Social Factors in Wind Energy Development of Denmark in 1980s – 1990s: Society and Technology

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Abstract

During the 1970s, the oil price in global market was raising nearly to US$ 100 per barrel. At that time, 92 % of electricity production in Denmark depended on the imported oil. The global oil crisis forced the Danish government to seek the alternative energy solutions, while the government cancelled their plan for atomic power in 1985. Electricity from wind, biomass, and solar power became the answer of Danish government.

Nowadays, Denmark becomes one of the world leaders in wind energy. This paper believes that the collaboration between the people's reaction and the policy of Danish government in 1980s-1990s is the main factor of the today's success of the wind energy development in Denmark. Therefore, this paper will examine the social factors behind the industry development of wind energy in Denmark.

Key words: Wind Energy, Denmark, Oil Crisis, Industry Development, Policy Implementation, Relationship between Society and Technology

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Introduction

During the 1970s, the oil price in global market was raising nearly to US$ 100 per barrel (Minister of Natural Resources of Canada (NRCan), 2010: Online). At that time, 92 % of electricity production in Denmark depended on the imported oil (Maegaard, 2009: 46). The global oil crisis forced the Danish government to seek the alternative energy solutions, while the government cancelled their plan for atomic power in 1985 (Maegaard, 2009: 46). Electricity from wind, biomass, and solar power became the answer of Danish government (Maegaard, 2009: 46).

The global oil crisis in 1970s and the 1985 cancellation of atomic power plant brought Denmark to the age of renewable energy (Maegaard, 2009: 46). However, according to Danish Energy Agency (2009: 5) geographically, the wind conditions of Denmark are more favorable for electricity production than other countries in Europe. Nowadays, Denmark becomes the world leader of wind energy (Center for Politiske Studier, 2009: 7). The 1980s and the 1990s were the expansion period of wind turbine industry in Denmark (Danish Energy Agency, 2009:. 56-59).

Historically, at the same time of the global oil crisis, from 1975 to 1979, Christian Riisager, Karl Erik Jørgensen, and Erik Grove-Nielsen were the Danish technology pioneers in wind energy development (Maegaard, 2009: 48-50; and Wind of Change, 2012: Online). They invented the several models of wind turbines (Maegaard, 2009: 48-50). In the 1980s, the wind turbine industry of Denmark was on the upswing (Madsen, 2009: 58-59). Later, in the 1990s, the total number of installed wind turbines was 2,069 units (Danish Energy Agency, 2009:8).

On the other hand, the statistical data and the historical phenomenon above could not provide the crystal-clear answer of how Denmark develops its own concept of wind technology in those periods of time. In other words, the key question of this paper could be "how could Denmark develop its market growth of wind turbine industry?" and "what are the social factors behind the growth of this industry?". Therefore, this article is aimed to discover the wind energy development in Denmark in the 1980s and in the 1990s, through the field of politics of science and technology.

Literature Review

The answer of Denmark's success in wind energy development seems to exist in the 1980s and the 1990s. That was because the growth of wind turbine industry remarkably emerged in those periods of time (Madsen, 2009: 54-59; Danish Energy Agency, 2009:8). The industry was grown, after Denmark had discovered its several models of wind turbines in 1970s for the wind energy development (Maegaard, 2009: 48-50).

Rinie van Est, an academician at Rathenau Institute, in the Netherlands, made a comparison of wind turbine development between California and Denmark in 1999 (Van Est, 1999:16). The work of Van Est has found that the five factors in wind energy development of Danish history supports Denmark to grasp the position of the world's leader in wind energy today (Center for Politiske Studier, 2009: 7; Madsen, 2009: 52-53; Nielsen, 2009: 60-63). These factors are (1) scientific research, (2) technological development, (3) production and marketing, (4) consumption and economic-valuing of product, and (5) policy-making. In the work of Van Est, these factors are considered as the five poles of wind energy development of Denmark (Nielsen, 2009: 60-63).

Besides those 5 factors, Van Est analyzed the strength of local communities, the principle of Danish social democracy and the rural farmers in Denmark were assisting the policy implementation of wind energy in Denmark (Van Est, 1999: 132-140). Van Est collected several evidences to trace back the political philosophy behind the movement of wind energy development. Finally, he found that the Danish people in the countryside were the main influencer in the wind energy development of Denmark (1999: 75-87 and 161 -164).

As discovered by Van Est, the political ideology of the Danish people in rural areas, as a driving force, are influenced by Nikolaj Frederik Severin Grundtvig, or known as N.F.S. Grundtvig (Van Est, 1999: 161-162; Lawson, 1993: 3-4). In the work of Van Est (1999: 161-164), it shows that the Grundtvig's concept of learning impacted the mentality of the today's peasants in Denmark. That is one of the key answers for the today's success of the wind turbine development in Denmark.

Moreover, Kamp also made a comparison of wind turbine industry development between Denmark and the Netherlands (2002:1-2). However, the work of Kamp focused on the learning process of the technology development in the Danish wind energy sector (2002:1-3). The success of the Danish wind turbine development is influenced by 4 learning processes. These are (1) the Learning by Searching, (2) the Learning by Doing, (3) the Learning by Using, and (4) the Learning by Interaction (Nielsen, 2009: 63-64).

At the certain point of argument, Kamp and Van Est agreed that the social democracy in Danish society and the rural empowerment influenced in the industry development of wind turbines in Denmark. However, the work of Kamp is focusing on the social interaction through the historical development of the wind energy in Denmark, while the work of Van Est is focusing on the political ideology, and the historically political movement of the Danish society.

However, to strict only the work of Kamp and Van Est may not be able to provide a completed argument, because the most of data from the work of Kamp and Van Est are concentrated in qualitative data. The information from the Danish Energy Agency, statistics and other resources will provide the quantitative data. Therefore, the main discussion of this paper will mainly apply the analysis of Van Est and Kamp in order to summarize the social factors in the wind turbine development.

