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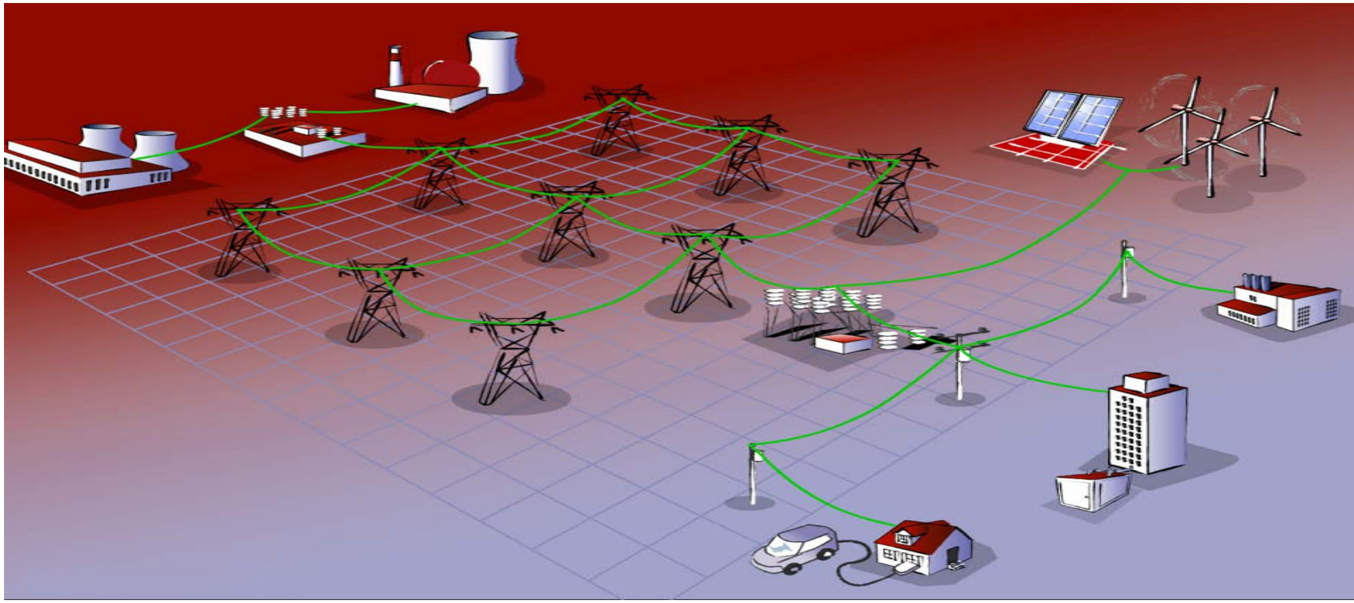

Environmental Impact of Smart Grid

January 10, 2011

Agenda

- **Review of Paper**
  - Introduction
  - Key Areas of Impact
  - Findings
  - Conclusions
  - Recommended Topics for Further Research

Introduction

Provide background for the current state of environmental impact of Smart Grid

- Summarize key components of criteria pollutants from electricity and transportation sectors
- Define the Smart Grid and how it can be used to reduce pollutants
- Evaluate impact from Smart Grid on reducing pollutants through:
  - Demand Response
  - Electric Vehicles
  - Demand Side Management
  - Renewables and Distributed Energy Resources
  - Transmission and Distribution Systems

Use this knowledge to address topics for further research

Key Areas of Impact

Key Areas of Review and Consideration for Environmental Impacts

- What other research has been performed in this area before?
- How will a Smart Grid enable renewable technologies like solar and wind to benefit the environment?
- What are the environmental impacts of a move from internal combustion vehicles to plug-in hybrid or all-electric vehicles on the environment?
- How will electricity supply dispatch curves be affected by Smart Grid integration in the grid, and how will this affect overall system emissions?

Focus of Existing Literature

- Demand Response
- DSM: Changes in consumer behavior and incorporation of Smart Devices to drive energy efficiency
  - Overview of the major report studies on how the Smart Grid drives changes in consumer behavior and the communication with Smart Devices
- The Smart Grid's ability to facilitate increased EV penetrations
- Facilitation of increased renewable penetration
  - Discussion of this impact area and an overview of some of the major report studies on how the Smart Grid will facilitate higher penetration rates
- Impacts on T&D infrastructure efficiency and energy delivery

