# Development of smart grid technologies: organizational and communication aspects

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**Abstract.** This paper concentrates on the organizational and communication aspects of development of the smart grid technologies. The paper highlights the potential of decentralised electricity generation for generating electricity from less energy-intensive and cost-efficient sources. It shows that renewable and unconventional energy sources may be integrated into decentralised electricity grids – the generation lines that have an intelligent grid. In addition, the paper focuses on the benefits and risks of different smart grid applications and their impact. We show that smart grids have the potential to minimise costs, but the use of smart grid technology also affects the level of risk, so the organizational and communication aspects are of a great importance.

## 1 Introduction

Integrating renewable energy sources and electricity generation into smart grid systems can be an important step in the transition to a more efficient and sustainable energy system [1]. Smart grids can transform a 20th century electricity grid into a 21st century electricity grid, allowing consumers to have greater control over the distribution of electricity and the production of energy from renewable sources such as wind, solar, geothermal, hydroelectric, biomass and hydroelectric, as well as energy storage and transmission [2]. An intelligent grid system improves the efficiency of electricity distribution, takes into account the need for more reliable, cost-efficient and reliable generation, transmission and distribution of energy, and can also take into account energy security, energy efficiency and energy saving [3]. The primary effects of the smart grid technologies are cost reduction, improved grid reliability and resilience, and greenhouse gas emission reductions [4]. Smart grids can also create new markets for the private sector to develop new technologies such as energy storage, energy efficiency and renewable energy generation.

Traditionally, smart grids have been designed to transport electricity generated by central power plants to consumers. Smart grid technologies such as energy storage, energy efficiency and renewable energy generation enable networks to adapt to evolving electricity markets. The changing mix of electricity generation operates centralised power plants as decentralised or decentralised generation and the changing flow of electricity as a result of the generation of renewable energies [5]. The fluctuating availability of renewable energy sources such as

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wind and solar places additional strain on the existing grid and requires more efficient and reliable electricity generation [6].

With regard to the above, one needs to consider how we can build and optimize infrastructure to provide data centres with the reliability, bandwidth, and data they need to keep their data centres and other critical infrastructure running. The answers come when one thinks about how the electricity needed gets into these plants in the first place, and that comes when she or he thinks about the energy grid [7]. When we look at the challenges of using and maintaining an electricity grid, smart grids and natural gas generators have the potential to address these challenges and help offset some of the pressure of dependency on traditional utilities. The installation of distributed energy generation can prepare cities for a smarter future, but also give consumers greater control over their electricity consumption.

Furthermore, smart grids would be characterised by the more decentralised electricity generation with a focus on the information, supply and demand side. In this way, they would focus on solar and wind energy which can be installed relatively easily in households, communities and business premises. An intelligent grid would allow these practices to be combined with other technologies such as wind and solar energy and other renewable energy sources. This would ensure a more reliable local electricity supply, while helping to create the transition to a clean and sustainable energy economy [8].

In addition, smart grids would also support the growing use of electric and hybrid vehicles, as they are more efficient and cost-effective than conventional vehicles [9]. A typical smart grid would use renewable energy sources to provide the same level of electricity as traditional fossil fuels such as coal, gas and oil. Smart grids provide a means of connecting various decentralised energy resources and installations to the grid and managing and distributing this energy. Data collection means smart grids can heal themselves if they spot service problems, rather than waiting for customers to report outages. The more stable power supply through smart grid technology will reduce downtime and prevent such high costs. By optimising the flow of electricity, waste can be reduced and the resources of cost-effective power generation can be fully utilised [10].

Additionally, harmonisation of energy production, transmission, distribution and distribution, as well as energy storage, improves the use of existing grid facilities and reduces network congestion, which can ultimately save consumers money. Smart grids continue to support traditional electricity loads, but decentralised generation methods such as wind, solar, geothermal, hydro and wind will increase the overall capacity of the grid. As electricity suppliers integrate information and communication technologies to modernise the power supply system, there is a chance to use decentralised generation reliably and cost-effectively. Existing low-cost decentralised power generation methods such as wind, solar, geothermal, hydropower and wind can be used to generate electricity with less energy - intensive and cheaper energy sources.

