Fiber to the Home: A Key Element for Smart Electric Grids

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Introduction

The development of Smart Electric Grids has become essential for utilities and consumers in order to gain the efficiencies and economics necessary to support load growth, new environmental standards and keep consumer costs at reasonable levels. Fiber to the Home (FTTH) is a key element that provides the medium to connect smart consumer devices to the local utilities Smart Grid network.

What is a Smart Grid

A Smart grid is a type of electrical grid which attempts to predict and intelligently respond to the behavior and actions of all electric power users connected to it - in order to efficiently deliver reliable, economic, and sustainable electricity services.

In the United States, the Smart Grid concept is defined as the modernization of the nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth and to achieve each of the following, which together characterize a Smart Grid:

1. Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.

2. Dynamic optimization of grid operations and resources, including automatic generation control and economic dispatch.

3. Deployment and integration of distributed resources and generation, including renewable resources.

4. Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.

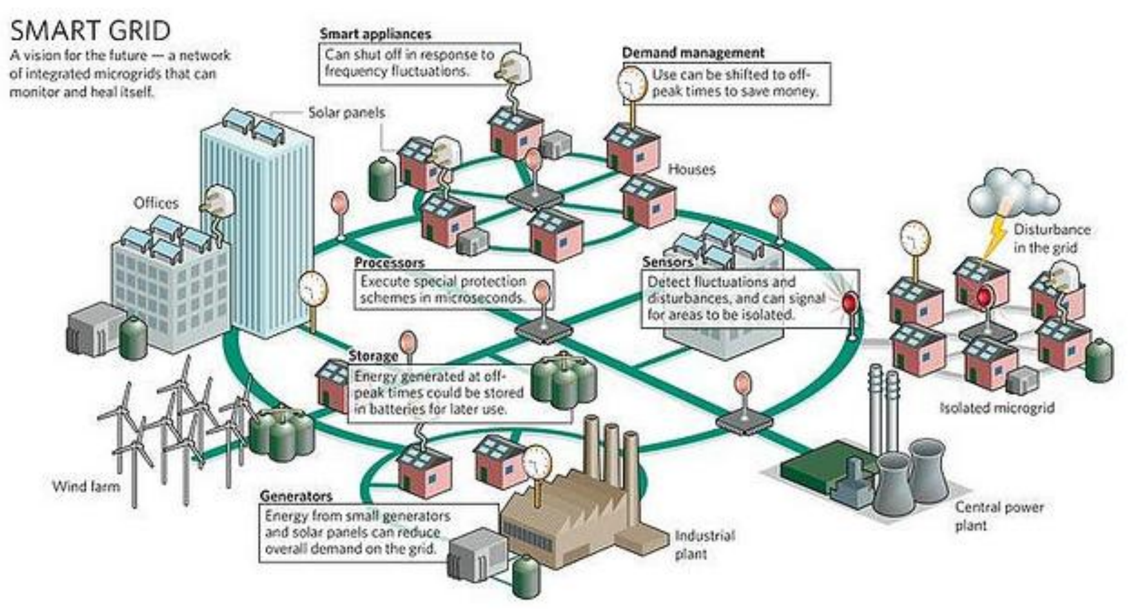
5. Deployment of `smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.

6. Integration of `smart' appliances and consumer devices.

7. Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.

8. Provision to consumers of timely information and control options.

9. Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.



Broadly stated, a smart grid could respond to events which occur anywhere in the power generation, distribution and demand chain. Events may occur generally in the environment, e.g., lower than expected winds resulting in reduced wind-turbine production, clouds blocking the sun and reducing the amount of solar power or a very hot day requiring increased use of air conditioning. They could occur commercially in the power supply market, e.g., customers change their use of energy as prices are set to reduce energy use during high peak demand. Events might also occur locally on the distribution grid, e.g., an MV transformer fails, requiring a temporary shutdown of one distribution line. Finally these events might occur in the home, e.g., everyone leaves for work, putting various devices into hibernation or shutting them down completely. Each event motivates a change to power flow.

