wiser, 2007; Lund, 2009).

Extant research has investigated reasons for these differences, for example, how different actors have been able to influence energy policies. Citizens influencing by voting green parties, supporting anti-nuclear movements or parties with environmental programs have brought about changes in energy policies and technologies (O'Neill, 1997). Though there is no clear evidence that a green party itself in government would guarantee changes in electricity industry (Jamison, Eyerman, Cramer, & Laessoe, 1990; O'Neill, 1997; Müller-Rommel & Poguntke, 2002). Also, there is no clear link between a particular political party domination, model of capitalism or political decision-making system would bring about the most changes (Dresner, Dunne, Clinch, & Beuermann, 2006; Hoffmann & Trautmann, 2006; Neumayer, 2003). For example, the oil industry has traditionally lobbied for its interests slowing down changes in energy technologies (Deutsch, 2008). Similarly, in response to liberalization incumbent utilities have increased their market shares through consolidations to control electricity generation and prices (Domanico, 2007; Thomas, 2003). However, their responses to new energy technologies are less consistent. While some incumbent utilities have used their power to held up changes in the electricity industry (Iida, Kanie, Maruyama, Nishikido, & Hondo, 2006; Pehle, 1997; Stenzel & Frenzel, 2008), there are also incumbents that have chosen to invest in new energy technologies' businesses and be drivers of changes in the industry (Stenzel & Frenzel, 2008).

As it can be seen from the above-mentioned and as also suggested by Cowan (1990) and Granovetter & McGuire (1998), changes in electricity industry are not as rational as they are often depicted and strong actors can influence changes in the industry. Also Wedel (2009) suggests that not all actors have equal access to decision-making processes. Thus, more research is needed on how actors and their interests influence changes in electricity industry. The focus of the analysis in this paper is why some alternatives are considered "the best" ones, how "the best" is defined and by whom.

In what follows is a description of the typology of how electricity industries change. The typology is based on evaluation of changes in the actors of the industry and changes in electricity technologies (Granovetter & McGuire 1998). After that the qualitative case study methodology of this paper is presented. Next, the changes in electricity industry in Denmark, Germany, Finland and Spain are presented. The paper ends with discussion and conclusions.

2. Changes in electricity industry: actors and technologies

In this section we present a typology for analysing similarities and differences in the manner electricity industries have changed in different countries (Marradi, 1990). The intention is to evaluate the combined impact of several policies, such

as technology, energy and climate policies (Vicente, Manjón 2010). Electricity industry is perceived as a contextual and dynamic social constellation of self-interested actors in and around it (Callon, 1980; Granovetter, 1985; Granovetter & McGuire 1998; Whittington, 1993; Wright, 1998). We chose this approach to capture the unique actors and dynamism between national actors in power and those in the margins (Granovetter, 2005; Henderson & Clark, 1990) that would be missed if the classification was based on, for example model of capitalism adopted (Vogel, 2001) or other national characteristics (See for example Chhokar, Brodbeck, & House, 2007; Whitley, 2000).

Following Künneke (2008) and Granovetter & McGuire (1998) the classification criteria are based on changes in actor constitution in and around electricity industry and in electricity technologies. The scale of relative changes in the actor constitution runs from low to high. Attention will be paid to organizations comprising the industry and their downstream and upstream trading partners (for example equipment suppliers, trading partners and capital). Similarly, attention will be paid to relations among actors, for example, relations among industry firms (for example cross-stock-holdings, trade associations), among industry firms and outside institutions (such as political parties, non-governmental or environmental organisations and unions) and relations between the industry and government at all levels (Granovetter & McGuire, 1998; Wright, 1998). The more there are links between the actors the more rigid the relations are and the less likely it becomes there are changes in actors in the industry (Granovetter, 2005; Vogel, 2001).

The second dimension is changes in electricity technologies. The scale of relative changes also runs from low to high. This dimension is evaluated by relative changes in electricity technologies produced and installed in relation to existing technologies. Here, the focus is on wind and photovoltaic technologies. These technologies were chosen because; wind technology has undergone rapid development and considerable market growth being currently the most exploited new energy technology, whereas the growth of photovoltaic technology has just begun. Also, these kinds of distributed electricity generation technologies are required for successful liberalization of the electricity industry (as suggested by Künneke, 2008).

