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Smartgrid: An Introduction

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Abstract

This paper provides an overview of the Smartgrid paradigm. This includes the basic architecture, key feature, Advantages, disadvantages and challenges to its adoption. The accelerating installation of renewable generation has made the requirement for a revised electrical power system design more pressing. Based on specific configurations, appropriate rules and regulation will then need to be developed. The Smartgrids can meet the cost, efficiency, and environmental benefits; and the demanding requirements for security, quality, reliability, and availability benefits of on-site generation, achieved by incorporating modern controls and operating with a degree of autonomy. This will also useful for the reduction of CO2 emission.

Index Terms

Smartgrid, Renewable energy sources, Power grid, World energy growth.

1. Introduction

Modernization of the electricity delivery system so that it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, electric vehicles, appliances and other household devices. They need to achieve specific goals, such as reliability, carbon emission reduction, diversification of energy sources, and cost reduction, established by the community being served. Like the bulk power grid, smartgrids generate, distribute, and regulate the flow of electricity to consumers.

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Smart Grids are an ideal way to integrate renewable resources on the community level and allow for customer participation in the electricity enterprise [1]. The Smart Grid is a combination of hardware, software and management system, which make it an intelligent communications infrastructure. In the Smart Grid, consumers and utility companies alike have tools to manage, monitor and respond to energy issues. The flow of electricity is a two-way conversation from consumer to utility or to consumer, saving consumer's money, delivering more transparency in terms of end-user use, and reducing carbon emissions. The Smart Grid in large, sits at the intersection of Energy, Defense, Research, IT and Telecommunication Technologies. A smartgrid is a semiautonomous grouping of generating sources and end-use sinks that are placed and operated for the benefit of its members, which may be one utility "customer," a grouping of several sites, or dispersed sites that nonetheless operate in a coordinated fashion. The supply sources may include reciprocating engine generator sets, microturbines, fuel cells, photovoltaic and other renewable generators, storage devices, and controllable end-use loads[2]. All controlled sources and sinks are interconnected in a manner that enables devices to perform the smartgrid control functions unnecessary for traditional DER. For example, the energy balance of the system must be maintained by dispatch, and non-critical loads might be curtailed or shed during times of energy shortfall or high costs.

2. Smartgrids installation

Originally the idea was to improve reliability for specific customer and critical loads. Today, smartgrid can be installed to provide better reliability, improve dispatch ability of a customer's load, firm up variable generation, and control energy costs [3].

Three key potential features of the Smartgrids are:

1. Design of smartgrid around all system energy requirements.
2. Its provision of better level of power quality and reliability to end-uses.
3. Its presentation to the smartgrid as a single controlled entity.

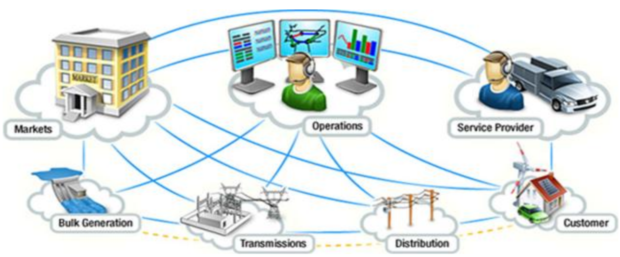

Fig 1. Smart Grid Conceptual Model as adopted from the National Institute of Standards and Technology (NIST smart grid framework 1.0 January 2010)

3. The Major Benefit of Smartgrids

- Providing energy services tailored to the requirements of smartgrid end users, such as service continuity in time of main grid outage and increased renewable generation.
- The manufacture, operation and
- Maintenance of the smart grid system and its components will create new jobs within the state.
- Enabling parallel operation with the main grid for improved financial performance through economic exchange of energy and ancillary services between the two.
- Enabling parallel operation with the main grid for improved service reliability through coordinated response during emergency situation to serve critical loads and to reduce outage impacts.
- The combination of lower costs, improved reliability and better customers control will raise satisfaction among all types of customers.

4. Ongoing Smartgrid Activities

The bulk of the Department of Energy's smartgrid R&D effort to date have focused on demonstration activities to meet niche application needs, such as those for meeting peak load reduction, renewable energy mandates and directives, and energy surety and reliability at certain critical facilities, including military installation[4]. These ongoing smartgrid demonstration projects consist of lab and field scale R&D test beds, renewable and distributed systems integration projects for peak load reduction, select Smart Grid demonstration program projects funded under the American Recovery and Reinvestment Act of 2009 as part of office of Electricity and Energy Reliability implementation of grid modernization, and assessment and demonstration projects jointly supported by the U.S. Department of Energy and Defense.

