Towards Energy Democratization

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INTRODUCTION

This Article examines the progress of renewable energy and energy decentralization in Sweden and Denmark. Both countries have numerous projects underway aimed at reducing dependence on fossil fuels and promoting greener energy options. These projects include boosting energy usage from renewable sources and adopting tools and technologies that will facilitate energy security and efficiency. Much of the work taking place in the two countries has the potential to be replicated in other jurisdictions.

Denmark is at the epitome of renewable energy and sustainable development. With twenty-seven percent of its total energy production sourced from wind turbines and twenty-four percent from natural gas, it is one of the leading countries in the world in renewable and sustainable energy production and consumption. Denmark is an excellent model for smart grid usage because it is the country's primary source of transmitting electrical energy to end-users.

In Sweden, the energy and climate policies are based on both European Union ("EU") legislation and national targets. In 2008, the Swedish government implemented a large-scale climate and energy

policy.[1] The Swedish government decided that by 2020, fifty percent of the country´s energy production should come from renewable energy sources.[2] In fact, Sweden is ahead of its target and the country now expects to reach a production level of fifty-five percent from renewables by 2020.

Sweden's overall goals are to have 100 percent renewable electricity production by 2040, net-zero greenhouse gas ("GHG") emissions into the atmosphere by 2045, and increased energy efficiency of fifty percent by 2030.[3] Sweden´s ambitious energy and climate goals signal both a need for further improvement and the intention by the government to make those improvements.[4] Establishing a "smarter" energy system and enabling smart grid solutions to a greater extent will be important to achieving these goals.[5]

Section I of this Article focuses on Denmark, Section II considers Sweden, and finally there is a conclusion based on the two countries. This Article analyzes regulations in both countries that promote renewable energy, increase energy security, and achieve decentralization via technology such as smart meters and smart grids. This Article also identifies current barriers to achieving these goals. Further, this Article also addresses the countries progress towards electric vehicles and their storage systems. As data protection is a key concern with the advent of smart grids and smart meters, this Article analyzes regulatory considerations regarding data privacy and protection, both at the EU level and specifically within Denmark and Sweden. This Article provides recommendations for both countries, such as the need for further deregulation and greater financial commitments, among others.

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1 Proposition [Prop.] 2008/2009:163 En sammanhållen klimat- och energipolitik – Energi [A Coherent Climate and Energy Policy – Energy] (Swed.).

2 MINISTRY OF THE ENV'T & MINISTRY OF ENTER., ENERGY AND COMMC'NS, AN INTEGRATED CLIMATE AND ENERGY POLICY – INFORMATION SHEET ABOUT THE GOVERNMENT BILLS 2008/09:162 AND 163 1 (2009) (Swed.).

3 Proposition [Prop.] 2016/2017:146 Ett klimatpolitiskt ramverk för Sverige [Sweden's Energy and Climate Goals] (Swed.).

4 *See* MINISTRY OF THE ENV'T & MINISTRY OF ENTER., ENERGY AND COMMC'NS, *supra* note 2, at 16.

5 Statens Offentliga Utredningar [SOU] 2017:2 Kraftsamling för Framtidens Energi [Power Collection for the Energy of the Future] [government report series] (Swed.) [hereinafter Power Collection for the Energy of the Future].

I. DENMARK

Prior to the embargo of 1973, Danish energy supply was heavily dependent on imported oil.[6] The 1973 oil and gas crisis was a wake-up call for the country's environmental and energy strategy. To ensure energy security, Denmark implemented immediate and long-term measures, including measures to achieve its ambitious development agenda and the diversification of its energy portfolio.[7] Government regulation was vital to this retreat from extreme oil and gas dependency. Denmark founded the Danish Energy Agency ("DEA") in 1976 as a ministerial branch to oversee the electricity market.[8]

The DEA identified three main tasks required for the turnaround: (1) reduce vulnerability of the energy system via diversification and stock building in accordance with International Energy Agency and European Commission guidelines, (2) reduce the growth rate of energy consumption by enhancing efficiency in production and consumption, and (3) recognize energy related issues by promoting research and development.[9]

The implementation of a multi-tiered energy supply system prompted a shift towards domestic, rather than imported, energy sources. This pressured Denmark to expand its exploration in the Danish segment of the North Sea in search of locations to house natural gas and build a long-term energy stockpile.[10] Strategies for increased diversification were identified early, which made Denmark understand the importance of security of supply and other behavioral traits such as regulation on reduced imported fuels to increase national supply.[11] Diversification and a multi-tiered energy supply system would not only support the country's energy security, but these programs would also help the Danish economy support its growing population.

The oil crisis changed the scene from a largely market-driven system to a policy-driven system. Planning and regulation were at the heart of Denmark's strategy to secure electrical energy supply and reduce dependency on fossil fuels. Although planning was the main tool used to

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6 *See Denmark Oil Consumption*, CEIC, https://www.ceicdata.com/en/indicator/denmark/oil-consumption (last visited Sep. 21, 2019).

7 Jim Malewitz, *1 Energy Crisis, 2 Futures: How Denmark and Texas Answered a Challenge*, TEXAS TRIBUNE (NOV. 21, 2016, 12 AM), https://www.texastribune.org/2016/11/21/denmark-texas-climate.

8 Mogens Rüdiger, *The 1973 Oil Crisis and the Designing of a Danish Energy Policy*, 39 HIST. SOC. RES. / HISTORISCHE SOZIALFORSCHUNG (SPECIAL ISSUE) 94, 103 (2014).

9 *Id.* at 103.

10 *Id.* at 98.

11 *Id.* at 107.

achieve the targets, introducing financial and tax incentives changed consumer behavior and demand.

A. Denmark's Renewable Energy Sources

In the 1980s, efforts grew to explore renewable energy sources ("RES") for generating electrical energy. Denmark set an RES target of four percent of the country's total energy production. Wind turbines were already well established in Denmark and were popular amongst policymakers. Initially, commercial companies found it too expensive and cumbersome to build and maintain wind turbines. However, in 1990, the government introduced "Energy 2000," designed to reduce energy consumption and CO_2 emission.[12] In turn, the government program Energy 2000 would replace the national dependency on fossil-based fuels.[13]

Today, Denmark ensures continuity in its ambition to grow their Energy and Climate Outlooks. These targets are deeply embedded in Denmark's political strategy to become more sustainable and to mitigate its GHG emissions. Denmark's current energy agreement expires in 2020. Denmark needs a new strategy for the coming decade, 2020-2030, that will satisfy the country's future energy needs.[14]

B. Denmark's Electrical Energy

Denmark's energy independence is unique in the EU. Denmark is almost entirely self-sustained in its energy usage.[15] Almost thirty percent of the country's total energy production derives from renewable energy sources.[16] Wind turbines take great advantage of the windy climate and flat landscape, both on and offshore. For the past fifteen years, Denmark has had the highest wind energy production per capita, and its per capita production is almost twice that of the runner up for industrialized countries

12 *Id.* at 108.

13 HANS FALSTER ET AL., CTR. FOR BIOMASS TECH., WOOD FOR ENERGY PRODUCTION 6 (Helle Serup, ed., 2nd ed. 1999).

14 *See id.*

15 *See* DANISH ENERGY AGENCY, ENERGY STATISTICS 2017 3–4 (2017), https://ens.dk /sites/ens .dk/files/Statistik/energystatistics2017.pdf.

16 *Id.* at 8–9.

in the Organization for Economic Co-Operation and Development ("OECD").[17]

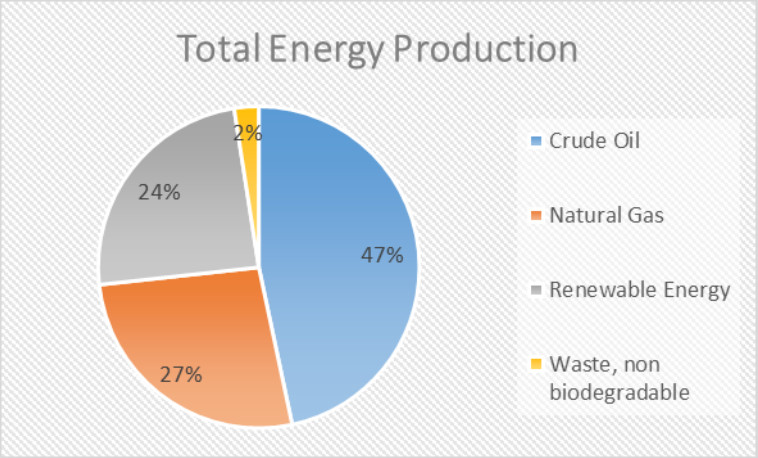

Figure 1: Energy production data, 2016[18]

1. Renewable Energy

Crude oil is the highest contributor to Denmark's energy production.[19] However, Denmark is moving towards energy production from RES.[20] Renewable energy, as a share of total energy production in Denmark, has grown significantly since the turn of the century.[21] In 2000, renewable energy represented 6.9 percent of total energy production, whereas renewables in 2016 amounted to twenty-four percent of total energy production.[22] Denmark's renewable energy production is now almost a quarter of its total energy production.[23]

17 *See Denmark: The Most Wind Energy Producing Country Per Capita*, STATE OF GREEN (Aug. 9, 2017), https://stateofgreen.com/en/partners/state-of-green/news/denmark-the-most-wind-energy-producing-country-per-capita/

18 *See* DANISH ENERGY AGENCY, ENERGY STATISTICS 5 (2016), https://ens.dk/sites/ens.dk/ files/Statistik/energy_statistics_2016.pdf

19 *See id.*

20 *See id.*

21 *See id.*

22 *See id.*

23 *See id.*

Since 1990, Denmark has seen a staggering 241% increase in renewable energy production.[24] The two most improved renewable energy sources are solar (4,659%) and wind power (1,994%).[25] At present day, wind power is the second highest contributor to Denmark's renewable energy production.[26] In front, combined biomass production topples wind power at fifty-five percent of total renewable energy production.[27] Recent figures show renewable energy production is constantly on the rise as regulation and market demand support new solutions for green technology.[28]

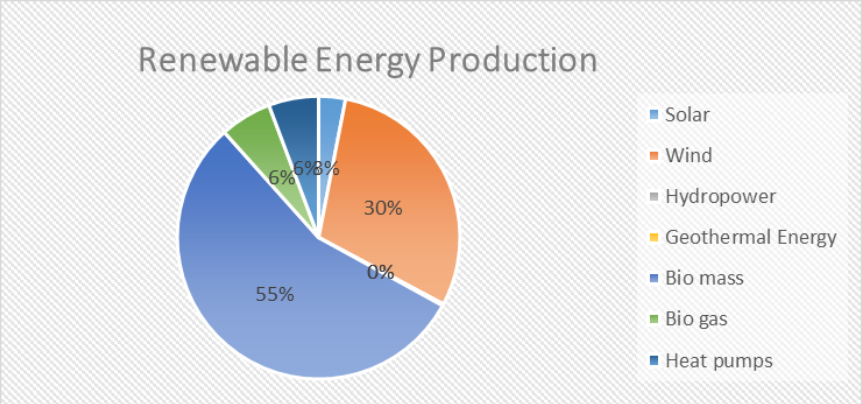

Figure 2: Annual RES production of total energy produced data, 2016[29]

Wind power alone stood for 43.4 percent of electrical generation in 2017.[30] Electrical energy generation by wind turbines in Denmark is setting records worldwide whilst displaying a steady rise each year.[31] The numbers illustrate drastic change to the Danish and European energy

24 *See id.*

25 *See id.*

26 *See id.*

27 *See id.*

28 *See id.*

29 *See id.*

30 DANISH MINISTRY OF ENERGY, UTILS. & CLIMATE, DENMARK: ENERGY AND CLIMATE PIONEER – STATUS OF THE GREEN TRANSITION 7 (2018), https://en.efkm.dk/media /12 032/denmark_energy_and_climate_pioneer_pdfa.pdf.

31 *See id.*

systems, and provide insight into how renewable energy is changing the way the electrical energy system operates.[32]

It is crucial that policies and regulations continue forward progress. Grids need to account for new sources of electrical energy production, and governments need to deregulate to allow for new market players to enter the electrical grid. Digital systems are also fundamental to processing all the new data that accompanies new technologies. At the heart of data collection in the EU is consumer protection. To continue a larger scale objective to decarbonize our climate, interstate co-operation is required amongst the European countries to connect multiple grids to form a multilateral grid network.

Possibly more important than the increase in renewable energy and biomass production is Denmark's reduction of fossil fuels.[33] Between 2012 and 2016, data from the DEA displayed a significant reduction of fossil fuels.[34] Denmark's crude oil production decreased by thirty-one percent in this four year period.[35] Furthermore, out of the 82,707 gWh crude oil produced in 2016, over fifty percent was not retained for domestic consumption, but rather exported to other countries more dependent on burning fossil fuels.[36] The export of commodities such as oil is still a strong economic model, which in the short-term may assist funding medium- to long-term renewable energy source production and technological advancements, including electric grid technologies.

2. Consumption

In 2016, Denmark's total consumption of oil was 15.02 million tons. In descending order, electrical energy consumption by sector was: (1) transportation at thirty-four percent; (2) residential at thirty-one percent; (3) industry at twenty percent; and (4) trade and service at thirteen percent.[37]

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32 *See* DANISH ENERGY AGENCY, *supra* note 18, at 5.

33 *See* ANNUAL AND MONTHLY STATISTICS, DANISH ENERGY AGENCY, https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/annual-and-monthly-statistics (follow "monthly energy production and consumption statistics" hyperlink) (last updated July 2019).

34 *See id.*

35 *See* DANISH ENERGY AGENCY, *supra* note 18, at 18.

36 *See id.* at 22.

37 *See id.*

3. Highlighted Challenges

The following Sections describe the significant challenges Denmark faces in improving its energy system. These challenges include: (1) large financial commitments; (2) the need to deregulate; (3) expanding RES; and (4) decentralizing energy policy.

4. Large Financial Commitments

Although large financial contributions are being deployed to develop the Danish grid, more funds are needed to secure the country's ambitious growth. The 2016 Public Service Obligation ("PSO") agreement provided significant funding for green transition costs, an encouraging change in allocation of the National Budget.[38] Funding for green energy systems remains an important topic in all fiscal prioritization discussions.

5. The Need for Deregulation to Foster Modernization and Funding of the Energy System

In the last few decades, strict regulations and planning have dominated energy policy.[39] In a market that is constantly changing on a global scale, micromanaging policies is not an effective solution. Denmark needs to deregulate the market to allow for organic growth and new players to enter the market.

Regulatory chains impinge upon the ability of RES to prosper in the market.[40] The regulatory chain allows for fewer cost-effective methods which ultimately increase consumer process.[41] For example, deregulated offshore wind turbines, subject to competition, have promised avid benefits in pricing and development. Additionally, only power plants are permitted to directly access the electricity market.[42] This regulation limits the potential for innovative business models that could provide more cost-effective solutions.[43] Such flexible and integrated systems will soon be necessary as renewable energy becomes more prominent.

The country's tax structure is based on an era of fossil fuel reliance to produce electricity and, therefore, needs an overhaul. Prohibitive taxes on electrical heating and electricity creates obstacles to greener energy solutions as self-generating technology is too expensive to use.[44] In

38 *See id.* at 45.

39 DANISH MINISTRY OF ENERGY, UTILS. & CLIMATE, *supra* note 30, at 32.

40 *Id.*

41 *See id.*

42 *Id.*

43 *Id.*

44 *Id.*

socioeconomic terms: green solutions such as heat pumps are not utilized due to less disposable income and high taxes and further development is not taking place.[45] In turn, the population is experiencing a deficit in economic gain and benefit. Therefore, there is a great need for flexible consumption to be explored in detail.

With an electricity system that has historically centered around power plants, regulation is not able to keep up with the increasing volumes of fluctuating green energy from smaller sources as well as international sources of energy. Larger power plants will diminish earnings under pricing pressure. On that basis, the system's operating framework needs to adapt on a large scale, including connecting grids together.

6. Proliferation of RES is Pushing the Grid's Capacity

One of Denmark's top priorities is to expand the practical usage of green energy.[46] However, due to expensive technology, there is an increase in the cost of producing energy and selling it in the market. When technology is in its early stages, optimizing output is not the main priority, as this would limit the security of supply. Instead, early-stage technology should focus on defining its long-term benefit and how it can continuously grow to reach targets.

To innovate, Denmark will need to face its increasing volume of renewable energy with a more flexible and integrated system. Otherwise, it will be too costly to maintain the current security of supply in the energy, heating, and gas sector. Adapting to new technologies requires investing in storage and off-grid solutions. These technologies are crucial to balancing the system in times of over and under saturated production.

7. Decentralization of Energy Policy

Wind and solar energy are expected to double in northwestern Europe between 2020-2035 according to Denmark's climate outlook.[47] The increasing volume of renewable energy will require even greater international cooperation. Therefore, the security of supply is transitioning from being a national issue to a supranational issue.[48] This might be classified as an opportunity where grid systems in multiple countries will be adjoined, creating interdependence between the adjoining grids. For instance, the price of wind power in Germany and the hydroelectric power produced in Norway is influencing electricity prices in Denmark more

45 *Id. See also Tax on Personal Income*, OECD, https://data.oecd.org/chart/5GGR.

46 DANISH MINISTRY OF ENERGY, UTILS. & CLIMATE, *supra* note 30, at 33.

47 *Id.*

48 *Id.*

than electricity produced domestically. Thus price fluctuation may be seen within the national borders. During 2017, ninety-two percent of west Denmark had similar prices to one or more neighboring countries, whilst east Denmark shared the same prices with neighbors ninety-six percent of the year.[49] Policy drafters will need to keep this in mind when designing future incentives and trade agreements.

C. Denmark's Governance System

For several years, Denmark has worked on its smart grid system, first identified in 2010 when a smart grid network was established along with major market players to make recommendations on how they thought the electricity sector and authorities could front smart grids. Through careful governance, the Energy Agreement of 2012 established political support to transition into a greener energy market, with an ambition to achieve fifty percent of electricity demand through wind power.[50]

To achieve ambitious climate targets, a close relationship between the central government and the energy sector is important. The energy sector plays the important role of developing technology that the consumer will adopt, making it attractive for households and businesses to make their consumption available for the smart grid system. Emerging trends are also key for policymakers to keep an eye on. For example, there have been many initiatives for developing wind turbine technology.[51]

1. Legislation

Together with executive orders, the main legislation governing the Danish electricity grid and energy trade is the Danish Electricity Supply Act ("DESA") of June 27, 2018.[52] The DESA ensures that the electricity market is regulated and provides for the security of energy alongside social, economic, environmental, and consumer protection. The DESA also sets an objective to secure consumer access to low-cost electricity.[53]

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[49] *Id.*

[50] *Danish Energy Agreement for 2012-2020*, IEA, https://www.iea.org/policies/606-danish-energy-agreement-for-2012-2020 (last updated Nov. 5, 2**0**17).

[51] *See Facts about Wind Power*, DANISH ENERGY AGENCY, https://ens.dk/en/our-responsibilities/wind-power/facts-about-wind-power (last visited Jan. 15, 2019).

[52] *See* Bekendtgørelse [Bkg] nr. 1009 af 27.06.2018 om lov om elforsyning [Order on the Electricity Supply Act] (Den.) [hereinafter Electricity Supply Act].

[53] *Id.* at § 1.

The Promotion of Renewable Energy Act of October 27, 2016 is perhaps equally important.[54] This Act promotes renewable energy production, mitigates dependency on fossil fuels, secures energy supply, and reduces carbon-based emission.[55] The legislation also incentivizes wind turbines and other renewable energy production facilities, promotes construction of wind turbines, increases access to offshore hydro and wind energy, and regulates renewable electric generation.[56]

2. Authorities

The main market participants of the Danish electrical market have a clear structure of roles and responsibilities. The Danish Ministry of Climate, Energy and Utilities ("Ministry") supervises and regulates the energy industry and oversees developing strategies.[57] The Ministry is the key government institution affecting national regulation and matters regarding energy and energy trade.

Beneath the Ministry is the DEA. The DESA authorizes the DEA to issue executive orders, propose regulations, and ensure compliance with the DESA for the relevant sections.[58] The DEA is also responsible for issuing licenses related to electricity production, transmission, and distribution.

The Danish Utility Regulator ("DUR") oversees prices and market terms for and transmission companies connected to the grid.[59] The Danish Energy Board of Appeal, an independent body under the Ministry, formally questions decisions made by the DUR and the DEA.[60] In addition, the Energy Supplies Complaints Board handles legal complaints

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54 § 18 Bekendtgørelse [Bkg] nr. 1288 af 27.08.2016 om fremme af vedvarende energi [Order on the Promotion of Renewable Energy Act] (Den.) [hereinafter Promotion of Renewable Energy Act].

55 *Id.* at § 1.

56 *Id.* at § 2.

57 *The Ministry*, DANISH MINISTRY OF CLIMATE, ENERGY & UTILS., https://en.kefm.dk /the-ministry/ (last visited Jan. 15, 2019).

58 *See generally About the Danish Energy Agency*, DANISH MINISTRY OF CLIMATE, ENERGY & UTILS., https://ens.dk/en/about-us/about-danish-energy-agency (last visited Jan. 15, 2019).

59 *See Network Codes*, ENERGINET, https://en.energinet.dk/Electricity/Rules-and-Regulations#NetworkCodes (last visited Nov. 4, 2019).

60 EUROPEAN ENERGY HANDBOOK: A SURVEY OF THE LEGAL FRAMEWORK AND CURRENT ISSUES IN THE EUROPEAN ENERGY SECTOR 14, 141 (Herbert Smith Freehills, 10th ed. 2017), https://sites-herbertsmithfreehills.vuturevx.com/18/14909/landing-pages/european-energy-handbook---tenth-edition---2017-complete-v2.PDF [hereinafter EUROPEAN ENERGY HANDBOOK]; *See About Us*, FORSYNINGSTILSYNET (Feb. 28, 2018) https://forsyningstilsynet.dk/about-us.

and disputes between private household consumers and the energy companies.

The Danish Transmission System Operator ("TSO"), Energinet.dk, is a state-owned independent public entity established by the DESA.[61] The TSO is responsible for securing the supply of electricity and gas and running efficient respective markets[62] The TSO is also responsible for ensuring the short- and long-term security of supply. [63] Further, as the owner and operator, Energinet.dk is responsible for DataHub.[64] DataHub, as a technical prerequisite to the supplier centric model and as a common data platform; facilitates and automates market interactions, including business transactions of the retail market; and receives meter readings from approximately 3.3 million metering points for both production and consumption. The centralized data system provides the market and all its participants with a level playing field. [65]

Denmark is part of the Nord Pool Group, a European electricity exchange. An entity that has entered into a Balance Responsible Party Agreement ("BRPA"),[66] the balance responsible party, oversees the buying and selling of electricity on the exchange. Daily, the responsible party must submit scheduling plans to the TSO for the expected energy consumption and production during the next 24 hours.[67]

In Denmark, the Distribution System Operator ("DSO") owns and controls the network between the transmission grid and the consumer, and it has a monopoly on the transportation of electricity in its geographically demarcated grid.[68] Part of the DSO's responsibility is to measure electricity consumption and generation within its regional grid and report the data to a metering point administrator.

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61 EUROPEAN ENERGY HANDBOOK, *supra*, note 60, at 141.

62 *See* Electricity Supply Act, *supra* note 52.

