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Simulation of consumers and markets towards real time demand response
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Evaluation of Smart Grid Implementations in the Consumer's Energy Bill

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Abstract

The need to increase the share of renewable energy resources in several countries around the world led to the development of new strategies, in order to implement more effective energy policies. These resources have a distributed nature and are one of the main paths to incentive the reduction of CO2 emissions, and their impact on the environment. Many countries are making efforts to advance in the implementation of their own strategies to achieve the fossil fuels independency. Therefore, the intent is to stipulate energy policies that increase renewable energy share in the energy mix. These policies depend on regulations, taxation, incentives and promotional schemes. In this paper, it is presented a brief introduction to the energy policies in two countries, Denmark and Finland. Demand Response (DR) aspects and its impact in the energy market are also discussed.

Keywords: demand response, distributed generation, energy markets, energy policies, smart grid

1. Introduction

The smart grid (SG) is a study field of growing importance and interest. It is associated to the development of the electrical grid, in terms of network trustworthiness and in energy quality, which significantly improves its efficiency. SG is expected to improve grid reliability since it provides the means to controlling and managing the power generation and consumption. As it is described in [*1*], a SG intends to introduce Distributed Generation (DG) in the electrical grid by maximizing the penetration of renewable energy sources, and to foster Demand Response (DR) programs through active consumers participation in network operation.

Several countries around the world are planning strategies to reduce their dependency on fossil fuels, aiming to reduce CO_2 emissions. Therefore, the implementation and high penetration of DG can bring several benefits regarding this issue. This type of generation, many times referred as decentralized generation, is considered a good solution, also reducing the need of improving the high voltage transmission system. It's implementation represents a measure of small investment, once it is located near the consumer, avoiding long distance transmission lines [*2*]–[*4*].

Demand Side Management (DSM) consists on means developed in order to improve the energy system management, operating in the consumption-side [*5*], [*6*]. DR is often defined as changes in electricity usage by end-use customers from their normal consumption patterns in response to changes in the electricity price (price responsive DR), or to incentive payments designed to induce lower electricity use at moments of high wholesale market prices or when system reliability is jeopardized [*7*]. Demand response options are divided into Price-Based and Incentive-Based Programs [*8*]. According to the literature, many research focus the demand response price-based strategies, highlighting the following programs: Real-Time Pricing (RTP) [*9*], Time-of-Use Tariffs (ToU) [*10*] and Critical Peak Pricing (CPP) [*11*].

Nowadays, one of the world top priorities is the implementation of sustainable energy policies, allowing the restructuring of the National Renewable Energy Action Plan (NREAP). Therefore, it is essential to shift from non-renewable to renewable energy sources (RES), in order to move towards a sustainable energy system. According to present literature, several barriers need to be addressed in order to increase the penetration of RES. These barriers include cost-effectiveness, technical, market (such as inconsistent pricing models), institutional, political and regulatory, and social and environmental barriers. These challenges differ between countries or regions [*12*].

One of the main barriers is the fact that distributed generation resources are small-sized, dispersed in the distribution level with no direct access to the wholesale market. Nevertheless, a measure was necessary to be considered to solve this problem, therefore the renewable energy resources aggregation was deliberated. This procedure aims to aggregate several generation units, in order to achieve the minimum power required for participation in wholesale market [*13*]–[*15*].

In this paper, two countries are presented in which is intended to perform a comparison between them in terms of energy policies promoted to increase renewable energy penetration and, also, the DR programs implementation. The countries to be studied are Denmark (DK) and Finland (FI). The main purpose of this paper is to give a perspective on how the implementation of DG and DR are being currently developed, including the main difficulties and challenges in its employment.

This paper is organized as follows: section I refers the introduction, section II and III presents a portrayal of Denmark and Finland, in terms of DG, DR and energy policies promoted, respectively, and in section V presents the concluding remarks.

