



Finnish smart grid vision

Smart grid working group

31 October 2016



Työ- ja elinkeinoministeriö
Arbets- och näringsministeriet



Table of contents

- **Contents**
- **Definitions**
- **Summary - Smart grid vision 2025**
- **Vision background, tasks and implementation**
- **Current state of the electricity market and changes in the operating environment**
- **Smart grid concept**
- **Smart grid visions in other countries**
- **Smart grid vision**

Disclaimer: this is a unofficial translation of the original Finnish version of the Smart Grid vision (30.10.2016).

Definitions 1/2



Energy efficiency

Permanent reduction and efficiency improvement of energy use

Distributed electricity generation

Small-scale electricity generation connected to the distribution network, typically located in close proximity to the sites where it is used

Distributed energy resources

Usually refers to distributed electricity generation connected to the distribution network, consumption and flexibility sites, and energy storages.

Disconnectable load

A load where the electric power consumption can be controlled or disconnected manually or automatically

Flexibility

New means of exchange, i.e. a commodity on the electricity market. There can be flexibility in consumption or generation. Covers demand-side management, storage, transmission connections, flexible generation and automated power network management.

Flexibility service provider

Provider which sells its customers flexibility in electric power related to power consumption and generation on an organised electricity market or make use of it in managing the electricity balance. For example, a power supplier and an independent aggregator can serve as a provider of flexibility services.

Cyber security

Aspect of security in which an effort is made to ensure the security of a digital, networked society. In cyber security, the impacts of disruptions to digital, networked systems are identified, prevented and prepared for.

Demand response

Temporary change in a customer's normal or momentary electric power consumption or microproduction based on the price of electricity or another incentive.

Definitions 2/2



Power balance

The power balance between electricity generation and consumption.

Technical flexibility operator

A role which is related to the technical service platform of demand-side management in order to facilitate the control of consumption and generation-specific operations. A technical flexibility operator provides a technical service platform for flexibility service providers in exchange for financial compensation.

Security of supply

The ability of the power system to produce and transmit electricity reliably and with good quality in order to meet the customers' needs at any given time. Security of supply consists of adequate electric power and transmission reliability.

Intermittent generation

Weather-dependent generation, such as solar and wind power, which is subject to seasonal variability and and the generation includes weather-related forecast uncertainty

Vision

An outlook or goal to be realised in a certain period of time. A vision describes the desired future.

Smart grid, smart electricity system

An extensive functional entity--a service platform--which covers not only the physical transmission and distribution of electricity, but also generation, distributed energy resources, power system flexibility and various smart grid applications. It links the physical transmission of electricity to wholesale and retail markets.

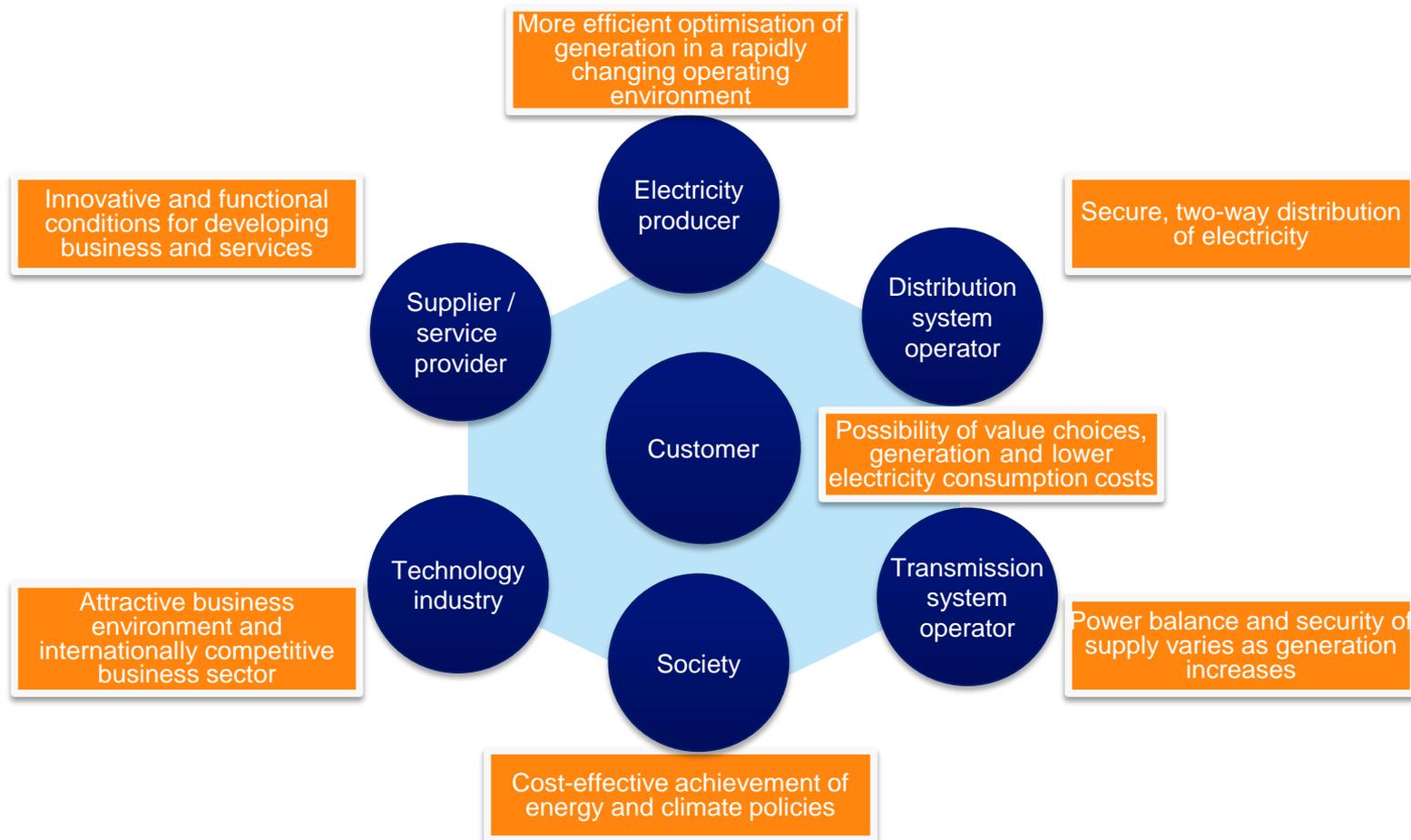


Summary

Summary – Vision for Smart Grids in Finland 2025



Smart grids will work as a service platform in the transition towards a more distributed and carbon-neutral power system. They will give the customers better possibilities for participating in the electricity market, improve security of supply and create new business opportunities for companies, while also ensuring cost-efficiency.





Vision background, tasks and implementation

Ministry of Economic affairs and Employment decision on appointment of the Smart grid working group



Appointment and tasks of the Smart grid working group

- The Finnish power system is currently undergoing one of the most significant changes in decades. An increase in intermittent generation and a reduction in conventional regulated generation capacity have raised concerns regarding generation adequacy during peak consumption times.
- Electricity consumption will play an increasingly important role in increasing flexibility of the power system. Small consumers, however, have shown little interest so far in participating in the electricity market.
- The Ministry of Economic Affairs and Employment (MEAE) decided to appoint a Smart grid working group, whose purpose is to explore the possibilities of smart electricity system ("smart grids") in promoting the active involvement of consumers in the market and improving the power system's security of supply.
- The task of the working group is to:
 - create a common vision for the future smart grids
 - explore and propose concrete measures, by means of which smart grids can facilitate the ability of customers to actively participate in the electricity market and generally promote preserving the security of supply
 - make recommendations for changing operating methods and regulations related to the above-mentioned themes
- MEAE serves as chair of the working group, while Energy Authority and Fingrid Oyj are participating in the secretariat
- Members and experts from various stakeholder groups are appointed to the working group
- The working group term is two years
- The working group will submit its final report by 30 September 2018