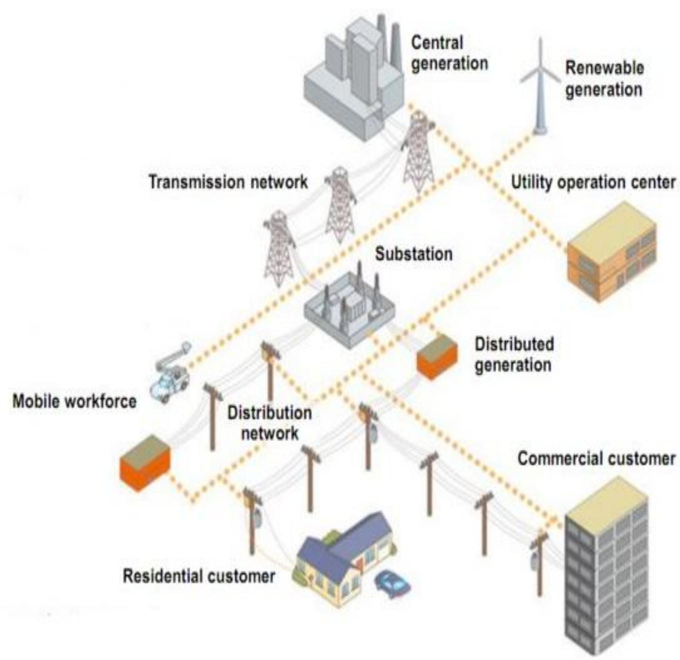
The function of an electrical grid is not a single entity but an aggregate of multiple networks and multiple power generation companies with multiple operators employing varying levels of communication and coordination, most of which is manually controlled. Smart Grids increase the connectivity, automation and coordination between these suppliers, consumers and networks that perform either long distance transmission or local distribution tasks.

In addition to changes in consumer use, there are also changes in how power is generated. Transmission networks move electricity in bulk over medium to long distances, are actively managed, and generally operate from 345kV to 800kV over AC and DC lines.

Local networks traditionally moved power in one direction, "distributing" the bulk power to consumers and businesses via lines operating at 132kV and lower.

This paradigm is changing as businesses and homes begin generating more wind and solar electricity, enabling them to sell surplus energy back to their utilities. Utility grid modernization is necessary for energy consumption efficiency, real time management of power flows and to provide the bi-directional metering needed to compensate local producers of power. Although transmission networks are already controlled in real time, many of the US systems are antiquated by world standards, and unable to handle modern challenges such as those posed by the intermittent nature of alternative electricity generation.

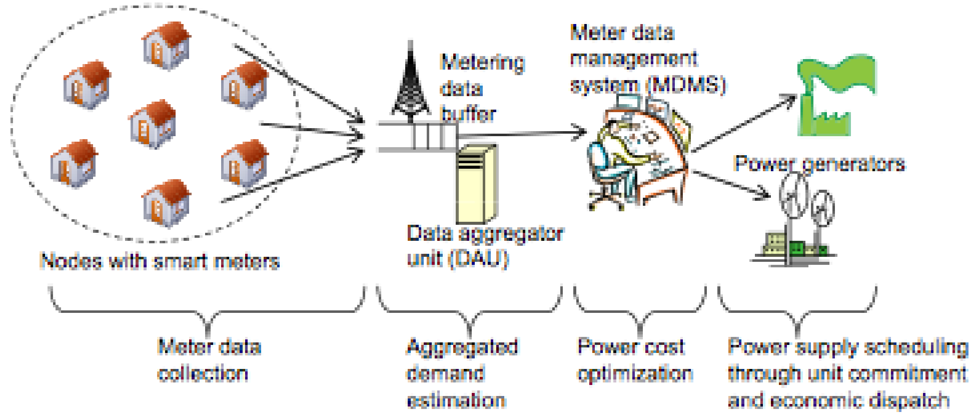
Some communications are up to date, but are not uniform because they have been developed in an incremental fashion and not fully integrated. In most cases, data is being collected via modem rather than direct network connection. Areas for improvement include: substation automation, demand response, distribution automation, supervisory control and data acquisition (SCADA), energy management systems, power-line carrier communications, and greater use of fiber-optics. Integrated communications will allow for real-time control, information and data exchange to optimize system reliability, asset utilization, and security.



