The Smart Grid: Operational, Privacy, Security & Economic Issues

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Introduction

The Smart Grid is a modern and advanced electrical power grid which uses various forms of communication systems along with advanced infrastructure to improve efficiency, reliability, economy, and sustainability of the production, distribution, and consumption of electricity. The Smart Grid involves the use of distributed generation of power by using small scale or large scale distributed generators, a two way networked communication system and bidirectional flow of power in the grid. The Smart Grid also includes advanced measuring devices to identify the state of the grid. Introduction of a smart grid technology to the current grid has a couple of advantages listed below.

- Smooth's peaks in demand by enabling the use of *Demand Response* and *Time of Use Pricing*
- Reduces green house gas emissions
- Facilitates integration of renewable energy sources with the conventional grid
- Supports the use of *EVs* and other green technologies
- Improves reliability and energy efficiency of the grid by quick fault detection and mitigation
- Reduces congestion and possible blackouts in the grid
- Reduce line losses in transmission and distribution lines
- Provides for better power management in the grid
- Enables the formation of *Micro-grids* which are small scaled self-sustaining smart grids capable of being selectively isolated from the main grid

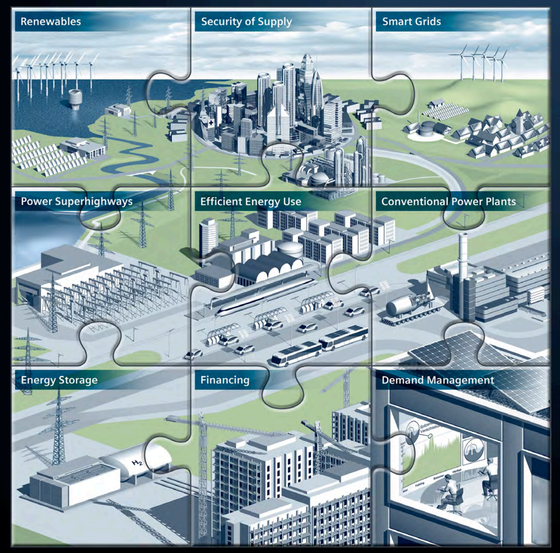

Figure 1: The Smart Grid Puzzle

Problems with Distributed Generation

A multitude of operational issues are faced by renewable energy sources which constitute to distributed generation. These issues are related to the generational characteristics, power quality & quantity, reliability, and the control of the generator. Mainly Solar and Wing energy have been discussed here as these are the major renewable energy sources currently deployed on a large scale. Also, government policy is moving towards more '*green*' power generation capacity and this leads to major operational issues with these generators.

Dealing with Wind energy generation issues

Wind Power generation is not reliable as wind itself it pretty variable. The graphs show the variability of a single wind turbine. Aggregating Wind turbines solves this problem

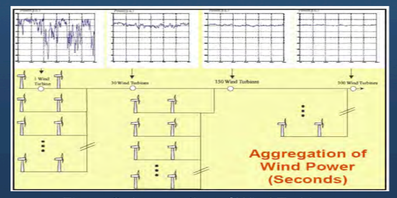

Figure 2: Aggregation of Wind Turbines

Ladakh Solar Project

Ladakh is High altitude plateau & a cold dessert with very little precipitation and has altitude of over 10,000 feet. The Summer range 15°C and -10°C in winter. This is an ideal location to build PV solar power plant as it favors the characteristics of PV cells

Figure 3: Solar Power in Ladakh

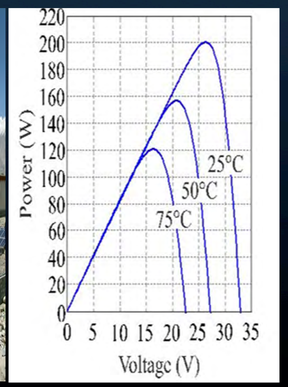

Figure 4: PV panel characteristics

Implementing a Smart Grid And Related Issues

One of key components of a Smart Grid include the regulation and reduction of peak demand. This peak demand of energy puts great strain on the grid and requires redundant generating plants that lie idle for most part of the day. The power produced by these plants is really expensive and thus we need to implement certain strategies to reduce this demand. This reduced demand reduces the price of power and also reduces grid congestion and transmission losses.

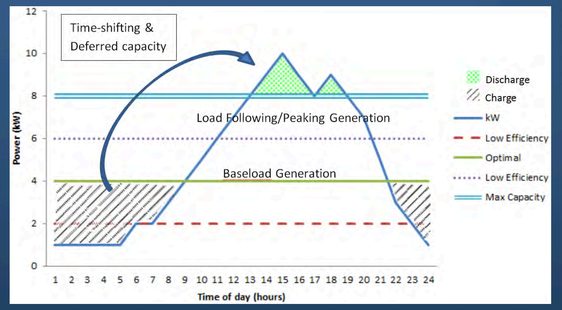

Figure 5: The Demand Response Concept

Demand Response is the concept wherein the utility can regulate certain power intensive processes to reduce peak power demand. Another related concept to demand response is *Time of Use (ToU) pricing* wherein the costs of expensive peak load power is passed on to the consumer. To implement these concepts, we need an Advanced Metering Infrastructure in place.

Smart meter

Smart are electric power meters which have small embedded computers. These meters combine advanced metering techniques and a communication system which enables utilities to measure the consumer power consumption in a real time basis. This enables the utility to implement Demand Response and ToU pricing strategies.

Figure 6 & 7: Smart Meters and their Opposition

Issues

The major issues with implementing various aspects of the Smart Grid are technological and many are non-engineering issues and they are grouped under Economic Issues and Privacy-Security Issues. Economic Issues arise from the fact that to implement a Smart Grid, a enormous investment in capital is required. The costs to be born by consumers, utilities and the government are huge! Also, there is a vehement opposition to the installation of smart meters. which stems from the fact that there are many Privacy and Security concerns for the use of Smart Meters. A smart meter has a capability to collect and transmit a lot of information regarding a consumer such as home occupancy, targeted advertising, policing, spying etc. Also, there is misguided concerns regarding the RF signals produced by these smart meters and the effect the have over human health. This is a major obstacle in implementing Smart Meters and the Smart Grid as a whole.

Conclusion and future work

Numerous issues need to be solved before a Smart Grid can be successfully implemented and realized. The future of electric grid lies with the realization of the smart grid and for this a lot of effort is required to solve these Operational, Privacy, Security and Economic issues. We have **to open minded** and **innovative** to surpass all these hurdles.

- **Engineering**: Locally distributed generation, advances in power electronics and *HVDC*, signal processing, communications networks, real time control systems and cyber security.
- **Economy**: Time of Use (TOU) pricing support for better demand regulation and demand automation. Subsidizing renewable sources. Wind costs unto $1million per MW to install. The same cost for solar is $3million!
- **Legislations**: Skill development for a smarter workforce, research incentives to develop newer technologies, development of green technologies for environmental protection, development of standards of new technologies. Amendments to privacy protection laws

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