Purpose and tasks of the vision work



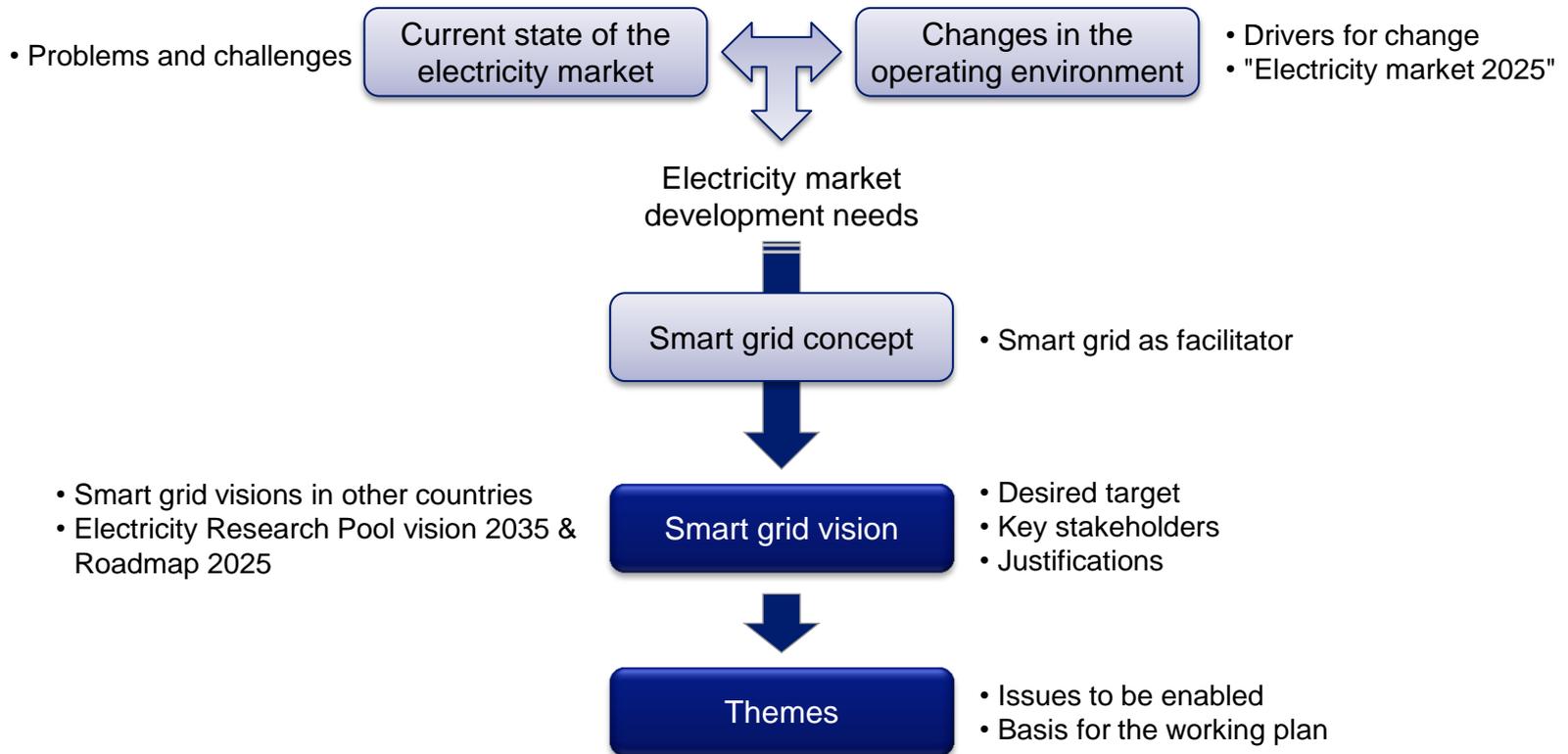
Goal: a Smart grid vision for 2025

- **The purpose of the vision work is to draft a vision ("Smart grid vision") for guiding the Smart grid working group**
- **Vision work involves the following:**
 - Outline a smart grid vision and the justifications for it
 - Specify what the solutions created in the Smart grid working group should enable, i.e. key themes for realising the vision goals
 - Take key operating environment perspectives into consideration, such as EU development, Nordic development and changes in the operating environment as well as existing visions
- **The purpose of the vision is to guide the organisation and function of the working group**
- **The vision does not take a stance on solutions - the focus is to present smart grids as a facilitator**
- **Where concrete measures are concerned, the indicative timespan of this vision extends to 2025, but it may also go beyond this.**
- **The smart grid vision was jointly prepared by the secretariat and a consultant**
- **The proposal for a smart grid vision was addressed at the first meeting of the Smart grid working group on 30 September 2016**

Framework for drafting the smart grid vision



The goal of the vision is to guide the activities of the Smart grid working group





Current state of the electricity market and changes in the operating environment

**What kind of electricity market and operating
environment is the smart grid vision being drafted
for?**

Key forces of change affecting the electricity market and power system



The electricity market and power system is currently undergoing one of the most significant changes in decades. The strong interaction between change factors makes it very difficult to predict and manage future developments.

- Increase in weather-dependent, intermittent generation and its impacts on the adequacy of electric power and frequency response
- Increase in the need for flexibility
- Activation of small-scale customers and desire for local generation
- Technology development and cost reduction
 - Technology for facilitating demand-side management
 - Distributed generation and electricity storage
 - Building energy efficiency requirements and changes in heating methods
- Electricity market integration and harmonisation development
 - European Energy Union
 - Nordic electricity retail market
- Goals of Finland's National Energy and Climate Strategy
 - Increasing use of renewable energy sources
 - Reducing greenhouse gas emissions
 - Security of supply
- Role of electricity distribution network function and developing regulations
- Cyber security



Growth in renewable and intermittent generation will pose challenges to the security of supply



How can we ensure an adequate power supply at all times?

1 Adequacy of electric power

Overview

- The low electricity prices reduced by renewable energy subsidies will force the closure of unprofitable thermal power generation

Problem

- Thermal power (condensate and CHP) has traditionally guaranteed security of supply during peak hours and in other exceptional situations

Possible solutions

- Incentives for consumption flexibility during peak hours
- National power reserves as support mechanisms
- Capacity mechanisms as a last resort
- Developing transmission network and operation
- Developing market regulations

2 Need for frequency response

- The percentage of renewable generation and, in Finland, also nuclear power is increasing significantly
- The amount of flexible generation is decreasing

- Frequency response is needed more while conventional resources providing flexibility (thermal power) are diminishing
- Demand is no longer the only thing that varies

- Equal treatment of all sources of flexibility, including consumption
- Costs for balancing the system to be fully accounted for in pricing and using matching principle for allocation of costs.
- Roles of market participants and network operators in balancing the system

Finland will still be dependent on imported electricity in the future

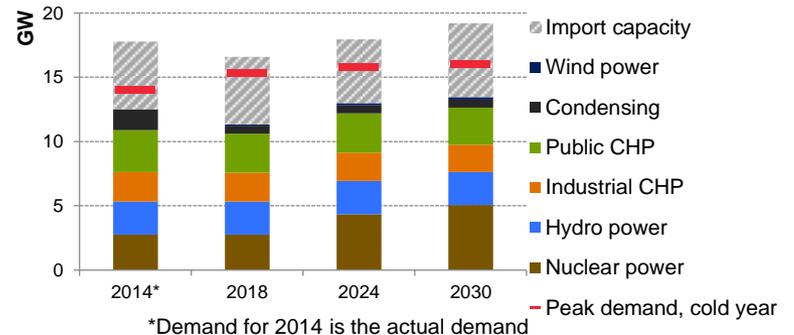


Finland is a part of the European electricity market, which makes it possible to import inexpensive electricity from the neighbouring countries

- In a report done by Pöyry on the adequacy of electric power in Finland¹, it was found that the available domestic and import capacity are adequate enough to handle peak demand during a cold year
- Due to a loss in condensating capacity, the difference between available capacity and peak output will be at its minimum prior to the start-up of OL3 nuclear power plant in 2018
- A change in the generation structure will pose challenges to maintaining capacity adequacy and system balance, even at the Nordic level

1) Finnish-language report titled "Suomen sähkötehon riittävyys ja kapasiteettirakenteen kehitys vuoteen 2030" and an English summary ("Adequacy of power capacity in Finland and the development of capacity structure until 2030") 23 January 2015

Adequacy of power capacity during peak hours in Finland 2014-2030



Change in generation structure in the Nordic countries 2010-2024



The need for flexibility in the power system is increasing



In Finland, participation to the flexible markets is limited to large-scale industry. There is unrealised potential, particularly among small-scale customers.