63 *Id.* at § 6.

64 *Id.* at § 6.

65 *See What Is the Purpose of Data Hub?*, ENERGINET.COM, https://en.Energinet.dk/Electricity/DataHub#Document (last visited Sept. 19, 2019).

66 BRPA means an agreement between a TSO (or its nominee) and any person wishing to participate in the electricity balancing market operated by the TSO. This means the person is required to maintain the balance of electricity demand and supply with respect to the TSO's system, and where there are shortcomings, compensate the TSO for any imbalance in accordance with the terms specified in the BRPA. *See Regulation C1: Terms of balance responsibility*, ENERGINET, https://en.energinet.dk/-/media/1A6F1C8A27C646DA86B5F84675213B9D.pdf (last updated 2015).

67 *Roles & Responsibilities*, ENERGINET, https://en.energinet.dk/Electricity/New-player /Roles-and-responsibilities (last visited Sept. 19, 2019).

68 Electricity Supply Act, *supra* note 52, at § 19.

3. National and Regional Transmission – Public Service Obligations and Smart Metering

Fifty-seven local electricity distribution companies own and operate the distribution grid. Local municipalities or organized end-users own and control the grid supply area.

The Danish TSO charges a Public Service Obligation ("PSO") tariff to cover the costs related to the public service obligations of the TSO and the grid companies as provided in the DESA and the Danish Promotion of Renewable Energy Act. The tariff is a charge levied to support renewable energy and is paid by the suppliers to the TSO based on total electricity consumed in their area of delivery. In November 2016, an agreement regarding the PSO was reached by a majority in the Danish Parliament. Parliament agreed to gradually abolish the PSO tax but have expenses shifting between the consumer-paid PSO tariff and the Finance Act.[69] Now, the DEA calculates and sets quarterly and yearly PSO tariffs.[70]

Denmark defines incentives and subsidies for renewable and green technology for energy production. The Promotion of Renewable Energy Act's wind turbine subsidies serve as one example of such subsidies. For example, onshore grid-connected wind power, connected since February 2008, benefits from a feed-in premium of 0.25 Danish krone ("DKK") per kWh of electricity for the first 22,000 hours.[71] Offshore wind farms are subject to separate incentive schemes. A feed-in premium by the wind farm at Horns Rev 2 enjoys an added DKK 0.518 per kWh, and the wind farm at Rødsand 2 receives DKK 0.629 per kWh.[72] These premiums apply to electricity production of 10 Terawatt hours ("TWh") for a maximum of twenty years.[73] Furthermore, smart meter rollouts are sourced to independent companies. Smart grids and meters are at the forefront of the Danish energy strategy–fully supporting grid technology and connectivity to the grid and constantly investing in new technologies. Several grid companies are in the process of installing smart meters in their supply

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69 *Current PSO rate*, ENERGISTYRELSEN, https://ens.dk/service/statistik-data-noegletal-og-kort/aktuel-pso-tarif (last visited Sept. 19, 2019).

70 *Id.*

71 Renewable Energy Act, *supra* note 54, at § 18.

72 *Id.* at § 37(2)–(1).

73 *Id.* at § 37(4).

area.[74] By 2020, intelligent remote-readable electricity meters should be installed in each of Denmark's 3.3 million usage points. [75]

4. Inter-State Cooperation

Denmark has an active energy partnership with Germany. This is a formal continuation of earlier relationships, where the aim for a two-year period between 2017 and 2019 was to enhance cooperation between the two authorities. This valuable partnership will be used to share and learn from each other's experiences; ultimately transitioning towards a greener energy dependency.[76] Danish and German stakeholders have shared that the partnership aims to develop areas of Combined Heat and Power ("CHP") production, including district heating and energy efficiency in buildings, industry, and energy production facilities.[77]

This intergovernmental partnership brings a rich history of strong energy regulation and technological advancement to the table. Denmark leverages decades of experience in transforming their own energy system. Additionally, Denmark has knowledge on information sharing of green efforts for clean, prudential, and stable energy systems from other past and ongoing collaborations with numerous countries.[78] This cooperation explores topics in the aforementioned areas by analyzing, *inter alia*, different policy measures, infrastructure, obligation schemes, taxes and legislation, storage solutions, and interactions between energy sources.[79] Danish government institutions assign specialists to aid international cooperation.[80]

This cooperation takes place by exchanging experts and specialists from the DEA and the Danish Embassy in Berlin, with the DEA closely managing and engaging in regulatory matters. There is also evidence of close connections between the Embassy, the DEA, and external organizations and businesses who can advise on matters related to technical developments, regulatory affairs, and energy framework in

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74 Hansen, Louise V., *Radius and Kamstrup Begins Roll-out of Large-scale Smart Metering Project*, STATE OF GREEN (Jan. 28, 2017), https://stateofgreen.com/en/partners/kamstrup/news/radius-and-kamstrup-begins-roll-out-of-large-scale-smart-metering-project/.

75 *Id.*

76 *German-Danish Energy Cooperation* 1, MINISTRY OF FOREIGN AFFAIRS OF DENMARK, THE TRADE COUNCIL, https://ens.dk/sites/ens.dk/files/Globalcooperation/Short_materials/german-danish_energy_cooperation.pdf.

77 *Id.* at 2.

78 *Id.* at 1.

79 *Id.*

80 *Id.*

Germany. This form of knowledge exchange and partnership is imperative to facilitating a deregulated market where multiple participants create an interlinked interstate grid network throughout the EU and European Economic Area ("EEA").

D. Electricity Markets

This Section introduces the Danish regulatory framework by discussing the oversight and governance of the electricity market. The first Subsection details regulated activities, non-regulated activities and the status of unbundling in the Danish market. The second Subsection analyzes relevant tariffs related to the production, use, and trade of electrical energy, and ultimately how it affects the end user. The third Subsection introduces some of the incentives available for renewable energy technologies. Lastly, the fourth Subsection analyzes the Danish energy security dimensions and how the Danish grid is evolving through interconnectivity.

1. Regulatory Framework

The DESA is the main law governing electrical energy in Denmark.[81] The DESA's purpose is to ensure the electrical energy distribution in Denmark is safe and in accordance with a socially conscious, climate friendly, and consumer protective approach.[82] The aim of the legislation is to ensure that consumers have access to low-cost electrical energy.[83] Accordingly, the legislation promotes sustainable energy by encouraging energy savings, use of CHP, and environmentally friendly sources of energy, while securing the efficient use of financial resources to support healthy competition in the electricity market.

In Denmark, smart grids are regulated under the Executive Order on Energy Saving Services in Grid and Distribution Entities. The Executive Order promotes grid and distribution entities' cost effective and low energy consumption methods for energy consumers and society at large.[84] The main focus of this Executive Order is to ensure that distribution and grid entities ensure efforts of energy saving for the end-user.[85] Annex 1

81 *See generally* Electricity Supply Act, *supra* note 52.

82 *Id.* at § 1.

83 *Id.*

84 Bekendtgørelse nr. 864 af 26.08.2019 om energispareydelser i net-og distributionsvirksomheder [Order on energy saving services in network distribution companies].

85 *Id.*

and section 6 to the Executive Order display targets for the average energy saving distribution that grid companies must strive to achieve.[86]

i. Regulated Activities

The DEA requires a license to carry out activities related to energy exploration, production, transmission, distribution, and storage. Additionally, a permit is needed for establishing plants and for any expansion or changes to plants where pollution may increase.[87] The city or regional council issues permits depending on the size of the plant.[88] If a major plant is to be built, the Planning Act may require a public hearing and an environmental impact assessment.[89]

ii. Regulatory Status of Unbundling

Following the third Energy Package Directive,[90] European electricity grids are subject to unbundling obligations to ensure the separation of vertically integrated utilities. This results in separation of the various energy supply stages ranging from generation and production to distribution, transmission, and the supply of electrical energy to the end-users. In order to adhere to the unbundling principles, a DSO must hold the necessary human, technical, financial, and physical resources to operate independently. This must be obtained without the managerial or financial influence or assistance from vertically integrated undertakings.[91] A DSO must therefore be able to retain the necessary resources at its disposal to primarily operate, maintain, and develop its network without unduly relying on the services and other parts of vertically integrated undertakings.[92]

The main transmission grid in Denmark has secured unbundling.[93] Conversely, there are fifty DSOs in Denmark covering a total distribution grid of 159,000 kilometers ("km") and delivering electrical power to

86 *Id.* at § 6.

87 *See* Bekendtgørelse [Bkg] nr. 1189 af 29.09.2016 om lov om miljøbeskyttelse [Order on the Environmental Protection Act] §§ 33, 35.

88 Bekendtgørelse [Bkg] nr. 287 af 16.04.2018 lov om planlægning [Order on the Planning Act].

89 Bekendtgørelse [Bkg] nr. 1225 af 25.10.2018 om miljøvurdering af planer og programmer og af konkrete projekter (VVM) [Order on Environmental Assessment of Plans and Programs and of Specific Projects] § 8.

90 Council Directive 2009/72, 2009 O.J. (EC).

91 Council Directive 2009/73, art. 26, 2009 O.J. (EC).

92 European Commission Staff Working Paper, *Interpretative Note on Directive 2009/72/EC and Directive 2009/73/EC* 23–29 (Jan. 22, 2010).

93 DANISH ENERGY REGULATORY AUTHORITY, NATIONAL REPORT: DENMARK STATUS FOR 2016 37 (2017).

approximately 3.3 million end-users.[94] The obligations in the Electricity Directive Article 26 on unbundling have achieved integration in the Danish ESA.[95] The legislation together with an Executive Order on internal monitoring program for network and transmission companies and Energinet sets out the legal framework that binds DSOs to ensure that they will not be influenced by commercial means or interests.[96]

2. Tariffs

Historically, Danish tariffs included a grid tariff, a system tariff, and a PSO tariff.[97] Tariffs for the use of the electricity grid are fixed by the grid owners and subject to DERA regulation.[98] Tariffs are regulated based on a revenue framework that sets out the maximum annual revenue for a distribution company.[99] In principle, the tariffs are fixed at 2004 levels and may only increase by a regulated inflation rate.[100] Capital costs for necessary new investment, or other expenses by the grid companies, may also result in increased tariffs subject to the approval of DERA.[101] Tariffs and actual revenues are reviewed annually by DERA, and any differences between the approved revenues and actual revenues are settled in the tariffs.[102]

Because Energinet.dk is a state-owned company, it is regulated not to build up any equity or pay dividends to the Danish Ministry of Energy, Utilities, and Climate—its owner.[103] This strict cost plus regime is closely monitored for the TSO to recover necessary costs and return on capital to ensure its efficient running.[104] In the event that the TSO encounters any surplus capital gains, it must transfer them back to the consumer via

94 *Id.* at 11.

95 *See* Electricity Supply Act, *supra* note 52.

96 Bekendtgørelse [bkg] nr. 667 af 19.05.2019 om program for intern overvågning for net-og transmissionsvirksomheder og Energinet.dk i henhold til lov om elforsyning [Order on internal monitoring program for network and transmission companies and Energinet according to the Electricity Supply Act].

97 *Tarrifs*, ENERGINET, https://en.energinet.dk/Electricity/New-player/Roles-and-responsibilities (last visited Jan. 15, 2019).

98 *See* Bekendtgørelse [Bkg] nr. 816 af 27.06.2016 om økonomisk regulering af Energinet.dk [Order on Financial Regulation of Energinet.dk] § 2 [hereinafter Financial Regulation of Energinet.dk].

99 EUROPEAN ENERGY HANDBOOK, *supra* note 60, at 142.

100 *Id.* at § 7.

101 Financial Regulation of Energinet.dk, *supra* note 99, at § 4.

102 *Id.* at § 7.

103 Electricity Supply Act, *supra* note 52, at § 71.

104 Financial Regulation of Energinet.dk, *supra* note 99, at § 2.

reduced tariffs.[105] This return to the consumer normally happens the following calendar year, though in some cases it may take longer for balancing purposes. Likewise, when the TSO suffers a loss, consumer prices increase.[106]

DERA also determines DSO's capital returns ceiling.[107] The revenue cap allowed by Danish DSOs is a regulatory price per kWh multiplied by the anticipated kWh transported in the following year.[108] This ensures that fixed price tariffs are not unduly increased, and provides control over the market price.[109] The DESA mandates that the maximum returns on grid assets are fixed to the yield of a long-term mortgage bond rate plus one percent.[110]

The grid tariff covers the TSO's costs relating to the operation and maintenance of the national and regional transmission grids (400/150/132kV). Whilst the system tariff covers costs relating to reserve (production) capacity and system operation.[111] The PSO tariff covers the TSO's costs relating to public service obligations as provided for in ESA.[112] The supplier, and ultimately the end-users, pay the tariff based on the amount of electricity consumed in their area of delivery. Previously, Energinet.dk set the PSO tariff, but due to a change in system, the DEA is not responsible to determine the tariff quarterly.[113]

3. Incentives

In 2017 a new subsidy scheme for electricity intensive businesses was established through after the EU approved the PSO tariff change

105 *Id.* at § 10(3); EUROPEAN ENERGY HANDBOOK, *supra* note 60, at 142.

106 *See* Electricity Supply Act, *supra* note 52, at § 8.

107 *Id.* at § 69.

108 *Id.* at § 69(3).

109 *Id.* at § 69(4).

110 The relevant legal instruments to govern tariffs are DESA and Executive Order No. 195 of March 4, 2016 on revenue framework for distribution companies and regional transmission companies. *See id*. at § 8; Bekendtgørelse [Bkg] nr. 195 af 04.03.2016 om indtægtsrammer for netvirksomheder og regionale transmissionsvirksomheder omfattet af lov om elforsynin [Order on Revenue Frameworks for Network Companies and Regional Transmission Companies Covered by the Electricity Supply Act].

111 *See* Financial Regulation of Energinet.dk., *supra* note 99.

112 *See Aktuel PSO-tarif*, ENERGISTYRELSEN, https://ens.dk/service/statistik-data-noegletal-og-kort/aktuel-pso-tarif (last visited Jan. 15, 2019).

113 *See id.*

proposal.[114] In total, the scheme established a pool of 185 million DKK[115] to cover the period of 2015-2020. Eligible companies can apply to cover part of their PSO related to their electricity usage.[116] Furthermore, at the beginning of 2018, the government abolished PSO tax, allowing more investment in coastal areas for offshore wind turbines and farms. The government has also invested one billion DKK in wind and solar technology for 2018 and 2019.[117]

4. Energy Interconnections

The Danish electricity system is in a state of rapid transformation. There is evidence of proliferation of renewable energy and interconnections with other countries. Denmark is a major participant in the Northern European Nord Pool grid. New and different production and technology patterns are creating a new-era demand which will lead to a Danish electricity system that differs significantly from today's system. By increasing the number of interconnections, Denmark will become a key part of a regional, rather than a national, electricity grid system. Comparable developments are also taking place in neighboring countries. The Nordic model is displaying an important value of emerging towards the same holistic goal. The European Council endorsed a plan to support an Energy Union to further promote regional connectivity and collaboration on security of supply.

E. Renewable Energies in the Grid

The objective of the Promotion of Renewable Energy Act is to promote renewable energy and the security of energy supply while reducing GHG emissions.[118] Together with the DESA, the Act successfully implements the EU Directive of Renewable Energy. The legislation established a "green scheme" for the Ministry to provide grants

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114 *PSO-godkendelse: Regeringen letter virksomheders elregninger med 185 mio. kr. fra 2017*, (PSO-approval: Government relieve businesses' electricity costs with 185m [DKK] from 2017), DANISH MINISTRY OF CLIMATE, ENERGY & UTILS., (Dec. 14, 2016) https://kefm.dk/aktuelt/nyheder/2016/dec/pso-godkendelse-regeringen-letter-virksomheders-elregninger-med-185-mio-kr-fra-2017/.

115 1 EUR = 7.47 DKK, 185m DKK = 24.77 million EUR

116 *See generally* Promotion of Renewable Energy Act, *supra* note 54.

117 Stine Jacobsen & Teis Jensen, *In Windy Denmark, Clouds Clearing for Solar Power*, REUTERS (Sept. 27, 2017, 8:33AM), https://www.reuters.com/article/us-denmark-renewables/in-windy-denmark-clouds-clearing-for-solar-power-idUSKCN1C220X.

118 *Id.* at § 1.

to companies to undertake renewable energy projects, explore offshore energy, and connect more wind turbines to the grid.[119]

Building on the green scheme, the legislation offers detailed feed in premiums[120] for the production of electrical energy by using renewable resources and enforcing reporting obligations on participating grid companies.[121] There is also an initiative to fund small-scale renewable energy plants that are connected to the grid. The fund allows for up to twenty-five million DKK per year for four years and will be managed by Energinet.dk. As determined by Energinet.dk, renewable energy grants respond to spot or sample prices on the electricity market.[122] At this point, renewable energy plants are still unable to compete financially with fossil-based energy production plants, so wind turbine owners may benefit from subsidies. The subsidy amount is based on when the wind turbines were connected to the grid and their size.[123]

F. Energy Trading and Cross-Border Relations

Interconnected trade increases the security of Denmark's energy market and, by extension, the EU market. Denmark trades with nearly all its neighbors, mainly through participation in Nord Pool, which runs a central power market in northern Europe. To date 360 companies from twenty countries trade on Nord Pool, with 524 TWh of total volume traded.[124]

Independent traders do not need a license to enter the energy market, nor are they required to have a local presence or subsidiary in order to pursue local energy trade. However, the TSO must grant an approval to the trader before they are admitted.[125]

The absence of a license to trade physical power between wholesalers or end-users makes it possible to supply all Danish end-users with physical power without a license. However, commercial users and traders have

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119 *Id.* at § 18.

120 *Feed-in Premium Tariffs for Renewable Power (Promotion of Renewable Energy Act)*, INT'L ENERGY AGENCY (Sept. 9 2013, 9:56 AM), https://www.iea.org/policiesandmeasures/pams/denmark/name-24650-en.php (on file with Colorado Natural Resources, Energy, and Environmental Law Review as "Leal FN 118").

121 Renewable Energy Act, *supra* note 54, at §22(4).

122 Spot Price – meaning current price for electricity. *Id.* at § 51.

123 *See id.* at § 35.

124 NORD POOL, 2018 ANNUAL REPORT 8–9 (2018), https://www.Nordpoolgroup.com/globalassets/download-center/annual-report/annual-report_2018.pdf.

125 Bekendtgørelse af lov om elforsyning LBK nr. 840 af 18/08/2019 [Electricity Supply Act], §21, https://www.retsinformation.dk/Forms/R0710.aspx?id= 206394.

strict reporting requirements.[126] The reporting must include conditions which help to ensure the best possible competition for electricity production and trade.[127] These requirements help protect the market and secure healthy competition.

G. Smart Metering Systems

Denmark's electrical energy system is based on a supplier-centric model.[128] This model was introduced in April 2016 with the objective of introducing a new market design, increasing competition, and allowing for new product and service developments that satisfy consumer needs and demands.[129] The function of the supplier-centric model permits 100 percent of consumer contracts to run via electricity suppliers.[130] This leads to the consumer receiving one bill with one point of contact to the electricity market. The electricity supplier bills the consumer directly for network usage, energy taxes, and levies, before settling its end with the TSO and DSO.[131]

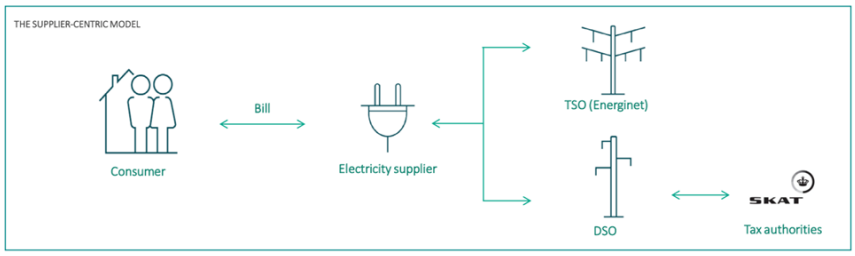

Figure 3: The Danish Electrical Energy Market[132]

126 *Id.* at § 31.

127 *Id.*

128 ENERGINET, THE DANISH ELECTRICITY RETAIL MARKET: INTRODUCTION TO DATAHUB AND THE DANISH SUPPLIER-CENTRIC MODEL, 2, 4. https://en.energinet.dk/-/media/Energinet/El-RGD/El-CSI/Dokumenter/ENGELSKE-DOKUMENTER/Danish-electricity-retail-market.pdf.

129 *Id.*

130 *Id.* Together with a new price comparison tool (PCT): elpris.dk. This tool is governed by DERA and allows customers to compare electricity prices of various providers on the Danish electricity market. *Sådan estimeres prisen på elpris.dk* [*How to estimate the price of elpris.dk*], ELPRIS.DK, http://elpris.dk/#/article/prisen_som_betales (last visited Sept. 25, 2019).

131 ENERGINET, *supra* note 128, at 4.

132 *Id.*

This model is reliant on the flow of data, facilitated by DataHub, and established in the DESA Section 5(2) as an IT platform that Energinet.dk owns and controls.[133]

A level playing field is extremely important for market transparency, and it allows new players to enter the market at a lower entry cost. DataHub enables a standardized process for registration and distribution of market data, ultimately allowing businesses, suppliers, and consumers access to the same data simultaneously.[134] Denmark has gone to great lengths to understand consumer needs by granting them easy access to their metering data.[135] There is a major difference between before and after DataHub was initialized, as illustrated below.

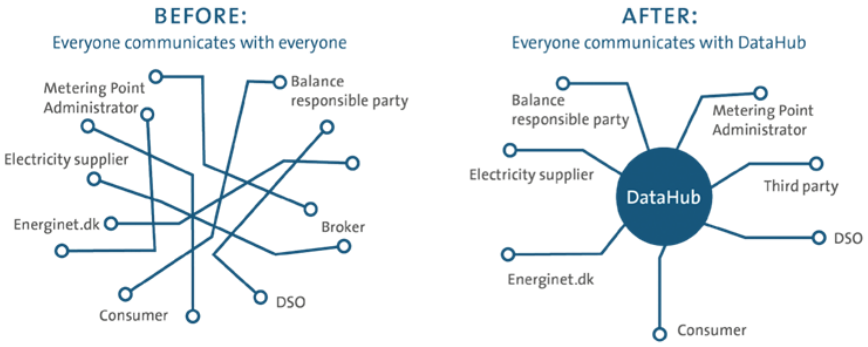

Figure 4: The Danish Electrical Energy Market[136]

DataHub developed a four-layer approach to describe its functionality. First, the security layer provides a protected access portal that retains the user information in an encrypted and traceable environment.[137] Second, the presentation layer houses services related to market support and monitoring as well as operational administration for the general running of the electrical services.[138] Third, the business logical layer handles alterations in consumer information, such as address changes, provider changes and submissions of consumer master data.[139] A

133 *Id.* at 5.

134 *Id.*

135 "The Danish Electricity Retail Market: an introduction to DataHub and the Danish supplier-centric model." *Id.* at 12.

136 *Id.* at 5.

137 *Id.* at 6.