2. Denmark

Since 2012, Denmark has been continuously updating its energy infrastructure in order to adapt it for smart grid integration. Taking into consideration Denmark's 2050 path strategy

[*16*], the share increase of renewable sources into the energy mix will most likely cause difficulties to the balancing and regulation markets. In this way, smart grids are implemented to integrate several types of DER, improving overall efficiency.

2.1. Distributed Generation

Currently, Denmark is a successful case of DG integration with special focus on wind energy resources. The investment is concentrated in sustainable energy (thus reducing energy dependency and costs) and district heating (being a cold region, the needs for heating are significant) [*17*]. Regarding the first issue, it covers the implementation of large wind farms and gradually replacing fossil fuels by biofuels. The potential of biofuels, biomass and biogas, is well recognized by Denmark integrating their strategy for a 100% renewable sources share for 2050.

For the second issue, district heating is accomplished by the installation of small and distributed Combined Heat and Power (CHP) plants [*18*]. These, according with the Danish Energy Agency (DEA), will be a key factor for the large integration of renewable sources, since any excess power produced can be used by CHP plants to produce heat for the community. Having the possibility of enabling heat storage, this strategy can be very useful for the Danish energy infrastructure and their plan for 2050. Considering the Energy Policy Agreement of 2012 [*19*], Denmark defined the path to reach 100% renewables share [*16*]. Also, the support for solar and other small-size installations, has been taken into consideration by the Danish government, publishing an official document named the Agreement of November 2002. Regarding the promotion schemes, Denmark makes use of fixed feed-in tariffs, feed-in premium tariffs, tenders, and tax benefits [*17*]. Tenders are used together with feed-in premium for wind farms, mostly offshore, while fixed feed-in tariffs are applied to other renewables. Tax benefits are also for wind farms installation, normally allowing an initial period of tax-free operation. The duration of these schemes depends upon the technology considered, time of installation, and owner. In this way, the DEA presents promotion strategies for wind (onshore and offshore), biogas plants, solar, wave power, biomass, CHP, and several others. The most relevant and recent subsidiaries schemes for DG in Denmark are [*20*], [*21*] (all prices are in the Danish monetary unit, DKK/kWh):

- **Wind Onshore –** the owner deals with all the activities related with the sale of energy in the energy markets. An allowance of 0.023 is given for balancing costs. The installation receives 0.25, during 6 600 full load hours. The price is reduced in 0.01 each point that the market price exceeds 0.33;

- **Wind Offshore –** the owner deals with all the activities related with the sale of energy in the energy markets. The supplement is divided by energy perimeters, namely, 0.518 (Horns Rev 2), 0.629 (Rødsand 2), and 1.051 (Anholt). This scheme has limits by energy supplied and duration, 10 (Horns Rev 2 and Rødsand 2) or 20 TWh (Anholt) and 20 years;

- **Wind Households –** turbines with less than 25 kW, receive 2.50 during 10 years. If capacity is less than 6 kW, the installation receives 1.30 that is reduced yearly during 4 years in 0.14, in a total of 10 years also;

- **Biogas Plants –** receives a normal tariff of 0.793, however, if capacity is less than 6 kW, then the same conditions of wind households for this situation, are applied in these plants.

These features are only valid for plants using biomass as fuel for production of biogas. Other plants receive 0.431;

- **Solar –** if capacity is less than or equal to 400 kW, the conditions of wind households are applied. If capacity is greater than 400 kW, then for the first 10 years it's applied 0.6, while for the next 10 years it's applied 0.4, in a total of 20 years of promotion. For collective installations, a 1.45 tariff is used and reduced annually by 0.17 for 4 years, in a total duration of 10 years;

- **CHP –** the owner deals with all the activities related with the sale of energy in the energy markets. If biomass is used as fuel, a supplement of 0.15 is given.

It is importance to notice that the promotion of these energy sources are costly, and therefore, the financial reliability has to be assured by the country, taking into consideration the impacts that it causes on the involved parties.