Amount of demand response in 2016

Marketplace	Demand response (MW)
Elspot market	200 – 600
Elbas market	0 – 200
Balancing market	100 – 300
Power reserve	10
Frequency controlled disturbance reserve	100
Frequency controlled normal operation reserve	0.2
Balancing capacity market	New marketplace

Flexibility potential among small-scale customers

- **The largest amount of unrealised potential is found among small-scale customers connected to the distribution network**
 - Controllable load with AMR control relays can be over 1,000 MW
 - The potential for technical control is manifold
- **The involvement of small-scale customers is currently concentrated on the day-ahead market, with various time-of-use and spot-priced products.**
- **Remote read meters have made it possible to offer hour-rate products and, to a certain extent, also load control**
- **It has not been possible to use current remote reading technology directly on the balance power and reserve markets. Instead, flexible solutions have been based on different frequency relays**

New revenue models for demand-side management



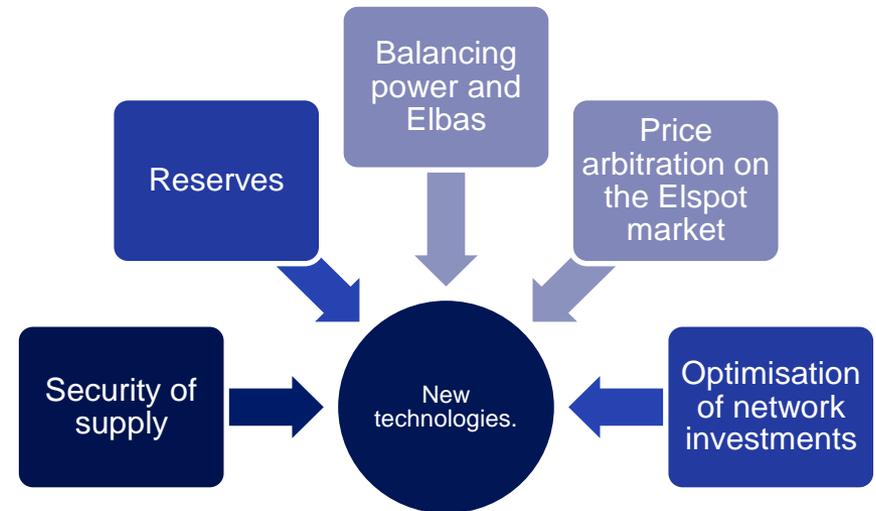
In the Nordic countries, the price volatility of the Elspot market alone is not enough to make investments in new technologies and revenue models profitable

Price volatility

- The Nordic countries have a relatively large amount of flexible hydropower and cross-border connections within the Nordic region as well as with other countries
- This protects the Nordic countries from the same kind of price volatility on the Elspot market as is usually found in Central Europe
- Investments in new technologies and business models which facilitate flexibility are not currently profitable, simply due to the market price of electricity
- However, flexibility also has value other than just stabilising demand
→ The profitable business model is based on the fact that value can be generated from several different sources



Sources of different demand-side value



- Demand-side management
- Distributed electricity generation
- Energy storage

European integration of electricity markets



Toward forming a European Energy Union

- **On 25 February 2015, the European Commission published its Communication on the Energy Union Package, which describes the visions and targets of the future EU energy policy and specifies the measures to be taken toward forming an Energy Union**
- **The goal is to offer Europe and its citizens reasonably priced, secure and sustainable energy. Special measures will be taken in five policy areas:**
 - Energy security; a fully-integrated internal energy market; energy efficiency; a decarbonisation of the economy; and research, innovation and competitiveness.
- **As part of the Energy Union strategy, the Commission made proposals in its "Summer Package" in July 2015, including strengthening the position of energy consumers and redesigning the European electricity market**
 - The communication concerning the retail energy market (COM(2015) 339) emphasises opportunities for consumers to save money and energy through better information, provide consumers with a wide choice of action on the energy market, and maintaining full protection for consumers
 - The communication concerning the new energy market design (COM(2015) 340) introduced a public consultation process, which includes: improving the function of the electricity market; adapting market design to renewables; linking wholesale and retail markets to one another; increasing regional co-operation; ensuring the security of supply
 - Intelligent electricity networks play a key role in achieving the targets set for the European Energy Union
- **At the end of 2016, the Commission will publish its proposal ("Winter Package") on concrete legislative amendments for a redesign of the electricity market**

European Commission Summer Package 2015



The European Commission Summer Package is the Commission's communication on plans for a redesign of the electricity market

Customer interface, demand-side management, small-scale generation

- **Price variations in the wholesale market must be passed down to the customers in the retail markets**
 - Dynamic tariffs for electricity and possibly also for network charges
 - Remote read meters and hourly imbalance settlement
- **Switching electricity suppliers easily, quickly and reliably, without extra costs**
 - Switching based on easily understood, reliable, transparent and comparable information on prices, contracts and the energy sources used by the supplier
 - Improving the clarity and comparability of electricity invoices
- **Consumption reporting in near real-time and the consumer's right to a smart meter.**
- **Small-scale generation, possibilities for energy storage and demand-side management increase each customer's ability to manage their energy needs**
 - Connecting small-scale generation to the network and developing contracts and services for consumer/generators
 - Net metering only possible as a transition phase solution
 - Fair allocation of benefits and costs
- **Opportunities for customer involvement through brokers and collective arrangements**
 - New operators (e.g. energy service providers, aggregators, brokers and data management companies) and business models

European Commission Summer Package 2015



Network technologies and system solutions

- **Smart grids and smart technologies at home should promote customer involvement in the retail markets**
 - Automated solutions to simplify actions to be taken by customers
- **Standards and compatibility between energy management systems and equipment**
 - Installing and using equipment fitted with energy demand control functions
- **Home automation control systems improve the possibilities for flexibility in power systems**
 - For example, shifting thermal loads to hours with lower demand
 - Connecting heating and cooling with electricity networks to reduce total costs
- **Supporting the sector so that standards can be fine-tuned and implemented quickly**
- **ESIF (European Structural and Investment Funds) has earmarked approximately one billion euros for smart distribution network development projects during the period 2014-2020**

European Commission Summer Package 2015



Digitalisation, automation and information management

- **A large part of the energy market's value is generated by large data flows and the use of information technologies in energy systems**
 - Access to data produced by metering system by consumers and authorised third parties
 - Access to consumer consumption and invoicing data by consumers and authorised third parties
- **Effective customer protection against unfair or misleading marketing practices**
- **In 2016, the Commission proposed a European initiative for the free flow of data as part of the strategy for internal digital markets**
 - Data ownership, compatibility, usability and availability are all taken into consideration
 - This also applies to the energy sector

European Commission Summer Package 2015



Market and business models, services and regulation

- **Integration of renewable energy into the energy system requires the creation of a cross-border within-day market and balance management market**
- **The market must send the right price signals for the investments**
 - Electricity price regulation and price caps must be eliminated
 - Prices must be allowed to indicate scarcity during peak demand
- **Renewable energy, distributed generation and demand response affect control of the power system**
 - Increasing and developing co-operation between distribution and transmission network companies
- **Distribution network operators must facilitate market-based development of new product and service concepts for all parties**
- **Energy services and demand response services must have access to markets**
- **Primary approaches for ensuring capacity adequacy:**
 - Coupling of the European wholesale markets
 - Improving cross-border transmission interconnections
 - Increasing the efficiency day-ahead markets
 - Removing price caps
 - Capacity mechanisms in some cases