5. Smartgrid Operation and Investment

A typical smartgrid portfolio includes photovoltaic (PV) and wind resources, gas-fired generation, demand-response capabilities, electrical and thermal storage, combined heat and power (CHP), and connectivity to the grid. Advance technologies such as fuel cells may also be included [5].The value of a smartgrid portfolio depends on its projected return on investment and the potential growth in its operating income.

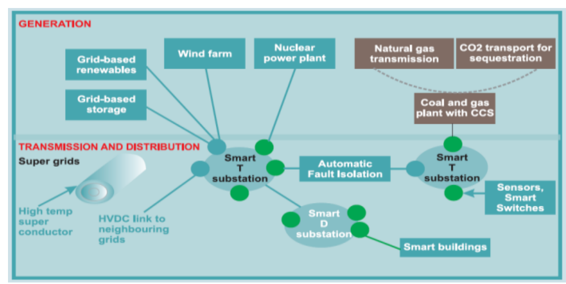

Fig 2.Overview of Smart Grid

For a portfolio of financial assets, valuations are based on projections of the market prices, industry trends, and futures prices as a basis for the projections. For a smartgrid, the investment payoff is directly linked to the operation of the physical assets, and return on investment depends on how these operations will be optimized and utilized in the short term.

6. Deployment of Variable Generation Technology

Variable generation technologies like solar, wind or tidal produce electricity that is dependent on climatic or other conditions, meaning there is no guarantee that it can be dispatched as needed. This includes electricity generation from wind, solar system, photovoltaic, run-of-river hydro, combined heat and power, and tidal technologies. There are some good examples of successful approaches to variable resources. Ireland's transmission system operator, EirGrid, is deploying smart grid technologies, including high temperature, low-sag conductors and dynamic line rating special protection schemes, to manage the high proportion of wind energy on its system and maximize infrastructure effectiveness.

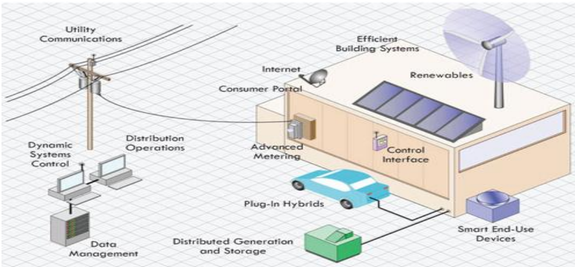

Fig 3. Enabling Smart Grid (The University of Arizona Photovoltaic- Smart grid and the watery Project)

7. Smartgrids Metering

Smart meter is an advanced energy meter that measures the energy consumption of a consumer & provides added information to the utility company compared to regular energy meter. Smart meter can read real time energy consumption information including the values of voltage, phase angle and the frequency and securely communicates that data [6]. The ability of smart meters for bidirectional communication of data enables the ability to collect information regarding the electricity fed back to the power grid from customer premises. A smart meter system includes a communication software, control devices and smart meter,. Smart meters can be control by remote, it can communicate and execute control commands remotely as well as locally [7]. Smart meters can be used to monitor and also to control all home appliances and devices at customer's premises. They can also collect information about the distribution lines or grid, home appliances, and can communicate with other meters. They can measure electricity consumption from the grid, support decentralized generation source and energy storage devices, and bill the customer accordingly [8].

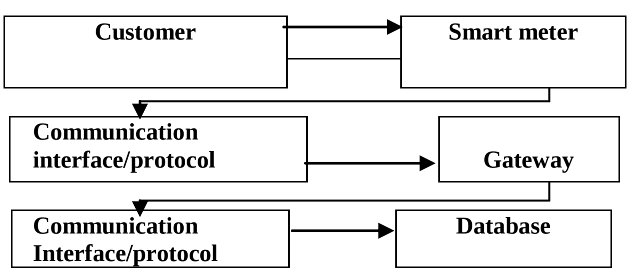

Fig 4. Smart Meter architecture of conventional energy meter and smart meter

8. The Future of Smartgrids

Participation in the capacity markets and ancillary services markets are attractive revenue streams for smartgrids. Inclusion of ancillary market commitments in day-ahead and intraday operations is a well-understood problem; the mathematics is very similar to that used for the co-optimization that independent system operator (ISO) market operations practice when scheduling grid resources today. As with ISO-level market operations, incorporating significant storage in the formulation and obtaining co-optimized solution are challenges [10]. Incorporating ancillary participation into investment decision is more complicated, however, as bidding strategies come into play. In the examples shown above, the smartgrid is a simple "price taker" in the market that optimizes its resources once market prices are known. But to participate in the ancillary markets, the smartgrid operator must make informed decisions about what ancillaries and what energy to offer the markets as a bidder. This complicates the process of decision taking and the investment decision required to enable that participation. There is also interest from very large facility operators in co-optimization energy operation across multiple smartgrids. This is an area being intensively investigated at Rutgers.