138 *Id.*

139 *Id.*

large portion of processing, calculation, and flow of data also occurs in the third layer. Finally, the data layer contributes aggregation and reconciliation.[140] This is also where DataHub processes time series, meter readings, and master data.[141]

1. Smart Meter Penetration

The Decree on Smart Meters and the metering of electricity incorporates EU Directive 2012/27/EU to install a smart meter in every Danish household by December 31, 2020.[142] When the decree was implemented, 3.25 million households were identified as complying with the installation target.[143] In conjunction with its 2020 objective, Energinet.dk has been moving towards hourly reading of electricity.[144] The model is currently in effect with consumers whose consumption exceeds 100 MWh per year. Currently, large consumers consist of fifty percent of electricity consumed.[145] Almost two thirds of Danish consumers, or approximately two million people, have a smart meter installed.[146] To achieve this objective, all IT systems currently in place, including DataHub, must be able to read and receive hourly data from smart meters, for hourly settlement.

Technical specifications set out in the Decree on Smart Meters stipulate that smart meters must be able to register and deliver data on electrical energy in 15 minute intervals.[147] The registered data must also be stored by DataHub for the consumer to review their consumption and anticipated cost.[148] Grid companies use the transmitted data to estimate consumption and determine pricing.[149]

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140 *Id.*

141 *Id.*

142 Bekendtgørelse om fjernaflæste elmålere og måling af elektricitet i slutforbruget, BEK nr. 1358 af 03/12/2013 [Remote Sensing Electricity Meters and Measuring Electricity in Final Consumption], §2, https://www.retsinformation.dk/Forms/R0710.aspx?id=206623 [hereinafter Decree on Smart Meters].

143 ENIRGINET, *supra* note 128, at 10.

144 Decree on Smart Meters, *supra* note 141, at § 51.

145 ENIRGINET, *supra* note 128, at 10.

146 *Id.*

147 For technical specifications, *See* Decree on Smart Meters, *supra* note 141, §§ 4–7.

148 ENIRGINET, *supra* note 128, at 12.

149 *Id.*

H. Demand Response

The definition of demand response may be explained as follows:

> Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.[150]

The European Parliament's committee on Industry, Research, and Energy ("ITRE") stated during one of its workshops that to cope with an increasing amount of intermittent RES, the old paradigm of consumption-based (demand-based) supply will no longer be applicable. Instead, to ensure a more cost-efficient model, the electricity system needs to become more flexible to secure a constant balance between supply and demand. [151]

There are two basic goals of demand response: (1) to lower overall demand and (2) to flatten the daily demand curve. In a comparison of total consumption data between 2007 and 2017, there was little change in response, and where improvement was visible it was only negligible.[152] Demand response through smart meter installation has a 2020 target of reducing nationwide electrical energy demand in Denmark by two percent.[153] In Denmark, energy consumption has reduced by approximately ten percent per capita over the ten-year period 2007-2017.[154] During this period, residential electricity rates increased by approximately sixteen percent.[155]

When posed with issues of grid efficiency and expansion, the DESA requires consideration of control of demand and decentralized production

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150 Fed. Energy Reg. Comm'n., Reports on Demand Response & Advanced Metering (June 25, 2019), https://www.ferc.gov/industries/electric/indus-act/demand-response/dem-res-adv-metering.asp.

151 LUC VAN NUFFEL & JESSICA YEARWOOD, THE POTENTIAL OF ELECTRICITY DEMAND RESPONSE (Janetta Cujkova eds., 2017), 5, http://www.europarl.europa.eu/RegData/etudes/STUD/2017/607322/IPOL_STU(2017)607322_EN.pdf.

152 In 2007, the energy consumption had a fuel equivalent of 795,674 and in 2017 the energy consumption had a fuel equivalent of 863,850. This is a change of 8.56 percent in total energy consumption. *See Annual and Monthly Statistics*, DANISH ENERGY AGENCY, https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/annual- and-monthly-statistics (last visited Sept. 25, 2019).

153 Roger Andrews, *Why "Demand Response" Won't Work*, EUANMEARNS: ENERGY MATTERS (May 17, 2018), http://euanmearns.com/why-demand-response-wont-work/.

154 *Id.* at fig.3.

155 EUROSTAT, ELECTRICITY PRICES BY TYPE OF USER - EUR PER KWH: DENMARK, https://ec.europa.eu/eurostat/tgm/graph.do?tab=graph&plugin=1&pcode=ten00117&language=en&toolbox=data (last visited Sept. 25, 2019).

before looking at the need to expand capacity.[156] With the proliferation of renewable energy technologies and the Danish government's ambition of replacing fossil fuels with RES by 2050, the electricity grid will experience a vast increase in volume and with that, growing challenges.[157] Smart grid technologies will help support this development by, for example, enabling DSOs to automatically adjust the electricity consumption of end-users. This may be done by shifting consumption to off-load the grid, for instance by lowering temperature, light, or ventilation levels in houses or other structures.

The price increase and demand decrease must be counter measured against an increasing population. In the ten-year time span of 2007-2017, the population increased by approximately 300,000.[158] This will ultimately increase demand for electrical energy but may be offset by energy efficiency, indicating that the market will require better flexibility.[159] Several recommendations on demand flexibility for the Nordic market are being published via a report by THEMA Consulting Group.[160] Compared to the rest of Europe, Denmark and Germany already have the highest electricity rates. It is therefore not wise to increase the price of electricity without also allowing consumers better opportunities to resell excess production of their own energy from SV panels, hydropower, wind, heat pumps, or other green technologies back to the grid.

In terms of actual usability and impact on consumer prices, Radius, an energy supplier, published their new hourly tariffs after smart meter installations.[161] Smart meters and smart homes allow consumers better insight into when they use their heavy consumptive appliances, washing machines/tumble dryer, TV, oven, etc., and when they should use them for better cost-efficiency.[162] However, the majority of consumption is

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156 Electricity Supply Act, *supra* note 52, at §22(8).

157 Lars Chr. Lilleholt, *Preface* to DANISH MINISTRY OF ENERGY, UTILI. AND CLIMATE, DENMARK: ENERGY AND CLIMATE PIONEER, 4–5 (2018), https://en.efkm.dk/media/12032/denmark_energy_and_climate_pioneer_pdfa.pdf.

158 *See* Data, Organistion for Economic Co-operation and Development, https://data.oecd.org/pop/population.htm (last visited Sept. 25, 2019).

159 VAN NUFFEL & YEARWOOD, *supra* note 150, at 5.

160 *See* NORDON, THEMA CONSULTING GROUP, DEMAND RESPONSE IN THE NORDIC ELECTRICITY MARKET (2014), https://www.nordicenergy.org/wp-content/uploads/2014/10/Demand-response-in-the-Nordic-electricity-market.pdf.

161 *Din elpris består af flere dele* [*Your Energy Consists of Several Parts*], RADIUS, https:// radiuselnet.dk/Elkunder/Priser-og-vilkaar/Din-elpris-bestaar-af-flere-dele (last visited Sept. 25, 2019).

162 *About – Welcome to Energy Data Service!*, ENERGI DATA SERVICE, https://www.energidataservice.dk/en/about (last visited Sept. 25, 2019).

between 5 p.m. and 8 p.m., creating a significant increase in costs to the consumer over the year.[163] Danish consumers have voiced their concerns regarding this cost increase.[164]

The data generated from smart meters is, and will continue to be, available for consumers and market needs. Transparency echoes through the Danish model and highlights areas where the Danes may inspire other countries to emulate the same. Increasing transparency for the consumer via hourly rates and price signals from the wholesale market makes it easier to identify the actual cost of energy. Smart meters and their data incentivize Danish consumers to adjust consumption according to price. For instance, a Danish consumer might opt to charge their electrical vehicle at night when the price is low or switch off appliances that consume a lot of energy when they are not using them. Ideally, smarter technology should be able to detect price fluctuations via integrated artificial intelligence ("AI") systems and regulate a household's energy consumption without manual input. Overall, Denmark is on track to reach 100 percent smart meter rollout by 2020.

I. Data Protection

The Danish Data Protection Authority ("DPA") is responsible for enforcement of the Danish Data Protection Act, and ensuring compliance of entities required to follow its provisions.[165] The DPA aims to supplement and implement the articles set out in the General Data Protection Regulation to protect a person's rights and freedoms and mitigate the unlawful processing and collection of personal data.[166] Furthermore, the Danish Data Protection Act requires controllers and

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163 *Din elpris bestar af flere dele*, *supra* note 160.

164 Thomas Harder, *Thorkild har fået ny 'spion'-elmåler: Nu er han stiktosset [Thorkild has got new 'spy' electricity meter: Now he's stitched]*, EKSTRABLADET (Nov. 27, 2017, 10:12 AM), https://ekstrabladet.dk/nationen/thorkild-har-faaet-ny-spion-elmaaler-nu-er-han-stiktosset/6933447.

165 Lov om supplerende bestemmelser til forordning om beskyttelse af fysiske personer i forbindelse med behandling af personoplysninger og om fri udveksling af sådanne oplysninger (databeskyttelsesloven) [Act on supplementary provisions for regulation on the protection of physical persons in connection with the processing of personal data and about free exchange of such information], Lov nr. 502 af 23.5.2018 [Data Protection Act)], https://www.datatilsynet.dk/media/6894/danish-data-protection-act.pdf [hereinafter "Danish DPA"].

166 *See* Regulation 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC, art. 4 § 1, (L 119) 1, 33 (EU) [hereinafter "GDPR"].

processors of personal data to draft internal regulations to ensure compliance and data security.[167]

1. Digitalization to Promote Smart Grids

The Danish Ministry of Energy, Utilities, and Climate believes in transparency and value creation through digitalization.[168] It uses data collection, processing, and distribution to promote growth of renewable energy technologies.[169] By supporting data sharing among major market contributors, such as authorities and companies, society may benefit from new value and important profits resulting in efficiency gains. These efficiency gains can be achieved via centralized data collection that is readily available to a number of administrative systems and sectors.[170] Currently, all data on energy is collected via DataHub.[171]

2. Data Protection and Smart Meters

Denmark's data protection regulation is set out in the Danish Data Protection Act.[172] This comprehensive piece of legislation is of general application and therefore applies to smart grids.[173] The Act defines personal data broadly to include not just data related directly to natural persons, but also data by which a person may be indirectly identified by reference to other kinds of personally identifiable information.[174] The legislation has successfully incorporated the General Data Protection Regulation ("GDPR") to cover the collection and processing of personal data carried out, in full or in part, that is contained or is intended to be contained in an electronic or physical filing system.[175] It sets out a firm framework to cover all the basic requirements for securely using, processing, and collecting personal data. Obligations for controllers of data include: (1) prior consent to personal data collection and processing; (2) registration of data controllers and processors; (3) obligations for data controllers to uphold data security; (4) obligations to promptly inform data

167 Danish DPA, *supra* 165, at § 5.

168 DANISH MINISTRY OF CLIMATE, ENERGY AND BUILDING, SMART GRID STRATEGY: THE INTELLIGENT ENERGY SYSTEM OF THE FUTURE 39 (2013), https://ens.dk/sites/ens.dk/files/Globalcooperation/smart_grid_strategy_eng.pdf.

169 *Id.* at 9–10.

170 ENERGINET, *supra* note 128, at 5.

171 *See* Electricity Supply Act, *supra* note 52.

172 Danish DPA, *supra* note 165, at § 1.

173 Smart Grids collect data on natural persons, and the custodians of data will be required to comply with data protection regulations. *Id.* at § 1.

174 *See Id.* at § 1.

175 *Id.* at § 1.

subject, the data protection authority, of data breaches which compromise personal data; (5) data subject access request; (6) data subject data deletion request; and (7) portability rights.[176]

DSOs are required under the DESA to submit information regarding consumption to consumers.[177] Most Danish end-users already have a smart meter installed, and the DESA requires DSOs to publish hourly consumption data.[178] DataHub is the central source of information where end-users may log onto their account to view and download their energy consumption and billing information.[179] All consumer data is stored on DataHub's central platform and submitted to energy suppliers via encrypted files. Suppliers may only view data for their own consumers, unless consumers have given their consent.[180] Smart metering data is the property of Energinet's DataHub—a DSO—but the data collection aspect lies with energy distributors to submit data to suppliers, DataHub, and end-users for billing and payment purposes.[181]

Smart meters themselves have technical requirements to store encrypted data which must be readily available for the consumer.[182] This data is also sent to energy distributers, who are responsible for providing hourly meter readings to DataHub. Energy companies have a responsibility to protect consumer information, and they are subject to the Data Protection laws as a controller and processor of data.

3. Consumer Safeguarding

Consumer safeguarding is of the highest priority to the European internal energy market. The Danish Data Protection Act requires controllers to ensure that any processor they instruct will guarantee adequate personal data security and compliance with the GDPR.[183] In this respect, controllers must have contracts with their processors that contain

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176 *See* GDPR, *supra* note 166, at art. 5-7, 9-11, 12-21, 32, 33 and 34.

177 Electricity Supply Act, *supra* note 52, at §28(6).

178 *Id.* at § 59

179 *See generally* DATAHUB, https://datahub.io/ (last visited Sept. 25, 2019).

180 HLJ & MLJ, *VILKÅR FOR ADGANG TIL OG BRUG AF DATAHUB - ELLEVERANDØR* [*TERMS OF ACCESS TO AND USE OF THE DATA HUB –electricity supplier*], ENERGINET, https://energinet.dk/-/media/96E84DC389B240129926F186E3CE1B9C.pdf [hereinafter "*DATA HUB*"].

181 *See DataHub*, SVENSKA KRAFTNÄT (mar. 27, 2019), https://www.svk.se/en/stakeholder-portal/Electricity-market/data-hub/.

182 Bekendtgoerelse nr. 1358 af 12.3. 2013 om fjernaflaeste elmalere og maling af elektricitet I slutforbrugete § 4(3).

183 GDPR, *supra* note 166, at ch. I, art. 1, § 1; Danish DPA, *supra* note 165, at ch. I, art. 1, § 1.

enhanced processor clauses.[184] These measures help protect personal data insofar as processors are responsible to report any breach of data.[185] Any data breach that meets the requirements must be reported to the data protection authority within seventy-two hours, and if found to have a high likelihood of impact on an individual's rights and freedoms, then communication must also be sent to the data subject without undue delay from the time of awareness.[186]

Although smart meters have taken a great leap, their continuous development is crucial to better handle, store, and communicate data. Bearing in mind the drastic expansion of smart meter installations in Denmark, and Europe in general, they need to feature state-of-the-art secure storage and backup systems as well as convincing contingency plans.

A smart meter is essentially a big data collector which gives insights into the daily habits of a household, such as time spent at home, schedule for work and school, appliance usage, and other habits. Such information is extremely valuable for many parties and makes the consumer a key stakeholder for future insights and development of household energy technology and consumer needs.[187]

In order to successfully deploy and develop smart technology such as smart meters or smart homes, data management technologies must be in place to securely encrypt and handle increasing amounts of consumption data. Consumer privacy protection reflects the basic requirements to protect an individual's rights and freedoms and must be one of the foundational building blocks to smart meter technologies. Once in place, smart meters may be used as an important tool to motivate consumers to be more energy efficient by being more aware of their consumption. Smart meters may also aid in creating a more resilient energy security system.

4. Concerns About Smart Meters

Concerns include the amount of data collected, the means of collection, and what happens with the data.[188] Large conglomerates and small start-ups are all fighting to get their hands on consumer data in order to get a better picture of consumer demand, and this puts a high price on an individual's data. Consumer data has become one of the most valuable

184 GDPR, *supra* note 166, at ch. IV, § 1, art. 28.

185 GDPR, *supra* note 166, at ch. IV, § 4, art. 38.; Danish DPA, *supra* note 165, at ch. VII, pt. 12, § 39.

186 GDPR, *supra* note 166, at ch. IV, § 2, art. 33, 34.

187 *See* Henriette Soja, Charlotte Kunckel, *Persondata når du bruger fjernaflæste målere*, Ret & Indsigt (2017) (Den.).

188 *Id.*

commodities. Some Danish consumers are alarmed by the forced installation of smart meters in their homes and have raised arguments that the State is concealing the true purpose of smart meters.[189]

Though there are data protection mechanisms in place, consumers have the right to choose which data is collected and what is done with that data.[190] However, there is no "real" consumer choice in whether to have a smart meter installed in their household.[191] Many Danes consider this an invasion of privacy, which goes against an individual's rights to protection of personal data under the EU Charter of Fundamental Rights.[192] The thought that government agencies and energy companies are monitoring and controlling patterns of household consumption makes many Danes anxious.[193]

J. Electric Vehicles and Storage

Denmark has an ambitious target of selling its last petrol-fueled vehicle in 2030 and becoming independent of fossil fuels by the year 2050.[194] Currently, personal vehicles account for approximately half of emissions within the transportation sector.[195] Electric vehicles ("EV") are likely to play a prominent part in helping Denmark reach this target.[196] EVs have a high level of energy efficiency and are able to utilize electricity generated from renewable energy sources. Due to the lack of a domestic automotive industry, external producers will highly influence the availability and affordability of transportation technology. However, this does not mean that Denmark will lack influence in the sphere of developing policies to promote such technologies.

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189 *Id.*

190 *See* GDPR, *supra* note 166.

191 Martin Beindahl Kruse & Thomas Hedin, *Er din nye elmåler en spion, livsfarlig og tyvens forlængende arm?*, MANDAG MORGEN (Dec. 3, 2018, 1:59pm), https://www.mm.dk/tjekdet/artikel/er-din-nye-elmaaler-en-spion-livsfarlig-og-tyvens-forlaengede-arm.

192 2000 O.J. (C 364) 10.

193 *Id.*

194 ENERGI-, FORSYNINGS-OG KLIMAMINISTERIET, SAMMEN OM EN GRØNNERE FREMTID 18–19, 37 (2018), https://efkm.dk/media/12350/klimaministeriet_klimaogluftudspil_digital.pdf.

195 KLIMARÅDET, FLERE ELBILER PÅ DE DANSKE VEJE FORSLAG TIL PEJLEMÆRKER OG VIRKEMIDLER TIL ELEKTRIFICERING AF PERSONBILERNE 4, https://www.klimaraadet.dk/da/system/files_force/downloads/elbilanalyse_final.pdf?download=1.

196 *See* PowerLabDK, *How Can Electric Vehicles Be an Asset to the Power System?*, STATE OF GREEN, (Jul. 13, 2017), https://stateofgreen.com/en/partners/powerlabdk/news/how-can-electric-vehicles-be-an-asset-to-the-power-system/.

1. Electric vehicles

In Denmark, there are approximately 20,000 electric vehicles.[197] Denmark's 2030 goal is to stop the sale of new internal combustion vehicles and sell 100 percent emission friendly cars–whether electric or plug in hybrids.[198] Until 2016, registration fees for electric vehicles were waived, which attracted many buyers.[199] However, this was halted when the government decided that this was an infringement on the free market and gradually reintroduced registration fees of EVs until reaching a parity with conventional vehicles in 2022.[200]

The removal of the EV incentive scheme had a major impact on the sale of EVs in Denmark.[201] Up until the exit of 2018, there was a lack of incentives for consumers to choose an EV or hybrid vehicle over an internal combustion vehicle in Denmark. Despite other barriers, such as lack of charging stations, lack of free urban parking, high costs of EVs and short range, Demark sold 2986 EVs between January 1, 2019 and October 1, 2019. This was a 321 percent increase from the same period in the preceding year.[202] Importantly, Danish tax authorities decided in 2018 to require annul registration fees for EVs with a value up to 59,000 United States Dollars ("USD"). EVs with a value exceeding this will pay a registration fee of twenty percent.[203]

Compared to its Nordic neighbors, the 2018 sales number is extremely low. Norway has a total of 251,307 EVs and 110,274 PIHV.[204] This high number is likely due to government incentives designed to meet its 2025 target. By 2025, the Norwegian Government aspires to only sell

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197 Ingeborg Moe, *I Danmark ser de til den norske elbilrevolusjonen og lurer på om de har råd*, AFTENPOSTEN (June 4, 2019, 7:22 PM), https://www.aftenposten.no/verden/i/70BW4V/i-danmark-ser-de-til-den-norske-elbilrevolusjonen-og-lurer-paa-om-de-har-raad.

198 ENERGI-, FORSYNINGS-OG KLIMAMINISTERIET, *supra* note 194, at 17–18.

199 *Betaling af og Satser for Registreringsafgift*, SKAT.DK, https://skat.dk/skat.aspx?oid=2234529.

200 Jesper Berggreen, *Denmark Goes Backward, Lowers Tax on Dirty Cars – Wha??*, CLEANTECHNICA (Oct. 1, 2017), https://cleantechnica.com/2017/10/01/denmark-goes-backward-lowers-tax-dirty-cars-wha/.

201 *Id*.

202 Ditte Lunde, *Salg Af Elbiler Stiger Med 321 Procent*, EKSTRA BLADET (Oct.2, 2019), https://ekstrabladet.dk/biler/salg-af-elbiler-stiger-med-321-procent/7815503.

203 *L 120 Ændring av registreringsavgiftsloven vedrørende elbiler*, SKAT.DK (Dec. 27, 2018, 1:37 PM), https://skat.dk/skat.aspx?oid=2284142.

204 *Statistikk elbil*, NORSK ELBILFORENING, https://elbil.no/elbilstatistikk/ (statistics as of Oct. 30, 2019).

zero-emission vehicles.[205] The Danish government has promised half a million EV or plug-in hybrid electric vehicles ("PHEV") on the Danish roads by 2030.[206] To reach this goal by 2030, the Danish government is rethinking its strategies to incentivize consumers to switch from internal combustion-based vehicles to zero-emission vehicles.[207]

i. Regulatory Improvements and Incentives

The relevant legislation that has adopted the clean vehicles directive is the Decree on Climate Conscious Purchases of Vehicles for Road Transportation.[208] The Decree's purpose is to promote cleaner, more energy efficient vehicles.[209] The Decree requires contractors and official bodies to consider the vehicle's energy and environmental impacts of its lifecycle, including impacts around energy consumption, CO_2 emissions, emissions of NO_x NMHC, and other particles.[210]

Though the Decree promotes the purchase and regulation of climate conscious vehicles, there are no direct incentives incorporated in the Decree for purchasing a climate friendly vehicle. The legislator had an ample chance to establish regulatory incentives for EV and PHEV buyers but missed an opportunity to do so.[211]

The Danish Council on Climate Change ("Council") is an independent expert organization that annually reviews climate issues and writes recommendations to the relevant government institutions.[212] The Council's 2017 report contained several suggestions about how the Danish government can do more to promote EV market penetration, including:

> (1) There needs to be a long-term climate strategy for transportation with a focus on reducing CO_2 emission. The following elements could help contribute:

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205 SAMFERDSELSDEPARTEMENTET, *En grønnere transporthverdag: Nasjonal transportplan 2018–2029* , REGJERNGEN.NO (Apr. 5, 2017), https://www.regjeringen.no/no/aktuelt/en-gronnere-transporthverdag/id2548633/.

206 KLIMARÅDET, *supra* note 195, at 3.

207 *Id.*

208 Bekendtgoerelse nr. 1394 om miljobevidste indkob af koretojer til vejtransport [Executive Order 1394 on environmentally conscious procurement of road transport vehicles] (2010) (Den.).

209 *Id.* at ch. 1, § 1.

210 *Id.* at ch. 2, § 5.

211 *See generally* EA ENERGY ANALYSES, PROMOTION OF ELECTRIC VEHICLES: EU INCENTIVES & MEASURES SEEN IN A DANISH CONTEXT 4.