Nordic electricity retail market



Current state and development of retail market harmonisation

- The national implementation supplier-based market model, as recommended by Nordreg, has been slow
- A fully-integrated end-user market is no longer the common goal - instead, the continuous development of the Nordic markets is both important and necessary
- Data hubs play a crucial role in facilitating joint Nordic retail markets
 - harmonises retail market processes and data exchanges, despite national differences
 - The Nordic dimension is emphasised with the adoption of data hubs in Denmark as well as Norway, Finland and Sweden.
- A supplier-based market is becoming the predominant retail market model in the Nordic countries
- The retail market model can affect the functionality of a demand response market and the possibilities of the customer to participate on the markets¹, but, on its own, it will not solve the incentive problem of demand response

Country	Data hub	Combined billing	Market processes
Denmark	2013	<ul style="list-style-type: none"> • 04/2016 • One contract 	<ul style="list-style-type: none"> • Supplier-centric model
Sweden	2020* (Ei recommendation)	<ul style="list-style-type: none"> • Ei recommendation • Two contracts 	<ul style="list-style-type: none"> • Ei recommendation on the supplier-based model
Norway	2017*	<ul style="list-style-type: none"> • Voluntary • Obligatory after the data hub (legislative amendment pending) 	<ul style="list-style-type: none"> • Supplier-centric model along with the data hub
Finland	2019*	<ul style="list-style-type: none"> • No common sector outlook • No decision 	<ul style="list-style-type: none"> • Supplier-centric, excluding invoicing and customer service

*) Planned estimate

1) E.g. European Commission, COM(2015) 340 final, 15 July 2015: CEER C14-SDE-40-03, 26 June 2014

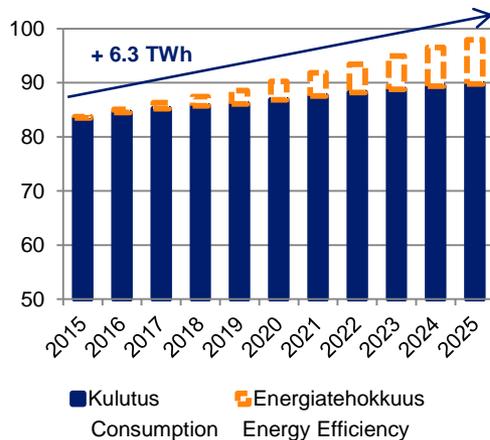
National energy and climate strategy: Electricity market in 2025



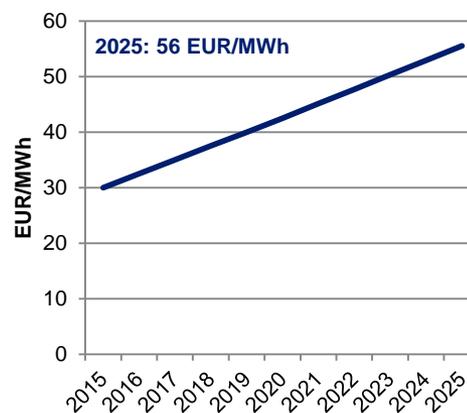
What kind of electricity market should the smart grid vision prepare for?

- In the basic scenario of the National Energy and Climate Strategy being prepared by the Finnish Government, the demand for electricity is expected to rise moderately¹
- The price of electricity will be nearly double the present level in 2025
 - In the basic scenario, the price will be increased by a rise in the fuel prices and emission allowances as well as growth in demand
- The share of nuclear power and renewables in electricity generation will increase significantly
- The amount of flexible generation will decrease at the same time that the need for electric power might increase

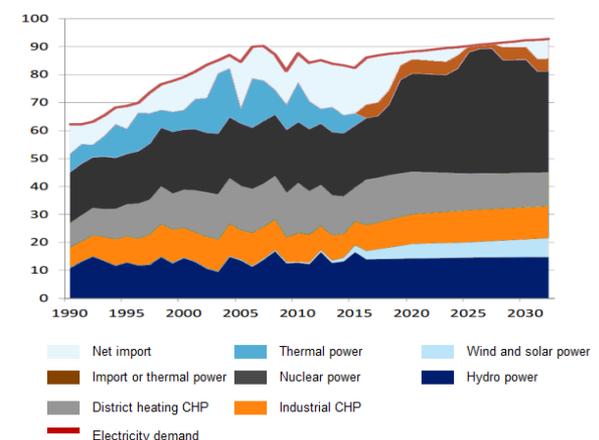
Electricity consumption



Electricity price



Electricity generation



1) Background assumptions of the basic scenario in the national energy and climate strategy, 15 June 2016

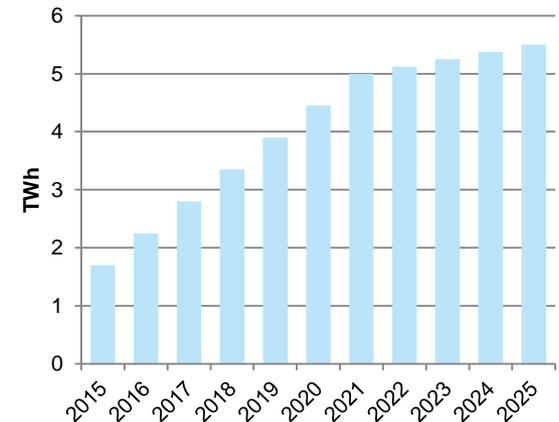
National energy and climate strategy: Electricity market in 2025



The move to a distributed energy system poses challenges for both power balance management and electricity market models as a whole

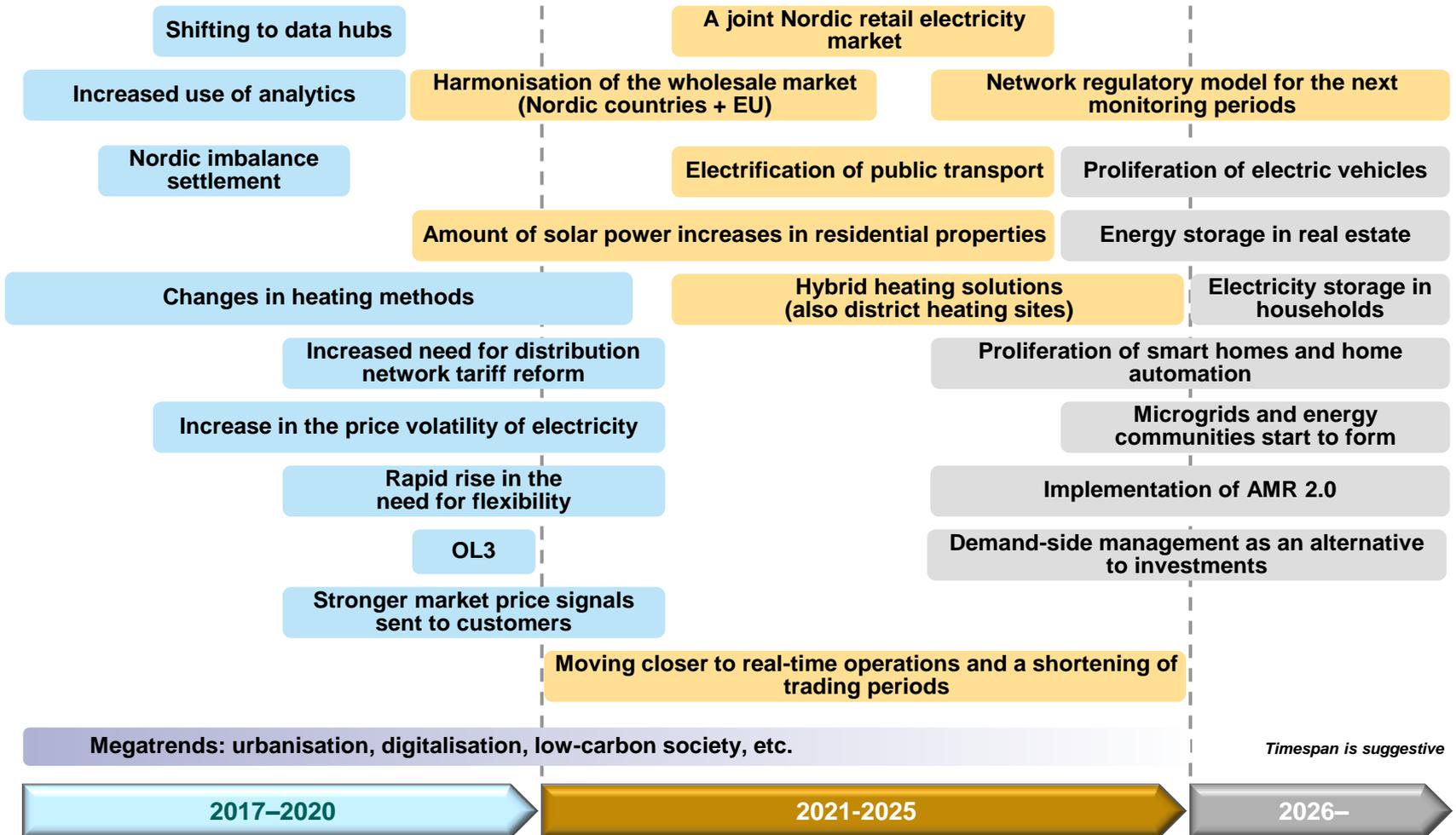
- The profitability of renewable electricity generation and electricity storage will improve with the development of technologies and increase in the price of electricity. Other factors will also steer the growth of renewable electricity generation.
- Finland's own electricity generation capacity is not adequate to meet peak demand, not even in the future
- Maintaining the power balance will become more difficult as intermittent generation increases and flexible capacity decreases
- It will become more difficult to predict demand and to form a real-time situational overview
- The volatility of electricity price will increase
- Although the flexibility potential of small-scale customers connected to a distribution network is over 1000 MW, there are several factors that hinder taking advantage of that potential
- The number of controllable appliances connected to the network is growing exponentially
- Data hubs in the Nordic countries are making a joint Nordic retail market possible
- Changes in the operating environment put pressure on regulatory reform.

