DUMB GRIDS, SMART GRIDS, OUR GRIDS

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SOME BASIC FACTS ABOUT ELECTRICITY SECTOR

- Accounts for 42% of primary U.S. energy consumption
- Accounts for 35% of U.S. fossil fuel consumption
- Accounts for 40% of U.S. CO₂ emissions and this share projected to grow in BAU
- Uses almost no petroleum: Oil accounted for 17% of generation in 1973 and only 1% today
- Relies primarily on North America for fuel
- Solar + Wind ~ 2.0% of total electricity generation but growing fast
- Electricity consumption projected to grow faster than total energy consumption
SMART GRID INVESTMENT IS “IN”

• 2009 Federal stimulus bill designated about $3.5 billion for “innovative” smart grid investment grants, pilot programs and R&D
  – About 2/3 allocated so far
  – Very little has actually been spent

• A growing number of states have ordered electric utilities to make “smart grid” investments of one type or another and include the costs in regulated distribution prices
THE GRID

- Generator
- Step-up
- Network switchyard
- Transmission lines 230-500 kV
- Transmission subs
- 66-115 kV lines
- Distribution subs
- Distribution lines
North American Electric Power Grids

Source: NERC
Vertical Integration + Monopoly + COS Regulation

Generating Units → Transmission Network → Network Operations and Dispatch → Distribution

Wholesale Market → Other Control Areas

Consumers
The service boundaries on this map are a general representation of individual utility regions and do not necessarily depict the exact legal boundaries of the regions. Information on this map is believed to be accurate but is not guaranteed.

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ISO/RTOs in the United States 2006

MAJOR CONGESTED INTERFACES

Source: Platts
STATUS OF RETAIL COMPETITION AND RESTRUCTURING REFORMS 2007

- Blue: No retail competition
- Red: Retail competition for all classes
- Purple: Retail competition for (selected) large customers only
- Orange: Restructuring and retail competition suspended
- Green: No Retail competition Restructuring law repealed
WHAT IS A SMART GRID?

• “Smart” end-user meters
  – Current meters for residential and small C&I customers are “dump”
  – Smart meters allow for real time pricing
  – Smart meters allow for remote reading
  – Smart meters can have advanced communications capabilities
  – Smart meters + real time pricing create incentives for real time control of appliances and equipment with necessary communications and control features
Figure 3-23: System real-time price-duration curves, prices in most expensive 5% of hours, 2002–2005.

Smart Meter Issues

• Do the consumer benefits exceed the costs?
• Smart meters cost ~ 5 times traditional residential and small commercial meters
• Remote meter reading ends the need for meter readers and this may account for as much as 50% of costs savings
• Data management and analysis is costly
• Allows real time pricing to give consumers better price signals to decide when and how much to consume
  – Peak prices could be as much as 1000 times off-peak prices
Smart Meter Issues

• Short run vs. long run responses uncertain
  – Consumers must be able to see and react to real time price signals
  – Requires investment in communications, monitoring and control equipment
  – Or retail supplier must offer simpler contractual arrangements (e.g. AC cycling)

• Technology to control equipment and appliances in response to price signals and from remote locations is important, must be deployed and is still evolving

• There will be gainers and losers
WHAT IS A SMART GRID?

• Improve real time monitoring and control of the distribution network
  – Improve network reliability and response to failures --- distribution network is the most “unreliable” piece of the system
  – More efficient network utilization
  – Accommodate small scale generation connected to homes and business or the distribution network
  – Costs and benefits are very uncertain
Figure 2.12: PV Plant output on a partly-cloudy day (Sampling time 10 seconds)
WHAT IS A SMART GRID?

• Improve real time monitoring and control of the high voltage transmission network
  – Improve reliability by enhancing real time monitoring and control
  – Increase effective capacity of the high voltage grid by reducing contingency-related congestion
  – Large scale intermittent generation (wind and centralized solar) makes efficient and reliable network utilization a more challenging problem
  – Costs and benefits are uncertain
Figure 3.2: CAISO wind generation during the 2006 heat wave
WHAT ISN’T A SMART GRID ISSUE?

• Building more transmission lines to bring power from renewable sources located at remote locations to where it is consumed

• An important grid issue but not a “smart grid” issue per se
Figure B: Wind Availability and Demand Centers in the U.S.

Blue - high wind potential,
Brown - large demand centers, and
Green - little wind and smaller demand centers.
CONCLUSIONS

- There are many different components of an electric power grid
- There are many different types of smart grid investments
- The benefits of “smart grid” investments are diverse and have not been quantified very well
- The costs are substantial
- There are gainers and losers
- Institutional and regulatory barriers associated with the U.S. electric power industry are much more important than problems raising the necessary capital