1. Brief Background of the Danish Political History

Before understanding the whole situation in Denmark, Van Est suggests to look at the general situation of social movement in Denmark in the midst of 19th Century (1999: 161-163). That was the transitional time for Denmark to change the form of government, from the regime of absolute monarchy to the regime of constitutional monarchy (Van Est 1999: 161-163). Influenced by the political changes in European countries, the King Christian VIII decided to set up the national assembly, while he passed the law of compulsory education for the Danish society (Jayasinghe, 2011: Online; Lawson, 1993:1). The creation of the national assembly of Denmark was aimed to aggregate every representatives from the estates in Danish society (Van Est 1999: 161-163; and Lawson, 1993:1). At that time, the estates in Danish society were peasantry, bourgeoisie, clergy and nobility (Van Est 1999: 161-163; and Lawson, 1993:1).

However, the King Christian VIII could not lead Denmark to the era of Democracy before his death in 1848 (Jayasinghe, 2011: Online; and Kurrild-Klitgaard, 1998: 73). Thus, before the King Christian VIII passed away, he had had an order to his son to bring the free constitution to the Danish people (Jayasinghe, 2011: Online; and Kurrild-Klitgaard, 1998: 84). Therefore, after the King Frederick VII signed the first constitution of Denmark, in 1849, Denmark entered the era of democracy under the constitutional monarchy (Kurrild-Klitgaard, 1998: 73).

Although the democracy started from the roof of the Danish society, the movement from the grassroots was the main force of the social change. During the chaotic time of Denmark in the midst of 19th Century, Denmark was facing two key movements. The first movement was *Danish agricultural cooperative movement* (In Danish: *Andelsbevægelsen*) in 1882, while the second

movement was the educational reforms led by *Nikolay Frederik Severin Grundtvig* (Hereafter referred to "Grundtvig"), one of notable Danish philosopher in 1844 (Chloupkova 2002: 15-16; Chloupkova et al., 2003: 242; Jakobsen, 2006: 83-84; and Van Est 1999: 161-163). Later, those two political movements in the history of Denmark led the Danish society to see the effects of two reforms (Chloupkova 2002: 15-16; Chloupkova et al., 2003: 243; Van Est: 161-166). The wind energy development is a result of the educational reforms, while the cooperative ownership of the rural power stations in Denmark is a result of cooperative movement in the history of Denmark (Chloupkova 2002: 15-16; Chloupkova et al., 2003: 243; Van Est: 161-166).

1.1 Grundtvig's Beliefs and the Rural Empowerment

Grundtvig's concept of life-long education has created an educational access for the peasants in Denmark since 1844 (Van Est, 1999: 161-162; Lawson, 1993:3). This is simply explaining that the education in the countryside of Denmark in 19th Century impacted the mentality and the cooperative movement of the Danish peasants from the year of 1844 to today (Chloupkova 2002: 15-16; Chloupkova et al., 2003: 242; and Jakobsen, 2006: 83-84). In the work of Van Est (1999: 161-164), later, the heritage of education for the Danish peasants in the past encourages the today's peasants in Denmark to set up the cooperatives to possess the wind turbines for their own communities.

Grundtvig's thoughts of life-long education led a group of his followers to create Grundtvigianism schools. Today, the Grundtvigianism schools were known as "Danish Folk High School" (Van Est, 1999: 161-162; Lawson, 1993:3). The first Danish folk high school was created in 1851, in Rødding, by Christen Kold, a follower of Grundtvig's concept (Lawson, 1993: 5).

To provide an access to education for the Danish peasants and everyone in the Danish societies is a goal of Grundtvig's idea (Van Est, 1999: 161-162; Lawson, 1993:1). The key method of teaching in the folk high schools emphasized the living interaction of all people in the classes, and the creation of fellowship among the class participants (Lawson, 1993: 3). As a result, the Danish peasants can access the knowledge, have better way of living, and become a place to unite all Danish people from their different social classes and economic strata (Van Est, 1999: 161-162; Lawson, 1993:3-4). Therefore, the Danish folk high school will not give any examinations to their students, and become a place of "School of Life" (Lawson, 1993: 3).

However, in fact, the original idea of Grundtvig's concept of life-long education comes from the political thoughts of Grundtvig during the political transition of Denmark, from the regime of absolute monarchy to the regime of constitutional monarchy (Van Est 1999: 161-163). As Grundtvig believed, if the "lower orders", or the peasants and other people in rural areas, in society had a voice in the advisory assemblies, they should have to have an access to an appropriate education (Van Est, 1999: 161-162; Lawson, 1993:1).

Therefore, the folk high school for the farmers supported the growth of social unity and social harmony in the Danish society (Chloupkova et al., 2003: 242). Besides that, it allowed the farmers to access the free schools and the knowledge of the social situation in the up-to-date time (Chloupkova et al., 2003: 242).

1.2 Movements for Cooperative Ownership

It is not possible to discuss about the wind turbine development in Denmark without mentioning the cooperative ownership. The cooperative ownership is a result of the education from the Danish folk high schools (Chloupkova 2002: 15-16; Chloupkova et al., 2003: 242; and Jakobsen, 2006: 83-84). After the creation of folk high schools in several areas of Denmark, the peasants and the rural populations have an access to an appropriate education under the conditions of interactive teaching and fellowship across the different social classes and economic strata (Lawson, 1993: 3-6).

The deep explanation about the relationship between the Danish folk high school and the cooperative movement in Denmark in 1880s will be explained. In 1864-1876, the main participants of the Danish folk high schools, as their key educational instrument, were a group of independent farmers, and rural elites (Van Est 1999: 161-163). In addition, the Danish peasants became independent from the landlords since the effective date of the Law of Abolition of the Landlords in 1787 (Jakobsen, 2006:68). Besides their participation in the Danish folk high schools, they also took classes in the agricultural schools (Jakobsen, 2006:83). Therefore, the Danish folk high schools and the agricultural schools provided a bunch of concrete knowledge for the farming and living for those independent farmers, and rural elites (Van Est 1999: 161-163; and Jakobsen, 2006:83).

Also, the fear of the foreign capitalists pushed the Danish peasants to seek for the establishment of cooperatives (Van Est 1999: 163-164). In 1870s, the railroad and steamship transports had supported the American and Russian farmers to export their cheaper grains across Europe, due to the mass production in those countries (Van Est 1999: 163-164). Later, the Danish farmers started to fear the fall of grain prices (Van Est 1999: 163-164). At that time, there was no organization to support the Danish peasants to fight against the coming of foreign monopoly (Chloupkova et al., 2003: 242).