Solar and wind power generation



Energia- ja ilmastostrategian ja keskipitkän aikavälin ilmastopolitiikan suunnitelman perusskenaario, 15.6.2016

Which future should smart grids prepare for?





Smart grid concept

Why and how could future smart grids be part of the solution?

Smart electricity system ("smart grids")

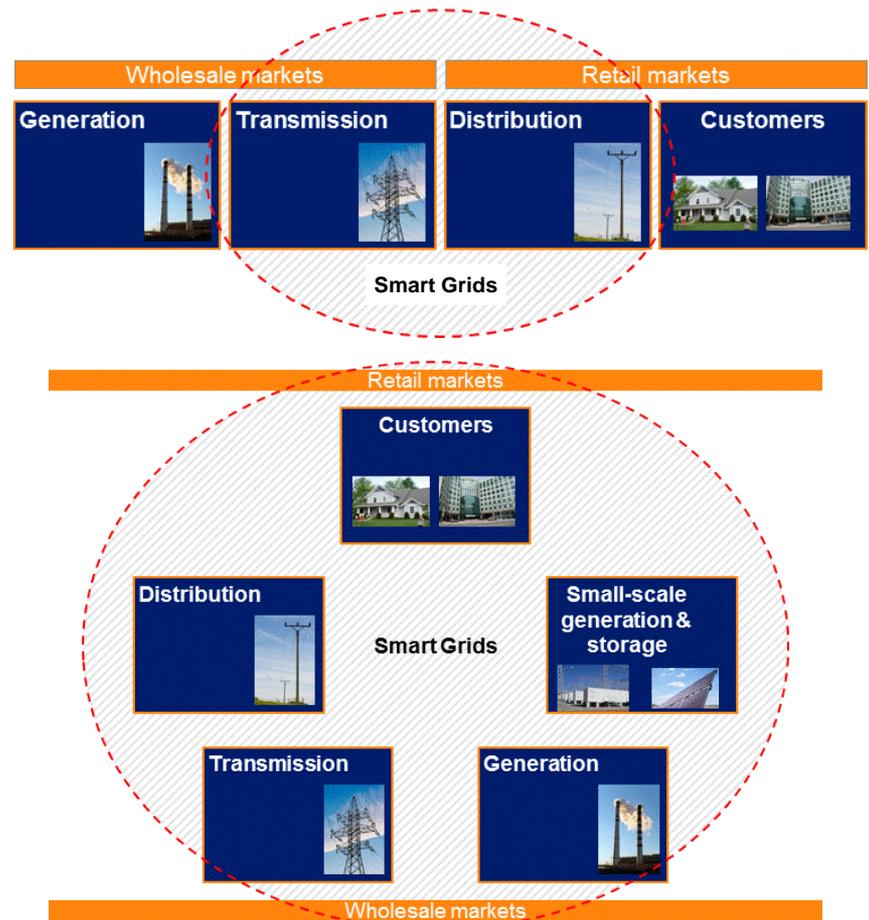


In this smart grid vision, future smart grid solutions are examined in terms of the functionality of the electricity market

- Smart electricity system usually refers to physical power grids, which link electricity generation and consumption with one another, e.g.

“Smart grids are networks that monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users.” (IEA)

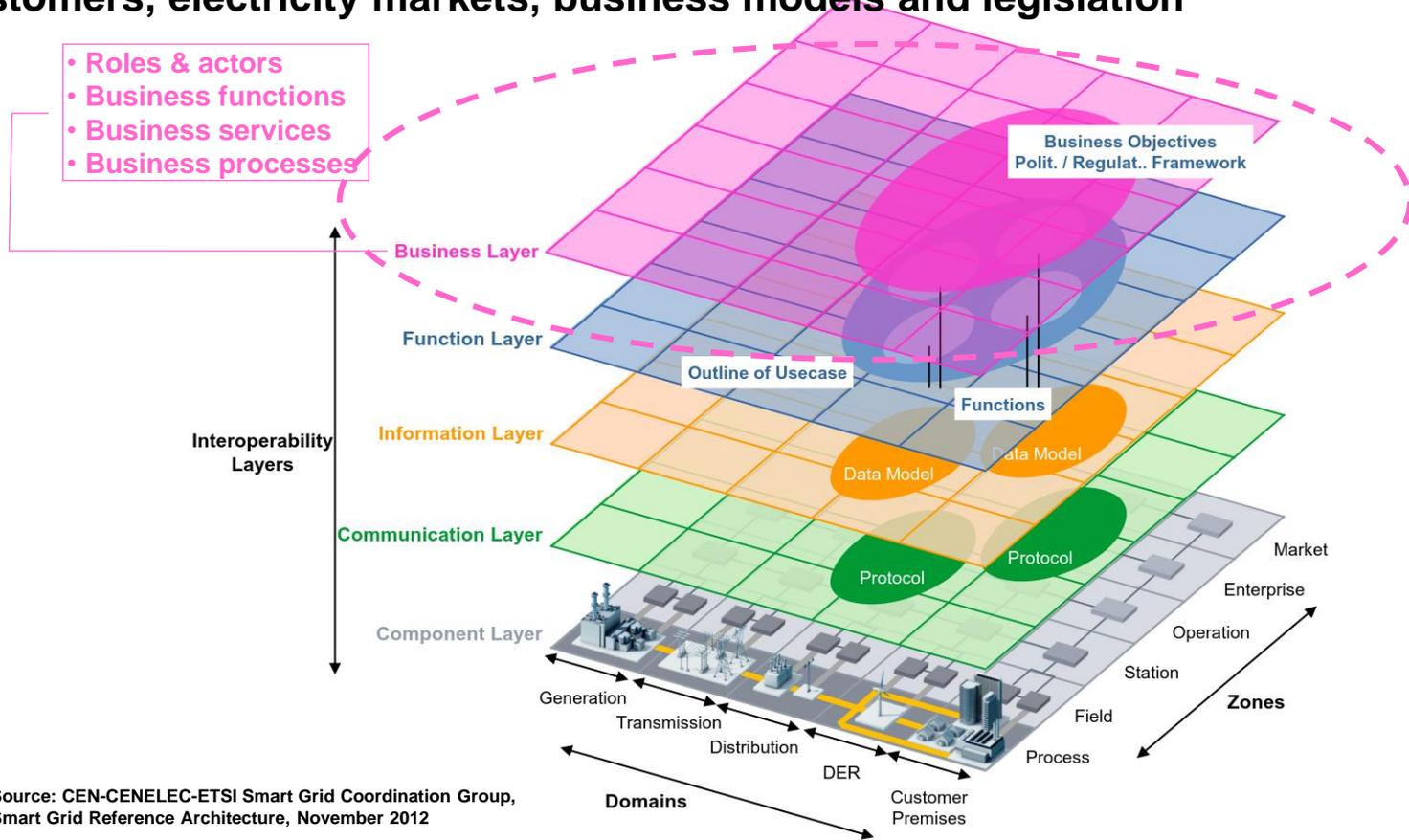
- In this vision, smart grids are seen as an extensive functional entity--a *service platform*--which covers not only the physical transmission and distribution of electricity, but also generation, distributed energy resources, power system flexibility and various smart grid applications. It also links the physical transmission of electricity to wholesale and retail markets.