Moreover, it is clear that decentralised generation that is used in smart grids also greatly benefits the environment, as its use reduces the amount of electricity that needs to be generated in central power plants. This in turn can reduce the environmental impact of centralised production and reduce greenhouse gas emissions. This concept is practical and reliable, as numerous energy sources such as solar, wind, biomass and hydropower are available.

## 2 Components of smart grid development

The smart grid starts with sensors that provide important location data - based data that helps us better understand how to build a more robust, sustainable grid. This means that utilities will take different approaches to creating their smart grids and different utilities will create them at different implementation rates [11]. Experience and results from the development of demonstration sites will help in integrated testing and lay the foundation for the future development and implementation of the smart grid projects and for research and development. Households can be connected with smart meters linked to the low-bandwidth network communications to study the state of play of grid modernization efforts [12].

The adoption of smart grid technology is driving increased integration of renewable energy, energy efficiency and energy storage into the grid. At the forefront of the shift to smart grids is the ability to improve technology and exchange information on electricity use. Smart grids are a key component of energy security and economic development in developing countries [13]. Given that the technology enables more efficient generation, transmission and distribution systems, more reliable electricity distribution and better management of electricity generation and lines, a smarter grid is crucial to improve access to electricity and improve developing countries' economies. An intelligent electricity grid is a crucial component in the development of a sustainable energy system in every country. Industry experts usually state that the development of smart grids is transforming the energy industry by changing the way utilities interact with customers and allowing customers to proactively manage their energy consumption. In a way, smart grid technology offers many benefits to consumers, utilities and the energy industry [14].

An efficient smart grid requires spectrum capacity to support the broadband communications infrastructure required to operate the network. This type of communication network is currently in operation on the country's electricity grid, but has yet to be implemented to the extent required to enable a smart grid [15]. The availability of suitable frequencies for wireless connections, which is adopted by smart grid strategies, could fall far short of their intended objective if spectrum policies are coordinated. One way that a smart grid creates new opportunities is to give companies a competitive advantage in hiring. Another way smart grid might create new opportunities is in providing access to a wide range of services, such as information and communication services that companies provide when hiring staff, and to create new business opportunities. Business partnerships with utilities help turn these efforts into economic growth, and we discuss the role of clean technology and technology in government [16].

In addition to creating a more reliable and resilient electricity system and strengthening our existing infrastructure, we are also deploying new technologies such as self-optimising smart meters and smart thermostats, as well as smart energy management systems. One can highlight the impact of smart grids on the economy, from energy efficiency and renewable energy to clean energy and energy storage, energy efficient vehicles, smart homes, energy efficient buildings and more. Networked control interfaces that coordinate network operation over the entire network coordination framework. These include integrated mechanisms such as smart meters, smart thermostats and smart homes, as well as devices to coordinate grid operation within the grid. Networked controllers and interfaces to connect all these and other smart grid systems, from smart meter systems to smart buildings. Networked control interfaces that coordinate network operations across the entire network coordination framework, from smart meters to smart thermostats and smart homes to smart buildings [17].

Smart grid deployment is accelerating at different speeds in the United States and other countries around the world, largely dependent on the availability of the right technologies, infrastructure, and infrastructure management tools. The networking of the devices that are integrated into the intelligent network opens up new possibilities for cyber and physical technologies to connect cyber systems with physical systems, thus removing barriers between the virtual - physical and the real world. The smart grid is considered a critical national infrastructure, and the growing reliance on smart grids for generation, transmission and distribution makes it an important part of the national energy system [18]. Security is a key concern for the future of smart energy systems in the United States and worldwide. Smart grids are a significant part of our country's energy infrastructure and a major threat to our national security.

