

Strategic analysis of diffusion of renewable energy in the Nordic countries

Alireza Aslani ^{a,b,*}, Marja Naaranoja ^c, Kau-Fui V. Wong ^d

^a Industrial Management Department, Faculty of Technology, University of Vaasa, Vaasa 65101, Finland

^b Department of Engineering and Public Policy, College of Engineering, Carnegie Mellon University, 5000 Forbes Avenue., Pittsburgh, PA 15213, USA

^c Industrial Management Department, Faculty of Technology, University of Vaasa, Vaasa 65101, Finland

^d Department of Mechanical and Aerospace Engineering, College of Engineering, University of Miami, Miami, FL 33146, USA

ARTICLE INFO

Article history:

Received 7 August 2012

Received in revised form

27 January 2013

Accepted 31 January 2013

Available online 15 March 2013

Keywords:

Diffusion of renewable energy

Strategic analysis

Energy security

Energy policy

Nordic countries

ABSTRACT

Today, there are concerns related to security of energy supply, growing energy demands, limitations of fossil fuels, and threats of disruptive climate changes. To overcome the challenges, diversification and utilization of renewable energy resources are defined as the main strategies. However, successful diffusion of renewable energy requires consideration to many factors including social, economic, and technical ones. Nordic countries are among the leading countries on successful development of renewable energy and energy efficiency. This research, in the frame of a strategic conceptual analysis, studies the policies and achievements of the Nordic region in their development of renewable energy. The framework consists of four layers including dimensions, characters, objectives, and key schemes.

© 2013 Elsevier Ltd. All rights reserved.

Contents

1. Introduction	497
2. Analytical framework of energy supply in the Nordic countries	498
3. Research methodology	499
4. Discussion and analysis	500
4.1. Dimensions of policy making in renewable energy development in the Nordic region	500
4.2. Effective characters on decision making related to RE policies in the Nordic countries	501
4.3. Objectives of diffusion of renewable energy in the Nordic countries	501
4.3.1. Energy security and diversification	501
4.3.2. Energy efficiency	501
4.3.3. Economic efficiency	502
4.3.4. CO ₂ reduction	502
4.4. Key schemes of diffusion of renewable energy in the Nordic countries	502
4.4.1. Energy financing	502
4.4.2. Energy taxes	502
4.4.3. Open energy market	503
4.4.4. Encouragement packages and green certificates	503
4.4.5. Administration of research and innovation and policy instruments	503
4.4.6. International cooperation	503
4.4.7. Feed-in-tariff (FIT)	503
5. Conclusion	503
References	504

* Corresponding author at: Industrial Management Department, Faculty of Technology, University of Vaasa, Vaasa 65101, Finland. Tel.: +358 44 255 0010.
E-mail addresses: alireza.aslani@uva.fi, aslani@andrew.cmu.edu (A. Aslani).

1. Introduction

Although carbon-based fuels are dominant resources of power generation for residential and industrial needs, they do not offer

long term and sustainable perspectives. According to the IEA reports, approximately 81% of the world's energy demand was supplied by fossil fuels in 2009 [1]. Since they are not located equally in the world, European countries depend largely on fossil fuels imports from other regions such as Middle East and Russia. Thereby, concerns and challenges (e.g., fluctuating carbon based fuel prices and uncertain oil and gas supplies) exist to have a secure energy supply in Europe. In response, various strategies are suggested and developed by governments and related authorities (e.g., European Union) such as upstream investment in producing countries, utilizing domestic and local natural resources, long-term contracting at premium prices, diversifying fuels and suppliers, decentralized forms of utilization etc. [2]. However today, environmental considerations influence energy security calculations. Therefore, policies like development of renewable alternatives are encouraged to contribute diversification and security of energy supply.

Studies show that the Nordic countries (NCs) including Finland, Sweden, Norway, Denmark, and Iceland are good examples to enhance the level of their energy security indicators [3]. For example, while Sweden, Finland, and Iceland are highly dependent to the fossil fuels, they are among top secure countries from energy supply viewpoint [3]. Further, although Norway is one of the main oil and gas exporters, it has the lowest level of dependency to the fossil fuels on its energy systems. In other words, the NCs have made considerable and successful efforts to improve the diversification strategy of their energy supply with core focus on utilization of renewable energy resources (RER). In 2010, Norway and Iceland are among top 10 renewable electricity producers with 96.6% and 100% of their electricity generation from RERs in the world [4]. Denmark has also one of the highest and fastest growth levels of wind power utilization in the world. Therefore, while NCs have only 0.37% (less than 1%) of the world's population, they stand among the countries with highest contribution to primary energy supply from RERs. Table 1 shows the total electricity generation from RER in the Nordic countries and some selected countries and regions in 2009 [3].