Smart electricity system - Reference architecture



Whereas smart electricity system is, for the most part, comprised of technology, equipment and information management, the smart grid vision is concentrating in customers, electricity markets, business models and legislation



Source: CEN-CENELEC-ETSI Smart Grid Coordination Group, Smart Grid Reference Architecture, November 2012

Why are smart grids a key part of the solution?



Future smart grids play a key role in maintaining the security of supply and promoting active customer involvement

- **They pave the way for new electricity products and pricing models, which can be used to get consumers, organisations and companies to actively participate in the electricity markets**
- **They provide customers with possibility to make value choices when it comes to the consumption and generation of electricity**
- **They support the integration of variable, renewable generation into the power system and the move toward becoming a low-carbon society**
- **They promote the security of supply and power balance management by offering more precise and real-time information on consumption and generation as well as tools for the management of active energy resources**
- **They offer tools for investigating faults and preventive maintenance**
- **They offer tools for the management of distribution network bottlenecks and the quality of electricity**
- **They improve the economical use of power system resources, such as by facilitating flexibility**
- **They help to make more efficient use of electricity networks, which can reduce investment and/or operating costs as well as the size of customer bills**
- **They allow for new business models and integration of the power system with other energy systems (e.g. heating systems) and infrastructures (e.g. smart city)**



**Smart grid visions from
other countries and the
Electricity Research Pool
Electricity market and grid
vision 2035 & Roadmap
2025**

United Kingdom (UK)



“A smart electricity grid that develops to support an efficient, timely transition to a low carbon economy to help the UK meet its carbon reduction targets, ensure energy security and wider energy goals while minimising costs to consumers. In modernising our energy system, the smart grid will underpin flexible, efficient networks and create jobs, innovation and growth to 2020 and beyond. It will empower and incentivise consumers to manage their demand, adopt new technologies and minimise costs to their benefit and that of the electricity system as a whole.”

- The vision was drafted by the Smart Grid Forum in 2014. The organisation formed the Department of Energy and Climate Change in co-operation with the Gas and Electricity Market Authority (Ofgem). The organisation consists primarily of sector companies and organisations
- The smart grid vision places an emphasis on macroeconomic benefits and the position of end users

Smart grid definition	Goals	Methods
<ul style="list-style-type: none">• A smart grid is a modernised electricity network, which uses ICT for the real-time monitoring and management of supply and demand.• It offers a more reliable and cost-effective way to transmit electricity• Remote read power meters are the driving force behind a smart grid, providing information for improving network management and making demand-side management and distributed generation possible	<ol style="list-style-type: none">1. A smart grid reduces customer costs by lowering electricity network costs2. It promotes economic growth and employment3. It improves security of supply and the integration of low-carbon technologies	<ul style="list-style-type: none">• Regulation and commercial arrangements facilitate and support the adoption of smart technologies and new business models• Smart grid ensures that consumers understand and are convinced of the benefits offered by the installation of smart meters and demand-side management• It increases investments in research and development as well as co-operation with small and medium-sized enterprises

Smart Grid Forum, Smart Grid Vision and Routemap, February 2014

Norway



“The vision of the deployment of the smart grid in Norway is to work in a coordinated approach and make the needed development on [several different research topics] to achieve a flexible and reliable future energy supply system.”

- The smart grid vision was drafted by the scientific committee of Norwegian Smart Grid Centre in 2015. The Committee consists primarily of universities and research institutes
- The Norwegian Smart Grid vision is R&D-oriented, focusing on improving the capabilities needed for developing smart grids in Norway
 - The Smart Grid vision emphasises, among others, the importance of research projects

Smart grid definition

- **A smart grid is an electricity transmission system of the future that makes use of:**
 - Two-way communication for the exchange of information used in monitoring, coordinating and controlling the system
 - New sensor and actuator technologies, which improve the capacity detection and safe use of the system
 - a smart functionality, which makes it possible to automatically optimise system operation in order to ensure security of supply

Goals

1. **Create a stable and reliable power system**
2. **Develop smart grid expertise by focusing on essential research subjects, such as:**
 - Microgrids and distributed generation
 - Integration of renewable energy
 - Electric vehicle infrastructure and charging
 - ICT and big data in smart grids

Methods

- **Increasing co-operation between universities, companies and research centres**
- **Establishing and funding research centres**
- **Developing university teaching programmes**
- **Developing vocational training for industry at universities and universities of applied sciences**
- **Establishing a strong public strategy and research funding programme**

Norwegian Smart Grid Research Strategy, The Scientific Committee of the Norwegian Smart Grid Centre, 2015

Denmark



“Strategy sets the course for development of a smart grid which can make [ongoing] green transition cheaper, provide savings on electricity bills and help promote new services and products to the benefit of consumers.”

- The smart grid vision was drafted by the Danish Ministry of Climate, Energy and Building in 2013, in close co-operation with the Smart Grid Network, which is comprised of operators in the sector
- The Danish smart grid vision is end user-oriented. A key aspect of the strategy is that promotion and development of the smart grid requires consumer involvement in demand-side management

Smart grid definition

- A smart grid is a system in which:
 - a majority of generation is based on renewable sources of energy, such as wind power
 - consumers, the district heating network and gas distribution can contribute to demand-side management
 - Remote read meters allow for the real-time monitoring of consumption and make new kinds of services possible

Goals

1. A smart grid allows for a large volume of renewable energy in the system
2. It makes the transition to renewable energy sources as economical as possible
3. It makes Denmark a centre of expertise in smart grids

Methods

- Installation of remote read power meters for all end users
- It encourages end users to participate in demand-side management by offering hourly-rate invoicing
- Creating a data hub to facilitate the monitoring of power consumption and switching suppliers
- Adjusting regulations, taxation and support to promote the smart grid

Smart Grid Strategy – The intelligent energy system of the future, Danish Ministry of Climate, Energy and Building, 2013

Sweden



“The vision: Sweden is a world leader in the field of smart grids that enable greater customer empowerment, sustainable development, security of supply and growth.”