2.2. Demand Response

Demand response in Denmark is still under development, has it can be seen in [*22*]. Although flexibility is possible to be obtained from several resources, the integration of consumers into energy systems presents a sustainable solution. Consumer's flexibility is a fundamental part of smart grids integration, allowing a wide variety of solutions to them [*23*]. Denmark has a few issues on the demand response path, namely, the participation conditions that have not yet been adequate to DR consumers. Independent aggregators are in a disadvantageous position towards internal entities (such as, Balance Responsible Parties – BRPs) and payments are not as attractive as they should be. Considering all of these issues, one can say that Denmark has a long way to go in order to reach smart grids full potential.

According to [*24*], Denmark can have the following advantageous in the implementation of flexibility resources: easily handle seasonal demand variations, and management of fluctuations caused by renewables, peak demand, network balancing and reliability. In Denmark DR resources can access ancillary services, wholesale, and strategic reserves market. Denmark is divided into two transmission zones, namely, Western – DK1 and Eastern – DK2, making their management easier to perform. Table 1, presents the DR programs available in Denmark [*25*].

Table 1: Danish demand resource's programs.

Program	Details	Min. size
Primary Reserve (DK1)	• This program is activated automatically through the TSO • Max. activation duration of 15 minutes • The loads are notified 30 seconds before activation, having 15 seconds to provide half of reserve • It's used for frequency control when the same is in the interval 49.8-50.2 Hz • Auctioned in a daily basis, with a day-ahead planning, divided into 6 time blocks	0.3 MW

Frequency-controlled normal operation reserve (DK2) **Frequency-controlled disturbance reserve (DK2)**	• This program is activated automatically through the TSO • In normal operation, the notification time is 150 seconds, while in disturbance, 50% have to be available within 5 seconds, and the remaining in 25 seconds • Need for frequency measurement equipment, with sensitivity better than 10 mHz • Auctioned in a daily basis, where a part is procured two days before (D-2), and the rest one day before de planning day (D-1) • Max. activation duration of 3 hours when D-1, or 6 hours if D-2 • Disturbance reserves are used when frequency is lower than 49.9 Hz	0.3 MW
Secondary Reserve (DK1)	• Has a notification time of 15 minutes • Symmetrical bids with up/down regulation • Online metering is needed in this program • Auctioned in a monthly basis	1 MW
Tertiary Reserve	• Is a voluntary participation of consumers, with manual activation • Involves a 24/7 control center to manage	5 MW
Manual Reserve	• Notice time of 15 minutes • Daily auctions, a for all hours of the next day • Used for manual up/down regulation service, helping together with other programs, in frequency problems	10 MW

Additionally, to what is presented above, DR resources can participate in Danish energy markets as strategic reserves, with a maximum amount of 20 MW. This capacity is auctioned on a tender linking producers and consumers, with 24/7 availability.

Although load aggregation is possible, the truth is that external market entities are impaired with internal entities, namely, suppliers/BRPs. In this way, independent aggregators have to accomplish agreements with both BRPs and consumers.

In Denmark's energy infrastructure, BRPs play an important role since all production and consumption has to be known by these entities. Therefore, when consumption is reduced by external entities, the BRP needs to know about it, thus the need for the aggregator to have an agreement with the BRP/TSO.

According to [*26*], aggregators have a relevant role in what concerns DR implementation and the introduction of flexibility in the markets, mainly by two reason:

- Manages retail demand resources, supporting their participation;
- Joins several small-size consumers (aggregation), enabling them to participate in the wholesale markets.

2.3. Progress vs Status Quo

In what concerns the development of renewable energy in the Danish energy infrastructure, wind energy raises as the main source. Wind's high energy share of 39% in the total electricity supply, grants the Danish the rank of one of the best countries in producing renewable energy. According to DEA, by July of 2014, Denmark had 5,252 wind turbines obtaining a total of 4,810 MW of installed capacity (1,271 MW on offshore alone).

