The Smart Grid Network

Summary and reccomendations

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DANISH MINISTRY OF
CLIMATE, ENERGY AND BUILDING

THE SMART GRID NETWORK

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Preface

The government aims for Denmark's greenhouse-gas emissions in 2020 to be reduced by 40 percent compared to 1990 levels. By 2050, our entire supply of energy must be provided by renewable sources. By 2035, our electricity and heating supply must be provided by renewable energy. Oil burners and coal must be phased out of Danish power plants no later than 2030, and half of Denmark's traditional electricity supply must come from wind power by 2020.

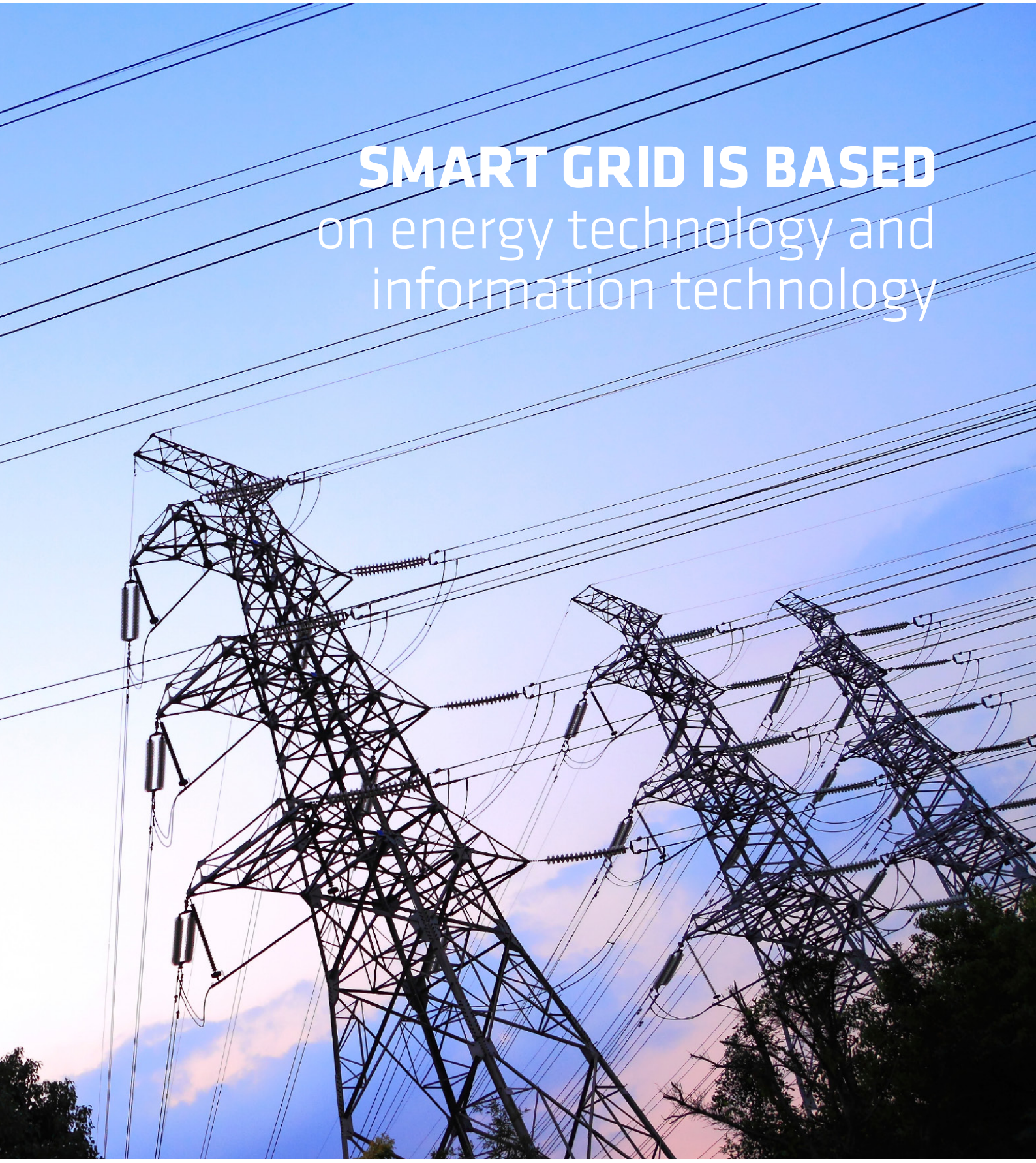
The government's goal will require an enormous phase-in of renewable energy, particularly from wind power. Along with the fact that the amount of electricity used for electric cars and heat pumps, for example, will also increase markedly, this presents a major challenge for the electric grid in the long term. If we want to avoid large investments in new cables, there must be a significant effort to promote a *Smart Grid*; that is, a smart electricity network. A Smart Grid is the key to the challenges facing the energy system because it can connect fluctuations in production to consumers' electricity usage.