212 KLIMARÅDET, *supra* note 195, at 2.

> (a) Denmark needs to establish a specific minimum number of zero-emission vehicles by 2030. An ambitious but realistic goal should be at least 500,000 – EVs should be in the majority;
>
> (b) From the year 2030, the sale of personal vehicles fueled partly or wholly by petrol or diesel should come to a complete halt.
>
> (2) The current tax on vehicles is not socioeconomically viable and the Climate Council recommends that further regulatory changes must be made to EV registration fees:
>
> (a) Subsidies for large batteries should be made permanent, extending beyond the deadline of 2021;
>
> (b) Abolish the minimum limit in the registration fee so that especially smaller EVs can get a greater benefit from their deductions related to battery size
>
> (3) Better economic support for the sale of EVs and PHEVs. This proposes to replace the current subsidy scheme for registration fee with a quota obligation of EVs sold during the year.[213]

The Council's report is extremely detailed and contains further suggestions on how the Danish government can shift its policies to better promote the sale and usability of EV nationally.

ii. Research in Electric Vehicles

The DEA provided funding for seventy-six EV projects in the Danish electrical grid system.[214] The projects research the following areas: the possibility of using EVs as a flexible storage unit, returning electricity to the Danish grid; barriers to the development and use of EVs; areas of advantage; and technical, organizational, and environmental conditions related to the use and maintenance of EVs.[215]

In the "test an electric vehicle" project, volunteers drove 198 EVs over 4 million kms, saving an estimated 16.1 tons of CO_2 emissions for 1,578 participating Danish test families.[216] At the time, this project was one of Europe's largest EV tests.[217] During the project, a vast amount of

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213 *Id.* at 21.

214 *Forsøgsordning for Elbiler*, ENERGISTYRELSEN (Last visited Jan. 15, 2019), https ://ens.dk/ansvarsomraader/transport/alternative-drivmidler/forsoegsordning-elbiler.

215 *Id.*

216 CLEVER A/S, TEST-EN-ELBIL SLUTRAPPORT JULI 2014 4, 11 (2014).

217 *Id.* at 4.

data was collected around security of use, EV charging pattern/optimization, and driving needs.[218]

The majority of these EV projects confirmed their hypotheses on the positives and negatives with EV integration and usage.[219] The studies showed that intelligent charging, which draws electricity at lower price-points and returns electricity to the grid, mitigates CO_2 emissions and results in economic savings for every km driven.[220] Additionally, the studies demonstrated that knowledge of locations and functioning of public charging spots would incentivize EV owners to more frequently use them.[221] The report also displayed that out of 55,000 charges, sixty-nine percent happened at home, twenty-four percent outside of the home by use of alternating current ("AC") structures, and eight percent by use of direct current ("DC") structures.[222] The report found that there is a real opportunity to incentivize employers to install the proper infrastructure for charging EVs. In turn, charging infrastructure would be a deciding factor for a person to purchase an EV in the future.[223]

iii. EU-Wide Measures to Promote EVs Nationally

Implementing an EU-wide industry mandate to deliver a set minimum target of EVs could increase the number of electric vehicles in Denmark, and in other markets. Such a measure could also boost research and development in electric vehicle production and batteries. In return, this research could yield better vehicles with longer range, longer lifespan, and better consumer prices. The short-term market penetration for manufacturers would also have long-term learning effects to better predict market needs and help research and development to focus on developing the correct technologies. This type of policy could also set minimum standards in order to prevent low quality among EVs, thereby addressing several consumer concerns.

2. Storage

An inherent factor in creating a balance to the energy system's fluctuation between supply and demand is efficient energy storage systems. Ideally, storage systems will have the ability to detect when there is excess electric energy entering the electrical grid. The electric storage

218 *Id.* at 47–52.

219 *Id.*

220 *Id.* at 31.

221 *Id.* at 34.

222 *Id.* at 25.

223 *Id.* at 37.

resource will retain the excess energy and supply the grid when generation is scarce or demand is high. Currently, it is difficult to efficiently store energy at the required scale without significant loss. Denmark, as well as many other countries, require a close symbiosis between several technologies to fulfil the role of storage.[224]

There are many projects exploring the possibilities of energy storage in Denmark. The Danish government has agreed to use 130 million DKK (19.32 million USD) to develop large-scale storage systems.[225] These storage utilities would assist with optimizing the Danish grid to handle increased renewable energy generation.[226] The Danish Ministry of Foreign Affairs, which promotes foreign investments, has highlighted a few examples of projects that are currently being explored and tested.[227]

Amongst these storage projects is the Copenhagen Residential Area EnergyLab Nordhavn.[228] This project is exploring innovative energy storage solutions for urban areas and it has incorporated a full-scale smart city energy lab to its test area.[229] Since its commencement, the project has demonstrated how intelligent solutions can create a flexible and optimized energy system by integrating electricity, heating, energy-efficient buildings, and EVs. In terms of hard storage technologies, the company ABB has supplied battery technologies[230] for this project and supplies power to around 200 apartment units during peak demand hours.[231]

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224 "Facilitating energy storage to allow high penetration of intermittent renewable energy: Overview of current status and future development scenarios of the electricity system in Denmark – allowing integration of large quantities of wind power." PETER SORKNES ET AL., STORE PROJECTS, FACILITATING ENERGY STORAGE TO ALLOW HIGH PENETRATION OF INTERMITTENT RENEWABLE ENERGY 33–34 (2013).

225 CleanTech, *Denmark Ready to Fund Large-scale Energy Storage Projects*, COPENHAGEN CAPACITY (Mar. 28, 2018), http://www.copcap.com/newslist/2018/denmark-ready-to-fund-large-scale-energy-storage-projects.

226 *See* Maria Berg Badstue Pedersen, *Ny aftale: 130 millioner til energilagring*, ENERGY SUPPLY DK (Feb. 2, 2018, 10:38), https://www.energy-supply.dk/article/view/583327/ny_aftale_130_millioner_til_energilagring.

227 Ministry of Foreign Affairs Denmark, *Great Conditions for Smart Grid Research in Denmark*, INVEST IN DENMARK (last visited Jan. 15, 2019), https://investindk.com/set-up-a-business/cleantech/energy-storage-and-smart-grid.com

228 *Id.*

229 *See Utilising Bricks for Heat Storage in New Test Project*, STATE OF GREEN (Dec. 19, 2018), https://stateofgreen.com/en/partners/state-of-green/news/utilising-bricks-for-heat-storage-in-new-test-project/.

230 *ABB delivers first urban battery storage solution in Denmark to support renewables*, ABB, https://new.abb.com/high-voltage/capacitors/reference-radius-elnet-denmark (Last Visited Oct. 30, 2019).

231 *Id.*

In Denmark's Danish Society of Engineers' ("IDA") Climate Plan 2050[232], Danish CO_2 emission are expected to be reduced by ninety percent compared with levels in the year 2000.[233] This climate plan assumes that the external transmission capacity remains the same.[234] The plan describes a scenario where transmission between the western and eastern Danish grid capacities are significantly enhanced by removing any bottlenecks.[235] Carrying out the IDA Climate Plan requires the transmission net to accommodate a large amount of renewable energy penetration.[236] Traditional electricity consumption will also have to decline to facilitate a more flexible electricity model. Creating more flexibility will allow for generated electricity to be consumed instantly, allowing fluctuation of renewable energy sources.[237] Similarly, the pricing structure will need to suit a model of flexibility, providing incentives to consume when electricity production is high.[238] According to the plan, the main elements that will take advantage of this model are electric heat pumps, EVs, and refrigerators.[239]

II. SWEDEN

Sweden, like Denmark, used to be highly reliant upon oil imports to sustain its energy demand.[240] After the oil crisis in the 1970s, the government, in an attempt to make Sweden´s energy supply more secure and less dependent upon imports, introduced nuclear power into the country´s energy mix.[241] In addition to developing its nuclear capacity, Sweden has long been exploiting its renewable resources. Sweden's most

232 "The IDA Climate Plan 2050: Technical energy system analysis, effects on fuel consumption and emission of greenhouse gases, socio-economic consequences, commercial potentials, employment effects and health costs." BRIAN VAD MATHIESEN ET AL., THE IDA CLIMATE PLAN 2050 16 (2009), https://www.en.plan.aau.dk/digitalAssets/167/167987_ukfuture_climates_background_report-kopi.pdf.

233 *Id.*

234 *See generally id.*

235 *See id.* at 13–14.

236 SORKNES ET AL., *supra* note 224, at 32.

237 *Id.*

238 *Id.*

239 *Id.*

240 MICHAEL CRUCIANI, ETUDES DE L'IFRI, THE ENERGY TRANSITION IN SWEDEN, 8 (2016), https://www.ifri.org/sites/default/files/atoms/files/etude_suede_gd_ok-db2_complet.pdf.

241 *Id.*

important resources are hydropower, onshore wind, and biomass.[242] While Sweden has among the highest levels of electricity use per capita in the world,[243] it has the second lowest CO_2 emissions per capita.[244] This is partly due to the nearly decarbonized space heating and electricity generation made possible by relying on renewable resources and nuclear energy.[245] Overall, Sweden´s longstanding policies that focus on moving away from fossil fuels and towards renewable energy have been quite successful. However, challenges remain in phasing out nuclear power and increasing energy efficiency across all sectors.[246] This Article will start by explaining Sweden´s energy profile and consumption levels. Then, this Article will introduce some of Sweden´s challenges concerning its energy profile and discuss some of Sweden´s initiatives related to smart grid solutions.

A. Energy Profile

Sweden, like most other European countries, still depends on imports to meet their domestic energy demand, especially in the transportation sector.[247] However, Sweden´s need for supply of fossil fuels has decreased significantly since the 1980s, due to the introduction of nuclear power and increased energy production from biofuels.[248] Sweden's main sources of renewable energy include hydroelectric, wind, and biofuel.[249] Eurostat estimates Sweden´s overall dependence level to be thirty-two percent.[250]

1. Electricity

Most of Sweden´s electricity production comes from non-fossil sources, primarily hydroelectric and nuclear power.[251] In addition to hydro

242 *Energy Use in Sweden*, SWEDEN.SE, https://sweden.se/society/energy-use-in-sweden/ (last updated Feb. 28, 2019).

243 "Sweden´s electricity use is high, partly due to Sweden´s energy intensive industry sector, and the relatively cold winter climate." *Sweden*, IEA, https://www.iea.org/countries/Sweden/ (last visited June 11, 2019).

244 *Id.*

245 *Id.*; *See* SWEDISH ENERGY AGENCY, ENERGY IN SWEDEN 2017 37 (2018).

246 *See* SWEDISH ENERGY AGENCY, *supra* note 245, at 44, 81.

247 *Id.* at 4.

248 *See Id.* at 4, 6.

249 *Id.* at 5–6.

250 EUROSTAT, ENERGY STATISTICS 4 (2017 ed. 2016).

251 *See* SWEDISH ENERGY AGENCY, ENERGY IN SWEDEN: FACTS AND FIGURES 2018 6.2 (2017), http://www.energimyndigheten.se/statistik/energilaget [hereinafter FACTS AND FIGURES 2018].

and nuclear power, Sweden also produces electricity from wind,[252] CHP,[253] and solar.[254] While electricity production currently relies on hydro and nuclear power, production from wind and biofuel is steadily increasing.[255]

Sweden's public utility and the responsible authority for the national grid, is Svenska Kraftnät.[256] The company operates the transmission lines, substations, and international 400 and 202 kilovolt ("kV") interconnections.[257] Svenska Kraftnät is also the sole system operator for electricity—a TSO—in Sweden.[258] Three major companies—DSOs—own most of the regional grids: Vattenfall Eldistribution AB, Eon Energidistribution AB, and Ellevio AB. Together, these companies account for about 97.8% of all energy outtake.[259]

There are approximately 156 operators on the Swedish electric grid.[260] However, about half of Swedish customers purchase electricity from the three largest DSOs, who own about half of the local grids.[261] Every grid owner must attain a grid license from the Energy Market Inspectorate in order to build power lines.[262] The license obliges each operator to collect and report measurements on production and consumption, and to connect electricity plants in their area to the grid.[263] The cost of connecting to the grid is covered by the producer through network tariffs.[264] Swedish power plants are connected to the grid using a principle of non-discrimination. This means that renewable energy

252 Wind accounted for 15.5 TWh in 2016. *Id.*

253 Of which 5.5 TWh in industry, and 9 TWh in district heating. *Id.*

254 Amounting to 74 GWh, 2017. *Id.* at 6.5.

255 SWEDISH ENERGY AGENCY, *supra* note 245, at 36, 53.

256 SVENSKA KRAFTNÄT INFORMATION, THE ELECTRICITY MARKET IN SWEDEN AND THE ROLE OF SVENSKA KRAFTNTNÄT 10 (Irene Klee ed., 2011).

257 *Id.*

258 *Id.*

259 SWEDISH ENERGY MARKET INSPECTORATE, LEVERANSSÄKERHET I SVERIGES ELNÄT 2017: STATISTIK OCH ANALYS AV ELAVBROTT [DELIVERY SECURITY IN SWEDEN'S ELECTRICITY GRID 2017: STATISTICS AND ANALYSIS OF POWER OUTAGES] 11 (2017).

260 *Id.* at 9. As of 2017 these operators are either owned by the state, municipalities, private companies, or economic associations. *See* KARIN WIDEGREN, SWEDISH COORDINATION COUNCIL FOR SMART GRID, THE SWEDISH ACTION PLAN FOR SMART GRID (n.d.), https://cleanenergysolutions.org/sites/default/files/documents/widegren_karin_isgan_webinar_1_21_15_0.pdf.

261 Widegren, *supra* note 260.

262 *Grid Companies*, SWEDISH SMARTGRID, http://swedishsmartgrid.se/in-english/the-swedish-electricity-market/grid-companies/ (last visited Jan. 2, 2019).

263 *Id.*

264 *See* 4 ch. 2 § (Svensk Författningssamling [SFS] 1997:857) (Swed.).

producers are not given priority, nor are they discriminated against.[265] Under certain conditions, a grid operator may reasonably deny a producer grid connection. This generally happens if the grid capacity is insufficient.[266]

2. Consumption

Sweden´s energy usage is divided into three main sectors: (1) industry, (2) transportation, and (3) residential and service. According to Eurostat, 53.8% of Sweden´s gross final energy consumption[267] comes from renewable sources.[268] Still, Sweden´s energy consumption is currently higher than its 2020 goal.[269]

Sweden's total energy use has decreased in the three main sectors over the last decade.[270] The transportation sector saw the largest decrease[271] which can be attributed to the introduction of more fuel-efficient vehicles.[272] These decreases have occurred despite growth in population.[273] The use of oil and other fossil fuels are declining, while the use of renewables are increasing.[274] In fact, biomass has become the third largest energy source in Sweden.[275] Despite the relatively constant energy consumption rate, and the slight decrease over the last decades, Sweden´s energy consumption per capita is still about fifty percent higher than the

265 3 ch. 6 § (Svensk Författningssamling [SFS] 1997:857) (Swed.).

266 Oskar Vågerö, *Connection to the Grid*, RES LEGAL EUR. (Jan. 17, 2019), http://www.res-legal.eu/search-by-country/sweden/single/s/res-e/t/gridaccess/aid/connection-to-the-grid-3/lastp/199/.

267 Amounted to 32.6 TOE in 2016. *Final Energy Consumption*, EUROSTAT (Oct 10, 2018), https://ec.europa.eu/eurostat/tgm/table.do?tab=t able&init=1&plugin=1&language=en&pcode=t2020_34.

268 *Share of Renewable Energy in Gross Final Energy Consumption by Sector*, EUROSTAT (Aug. 28, 2019), https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=sdg_07_40.

269 *See Final Energy Consumption*, *supra* note 267 (consumption levels amounting to 32.6 TOE in 2017, while their goal is 30.3 TOE by 2020).

270 SWEDISH ENERGY AGENCY, *supra* note 245, at 10, 19, 27.

271 *See* Facts and Figures 2018, *supra* note 251, at 2.2. Transport is down from 93 TWh used in 2007 to 87 TWh used in 2016. *Id.* at 2.2.

272 *See* SWEDISH ENERGY AGENCY, *supra* note 245, at 28.

273 *There Are More of Us, but We Use Less Electricity*, SCB (Nov. 30, 2018), https://www.scb.se/en/finding-statistics/statistics-by-subject-area/energy/energy-supply-and-use/annual-energy-statistics-electricity-gas-and-district-heating/pong/statistical-news/electricity-gas-and-district-heating-supply-2017/.

274 *See* SWEDISH ENERGY AGENCY, *supra* note 245, at 5.

275 *Id.* at 6.

EU average.[276] Sweden has energy intensive industries, high transportation demands due to long distances between populated areas, and a relatively cold climate.[277] As such, it will be challenging for Sweden to reduce energy consumption to a more sustainable level.[278]

The main source of energy in the transport sector is oil and derived products like diesel, petrol, and aviation fuel.[279] However, the Swedish government has, as part of its long-term climate goals, set a target for the country´s vehicle-fleet to be fossil fuel independent by 2030.[280] While biofuels (mainly biogas, biodiesel, and ethanol) and electricity are growing sources of energy in this sector, [281] Sweden is still far from reaching its goal.[282] On the other hand, almost all Swedish fossil fuel consumption is attributed to the transport sector, and a shift away from this source would therefore have significant impact on the country´s overall energy profile.[283]

The industry sector accounts for approximately thirty-eight percent of the total energy use in Sweden,[284] and most of the energy used in that sector derives from biofuels and electricity.[285] Additionally, some energy comes from coal, oil products, natural gas, district heating, and other fuels.[286] Sweden's industry sector energy consumption has remained relatively unchanged,[287] despite a moderate increase in production.[288] However, the increase in production has not led to an increase in energy use because industry actors have made structural changes and become more energy efficient.[289] Still, there is room for improvement in both energy efficiency and choice of energy carriers in the Swedish industry.

As early as 1991, Sweden was one of the first countries to introduce a carbon tax scheme, shifting industry´s tax burden from labor to carbon

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276 Proposition [Prop.] 2017/2018:228 Energipolitikens Inriktining [government bill] (Swed.).

277 *Id.*

278 *See id.*

279 Facts and Figures 2018, *supra* note 251, at 5.1.

280 Statens Offentliga Utredningar [SOU] 2013:84 Fossilfrihet på väg [government report series] (Swed.).

281 *See* Facts and Figures 2018, *supra* note 251, at 5.2.

282 *See* SWEDISH ENERGY AGENCY, *supra* note 245, at 80.

283 *Id.* at 63.

284 *See* Facts and Figures 2018, *supra* note 251, at 1.1.

285 SWEDISH ENERGY AGENCY, *supra* note 245, at 19.

286 Facts and Figures 2018, *supra* note 251, at 2.1.

287 Albeit with a slight decrease in recent years.

288 SWEDISH ENERGY AGENCY, *supra* note 245, at 19.

289 *Id.*

and energy consumed.[290] Several studies indicate that this reform has had an influence on reducing GHG emissions and affected the move towards the use of biomass in the district heating system.[291] Over the years, the government has introduced many different tax schemes in order to stimulate a reduction in energy usage, especially from fossil fuels.[292] These taxes include energy taxes, pollution taxes, resource taxes, and transportation taxes.[293] While these taxes impacted the decline in GHG emissions, accounting for some variation over time, a steady decline occurred before introducing these scheme.[294] Due to the international oil crisis in the 1970s, Sweden introduced nuclear energy in order to be less dependent upon oil imports.[295] This, combined with the simultaneous increase in renewables such as biomass, resulted in a decrease in oil use.[296]

The residential and service sector mainly uses energy from electricity and district heating, in addition to biomass and oil, accounting for around thirty-nine percent of the total energy use in Sweden.[297] Electricity from hydro and nuclear power is the main source of energy in the service sector, whereas heating and hot water accounts for about half of the energy used, including both residential and non-residential housing.[298] Additionally, a large portion of electricity goes towards household electricity and business electricity.[299]

Across Sweden, district heating is used extensively. By exploiting the excess heat created from CHP plants, the heat (and cold) supplied from these plants is distributed to industry and residential buildings through a network of pipes. This efficiently utilizes the CHP energy.[300] District heating is currently the main source of heating for dwellings and non-residential buildings, accounting for over half of the heating market. [301]

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290 Stanislav E. Shmelev & Stefan U Speck, *Green Fiscal Reform in Sweden: Econometric Assessment of the Carbon and Energy Taxation Scheme*, 90 RENEWABLE AND SUSTAINABLE ENERGY REVS. 969, 969 (2018).

291 *Id.* at 974.

292 *See id.*

293 *Id.*

294 Facts and Figures 2018, *supra* note 251, at 2.1.

295 Especially considering the fact that oil dominated the district heating market with around ninety percent of energy used for this purpose. *See* Shmelev & Speck, *supra* note 285, at 975.

296 *Id.*

297 *See* Facts and Figures 2018, *supra* note 251, at 1.1.

298 *See id.* at 1.1, 3.1, 3.4, 6.2.

299 *Id.* at 3.2.

300 *See* Sven Werner, *District Heating and Cooling in Sweden*, 126 ENERGY 419, 420 (2017).

301 *Id.*

District heating was initially fueled by fossil fuels.[302] However, over the last few decades the energy input has changed to include heat recycling and renewable fuels.[303] The largest amount of energy input today comes from biomass.[304] The second largest input source is waste incineration, in addition to a small amount from other sources, including fossil fuels like oil and coal.[305] In order to meet the national goal of no fossil fuels for heating by 2020, district heating distributers will have to move away from these energy input sources completely.[306] Studies estimate that by using new technology to implement better detection systems, thereby accounting for errors in the system and individual thermostats at an earlier stage, district heating will no longer need fossil fuels to meet peak demands.[307]

3. Challenges

One of the most controversial issues in Swedish energy policy is nuclear power. Sweden has experienced both political and public pressure to phase out nuclear power and the government has initiated various policies to this end.[308] For example, a national referendum in 1980 proposed a decommission of all reactors by 2010, but was later changed to abandon the target date of 2010. Additionally, a proposal in 1997 aimed to shut down two reactors but so far has only resulted in the decommissioning of one.[309] Unsurprisingly, nuclear power is a contentious area in Swedish politics because Sweden is heavily reliant on nuclear power for electricity production.[310] Studies also show that replacing nuclear power in Sweden is likely to increase GHG emissions and negatively impact electricity prices as energy import would have to increase.[311]

Currently, the government will not enforce the phase-out of nuclear power. Indeed, Sweden permits the construction of new reactors, but only

302 *Id.* at 423.

303 *Id.*

304 *See id.* at 423.

305 *See id.*

306 *See* MINISTRY OF THE ENV'T & MINISTRY OF ENTER., ENERGY AND COMMC'NS, *supra* note 2, at 28.

307 *See* Henrik Gadd & Sven Werner, *Fault Detection in District Heating Substations*, 157 APPLIED ENERGY 51, 58 (2015).

308 *See* Yan Wang, *Renewable Electricity in Sweden: An Analysis of Policy and Regulations*, 34 ENERGY POLICY 1209, 1219 (2006).

309 *Id.*

310 *Id.* at Table 1 at 1211.