Although renewable energy share has been raising considerably, also the electricity costs for the consumers have been increasing over the years, namely, almost 25% since 2007 to 2014, as shown in [*27*]. Developing a renewable energy promotion infrastructure, comes with associated costs. For this, Denmark has introduced the Public Service Obligation, which comes in a form of an electricity supply tax for consumers, being this the major reason for energy price raise.

DR implementation is very limited and information about this is not easily found. Denmark's use for demand response in its energy infrastructure is almost inexistence, except for some participations of consumers in pilot projects or occasional tests for the existing DR programs – status quo in DR.

3. Finland

In this section it is presented detailed information about Finland. It is intended to approach the main barriers that this country faces in implementing DG and DR.

3.1. Distributed Generation

The CO_2 emissions in Finland are fairly high when compared with the international standards. This poor performance is explained by the following: northern European climate, sparsely populated (17 inhabitants/km^2), and its industry that is composed by intensive consumers. These factors lead to a considerable energy use in the heating of homes and other buildings, and in travelling long distances [*28*].

As a member of the EU, Finland is involved in negotiations about climate and energy issues. In 2008, a Long-Term Climate and Energy Strategy was approved by the government, with detailed measures for the period of 2020-2050 [*29*]. Finland has a target to increase the share of renewable energy sources to 38% by 2020.

According to government estimations, the share of electricity in final energy consumption will be around 36% in 2050, while the need for fossil energy will fall by 24 TWh over the period 2005–2020, and by 104 TWh over the period 2020–2050. In 2050, the fossil energy need will be just around 88 TWh [*30*]. In terms of the need of fossil energy, the established target consists in a decrease of 11% by 2020 [*30*].

Finland's energy system has traditionally been based on a strong control and regulation state [*31*]. However, since 2000, the ownership arrangements for the different types of companies, and their roles in the energy sector, have changed becoming less distinguished. Also, a number of foreign energy companies have enrolled the Finnish energy market.

Companies in the energy sector have had to face challenges in managing their energy balance, and in satisfying consumer needs comprehensively [*32*]. Many experience is gained with the voluntary agreements, which energy operators have devoted themselves to develop a sustainable energy sector [*33*].

Currently, RES has a share of one third of total consumption, in Finland, where the largest share is from nuclear power [*34*].

The current policy mechanism that supports RES producers, includes investment subsidies in the form of a state grant ("Energy Aid") and a feed-in tariff system [*35*], [*36*]. In the feed-in tariff system, the producer is paid a tariff that is equal to the difference between the target price and the spot market price, over a three-month average. To be eligible in this tariff scheme, the minimum capacity of the generators must be at least 500 kVA for wind and 100 kVA for biogas and biomass [*35*]–[*37*]. It is important to refer other conditions, such as producing electricity only for commercial and fulfilling specific long-term economic parameters [*36*]. Table 2 presents the subsidies applied to each source type, in Finland.

Table 2: Finland subsidiaries summary [*37*].

Source	Size (MVA)	Basic Subside	Alternative subsidy	Subsidy Condition
Wind	0.5		• Difference between €105.30/MWh and market price instead of basic subsidy	• Paid until 31/12/15, for max. of 3 years
Biogas	0.1	Difference between €83.5/MWh and market price	• €50/MWh heat premium on top of basic subsidy	• Efficiency 50% min. or 75% if nominal capacity of generator exceeds 1 MVA
Wood Fuel	0.1 - 8		• €20/MWh heat premium on top of basic subsidy	

In terms of heat production, three different mechanisms are identified in Finland: the same mechanism that is available for electricity producers, a price-based incentive (called "heat bonus") and a special subsidy for farmers who invest in renewable CHP [*36*], [*37*]. The heat bonus is applied only in CHP plants using biogas or biomass, with an efficiency of more than 75%, and having a minimum capacity installed of 1000 kVA. The bonus is fixed at 50€/MWh for plants exploiting biogas and 20€/MWh for plants using wood.