Economic Dispatch
The concept of a Smart Grid goes well beyond the ability for utilities to remotely read electric meters and consumers to maximize time of use electric rates – fundamentally it provides for the economic dispatch of generation throughout multiple utility company electric grids based on real time load and intelligent data gathered from consumers.

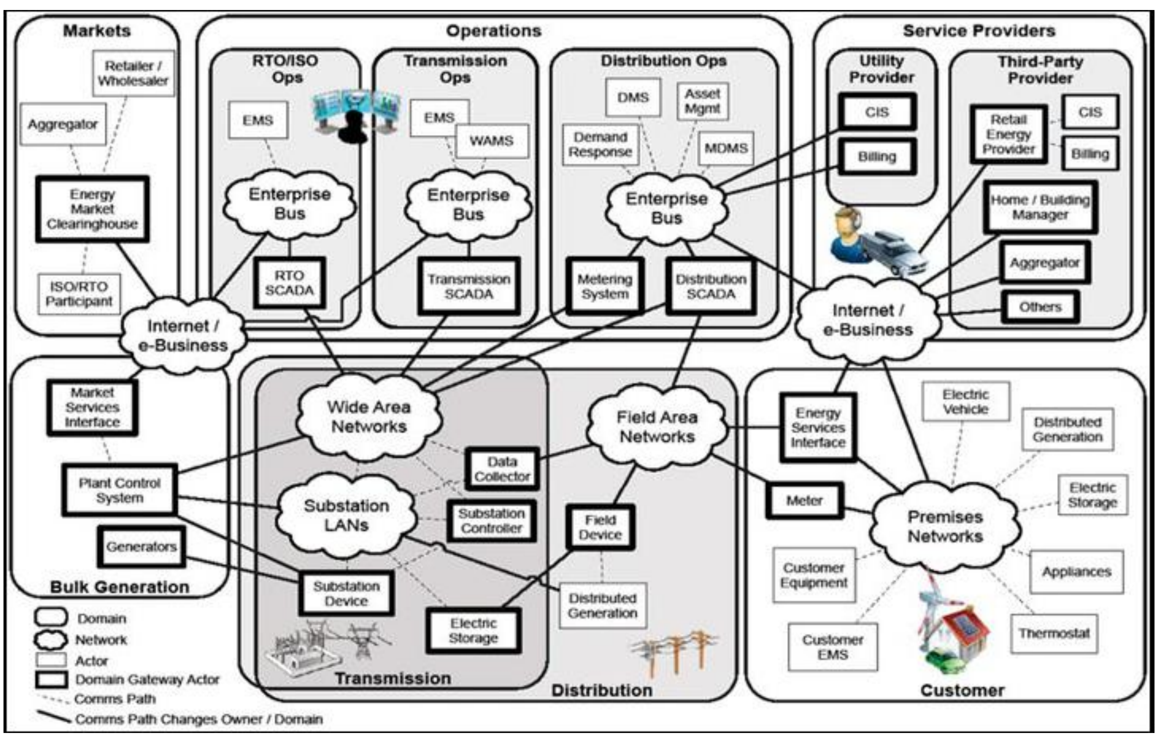
Utility companies use economic dispatch to distribute reserved power to consumers after calculating demand. Economic dispatch along with unit commitment is a way in which utility companies can predict and schedule electric supply based on estimated consumer use. Smart Grid meters and consumer devices provide the data to utility companies to predict power usage and further optimize cost through economic dispatch.