311 Sanghyun Hong, Steffan Qvist, & Barry W. Brook, *Economic and Environmental Costs of Replacing Nuclear Fission with Solar and Wind Energy in Sweden*, 112 ENERGY POLICY 56, 63 (2018).

on existing sites.[312] Still, as the Framework Agreement stipulates, Sweden has a target of 100 percent renewable electricity production by 2040. As such, it seems unlikely that investors will find building new nuclear reactors attractive.[313] In fact, due to policy decisions, low electricity prices, and the age of existing reactors, it is expected that more reactors will shut down earlier than intended. As of now, there are eight active reactors in Sweden, four of which the government will decommission by 2020.[314]

Meeting the demand for electricity will become more challenging with the phase out of nuclear power and the increased use of renewables.[315] While increased use of electricity from hydro and wind power replaces fossil fuels, especially in the industry and transportation sector, it is also adds pressure to Sweden´s grid to meet the heightened demand from fewer input sources.[316] The electricity grid in Sweden is one of the world's oldest national grids, and many of the installations are in their operational end cycle.[317] Due to the inclusion of more intermittent energy, the country needs to upgrade the grid to secure its reliability in the future. Svenska Kraftnät is currently working on both assessing the grid and expanding new lines to meet these needs, as well as preparing for a common European electricity market.[318] In addition to upgrading the physical grid, these changes will require increased flexibility in planned production, and the possibility for energy storage and demand/response flexibility, to ensure a reliable power system.[319]

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312 *The Framework Agreement between the Swedish Social Democratic Party, the Moderate Party, the Swedish Green Party, the Centre Party and the Christian Democrats, 'Agreement on Swedish Energy Policy',* GOVERNMENT OFFICES OF SWEDEN, https://www.government.se/49d8c1/contentassets/8239ed8e9517442580aac9bcb00197cc/ek-ok-eng.pdf (last visited Sep. 30, 2019) [hereinafter *Framework Agreement*].

313 EUROPEAN ENERGY HANDBOOK, *supra* note 60, at 457.

314 Statnett, Energinet, Svenska Krantnät and Fingrid, CHALLENGES AND OPPORTUNITIES FOR THE NORDIC POWER SYSTEM at 2 (2016), available at https://www.svk.se/contentassets/9e28b79d9c4541bf82f21938bf8c7389/stet0043_nordisk_rapport_hele_mdato1.pdf; *Nuclear Power in Sweden*, WORLD NUCLEAR ASS'N (Jun. 2019), https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/sweden.aspx.

315 *See* Power Collection for the Energy of the Future, *supra* note 5.

316 *See id.* at 14–15, 23.

317 *We are developing the national grid,* SVENSKA KRAFTNÄT, https://www.svk.se/en/grid-development/driving-forces/?id=838 (last visited Dec. 14, 2018).

318 *Id.*

319 *See* SWEDISH ENERGY AGENCY, *supra* note 245, at 13.

4. Smart Grid Current Status

There are challenges associated with Sweden's move away from nuclear power to intermittent renewable energy.[320] Meeting these challenges and more, Sweden is attempting to make the energy system "smarter" by implementing different smart grid solutions.[321] A variety of research and development and pilot projects are currently working to determine the most cost-effective, durable, and efficient ways to implement smart grid solutions.[322] In 2012, the government established the Swedish Coordination Council for Smart Grid,[323] which was tasked with establishing a national platform for knowledge sharing and drafting an action plan for the expansion of smart grid solutions in Sweden.[324] The council published its action plan "Planera för Effekt!" (Planning for Effect) in 2014.[325] The plan is based on three main pillars: (1) political framework and market terms and conditions; (2) customer participation and societal aspects; and (3) research and development, innovation, and growth.[326] After receiving the action plan, the government established the Swedish Smart Grid Forum as a permanent successor to the council.[327]

SweGRIDS is another research and development organization, established as a partnership between academia, industry, and public utilities, largely funded by the Swedish Energy Agency ("SEA").[328] The organization is running many different research projects related to smart grids, including the development of electric power grids and management of renewable energy input.[329] The research projects will run until 2021.[330]

Sweden started another pilot project between 2012 and 2017 as a cooperative project involving the SEA, the Swedish Smart Grid Forum,

320 Prop. 2017/2018:243 Vattenmiljö och Vattenkraft [government bill] (Swed.).

321 *See* Statens Offentliga Utredningar [SOU] 2014:84 Planera för Effect! m.m 4.2-4.3 at 23 [government report series] (Swed.).

322 *See id.* at 16, 21.

323 Elnät Kommitédirektiv 2012:48: Samordningsråd med Kunnskapsplatform for Smartare [council directive] (Swed.).

324 Planera för Effect, *supra* note 321, at 11.

325 *Id.* at 1.

326 *Id.* at 22–24.

327 *Bakgrund – Samordningsrådet för smarta elnät,* SWEDISH SMART GRID, http://swedishsmartgrid.se/om-oss/bakgrund—samordningsradet-for-smarta-elnat/ (last visited Sep. 30, 2019).

328 *Swedish Centre for Smart Grids and Energy Storage,* SWEGRIDS, https://www.Kth.se/swegrids (last visited Sep. 30, 2019).

329 *Id.*

330 *Id.*

relevant industry actors, and private individuals.[331] The aim of the project was to implement smart grid solutions at Gotland, a small island in Sweden, to test how different solutions would affect the electricity grid, the customer's experience, and consumption.[332] By installing smart meters, the grid operators received near real time updates on the grid status, and the costumers are able to shift their usage to take advantage of peak production hours[333] as opposed to peak load hours.[334] The project also tested the functionality of existing grids with higher amounts of wind power and it demonstrated that new smart technology can improve the electricity quality in rural grids with high levels of distributed power production at a low societal and economic cost.[335]

Another Swedish pilot project, aimed at building the world's smartest electricity grid, is the Stockholm Royal Seaport.[336] The project involves the SEA, together with research institutes and various industry actors, in cooperation with C40 (the Cities Climate Positive Development Program).[337] The groups started the project in 2009 and they estimate that the construction of homes, workplaces, and infrastructure will be completed in 2030.[338] One of the project's main objectives is to drastically reduce GHG emissions and develop a climate positive urban district.[339] The main difference between the two large-scale research and development projects at Gotland and Stockholm Royal Seaport is that the Gotland project is testing smart grid solutions in a rural setting, while the Stockholm Royal Seaport is an urban project.[340]

These examples are just a few of the many research and development projects conducted in Sweden. However, most smart grid solutions are in development and not yet fully in effect.

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331 *We Have A Result!* SMART GRID GOTLAND, http://www.smartgridgotland.se/ (last visited Sep. 30, 2019).

332 *Id.*

333 Hours with lower prices, and greater access to renewable energy. *Id.*

334 Hours with higher prices, and possibly reserve energy sources. *Id.*

335 *Sub Projects*, SMART GRID GOTLAND, http://www.smartgridgotland.se/eng/subproj.pab (last visited Sep. 30, 2019).

336 *See Stockholm Royal Seaport*, STOCKHOLM VÄXER, https://växer.stockholm/omraden/norra-djurgardsstaden/in-english/ (last visited Sep. 30, 2019).

337 *Id.*; *Research and development*, STOCKHOLM VÄXER, https://växer.stockholm/omraden/norra-djurgardsstaden/in-english/ (last visited Sep. 30, 2019).

338 Stockholms Stad, *Sustainable Urban Development Programme*, https://vaxer. stockholm/globalassets/omraden/-stadsutvecklingsomraden/ostermalm-norra-djurgardsstaden/royal-seaport/media/sustainable_urban-development-programme.pdf (last visited Oct. 30, 2019).

339 *Stockholm Royal Seaport*, *supra* note 336.

340 *Id.*

B. Governance System

Sweden reduced GHG emissions by 22.5 percent from 1990 to 2016, meeting its national targets.[341] However, due to an increase in primary energy consumption during 2016, the country fell short of meeting its 2020 targets. [342] In the transport sector, the aim is to achieve at least ten percent renewable energy consumption by 2020.[343] To further Sweden´s commitment towards a more sustainable energy profile, the government tasked the Parliamentary Commission's Cross-Party Committee on Environmental Objectives with determining a comprehensive long-term climate strategy.[344] The goal was to establish a broad cross-party agreement regarding the country's energy policies that would not be easy to change.[345] This would help in the election of successive governments by achieving a more controlled and continuous transition into a completely renewable electricity system. The Framework Agreement presented by the committee[346] was adopted by the Parliament (Riksdagen) in 2017.[347] The climate policy framework of Sweden now consists of three pillars: (1) the Climate Act,[348] (2) the climate goals,[349] and (3) a Climate Policy Council.[350]

First, the Climate Act of January 2018 is the over-arching legislation in Sweden related to climate.[351] The Act requires the government to implement policies based on the climate goals.[352] Additionally, the Act requires the Swedish government to present an annual climate report

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341 *Europe 2020 indicators – Sweden*, EUROSTAT, https://ec.europa.eu/eurostat/statistics-explained/index.php/Europe_2020_indicators_-_Sweden#Overview (last updated October 2, 2019).

342 *Id*.

343 STATENS ENERGIMYNDIGHET, ENERGIINDIKATORER 2018: UPPFÖLJNING AV SVERGIES ENERGIPOLITISKA MÅL [Energy indicator 2018: Follow-up on Sweden´s Energy Policy Goals] 3 (2018) (SWED.) *available at* https://epi6.energimyndigheten.se /PageFiles/54644/Energiindikatorer%202018.pdf.

344 SWEDISH ENERGY AGENCY, *supra* note 245, at 82.

345 *See id.*

346 *Framework Agreement*, *supra* note 312.

347 *See id.*

348 Svensk Författningssamling Klimatlag 2017:720 [The Swedish Code of Statues 2017:720 Climate Act], *available at* https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/klimatlag-2017720_sfs-2017-720.

349 Sweden's Energy and Climate Goals, *supra* note 3.

350 Förordning 2017:1268 [ordinance], *available at* https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20171268-med-instruktion-for_sfs-2017-1268.

351 *See* Climate Act, *supra* note 348.

352 *See id.*

together with the state's budget bill and to draw up a climate policy action plan every four years.[353] The aim of the Climate Act is to insure that each consecutive government pursues a coherent climate policy, based on the goals set out in the Framework Agreement.[354]

Second, as mentioned above, Sweden established the goal of 100 percent renewable electricity production by 2040.[355] However, this goal does not automatically prohibit nuclear electricity production after 2040.[356] In the domestic transportation sector, Sweden is attempting to become fifty percent more energy efficient and reduce GHG emissions by at least seventy percent by 2030.[357] Sweden is also attempting to have net-zero GHG emissions by 2045, and thereafter achieve negative emissions.[358] In the short term, Sweden aims to have emissions at least sixty-three lower by 2030 and seventy-five percent lower by 2040.[359] This will be achieved by increasing the forests' CO_2 uptake and by investing in various climate projects abroad, in addition to actual GHG reduction.[360] Still, such measures may only account for a maximum of eight percent of the 2030 and two percent of the 2040 emission targets respectively.[361]

Third, a climate policy framework of any country is susceptible to change after an election where a new government takes the reins.[362] Thus, the role of the Climate Policy Council is to independently assess whether or not each government's policy framework is consistent with the climate goals.[363] The three-part Swedish policy framework fosters legally required coherence and consistency in policy initiatives across party lines, regardless of the specific party formation in government and Parliament.

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353 *Id.*

354 *Id.*

355 *Framework Agreement*, *supra* note 312.

356 *Id.*

357 Domestic aviation is not included in the European Union Emissions Trading System and is therefore excluded from the statistics of this goal as well. SWEDISH ENERGY AGENCY, *supra* note 245, at 81–82.

358 Sweden's Energy and Climate Goals, *supra* note 3, at 25.

359 Compared to emission levels in 1990. *Id.*

360 *See generally* Climate Action, *Climate Action: Effort Sharing: Member State's Emission Targets*, EUROPEAN COMMISSION, https://ec.europa.eu/clima/policies/effort_en (last visited Dec. 11, 2018).

361 Sweden's Energy and Climate Goals, *supra* note 3.

362 SWEDISH CLIMATE POLICY CENTER, DET KLIMATPOLITISKE RAMVERKET: RAPPORT 2018, at 19 [CLIMATE POLICY FRAMEWORK: REPORT 2018] (2018) (Swed.).

363 *See* Statens Offentliga Utredningar [SOU] 2016:21 Ett Klimatpolitiskt Ramverk för Sverige [A Climate Policy Framework for Sweden] [government report series] (Swed.); Statens Offentliga Utredningar [SOU] 2016:47 En Klimat- Och Luftvårdsstrategi för Sverige [A Climate and Air Conservation Strategy for Sweden] [government report series] (Swed.).

Still, the Climate Act does not contain any possibilities for placing sanctions on a government that is not fulfilling its duty towards the climate goals.[364] As stated in the Swedish constitution, it is each government's privilege to govern in the way it sees fit.[365] As such, any government may amend or abolish the Climate Act, if a majority in the parliament so chooses.[366] The Climate Act sets out the overarching climate goals but does not specify how the government must proceed with its policy making.[367]

Only time will show whether the Act will in fact enhance the Swedish government's efforts in climate preservation, or if it will simply stand as a political document with no real impact.[368] The goals set by the Swedish government may in large part go beyond the EU targets, although it should be noted that the EU targets are in some instances more specific and binding. The Climate Action Network ("CAN"), Europe´s leading NGO coalition fighting climate change in Europe, has ranked Sweden as having the best climate policy framework within the EU.[369] Thus, Sweden has a strong policy framework on fighting climate change, but there is still room for further improvements.

There are various institutions responsible for the country's energy policies. Agencies assigned with various tasks related to energy, climate, and the environment include: The Energy Commission ("Commission"), the SEA, and the Swedish Environmental Protection Agency.[370]

364 SWEDISH CLIMATE POLICY CENTER, *supra* note 362.

365 Albeit with some constraints relating to finance (budget bills) and foreign policy. *See* 9 ch. KUNGÖRELSE OM BESLUTAD NY REGERINGSFORM [ANNOUNCEMENT ON DECIDED NEW FORM OF GOVERNMENT] (Svensk författningssamling [SFS] 2011:109) (Swed.); BUDGETLAG [BUDGET] (Svensk författningssamling [SFS] 2011:203) (Swed.).

366 SWEDISH CLIMATE POLICY CENTER, *supra* note 362.

367 *See* KLIMATLAG (SFS 2017:720) (Swed.).

368 Matilda Hellström, *New Climate Act – Pioneering or Meaningless?*, LEXOLOGY (Mar. 13, 2017), https://www.lexology.com/library/detail.aspx?g=241ce380-87a8-44f2-a099-4f1061a5cb44.

369 CLIMATE ACTION NETWORK EUROPE, OFF TARGET: RANKING OF EU COUNTRIES AMBITION AND PROGRESS IN FIGHTING CLIMATE CHANGE 4–5 (2018), http://www.cane urop e.org/docman/climate-energy-targets/3357-off-target-ranking-of-eu-countries-ambition-and-progress-in-fighting-climate-change/file.

370 The Swedish Environmental Protection Agency is also known as ´Naturvårdsverket´.

The Commission's role is to introduce policy proposals, and update Sweden´s climate goals.[371] Notably, the Commission established the basis for the Framework Agreement.[372]

The SEA's work is related to international cooperation in the fields of climate, environment, and energy,[373] and it manages the Electricity Certificate System and the EU Emission Trading System.[374] In order for Sweden to meet its target of becoming fifty percent more energy efficient by 2030, the government tasked SEA with producing sector specific codes of conduct related to energy efficiency, in cooperation with industry actors.[375] The Agency also finances research on smart grids and renewable energy technologies.[376]

The Swedish Environmental Protection Agency´s main tasks include information gathering and dissemination, developing environmental policies, and implementing environmental policies as they pass through government and Parliament.[377] The Environmental Objectives Council[378] coordinates with the many different agencies responsible for various environmental and climate objectives. The Council delivers annual reports evaluating the government's policy efforts and provides measures for improvement.[379]

The governance structure in Sweden is mainly unitary and state-level, with the Government and/or the Parliament making most policy decisions. However, Sweden's 290 municipalities are delegated power to handle certain responsibilities.[380] As such, the municipalities function as policy

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371 *See* STATENS ENERGIMYNDIGHET, ER 2018:11, ENERGIINDIKATORER 2018: UPPFÖLJNING AV SVERIGES ENERGIPOLITISKA MÅL (2018).

372 Framework Agreement, *supra* note 312.

373 *Cooperation*, SWEDISH ENERGY AGENCY, http://www.energimyndigheten.se/en/cooperation/ (last updated July 9, 2019, 10:38 PM).

374 SWEDISH ENERGY AGENCY, *supra* note 245, at 88.

375 Gunilla Hjalmarson, *Överenskommelse om Sveriges Mål för Energieffektivisering* [*Agreement on Sweden´s Energy Efficiency Goals*], REGERINGSKANSLIET (Nov. 26, 2018), https://www.regeringen.se/pressmeddelanden/2016/11/overenskommelse-om-sveriges-mal-for-energieffektivisering/.

376 *About Us*, SWEDISH ENERGY AGENCY, http://www.energimyndigheten.se/en/about-us/ (last updated July 9, 2019, 10:38 PM).

377 Berit Oscarsson, *About the Swedish Environmental Protection Agency*, SWEDISH ENVIRONMENTAL PROTECTION AGENCY, http://www.swedishepa.se/About-us/ (last updated Nov. 4, 2018).

378 ´Miljömålrådet´.

379 *The Environmental Objectives System*, SVERIGES MILJOMAL, https://www.miljomal.se/Environmental-Objectives-Portal/Undre-meny/About-the-Environmental-Objectives/ (last updated Nov. 19, 2018).

380 Lennart T. Norman et al., *Sweden*, ENCYCLOPAEDIA BRITANNICA, https://www.britannica.com/place/Sweden (last updated Sep. 22, 2019).

implementers, enforcers, and stakeholders in different energy, climate, and environmental projects.

For example, in the transportation sector, municipalities are expanding infrastructure for bicycles, improving the public transport system, and expanding use of renewable fuel in public transport.[381] In one initiative, the national government provides an energy adviser to each municipality to advise the public on how to improve energy efficiency.[382] Sweden recognizes that such measures are more effective at the local level.[383] Also, improving energy efficiency by empowering the public at the local level is increasingly important with Sweden's move towards a decentralized energy system (including micro-energy systems).[384] Indeed, if Sweden is to reach its goal of becoming an emission free state, it is important to decrease emissions from households.[385] On the other hand, one problem with having semi-autonomous regions and municipalities is that there will be disparities between regions with regards to effort and results.[386]

C. Electricity Market

Sweden's sole TSO is Svenska Kraftnät,[387] with the Swedish Energy Market Inspectorate as the main supervisory and regulatory authority.[388] The Swedish electricity market went through a structural reform in 1996, which opened the market to competition in trading and production of electricity, aiming for a more effective use of production resources.[389] The electricity market consists of two main attributes: the transmission network and the financial trading of electricity.[390] The electricity grid

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381 SVERIGES KOMMUNER OCH LANDSTING, ÖPPNA JÄMFÖRELSER: MILJÖARBETET I REGIONER OCH LANDSTING 2018 [OPEN COMPARISONS: ENVIRONMENTAL WORK IN REGIONS AND COUNTY COUNCILS 2018] 35 (2018).

382 *Sweden Tackles Climate Change*, SWEDEN, https://sweden.se/nature/sweden-tackles-climate-change/ (last updated Oct. 5, 2018).

383 *See* Are E. Kjeang et.al., *Local Energy Advising in Sweden: Historical Development and Lessons for Future Policy-Making*, 9(12) SUSTAINABILITY 2275 (2017).

384 *Id.* at 10.

385 *See Energy Situation: Statistics*, ENERGIMYNDIGHETEN (June 3, 2019, 9:00 AM), http://www.energimyndigheten.se/statistik/energilaget/.

386 SVERIGES KOMMUNER OCH LANDSTING, *supra* note 381, at 8.

387 EUROPEAN ENERGY HANDBOOK, *supra* note 60, at 457.

388 *More About Us*, SWEDISH ENERGY MARKETS INSPECTORATE, https://www.ei.se/en/About-Ei/About-us/ (last visited Dec. 23, 2018).

389 SWEDISH ENERGY MKTS. INSPECTORATE, THE SWEDISH ELECTRICITY AND NATURAL GAS MARKET 2017 6, Ei R2018:11 (2018).

390 *Electricity's two routes*, SVENSKA KRAFNÄT, https://www.svk.se/en/national-grid/operations-and-market/electricitys-route/ (reviewed Feb. 10, 2016).

includes the national grid, operated by Svenska Kraftnät, and the regional and local grids which transport electricity from producers via the grid to end consumers.[391] Producers sell electricity to competing electricity traders, either directly or through the power exchange.[392] When traders and suppliers sell the electricity to end consumers, they charge consumers two service fees, one for the physical transmission, and one for the consumption of electricity.[393] The Swedish electricity market and its initiatives towards a greener electricity market are closely linked to the markets of its neighboring Nordic countries, which will be described in the following Subsections.

1. Electricity Trade

The Swedish electricity system is part of an integrated Nordic system and market.[394] As part of liberalizing the electricity market, the Nordic countries formed a common Nordic electricity market, Nord Pool.[395] Nord Pool was established by Sweden and Norway in 1996, and it has since expanded both on the owner side and on the market side, now operating in Sweden, Norway, Denmark, Finland, and the Baltic countries Lithuania, Latvia, and Estonia.[396] Exchanges on Nord Pool, and the overall sale of electricity, are one of the main sources of income for renewable energy projects and green certificates.[397] Currently, Nord Pool is the leading power market in Europe.[398] Nord Pool is a free market where supply and demand determine the prices. The prices can therefore be highly volatile, a reflection of several factors.[399] One important factor in Sweden is weather changes, which affect the amount of wind and rain available for electricity production at wind and hydro power plants and demand during colder winter days.[400]

While trading can happen directly between seller and buyer and internally within the electricity company, most of Sweden's electricity

391 *Id.*

392 *Id.*

393 *Id.*

394 SWEDISH ENERGY AGENCY, *supra* note 245, at 42.

395 *Id.*

396 *History*, NORD POOL, https://www.nordpoolgroup.com/About-us/History/ (last visited Dec. 11, 2018).

397 *See generally* Fredrik Finjord et al., *The impact of Norwegian-Swedish Green Certificate Scheme on Investment Behaviour: A Wind Energy Case Study*, 123 ENERGY POLICY 373, 375 (2018).

398 *See generally* NORD POOL, https://www.nordpoolgroup.com/ (last visited Oct. 30, 2019).

399 Finjord et al., *supra* note 397, at 275.

400 *Id.*

trading occurs on the Nord Pool day-ahead market ("Elspot") or intraday market ("Elbas").[401] There are about 120 different traders active in the Swedish electricity market, including large power utilities, municipally owned companies, and co-owned companies. These companies often consist of municipalities that have merged to form a joint trading company, as well as a number of smaller independent trading entities.[402] Svenska Kraftnät is currently working towards launching a single EU market for trading electricity. It is also working closely with its Nordic counterparts to create a single Nordic retail market to allow customers to purchase electricity from any of the Nordic suppliers.[403]

The Swedish electricity market and the larger Nordic system is changing. Most notably, there are new actors both on the supply side and on the demand side.[404] These changes will require more clearly defined roles and responsibilities and increased coordination measures among the many actors in order to ensure an efficient energy market for the future.[405]

2. Regulatory Framework

In the interest of stimulating increased electricity production from renewable energy sources, Sweden has introduced a number of different policy strategies, including: (1) tax regulation mechanisms; (2) a green certificates; (3) subsidies for distributed solar electricity production; and (4) subsidies for distributed energy production for other sources.

i. Tax Regulation Mechanisms

In Sweden, owners of power plants (and in some instances landowners) must pay an annual real estate tax. Until 2017, hydroelectric plants were subject to a higher tax rate compared to other electricity plants.[406] However, the State Property Tax Act was amended according to the Framework Agreement,[407] and it now states that for hydro power

401 *See generally Elmarknader och elhandel*, Swedish Energy Markets Inspectorate, https://www.ei.se/sv/ei-s-verksamhet/Elmarknader-och-elhandel/.