Based on these two dimensions, four categories are formed to illustrate the main characteristics of the changes in electricity industry:

- Electricity as a raw material and commodity
- Electricity as a technological possibility
- Opportunistic approach to electricity
- Electricity as a business

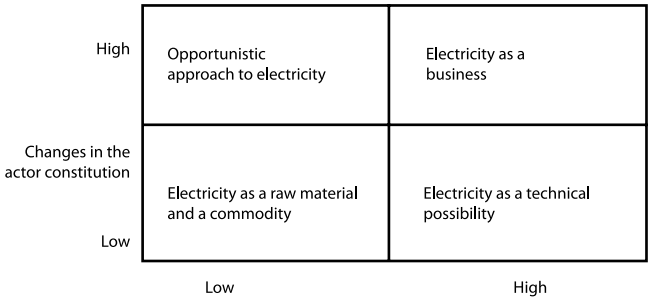

Figure 1 - A typology of relative changes in electricity industry

Figure 1 above illustrates how the four categories relate to the aforementioned two dimensions of change. These categories can also be perceived as reflections of different periods in the electricity industry's history. Electricity as a raw material and commodity can be perceived as representative of the actors and technologies when electricity generation was a state owned monopoly. Changes in electricity industries can begin with changes in technologies or actors, and electricity as a technological possibility represents the first changes in technologies, while opportunistic approach to electricity represents that of actors. Finally, electricity as a business depicts the fully liberalised electricity markets. In what follows, each category is described in more detail.

Electricity as a Raw Material and Commodity

Countries that fall in this category have low degree of changes in the electricity industry. Electricity is perceived as a raw material or basic commodity and national policies focus on centralised electricity generation. Changes in the industry are held up by few strong actors who have strong and close relations with the government. There are very limited possibilities for other actors to influence decision-making. For example, the US oil industry and its close relations with the Republican Party is an example of this. Also research and development funding of new technologies research has been influence by these relations (Deutsch, 2008; Eikeland, 1993; Kobos; Erickson, & Drennen, 2006). For this reason there are only limited policies to support changes in electricity industry and the wind energy and photovoltaic technologies are developed and installed at a marginal level at the most.

Electricity as a technological possibility

In this category there is a relatively low degree of changes in actors but high degree of changes in electricity technologies. Often however, there are a few relatively strong actors with close relations with the government that can slow down systematic, long term changes in actors or in technologies. Henceforth, there are only few new actors in the electricity industry. Japan is an example, where the incumbents have

through their relations with the government to influence energy policies and held up changes in it (Iida, Kanie, Maruyama, Nishikido, & Hondo, 2006). Subsequently, wind and photovoltaic technologies are developed mainly for export; domestic markets are small, which limits the exploitation of these technologies for electricity generation (Lund, 2009).

Opportunistic approach to electricity

In this category countries have high degree of changes in the actors and low in electricity technologies. There are many actors in the electricity industry and the relations between them are fluid. There can be so fluid that constant changes in them, for example, in the electorates can prevent long-term decision making and systematic changes in electricity technologies. An example of this is Sweden. The Swedish political debate was delimited only to phasing out or continuing the life time of the nuclear power plants. This debate slowed down construction of new electricity generation capacity, which began only in 2003 (Jacobsson & Bergek, 2004; Jamison, Eyerman, Cramer, & Laessoe, 1990). This kind of instability can also create opportunities for changes in technologies as opposition to changes is likely to be rather unorganised. The level in which wind energy and photovoltaic technologies are developed and installed depends on interests of actors such as the incumbents, technology developers and the government as the opportunities to do so exist.

Electricity as a business

Countries in this category demonstrate substantial changes in the actors and electricity technologies. There are actors whose interests are to support long term and systematic changes in actors and electricity technologies. The support have introduced changes in the incumbent utilities, their business partners, other organisations and the government introduced by governmental regulation based on assurance of competition. The relations between the actors can be fluid enough to bring about changes but rigid enough sustain changes and to allow for new actors to gain political and economic influence. Wind and photovoltaic technologies are extensively developed and exploited for electricity generation. Denmark, which is presented in the article later, is a good example of this kind of development. However, for example the EU, the USA, China and South Korea have formulated policies that perceive large scale technological changes and electricity as a business.

In line with the above-presented it should be noted here that this typology is intended to be a representation of possible interpretations of nations at a particular point of time. At another point of time, changes in the industry structure and electricity technologies are likely to result in different interpretations. Thus, particular attention should be paid to the contextual nature of this typology and its implementation. It should be noted that is not intended to be a prediction of future developments.

3. Sample and data

This article presents a qualitative case study of the changes in national electricity industries to analyse what alternatives are considered "the best" and how "the best" is defined and by whom? To analyse changes in electricity industry, data has been collected from multiple sources. The research material consists of statistics, research reports and governmental and non-governmental publications as listed in the references. Similarly, statistic data was collected from databases, which generate tables according to the selected variables. Therefore, only the main page link is used as a reference.