- The smart grid vision was drafted by the Coordination Council, which was appointed by the Swedish Government, and the Forum for Swedish Smart grid. The Forum consists primarily of participants from the business sector.
- The Smart grid vision places an emphasis on the end customer and the market-based achievement of public benefit
- The vision also strongly emphasises smart grid technology as a growth industry in Sweden

Smart grid definition	Goals	Methods
<ul style="list-style-type: none">• Cost-effectively link all the decisions and behaviour of customers connected to the grid -suppliers, consumers and producers/consumers- to one another, thus ensuring the stability, high quality and low loss of the power system as well as security of supply and safety• Increasingly use ICT at the technical level and process large volumes of data• Create the conditions for providing services to new types of customers	<ol style="list-style-type: none">1. Set clearly-defined market rules2. Enhance opportunities for empowering customers3. Lay a solid foundation for developing the smart grid4. Promote the position of smart grids as a growth industry in Sweden	<ul style="list-style-type: none">• Develop a political and legislative framework that is conducive to the effective, market-based development of smart grid technologies• Promote customer involvement by establishing frameworks that support it• Engage in smart grid R&D activities

Planera för effekt! – Slutbetänkande från Samordningsrådet för smarta elnät, Statens offentliga utredningar, 2014

Finnish Electricity Research Pool: Electricity market and network vision 2035 & Roadmap 2025



Approach based on the distribution network business

- **Goal: electricity network and electricity market vision extending to 2035 ("target ") and development path extending to 2025 ("roadmap")**
- **Key sector challenges**
 - Increasing weather-dependent, unregulated electricity production on the electricity market
 - Power balance management
 - Unprofitability of other "conventional" electricity generation
 - Improving the reliability of mandatory electricity networks
- **Solutions**
 - Strong transmission network, foreign connections, automation, cabling, demand side management., energy reserves and renewable energy
 - Development of business models and regulation
 - Development of primary network development and supporting the application of ICT through co-operation, funding programmes and legislation
- **Roadmap to a flexible system = key research and development areas**
 - Market and business models, services and regulation
 - Small-scale generation, demand-side management, energy storage and customer interface
 - Grid technology system solutions
 - Digitalisation, automation and information management

Electricity Research Pool Vision: Finnish power system in 2035



The vision is a reliable, competitive system that serves both the electricity market and sustainable development. The exponential growth of renewable sources of energy demands flexibility, which is achieved by means of smart management and flexible resources. All-encompassing ICT, functional regulation and new business models have created these opportunities. The reliability and cost-effectiveness of the system have also been improved by developing the technology of primary networks.

1. Flexible power system

- New electricity generation to be built almost exclusively based on renewable energy
- The challenges posed by increasing weather-dependent generation and decreasing inertia have been tackled by, for example, market-based flexible products

2. Power system for cities

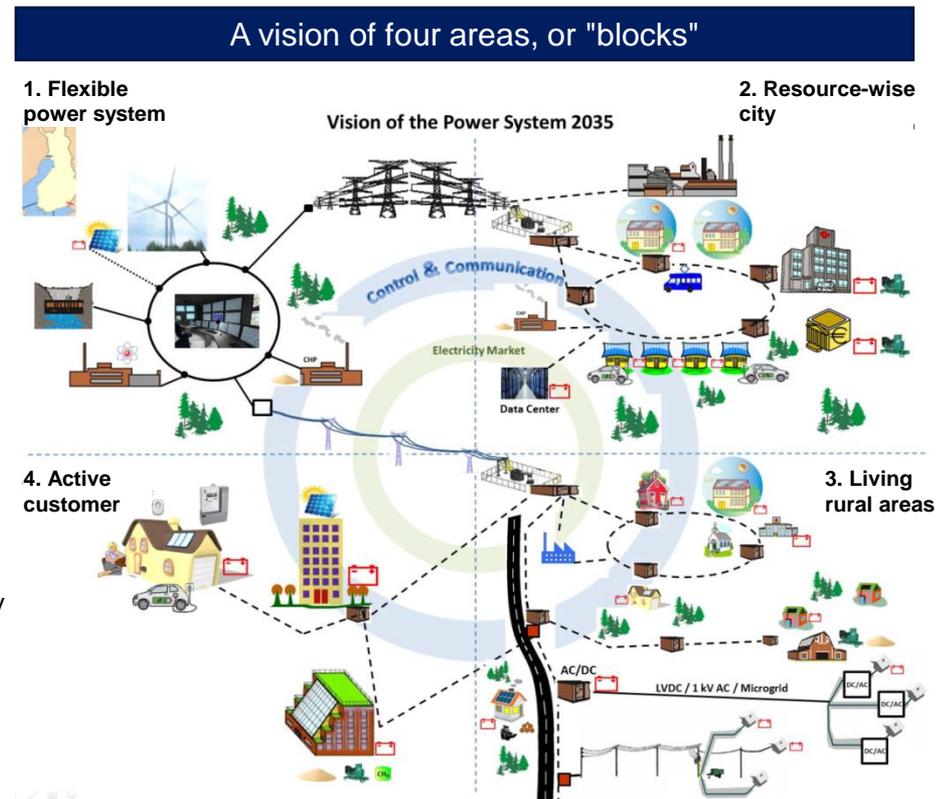
- Almost all transportation is electric
- Electricity and thermal reserves have been deployed
- Energy-efficient and mostly energy self-sufficient properties

3. Power system for rural areas

- Extensive use of network automation
- Energy storage, microgrids and reserve power will be utilised to ensure security of supply
- Cabling degree > 50 %

4. Active customer

- Small-scale production, new heating methods and energy reserves
- Customers are involved in the electricity market, thus making customer's resources available to the markets
- Power tariffs and flexible products support new load profiles

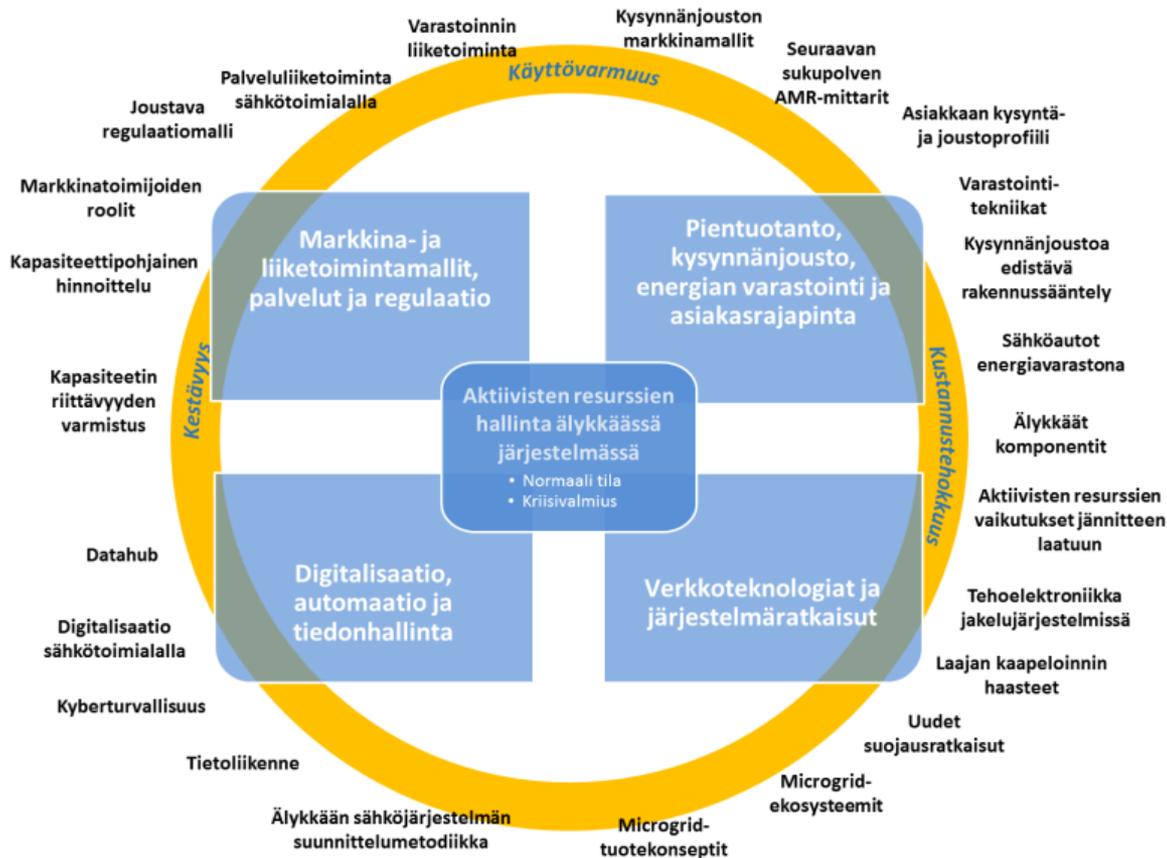


Electricity Research Pool: Roadmap 2025 – Electricity market and network vision 2035 & Roadmap 2025

Research and development roadmap 2025



Toward a more flexible system





Smart grid vision

Smart grid vision 2025



Smart electricity system will work as a service platform in the transition towards a more distributed and carbon-neutral power system. They will give the customers better possibilities for participating in the electricity market, improve security of supply and create new business opportunities for companies, while also ensuring cost-efficiency.