402 *Electricity Traders and Balancing Services*, SWEDISH SMARTGRID, http://www.swedishsmartgrid.se/in-english/the-swedish-electricity-market/electricity-traders-and-balancing-services/ (last visited Dec. 23, 2018).

403 *International Cooperation*, SVENSKA KRAFTNÄT, https://www.svk.se/en/national-grid/operations-and-electricity-markets/international-cooperation/ (reviewed Feb. 10, 2016).

404 *See* SWEDISH ENERGY AGENCY, *supra* note 245, at 42.

405 STATNETT ET AL., CHALLENGES AND OPPORTUNITIES FOR THE NORDIC POWER SYSTEM 12 (2016).

406 *See Framework Agreement*, *supra* note 312.

407 *Id.*

plants, the property taxes will gradually reduce to the same level as other electricity production plants.[408]

Commercial electricity producers must also pay taxes for the consumption of electricity.[409] The Energy Tax Act differentiates between various sources of energy to incentivize electricity use from renewable energy.[410] For electricity producers that have generator capacity lower than fifty kW, and do not transfer electricity to a licensed grid, the government does not levy taxes.[411] If producers utilize wind or wave energy, the threshold increases to 125 kW. If they utilize solar energy, the threshold increases to 225 kW.[412] Micro producers could manufacture more electricity than they use. As these micro producers earn profits from their excess electricity, this profit becomes taxable income.[413] However, since 2015, Sweden has implemented a special tax reduction scheme for micro production of renewable electricity.[414] This means that if a micro producer takes out and feeds electricity through the same connection point, and the connection point has a maximum fuse of 100 amps, that entity or individual is eligible for a tax reduction.[415]

ii. Green Certificates

Sweden and Norway have a tradable certification subsidy scheme that incentivizes production of and investments in renewable energy.[416] Sweden introduced this system in 2003 and included Norway in 2012.[417] The joint goal is for the certification scheme to contribute to 28.4 TWh of renewable electricity production in the two countries by 2020.[418] However, parts of the regulation differ between the two countries.[419] In

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408 *Id*.

409 11 ch. 5 § OM SKATT PÅ ENERGI [ON ENERGY TAX] (Svensk författningssamling [SFS] 1994:1776) (Swed.).

410 11 ch. 2 § OM SKATT PÅ ENERGI (SFS 2018:1887 amending 1994:1776) (Swed.).

411 *Id*.

412 *Id*.

413 67 ch. INKOMSTSKATTELAG (Svensk författningssamling [SFS] 1999:1229) (Swed.).

414 SWEDISH ENERGY AGENCY, *supra* note 245, at 44.

415 Ch. 67 § 27 INKOMSTSKATTELAG (Svensk Författningssamling [SFS] 1999:1229) (Swed.).

416 Caroline Asserup et al, EN SVENSK-NORSK ELCERTIFIKATSMARKNAD: ÅRSRARAPPORT FÖR 2017 8 (2017).

417 *Id*.

418 *Id*.

419 Maria Hanbo et al., *Government presents extension of electricity certificate system and increased target*, INTERNATIONAL LAW OFFICE (May 22, 2017), https://www.Internationallawoffice.com/Newsletters/Energy-Natural-Resources/Sweden/Advokatfirman-

April 2017, the Swedish government issued a bill extending the certification scheme until 2045 and increasing the quota by eighteen TWh by 2030,[420] while Norway did not change targets.[421] Having a joint certification scheme rather than two separate schemes increases the size of the market, and is also more efficient and cost-effective in directing investments towards the best projects.[422]

The price of the certificates is determined by supply and demand. Electricity suppliers and some large consumers[423] must purchase certificates corresponding to a certain portion of the electricity they sell or consume, under penalty of fines.[424] In Sweden, this portion amounted to 24.7 percent in 2017.[425] As such, the quota curve decided by the Swedish and Norwegian governments respectively regulates the demand, whereas the supply amounts to the number of certificates issued for that year in addition to possible surplus of certificates from previous years.[426] The Swedish and Norwegian electricity consumers assume the cost of the quota obligation by suppliers adding a surcharge to their services.[427] Furthermore, for every MWh of produced renewable energy, the governments issue certificates for which the producer can subsequently trade on the certification exchange to increase its profit.[428] In Sweden, a producer must apply and be approved by the SEA to trade on the certification exchange. The SEA can issue certificates for a maximum of fifteen-year term.[429] Also, the SEA may only allocate certificates for

Lindahl/Government-presents-extension-of-electricity-certificate-system-and-increased-target#

420 §1 par. 1 LAG OM ELCERTIFIKAT (Svensk Författningssamling [SFS] 2011:1200) (Swed.).

421 Hanbo et al., *supra* note 419.

422 Finjord et al., *supra* note 397, at 375.

423 Consumers that consume self-produced electricity, if the electricity consumed amounts to more than 60 MWh/year and is produced from a plant with installed power higher than 50 KW. And consumers that use electricity they have imported or purchased on the Nord Pool spot exchange.

424 Ch. 4 §§ 1, 4 LAG OM ELCERTIFIKAT (Svensk Författningssamling [SFS] 2011:1200) (Swed.).

425 Asserup et al, *supra* note 416, at 13.

426 Finjord et al., *supra* note 397, at 375

427 SWEDISH-NORWEGIAN ELECTRICITY CERTIFICATION MARKET - ANNUAL REPORT 2017 at 7 (2017), *available at* https://www.energimyndigheten.se/globalassets/fornybart/elcertifikat/marknadsseminarium-2018/elcertifikat-arsrapport-2017-se_web.pdf.

428 *Id.* at 9.

429 Ch. 2 § 7 LAG OM ELCERTIFIKAT (Svensk Författningssamling [SFS] 2011:1200) (Swed.).

electricity production from these six sources: hydro power, biomass fuels, wind power, solar power, wave power, or geothermal power.[430]

While the Norwegian regulation stipulates that for an electricity producer to be eligible to receive certificates production must start by December 31, 2021;[431] the Swedish regulation does not have the same deadline.[432] In contrast, Swedish investors are only restricted by the end date for the certificate scheme, which for Sweden is the end of 2045.[433] A recent study suggests that the optimal strategy to increase long-erm investments is the Norwegian model, with a clear medium-term deadline, preferably the year 2022. If the goal is to boost short term investment, the study suggests that an earlier deadline date will have a greater impact.[434] Overall, the study shows that uncertainty is a major factor affecting investment in renewable energy, including uncertainty related to future electricity and prices or certification schemes.[435] This suggest that for investors to take on large-scale production of renewable electricity, especially in newer areas, such as offshore wind or wave power, for which there are even greater uncertainties, the certificate scheme might not be enough of an incentive to attract larger investments.[436]

Sweden's current certification scheme equally funds all types of renewable energy technologies,[437] which favors more mature technologies[438] over newer technologies.[439] Thismight lead to competitive disparities and fewer investments in new renewable energy technologies, therefore leading to a less favorable long-term development of the entire energy sector.[440] Some industry actors and investors are more diversified than others in their renewable energy investment portfolios.[441] For example, in the Swedish market, biopower investors are generally better adapted to handle technical changes and more inclined to diversify into

430 Ch. 1 § 2 LAG OM ELCERTIFIKAT (Svensk Författningssamling [SFS] 2011:1200) (Swed.).

431 Lov om elsertifikater 2011 § 8 par. 4 (Norwegian Code of Statues 2011 on electrical certificates § 8 par. 4).

432 2 ch. (SFS 2011:1200) (Swed.).

433 *Id.* at § 11.

434 Finjord et al., *supra* note 397, at 381.

435 *Id.* at 383

436 *See* Anna Darmani, *Renewable Energy Investors in Sweden: A Cross-Subsector Analysis of Dynamic Capabilities*, 37 UTILITIES POLICY 46 (2015).

437 *Id.* at 46.

438 For example, wind (onshore) and hydro power in Sweden. *Id.*

439 *Id.*

440 *See Id.*

441 *Id.* at 53.

related industries.[442] Investors in the wind power sector, on the other hand, tend to be the least inclined to diversify and invest in other renewables.[443] Thus, Sweden may need to look into policy tools that target subsectors directly to increase investments in the less mature technologies before market structures can beneficially regulate growth.[444]

3. Distributed Electricity Production: Solar

The market for photovoltaic panels ("PV") is growing in Sweden.[445] While the country is not ideally located to extract solar energy compared to countries in the south, there is still some potential for households in the southern part of Sweden, where most of the population lives, to produce and sell solar energy.[446] Two surveys conducted between 2008 and 2016 show that the interest among Swedish households to engage in electricity production is increasing.[447] The first wave of interviews demonstrated that the most prominent motive for installing PVs, at least among those asked, was environmental concerns.[448] Similarly, in the second round of interviews, all but three households mentioned environmental concerns.[449] However, in contrast to the first round, all individuals asked in the second round mentioned financial motives for installing PVs.[450] While the surveys were quite small in size (twenty and forty-three households respectively), they did show signs of a "prosumer" trend in Sweden, or at least an increased awareness of the potential for financial gain through "prosumer" initiatives.[451]

The Swedish government has introduced a number of different policies to encourage the growth of the country's PV market. For example, in 2009 the government introduced a grant scheme for the installation of PVs.[452] Initially, the grant covered sixty percent of the total installation cost, but the grant has since been gradually reduced and now amounts to a maximum of twenty percent of the installation cost.[453] The grant scheme

442 *Id.*

443 *Id.*

444 *Id.* at 54.

445 Jenny Palm, *Household Installation of Solar Panels – Motives and Barriers in a 10-year Perspective*, 113 ENERGY POLICY 1, 1 (2018).

446 *Id.*

447 *Id.*

448 *Id.* at 2.

449 *Id.* at 5.

450 *Id.*

451 *Id.* at 1, 3, 5.

452 §2 FÖRORDNING OM STATLIG STÖD TIL SOLCELLER (2009:689) (Swed.).

453 Palm, *supra* note 445, at 3.

only lasts until 2020.[454] Another option for Swedish households is the tax deduction scheme[455] related to repairs, conversion, or extension of residential housing.[456] It is not a tax deduction specifically aimed at PVs but can be allocated in relation to the labor cost of installing PVs.[457] Some households have chosen this route instead, mostly due to the certainty that they will receive the deduction.[458]

Arguably contradicting the government´s intent to incentivize prosumers,[459] a new tax was implemented in 2016 that obliged every large producer of electricity from PVs (over 255 kW) to pay taxes on the electricity they produce, even if the producer consumes that energy.[460] While the tax may negatively affect incentives for developers to install PVs on chain stores and apartment buildings,[461] the effect on small household producers is arguably insignificant, as they seldom exceed 255kW produced.[462] Therefore, the incentives to install PVs on small households could still be effective. On the other hand, there is a reason to reduce the tax exemptions related to micro-production of solar electricity, as too much support for this technology in turn might distort the market due to overproduction.[463] This concern is substantiated by the fact that production of solar power is most effective during the summer and peak demand usually occurs during winter months.[464] Therefore, the Swedish government should be cautious not to stimulate excessive solar production as it would be neither cost-effective nor increase delivery reliability in the long-term.[465]

While deciding to levy taxes on solar electricity, the government also presented a proposal to increase the grants for PV installations, which

454 § 2 FÖRORDNING OM STATLIG STÖD TIL SOLCELLER (2009:689) (Swed.).

455 ROT avgrag.

456 *ROT and RUT Work*, SKATTEVERKET, https://www.skatteverket.se/servicelankar/otherlanguages/inenglish/businessesandemployers/declaringtaxesbusideclar/rotandrutwork.4.8dcbbe4142d38302d793f.html (last visited Jan. 4, 2019).

457 *See id.*; *See* Palm, *supra* note 445, at 7.

458 Palm, *supra* note 445, at 7.

459 Mindre aktörer i energilandskapet – förslag med effect (Statens Offentliga Utredeningar [SOU] 2018:15) (Swed.).

460 11 ch. 2 § LAG OM SKATT PÅ ENERGI (SFS 1994:1776) (Swed.).

461 As the tax is linked to the organization number of the owner of the panels, not the panels themselves.

462 Jannicke Nilsen, *Sverige innfører omstridt skatt på solcelleanlegg*, TU (July 6, 2016), https://www.tu.no/artikler/sverige-innforer-omstridt-skatt-pa-solcelleanlegg/349267.

463 *See* Darmani, *supra* note 436, at 46.

464 TOBIAS BONDESSON & RUNAR BRÄNNLUND, ELECTRICITY MARKET OF THE FUTURE: IVA ELECTRICITY CROSSROADS PROJECT 23 (Camilla Koebe ed., 2016).

465 *See id.*

attracted criticism from both the industry organization Solar Energy Association of Sweden and the National Institute of Economic Research ("NIER").[466] Due to the current market trend of reduced prices, substantial growth, and increased profitability, an increased grant would, according to NIER, be neither cost-effective nor technically neutral.[467] Therefore, the Solar Energy Association of Sweden argued, there was no longer a need for subsidies. Rather, it argued that the government should focus on simplifying the administration and regulations, making it easier and more efficient to produce and sell micro-generated electricity.[468]

Further, the SEA advised the government to phase out the grant and rely on the tax reductions scheme.[469] Despite this suggestion, the government increased the grant and allocated it in different amounts depending on whether or not the applicants were eligible to receive tax deductions.[470] While acknowledging that the new scheme simplified the application and allocation process somewhat and that eliminating the grant at this point would be counterproductive, the SEA, in agreement with the Solar Energy Association of Sweden,[471] suggested that the country gradually reduce and abolish the grant after 2020.[472]

Curiously, while several of the closest official government advisers and important solar industry players were opposed to the amendments, the government still chose to implement them as proposed. Additionally, the government ignored the experiences of other European countries with similar subsidy schemes for PVs. These other countries have demonstrated that making the solar energy market reliant upon governmental grants and budget bills, rather than letting the market conform to normal market forces, may lead to market crashes[473] when the subsidy scheme eventually concludes.[474] The government did not adhere to the industry´s advice on

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466 Johan Hultburg, *Det ökade ekonomiska stödet till solceller*, SVERIGES RIKSDAG, (Sep. 9, 2017), https://www.riksdagen.se/sv/dokument-lagar/dokument/interpellation/det-okade-ekonomiska-stodet-till-solceller_H5108; Wilhelm Löwenheim et al., *Debatt: Fasa ut stödet till solceller*, SVENSK SOLENERGI, (Oct. 1, 2017).

467 Hultburg, *supra* note 466.

468 Löwenheim et al., *supra* note 466.

469 Johan Lindahl, *National Survey Report of PV Power Applications in Sweden, 2016*, SWEDISH ENERGY AGENCY, PHOTOVOLTAIC POWER SYSTEMS PROGRAMME: 37 (Swed.).

470 *Id*.

471 Löwenheim et al., *supra* note 466.

472 *Id*.

473 JORGE MORALES PEDRAZA, ELECTRICAL ENERGY GENERATION IN EUROPE: THE CURRENT SITUATION AND PERSPECTIVES IN THE USE OF RENEWABLE ENERGY SOURCES AND NUCLEAR POWER FOR REGIONAL ELECTRICITY GENERATION at ch. 4 (Springer, 2015).

474 Löwenheim et al., *supra* note 466.

abolishing the grant scheme. On the other hand, they tasked the SEA with implementing an information portal to coordinate information on PVs and identify barriers, aiming to ease the process of becoming 'prosumers' of solar energy.[475]

4. Distributed Electricity Production: Other Renewable Technologies

In addition to solar energy, micro-production of wind, hydro, and bio-CHP powered electricity exists in Sweden. However, the amount of energy generated by these micro-producers is not particularly high. Hydropower production has the longest standing tradition in Sweden, and it has the largest volume of micro-production.[476] Hydropower production, including micro-production, is essential to energy supply reliability in Sweden because hydropower is a more constant source of energy than, for example, wind power.[477] Furthermore, hydropower may provide stability in local energy grids, and a more decentralized electricity production may help reduce the vulnerability in the Swedish energy supply in the long term.[478]

Besides expanding production sites, micro-producers can deploy technical measures that have the potential to make even micro-production hydro plants more efficient.[479] Making existing plants more efficient is important in order to produce larger amounts of electricity.[480] Improving existing plants is important because new hydropower plants must be balanced against other environmental concerns, such as the ecosystems in and around lakes and streams. As such, new plants may not be granted construction permits.[481] In accordance with the Framework Agreement, the Swedish government is currently attempting to incentivize micro-production thorough easing the regulation and authorization process for hydro power plants and reducing property taxes.[482]

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475 Regleringsbrev för Budgetåret 2017/2018: avseende Statens Energimyndighet, M2017/03110 (Appropriation letter to the Swedish Energy Agency for 2018).

476 Proposition 2017/2018:243 'Vattenmiljö och Vattenkraft' at 62 [Government Bill] (Swed.).

477 *Id.* at 63.

478 *Id.*

479 Statens Offentliga Utredningar [SOU] 2018:77 'Mindre Aktörer i Energilandskapet – Genomgång av Nülaget' at 67 [government report series] (Swed.).

480 *Id.*

481 Proposition 2017/2018:243 'Vattenmiljö och Vattenkraft' at 64 [Government Bill] (Swed.).

482 *See id.*

Wind power expansion in Sweden has been extensive over the last ten years.[483] On and offshore wind power are great opportunities which are currently underexploited.[484] While there are some offshore wind farms in Sweden and the government has granted construction permits to seven additional projects, the expansion process has been slow and uncertain.[485] This slow growth is mainly due to the high costs of construction and connecting to the grid.[486] However, there are signs that the cost of establishing offshore wind farms is falling to competitive levels,[487] and the Swedish government has proposed to remove the cost of connecting wind farms to the grid, reducing the project cost by about ten percent.[488] Sweden´s wind power industry is also requesting a comprehensive long-term plan from the government to facilitate investments.[489] Moreover, the industry proposes establishing pilot projects to strengthen knowledge and experience in the field, and a subsidy scheme directed at offshore wind production specifically.[490]

5. Energy Security Dimension

Ensuring available transmission capacity at all times is key to a well-functioning market, as well as to Sweden's energy security.[491] Currently, Sweden and six European countries have a connected grid, with AC connections to Finland, Norway, and Denmark, and DC connections to Germany, Poland and Lithuania.[492] Overall, Sweden has an estimated electricity interconnection capacity of 25.6 percent,[493] which is already

483 ENERGY IN SWEDEN, *supra* note 245, at 1.2.

484 Finjord et al., *supra* note 397, at 377.

485 Statens Offentliga Utredningar SOU 2018:15 'Mindre Aktörer i Energilandskapet – Genomgång av Nülaget' at 67 (Government Bill 2018:15 'Small Actors in the Energy Market – Review of the current situation´).

486 Statens Offentliga Utredningar [SOU] 2018:7 Energimyndighetens raport 'Slopade Anslutningskostnader för Havbaserad Vindkraft' (Swed.).

487 Statens Offentliga Utredningar SOU 2018:15 'Mindre Aktörer i Energilandskapet – Genomgång av Nülaget' at 67 (Government Bill 2018:15 'Small Actors in the Energy Market – Review of the current situation´).

488 Statens Offentliga Utredningar [SOU] 2018:7 Energimyndighetens raport 'Slopade Anslutningskostnader för Havbaserad Vindkraft' (Swed.).

489 Statens Offentliga Utredningar [SOU] 2017:3 Remissvar på Energimyndighetens Rapport om Havbaserad Vindkraft (Swed.).

490 *Id.*

491 SWEDISH ENERGY MARKET INSPECTORATE, *supra* note 259.

492 *See* Commission Staff, *Energy Union Factsheet Sweden*, 5, 23 EUROPEAN COMMISSION 2017, https://ec.europa.eu/commission/sites/beta-political/files/energy-union-factsheet-sweden_en.pdf. (last visited Jan. 7, 2017).

493 *Id.* at 5.

well above the EU targets.[494] However, a recent report by the Swedish Energy Market Inspectorate indicates that Sweden's dependence upon cross border electricity trade in the future will be even greater, resulting in a need for more interconnections.[495]

There are currently eleven interconnection lines between the Nordic countries and Europe and eight new lines are under construction or in development.[496] However, the Nordic TSOs expect to need more cross border corridors, plans for which the TSO will present in the 2019 Nordic Grid Development Plan.[497]

Introducing more renewable energy to the grid, combined with the forecasted decommissioning of both thermal and nuclear power plants, causes challenges for TSOs. The main challenge is the ability to meet the demand for flexibility, especially considering the variation in temperature between seasons in Sweden. Meeting the demand for flexibility is essential with regards to guaranteeing supply security to the market while maintaining sufficient inertia in the system to ensure operational security.[498] However, meeting the demand for flexibility will become increasingly challenging with the introduction of smart meters, micro grids, automated demand response, and with new participants, such as prosumers and aggregators.[499]

Due to the long-standing tradition of Nordic cooperation, the Nordic TSOs (including Sweden´s Svenska Kraftnät) are committed to meeting many of the challenges emerging in the transition to a new power system.[500] In a joint report by the Nordic TSOs, different challenges and possible solutions are discussed.[501] Although deciding not to officially establish a single Nordic TSO, the TSOs are taking measures to operate more as "one TSO."[502] The Nordic TSOs also cooperate specifically on electricity security under the Nordic Contingency Planning and Crisis Management Forum ("NordBER").[503] While ENTSO-E states that the

494 *Id.*

495 SWEDISH ENERGY MARKET INSPECTORATE, *supra* note 259.

496 Svenska Kraftnät, et. al, *Nordic Grid Development Plan 2017* FINGRID, ENRGINET.DK AND STATNETT 8–14 , http://www.svk.se/siteassets/om-oss/rapporter/2017/nordic-grid-development-plan-2017-eng.pdf (last visited Jan. 8, 2019).

497 *Id.* at 7.

498 Power Collection for the Energy of the Future, *supra* note 5.

499 *Id.*

500 *Id.* at 7.

501 *Id.*

502 *Id.* at 3.

503 *Preparedness Partnership*, NVE (May 6, 2019), https://www.nve.no/damsikkerhet-og-kraftforsyningsberedskap/kraftforsyningsberedskap/organisering-av-kraftforsyningsberedskap/beredskapssamarbeid/.