This material was used to identify various actors of the electricity industry—and changes in them—as well as changes in energy technologies. All the research material was used at face value and no content analysis was done. The aim of this paper is on analysing several nations and changes that have taken place within them and this form of data allowed for the broad scope of analyses needed here. The time period of this study is from the 1980s to 2011. This time period is characterised by major changes in the political scenery of electricity industry. For instance, the awareness of global environmental problems—most notably through the Agenda 21 and the Climate Treaty and its Kyoto Protocol—created many changes in the public's perception of electricity. Liberalization of the electricity markets and the EU policies for renewable electricity generation, in turn, have created changes in electricity industry.

Germany, Denmark, Finland and Spain were chosen for analysis because these countries are subject to the same EU energy and climate policies and directives over liberalization of electricity markets limiting the number of variables. However, each member state is responsible how these policies and directives are implemented. Moreover, the structure of the electricity industry is unique in each of these countries as are the actors in and around it them making the comparison interesting.

4. Changes in electricity industry in Denmark, Germany, Finland and Spain

In this section, the changes in electricity industry in Denmark, Germany, Finland and Spain are presented and analysed. In Denmark the electricity industry has been completely transformed, while the changes in Germany and Spain have been smaller and the industry is by large unchanged in Finland. We will first present what has been considered the best alternatives in each of these countries by describing the liberaliza-

tion of electricity markets and the total change in renewable electricity generation and in particular in wind energy and photovoltaic generation and technologies. After that we describe how the best was decided and by whom. Finally we will summarise the findings in the typology presented earlier.

4. 1 Liberalization of electricity markets

Regardless of the EU directives 96/92/EC and 2003/54/EC these countries have liberalized electricity markets quite differently. Utilities were privatized rather simultaneously in these countries (Green, 2007). However, in Denmark they were fully privatized and in Germany, Spain and Finland only partially. However, in Denmark in Dong Energy, the largest energy company, the government is a majority shareholder. In Germany municipalities own shares in the largest utilities. In Spain state has continually reduced its shareholding is utilities and it is currently a minority shareholder. In turn, in Finland state remains a shareholder in utilities and there are extensive cross ownerships between the state, state owned utilities and the largest privately owned utilities. The following table depicts liberalization of electricity markets in relation to ownership of utilities, opening of the markets, introduction of feed-in-tariffs and opening of the distribution for competition (Klima- og energiministeriet, 2010; The Federal Ministry of Economics and Technology, 2010; Ministry of employment and the economy, 2010; Ministry of tourism, industry and trade, 2010).

As it can be seen from the table 1, there are more differences in the opening of the markets where Germany and Finland were the first ones to fully open their markets, in Denmark and Spain the markets were partially opened in the 1990s and fully opened almost a decade later. However, Denmark and Germany were among the first European countries to support distributed electricity generation and to open the grid to third parties. Spain was soon to follow. In turn, in Finland the grid is partly privately constructed and owned. Therefore, unlike in most countries the grid in Finland has been open for third parties for decades (Pineau & Hämäläinen, 2000). However, there are no feed-in-tariffs to support deployment of small scale and private electric generation. Quite the contrary, all the costs of the grid connection and interface are born by the producer. Therefore, the generation must be constant and in measured in MWs to become profitable. On these countries Denmark is the only one that has opened distribution to competition. In Germany the grid and distribution is a regional monopoly. In Finland the grid company is owned by the state and the largest utilities Fortum and PVO, and distribution are regional monopolies.

4. 2 Changes in renewable electricity generation

The changes in electricity technologies are first presented in terms of how renewable electricity generation has increased to give an overall view of changes in electricity technologies. Again there are considerable differences between these countries. For example, the relative increase is biggest in Denmark whereas in Finland there are virtually no changes. The following figure depicts relative changes in share of electricity from renewable sources in gross final consumption of electricity (1990 = 100).

As it can be seen from the above presented figure the share of electricity from renewable sources in gross final consumption of electricity has grown rather dramatically in Denmark from 2.6% to about 30%. This is a result of the Danish energy policies, which have supported wind energy since the 1980s and later also other renewable energy technologies (Klima- og energiministeriet, 2010). In Germany the growth has been rather stable in line with the energy policies that have supported wind, bio and solar energy (The Federal Ministry of Economics and Technology, 2010). Currently, the share of electricity from renewable sources in gross final consumption of electricity is about 12% and the growth has been rather stable from 1990 when the share was only 4%. While in Finland the share of renewable electricity generation has remained rather unchanged at about 30% level. Of renewable fuel sources only the use of bio fuels has grown (Ministry of employment and the economy, 2010). However, the vast majority of that is residuals pro-