## 3 Stakeholders interactions in smart grid

There is currently a technology push approach that hardly involves an integrated approach to smart grids. The frameworks can help reduce complexity through local decision-making and demonstrate this complexity. According to the stakeholders, no current products or services are offered for smart grid controllers for the private sector [19]. The smart grid projects are embedded in a larger project structure and includes several links to other projects. The far-reaching decisions have to be taken and the progress of the project has stalled. Using the smart framework, one can briefly present the complexity of the cases, including the attributes of the community that influence actions in each situation. Transparency therefore requires the right language to explain how infrastructure decisions affect power generation options. Particularly, it is important how to increase stakeholder engagement in the early stages of grid expansion. One can assess the importance of proposed power transmission projects and has thus contributed to its forthcoming report on the role of stakeholders in the planning and implementation of smart grids. Improving this area is clearly an important step in gaining support for these projects and a key element in the development of an intelligent electricity network. This paved the way for a common platform for stakeholders in the development of a bi-directional smart grid. Opportunity to develop a smart grid strategy that meets the needs of consumers to increase their satisfaction and improve living standards in smart cities is needed. The importance of transmission line management and the role of the grid in the development of smart cities and smart lives. Upgrading the energy network and increasing its efficiency, reliability and cost-efficiency. By using modern technologies such as IoT and AI, we are enabling and ensuring energy independence through green and clean energy, smart cities and smarter lives through smart energy [20, 21].

Smart grid projects and group members share a common understanding of what smart grids entail and the need to connect renewable energy technology to the ICT level. However, members of the project groups have different views on how to implement them and different approaches to their implementation. However, the project groups have not discussed any further steps and seem unsure how the implementation process will proceed [22]. The uncertainty that exists among the parties is particularly evident in the fact that they have apparently not been able to agree on what agreements they could and should make and have never discussed how costs and benefits are to be distributed. We have used the strategic niche management framework to identify key stakeholders in smart energy products and services and their role in the development of the smart grid.

In the Southwest of the United States, the community, which was originally based on cooperation to reinvent the energy system, has joined forces to create one of the most remote energy projects of its kind in the United States. With this co-creative approach, the group applied, won and doubled funding, and what it built was a vision and strategy. The pilot project was so successful that it was oversubscribed, with participants buying in and being involved as stakeholders in the co-creative process. This might serve as an appropriate tool to facilitate the exchange of technical results and best practices and to accelerate the development of new technologies to accelerate the deployment of smart grid technologies in the private and public sectors [23]. The importance of promoting industrial engagement and the role of the private sector in smart grids is apparent. Thence, the current state of the art of smart grid technologies and technologies available to the public and private sectors, as well as the potential for the future, should be carefully studied and assessed [24].

There are some strategies that have not been developed in the past without full cooperation with stakeholders. The model deals not least with the interaction mi, which is characterized by a lack of coordination and coordination between stakeholders and the lack of a clear strategy for implementing the strategy. Moreover, the interactions between stakeholders are insufficient due to the limited number of stakeholders and the low level of cooperation. Governments also contribute to fragmentation of efforts and low-level coordination, while governments efforts are fragmented. Given the importance of facilitating a rapid and equitable transition to clean energy, focusing on the ecosystem of energy sector support is crucial to success. Civil society organisations need to identify ways to cooperate and support energy generation and distribution companies. Any ecosystem of civil society organisations that support and engage with discos consists of a number of organisations, some of which have existed for decades and in some cases overlap with thematic expertise and approaches.

To continue to grow and innovate successfully, renewable energy companies need to integrate and expand their ability to manage social governance risks as part of their business model. Renewable companies should pursue a strategy that takes into account the project context and the immediate environment. On the road to a low-carbon economy, some renewable energy projects may face the challenge of building and working in an environment with high environmental and social risks, as well as social and regulatory risks. The transfer of skills and experience is crucial for a successful energy transition. Much of this expertise comes from the extractive industries, and working in a high-risk environment can entail serious environmental and social risks. There are various non-profit organisations that want to promote the transfer of skills and experience in the field of renewable energy from the extractive industries. The National Renewable Energy Laboratory (NREL) is committed to taking a leading role in advancing the United States Department of Energy's renewable energy research and development goals. Public utilities which are often publicly owned and offer a range of services in the city, have quickly switched to more environmentally friendly energies over time. Among many other useful resources, libraries of renewable energy contracts can be complied that includes all the contract forms and permits needed to facilitate project development [25].