Nordic power system will be able to cover demand within these countries in 2025, their assessment is based on values and definitions which are not synonymous with the respective countries' national regulations. Consequently, harmonizing definitions and regulations and ensuring better coordination of methodologies is needed among the Nordic TSOs to operate as "one TSO" and manage the challenges ahead.[504]

It is also important to consider the connection points. If grid connections are enabled in deficit areas, it might affect the supply and the price of electricity in Sweden. Additionally, if a connecting country has a strained grid infrastructure, it might create bottlenecks which could affect both the Swedish and the broader Nordic infrastructure. Take for example, the congestion between the Nordic region and Germany caused by internal bottlenecks in Germany.[505] In order to remain competitive, Sweden´s energy intensive industry, which competes in global markets, is highly reliant upon electricity imports in times of scarcity in Swedish supply. Therefore, it is important for Sweden to consider whether certain connection points to the wider continent will be able to export energy to Sweden when needed.[506]

Sweden, per request by the EU Commission, divided the country into several bidding zones.[507] The purpose of this division was to avoid transmission constraints in one area of the grid unjustly affecting the prices for the entire grid.[508] As such, prices between different zones may diverge, but the prices within one zone will be the same.[509] Smaller bidding zones also make it more efficient to discover where in the grid readjustments are needed due to insufficient transmission capacity.[510] Despite the relatively extensive interconnections between the Nordic countries, the bidding zones line up with the state borders.[511] Arguably, a more ideal approach

504 *See generally id.*

505 SWEDISH ENERGY MARKET INSPECTORATE, *supra* note 259, at 6.

506 *Id.*

507 Svenska Kraftnät, *Swedish Interconnectors COMP Case No 39351, Monitoring report No 13* at 4 (2017) (Swed). https://www.svk.se/siteassets/om-oss/rapporter/2017/swedish-interconnectors-report-no.-13_rapport.pdf.

508 *See* Matthew Wittstein et al, *Electricity Security Across Borders: Case Studies on Cross-Border Electricity Security in Europe* INTERNATIONAL ENERGY AGENCY INSIGHT SERIES 2016 at 59 https://www.iea.org/publications/insights/insightpublications/ ElectricitySecurityAcrossBorders.pdf (last visited, Jan. 8, 2019).

509 *Id.* at 59–60.

510 "In 2011 both Norway and Sweden increased the number of national price zones in order to improve price signals to market participants to better reflect the physical state of the network. This should, in theory, allow for more efficient utilisation of the transmission lines and provide a more market driven response to periods of high congestion." *Id.* at 58.

511 *Id.* at 60.

would be to have the zone borders align with the points where the transmission system is constrained to better utilize the Nordic grid as a whole.[512]

Due to the threat of power outages and scarce supply, Sweden placed an obligation and a fixed target for reliability standards on Svenska Kraftnät to ensure a strategic reserve.[513] According to the Electricity Act, all electricity suppliers are obligated to supply the amount of energy required by their consumers, and it is ultimately the responsibility of Svenska Kraftnät to oversee that the demand is met.[514] Winters in Sweden, especially in the northern parts, can be quite cold, which makes planning ahead essential for reliability in the market.[515] Svenska Kraftnät has therefore procured contracts with a selection of electricity producers with backup power plants in order to secure sufficient delivery of electricity during demand spikes.[516]

D. Smart Metering Systems

The smart grid envisioned for the EU is reliant on accurate and real time data from smart meter readings.[517] Sweden started the first phase of installing smart meters in 2003, making monthly readings of electricity mandatory (hourly for large-scale consumers) and obligated the DSO to install smart meters for all their customers by 2009.[518] The law was effective, and practically all end-consumers now have smart meters in place.[519] While the DSOs assume that all consumers now have installed smart meters, the numbers are not entirely clear, as there are over one hundred different DSOs in Sweden, all responsible for enabling smart meters for their respective costumers.[520]

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512 *Id.* at 25.

513 *Id.* at 39.

514 *Operations and Market*, SVENSKA KRAFTNÄT, https://www.svk.se/en/national-grid/operations-and-market/ (last visited 14 December 2018).

515 *Power Reserve*, SVENSKA KRAFTNÄT, svk.se/en/national-grid/operations-and-electricity-markets/power-reserve/ (last updated Jan. 8, 2018).

516 *Id.*

517 NORDIC ENERGY REGULATORS, RECOMMENDATIONS ON COMMON NORDIC METERING METHODS 12 (2014), http://www.nordicenergyregulators.org/wp-content/ uploads/2013/02/Common-Nordic-Metering-Methods.pdf.

518 *See* Abhishek Shivakumar et al., *Smart Energy Solutions in the EU: State of Play and Measuring Progress* 20 ENERGY STRATEGY REV. 133, 142 (2018).

519 DANISH ENERGY REGULATORY AUTHORITY, NATIONAL REPORT: DENMARK STATUS FOR 2016 35 (2017).

520 Shivakumar et al, *supra* note 518, at 142.

After 2012, hourly metering has been available for all Swedish consumers.[521] However, consumers currently have the choice to implement hourly metering through contracts with their DSO at no extra cost.[522] While the roll-out of smart meters has been successful, data management systems are currently unable to handle the surge in information.[523] In 2010, a year after the completed rollout, the data management systems only had the capacity to process approximately thirty percent of the hourly data received.[524] As such, system upgrades are needed for the technology of smart meters in Sweden to be effective.[525] However, with the implementation of the "DataHub," explained in more detail below, this data management problem might be solved.[526]

The smart meters deployed in 2009 are now approaching the end of their technical lifespan and replacements are required by 2020.[527] Some Swedish DSOs have started rolling out the next generation smart meters, but this process has been slow due to regulatory difficulties.[528] The aim for the new smart meters is to empower the consumer by requiring the new smart meters to be able to send and retrieve more information at a higher frequency.[529]

E. Demand Response in Sweden

Demand response is when an electric utility customer changes their power consumption to match the demand for power and supply. Demand response is an important tool to handle peak-load situations, enable renewable integration, and improve market competition and consumer empowerment. To take full advantage of demand response, each member state must employ both explicit and implicit demand response

521 *See* ELLAG (Svensk Författningssamling [SFS] 1997:857) (Swed.) [hereinafter ELECTRICITY ACT].

522 *Id.*

523 RECOMMENDATIONS ON COMMON NORDIC METERING METHODS, *supra* note 516, at 18.

524 *Id.*

525 *Id.*

526 *DATA HUB*, *supra* note 180.

527 ENERGIMARKNADSINSPEKTIONEN, FUNKTIONSKRAV PÅ ELMÄTARE–FÖRFATTNINGSFÖRSLAG , R2017:08 14,41 (2017), https://www.ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202017/Ei_R2017_08.pdf.

528 *Id.* at 41–42.

529 *Id.* at 6.

mechanisms.[530] Explicit demand response refers to the aggregated demand-side resources traded in the wholesale, balancing, and capacity mechanisms markets.[531] Consumers can choose to either profit from their generation flexibility individually or through a contract with an aggregator (third-party aggregator, retailer, DSO).[532] With implicit demand response, the individual consumer has the opportunity to change consumption patterns in reaction to dynamic market or network pricing signals.[533] Thus, a prerequisite for demand response to function optimally is dynamic pricing mechanisms.[534]

1. Explicit Demand Response

Both demand response participation and aggregation of demand side resources are legally possible in ancillary services in Sweden. However, there are still issues related to accessing different markets[535] and the accompanying product requirements.[536] A Smart Energy Demand Coal report concluded that consumers need clearer definitions of the roles and responsibilities of the different actors in the Swedish regulations to inform their choice of demand response service providers.[537] Furthermore, while the reserves are legally open to the demand side, participation is still limited due to regulatory barriers.[538] For an independent third-party aggregator to operate, it needs to be a Balance Responsible Party ("BRP"), and it must have a contract with the consumer's retailer or BRP.[539] This requirement for a contractual relationship between competitors in the market may impede the demand response potential.[540]

Moreover, the minimum bid size requirements to participate in the Nord Pool markets are relatively low (around 0.1 MW), which should allow demand-side participation.[541] Conversely, the minimum bid size requirement for the balancing market is considerably higher (e.g., around

530 SMART ENERGY DEMAND COAL, EXPLICIT DEMAND RESPONSE IN EUROPE: MAPPING THE MARKETS 2017 23 (2017), https://www.smarten.eu/wp-content/uploads/2017/04/SEDC-Explicit-Demand-Response-in-Europe-Mapping-the-Markets-2017.pdf.

531 *Id.*

532 *Id.*

533 *Id.*

534 Shivakumar et al., *supra* note 518, at 143.

535 The wholesale market (Nord Pool, Elspot and Elbas), in the strategic reserve and to some extent in the distribution network services.

536 SMART ENERGY DEMAND COAL, *supra* note 530, at 182.

537 *Id.* at 200.

538 *Id.* at 182.

539 *Id.*

540 *Id.*

541 *Id.* at 186.

ten MW in the Nordic Regulating Power Market) and may hamper demand-side participation.[542] The current settlement period of sixty minutes is insufficient and a move to fifteen minute intervals, which is currently under discussion within Nord Pool, might help reduce this market barrier and allow participants to react to scarcity in real time.[543]

2. Implicit Demand Response

The Nordic Council of Ministers estimates that the largest potential impact from demand response is within the residential and housing sectors.[544] As such, it is important to engage and empower the end consumer.[545] The technical functionality of most of the smart meters installed in Sweden do not support hourly or fifteen minute metering frequency.[546] The ongoing rollout of newer smart meters will be key in facilitating implicit demand response, in addition to developing communication and collection systems that are able to handle the data load.[547]

However, there are additional barriers that might hamper demand response.[548] For instance, in the Nordic region, a majority of the DSOs offer volumetric tariffs where customers pay a consistent rate for the total amount of electricity they consume, regardless of the time of consumption. While this approach may incentivize overall energy efficiency, it does not incentivize demand response.[549] In Sweden, it is entirely up to the DSO to design the tariffs, with the only restraints being that they have to be objective, non-discriminatory, and compatible with efficient energy usage.[550]

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542 NORDIC ENERGY REGULATORS, STATUS REPORT ON REGULATORY ASPECTS OF DEMAND SIDE FLEXIBILITY, 7, http://www.nordicenergyregulators.org/wp-content/uploads/2016/12/NordREG-Status-report-on-regulatory-aspects-of-demand-side-flexibility.pdf (last visited Jan. 9, 2019).

543 TEMANORD, FLEXIBLE DEMAND FOR ELECTRICITY AND POWER: BARRIERS AND OPPORTUNITIES 11 (2017), http://norden.diva-portal.org/smash/get/diva2:1167837/FULLTEXT01.pdf.

544 *Id.* at 14.

545 *Id.* at 55.

546 Anne Vadasz Nilsson & Linda Weman Tell, *Introduction* to ENERGIMARKNADSINSPEKTIONEN, *supra* note 526, at 3.

547 RECOMMENDATIONS ON COMMON NORDIC METERING METHODS, *supra* note 516, at 40.

548 STATUS REPORT ON REGULATORY ASPECTS OF DEMAND SIDE FLEXIBILITY, *supra* note 542, at 35.

549 *Id.*

550 4 ch. 1 § ELLAG (Svensk Författningssamling [SFS] 1997:857) (Swed.).

A regulatory amendment might be necessary to specify that DSOs should use tariffs in a way that fosters more demand response, not just general energy efficiency.[551] In fact, in the Stockholm Royal Seaport pilot project, one of the aims was to test the response of the participating households in relation to a time-of-use-based electricity price tariff.[552] A subsequent study of the data gathered from this project suggests that demand response, together with dynamic pricing tariffs, has the potential to significantly reduce household consumption.[553] Certain Swedish DSOs already offer tariffs that stimulate demand response.[554] However, there are great disparities between the many different DSOs.[555] The implementation of tariffs that are better suited to stimulate demand response throughout Sweden is likely considering that the industry organization[556] and the Nordic regulators[557] have engaged in discussions on amending and harmonizing the tariff designs.[558] In short, Sweden and the other Nordic countries need to change and harmonize tariff design to enable dynamic price signals to the end-consumer and thereby incentivize behavioral change.[559]

Generally, Swedish consumers are not engaged in demand response. In addition to the reasons previously stated, this lack of engagement results from the type of contract and the accompanying electricity prices.[560] While Swedish DSOs offer various electricity contracts, the most common contract usually comes with a fixed monthly price or with variable prices adjusted for seasonal factors.[561] Thus, there is no real incentive for the Swedish consumer to adjust consumption patterns.[562]

Even if incentives for the end consumer to change its consumption patterns through dynamic price signals is enabled, this might not be

551 TEMANORD, *supra* note 543, at 13.

552 Anders Nilsson et al., *Household Responsiveness to Residential Demand Response Strategies: Results and Policy Implications from a Swedish Field Study*, 122 ENERGY POLICY 273, 276 (2018), *available at* https://doi.org/10.1016/j.enpol.2018.07.044.

553 *Id.* at 282.

554 STATUS REPORT ON REGULATORY ASPECTS OF DEMAND SIDE FLEXIBILITY, *supra* note 542, at 34

555 *See id.* at 36.

556 Energiföretagens Sverige.

557 NordREG.

558 TEMANORD, *supra* note 543, at 12.

559 *Id.*

560 Shivakumar et al., *supra* note 518, at 147.

561 Kjeang et al., *supra* note 383, at 2.

562 Shivakumar et al., *supra* note 518, at 142.

enough.[563] Aggregated demand response resources could fill this gap in the market where the consumer does not bother adjusting consumption.[564] Therefore, Sweden should enable further use of aggregation services, which can gather demand flexibility from multiple sets of consumers and thereby alleviate both the costs and nuisance related to administration requirements. DSOs, electricity retailers, and others can all provide aggregation services, so Swedish law should start regulating them on equal terms.[565]

F. Data Protection

While the expansion of recent technology and digitalization of the energy system is a positive and necessary development, it also poses new risks and challenges, especially in terms of cyber security of the network and data protection with regards to personal information.[566]

1. Data Protection and Smart Meters

Like the other EU countries, the smart grid solutions of Sweden, including smart metering systems, will have to be compliant with the data protection and privacy regulations at the EU level. Notably, the recently adopted General Data Protection Regulation[567] ("GDPR"),[568] at least to the extent that the information gathered and processed is categorized as personal information.[569] One of the functions of smart meters is to gather data about household consumption patterns which different entities analyze to create a customer profile.[570] With access (authorized or unauthorized) to metadata from smart meters or customer profiles, it would be possible to determine when people of the household are usually

563 STATUS REPORT ON REGULATORY ASPECTS OF DEMAND SIDE FLEXIBILITY, *supra* note 542, at 36.

564 TEMANORD, *supra* note 543, at 67.

565 *Id.* at 68.

566 *See generally* Maria Andersson & Lars Westerdahl, *The Swedish Electricity Supply System: How to Deal with Increasing Vulnerability*, TOTALFÖRSVARETS FORSKNINGSINSTITUT, Memo 6204 (2017).

567 Dataskyddsförordning.

568 1 ch.1 § LAG DATASKYDDSFÖRORDNING (Svensk Författningssamling [SFS] 2018:218) (Swed.).

569 GDPR, *supra* note 166, at art. 1.

570 ENERGIMARKNADSINSPEKTIONEN, AN INFORMATION MANAGEMENT MODEL FOR THE FUTURE SWEDISH ELECTRICITY MARKET, R2015:15, 47 (2015), https://www.ei.se/PageFiles/140613/Ei_R2015_15_An_information_managment_model_for_the_future_Swedish_electricity_market.pdf.

home.[571] Thus, these data sets will likely be considered personal data pursuant to the GDPR,[572] and the DSO and other entities processing smart metering data will most likely fall under the scope of the regulation.[573]

According to the GDPR, actors involved in data processing have different levels of responsibilities, namely: "controller;" "processor;" or authorized "third-parties."[574] DSOs are the owners and operators of smart meters in Sweden and are categorized as the controller pursuant to the regulation.[575] However, due to the number and complexity of relationships related to the processing of metering data, assigning the right definition to each and every actor involved could prove challenging.[576] Therefore, the EU Commission proposed amendments to the existing Directive on the Internal Market in Electricity[577] in an effort to regulate data protection for smart meters.[578] However, the provisions of the GDPR will apply in most circumstances, and the recast could provide some clarity for the electricity sector, smart metering, and the participating actors.[579]

In Sweden, the Energy Market Inspectorate ("EMI") was tasked with investigating and recommending a general framework for information management suited to the future electricity market.[580] The EMI´s work lead to the implementation of the DataHub,[581] which is to be managed and further developed by Svenska Kraftnät.[582] The DataHub will be an access and exchange point for information from the increasingly "smart"

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571 *Id.* at 25.

572 GDPR, *supra* note 166, at art. 5.

573 Alessandra Fratini & Giulia Pizza, *Data Protection and Smart Meters: The GDPR and the 'Winter Package' of EU Clean Energy Law*, EU LAW ANALYSIS: BLOGGER (Mar. 22, 2018), http://eulawanalysis.blogspot.com/2018/03/data-protection-and-smart-meters-gdpr.html.

574 GDPR, *supra* note 166, at art. 4 (7), (8), (10).

575 Fratini & Pizza, *supra* note 573.

576 *Id.*

577 Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 Concerning Common Rules for the Internal Market in Electricity and Repealing Directive 2003/54/EC (L 211) 55, 62 (EU).

578 *Proposal for a Directive of the European Parliament and of the Council on Common Rules for the Internal Market in Electricity (Recast)*, at 74 COM (2016) 864 final (Feb. 23, 2017).

579 Fratini & Pizza, *supra* note 573.

580 *An Information Management Model for the Future Swedish Electricity Market Ei R2015:15*, SWEDISH ENERGY MARKETS INSPECTORATE 10–11 (Jun. 2014), https://www.ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202014/Ei_R201515.pdf [hereinafter SWEDISH ELECTRICITY MARKET EI R2015:15].

581 DataHub translated from Elmarknadshubben.

582 Uppdrag att utveckla och driva en central informationshanteringsmodell [Mandate to Develop and Operate a Central Information Hub], M2015/2635/Ee (Jun. 25, 2015) 1 (Swed.).

electricity system.[583] It will also take into account the privacy and data protection risks accompanied with this dissemination of information.[584] The DataHub will most likely reduce data handling costs for DSOs and others, while helping improve data managing capacity.[585] It is expected that the DataHub will be operational by 2022.[586]

2. Information Security

There are also growing concerns related to data theft or fraud from cyberattacks on smart meters and related technologies.[587] The NIS-Directive ("Directive") regulates information security in the EU's energy sector.[588] However, even though the Directive is concerned with the energy sector, it does not mention any specific requirements targeting smart grids and smart meters.[589] Micro and small enterprises offering digital services are exempt from the Directive's provisions, arguably so that they do not disproportionally burden smaller enterprises.[590] However, the same micro and small enterprises will be important to the future smart grid of Sweden and the EU.[591] As such, this exemption may cause a significant deficit in the information security of the entire system.[592]

In 2017, the Energy Market Inspectorate published a proposal[593] to add functionality requirements to the existing Ordinance on Electricity

583 *DATA HUB*, *supra* note 180.

584 SWEDISH ELECTRICITY MARKET EI R2015:15, *supra* note 580, at 30.

585 *See generally DATA HUB*, *supra* note 180.

586 *Id.*

587 Anderson & Westerdahl, *supra* note 566.

588 Directive 2016/1148, of the European Parliament and of the Council of 6 July 2016 Concerning Measures for a High Common Level of Security of Network and Information Systems Across the Union, 2016 O.J. (L 194) 1, 2 [hereinafter Directive 2016/1148]; 11–16 §§ SÄKERHETSÅTGÄRDER, LAG OM INFORMATIONSSÄKERHET FÖR SAMHÄLLSVIKTIGA OCH DIGITALA TJÄNSTER (Svensk författningssamling [SFS] 2018:1174) (Swed.).

589 *See* Directive 2016/1148, *supra* note 587.

590 *Id.* at (53).

591 Directive 2009/72, of the European Parliament and of the Council of 13 July 2009 Concerning Common Rules for the Internal Market in Electricity and Repealing Directive 2003/54/EC, 2009 O.J. (L 211) 55, 59–60 (EU).

592 M.-T. Holzleitner & J. Reichl, *European provisions for cyber security in the smart grid – an overview of the NIS-directive*, 134 E & I ELEKTROTECHNIK UND INFORMATIONSTECHNIK 14, 15 (2017) (Swed.).

593 Linda Weman Tell et al., *Funktionskrav på elmätare – Författningsförslag* [*Functional Requirements for Electricity Meters – Proposal for Ordinance*], ENERGIMARKNADSINSPEKTIONEN 14 (Nov. 2017), https://www.ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202017/Ei_R2017_08.pdf.

Metering.[594] The proposal attracted criticism from industry actors, most notably from Svenska Kraftnät.[595] Specifically, industry said the proposal did not adequately protect the privacy and security of customers' personal information.[596] Svenska Kraftnät suggested that in order to authenticate that only individual customers can access their own personal data, the authentication process should go through the DataHub by means of electronic ID (such as Bank ID) or a single-use code.[597] However, the government chose not to follow Svenska Kraftnät´s suggestion in the new ordinance.[598] Perhaps such measures will follow once the DataHub is operational, but for now an authentication process through an open customer interface will have to suffice.[599]

The implementation of smart meters may be increasing the system's vulnerability because the possible points of attack have multiplied.[600] Therefore, it is important that adequate security measures are in place at each "entry point".[601] A greater level of coordination is required in deploying security measures and in monitoring and controlling all components within the system.[602] The NIS-Directive and other regulations, such as the GDPR and the smart meter functionality requirements, all stipulate an appropriate level of security in all information processing services, including in smart meters.[603] Still, these rules remain ambiguous and fail to specify what security measures are appropriate or adequate for each specific component or service.

The EU is currently working on new and more specific rules and guidelines specifically aimed at security and data protection issues related

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594 FÖRORDNING OM MÄTNING, BERÄKNING OCH RAPPORTERING AV ÖVERFÖRD EL (Svensk författningssamling [SFS] 1999:716) (Swed.) [hereinafter ORDINANCE ON MEASUREMENT, CALCULATION, AND REPORTING OF TRANSMITTED ELECTRICITY].

595 *See Remiss av Energimarknadsinspektionens rapport Ei R2017:08, Funktionskrav på elmätare* [*Referral by the Energy Market Inspectorate report Ei R2017: 08, Functional requirements on electricity meter*], SVENSKA KRAFTNÄT (Feb. 7, 2018), https://www.regeringen.se/492165/contentassets/c86e1327daef4d3ca55ab3f3874c6f00/datainspektionen.pdf.

596 *See id.* at 2.

597 *See id.* at 4–5.

598 *See* ORDINANCE ON MEASUREMENT, CALCULATION, AND REPORTING OF TRANSMITTED ELECTRICITY, *supra* note 594.

599 *Id*.

600 Anderson & Westerdahl, *supra* note 565, at 1–2.

601 *See id.*

602 *Id*. at 2.

603 SÄKERHETSÅTGÄRDER 11–14 §§ LAG OM INFORMATIONSSÄKERHET FÖR SAMHÄLLSVIKTIGA OCH DIGITALA TJÄNSTER (Svensk författningssamling [SFS] 2018:1174) (Swed.), *supra* note 587; *GDPR*, *supra* note 166. *See* ORDINANCE ON MEASUREMENT, CALCULATION, AND REPORTING OF TRANSMITTED ELECTRICITY, *supra* note 594.

to a smarter electricity system.[604] Public emphasis on securing smart meters and the electricity system may lead to increased trust and possibly to increased participation.[605]

G. Electric Vehicles and Storage

As part of Sweden's long-term climate goals, they have set a goal for their vehicle fleet to be fossil fuel independent by 2040.[606] This might be one of Sweden's greatest challenges, as their transport sector is heavily reliant upon fossil fuels at this time. However, Sweden does have, behind Norway (6.4 %) and the Netherlands (1.6 %), the third largest share of EVs in the world, amounting to one percent in 2017.[607] In fact, EVs accounted for 6.3 percent of new sales[608] in 2017, including both battery electric vehicles ("BEV") and plug-in PHEVs.[609] The trend in Sweden is that PHEVs are gaining popularity faster than BEVs, with seventy-nine percent of the EVs sold in 2017 being PHEVs.[610]

A report by the International Energy Agency´s ("IEA"), "Nordic EV Outlook 2018", describes the Nordic region as world leaders in EV market penetration, and argues that the main reason for this is the range of different policy support measures implemented by the governments.[611] The key role of policy instruments for growth in the EV market becomes evident when comparing Denmark to the other Nordic countries. Whereas the Nordic countries have had relatively reliable EV policy schemes in place over the last years, the Danish government decided to make a shift in 2016, which subsequently resulted in a substantial decline in market growth.[612] This implies that to accomplish further EV market growth, Sweden must continue to make EVs appeal to customers, encourage up-scale in EV production, and reduce risk for investors; favorable policy measures are still necessary in Sweden, as well as the Nordic region.