	Privatization of the utilities	Full opening of the markets	Feed-in-tariffs introduced	Distribution opened for competition
Germany	partially in 1990s	1999	1990	not introduced
Denmark	in 1990s	2004/2007	1986	2003
Finland	partially in 1990s	1997	not introduced	not introduced
Spain	partially since 1990s	2004/2007	1998	not introduced

Table 1 - Liberalization in Germany, Denmark, Finland and Spain

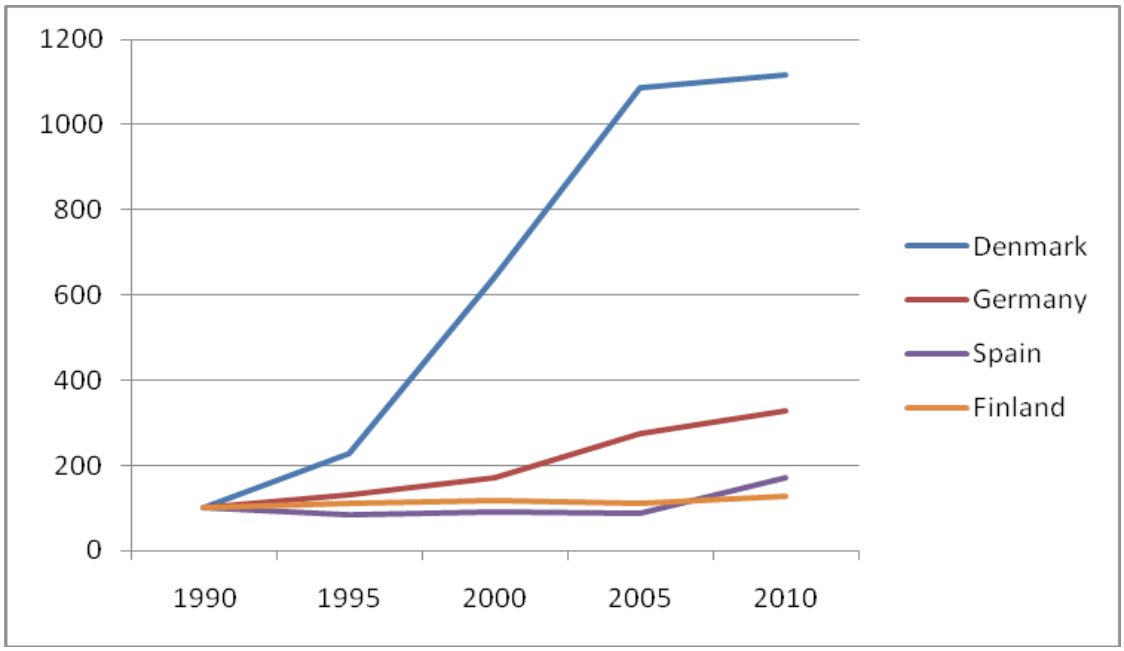

Figure 2 - Relative changes in share of electricity from renewable sources in gross final consumption of electricity (1990 = 100 index) (Eurostat, 2011)

duced and used in forest industries. The relative share of renewable electricity in Spain has also grown from about 17% of gross electricity consumption to 30%. In Spain hydro power has been the main source of renewable electricity but most of the growth has come from wind power. However, successive policy measures to increasing number of technologies and constantly raised national targets have guaranteed the growth of renewable electricity generation (Ministry of tourism, industry and trade, 2010).

4.2.1 Wind energy

To analyse these countries and the usage and deployment of wind the above presented differences become even clearer. The majority the renewable electricity Denmark, Germany and Spain is wind energy, though the share of other technologies and fuel sources, for example, solar and combined power and heat are increasing. In line with the above presented Denmark, Germany and Spain are the world's leading countries in wind energy use and technology. In Finland wind energy generation is only marginal as it can be seen from the table 2 presented below.

The design of the modern windmill was developed in Denmark in the 1970s. Since the mid-1980s there have been support wind energy technology development and installations. Moreover, wide support for wind energy was insured by supporting private ownership of wind mills (Lyhne Ibsen & Skovgaard Poulsen, 2007; Meyer, 2007). For example, the Middelgrunden Offshore Wind Farm (40 MW) is the world's largest cooperatively owned wind farm with more than 8000 members. Also, the Samsø project (23 MW) off the east coast of Jutland is a cooperative with people on the island of Samsø and the municipality (Danmarks vindmølleförening, 2009).

In Germany research and development and deployment of wind energy technologies began early on. However, the research and development was not as successful as in Denmark (Klaassen, Miketa, Larsen, & Sundqvist, 2005). Nor were the incumbent utilities interested in making investments in wind energy. Most of the wind energy installations are owned by private consumers, cooperatives or other new comers to electricity business (Stenzel & Frenzel, 2008).