In the Danish folk high schools, the rural population learnt not only about the social fellowship, but also about the democracy (Jakobsen, 2006:83 - 87). Moreover, the cooperative ownership could help them to control the price, and gain the competitiveness against the private merchants (Jakobsen, 2006:85). Finally, the external economic factor and the social factor of Denmark led the Danish society to create the first cooperative in Denmark in 1882 (Chloupkova et al., 2003: 242-243). The first cooperative was a dairy cooperative (Chloupkova et al., 2003: 243).

1.3 Danish Folk High School and the Emergence of Wind Turbine Development

After Christen Kold had established the first Danish folk high school in Rødding in 1851, Denmark confronted a war against Germany in 1864 (Lawson, 1993: 5). Later, the war was called "Schleswig-Holstein War". As the result of the war, Denmark lost Schleswig-Holstein to Germany in 1864 (Lawson, 1993: 5). Therefore, 15 Danish folk high schools in the territory of Schleswig-Holstein were suddenly under the rule of Germany after 1864, including the first Danish folk high school in Rødding (Lawson, 1993: 5). Therefore, Ludvig Schroder, the headmaster and two assistant teachers, moved to Ashkov Folk High School (Lawson, 1993: 5).

At Ashkov Folk High School, in 1891, Poul la Cour was a teacher of physics and mathematics of the school, and invented the first wind turbine of Denmark (Kamp 2002: 129; and Nissen, 2009: 6-8). The main of idea of la Cour was to use the wind energy as a possible key technology for rural electrification, because, as la Cour discovered, rural areas in Denmark at that

time needed electricity for their agricultural production (Van Est 1999: 163; and Quistgaard, 2009: 12-13). Later, la Cour and his team set up the *Danish Wind Power Society* in 1903 (Van Est 1999: 163). In 1908, la Cour and *Danish Wind Power Society* could set up 32 new wind power stations in rural areas of Denmark (Van Est 1999: 163).

Before la Cour was passed away in 1908, Johannes Juul took the la Cour's classes of rural electrician in 1904 (Van Est 1999: 163; and Thorndahl, 2009:40). From 1950, Juul started to work on his first wind turbine (10 kW wind turbine) (Thorndahl, 2009:42). In 1957, Juul developed his biggest model of wind turbine near Gedser town (Kamp 2002: 130-131; and Thorndahl, 2009:43-44). Nowadays, Juul's model of wind turbine, known publicly as "*Gedser Wind Turbine*", became the inspirational model for the Danish people's wind power in 1970s, particularly the *Tvindkraft Windmill* (Maegaard, 2009:48-50). The *Gedser Wind Turbine* of Juul had a 25-meter tower, three blades,and an asynchronous generator for 200 kW (Thorndahl, 2009:43-44).

When the oil crisis came to Denmark in 1970s, it pushed the Danish parliament to started a debate about the atomic power program as the alternative solution for the oil crisis in 1971 (Van Est 1999: 70; and Maegaard, 2009: 46). From 1969, the *Friends of the Earth Denmark* (Hereafter "NOAH"), started by a group of students from the University of Copenhagen, and the students from the Danish folk high schools started the anti-nuclear campaigns to resist against the decision of the Danish central government (Van Est 1999: 73).

When the Danish parliament was discussing about the atomic power programs, in 1975 – 1979, the teachers and students at Tvind Folk High School, located in Ulfborg, started the construction of the *Tvindkraft Windmill*, a 2MW wind turbine (Van Est 1999: 70-78; Tvind International Skolecenter, c. 2012: online; Kamp 2002: 144; and Maegaard, 2008: 48-49). Their goal of this construction intended to send a direct signal to the central government of Denmark that the Danish people would choose the wind energy as the alternative solution for the Danish energy crisis, rather than any forms of atomic power programs (Van Est 1999: 70-78; Tvind International Skolecenter, c. 2012: online; Kamp 2002: 144; and Maegaard, 2008: 48-49).

2. People's Movement in Wind Energy Development in 1980s - 1990s

The main consequences of the people's movement in wind energy development in 1980s – 1990s are the growth of home market (Madsen 2009: 59). However, to understand the growth of home market in 1980s-1990s, it is necessary to look back the several scenarios in 1970s – 1980s, such as the grassroots' movement in 1970s-1980s, cooperative ownership in wind energy, and the cancellation of atomic power programs in Denmark (Kamp 2002: 142-155). The advancement of the grassroots' movements will answer how Denmark had an achievement to create their home market (Kamp 2002: 152-153). Moreover, the statistics of the wind turbine installation between 1980s and 1990s is available in *Annex 2* of this paper.

2.1 The grassroots' movement in 1970s-1980s

According to Kamp (2002: 145), the Danish people had a strong intention to buy a wind turbine for their house, because they wanted to support the green movement rather than money-saving initiatives. Also, they intended to support the development of the renewable energy technologies

(Kamp 2002: 145). At this time, some of wind-turbine users had a problem with their purchased product (Kamp 2002: 145). Thus, in 1978, the users of wind turbines decided to set up the *Danish Windmill Owner Association* (In Danish: *Danmarks Vindmølleforening*) in order to bring feedbacks to the wind turbine manufacturers for the future improvement (Kamp 2002: 145). This association helped the wind-turbine users to have a stronger power of negotiation with the wind-turbine manufacturers, such as, safety, product reliability, and gearboxes (Kamp 2002: 145 - 146).

However, in fact, the grassroots' movement of wind-turbine users was set up in 1975 (Kamp 2002: 145 – 146). It was called "Wind Meeting" (Kamp 2002: 145 – 146). It was a meeting between wind-turbine users and wind-turbine manufacturers (Kamp 2002: 145 – 146). This meeting was held in 4-8 times a year (Kamp 2002: 145 – 146). The people at the meetings felt that they were a part of community (Kamp 2002: 145 – 146).

2.2 Cooperative Ownership in Wind Energy

According to Kamp (1999: 149), most of wind turbines in Denmark were sold to the cooperatives. One windmill cooperative in Sydthy Kommune can be a good example. Dating back to 1988, in Helligsø, in Sydthy Kommune, Bjarne Ubbesen, a local tearcher, was inspired to work by participating in meetings of people, who took an interest in windmills (Olesen et. al, 2002: 24-25).