Smart Grid will also reduce the amount of spinning reserve that electric utilities have to keep on stand-by, as the load curve will level itself through a combination of "invisible hand" free-market capitalism and central control of a large number of devices by power management services that pay consumers a portion of the peak power saved by turning their devices off.



Automatic Generation Control
Loads in one utility footprint may be best served by generation in another footprint. A true Smart Grid will enable the combination of consumer load data, bulk electric transmission and distribution capability, as well as generation availability to all be shared for an optimum combination of options for utilities and consumers.

Automatic Generation Control (AGC) looks at load on power usage more frequently then Economic Dispatch. AGC is able to investigate the load usage on a second-by-second basis which can then determine if adjustments need to be made.



The implementation of economic dispatch and automatic generation control via a Smart Grid has direct economic benefits. As an example, the state of West Virginia in 2010 published a Smart Grid Implementation study describing the first state-wide smart grid implementation. From this study a number of conclusions were drawn including:

Implementing a Smart Grid will:

- Radically improve system reliability
- Lower the carbon footprint
- Support a better sustainable business climate
- Generate benefits beyond the borders

The cost benefits were also significant in this report. At approximately 1 million meters, the total Smart Grid Cost is $1.9B with a total benefit of $10B. With a 5:1 cost benefit ratio, the additional annual benefits as seen in the chart below are also available.

WV Annual Benefits ($M)

Key Success Factors	Benefits	Annual Benefits ($M) (All Beneficiaries)
Reliability	Reduced Consumer Losses	$898
	Reduce Power Quality Events	$131
Economic	Reduce Price of Electricity	$399
	Job Creation	$215
	Consumer Sales of DER Resources	$175
	Increased Energy Sales as Exports	$7
	Reduced Transmission Congestion	$1
	Increased Transportation Fuels Business	$5
	Consumer Conservation	$20
	Operational Savings	$194
Environmental	Reduced Emissions	$7
Security	Reduced Blackout Probability & Dependence on Foreign Oil	$13
Safety	Reduce Hazard Exposure	$1

NATIONAL ENERGY TECHNOLOGY LABORATORY

In another example, the state of California investigated what aspects of energy and utility companies will be impacted when implementing a

Smart Grid system. One substantial change they noted would be network infrastructure. This is a key element in which FTTH will tie in. As the network infrastructures evolve to meet the needs of a Smart Grid system, a direct connection, such as FTTH will be necessary. A nationwide fiber system can meet the needs of the growing Smart Grid system and provide amble room to scale as utility companies implement Smart Grids.

The Pacific Northwest National Lab developed the following estimate of the impact of a national Smart Grid program. Here again we can see that there are huge financial incentives to building a fully integrated Smart Grid.

THE "SMART GRID" IS AN ELECTRIC SYSTEM that includes information and communications technologies to turn the traditional "one-way" grid into a more dynamic "two-way" system. The point is to improve the way electricity gets distributed and used across the entire power grid, from where power is generated to our homes, and back again. A smart grid lets power companies and consumers see more about how power is being used—in near-real time. With that kind of information, the power company can better match supply to the demand, to increase efficiency, and consumers can make more informed decisions about when and how they use energy. For example someone could run appliances at times when demand is low and pay less on their electric bill. The implementation of the smart grid is generally thought to have the potential to significantly cut energy usage and waste. A recent study looked at exactly how beneficial a smart grid could be if we implemented it by 2030.