In Finland research and development funding for wind energy has been rather modest. Also the utilities have had rather negative attitudes towards wind energy. As there is no adequate support for investments but many barriers against them the share of wind energy is marginal. Henceforth, wind energy technology industries' are mainly component manufacturers (Beckman, Lundtang Petersen, & Sellberg, 1992; Varho & Tapio, 2005).

In Spain the utilities began investing in wind energy technology and capacity in the 1990s. Iberdrola was the first utility to invest in this technology when its subsidiary Gamesa bought licences for the technology from the Danish Vestas.

Country	Share of total installed capacity	Share of yearly produced capacity	Local manufacturer, global market share %
Denmark	4 %	29 %	Vestas 28.4
Germany	28 %	23 %	Enercon 13.4 Siemens 5.6 Repower 3.1 Nordex 2.7
Spain	16 %	20 %	Gamesa 13.2 Ecotecnia 2.1
Finland	marginal	marginal	marginal

Table 2 - Wind power by country, share of total installed and produced capacity, largest manufacturers and their market shares in 2006 (Lund, 2009)

After a slow start also other utilities began investing in wind energy, in particular, after the feed in tariffs were introduced in mid-1990s. Currently, production of wind energy is around 40 percent of the total renewable electricity output of Spain. After Germany, Spain is the second largest country in the world in terms of installed wind capacity (European Union 2009).

4.1.2 Photovoltaic technology

Looking at the photovoltaic technology the situation is rather similar as with wind energy. Photovoltaic industries and installations have been growing rapidly, however, only during the recent years. Also the generation is smaller scale than wind power and thus statistical changes are less impressive (European Union 2009). The following table illustrates the photovoltaic installations and businesses in Denmark, Germany, Finland and Spain.

As it can be seen from the table 3, of these countries Germany and Spain are the leading countries in photovoltaic technologies. The technology has received substantial research and development funding in Germany (Commission of the European Communities, 2007). The policies have ensured growing domestic markets for the companies (Jacobsson & Lauber, 2006). Also, Spain is not only a technology developer but also substantial exploiter (del Río & Unruh, 2007); However, to a lesser extent than the German companies. The share of photovoltaic technology in Denmark is small; however, it is growing rapidly (Denmark Statistik, 2010). Again in Finland the development and usage of photovoltaic technology is marginal. The research and development funding has been rather modest as have the corporate interests in development of the technology (Pesonen, 1997).

Country	Share of total installed capacity	Share of yearly produced capacity	Local manufacturer, global market share %
Germany	35 %	19 %	Q-Cell 9.3 Schott Solar 5.5 Shell Solar 3.4 Deutsche Cell 2.2
Spain	1 %	4 %	Isofoton 3.1
Denmark	marginal	marginal	marginal
Finland	marginal	marginal	marginal

Table 3 - Photovoltaic by country, share of total installed world-wide and produced capacity, largest manufacturers and their market shares in 2006 (Lund, 2009)

4.2 Political decision-making processes concerning electricity industries

Denmark consisting of over 400 islands and of the peninsula of Jutland is the main reason why most of the Danish utilities are very small and local. Unlike in many other countries, in Denmark non-governmental anti-nuclear organisations have been the strongest supporters of renewable energies while the environmental party remains a rather marginal political actor (O'Neill, 1997). As in many other Western countries during the 1970s, also the Danish government had plans to develop nuclear energy. However, the government's plans to introduce nuclear energy faced strong resistance from the Organisation against Nuclear Power and the Organisation for Renewable Energy. Also, there are virtually no energy intensive industries, and thus no substantial supporters of nuclear energy in Denmark. After over a decade of debating, in 1986 plans to develop nuclear power in Denmark were rejected, and the Danish parliament decided that nuclear power should not be an element of future electricity supply (Jamison, Eyerman, Cramer, & Laessoe, 1990; Skou Andersen, 1997; Meyer, 2007). Instead since the energy policies have focused on wind energy and other forms of distributed energy generation and on supporting private ownerships in them.