Last year, the Minister for Climate, Energy and Building established the Smart Grid Network, which consists of a broad range of key players who were set the task of developing recommendations for future actions and initiatives. With these, it will be possible for the electric system to handle up to 50 percent of its electricity from wind power in 2020. The recommendations presented in this report are the results of the Network's efforts.

I see the Smart Grid as an important part of the energy system of the future, and the government supports a strategy for Smart Grid creation in Denmark. The Network's recommendations will provide major input into the development of this strategy.

As the newly appointed Minister, I look forward to further cooperation with all the players involved in developing a Smart Grid in Denmark. I owe a debt of gratitude to all the Network's members, and especially to the chairpersons of the Network's working groups for their particular efforts.

Martin Lidegaard
Minister for Climate, Energy and Building



SMART GRID IS BASED
on energy technology and information technology

Introduction and summary

Electricity will play a key role in the energy system of the future

Realisation of Denmark's ambitious climate and energy-policy objectives for reduced CO2 emissions, increased renewable energy consumption, along with an improvement in energy efficiency means that electricity will play an even more central and key role in the energy system than it does today.

Electricity, which is increasingly produced from renewable energy, especially from wind power, can beneficially replace fossil fuels in the heating and transport sectors, and thereby make a significant contribution to the attainment of climate goals. This means that the Danish energy system must be adapted and that significant changes must be made to the electricity system – both in relation to the way electricity is produced, and also to the use of electricity by electricity customers.

Electricity customers will become a resource in the energy system of the future

Until now, the electricity sector has adapted the electric system by laying more and larger cables underground, establishing more substations and ensuring access to adequate production capacity. Electricity customers have primarily been "passive" customers with a predictable and regular usage pattern. This will – with a significant increase in electricity usage for, among other things, heat pumps and electric cars – not be the most efficient economic solution for society. It will be more economically efficient to reduce the need for traditional expansion of the distribution networks by ensuring that a portion of the electric usage adjusts to the fluctuating electric production from renewable energy. For that to happen there is a need for an intelligent electric system – a Smart Grid. This will allow electricity customers to interact with the electric system and production plants. It must, among other things, happen through automated and intelligent control of their electric appliances by time-dependent price signals. This will allow electricity customers to benefit by offering their flexible consumption as a resource for the electric system.

Energy technology and information technology are closely connected

The Smart Grid is based on the combination of energy technology and information technology (IT). Realising the Smart Grid requires establishing a digital platform that ensures the communication interoperability between appliances, sensors, systems, etc. The related standardisations and basic research, development and demonstration activities should be undertaken as soon as possible, to the extent that they are not already known, well-defined and internationally accepted.

Adjusting electric usage reduces future investments
Another prerequisite for the Smart Grid to function is to offer electricity customers a price that reflects the actual production and distribution capacity, such that the price is higher when there is limited capacity and lower when there is excess capacity. In other words, it should be possible to offer hourly billing for usage, and tariffs for electricity distribution that varies throughout the day and which corresponds to the capacity shortage in the distribution network. At the same time, customers must be made more aware of the value of adjusting their electricity usage throughout the day, so that usage is increasingly adjusted to capacity. Shifting energy use in this way

▶ ELECTRICITY CAN BENEFICIALLY REPLACE FOSSIL FUELS IN THE HEATING AND TRANSPORT SECTORS, AND THEREBY MAKE A SIGNIFICANT CONTRIBUTION TO THE ATTAINMENT OF CLIMATE GOALS

to times with excess capacity and high production of renewable energy will contribute to a more efficient overall utilisation of the electric system's resources.

The advantage of encouraging a shift in electricity usage to times of excess capacity in the power grid, and thereby reducing investments in capacity expansion, is shown in Figure 1.