Later, Bjarne Ubbesen started to gather people, who were interested in the project (Olesen et. al, 2002: 24-25). The Ubbesen's idea concentrated on the local area, and limited to families living within a radius of about 5 kilometers (Olesen et. al, 2002: 24-25). The most important reason was the size of the investment, because this project was not run to make any business profit (Olesen et. al, 2002: 24-25). The guild (cooperative) was formed on March 3, in 1988, by 51 members as owners of the 200 kW windmill (Olesen et. al, 2002: 24-25). At that time, it was possible to own eight shares at 1,000 kWh per family (Olesen et. al, 2002: 24-25). The return from eight shares was approximately 700 Euro per annum (903 US Dollar, approximately) (Olesen et. al, 2002: 24-25). Also, it might make an additional income of 270 – 450 Euro per annum (348.30-580.50 US Dollar, approximately) after payment of installments and interest (Olesen et. al, 2002: 24-25).

In 1990s, it was a time for the windmill cooperative expansion across Denmark (Sørensen et. al 2002: 1-2). The size or model of each windmill cooperatives in Denmark might not have to be the same (Olesen et. al, 2002: 24-36). Another example will be given to demonstrate the model of a leading windmill cooperative in Denmark. In 1996, the Copenhagen Environment and Energy Office (Hereafter referred to as "CEEO") and Middelgrunden Wind Turbine Cooperative were coordinating to set up the first off-shore wind farm in Denmark. As it had been mutually planned, 10 wind turbines in the north were belonged to CEEO, while 10 wind turbines in the north were under the procession of Middelgrunden Wind Turbine Cooperative (Sørensen et. al 2002: 1-2). 3 percent of the total output from this wind farm would be supplied for the electricity use of Copenhagen (Sørensen et. al 2002: 1-2). Middelgrunden Wind Turbine Cooperative had 8,650 members (Sørensen et. al 2002: 1-2). The Middelgrunden Wind Farm could produce a rated power of 40 MW, and consists of 20 wind turbines in total (Sørensen et. al 2002: 1-2). Each of them can generate 2 MW per hour (Sørensen et. al 2002: 1-2).

Therefore, according to the two examples above, it signals that the Danish people considered the wind turbine, as a community-based product. In return, one wind turbine for one community

should be shared for everyone, but the agreement of wind-energy sharing should be written, or defined clearly.

2.3 Denmark's Cancellation of Atomic Power

As aforementioned in previous chapter, it seems that the strong intention of Danish people stopped the government's plan for the atomic power program in Denmark, while the rural populations in Denmark started to purchase wind turbines for their personal uses, or for rural power stations.

Since 1969, the Danish people had started to express their strong and long resistances against the atomic power programs (Van Est 1999: 70; and Maegaard, 2009: 46). Finally, in 1985, the central government of Denmark cancelled officially their intentions on any forms of the atomic power programs (Van Est 1999: 138; Maegaard, 2008: 46).

As a result, these three factors supported the stable growth of the wind turbine market. After that, it led a significant improvement of the industry development of the Danish wind energy sector.

2.4 Movement for Renewable Energy

The anti-nuclear campaigns of NOAH brought the Danish people to the discussion about the nuclear power, ecology and energy decentralization (Van Est 1999: 73-74). Later, these discussions inspired the Danish people to set up the Organization for Information about Nuclear Power (In Danish: *Organisationen til Oplysning om Atomkraft*, hereafter referred to as "OOA"), in 1974, in order to prevent the birth of nuclear power programs in Denmark by using the information, as the key instrument (Van Est 1999: 73-74; and OOA, 2004: Online). OOA also worked along with other folk high schools to launch several campaigns about the anti-nuclear programs (Van Est 1999: 73-74).

Apart from anti-nuclear campaigns, in 1975, the Danish people set up a non-government organization known as "Organization for Renewable Energy" (In Danish: *Organizationen for Vedvarende Energi*, hereafter referred to as "OVE"). The purpose of OVE's establishment is to promote the information about renewable energy to the Danish publics (VedvarendeEnergi, 2012: Online). Therefore, the OVE organized four meeting annually, namely "Wind Meetings (In Danish: *Vind-Træf*)", in order to provide the information and advices about how to use the renewable energy (Van Est 1999: 77). Also, the meetings of the OVE enabled to bring the amateurs and professionals to get involvement in the discussion about wind turbine construction (Van Est 1999: 77). Thus, the amateurs and the professionals in wind energy could share their information and experiences (Van Est 1999: 77). The OVE still operates in the modern days (VedvarendeEnergi, 2012: Online).

3. Industry Development of Wind Energy in 1980s - 1990s

After the grassroots' movement had pushed the industry of wind energy development earlier than the technological progress of the manufacturers, it drew an attention of the Danish government to support the wind energy industry.

First and foremost, the Danish government started to launch the subsidy scheme for the wind turbine buyers (Kamp 2002: 148). From 1979, the wind turbine buyers can receive the investment subsidy of 30 percent from the central government of Denmark (Kamp 2002: 148). However, this scheme was applied to the private wind-turbine buyers only (Kamp 2002: 148). This action of the Danish government helped the wind turbine manufacturers to develop the wind energy market in their domestic market (Kamp 2002: 148). However, later, the subsidy scheme was expired in 1989 (Madsen, 2009: 54). Although it was not existed any longer, the total accumulated cost on this account was about 274 million Danish kroner (US$ 40 million approximately) (Madsen, 2009: 54).

Moreover, in 1981, the wind-turbine manufacturers also developed their own association, after the consumers of wind turbines had set up their own association, or known as "*Danish Windmill Owner Association*" in 1978, (Kamp 2002: 145; and Madsen, 2009: 54). However, today, *Danish Windmill Manufacturer Association* is renamed "*Danish Wind Industry Association*". So, this would help the group of windmill manufacturers to set up a talk with their consumers, and negotiate with the Danish government easily.

At the beginning of the establishment of *Danish Windmill Manufacturer Association*, only 23 manufacturers joined the membership of the organization (Madsen, 2009: 54). Vestas, Nordtank, Micon, and Danregn (Or later known as "Bonus") (Madsen, 2009: 54-57) have been one of the early players in the wind energy industry since the industry was organized since 1980s (Madsen, 2009: 54-57). However, as the time passed by, Vestas could merge Nordtank and Micon into its empire in 2002 (Madsen, 2009: 54-57). In 2004, Siemen Power could acquire Bonus (Madsen, 2009: 54-57).

