Smart Policies for Smart Grids: Making the Most of New Technology

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**RAP** is a global, non-profit team of experts providing technical and policy assistance to government officials on energy and environmental issues. RAP has advised governments in more than 30 nations and 55 states and provinces.

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A member of the IEA DSM Executive Committee, he served 12 years as Chair of the Vermont PSB (utilities regulator), Chaired the NARUC Committee on Energy & Environment, and the National Council on Competition and the Electric Industry. He now also serves as Chair of the US Department of Energy’s Electricity Advisory Committee.

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Topics for today

1. Smart Grid: Expensive distraction, or essential enabling technology?
2. What are the (potential) benefits of Smart Grid investments?
3. Smart Grid pilots in the US and EU – What lessons are we learning?
4. Smart policies for the smart grid – What should regulators, utilities, Governments focus on?
Evolving views of the Smart Grid

EARLIER VIEW: “Expensive distraction”
- “Smart Meters – Dumb Utilities” headlines
- AMI doesn’t change anything except utility payrolls;
- Just an easy way to build ratebase in a recession;
- Customers hate Time of Use rates anyway.

EMERGING: “Essential Component of Reliable, Low-Carbon Grid”
- Reliability MUST be maintained
- Wide-area grid management for renewables integration
- ~20% of load must be dispatchable to balance renewables in a high-RES portfolio
- “Smart-charging” electric transport is a must;
- Smart meters enable rate designs for lower bills.

BUT – We’re not anywhere close yet!
- Small fraction of Smart Grid in place,
- “Smart Policies” even further behind what is needed
European Setting for Smart Grids

- EU soft mandates:
  - “Intelligent” metering references in 3rd Liberalization Package, Electricity and Gas Directives
  - Soft mandate for smart meters “where appropriate” for new/renovated buildings in EPBD

- Policy awareness:
  “These issues are high on the agenda of European energy regulators primarily because intelligent grid/intelligent metering is the core activity of regulated grid operators” – Mariusz Swora (2010)

- Smart Grids can drive a basic shift in utility system models:
  - From sales and consumption, to conservation and efficiency
  - From central stations alone, to distributed resources
  - From primarily fossil, to primarily low-carbon
  - From load as given, to load as a dynamic system resource
How could smart grids help utilities, customers, and clean energy goals?
Potential Smart Grid Benefits

- Reduced operating costs
  - Meter reading, outage management
  - Better bill collection
- Enhanced reliability, quick response
- Peak load management
  - Reduced energy, capacity, and transmission & distribution costs
- Reduced energy consumption
  - Automation and behavioral changes that complement energy efficiency programs
- Ability to control (“dispatch”) large new loads
  - Including electric vehicles, heat pumps
- Interconnect, balance and deliver renewable resources
Big Picture: Costs and benefits of smart meters across the EU
(low case = 20% adoption; high case = 80% adoption)

Source: Brattle group, Faruqui, Lessons from Demand Response: Trials and Potential Savings for the EU (2009)
(1) Smart Grid and Distribution Efficiency

**Savings Mechanism 1**

- Optimize voltage and reactive power on distribution systems to reduce line losses and end-use consumption
  - Conservation voltage reduction (CVR) does not require smart grid
  - But smart grid’s real-time data communication and remote control enables precise voltage control

**Pilots Show:**

- CVR savings
  - 1-3% reduction in energy use
  - 1-4% peak load reduction
  - Most energy savings: *end-use* equipment at lower voltage
  - Cost is low (2/3 of potential savings in NW US < $30/MWh)
  - *Incremental* impact of smart grid for CVR estimated at 2%; studies needed to confirm

*Estimates from Electric Power Research Institute, Northwest Energy Efficiency Alliance, Northwest Power and Conservation Council*
(2) Benefits -- Capacity savings from peak load management

Example from the French load duration curve

Capacity only used for 1% of hours.
Peak load management – historic view
-- Residential load in an area with air conditioning (like much of the US)
**Roadmap 2050**: 80% carbon reduction requires RES power supply, electric vehicles, heat pumps, and demand response