Since the adoption of the Renewable Energy Sources Act, which guarantees providers the right to feed renewable electricity into the grid, the renewable energy sector in Germany has been booming. In the German energy sector, renewable energy generation technologies are developed, owned, operated, produced and operated by a wide range of companies, be it private, public or public-private partnerships such as the municipal utilities. The partnership works closely with local governments, energy companies, utilities and other renewable energy stakeholders to facilitate the development of new projects and promote their environmental and economic benefits [26]. There are some business companies that make the world leaders in helping consumers, homeowners and businesses save money and protect the environment through certified energy-efficient products and processes. They can teach citizens how to be on track and identify energy saving strategies for their home or business. It is a voluntary support and partnership programme that promotes the recovery and beneficial use of landfill gas by reducing or preventing methane emissions from landfills.

## 4 Smart grid assessment systems

Another interesting aspect of smart grids is that they can also enable system operators to reduce the risk of failure by accessing previously unconsidered data, from weather forecasts to data from social networks. Outage reports combined with weather reports can be enabled by automated controls that check and evaluate the status and condition of the network to detect anomalies or problems in any condition. In 2023, 65% of electricity companies will invest in digital technology platforms to support flexibility and service, thereby unlocking the potential for more efficient and cost-effective use of installed capacity. Centralised electricity generation will be decentralised as new technologies continue to enable the integration of smart grids into the electricity supply chain and the provision of energy services. This could cost between $338 billion and $476 billion over the next 20 years, with an average annual benefit of $1.5 billion over that period [27]. These benefits include a reduction in the cost of electricity generation and the provision of energy services, as well as the creation of new jobs. The cost of fully rolling out a smart grid over the next 20 years could be between $1.5 billion and $2 billion a year, bringing a trillion-dollar benefit to the United States. Moreover, the estimated cost of using digital control applications in the electricity grid, on average $17-24 billion per year, will fall most heavily on the utility systems that supply electricity to end users [28]. This will require improving the infrastructure needed to enable smart grid technologies and replace aging equipment and could save utilities up to $3.6 billion annually in costs. Thence, the cost of upgrading the United States electricity system and deploying a smart grid in response to a call for proposals from the United States Department of Energy's Energy Information Administration might be too high for many stakeholders and citizens to accept. Investing in edge analytics and computing as one strives for smarter, more efficient and more cost-effective energy management systems [29].

In addition, when people first hear about smart grid initiatives, they are most interested in smart meters. Smart meters are at the heart of a development that began decades ago and has led to the roll-out of smart grids in many parts of the world, from the United States to Europe to Asia but that would also cost lots of money. Micro grids play an important role in building a low-carbon future by bringing resilience to the main grid, optimising energy costs, enabling the use of renewable energy, improving the integration of electric vehicles and improving energy availability [30]. It is about decentralised energy resources and the question for them is whether systems can handle them and to help to find reliable and affordable ways for utilities and grid operators to use new ways to produce, supply, and use electricity.

## 5 Conclusions

In this paper, an intelligent grid was scrutinized as a system with distributed energy resources and distributed control over their distribution. The implementation of smart grids therefore depends on whether system developers have the tools to assess the reliability of the system as portfolio development progresses. As the number of smart grid applications continues to grow, the benefits and risks of their implementation and their impact on the environment need to be fully understood and assessed.

The paper also discusses the most important impacts of smart grid deployment on smart cities in different ways, and then presents a series of evaluation criteria for smart grids that go beyond purely financial aspects. It also provides a framework for monetising smart grid benefits, thereby contributing to the development of an evaluation criterion that could be used in other applications.

Speaking about the possibilities of future research, it is apparent that the methodology set out in this paper as well as its major concepts can, of course, also be extended further to the evaluation of proposals for the development of smart grids in the smart cities. New methods are therefore needed to assess the benefits and risks of different smart grid applications and their impacts.

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