Applying the Smart Grid to Climate Change Mitigation: *Emissions Impact Estimation Tool for Smart Grid Projects*

ROB PRATT

Pacific Northwest National Laboratory

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Topics for Today's Presentation

- What do we mean by an emissions impact estimator? Why is that important?
- What is the potential scope of smart grid projects involved?
- What do we have to base the impacts estimates on?
- Impact mechanisms vs. project types for a project impact estimator
- Development process for the estimator

What is an Emissions Estimator? Why Build One?

- **Goal** – construct a web-based tool that:
  - Uses a (new) *standardized methodology* for estimating the environmental impacts of a range of types of smart grid projects
  - Uses *quantitative inputs describing the scope* of a project
  - Computes *impacts on carbon, particulates, & transportation fuel* use
  - *Reflects regional differences* regarding effects of displacing generation

- **Objectives**:
  - Help utilities & policymakers (e.g., public utility commissions) *evaluate smart grid projects*
  - Provide a *transparent, objective process* for estimating impacts that helps acceptance
  - *Document all input assumptions*

- This is a new Office of Electricity funded project just getting underway

Previous Study – *The Smart Grid: An Estimation of the Energy and CO2 Benefits**

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- ***Question***: Does a smart grid have a substantial role to play in the nation's carbon management agenda?
- ***Goal***: Estimate the range of potential energy & carbon benefits attributable to a smart grid
- ***Nine mechanisms*** for a smart grid to help reduce energy & carbon were investigated
- ***Two classes of benefits*** reducing in energy consumption & emissions:
  - ***direct*** from smart grid applications
  - ***indirect*** from reduced costs for operating renewables in the grid
- Other potential environmental benefits were not examined (particulate emissions, land use, etc.)

- Separate analysis of ARRA smart grid projects** developed methods for
  - Regional impacts on generation mix from shifting load (or net load)
  - Reductions in utility truck rolls

* https://www.smartgrid.gov/sites/default/files/doc/files/The_Smart_Grid_Estimation_Energy_CO2_Benefits_201011.pdf
** see: http://gridlab-d.sourceforge.net/wiki/index.php/Publications#2012

Primary Results from the Previous Study

Mechanism	Electric Sector Energy CO_2 Reductions	
	Direct	**Indirect**
Conservation Effect of Consumer Information and Feedback Systems	3%	-
Joint Marketing of Efficiency and Demand Response Programs	-	0%
Diagnostics in Residential and Small/Medium Commercial Buildings	3%	-
Measurement and Verification for Efficiency Programs	1%	0.5%
Shifting Load to More Efficient Generation	< 0.1%	-
Support Additional Electric Vehicles (EVs) / Plug-In Hybrid Electric Vehicles (PHEVs)	3%	-
Conservation Voltage Reduction and Advanced Voltage Control	2%	-
Support Penetration of Solar Generation (RPS > 25%)	(1)	(2)
Support Penetration of Wind Generation (25% RPS)	< 0.1%	5%
Total, Share of U.S. Electric Sector Energy and CO_2 Emissions	**12%**	**6%**

* Assumes 100% penetration of smart grid in 2030; lower penetration produces proportionately smaller impacts

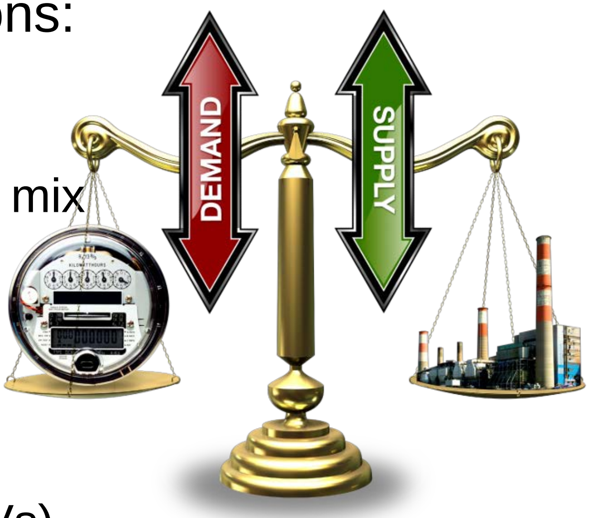
EPRI's *Green Grid Report* estimates (direct-only) reductions in range of <u>2% to 7%</u> at less than 100% smart grid penetration

- Note EPRI investigated somewhat different mechanisms, on a different basis

- Considerable uncertainty exists for each mechanism investigated: typically ~ ±50%

Direct vs. Indirect Benefits

- ***Direct benefits*** attributable to smart grid applications:
  - Energy efficiency (generation, T&D losses, loads)
  - Shifting (net) load to periods with cleaner generation mix
  - Reduction in use of generation (fuel used) for balancing/ancillary services
  - Reduction in VARs supplied by generation
  - Shifting fuel-based load to cleaner electricity (e.g. EVs)



- ***Indirect benefits*** are reduced costs for operating renewables
  - Reduced operating costs will enable increased penetration of renewables
  - How did we translate $ saved to a CO_2 benefit?
  - Assumed savings reinvested in cost-effective renewables or efficiency
  - Credits smart grid with the extra renewables that presumably would result

Impact Mechanisms vs. Project Types

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Project Type	Direct		Indirect
	Displaced Generation Emissions	Displaced Vehicle Emissions	Reduced Cost for Renewables
Substation automation		X	
Feeder automation/reconfiguration		X	X
Distribution management systems		X	X
Transmission energy management systems	X		X
Volt-VAR control & CVR	X		X
Smart inverter (& load) coordination	X		X
Protection schemes for solar PV		X	X
Advanced metering infrastructure w/ dynamic rate	X	X	
Demand response/flexible loads	X		X
Distributed storage	X		X
Charging & V2G from electric vehicles	X	X	X

Developing an Emissions Estimator

- Federally-hosted, web-based tool
- Map smart grid project types to impact mechanisms
- Impact estimates from the literature & first principles
- Regional emissions profiles based on EIA data or production cost models (must be able to update)
- User inputs define scope & scale of project
- User interface may allow impact mechanisms & emissions profiles assumptions to be modified (within limits)
- Printable format documenting all inputs & results

- <u>Review committee for project will be established by DOE to gather stakeholder input</u>

Thank you … and, Questions …

Rob Pratt
Pacific Northwest National Laboratory
robert.pratt@pnl.gov
509 375-3648

Impact Mechanisms vs. Project Types

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Project Type	Direct		Indirect
	Displaced Generation Emissions	Displaced Vehicle Emissions	Reduced Cost for Renewables
Substation automation		Truck rolls	
Feeder automation/reconfiguration		Truck rolls	Increased PV hosting
Distribution management systems		Truck rolls	Increased PV hosting
Transmission energy management systems	More efficient gen. dispatch		Increased hosting, displaced operational costs
Volt-VAR control & CVR	Displaced VARs (losses & gen.); lower loads; load shifting		Increased PV hosting
Smart inverter (& load) coordination	Displaced VARs (losses & gen.)		Increased PV hosting
Protection schemes for solar PV		Truck rolls	Increased PV hosting
Advanced metering infrastructure w/ dynamic rate	Load shifting (behavior)	Truck rolls	
Demand response/flexible loads	Load shifting (tech.)		Increased hosting, displaced operational costs
Distributed storage	Load shifting net of charging losses		Increased hosting, displaced operational costs
Charging & V2G from electric vehicles	Scheduled charging	Tailpipe vs. gen. emissions	Increased hosting, displaced operational costs (V2G)