New technology will optimise the utilisation of grid capacity

Power utilities can also benefit by improving measuring, monitoring and automation of the power grid, which could optimise utilisation of the grid and thus bring the grid closer to maximum capacity. Both advantages – adjusting electricity usage to times with excess capacity, along with introducing new technology in the power grid – help to reduce additional future investments in capacity expansion. This double-benefit – relative to alternative investments – is illustrated in Figure 2.

▸ POWER UTILITIES CAN BENEFIT BY IMPROVING MEASURING, MONITORING AND AUTOMATION OF THE POWER GRID, WHICH COULD OPTIMISE UTILISATION OF THE GRID AND THUS BRING THE GRID CLOSER TO MAXIMUM CAPACITY

Ensuring stability and balance in an electric system based on renewable energy

Optimal use of wind power and the overall balance of the electric system between fluctuating electricity production and future flexible consumption are important. It should be emphasised that the electric system also needs to achieve an immediate power balance between usage and production – a quick response in consumption can help with this – which would be cheaper and more environmentally efficient than balancing with central regulating power plants.

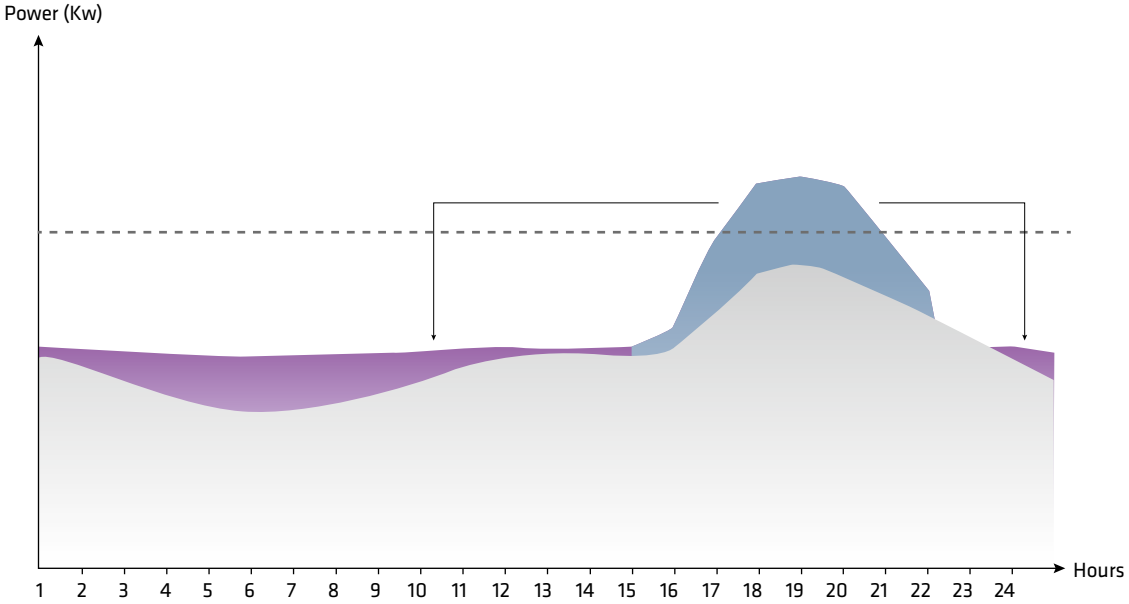
Another crucial function in the electric system is the so-called ancillary services - i.e. technical system stability services. These technical services must always be present in order to maintain the stability of the electric system. The electric system only works if there is always enough capacity to supply the ancillary technical services. Large central power plants have thus far supplied most of these necessary technical services. As the large power plants are expected to be phased out, these properties must be ensured in other ways. In the long term, the Smart Grid has the technological potential to provide some of these services to the power grid.