Findings

Demand Response

- DR offers financial compensation for utility curtailment of electric loads during peak demand hours
- DR can be used to regulate power demands of specific devices to avoid transmission or distribution issues or minimize emissions
- EPRI estimated several types of potential savings programs for energy efficiency and demand response options
- A recent PNNL paper finds minimal reductions in electricity production specifically from DR programs

Demand Side Management

- DSM is the process of managing the consumption of energy by the consumer
- EPRI describes how enhanced communications and control of a Smart Grid can facilitate greater levels of energy savings
- DSM is only effective when consumers are motivated to reduce electrical use
  - Happens through price point incentive
- DSM has been very successful for industrial consumers who use a lot of energy
- Questions remain regarding price elasticity and consumers’ willingness to change their behavior

Electric Vehicles

- EVs have the potential to offset portions of the environmental impacts from the direct transportation sector and from the electricity generation sector
- EVs also pose a large threat to the current infrastructure if they are not managed properly
- EPRI found that high penetration of PHEVs can reduce GHG emissions by as much as 20% by 2050
- PNNL estimates only a 3% reduction in emissions but excludes V2G

Renewable Energy and Distributed Storage

- Renewable energy sources have clear advantages in terms of minimizing overall environmental impacts
- Wind and solar have uncertain generation schedules, making more them difficult to manage and fully integrate into a network
- As renewable energy penetration rates increase, there will be more inherent difficulty in managing these intermittent, distributed resources
- PNNL describes the incremental percentage penetration of renewable (wind and solar) energy that can be achieved through the use of Smart Grid technologies

Renewable Energy and Distributed Storage

- EPRI estimates the potential CO_2 reductions from the Smart Grid's facilitation of renewable energy penetration through:
  - **More accurate generation profiles**
  - **More real-time wind generation data**
- Consumer back-up generators (BUGs), are another form of distributed storage that would behave similarly to PHEVs in V2G mode
- NETL estimates the potential emissions reductions from the current "fleet" of BUGS.
  - **Even these diesel-fueled generators can realize net emissions reductions relative to their peak load alternative**

Improvements to Transmission and Distribution Systems

- Line losses associated with T&D average nearly 6% of total electricity generation
- Most line losses result from poor management and maintenance due to lack of real-time operating information
- The Smart Grid can reduce reactive power flow and maximize the amount of real power that can be transmitted on the grid, thereby minimizing transmission losses
- The Smart Grid can facilitate the application and monitoring of devices that inject or absorb reactive power in the grid

Improvements to Transmission and Distribution Systems

- EPRI estimates that the Smart Grid can reduce line losses in the distribution networks through adaptive voltage control at substations and line drop compensation on voltage regulators
- PNNL defines distribution automation and feeder automation (DA/FA) assets that support integration of the following grid functions:
  - **Integration of renewables, energy efficiency, and improved reliability**
- The Smart Grid can enhance reliability in two ways:
  - **Wide area control and visualization tools**
  - **Dynamic thermal rating that accounts for local weather**

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Conclusions

Conclusions

- Energy efficiencies can be broken into the categories of consumer driven and utility driven
- Utility-driven efficiency, or DR, is based on the real-time incremental cost of energy that becomes the basis for consumer pricing
- Consumer-driven efficiency, or DSM, is based on consumers' willingness and ability to become involved in managing their cost of energy - a continually active process
- The role of Smart Grid in managing EVs while they are charging and discharging is critical to successful deployment

Conclusions

- The Smart Grid can support incremental increases in renewable (wind and solar) energy systems
- Reverse Power Flow will be necessary above certain penetration thresholds:
  - 20% for Solar; 25% for Wind
- The incremental impact of the Smart Grid will come from its ability to displace the need for additional ancillary capacity
- To reduce T&D losses, utilities can use the Smart Grid to:
  - Incorporate devices that inject or absorb reactive power in the grid
  - Reduce line losses

Recommended Topics for Further Research

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- Evaluate the impact of state and national RPS standards on emissions, and the need for a Smart Grid to achieve the standards from 2010 to 2030
  - Evaluate how the Smart Grid will affect electricity supply dispatch curves, and how will this affect overall system emissions
  - Identify tiered levels of Smart Grid technology penetration to measure environmental impact at state or NERC region level
- Develop microgrid simulation to determine critical levels of renewables that can be added without the use of a Smart Grid

Recommended Topics for Further Research

- Evaluate actual power production capacity at wind farms in operation in the country to assess the contribution that wind turbines can make
  - And associated need for Smart Grid to manage ancillary generation
- Evaluate HANs to determine impact of additional smart appliances and additional residences in the country
- Evaluate the need for improved power requirements and power quality for digital devices