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604 *Smart Grids and Meters*, EUROPA.EU, https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters (last visited June 12, 2019).

605 Fratini & Pizza, *supra* note 573.

606 Statens Offentliga Utredningar [SOU] 2013:84 Fossilfrihet på Veg Del 1 at 41 [Official Reports of the Swedish Government, Fossil-freedom on the road Part 1] (Swed.).

607 I INTERNATIONAL ENERGY AGENCY, NORDIC EV OUTLOOK 2018: INSIGHTS FROM LEADERS IN ELECTRIC MOBILITY 19–20 (2018), https://webstore.iea.org/download/direct/1010?fileName=NsordicEVOutlook2018.pdf.

608 Sales exclude second-hand imports.

609 INTERNATIONAL ENERGY AGENCY, *supra* note 607, at 16.

610 *Id.* at 17.

611 *Id.* at 11.

612 *Id.* at 24–25.

In 2006, Sweden introduced purchase incentives for energy efficient vehicles or vehicles fueled by renewable energy. First in the form of a rebate, then changed in 2012 to a purchase subsidy (supermiljöbilspremie) for vehicles with lower than fifty g CO_2/km (20,000 SEK, ≈ € 2160) or zero-emission vehicles (40 000 SEK,≈ € 4317).[613] In 2016, the government changed the policy again, introducing the current bonus-malus-scheme, in effect for vehicles registered after July 1, 2018.[614] The new subsidy scheme provides a bonus for private or company cars with lower than sixty g CO_2/km, (maximum SEK 60 000 (≈ € 6475) and minimum SEK 10 000 (≈ € 1079)), and progressively higher taxes on cars exceeding sixty g CO_2/km, in the first three years after registration.[615]

Additionally, low-emission vehicles registered before July 1, 2018 are exempt from the circulation tax, which is based on the weight of the vehicle and CO_2/km, in the first five years after registration.[616] For low emission vehicles registered after July 1, 2018, this exemption will no longer apply.[617] The main reason for the government deciding to abolish this tax exemption was that the definition of low emission vehicles in the Vehicle Tax Act[618] resulted in small (light) diesel vehicles being eligible for the exemption.[619]

The effect of purchasing incentives are, arguably, only as effective as the final purchase price. The bonus mechanism in Sweden reduces the price of EVs, but due to EVs being slightly more expensive than internal combustion engine vehicles ("ICE") when similar models are compared, the bonus is usually not sufficient in closing the price gap for the initial purchase.[620] Conversely, a study comparing more variables when equating

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613 Statens Offentliga Utredningar [SOU] 2011:1590 Förordning (2011:1590) om Supermiljöbilspremie [Regulation on Super-Environment Car Premium] (Swed.), https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20111590-om-supermiljobilspremie_sfs-2011-1590 [hereinafter Regulation on Super-Environment Car Premium].

614 *See generally* Statens Offentliga Utredningar SOU 2016:33 'Ett Bonus-Malus-System för Nya Lätta Fordon' (Official Reports of the Swedish Government 2016:33 'A Bonus-Malus-System for New Light Vehicles').

615 Finansdepartementet, Bonus-malus och Bränslebytet [Bonus-Malus and Change of Fuel] (2017), https://www.regeringen.se/artiklar/2017/09/bonus-malus-och-branslebytet/ (Swed.).

616 Regulation on Super-Environment Car Premium, *supra* note 613.

617 *Id.*

618 *See generally* FORDONSSKATTELAGEN (SVENSK FÖRFATTNINGSSAMLING [SF] 1988:327 [THE SWEDISH CODE OF STATUTES, VEHICLE TAX ACT 1988:327)] (Swed.).

619 *Bonus-malus och Bränslebytet* (Bonus-Mauls and change of fuel), REGERINGEN (Sept. 3, 2017) https://www.regeringen.se/artiklar/2017/09/bonus-malus-och-branslebytet/.

620 INTERNATIONAL ENERGY AGENCY, *supra* note 607, at 22.

the total cost of ICE, PHEVs and BEVs, found that BEVs could be the slightly cheaper option.[621] However, relevant data to make such comparisons are not readily available to consumers and might therefore not have the desired impact on the diffusion of EVs, implying that more transparency is needed.

While the Swedish EV share is one of the highest in the world, the adoption rate of EVs is still slow and varies considerably across municipalities.[622] Additionally, while the share of EVs among the new vehicle sales is increasing, most of these were PHEVs in 2017, whereas BEVs would be preferable. Since electricity production in Sweden is generated in large parts from renewable energy sources, combined with the fact that BEVs only require electricity as fuel, the impact of increasing the share of BEVs over PHEVs would indeed increase Sweden's ability to significantly reduce GHG emissions from the transport sector.[623]

The choice between BEVs and PHEVs is not only related to policy and incentive measures.[624] There is also a technological restraint related to the range of EV batteries, especially concerning BEVs.[625] This might also, to some extent, explain the variations in adoption across Swedish municipalities. Citizens in some municipalities and cities, especially in the south, experience shorter distances between work, home, etc., while other municipalities have substantially greater distances.[626] Therefore, it might not be possible or, at least practical, for every Swedish citizen to choose BEVs at this time. However, in view of the current development within battery technology, the range of BEVs might not be a deterrent in the future.[627]

Moreover, expanding the charging points for EVs across the country, would have a positive effect,[628] not only in rural areas, but also in urban areas. Swedish people who live in detached houses prefer, to a large

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621 Jens Hagman, Sofia Ritzén, Jenny Janhager Stien & Yusak Susilo, *Total Cost of Ownership and its Potential Implications for Battery Electric Vehicle Diffusion* 18 RES. IN TRANSP. BUS. & MGMT. 11, 16 (2016).

622 Filippa Egner & Lina Trosvik, *Electric Vehicle Adoption in Sweden and the Impact of Local Policy Instruments* 121 ENERGY POL'Y 584, 584 (2018).

623 *Id.* at 584.

624 *See generally Attitydundersökning av svenskars kunskaper om och inställning till elfordon*, ENERGIMYNDIGHETEN 17–19 (May 22, 2014) https://www.energimyndigheten.se/globalassets/nyheter/2014/resultat-attitydundersokning-av-svenskars-kunskaper-om-och-installning-till-elfordon.pdf

625 Hagman et. al, *supra* note 621, at 11.

626 Egner & Trosvik, *supra* note 622, at 590.

627 *See generally* INTERNATIONAL ENERGY AGENCY, *supra* note 607, at 63–64.

628 *Attitydundersökning av svenskars kunskaper om och inställning till elfordon*, *supra* note 624, at 20.

degree, home charging. To this end, from January 1, 2018, the government offers a grant to private individuals installing home charging points.[629] In the larger cities, it is more common to live in dwellings and flats, where limited parking with charging points may affect customers' choices for vehicles. Increasing the number of publicly available charging points will be important in this regard. For example, so-called "charging streets" are being built in the capitol Stockholm, aiming to establish 500 charging point along certain streets before 2020.[630] Another interesting Swedish initiative,[631] to build the world´s first electric road, has been established in Gävleborg. This initiative is supplying larger transport vehicles with electricity while traveling.[632] Currently, the project consists of a two km stretch road, with a new pilot stretch to be announced in the summer of 2019 which aims to test two different charging techniques.[633] Depending on the effectiveness of these roads, it could prove to be an important instrument in reducing emissions, especially from the heavy goods vehicle traffic.[634]

According to current procurement legislation in Sweden, public authorities and municipalities are mandated to consider the environmental impact of vehicle purchases (with exceptions for emergency vehicles), but does not obligate them to purchase EVs specifically.[635] Additionally, in 2016 the government implemented an electric bus premium for public transport, for which eligible municipalities and regional public transport agencies can apply.[636] The amount of the grant varies between SEK

629 § 3 Förordning 2017:1318 om Bidrag till Privatpersoner för Installation av Laddningspunkt till Elfordon [Ordinance 2017:1318 on Grant for Private Individuals for the Installation of Charging Points for Electrical Vehicles].

630 *Laddgator i Stockholm [Laddgator in Stockholm],* STOCKHOLM CITY (Nov. 11, 2019),http://www.stockholm.se/Fristaende-webbplatser/Fackforvaltningssajter/Miljoforvaltningen/Miljobilar/Bilar--branslen/Miljobranslen/#Laddgator.

631 Financed by the Swedish Transport Agency, the Swedish Energy Agency, VINNOVA, Scania and Simens.

632 *See The World's first electric road on E16*, REGION GÄVLEBORG (Dec. 4, 2015), https://www.regiongavleborg.se/regional-utveckling/samhallsplanering-och-infrastruktur/elvag/the-electric-highway-in-english/.

633 *See About the Project*, REGION GÄVLEBORG (Mar. 4, 2016), https://www.regiongavleborg.se/regional-utveckling/samhallsplanering-och-infrastruktur/elvag/the-electric-highway-in-english/about-the-project.

634 *The World's First Electric Road on the E16*, REGION GÄVLEBORG (Apr. 9, 2019), https://www.regiongavleborg.se/regional-utveckling/samhallsplanering-och-infrastruktur/elvag/the-electric-highway-in-english.

635 §§ 2, 5 Svensk Författningssamling (SFS) Lag 2011:846 om Miljökrav vid Upphandling av Bilar of Vissa Kollektivtjänster [The Swedish Code of Statues, Act 2011:846 on Environmental Requirements for Procurement of Vehicles and certain Public Services].

636 *The World´s First Electric Road on the E16*, *supra* note 634.

100,000 and SEK 700,000 (≈ € 10,730 – 75,120), depending on the transport capacity and whether it is a BEV or a PHEV.[637] Both initiatives are aimed at encouraging the diffusion of EVs in the public transport sector, which may also cause positive spill-over effects to the EV market generally. For example, if EVs becomes a larger part of the public fleet, it may influence public opinion and awareness by making EV more common-place, influence prices by bulk purchasing, encourage up-scale in EV production, and stimulate increased investment in charging services.[638]

To further stimulate these effects, another large purchasing group may have the potential to be influential when purchasing company cars, namely in the private sector. A cooperation forum named Fossil Free Sweden was established, aiming to bring together government agencies, municipalities, organizations, and industry actors from across the country in order to meet the goal for Sweden to become one of (if not the) first fossil free welfare country.[639] One of Fossil Free Sweden's initiatives in this regard has been to launch a challenge for the business community. Namely, that all company cars, bought or leased from the year 2020 or earlier, should be either be BEV, PHEV, or biogas vehicles.[640] So far more than 115 actors have signed up for the challenge, and this number is expected to increase.[641]

A major part of Sweden's economy is the automobile industry,[642] and there are signs of changes occurring in this sector as well. Volvo has launched a separate electric vehicle brand, Polestar.[643] Saab went bankrupt in 2012, but its main assets were acquired by a new company, National Electric Vehicle Sweden ("NEVS").[644] NEVS is focusing solely on electrical vehicle manufacturing, starting in the Chinese market, then aiming to expand globally.[645] Another Swedish electric vehicle company

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637 Förordning 2016:863 om Elbusspremie [Regulation 2016:836 on Electric Bus Premium].

638 INTERNATIONAL ENERGY AGENCY, *supra* note 607, at 28.

639 *Roadmaps for Fossil Free Competitiveness*, FOSSIL FREE SWEDEN, http://fossilfritt-sverige.se/in-english/ (last visited Sept. 19, 2019).

640 *The Company Car Challenge*, FOSSIL FREE SWEDEN, http://fossilfritt-sverige.se/utmaningar/tjanstebilsutmaningen/ (last visited Sept. 19, 2019).

641 *Id*.

642 Benjamin Elisha Sawe, *What Are the Biggest Industries in Sweden?*, WORLDATLAS (June 5, 2019), https://www.worldatlas.com/articles/what-are-the-biggest-industries-in-sweden.html.

643 *This is Us*, POLESTAR, https://www.polestar.com/ (last visited Sept. 19, 2019).

644 *See generally About us*, NEVS, https://www.nevs.com/en/about/ (last visited Sept. 19, 2019).

645 *Id*.

is Uniti, which started as a research project at the Swedish university Lund.[646] Uniti vehicles are currently only available for pre-order, but they have announced a partnership with E.ON to provide Swedish customers with five years of electricity (guaranteed from solar) for home charging when purchasing a Uniti vehicle.[647] While Sweden's electric vehicle actors are mostly in introductory stages, these examples indicate a nominal change in the industry and market.

Currently, the electricity demand from EVs has had little effect on the total electricity demand in Sweden, and also little effect on the electrical grid. Considering the current low adoption percentage of EVs, this is not surprising. However, the number of EVs are expected and intended to increase substantially in coming years. While the Swedish grid, compared to other EU countries, is generally more resilient, increased demand could potentially stress the distribution grids unless properly managed. Smart grid solutions, such as demand response, dynamic electricity pricing, automated regulation of charging, and vehicle-to-grid solutions will be important to address the increase in electricity demand from an increased number of EVs.

H. Storage

Storing electrical energy is of increasing importance as Sweden introduces new intermittent renewable energy into the grid.[648] Sweden has large reserves of stored hydropower, such as the Suvora Dam.[649] Beyond this, however, there is no substantial storage capacity in Sweden, and market interest has been relatively limited thus far.[650]

Pursuant to the Energy Act, the TSO or the DSOs of Sweden may legally own stored energy, but they may only use the energy in

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646 *Our Story*, UNITI, https://www.uniti.earth/global/company/ (last visited Sept. 19, 2019).

647 *Uniti One electric car available to order from £15,100*, MOTORARTICLES (Oct. 13, 2019), https://www.motorarticlesorg.com/2019/10/13/uniti-one-electric-car-available-to-order-from-15100/.

648 ANNA NORDLING, Sweden's Future Electrical Grid: A Project Report 35–36 (Camilla Koebe, IVA ed., 2017), https://www.iva.se/globalassets/info-trycksaker/vagval-el/vagvalel-swedens-future-electrical-grid.pdf.

649 *Id.* at 35.

650 *See Id.*; *See* ANNA NORDLING ET AL., ENERGY STORAGE ELECTRICITY STORAGE TECHNOLOGIES IVA'S ELECTRICITY CROSSROADS PROJECT 10 (Camilla Koebe, IVA ed., 2016), https://www.iva.se/globalassets/rapporter/vagval-el/201604-iva-vagvalel-ellagring-rapport-english-e-ny.pdf.

emergencies.[651] They are not permitted to store energy to later trade it so as to insulate the market price of electricity.[652] For energy storage to become commercially possible and attractive for the TSO, DSOs, and others, the government will have to make amendments to the Electricity Act. With more storage capacity, Sweden would increase its self-sufficiency.[653]

Even if grid operators only have a few circumstances where they can legally use their stored energy, they still have the option of purchasing stored energy from third-party actors.[654] However, many actors may hesitate to store energy for this purpose, since an entity selling electricity must be a BRP or have a contract with a BRP.[655] Further, the energy tax is applicable to these entities. Thus, the entity selling energy to the grid operators would be paying for the distribution of the energy through both grid and connection tariffs.[656] Unlike DSOs, these entities cannot recoup their losses by selling the electricity to end consumers.[657] As such, they might have to sell electricity to grid operators at a higher price to make a profit.[658] On the other hand, these individual entities or households could engage a managing aggregator and combine their storage capacities. Laws and regulations should be amended to better correspond to different market actors, related to minimum bid size and fees.[659]

In Sweden, batteries are expected to make up a larger part of the energy system in the future,[660] both with regards to residential storage and the increased use of electric vehicles.[661] In 2016, the government introduced a support grant to private individuals for the storage of self-produced energy.[662] However, this grant is only applicable for measures initiated between January 2016 and December 2019, and only if the system

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651 For example, to cover grid losses or in case of power failures. ELECTRICITY ACT, *supra* note 521, at ch. 3, §§ 1a–1f.

652 *Id.* at ch. 3, § 1a.

653 NORDLING, *supra* note 648, at 31.

654 MALIN HANSSON, OLLE JOHANSSON & BO NORMARK, ENERGILAGER I ENERGISYSTEMET [ENERGY STORAGE IN THE ENERGY SYSTEM] 1 (2014), http://powercircle.org/wp-content/uploads/2014/09/Underlagsrapport-Energilager-i-energisystemet.pdf.

655 SMART ENERGY DEMAND COAL, *supra* note 530, at 185.

656 HANSSON ET AL., *supra* note 654, at 16, 26.

657 *Id.* at 16.

658 *Id.* at 26.

659 SMART ENERGY DEMAND COAL, *supra* note 530, at 30.

660 NORDLING ET AL., *supra* note 650, at 5.

661 *Id.*

662 § 1 Förordning (2016:899) om Bidrag till Lagring av Egenproducerad Elenergi [Regulation (2016: 899) on Grants for the Storage of Self-Generated Electrical Energy] (Swed.) [hereinafter Ordinance on Storage of Self-Produced Electricity].

is connected to both the grid and a plant for self-production of renewable energy.[663] In addition to this subsidy scheme, Sweden will have to clarify and amend existing rules for the energy storage market to develop further.

CONCLUSION

The Danish climate strategy follows the holistic ethos of "if we all make an effort, together we can change the world." This ethos is apparent in the policies and regulations the Danish government passed. The Danish government was in a state of crisis in the late 1970s but was able to self-reflect and realize its shortcomings and develop aspirations. In response, the Danish government found a way to turn their energy strategy around to become one of the leading countries in the world on renewable energy, with a particular focus on wind power.

The Danish smart grid is particularly advanced in accommodating connectivity of an increasing amount of renewable energy. The Act on Promotion of Renewable Energy supports this end. Further, the Danish electricity market is maturing, with growing trends of renewable energy generation and reduced fossil fuel dependency. Large-scale investment is promoting technological projects such as smart cities, electric vehicles, smart meters, and energy storage. With these investments, Denmark will continue to increase its electric energy flexibility and trade energy with neighboring countries in line with EU targets.

Though some view Denmark as a pioneer, there are still challenges it needs to face. Importantly, Denmark must face these challenges while keeping the end consumer in mind. Allocating large amounts of public spending to grid technology and renewable energy will ultimately cost the taxpayer and the electricity user. Consumers are also experiencing tax hurdles and barriers to selling self-generated energy back to the grid as prosumers. These obstacles are ultimately hurting the market and restraining competition to occur outside government funded projects. Restructuring to phase out public spending is vital to creating a stronger energy system. Therefore, it is essential to focus on finding cost-effective ways to promote innovation.

The Swedish electricity system is, compared to most other electricity systems in the world, more sustainable and better equipped to manage flexibility. The natural availability of hydropower is the main reason that Sweden has a predominantly sustainable electricity production, and that the introduction of intermittent renewable energy from wind and solar has

663 *Id.* at § 2.

yet to cause major problems.[664] Sweden´s hydropower reserves are, however, not unlimited, and the introduction of even larger quantities of intermittent electricity will cause difficulties if not managed properly. Such development is placing increasing demands for balance and flexibility on the electricity system, especially considering the phase-out of nuclear power.[665]

Sweden expects that wind power will assume a larger share of electricity production in the future,[666] but the current offshore wind projects are not attracting the investment necessary to offset the nuclear phase-out within the 100 percent renewable timeframe.[667] To this end, the government must show a greater commitment and establish a clearer long-term plan.[668]

Subsidy schemes, such as the green certificate scheme, have been effective in incentivizing producers to invest in renewable electricity production, especially in the onshore wind sector. However, there is a concern that intensive subsidy schemes kept in place for too long will in turn hamper natural market growth.[669] The government needs to establish clearer goals and policy adjustments in order to better steer the market in the preferred direction.[670]

Maintaining the reliability of the Swedish electric grid is dependent upon the implementation of new smart grid solutions. In the storage market, the government should remove some of the legal barriers hampering the utilization of storage possibilities.[671] While a grant program supports individuals in installing storage capacity,[672] the barriers are still substantial on a larger scale and for aggregators, and the definitions and ownership rules remain unclear.[673]

Other smart grid solutions, such as demand response, dynamic electricity pricing, automated regulation of charging, and vehicle-to-grid

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664 Regeringens proposition 2017/18:243 Vattenmiljö och vattenkraft [Government Bill 2017/18:243 Aquatic environment and hydropower] (Swed.), https://www.riksdagen.se/sv/dokument-lagar/dokument/proposition/vattenmiljo-och-vattenkraft_H503243.

665 NORDLING, *supra* note 648, at 5.

666 *See* Finjord et al., *supra* note 397.

667 TANJA TRÄNKLE ET AL., STAKEHOLDER VIEWS ON THE FUTURE OF OFFSHORE ENERGY AND GRID IN THE BALTIC SEA 6 (2018), http://www.baltic-integrid.eu/files/Meetings/Country%20Workshops/Country%20Workshop%20Poland%20II%20-%20MSP%20Challenge/Baltic%20LINes%20BIG_CPH-MSP-Challenge-workshop_3031%20Oct%202018.pdf.

668 *Id.* at 4(6)–6(6).

669 BONDESSON & BRÄNNLUND, *supra* note 464, at 7–8.

670 *Id.* at 9–10.

671 *See* NORDLING, *supra* note 648, at 36.

672 Ordinance on Storage of Self-produced Electricity, *supra* note 662, at § 1.

673 *See* NORDLING, *supra* note 648, at 51.

will be important in the electricity system going forward. Currently, Swedish regulations relating to these solutions are not ideal. Also, current smart meters have limited technical possibilities. Yet, smart grid solutions, especially demand response and dynamic pricing, are dependent upon features enabled by smart meters.[674] Therefore, the development and roll-out of new smart meters is essential to enabling additional smart grid solutions.

While ambitious policy goals such as the Framework Agreement are a great start, Sweden still needs specific policies which directly target different smart grid features. Sweden appears to be moving in the right direction concerning regulation and policies, but a substantial gap between the overarching goals and enforced policies remains. On the other hand, there is arguably a need for further research before comprehensive regulatory amendments are implemented. Also, before smart grid solutions and markets can be expected to grow, increased consumer and industry awareness about smart solutions and their benefits will be required.[675]

674 *Smart Metering for Residential Costumers – aiming for smarter use of energy*, SMARTREGIONS, https://www.sintef.no/globalassets/project/smartr egions/residential_we b_4.pdf (last visited Sept. 19, 2019).

675 Johannes Kestera ET AL., *Promoting Vehicle to Grid (V2G) in the Nordic Region: Expert Advice on Policy Mechanisms for Accelerated Diffusion*, 116 ENERGY POL'Y, 422, 432 PG (2018).