Automatic control of customers' electricity usage

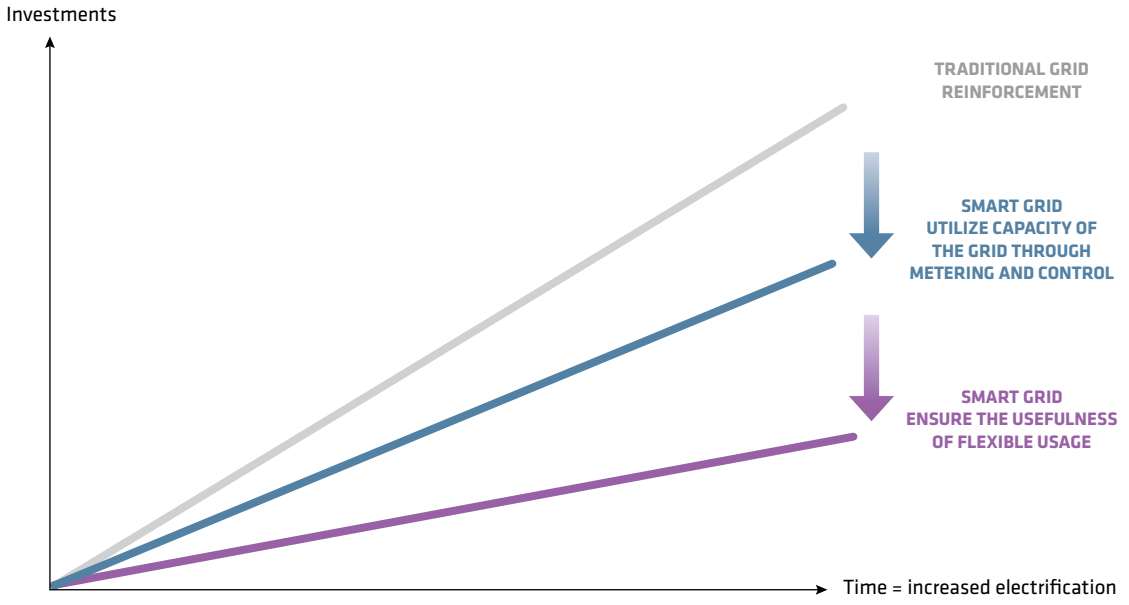
The establishment of the Smart Grid will increase the digitalisation of Danish households. There will be more metering, control and communication electronics in homes. This will give electricity customers an overview of their usage and the opportunity to achieve automatically controlled usage at times when production and grid capacity is abundant and thus the price lower. An extra advantage of the equipment is that electricity customers will be able to obtain a range of related services. For example, one can imagine that electricity customers would receive a text message if their heat pump breaks down while they are away on winter vacation. They could choose an automatic shutdown of the standby-usage in the house when they are not at home, and they would be able to control the temperature in the house remotely using a telephone or computer. It can be expected that there will be more new and innovative products that will utilise the new infrastructure, just as with mobile telephones and the internet.

In addition, the Smart Grid will ensure that owners of electric cars can get their energy needs for transportation individually and flexibly met, depending on how quickly they need an electric charge and what time of day it happens. This would allow the car's battery to be recharged at different electricity rates. At the same time, electricity customers with automatic efficiency solutions will have the opportunity to reduce their electricity bills by allowing their electrical appliances to operate automatically based on price and comfort requirements – for the benefit of the customer as well as for the electric system.

Figure 1. Shifting time of consumption optimises the capacity of the electric system



Figur 2. Smart Grid optimises investments in capacity expansion



The retail market and innovation should ensure an effective adjustment of electricity usage

It is ultimately the retail market that will provide an effective adjustment of electricity usage by offering attractive products and services to customers. Initiating an active standardisation effort is an essential prerequisite for effective innovation in the product and technology markets. This will ensure the interoperability between different suppliers' solutions, protecting customers from being locked in to one specific technology.

Rapid transition of the electric system will entail greater benefits

The Smart Grid is an effective way to expand the electric system, so it is ready to meet the challenges of the future. The full rollout of the Smart Grid is still several years away, but the fundamentals must be laid now, and the faster the transition happens, the greater the benefits.

The commercial potential of the Smart Grid

The overall assessment is that the combination of strong and well-proven system solutions, commercial solutions and large-scale testing environments makes Denmark a unique market for international companies to locate their development projects. Similarly, these strengths provide a unique platform for Danish consultancy companies to roll out international Smart Grid projects. An accelerated rollout of the Danish Smart Grid and a targeted focus on research and development will support this.

Broad collaboration will ensure an intelligent electric system

Many technologies are already advanced enough to be introduced in the electric system, but there is a continuing need for focused research, development and demonstration efforts to ensure a sustainable, effective modernisation of the electric system. It is crucial that all actors head in the same direction to keep focus on an effective deployment of the intelligent electric system. This requires close cooperation between many actors. The structure of an intelligent electric system and a short description of the different functions are shown in Figure 3.