Germany is by far the largest energy consumer in the EU and electricity generation is mainly based on nuclear power and fossil fuel (Statistisches Bundesamt Deutschland, 2010). From early on the opposition to nuclear energy was organised around the German Green Party. The main themes were the phasing out of nuclear energy and increasing the production of renewable electricity. The success was ensured by an electorate of young, radical and anti-materialistic voters who had a radical approach to environmental issues. However, green policies were slowed down during the 1990s by economic problems, which were compounded by the falling of the Berlin wall and the unification of Eastern and Western Germany. Subsequently, the Green Party lost votes and political power, and was forced to make several compromises (O'Neill, 1997; Rüdig, 2002). Also the utilities formed a strong lobby to resist the phasing out and collective bargaining processes aided in the resistance. No definite plans for phasing out the remaining nuclear reactors were made. However, a limit for nuclear energy production was established (Stenzel & Frenzel, 2008). After the 2009 elections an agreement was negotiated between the government and utilities that nuclear power stations will be progressively shut down as they age, with an estimated complete shut-down of all plants by 2022. However, that has since then been prolonged. On the other hand, according to the current estimates renewables could supply at least half or if not all the country's energy needs by 2050 (The federal environment agency, 2010).

The forest industry along with the incumbent utilities, some of which the forest industry also owns (PVO/TVO) are among the strongest actors in the electricity industry in Finland. There are also substantial gross-ownerships between state, forest industry and the incumbents (Lilja, Räsänen, & Tainio, 1992; Vehmas, 2002). Anti-nuclear movement was not as powerful in Finland as it was in Demark or in Germany and it has not been able to create any changes in the electricity industry. However, the atmosphere in Finland turned against nuclear energy after the Chernobyl accident. An environmental party, the Green League, emerged from several rather incoherent, ideological groups. Although the party has managed to get representatives in the parliament and in the cabinet, it has nevertheless remained more of an ideological movement, having rather marginal political power (O'Neill, 1997). The relations between the forest industry, incumbents and the governmental have been so strong that, there have been no parliamentary elections or referendums about nuclear energy in Finland. Though in Finland the liberalization of electricity markets appears to be advanced (as suggested by Pineau & Hämäläinen, 2000) in practice the manner it has been done changes in the industry depend on the interests of the forest industry and incumbent utilities (Kojo & Litmanen, 2009). And they have been campaigning for more nuclear reactors since the Chernobyl accident and in 2003 the parliament granted permission for one nuclear reactor and in 2010 for two more reactors (Ministry of employment and the economy, 2010).

The political environment in Spain differs considerably from other European countries. Liberal democracy was only re-established in the late 1970s, and the country still remains divided by many political cleavages. As a result, the development of green parties in Spain differs dramatically from other green parties around Europe. Unlike other parts of Europe, the Spanish green parties have not been able to develop or gain political power. Green parties and environmentalism remain rather marginal, yet emerging, phenomena (O'Neill, 1997). The Spanish electricity generation is organised mainly by the regional governments. The first state support for wind power in Spain was introduced in 1980. The rapid rise in Spain's wind energy capacity is due not to environmental concerns, but to meet the increasing electricity consumption. The Spanish wind farm investments have mainly been undertaken by the electric utilities, regional governmental agencies, and manufacturers. The driver of the development has been the need to increase electricity production capacity rather than reduce greenhouse gas emissions (Meyer, 2007). Also the Spanish utilities have also been quick to develop businesses from renewable energy technologies. Also the Spanish utilities, most notably Iberdrola and Endesa are conglomerates operating in different businesses, have also developed businesses from renewable energy technologies. This development has been supported by the governmental policies, which have been rather constant.

4.3 How the "best" alternative was decided and by whom

As it can be noted from the above presented there are quite considerable differences in changes in electricity industry between Denmark, Germany, Finland and Spain. The polar opposites are Denmark and Finland. In Denmark there have been the most changes in actors and technologies, while in Finland there have virtually been no changes in either. Germany and Spain changes have taken place, however at a slower pace than in Denmark. These changes reflect how in these countries the best have been defined and by whom it is defined. In what follows, we summarise and discuss how we have interpreted the changes in actor constitution and in electricity technologies in Germany, Finland, Denmark, and Spain in relation to the typology as summarised in the following figure.

Denmark is located in the category "Electricity as a business" because there have been considerable changes in actors and technologies. In Denmark the best has been increasing competition within the electricity industry. The incumbents have had loose relations with the government and they have not slowed the changes. The decisions about what is the best have been made through parliamentary processes. These decisions have had several consequences. There has been an increase of renewable electricity generation and introduction of new actors to the industry. At the same time the increasing competition and decreasing markets have forced the incumbent utilities to diversify to other business areas or to merger with others. The investments in research and development in wind energy have turned the green ideology into global business. Consequently, Denmark is now a net exporter of electricity. Although Denmark has been rather focused on wind power, it has also diversified to other renewable electricity technologies and it has continually grown its share of energy technologies' markets.