Therefore, today, Vestas, only the Danish wind-turbine manufacturer, becomes the leader in the global market (Madsen, 2009: 54-57). Also, in 2008, 20 percent of the global market share in wind energy industry is still belonged to Vestas (Madsen, 2009: 54-57).

The growth of the wind energy industry of Denmark brought the job creation to the local community around Denmark (Kamp 2002: 150 and 155). One main reason behind this growth of the industry at this time was the Danish export of wind turbines to the U.S.A., particularly California (Kamp 2002: 155). From 1982 to 1985, the number of employed people in the industry grew from 300 to 2,500 respectively (Kamp 2002: 155). At the end of 1982, 40 wind turbines from Denmark were sold to customers in California (Kamp 2002: 155). Later, the number of selling was increased to 2,000 wind turbines annually (Kamp 2002: 155).

To sum up, the industry development of wind energy in Denmark was an integrated solutions for everyone in the market. The benefits from this development can fall not only into the hand of consumers, but also in the hand of manufacturers and the central government of Denmark.

4. Reactions from Danish Government

The history of wind energy development of Denmark shows that the leader of wind energy in the Danish history was not the central government. But, in return, it was the Danish people, who were leading the government to do something for the future of Denmark. However, it does not mean that the historical role of the Danish government was not important. In fact, the Danish government took several actions to serve the people's needs.

4.1 Danish Government's Research Program

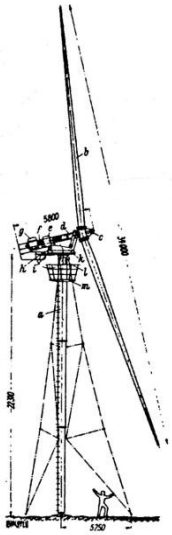
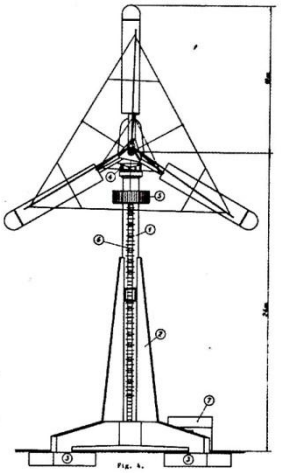
Along with the movement of the Danish people in wind energy sector, the central government of Denmark also had an involvement in the wind energy development. However, the R&D Program on Wind Energy of the Danish central government was not successful.

When the oil crisis came to Denmark in 1970s, the central government of Denmark decided to establish its research station on wind energy at Risø National Laboratory at the Technical University of Denmark in 1977 (Kamp 2002: 132). Moreover, this wind energy program was based on the Danish-US cooperation (Kamp 2002: 132-133). Apart from that, the Ministry of Industry of Denmark announced the R&D subsidy program for people who needed the funding for wind energy research (Kamp 2002: 146). The Danish Ministry of Industry offers to pay 5,000 – 10,000 US Dollar, they receives any proposal from them (Kamp 2002: 146-147).

However, although the test station at Risø National Laboratory had been involved in several testing of wind turbines for several years, the research program on several models of wind turbines could not draw any interests from the investors (Kamp 2002: 132 - 141). Finally, around 1990, the Danish government's R&D program on wind energy had to be ceased (Kamp 2002: 132 - 141).

Later, Nielsen (2009: 62-63) discovers the reason for the failure of the Danish government's research program on wind energy. The analysis of Nielsen can be illustrated in the *Table 1*.

Table 1: The Comparison of Wind Turbines between Danish government's model and Danish people's model

Indicators	Wind Turbine from Risø National Laboratory (Wind Energy Program of Danish government)	Wind Turbines from the Danish people's power
Research's Focus	Large-scale wind turbines (Rotor diameter is larger than 30 meters.)	Small-scale wind turbines (Rotor diameter is smaller than 15 meters.)
Targeted scale of users	One city / One region	One school / one community / one village / one town
Principle of Rotors	Light and high speed rotor	Heavy and low speed rotor
Key technical sponsorship	Officers and Scientists from Danish Government, U.S.A. and Germany	Danish people in countryside
Prototype for Research	Model of Ulrich Hütter (Austrian scientist)	Model of Johannes Juul (Danish scientist)
Picture of the prototype	 **Picture:** Hütter's model of wind turbine	 **Picture:** Juul's model of wind turbine

Source: Nielsen, 2009: 62-65; and Van Est, 1999: 76

According to the study of Nielsen (2009: 62-65), it shows why the American model of wind turbines were not accepted in Denmark. The rotor of the wind turbine is the key difference of these two models (Nielsen, 2009: 62-65). The rotor of the Danish wind turbine already reduced the engineering risks (Nielsen, 2009: 62-65).

Another factor is that the wind turbine of the Danish government's program was created for the large scale of wind farm and a big investment, not for the small investors or a community ownership (Van Est 1999: 83; and Kamp 2002: 141). It carried a high risk for the large investors in

Denmark at that time (Kamp 2002: 141). The wind turbines of the Danish people's power had passed several tests and failures from the real users, while the windmill users gave the feedbacks for the future improvement (Nielsen, 2009: 62-65). Also, later, the windmill users and the windmill producers set up several talks and worked together in order to reach the finest quality of the wind turbines (Kamp 2002: 145 – 146).

Although the research program of the central government failed to serve the need of Danish people in countryside, the central government of Denmark was convinced by the grassroots' movements of the Danish people in the countryside (Kamp 2002: 146-148). Therefore, the central government of Denmark accepted the Danish people's resistances against the atomic power program, and, finally, denounced officially its plans about the atomic power program in 1985 (Van Est 1999: 138; Maegaard, 2008: 46).

4.2 Energy Plan

Besides the technological innovation, the Danish government's plan to support the wind energy led a change of the energy situation of Denmark. The national energy plan of Denmark was designed to serve the need of the Danish people's movements on renewable energy (Kamp 2002: 152-153).