9. The Future of Smartgrids

1. Present Infrastructure is inadequate and requires
2. Augmentation to support the growth of SmartGrids.
3. Most renewable resources are intermittent and cannot be relied on (in its present form) for secure energy supply.
4. Regulatory Policies to deal with consequences of SmartGrid; like off peak, peak tariffs and other related matters.
5. Grid Operation : Monitoring & control

   Utilities have been reluctant to endorse smartgrids. The valid historical argument has been the safety concern of unintentional "islanding", that is, a part of the smartgrid that has become separated from the main grid but not shut down during a black out[10].

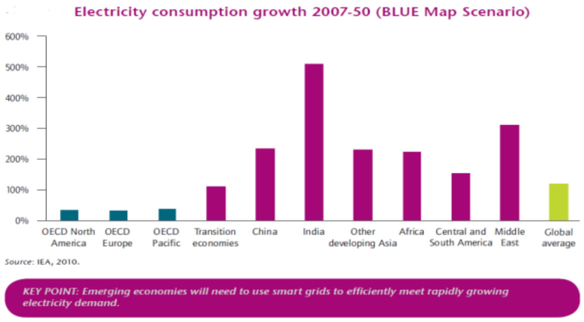

Fig 5. Electricity consumption growth 2007-50 (BLUE map Scenario)

The safety concern is that unintentional islanding can be dangerous to department workers, who may not be aware that a circuit within the "island" still has power. Secondly, islanding may prevent automatic reconnection of devices into the grid. Existing grid protocols address this concern in that they dictate that all distributed power generation must shutdown during power outages. To address these concerns, new inverter technologies are designed to integrate renewable energy sources such as solar and wind while allowing safe operation in island mode[9].Another challenge has been the lack of established standards for smartgrids. A positive step in addressing this was the 2011 adoption of the Institute of Electrical and Electronics Engineers (IEEE) standard, "Guide forDesign, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems". Some barriers have prevented the wider and more rapid deployment of Smartgrids. First, Smartgrid system developers have to persuade their customers or demand, smartgrids exceed the costs. In the electric area, it is hard to obtain an accurate assessment, and even when it's available, that assessment is difficult to understand. It requires an unusual degree of leadership for a major healthcare, education, or housing provider to understand the benefits and then make the decision to secure them by deploying a smartgrid.

There are four key components for any effective smartgrid.

1) Smartgrid has robust telecommunications with low latency and high bandwidth capability.
2) High-speed data processing to enforce interconnection rules.
3) Monitoring and control system to communicate instruction to devices.
4) Sophisticated cyber security to protect the integrity of the control system and confidentiality of the participants.

10. Smart Grid CO2 Emissions Reduction

Although electricity consumption only represents 17% of final energy use today, it leads to 40% of global CO_2 emissions, very high because nearly 70% of electricity is produced from fossil fuels (IEA, 2010). In the ETP BLUE Map Scenario, as a result of decarbonisation, electricity generation contributes only 21% of global CO_2 emissions, represent an yearly reduction of over 20 Gt of CO_2 by 2050. Smart grid technologies will be needed to improve and enable these emissions reductions.

11. Next In Smartgrid

Although the technical immaturity and current cost structure of smartgrids will limit their application to niche markets in the short term, the future for smartgrids is promising. Power equipment companies now investing in pilot smartgrid projects and currently available market opportunities will be well positioned for market leadership as the demand for smartgrids increases over time[12]. However, perhaps the largest benefactors of smartgrids will be foresighted utilities, communities, industrial parks and the like, that will leverage smartgrids to optimize their energy costs with the added bonus of generating revenue or income opportunities by selling electrical energy back to the grid during periods of peak demand.

12. Disadvantages of Smartgrid

- Biggest concern: Privacy and Security
- Some types of meters can be hacked
- Not simply a single component
- Expensive in terms of installation

13. Conclusion

Smartgrid is a very effective solution in the field of Electrical system. We need to improve and increase the area of smartgrid, by using this overall efficiency is increase of the system and carbon emission is also reduced.

Acknowledgment

Smart grid is an emerging technology to provide next generation power grid and is promoted by many governments in the sense of addressing energy independence, global warming and emergency resilience issues.

More research needs for a revised electrical system design more pressing. More research needs to be done in the areas of variable generation like solar or wind, storage, and system control, including their interactions. The many demonstration projects now underway will help direct the continuing evolution of the electrical grid.

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