Changes in Germany's electricity industry are characterised by relatively low degree of change in the actors and a relatively high degree of change in electricity technologies. Contrary to Denmark in Germany what is considered the best has changed from increasing renewable and phasing out nuclear energy to prolonging the life time of nuclear. Henceforth, we have located Germany in between the categories "Electricity as a technical possibility" and "Electricity as a business". The changes in the best in Germany are due to the changes in electorates and in the national economy. Also the German incumbents have used their relations with the government to influence the definition of the best and in

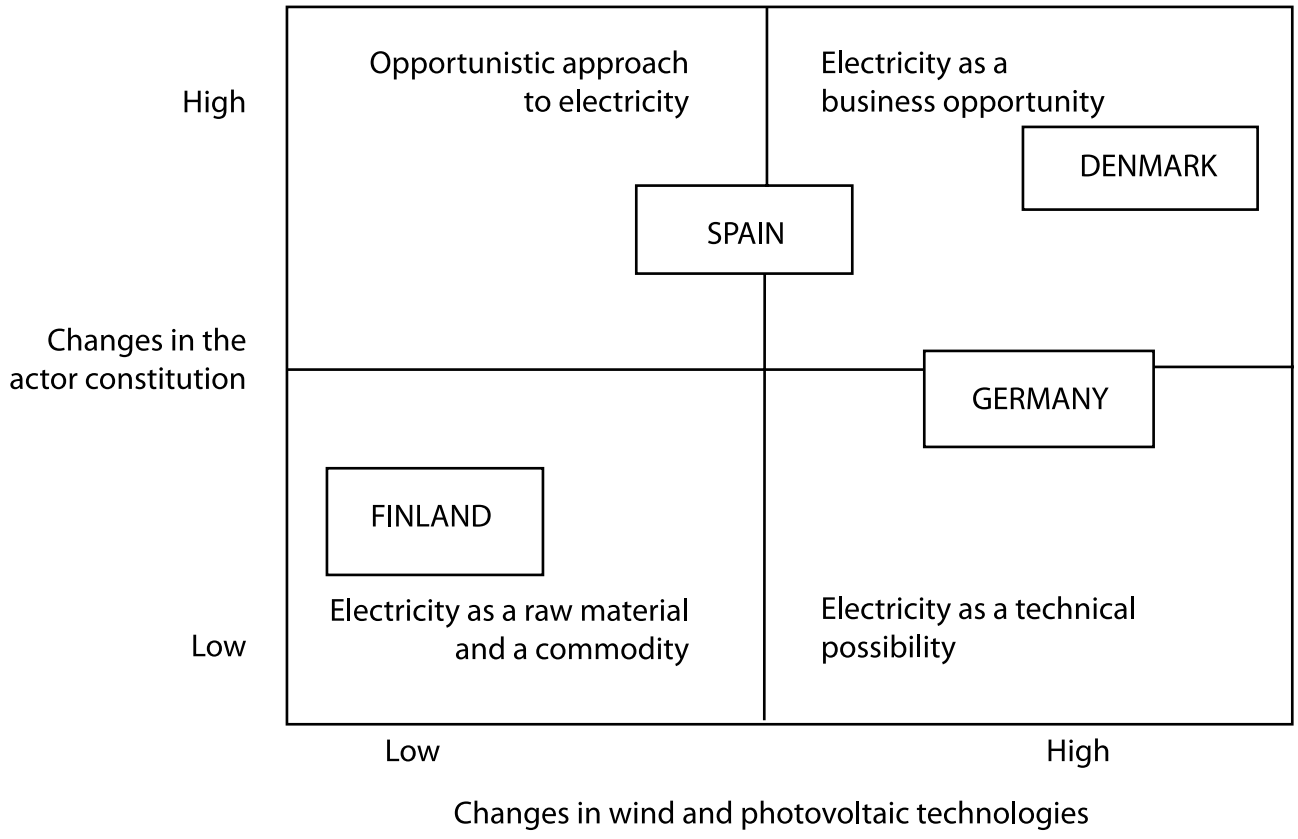

Figure 3 - Changes in electricity industries in Finland, Denmark, Spain and Germany

particularly to protect their nuclear electricity generation. Thus the changes in actors and technologies are smaller than in Denmark. However, German technology developers are among the largest in the world in wind and photovoltaic technologies. Furthermore, heavy investment in research and development has turned the ideology into a technical possibility. For example, within the European Union, Germany is the largest contributor to research and development in renewable energies (European Union, 2008). The future plans include, for example, strengthening Germany's position as an exporter of renewable technologies, increasing the share of all renewable energies, and constructing smart grids to reduce electricity consumption. However, it might take a while before the perception that electricity is a business opportunity will prevail in Germany.