3.2. Demand Response

Finland is one of the world's leaders in terms of DR practical implementation from technology and market perspective [*38*]. Since the beginning of 2014, almost every end-consumer has a smart meter [*39*]. At the moment is estimated, based on the viewpoints of the DSO staff, a total of 1800 MW of loads ready to be controlled via smart meters in Finland [*39*]. Finland has a long experience concerning the remote control of customers' loads. They are responsible for controlling the electrical heating loads based on ToU (Time-of-Use) tariffs for over 30 years [*38*].

In Finland, DR is supported even for small customers, because practically all customers are settled based on their hourly measured consumption. However, it is possible to verify some limitations in terms of aggregation measures.

The aggregators can combine several consumers belonging to a certain area balanced by the same Balance Responsible Party (BRP). This is a major concern, once it reduces the full potential of DR, because the consumers do not have access to choose freely the DR service they want [*22*].

The reserves markets and the balancing market are operated by the system operator "FINGRID" and accept demand side resources that are aggregated to meet the minimum requirements for response regarding resource size, etc. Depending on the type of the reserve market, the minimum size varies from 0.1 to 10 MW and the maximum response latency from seconds to 15 minutes [*40*]. The amount of dynamic DR in Finland is divided as follows: day ahead (Elspot: 200 – 600 MW), an intra-day (Elbas) energy markets offered by electricity exchange, balancing power market (100 – 300 MW), frequency controlled disturbance reserve (70 MW), fast disturbance reserve (354 MW) and power reserve (40 MW). The balancing and frequency controlled reserve power markets are offered by the main grid company, "FINGRID" [*22*], [*40*]. More details can been seen in Table 3.

The "FINGRID" has three main aggregators, namely, SEAM, Energiakolmio and There Corporation [*41*]. SEAM provides such customers covered by the DR services, in combination with the other end-use energy management service. Energiakolmio provides energy market services, such as, DR aggregation for balance management, etc. There Corporation provides technology for the Home Energy System (residential DR) and the dynamic pricing control.

Table 3: DR programs in Finland [*40*].

Market Place	Type of contract	Min. size (MW)	Price level
Frequency controlled normal operation reserve	• Yearly and hourly markets	0.1	• 15.8 €/MWh (yearly market) + price of electricity
Frequency controlled disturbance reserve		1	• 4.03 €/MWh (yearly market)
Frequency controlled disturbance reserve (on-off-model)	• Long-term contract	10	• ~0.5 €/MWh + 580 €/MWh + activation fee of 580 €/MW
Automatic frequency regulating reserve	• Hourly market	5	• Hourly market + energy price
Balancing power market		10	• Market price
Fast disturbance reserve	• Long-term contract		• ~0.5 €/MWh + 580 €/MWh
Elspot	• Hourly market	0.1	• Market price
Elbas			
Strategic reserves	• Long-term contract	10	-

3.3. Progress vs Status Quo

In Finland much of the generation is based on nuclear and thermal load, boosting the CHP. This last resource (CHP), accounts 45% of the total installed generation capacity [*42*]. The currently installed capacity of RES corresponds to 20% of total generated installed capacity. Small hydro (pumping excluded) has the highest share in RES, near 18% in total electricity supply. Wind and solar have the lowest share in DG, 1.3% and 0.01%, respectively [*42*]. The installed wind capacity is close to 400 MW, however an increase up to 2,500 MW has been targeted for year 2020. The main reason for this increase, is Finland's FIT system introduced in 2011, available for wind power, bio-gas and wood-driven power capacity [*43*]. A significant amount of controllable loads are available, through the use of smart meters [*44*].

4. Concluding remarks

Denmark, with its high integration and promotion of renewable energy can bring to a consumer more benefits than Finland. However, these benefits have a considerable influence in the energy costs for the consumer due to the Public Service Obligation tax.

Finland has an energy market well developed for DR integration and thus can provide flexible consumers with fewer advantages than Denmark. Also, energy costs for consumers in Finland are lower than in Denmark, mainly due to the primary energy sources considered. In this way, an equal characteristic consumer located in Denmark and Finland, can spend more in Denmark than in Finland in its consumer's bill. Denmark seems to be more developed and focused on the benefits of smart grid technologies than Finland, that isn't focused on renewable energy progress.