GtCO$_2$e per year

### EU-27 total GHG emissions

<table>
<thead>
<tr>
<th>Sector</th>
<th>Abatement</th>
<th>Within sector$^{1,2}$</th>
<th>Fuel shift</th>
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</thead>
<tbody>
<tr>
<td>Power</td>
<td>95% to 100%</td>
<td>&gt;95%</td>
<td>75% (electric vehicles, biofuels and fuel cells)</td>
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<tr>
<td>Road transport</td>
<td>95%</td>
<td>20%</td>
<td>20% (biofuels)</td>
</tr>
<tr>
<td>Air &amp; sea transport</td>
<td>50%</td>
<td>30%</td>
<td>5% (heat pumps)</td>
</tr>
<tr>
<td>Industry</td>
<td>40%</td>
<td>35% (CCS$^3$)</td>
<td>50% (heat pumps)</td>
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<tr>
<td>Buildings</td>
<td>95%</td>
<td>45% (efficiency and new builds)</td>
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</tr>
<tr>
<td>Waste</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>20%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>Forestry</td>
<td>-0.25 GtCO$_2$e</td>
<td>Carbon sinks</td>
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</table>

1 Based on the McKinsey Global GHG Cost Curve
2 Large efficiency improvements are already included in the baseline, especially for industry
3 CCS applied to 50% of industry (cement, chemistry, iron and steel, petroleum and gas, not applied to other industries)

**Energy solutions for a changing world**

SOURCE: McKinsey Global GHG Abatement Cost Curve; IEA WEO 2009; US EPA; EEA; Team analysis
(3) Future View: Managing Load to Match Variable Generation (Here, Wind)

PJM Wind Output vs Capability 2010

Capacity Factor = 26.7%
Solar PV Is Variable Too
-- Rapid 90% drop at the 4.6 MW TEP Solar Array (Arizona)

Source: Carnegie Mellon University
will now need to shape, not just shave, demand

And energy efficiency is needed to keep overall system costs affordable in the power system

Source: ECF Roadmap 2050 Study
(4) Load-side Energy Storage

- Key feature: balance the grid from the customer side, not just the supply side
- Customer storage: end-use customers store energy for their own later use – not to return it to the grid
- Differs from traditional demand response/cutting load at peaks
- Key opportunities:
  - Hot water thermal storage
  - Smart-charging electric vehicles
  - Ice storage to cool buildings
- The potential is much larger and cheaper than grid-to-grid electric storage.
Hot Water and Ice as Power Storage Solutions

- Thermal storage – low tech solution
  {“Ice Energy: A battery for your air conditioner”}
- Thermal resources are large-scale, inexpensive, widely distributed
- Example: 53 million connected water heaters in PJM
- Converted to storage, each has 60% more storage capability than “smart-charging” an electric vehicle.
- 30 GW of hot water heaters = >the 24GW of pumped storage on the PJM system today
- “So if we had a Smart Grid to do the controls and the water heaters, most of our problems on regulation go away.” –Terry Boston, CEO PJM Interconnection
(5) Fast Regulation: Water Heaters Respond Extremely Well

- Water heaters respond quickly and accurately to system operator requirements
- (Red) PJM Frequency Regulation Signal (RegA)
- (Blue) Response: Water heater power consumption +/- 2.25 Kw base point
(6) Integrating Distributed Resources

- Dynamically integrate distributed generation and energy storage with other resources and loads
  - Minimize losses, provide voltage support and improve reliability
- Microgrids – Interconnected network of loads, generation, and energy storage that works connected to or separate from grid
- Electric vehicles
  - Charge off-peak
  - Provide energy storage and ancillary services
  - Require advanced meters, smart rates and smart controls
Challenge: Will customers CHOOSE Time-of-Use Rates?