4.2.1 Energy Plan 1981 and the First 100 MW Agreement

In 1981, the central government of Denmark decided to launch the first national energy plan, later known as, "*Energy Plan 1981*" (In Danish: Energiplan 1981) (Kamp 2002: 152-153). Before the Danish parliament came out the final draft of the Energy Plan 1981, the public hearing had been conducted (Kamp 2002: : 152-153). Therefore, the content of the Energy Plan 1981 was based on the voice of the Danish people in rural areas (Kamp 2002: 152-153). According to the Energy Plan 1981, it was a must for Denmark to begin consuming the electricity from the renewable energy (Kamp 2002: 152-153). The main content of this plan was to install 60,000 small-scale wind turbines in Denmark to supply 8.5 percent of the energy's demand by 2000 (Kamp 2002: 152-153). As a part of this plan, the large wind turbines are encouraged as an alternative solution (Kamp 2002: 152-153).

To reach the high level of wind energy capacity, in 1985, the Danish government decided to impose the new agreement to all utilities (Van Est 1999: 89; Kamp, 2002: 159-160; and Madsen 2009:52). This agreement would turn over the 20 MW over the next 5 years (Van Est 1999: 89; Kamp, 2002: 159-160; and Madsen 2009:52). This agreement was called "*the First 100 MW Agreement*" (Van Est 1999: 89; Kamp, 2002: 159-160; and Madsen 2009:52). This agreement would become the restrictions for the private wind-turbine owners, and the power purchase of the central government (another form of government's subsidy in the energy investment) (Van Est 1999: 89; Kamp, 2002: 159-160; and Madsen 2009:52).

As the consequence of the First 100 MW Agreement, it allowed two investors to construct the large scale wind farms in Denmark (Van Est 1999: 89; Kamp, 2002: 159-160). The Ministry of Energy forced Elsam and Elkraft to install 55 MW wind farm, and 45 MW wind farm, respectively, from 1986 to 1990 (Van Est 1999: 89; Kamp, 2002: 159-160). However, the First 100 MW Agreement allowed the residents to receive the subsidy to compensate their loss of landscape (Van Est 1999: 89; Kamp, 2002: 159-160). The residents will receive subsidy, if the residents live within a

distance of 10 kilometer from a wind turbine, or live within the same municipality (Van Est 1999: 89; Kamp, 2002: 159-160).

4.2.2 Energy Plan 2000 and the Second 100 MW Agreement

The incident of 1986 Chernobyl nuclear disaster, and the other environmental problems urged the Danish government to legitimate the wind energy (Kamp 2002: 167-168). Therefore, in 1990, the central government of Denmark published the *Energy Plan 2000* (Kamp 2002: 167-168). The main objective of the plan was to be responsible for a 20-percent reduction in CO_2 emission by 2005, and to stabilize the global CO_2 emission by 2000 (Kamp 2002: 167-168).

As a part of the Energy Plan 2000, 1,500 MW of wind turbine capacity would be installed by 2005 (Kamp 2002: 167-168). Therefore, in 1990, the central government of Denmark decided to introduce the *Second 100 MW Agreement*, in order to establish 100 MW wind turbines before 1994 (Kamp 2002: 167-168). However, at this time, the new agreement made the central government to treat the utilities, and other wind turbine manufacturers as their co-developer, not just a turbine user (Kamp 2002: 167-168).

4.3 Policy on Grid Connection and the Power Purchase Agreement

In addition to the government's efforts to cancel the atomic power program, and the wind energy program, the Danish government had several plans to stimulate the use of renewable energy through its policy on the grid connection, and the power purchase agreement.

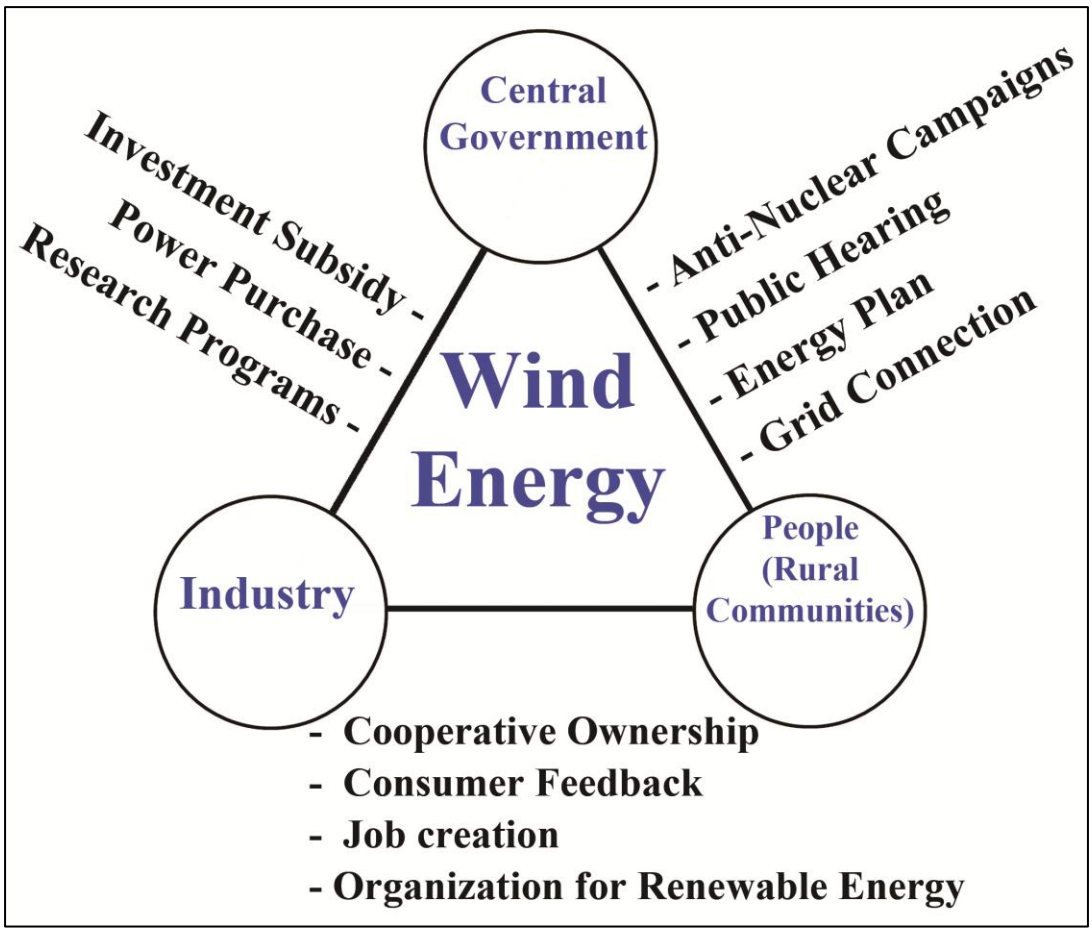
In 1984, Denmark passed a new law to seek a consensus between the electricity utilities, wind turbine manufacturers, and Danish Windmill Owner Association (Kamp 2002: 158). This agreement allowed the owners of renewable sources to earn 0.25 Danish kroner per 1 kWh from their electricity selling through the grid connection (Kamp 2002: 158). This agreement is known as "*10 Year Agreement*" (Larsen, 1993: Online). As mentioned in the 10 Year Agreement, the single owners of wind turbines received the rate of 85 percent of the end consumer price before tax (Larsen, 1993: Online; Kamp 2002: 158; and Madsen 2009: 52).