POTENTIAL ENERGY CONSUMPTION AND CARBON EMISSIONS REDUCTION FROM SMART GRID DEPLOYMENT IN RESIDENTIAL AND SMALL/MEDIUM COMMERCIAL BUILDINGS (*in* 2030)

ANNUAL REDUCTIONS IN U.S. ELECTRICITY

	ENERGY			CARBON EMISSIONS	
MECHANISMS	*% Reduction in U.S. Energy*	KWH/YEAR	SAVINGS *(assuming $0.088/kwh)*	*% Reduction in U.S. Carbon Emissions*	METRIC TONS/YEAR
Smart-meter feedback and demand response-enabled conservation	3	155,000,000,000	$13,640,000,000	3	92,000,000
More efficient performance of heating, ventilation, and air conditioning and lighting	3	152,000,000,000	$13,376,000,000	3	90,000,000
Increased efficiency due to better measurement and verification	1	59,000,000,000	$5,192,000,000	1	35,000,000
Reduced fuel and emissions from load shifting to more efficient power plants	0.04	2,000,000,000	$176,000,000	0.03	1,000,000
Reduced fuel and emissions from smart-charging-enabled electric vehicles	3	139,000,000,000	$12,232,000,000	3	82,000,000
Optimizing voltage distribution for reduced losses and end-use consumption	2	99,000,000,000	$8,712,000,000	2	59,000,000
Ability to support solar and wind generation	0.02	1,000,000,000	$88,000,000	0.02	1,000,000
TOTAL	12.06	607,000,000,000	$53,416,000,000	12.05	360,000,000

A COLLABORATION BETWEEN GOOD AND OLIVER MUNDAY   SOURCE: Pacific Northwest National Laboratory   IN PARTNERSHIP WITH IBM

Direct tangible consumer cost savings are also an important factor. To reduce demand during the high cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used.

To motivate consumers to cut back use and perform what is called peak curtailment or peak leveling, prices of electricity are increased during high demand periods, and decreased during low demand periods. It is thought that consumers and businesses will tend to consume less during high demand periods if it is possible for consumers and consumer devices to be aware of the high price premium for using electricity at peak periods. This could mean making trade-offs such as cooking dinner at 8pm instead of 5pm.

When businesses and consumers see a direct economic benefit of using energy at off-peak times they become more energy efficient. The theory is that they will include energy cost of operation into their consumer device and building construction decisions.

FTTH for Smart Grid

Before a utility installs an advanced metering system, or any type of Smart System, it must make a business case for the investment. Most utilities find it difficult to justify installing a communications infrastructure for a single application (e.g. meter reading). Because of this, a utility must typically identify several applications that will use the same communications infrastructure – for example, reading a meter, monitoring power quality, remote connection and disconnection of customers, enabling demand response, etc. Ideally, the communications infrastructure will not only support near-term applications, but unanticipated applications that will arise in the future. Regulatory or legislative actions can also drive utilities to implement only pieces of a smart grid.

Some features of smart grids also draw opposition from industries that currently are, or hope to provide similar services. An example is competition with fiber, cable and DSL Internet providers from broadband over powerline internet access. Providers of SCADA control systems for grids have intentionally designed proprietary hardware, protocols and software so that they cannot inter-operate with other systems in order to tie its customers to the vendor.

Because Smart Grid applications require relatively small amounts of communications capacity relative to typical residential broadband deployments, it is difficult for electric utilities to justify building a broadband network only for Smart Grid and not support other applications. Likewise, broadband providers such as MSO's, FTTH operators, etc. can easily carry the Smart Grid traffic but will look for incentives to integrate the necessary interfaces and support the capacity.

Fiber is the preferred medium for Smart Grid applications due to the capacity it can support (easily enabling multiple applications), better protection from electrical interference, ability to support non-field powered communications during utility outages, as well as universal deployment across residential and commercial applications. Fiber is also the universal medium for long haul transport networks which are necessary to connect utility Smart Grids across the country.

Working together, Smart Grid operators can offer economic incentives to the FTTH operators to both support the Smart Grid deployments and expedite the FTTH build-outs. Such incentives can be payments for capacity use, access to utility infrastructure at reduced rates (i.e. utility poles, conduits, substations, etc.), and unilateral access to all customer premises utilizing utility electric service.

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