The Nordic region is also playing a leading role in diffusion of renewable energy technologies such as Finland and Sweden in biomass technologies, Norway in hydropower development, Denmark with wind power, and Iceland with geothermal utilization. Therefore, not only investigation on strategic and policy perspectives of renewable energy development in the Nordic region is beneficial, it is also one of the best case studies to be followed by other countries and regions.

This article studies the policies and achievements related to renewable energy utilization in the Nordic region. The aim is to develop a strategic framework to evaluate energy policies and

decisions, and provides a structure to analyze the adoption of renewable energy. The article starts with a brief review of energy structure in the NCs. Some important and related statistics are reviewed in that section. Then, an innovative conceptual framework is presented and discussed to show the layers of renewable energy development policies. The layers include dimensions, characters, objectives, and key schemes.

2. Analytical framework of energy supply in the Nordic countries

The Nordic countries (NCs) are the northernmost countries in Europe. This region includes independent countries (Finland, Sweden, Norway, Denmark, and Iceland) plus three autonomous regions (Aland, Faroe Islands, and Greenland). The population of the NCs was 25,830,631 (0.37% of World) on April 2012 [3]. The region is among top developed countries from economic and social welfare indicators.

The NCs are energy intensive countries because of cold climate, their energy intensive industries, wide sparsely populated areas with long distances, and their high standard of living. For instance, Finland's per capita energy consumption is the highest within European Union [5]. Norway and Sweden are also among top countries in this indicator. Fig. 1 illustrates the primary energy consumption in the NCs by sources in 2009.

According to Fig. 1, Finland and Sweden have the largest diversity in their energy supply compared to other NCs. While Finland, Sweden, and Iceland have to import a substantial part of their fossil fuels, the annual production of energy in Norway is approximately 10 times of the domestic use [7]. Fig. 2 shows and compares the breakdown of final consumption by source in industry sector of the NCs before first economic recession (1970s) and 2009.

Fig. 2 illustrates that the shares of oil and coal in energy supply have been substantially reduced in the last three decades in the NCs, especially in Finland, Sweden, and Denmark (red and violet colors). In Finland, it dropped from 64% in 1973 to 28.7% in 2009. While electricity and district heating system consume the most part of energy supply, RERs are their main supply resources. Fig. 3 illustrates the energy consumption mix for electricity plants, combined heat and power plants (CHP), and heat plants.

Due to geographic situation of the NCs, solar energy is not a priority for economic utilization. However, Iceland derives 84.3% of its primary energy from indigenous RERs (64.1% geothermal and 20.2% hydropower) which cover 100% electricity generation (hydropower: 12279 GW h and geothermal: 4553 GW h in 2009) [8]. Hydropower is also utilized for more than 90% electricity generation in Norway (126,077 GW h in 2009). On the other hand, Finland and

Table 1
Share of RER in the total electricity generation (%) in the Nordic region and some selected cases in 2009 [3,6].

Country or region	Total electricity generation from RER (%)
Finland	31.56
Sweden	58.52
Norway	96.63
Denmark	27.4
Iceland	100
USA	10.5
Germany	20.1
UK	6.18
France	13.34
Belgium	6.53
Nordic average	62.82
Top 33 richest countries based on GDP	23.58
Top 33 richest countries based on GDP (without Nordic countries)	16.51

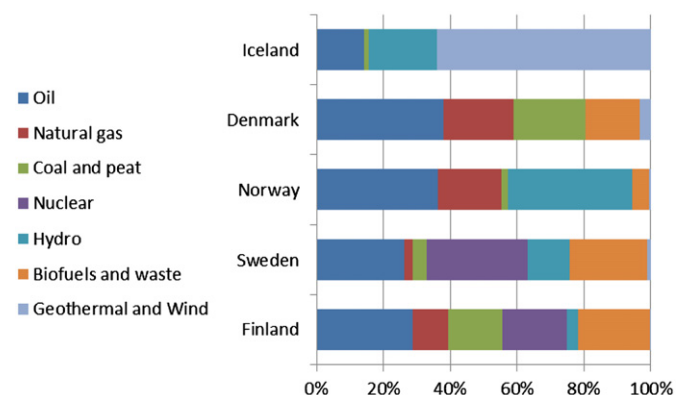


Fig. 1. Primary energy consumption in the Nordic countries in 2009 [6].

Download English Version:

<https://daneshyari.com/en/article/8122248>

Download Persian Version:

<https://daneshyari.com/article/8122248>

[Daneshyari.com](https://daneshyari.com)