Later, in 1992, the Danish government passed the Wind Turbine Act (Kamp 2002: 172-173). This law forced every utility to pay all the grid-reinforcement cost for grid connection with the erection of wind turbines, but the turbine owners had to pay for the wire connection cost with the public grid (Kamp 2002: 172-173). Also, this law also forced all electricity utilities to purchase the electricity from the all wind turbines owners at the same rate in 1984 (Kamp 2002: 172-173).

In 1993, the Danish government passed "*Promotion of Renewable Energy Act*" the scheme of feed-in-tariff to accelerate the use of renewable energy in Denmark (Cornfeld and Sauer, 2010:3). This law helped Denmark to become the world leader of wind energy today (Cornfeld and Sauer, 2010:3). This law still encouraged the Danish government to use the same payment rate of year 1984 (Cornfeld and Sauer, 2010:3).

Finally, all 3 main factors have been demonstrated. The key social factors of wind energy development in Denmark are people, central government and industry. The relationship of these three factors can be illustrated in *Figure 1*.

Figure 1: The Relationship of Social Factors in Wind Energy Development of Denmark in 1980s–1990s



Note: This chart is made by the author to simplify the main 3 social factors behind the wind energy development of Denmark in 1980s-1990s. The data was processed from the historical movements, as explained in this paper.

Summary

The wind energy development in 1980s-1990s is the fruit of the social unity of Denmark. The social unity of Denmark has three main actors. These are the Danish people in rural communities, the central government of Denmark and the people in industry. However, the main driving force in this social unity is the Danish people in rural communities.

To answer why the Danish people in rural communities has a strong willingness in wind energy, it needs to go back to the history of Denmark in the middle of 19th Century. That is because the wind turbine in the Danish society is the by-product, or secondary result of the emergence of Danish folk high schools, and the implementation of Gruntvig's concept of the life-long education development in the rural areas. Without the accesses of life-long learning for the rural populations, the social unity might be weakened by the industrialization in the middle of 19th Century. After the education was accessible for the rural populations in Denmark, it helped the rural populations to strengthen their own communities with their concrete fellowship. This became a path way to the creations of cooperatives in the late 19th Century.

While the Denmark's wheel of time moved to the late 19th Century, Pour la Cour discovered how to bring the rural electrification by wind energy. The experiences from agricultural cooperatives in the past, the tradition of fellowship, combined with willingness of environmental protection, seeded and inspired the Danish people to continue their working on the people's invention of wind turbines in the late 20th Century.

Therefore, in 1970s-1990s, the Danish people considered that the energy from wind turbines could replace the energy from atomic power. Later, they decided to set up their own network and coalition to bargain with the power of the central government, and the industry sector. After that, the central government had to hear the voice of the people. Finally, the central government would set up the legal tools to serve the needs of the people, and to support the industry sector.

Because of the efforts and the willingness of the Danish people, in 1985, the central government of Denmark gave up all programs about the atomic power. Eventually, the wind energy became the answers for electricity, environmental protection, job creation, community's fellowship, innovation and business opportunities for everyone in the Danish society in the late 20th Century.

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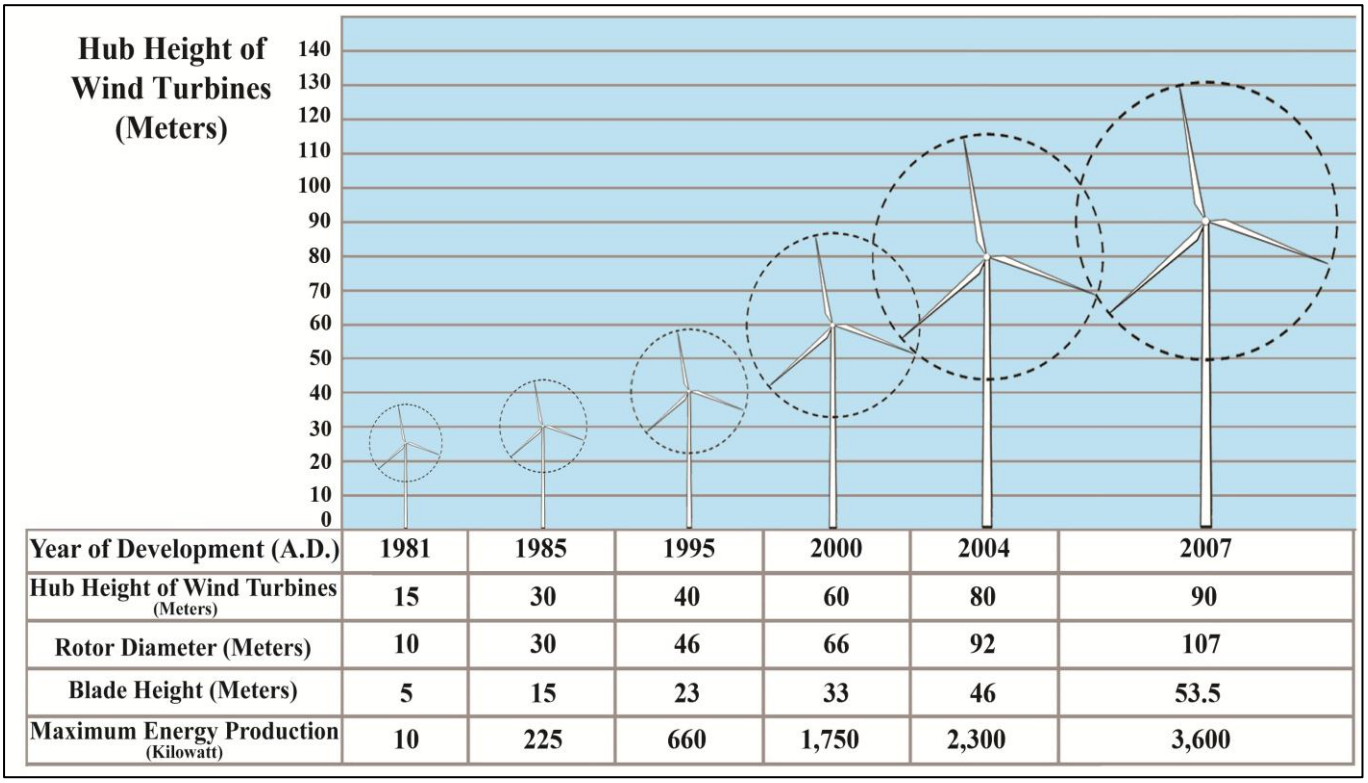
Annex 1: Technological Evolution of Wind Turbines in Denmark