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References

[1] G. K. Venayagamoorthy, "Dynamic, Stochastic, Computational and Scalable Technologies for Smart Grids," *Ieee Comput. Intell. Mag.*, vol. 6, no. 3, pp. 22–35, 2011.

[2] S. Mukhopadhyay and B. Singh, "Distributed generation — Basic policy, perspective planning, and achievement so far in india," in *2009 IEEE Power & Energy Society General Meeting*, 2009, pp. 1–7.

[3] T. Ackermann, G. Andersson, and L. Söder, "Distributed generation: a definition," *Electr. Power Syst. Res.*, vol. 57, no. 3, pp. 195–204, Apr. 2001.

[4] A. Yadav and L. Srivastava, "Optimal placement of distributed generation: An overview and key issues," in *2014 International Conference on Power Signals Control and Computations (EPSCICON)*, 2014, pp. 1–6.

[5] P. Palensky and D. Dietrich, "Demand Side Management: Demand Response, Intelligent Energy Systems, and Smart Loads," *IEEE Trans. Ind. Informatics*, vol. 7, no. 3, pp. 381–388, Aug. 2011.

[6] X. Guan, Z. Xu, and Q.-S. Jia, "Energy-Efficient Buildings Facilitated by Microgrid," *IEEE Trans. Smart*

Grid, vol. 1, no. 3, pp. 243–252, Dec. 2010.
[7] North American Electric Reliability Corporation, "Demand Response Discussion for the 2007 Long-Term Reliability Assessment," 2007.
[8] A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005, "Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them," 2006.
[9] A. J. Conejo, J. M. Morales, and L. Baringo, "Real-Time Demand Response Model," *IEEE Trans. Smart Grid*, vol. 1, no. 3, pp. 236–242, Dec. 2010.
[10] A. Faruqui and J. R. Malko, "The residential demand for electricity by time-of-use: A survey of twelve experiments with peak load pricing," *Energy*, vol. 8, no. 10, pp. 781–795, Oct. 1983.
[11] K. Herter, P. McAuliffe, and A. Rosenfeld, "An exploratory analysis of California residential customer response to critical peak pricing of electricity," *Energy*, vol. 32, no. 1, pp. 25–34, Jan. 2007.
[12] J. . Painuly, "Barriers to renewable energy penetration; a framework for analysis," *Renew. Energy*, vol. 24, no. 1, pp. 73–89, Sep. 2001.
[13] G. A. JimÉnez-EstÉvez, R. Palma-Behnke, R. Torres-Avila, and L. S. Vargas, "A Competitive Market Integration Model for Distributed Generation," *IEEE Trans. Power Syst.*, vol. 22, no. 4, pp. 2161–2169, Nov. 2007.
[14] EG3 Report - Smart Grid Task Force, "Regulatory Recommendations for the Deployment of Flexibility," 2015.
[15] H. A. Rahman, M. S. Majid, A. Rezaee Jordehi, G. Chin Kim, M. Y. Hassan, and S. O. Fadhl, "Operation and control strategies of integrated distributed energy resources: A review," *Renew. Sustain. Energy Rev.*, vol. 51, pp. 1412–1420, Nov. 2015.
[16] Aalborg Universitet, "IDA's Energy Vision 2050," 2015.
[17] Danish Energy Agency, "The Danish Energy Model: Innovative, Efficient and Sustainable," 2015.
[18] Klima-OG Energiministeriet, "National Action Plan for renewable energy in Denmark." 2010.
[19] Danish Ministry of Climate Energy and Building, "DK Energy Agreement," 2012.
[20] Danish Energy Agency, "Outline of the Danish support schemes for electricity generation based on renewables," 2013.
[21] D. Boldt, N. Borges, and J. Spínola, "European Policies Aiming the Penetration of Distributed Energy in the Energy Market." p. 10, 2015.
[22] Smart Energy Demand Coalition, "Mapping Demand Response in Europe Today 2015," 2015.
[23] Danish Ministry of Climate Energy and Building, "Smart Grid Strategy - The intelligent energy system of the future," 2013.
[24] THEMA Consulting Group, "Demand response in the Nordic electricity market," 2014.
[25] Energinet - Danish Energy Association, "Ancillary services to be delivered in Denmark Tender conditions," 2012.
[26] Energinet - Danish Energy Association, "Smart grid in Denmark 2.0."
[27] Danish Energy Regulatory Authority, "2015 National Report to the European Commission - Denmark," 2014.
[28] N. Valkila and A. Saari, "Experts' view on Finland's energy policy," *Renew. Sustain. Energy Rev.*, vol. 17, pp. 283–290, Jan. 2013.
[29] Finland Gonvernment, "Long-term Climate and Energy Strategy," 2008.
[30] N. Valkila and A. Saari, "Urgent need for new approach to energy policy: The case of Finland," *Renew. Sustain. Energy Rev.*, vol. 14, no. 7, pp. 2068–2076, Sep. 2010.
[31] I. Ruostetsaari, "Governance and political consumerism in Finnish energy policy-making," *Energy Policy*, vol. 37, no. 1, pp. 102–110, Jan. 2009.
[32] J. Moisander, "Attitudes and ecologically responsible consumption," 1996.
[33] Finergy, "Energy and sustainable development," 2002.
[34] Statistics Finland, "Energy statistics 2013," 2014. [Online]. Available: http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2013/html/engl0000.htm. [Accessed: 17-Dec-2015].
[35] RES-Legal, "Support schemes in Finland," 2014. [Online]. Available: http://www.res-legal.eu/search-by-country/finland/summary/c/finland/s/res-e/sum/128/lpid/127/. [Accessed: 17-Dec-2015].

