Pacific Northwest NATIONAL LABORATORY

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The Smart Grid: An Estimation of the Energy and CO_2 Benefits

A smart grid could help the United States by reducing our carbon emissions and energy use of the electric sector by up to 12% by 2030. The Department of Energy's Pacific Northwest National Laboratory's (PNNL) report, *The Smart Grid: An Estimation of the Energy and CO_2 Benefits* details distinct methods by which the smart grid can reduce energy use and carbon impacts. The study was funded by the DOE Office of Electricity Delivery and Energy Reliability. The report provides an assessment of nine mechanisms by which the smart grid can reduce energy use and carbon impacts associated with electricity generation and delivery, and use ranging from conservation effect of consumer information and feedback systems to helping reduce the cost of mitigating renewable wind and solar generation.

The report did not attempt to examine the current cost benefits of the smart grid, but instead focused on measuring the potential of the smart grid to reduce carbon emissions — an additional benefit outside of the already demonstrated operational cost benefits.

DIRECT AND INDIRECT IMPACTS OF A SMART GRID

The mechanisms and their impacts — a reduction in electric utility electricity and CO_2 emissions by 2030 — are analyzed in the report (see chart). The impacts can be divided into direct and indirect reductions: direct reductions are smart grid functions that themselves produce savings in energy and/or emissions consumed or by reducing generation requirements; indirect reductions are related to smart grid functions producing cost savings.

To calculate those reductions, direct reductions mechanisms that affected electricity and CO_2 emissions directly through implementation of smart grid technologies were examined.

Mechanism	**Electricity Sector Energy and Carbon Reductions***	
	Direct	**Indirect**
Conservation Effect of Demand Response Consumer Information	3%	-
Marketing/Outreach Synergy Between Demand Response and Efficiency Programs	-	0%
Measurement and Verification for Efficiency Programs	1%	< 0.5%
Smart Grid-Enabled Diagnostics in Residential and Small/Medium Commercial Buildings	3%	-
Conservation Voltage Reduction and Advanced Volt/VAr Control	2%	-
Load Shifting from Demand Response	< 0.1%	-
Support Additional Electric Vehicles (EVs) / Plug-In Hybrid Electric Vehicles (PHEVs)	3%	-
Reduced Need for Regulation and Reserves to Achieve 25% RPS of the electric sector:		
Solar Photovoltaic Integration and/or Wind Energy Integration:	< 0.1%	5%
Total Savings	**12%**	**6%**

These estimates assume **full deployment**, or 100% penetration, of smart grid technologies.

U.S. DEPARTMENT OF ENERGY

Indirect reductions trend towards reducing capital or operational costs for the deployment of efficiency programs or renewable programs, which offer reductions. These indirect reductions are found by estimating the cost savings for integrating renewable or operating efficiency programs into their energy and carbon equivalents, based on reinvesting the value of reduced generating capacity for ancillary services, or other operational cost savings, in the purchase of additional cost-effective energy efficiencies.

These cost savings can translate into important policy decisions; for example, reinvesting the energy savings to purchase additional efficiency and renewable resources, or "pocketing" those savings and reducing social costs of obtaining carbon reductions.

Five of these mechanisms could potentially provide reductions of significant impact. The combined effect of the direct and indirect mechanisms could have a critical, substantial result on the United States' total energy consumption and emissions for all sectors, including electricity.

These reductions and their significant impacts, detailed in the report, indicate that a smart grid could have a substantial role in contributing to the goals for achieving energy and carbon savings for the electricity sector. The smart grid also could help overcome any barriers to deployment of distributed solar renewables at penetrations of a much higher rate than the current distribution system is capable of handling.

LOOKING TOWARDS THE FUTURE

To implement these mechanisms and further research efforts, PNNL has provided several recommendations for future efforts based on this study:

- All technical mechanisms need to be considered at a greater analytical depth.
- The uncertainty associated with behavior-related mechanisms (notably, the effect of consumer information) spotlights the need to better understand customer responses and motivations to guide program administration and implementation efforts so that the potential benefits are achieved and sustained.
- Future work should more rigorously address the range of uncertainty for the potential electricity consumption and CO_2 emissions reduction estimates, as more definitive analyses are conducted with methods tailored to estimating each mechanism's potential.

SUCCESS RELIES ON DEVELOPMENT AND UNDERSTANDING:

- Develop the means to reduce transmission congestion with smart grid operations and the extent to which increased levels of central renewables (wind) can be supported as a result.
- Develop control strategies where demand response, distributed generation, and storage assets may be managed on energy, economic, air emissions, and/or CO_2-based criteria, or a mixture of all four criteria.
- Understand how to influence and integrate passive and active energy efficiency measures with voluntary conservation actions and demand response in the eyes of customers to bring about the maximum combined effect for consumers, the grid and the environment.

SMART GRID POTENTIAL BENEFITS ARE ESSENTIAL TO REDUCING CO_2 EMISSIONS

- Smart grid assets must prove to be cost-effective replacements for traditional grid infrastructure or there will be resistance from federal and state regulatory bodies upon its deployment.
- Developing a quantitative method for defining and monetizing the improvements in power reliability and quality would enhance the business case for a smart grid.
- Understand the business and regulatory models (money, risk, incentives, etc.) and involve stakeholders in changing these models to transform smart grid operations from centralized power to a more decentralized system.

For additional information and to receive a copy of the report, please contact Pamela Harrington at ***pamela.harrington@pnl.gov***.

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