- Data from pilots suggest peak savings of 2% to 10% or more might be possible from TOU rates alone.
- BUT where there is retail competition, customers must:
  1. First, *choose a time-sensitive rate*
  2. AND then, *alter consumption* in response to price signals.
- Most customers will NOT sign up for this!
  - UK: only 15% adopted simple TOU rate
  - Texas: most liberalised US state, has one of the lowest rates of use of smart meters
- What is the *value proposition* for customers?
  - I don’t like my smart phone because it’s smart – but because it has APPLICATIONS that I value. What are the “killer apps” for smart grids from the customer point of view?
Peak reduction varies GREATLY across 70 different pricing & technology combinations

Source: Ahmad Faruqui, Dynamic Pricing and Customer Behavior, The Brattle Group March 2010
Mandatory vs. Voluntary Time-Varying (TOU) Rates

- **Mandatory** TOU – Default rate, no opt out
  - Likely to achieve the largest overall economic benefits, but potential for windfall gains or losses and customer opposition

- **Voluntary** – Basic rate, but allows customers to “opt out”
  - Nudges people onto more efficient rate structure
  - Preserves customer choice
  - Reduces marketing and recruitment costs
  - Creates larger potential market to enable smart appliances, energy management options and competitive pricing

- **Voluntary** – TOU is a possible choice, customers can “opt in”
  - Least likely to provoke customer opposition, but will produce lowest participation rates and be more costly

- **Interesting note:** when TOU is the starting rate, and customers must “opt out,” 80% will stay in TOU. But when flat rates are the starting rate, and customers must choose TOU rates, only 20% will choose TOU.
Automation Improves Demand Response

• Types
  – Customer-programmable communicating thermostats
  – Smart appliances
  – Plug-load devices
  – Energy management systems/services

• Benefits
  – Increases magnitude and reliability of customer response
  – Provides “set it and forget it” energy management
  – Necessary for dispatch of day-ahead and day-of demand response
  – Necessary for integration of electric vehicles, distributed renewable resources and smart grid operations

Adapted from Ron Hofmann and Roger Levy, consultants to LBNL
Customers and EE

- Information-driven behavior changes
  - Customized analysis, comparisons, alerts & recommendations to consumers via Web, in-home devices, etc.
  - Advanced meter data can improve recommendations to customers for energy management

Pilots Are Showing:

- Savings from different feedback mechanisms vary widely*
  - Home energy reports: ~3%
    - Delivered via mail or Web
    - No smart grid needed, but advanced meters improve data
  - Recent surveys of all types of feedback mechanisms
    - ACEEE: 4% to 12%
    - EPRI: *could be* 18%
  - In-home displays
    - 7% for after-the-fact billing; about twice that for pre-payment (Brattle Group)

*References in *Is It Smart if It’s Not Clean? Part 2*
Customers Need Three Kinds of Information – Not Just Information from Meters

- How much do I use and what price(s) do I face? -- as information for my demand choices
- What is the energy use of my building/my block/my community and how does it compare to my neighbors/other blocks/other communities?
- What should I do to reduce my consumption (more efficiency) and lower my bills (more time-sensitive usage)?
# Smart Policies to Match Smart Grid Capabilities (some examples)

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<tr>
<th>Smart Grid Capabilities</th>
<th>Example Smart Policies</th>
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<tbody>
<tr>
<td>Optimize security, voltage and reactive power on T&amp;D systems</td>
<td>• Tariffs to support investments in advanced grid technologies—e.g., synchrophasors (PMUs)</td>
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<td>• Performance-based regulation for TSOs &amp; DSOs to reward quality service and system efficiency</td>
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<tr>
<td>Speed up use of distributed generation and allow operation during utility outages</td>
<td>• Support utility and non-utility investment in clean distributed generation</td>
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<tr>
<td></td>
<td>• Simplify and speed up interconnections</td>
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<tr>
<td></td>
<td>• Performance-based regulation to reward quick restoration and “islanding” during outages</td>
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<td>Dynamically integrate wind and solar resources</td>
<td>• Improve planning, siting, and interconnection process for RES and transmission for RES</td>
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<td>• Amend market rules to improve use of variable resources, such as intra-hour scheduling</td>
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<tr>
<td>Increase demand response</td>
<td>• Offer TOU and/or truly dynamic pricing</td>
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<td></td>
<td>• Allow Demand Response Resources to compete fully in power markets, capacity markets, etc.</td>
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<td>• Give consumers usage data and targeted advice</td>
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Conclusions

• Smart grid can engage many customers, but it’s only an enabler.

• **Pilots: Results vary greatly**
  across different technologies, rate designs, and information given to customers.

• Smart grid will not improve load management, energy efficiency, or renewable energy without smart policies.

• Without the right policies, smart grid may be an expensive “lost opportunity” for power systems.
For More Information