Finland is located in the category "Electricity as a raw material and commodity," which is characterised by a low degree of changes in the actors and technologies. In Finland the best has been to construct more nuclear energy capacity and it was largely defined by the large utilities and the energy intensive industries, again with the help of their close relations with the government. These industries still hold considerable power and there are no mechanisms to introduce new actors in decision-making. As a result of this, Finland has not been able to gain markets shares in the wind or photovoltaic markets and the installed capacity of wind or solar energy is marginal. Along with the permissions for nuclear reactors the markets are likely to be even more consolidated and controlled by the incumbent utilities.

We locate Spain in between the categories "Opportunistic approach to electricity" and "Electricity as a business opportunity". In Spain the best was to increase wind energy generation and photovoltaic to increase electricity generation and dependency to imported fuels. That was first defined by local incumbents and regional governments, later also by the national governments. Regardless of the multiple political cleavages and somewhat unstable political climate, in Spain renewable electricity generation have been supported and developed rather systematically. However, the share of renewable electricity is lower than in Denmark which is due to Spain's more centralised and capital intensive electricity system. Also changes in it take place at a slower pace than in Denmark where the system was distributed and smaller scale to begin with. Also in Spain the incumbents, with the help of the regional governments, were quick to exploit the new technologies. In recent years Spain has invested heavily in research and development for new electricity technologies. Through vertical integration to wind and photovoltaic electricity technologies the utilities have also expanded their markets geographically in the manner that is quite unique among the European incumbent utilities. Another consequence of the above described changes in electricity industry is that Spain is no longer dependent on imported electricity but has now excess electricity production capacity.

5. Conclusions and discussion

Liberalization of electricity markets, global warming and technology development are transforming the electricity industry, in particularly, the supply actors and technologies. However, the scope and nature of changes varies from country to country. We have discussed here how these issues have changed the actors of the electricity industry and electricity technologies. The national level was selected as bases for analyse because electricity industry and technologies are still regulated by national governments.

Electricity industries were analysed as dynamic social constructions and attention was paid to what is considered "the best" and how "the best" is defined and by whom. Of electricity technologies we analysed changes in wind and photovoltaic technologies. The countries analysed here were Germany, Denmark, Finland and Spain.

In Denmark the interests to increase renewable electricity generation and competition in the industry were strongest. That in conjunction with small and thus politically weak utilities allowed change to take place. However, in Germany the utilities used their political power to protect their market shares and to resist extensive changes in the industry. In Finland the utilities have such strong ties with energy intensive industries and the government that they have prevented any changes from taking place. In Spain there were multiple complementing interests for renewable energies: the need for more electricity, lack of domestic fuel sources and utilities, which are conglomerates were the combination of interests that created an atmosphere for changes.

Based on the above presented there are several different outcomes to change in the industry, which are not determined by technical or economic efficiency but changes in electricity industry are contextual and socially embedded (Granovetter, 1985; Whittington, 1993). National electricity industry is a rather unique both by the actors involved and in its dynamics. There are also national differences in which groups are marginalised and how (Granovetter, 2005; Henderson & Clark, 1990). Also rationalities behind the changes were quite different from country to country, as where interests behind them (Callon, 1980; Granovetter & McGuire 1998; Wright, 1998).

In line with the results presented here and as also noted by Müller-Rommel & Poguntke (2002), green parties in the parliament and the government do not always lead to technology changes. It appears that the political strength of green parties or how environmental issues are integrated in

the political parties' programmes in general is much more important (as suggested by, Jamison et al., 1990). As noted by Lewis & Wiser (2007)—and also supported by our preliminary findings—the importance of the dynamics of actors in governmental decision-making seems to be particularly noteworthy when analysing changes in electricity industry at least on two levels. First, national governments influence the manner electricity technologies are developed. Unless new interests can emerge in the government change is unlikely to take place. Second, creation of domestic markets for electricity technologies is important for the development of new businesses. These levels are clearly interlinked as the development of electricity technologies requires a home market.

Finally, there appears to be a shift from renewable electricity technologies as an ideology to renewable electricity technologies as a business. The trend will continue as new technologies become cheaper and thus available for the private households and local communities. Another important factor relates to high oil prices and public awareness of global warming. Finally, the increasing emphasis to increase competition in electricity generation markets will increase changes in electricity technologies. These trends will undoubtedly create changes in actors, making consumers and producers of electricity technologies much stronger actors in the near future than what they are today. These lasts aspects highlight the importance of multi-level policies, which focus on both high- and low-tech industries, on technical and social innovations, especially on new business innovations, new ways of making business (Hirsch-Kreinsen, 2009; Montiel Campos et al. 2009; Storbacka et al., 2009).

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