Smart electricity system, *smart grids*

- enable to reduce the total cost of electricity *for the customer* and allow customers to make **value choices** related to electricity use and generation;
- offer existing and potential *electricity suppliers and service providers* innovative, fair and functional conditions for business development and for providing products and services based on customer needs;
- offer *distribution network operators* solutions for the two-way distribution of electricity at an adequately high level of quality and reliability;
- offer *electricity generators* tools for more effective generation optimisation in a rapidly changing operating environment;
- help *the transmission system operator* to maintain the balance and ensure security of supply with the proliferation of variable electricity generation;
- create an internationally attractive operating environment for the *technology industry* for the development and export of products and services based on smart grid technologies, thus bolstering employment and business sector competitiveness;
- support *society* in the cost-effective achievement of energy policy and social goals.

Customer



Smart electricity system makes it possible to reduce the total cost of electricity consumption for the customer and allow them to make value choices related to electricity use and generation

- **The challenge is how to get customers interested and actively involved to increase flexibility in the electricity market; for the customer, active involvement usually bears no intrinsic value**
- **Incentives for involvement should be made by reducing the cost of electricity use or enabling different value choices**
 - The service content and quality as well as the power bill can be influenced through one's own choices
 - The point of reference for reducing the total cost of electricity use is not, however, the current price level, but rather cost savings, which customers can realise through their own choices
 - The customers can also maximise the revenues they earn from the electricity market, such as by selling their own production or demand response
 - Value choices can be related to, for example, one's own production, local energy, carbon footprint, security of supply, flexibility, living comfort, etc.
- **Smart grid solutions should increase the customers' number of choices as well as their freedom. Regulation should support these goals.**
- **Involvement must be made as easy as possible for customers**
 - Customers are not required to take active measures, but rather involvement is simple and automatic, such as through a service provider
- **Intelligent electricity networks should also support energy communities**
- **Harmonising the goals of individuals and society - the impact of active involvement should be consistent with the overall benefit of society or the system, or at least they should not prevent achieving the other goals of the vision**

Electricity supplier and service provider



Smart electricity system offers existing and potential electricity suppliers and service providers innovative, fair and functional conditions for business development and providing products and services based on customer needs

- **Fair and non-discriminatory treatment of market players when competing on the market**
 - Clarifying the role of electricity producers, flexibility service providers (electricity suppliers, aggregators), technical flexibility operators and energy service providers
 - Role of distribution network operators in demand-side management and electricity storage
 - Position of the electricity supplier in a vertically integrated company
- **Equal access of market players to measurement and customer data as well as to controllable loads, privacy and information security**
 - Information on the customers' controllable loads
 - Avoiding vendor lock-in
- **Developing new business**
 - Aggregation of distributed energy resources
 - Developing new products and services as well as service packaging to increase the number of customer choices; from electricity products to service entities ("living comfort") or common technical platforms, such as with care and security services
- **Market model choices**
 - Ease of customer transactions and freedom to choose a service model
 - Compatibility of company operating models at the Nordic and European level

Distribution network operator



Smart electricity system offers distribution network operators solutions for the two-way distribution of electricity at an adequately high level of quality and reliability

- **Meeting security of supply requirements set in the Finnish legislation and an increase in distributed energy resources will be some of the more significant forces of change in the years to come**
 - Security of supply requirements will be phased in by 2029, which will result in substantial investment needs, particularly for network companies operating outside urban areas
 - An increase in small-scale generation will affect network income streams as well as pose challenges to the fairness and non-discrimination of network service charges
 - Technological development itself also acts as a major driver for change
- **Smart electricity system offers distribution network operators new, cost-effective tools and methods for developing electricity distribution, such as flexibility, electricity storage, disconnectable loads, security of supply based on customer choice**
 - With smart grid technology, network operators receive better and more real-time information on generation and loads ("situational picture") connected to the distribution network
- **The role of a distribution network operator as a "facilitator" and marketplace provider for competitive electricity businesses will grow in the future**
 - Definition of the role of the distribution network operator
 - Broader adoption and use of smart grid technologies

Electricity producers



Smart electricity system offers electricity producers tools for more effective generation optimisation in a rapidly changing operating environment;

- **The challenge that the electricity producers are facing is the greater fluctuation of prices, as weather-dependent generation increases price volatility**
 - On a windy and sunny day, when there is a high volume of electricity generated, prices can be pushed down into negative figures. On the other hand, the price of electricity can also rise significantly when there is less production
- **Another challenge facing producers is the difficulty of forecasting as variability increases. Smart grids produce real-time information from the power system and electricity market, which helps in making forecasts**
 - Balance management by the balance responsible party
 - Involvement in balance and reserve markets
- **The value of production can be maximised by smart grids**
 - Storage makes it possible to supply electricity to the electricity market when it is most profitable
 - Ability to participate in the up and down-regulating of electric power
 - Creates possibilities for flexible generation
- **Enables virtual power plants**
- **The flexibility offered by smart grids can mitigate the price volatility of electricity, provided that demand is increasingly following generation patterns**
- **By increasing flexibilities smart electricity system can support the functioning of large-scale baseload power plants on the electricity market**

Transmission system operator



Smart electricity system helps the transmission system operator maintain power balance and ensure security of supply with the proliferation of variable electricity generation;

- **Intermittent generation poses challenges to power balance management**
- **The need for real-time information on the system state and active resources is also increasing for the distribution network**
- **The active management of distributed energy resources and inclusion of resources in maintaining the power system power balance (e.g. demand-side management) are also needed**
- **The smart grid increases the transparency of the electricity market**
- **Goal: operational cost-effectiveness of the entire power system**
- **The electricity market is getting "complicated" and the time to react to changes on the market is getting shorter; management tools need to be closer to real-time**



Technology industry

Smart electricity system creates an internationally attractive operating environment for the technology industry for development and export of products and services based on smart grid technologies, thus bolstering employment and business sector competitiveness;

- **The technology industry encompasses all equipment manufacturers and software companies developing or using smart grid technologies as well as service providers**
- **The technology industry needs support from strong investment in the fields of research and education (universities, universities of applied sciences, research institutes, etc.)**
- **Maintaining the position as a leading country in smart grid technology requires a strong domestic market**
 - Although Finland is still currently the leading country in smart metering, it won't be alone for long
- **Securing the export possibilities for products, applications, services and business models developed in Finland**
 - Standardisation of solutions
 - Having a market model that is sufficiently similar to those of other Nordic and European countries reduces the need to adapt and lowers the threshold for access to the market

Society



Smart electricity system supports society achieve energy and social policy goals cost-effectively.

- **Achievement of energy and climate policies**
 - Reducing emissions
 - Increasing use of renewable energy sources
 - Energy efficiency
- **Developing security of supply**
 - Electric power and capacity adequacy and customer-specific choices
 - Regional and distribution network security of supply
 - Cyber security
- **Developing the functionality of the electricity markets**
 - Role of distribution network operators as a promoter of the electricity markets
 - Choices related to wholesale and retail market models
- **Developing network business regulation**
 - Shift from being investment-based toward total economic optimisation
- **Promoting national competitiveness**



Summary – Vision for Smart Grids in Finland 2025



Smart grids will work as a service platform in the transition towards a more distributed and carbon-neutral power system. They will give the customers better possibilities for participating in the electricity market, improve security of supply and create new business opportunities for companies, while also ensuring cost-efficiency.