The data from the Danish Energy Agency shows how the wind turbines were developed in Denmark from 1981 to 2007. The data were taken to present in *Figure 2* and *Table 2*. The data generally implies that the today's wind turbine in Denmark was developed from a small-scale wind turbine in 1980s.

Figure 2: Technological Evolution of Wind Turbines in Denmark from 1981 to 2007



Year of Development (A.D.)	1981	1985	1995	2000	2004	2007
Hub Height of Wind Turbines (Meters)	15	30	40	60	80	90
Rotor Diameter (Meters)	10	30	46	66	92	107
Blade Height (Meters)	5	15	23	33	46	53.5
Maximum Energy Production (Kilowatt)	10	225	660	1,750	2,300	3,600

Source: Danish Energy Agency. 2009: 6-7; and Karkov, S. 2010: 4

Note: The references of data in *Annex 1* are compiled in the *Bibliography* of this paper.

Table 2: Technological Evolution of Wind Turbines in Denmark from 1981 to 2007

Time Period of Development	Hub Heights of Wind turbine (Meters)	Rotor Diameter (Meters)	Blade Length (Meters)	Maximum Energy Production (Kilowatt)
1981	15	10	5	10
1985	30	30	15	225
1995	40	46	23	660
2000	60	66	33	1,750
2004	80	92	46	2,300
2007	90	107	53.5	3,600

Source: Danish Energy Agency. 2009: 6-7; and Karkov, S. 2010: 4

Note: The references of data in *Annex 1* are compiled in the *Bibliography* of this paper.

Annex 2: The Statistics of the Installation of Wind Turbines (1978-2009)

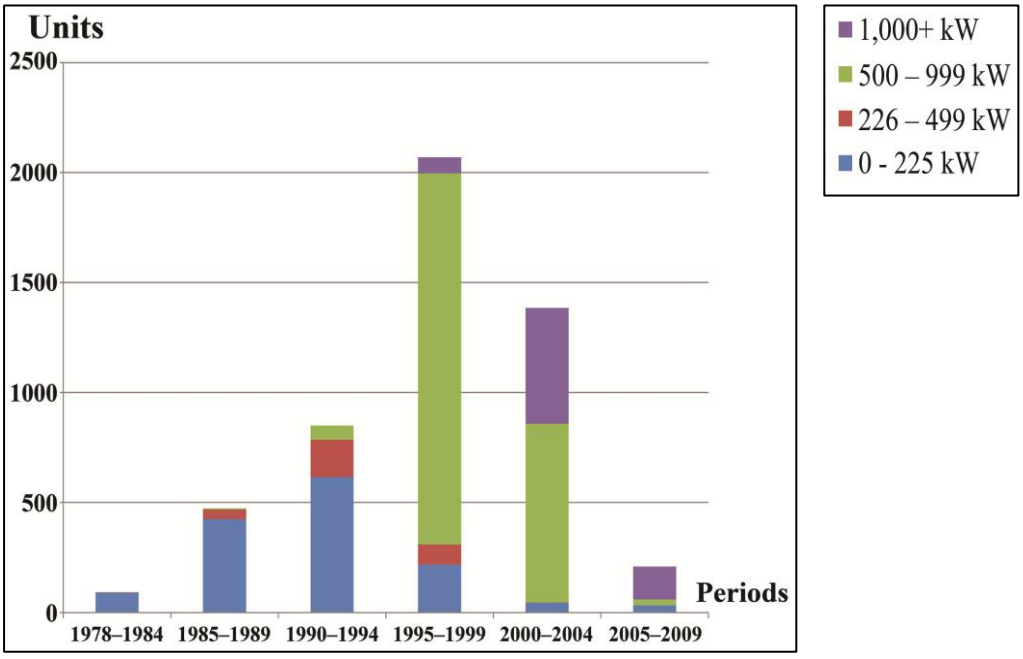
Table 3 and *Figure 3* are showing the growth of wind energy in Denmark through the statistics of wind turbine installation, under the classification of power output from 1978 to 2009. In fact, the bar chart in *Figure 3* is created from the data of *Table 3*.

Table 3: The Growth of Wind Turbine Installation in Denmark (Classified by Power Output)

Period	Number of Wind Turbine Units (Classified by Power Output)				
	0 - 225 kW	**226 – 499 kW**	**500 – 999 kW**	**1,000+ kW**	**Total**
1978 – 1984	91	1	0	0	**92**
1985 – 1989	425	43	6	0	**474**
1990 – 1994	616	169	65	0	**850**
1995 – 1999	218	91	1,687	73	**2,069**
2000 – 2004	44	2	812	526	**1,384**
2005 – 2009	33	0	26	150	**209**
Total	**1,427**	**306**	**2,596**	**749**	**5,078**

Source: Danish Energy Agency. 2009: 8
Note: The references of data in *Annex 2* are compiled in the *Bibliography* of this paper.

Figure 3: The Growth of Wind Turbine Installation in Denmark (Classified by Power Output)



Source: Danish Energy Agency. 2009: 8
Note: The references of data in *Annex 2* are compiled in the *Bibliography* of this paper.