Need for initiatives to achieve complete rollout of a Smart Grid

Smart Grids cannot be established without ensuring reasonable conditions for different actors involved. Establishing a clear commercial model with well-defined roles and areas of responsibility is essential. Moreover, there is a need to develop and implement a new communication and control concept, which will make it possible to achieve the ideal interaction between the technical control of the power system, electricity production and electricity usage. The future requires an expansion and supplementation of both the commercial and technical data-communication pathways and systems, with a possibility of connecting significantly more renewable energy producers at all levels of the electric system. And just as important is the establishment of completely new interoperable communication structures for both the commercial and technical usability on the consumption side of the electric system.

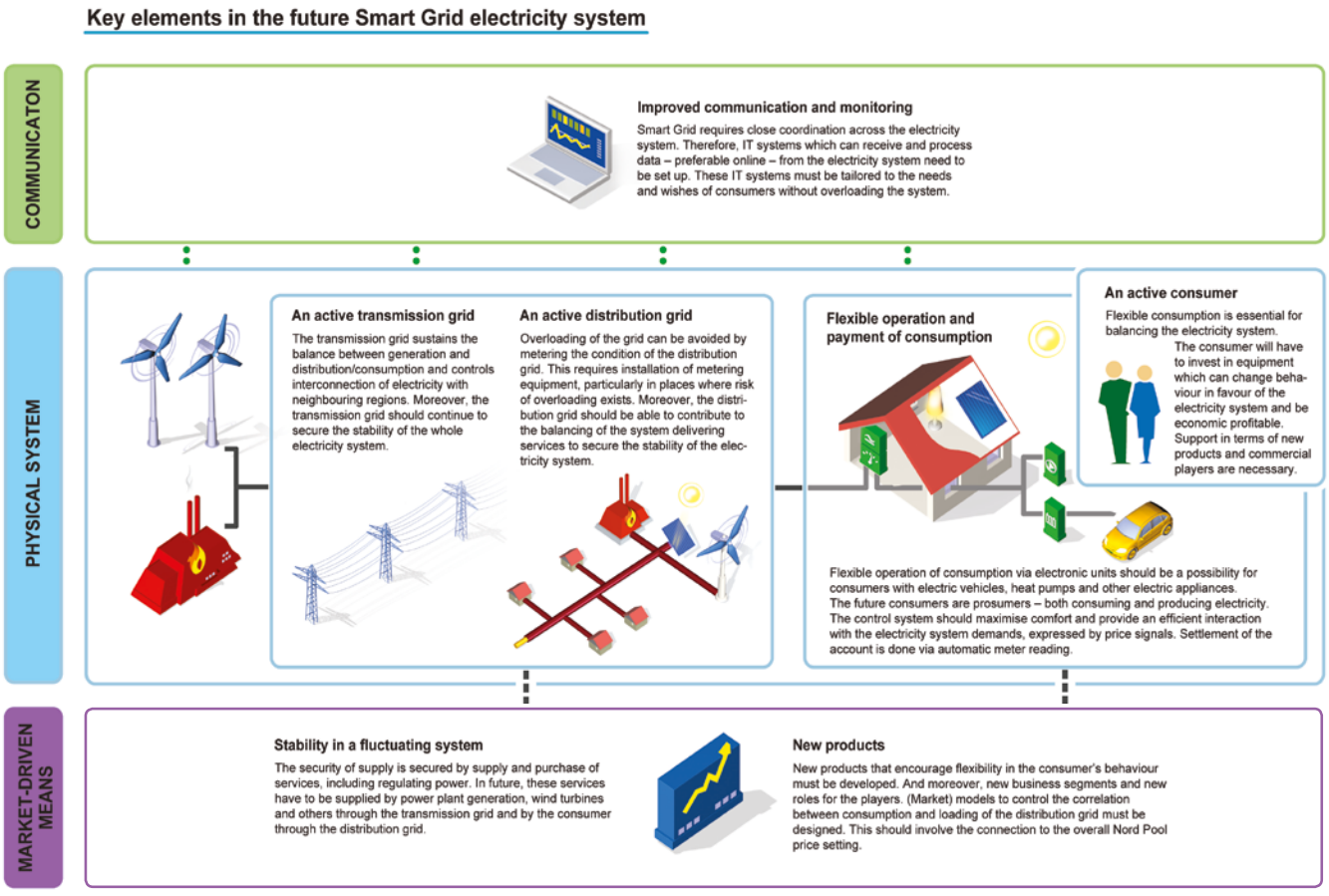
Effectively rolling out the Smart Grid before 2020 requires a number of initiatives to be implemented. The Smart Grid Network has identified the following nine key recommendations:

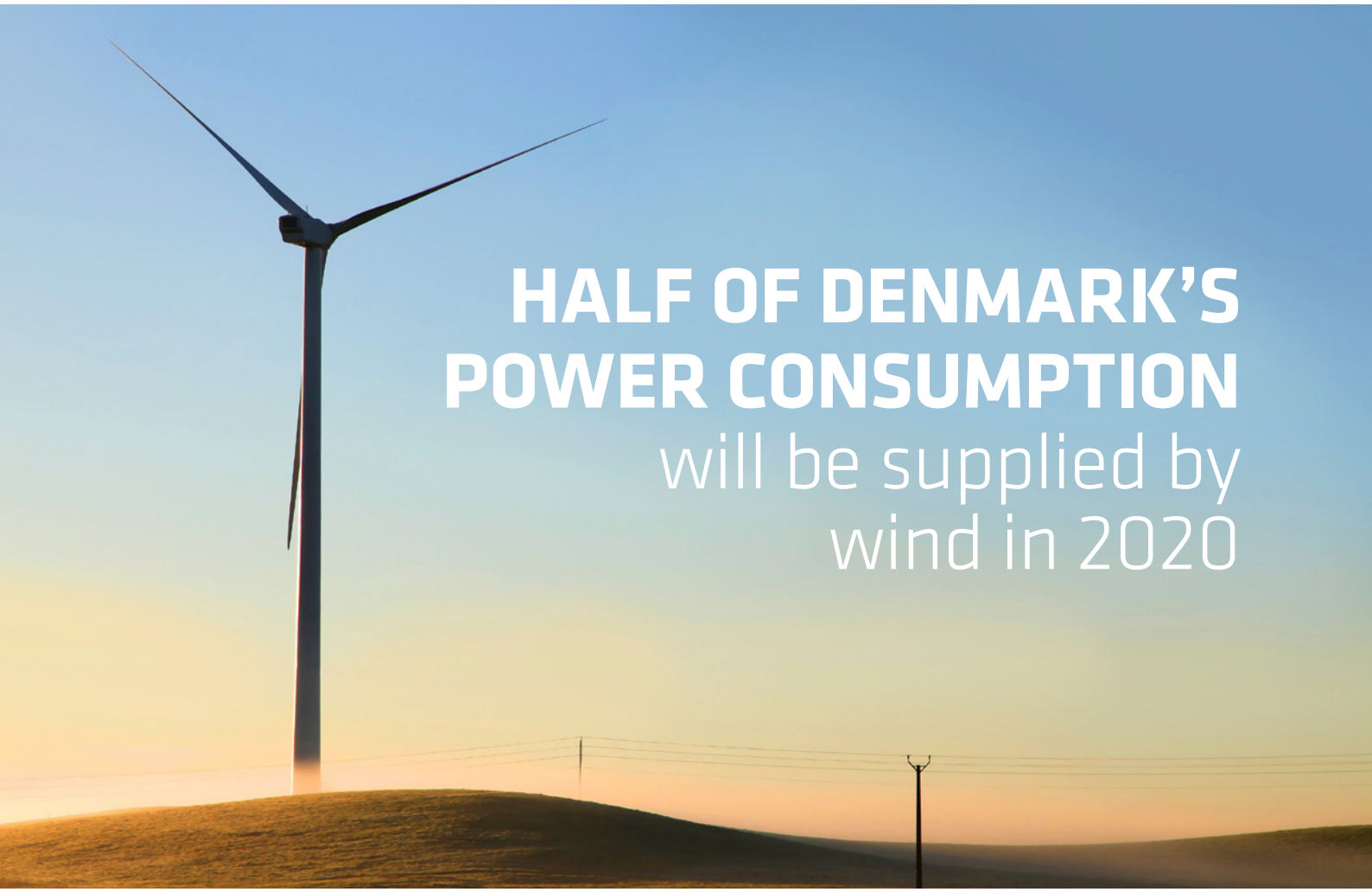
Key Recommendation 1 – Pricing signals to customers that reflect the value of flexible usage

Customers should be offered prices that reflect the current costs of electricity use at a given time, so that there is a financial incentive to shift electricity use to times of day when there is excess production and when the grid has spare capacity.

To accomplish this, all existing and future customers with the potential for flexible consumption should, at a minimum, should be billed on an hourly basis to the extent that this is possible. In particular, small and medium-sized manufacturers, but also customers with electric cars and/or heat pumps, are expected to make use of flexible pricing. Charging on an hourly basis is a key requirement if customers and other players in the sector are to achieve advantages for flexible consumption that Smart Grids allow.