[36] S. Ruggiero, V. Varho, and P. Rikkonen, “Transition to distributed energy generation in Finland: Prospects and barriers,” *Energy Policy*, vol. 86, pp. 433–443, Nov. 2015.

[37] E. Authority, “Feed-in tariff,” 2015. [Online]. Available: https://www.energiavirasto.fi/web/energy-authority/feed-in-tariff. [Accessed: 17-Dec-2015].

[38] Tampere University of Technology, Tampere University of Applied Sciences, and Lappeeranta University of Technology, “Demand Response – Practical Solutions and Impacts for DSOs in Finland,” 2015.

[39] “Honkapuro, S., et al. ‘Demand response in Finland–Potential obstacles in practical implementation.’ Proceedings of NORDAC 2014, 11th Nordic Conference on Electricity Distribution System Management and Development. 2014.”

[40] Fingrid, “Demand-side management,” 2015. [Online]. Available: http://www.fingrid.fi/en/electricity-market/Demand-Side_Management/Pages/default.aspx. [Accessed: 18-Dec-2015].

[41] P. Koponen, “DSM situation in Finland in 2014,” 2014.

[42] P. P. Capros, A. De Vita, N. Tasios, D. Papadopoulos, P. Siskos, E. Apostolaki, M. Zampara, L. Paroussos, K. Fragiadakis, N. Kouvaritakis, L. Höglund-Isaksson, W. Winiwarter, P. Purohit, H. Böttcher, S. Frank, P. Havlík, M. Gusti, and H. P. Witzke, “EU Energy, Transport and GHG Emissions - Trends to 2050,” 2013.

[43] Energy Authority, “National Report 2014 to the Agency for the Cooperation of Energy Regulators and to the European Commission,” 2014.

[44] S. Honkapuro, J. Tuunanen, P. Valtonen, J. Partanen, P. Jarventausta, and J. Heljo, “Pratical Implementation of Demand Response in Finland,” in *23rd International Conference on Electricity Distribution*, 2015.