Figure 3. Structure and functions in an intelligent electricity system





However, significant additional costs would be incurred if the type of hourly billing that is now available to customers with high electricity usage was used for customers who have a moderate consumption, as there are specific requirements for the quality of data and particular deadlines for data dissemination for high-use customers who are billed by the hour.

To work around this, electricity market regulations should establish a new independent billing group, in which adjusted requirements for validation and deadlines could reduce the additional costs for existing so-called "template customers" – that is, customers who consume less than 100,000 kWh per year.

This would make hourly billing a financially attractive option for customers with a flexible usage pattern, so that they could make use of daily variations in prices and rates. Furthermore, this would indemnify customers who have limited or no potential for flexible consumption.

Key Recommendation 2 – New economic regulation of distribution companies' Smart Grid activities

A new, modern way of regulating distribution companies should be designed, with an emphasis on establishing balanced and positive investment incentives for the rollout of Smart Grid solutions in the distribution system.

Moreover, the new regulations should allow and encourage distribution companies to introduce new technologies for the optimisation and utilisation of grid capacity (e.g., through improved metering, monitoring and automation), including engagement in research, development and demonstration activities.

Distribution companies should also be encouraged to effectively balance physical network construction solutions with operational solutions, which entail the active involvement of other agents in the electrical system on commercial terms. The new regulations should also ensure that distribution companies maintain a normal return on activities, which in turn will attract the necessary capital required for Smart Grid investments.

Furthermore, the regulations should ensure that customers without the potential for flexible consumption do not pay more to finance other customers' utilisation of their potential for flexibility.

Key Recommendation 3 – Electricity taxes that support an effective electrification

The energy tax system should be organised so that electricity customers are given a balanced incentive to switch their energy consumption in the heating and transport sectors from oil, gas and petrol to a flexible utilisation of electricity.

Implementing a further reduction in taxes on electricity used for transport and heating in permanent residences (i.e., heating sources with the potential for flexibility), including electricity usage in the heating by VAT-registered companies, is recommended in order to achieve a balance between the level of taxes for electricity and other fossil fuels. A reduction in taxes for electricity would make heat pumps and electrically powered vehicles more economically attractive for customers.

Key Recommendation 4 – Effective activation of storage and decentralised production

Framework conditions should be established to ensure the effective utilisation of storage facilities and decentralised production.

Taxes on electricity used for storage devices (batteries, etc.) should be set up in such a way that only the end-use of energy is subjected to tax. Otherwise, electricity storage devices would actually be subject to double taxation – i.e. taxes would be imposed on both storage as well as and on end-use. In practice, electricity storage devices should be handled according to the existing rules for the storage of fuels, whereby energy taxes are imposed only upon end-use of the fuel.

Customers are increasingly installing and connecting small renewable energy plants (below 6 kW), and the existing rules imply that they are not assessed capacity charge to pay for the grid capacity that they utilise i periods when they do not produce electricity themselves. To eliminate this, the framework for own-producers should be harmonised across production technologies and production capacities so that the conditions that apply today to own-producers with net-billed installations of above 6 kW also apply to smaller installations.

Furthermore, relevant commercial actors should be able to provide ancillary services to both the transmission system and the distribution system. This requires that distribution companies be able to optimise their operations by purchasing these services under market conditions.

Key Recommendation 5 – Strengthening of standardisation and interoperability

Goals should be established to ensure the establishment and implementation of standards of communication between the equipment of electricity customers and others involved in the electric system. The goal is a plug-and-play future, in which standards are so common that customers can easily install new equipment, including both consumer appliances and small production plants.

The rollout of the Smart Grid is particularly dependent on entering into international agreements about standards of communication between equipment and stakeholders in the electric system. Work on this is taking place within a number of standardisation groups with Danish participation. The Danish position is that the standards should be open and allow customers to easily change suppliers and equipment without being bound to particular producers.

▶ DISTRIBUTION COMPANIES SHOULD BE ENCOURAGED TO EFFECTIVELY BALANCE PHYSICAL NETWORK CONSTRUCTION SOLUTIONS WITH OPERATIONAL SOLUTIONS, WHICH ENTAIL ACTIVE INVOLVEMENT OF OTHER AGENTS IN THE ELECTRICAL SYSTEM ON COMMERCIAL TERMS

In relation to the standardisation process, one important activity is pre-standardisation, in which research projects are used as a starting point to influence and impact the standardisation process. There is a need for national awareness and political initiatives regarding standardisation in areas such as charging stations for electric cars, electricity meters, test facilities for demonstration of Smart Grid functionality, etc., in order to promote development and to ensure Denmark's position in Smart Grid development.

At the same time, the interoperability of Smart Grid solutions should be promoted. By using shared open-source software, the integration costs of cohesive Smart Grid solutions will be reduced for both existing and new standards. Furthermore, the interoperability between electricity-consuming and electricity-producing appliances in buildings will be promoted by requiring that these should be able to communicate with external control signals, including price signals.

Key Recommendation 6 – Research and development as a dynamo for green growth

A common vision and roadmap that outlines research, development and demonstration of the Smart Grid should be defined for research institutions, energy companies and industrial actors, in order to maintain and expand Denmark's position as the global leader regarding the Smart Grid.

Denmark holds a unique international position that can be used to promote green growth, with new value-adding jobs and the export of technology and knowledge. Intensified research and development are a prerequisite for the utilisation of this potential and for maintaining Denmark's leading position. In order to accomplish this, it is necessary to reinforce and market both research and experimental infrastructure that can position Denmark as a global hub for Smart Grid development. There is currently a need to strengthen advanced technical and basic research in the complex correlations in the electric system, as well as research in market design, consumer behaviour and Smart Grid interoperability.

Key Recommendation 7 – Strengthen consumer engagement

Electricity customers' engagement should be strengthened by increasing awareness and knowledge about the Smart Grid. This should be realised through the launch of Smart Grid education and information initiatives.

If the present customers are to be encouraged to take on the role of both flexible electricity consumers and decentralised electricity producers, with the rearrangement of daily routines that this entails, then it is imperative that they have an awareness of and knowledge about the Smart Grid. An important element in this is the electricity customers' knowledge about their options, and about the advantages and disadvantages of these for their private or business routines and economy, as well as for the climate and the electric system as a whole.

Key Recommendation 8 – Minimise the risks for electricity customers and actors

Possible risks for customers and other relevant actors who participate in Smart Grid activities should be minimised.

THE ENGAGEMENT OF ELECTRICITY CUSTOMERS SHOULD BE strengthened by increasing awareness and knowledge about the Smart Grid

Particular risks associated with investments, personal information and supply stability require attention and action. A lack of capabilities among suppliers of Smart Grid solutions or poor-quality solutions could prevent customers from participating in the Smart Grid. Therefore, Smart Grid competences should be developed among professional actors.

Furthermore the Smart Grid may entail IT security risks as a result of new connections and flows of information, based on information technology. With this in mind, a comprehensive risk assessment of the security of the Smart Grid should be undertaken, in order to establish a foundation for common framework for security.

Key Recommendation 9 –
Make it easier to create new services

Smart Grid data should be made available to service providers in an appropriate form and under appropriate conditions.

In the vision for the Smart Grid of the future, energy services will not only be provided by a traditional energy company, but by a series of actors who have developed different business models based on customers' individual energy-consumption patterns. New services in the Smart Grid will, among other things, be based on the utilisation of energy-consumption data and other data. Smart Grid data must therefore be available to service providers in the appropriate form and under appropriate conditions.

Several of the new services also require the preparation of electricity customers' buildings for the Smart Grid. Guidance as to how this could be done should be provided, including a basic digital infrastructure for both new and existing buildings in the form of data-communication options and digital building management.

Among the new service providers are so-called aggregators who can handle flexible electricity consumption or electricity production on behalf of individual customers. The cost of installing additional meters should be reduced by allowing the electricity meters provided by aggregators and read as part of their service to be used for utility billing as well. Finally, particularly small and medium-sized businesses capable of connecting to the Smart Grid may need a test and demonstration platform where they can show potential customers that their products or solutions function properly under realistic conditions.

Testing laboratories should be established, where small and medium-sized companies can test products and solutions under conditions similar to the actual electricity-supply system.

The Smart Grid Network has prepared a report explaining each of the nine key recommendations and 35 specific part-recommendations, which will each contribute to the realisation of the vision of a Smart Grid in Denmark by 2020. A more detailed examination of the key and part-recommendations can be found in the appendix reports1 from each of the working groups in the Network.

→ You can read more about the Smart Grid Network's Reccomendations in the main report, which you will find at www.kemin.dk

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