Demand Response and Renewables

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Practical Demand Response for a Complex Future

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By: Daniel Violette, Ph.D.
Summit Blue Consulting
Boulder, Colorado 80302
e-mail: dviolette@summitblue.com

DR and Renewables

- The passage of RPS standards and the introduction of intermittent renewable resources makes DR an obvious partner.
- From NERC site: Renewable resources need a "dancing partner," -- a resource that can provide operational flexibility to maintain reliability during the sharp down/up ramps that can be experienced with these resources.
- DR has many qualities that make it particularly well-suited to play this role.
- Communications technologies have made DR more dispatchable than ever before -- in many cases available to operators in a matter of minutes.
- ISOs/RTOs have identified a range of operational requirements for the power system to support increased levels of renewable resources:
  - An increased need for other resources to be able to ramp up and down quickly.
  - These operational requirements will be provided by generation, demand response and storage, and
  - And, potentially by increased controllability of intermittent resources.

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DR as the Solution?

- DR is clearly part of the solution, but integrating renewables into the grid poses a number of complex challenges.
  - DR providers and participating customers will want to understand and participate in the integration process.
  - There is a unique role for DR, but it will be used in concert with other tools needed to achieve integration.
  - The goal is not to maximize the use of DR, but to seek out its most economic applications.
- Understanding the role of DR in the renewables integration process will promote long-term stable markets.

The Challenge

- The adaptation to high levels of variable generation renewables has just begun in the United States.
- System operators have years of experience with the variability of *supply* but not with *demand*.
- The output of conventional generation is generally predictable and subject to operator control.
  - Unplanned outages and deratings are factored into reliable system operations, and failure to respond is subject to penalties.
- In contrast, wind and solar generation vary over short periods of time with changes in the weather,
  - They largely lack controllability, although future wind and solar technology may have greater control capabilities.
- DR is one answer, but the full set of integration actions help determine the eventual value of DR in integration.

Integrating Renewables -- Actions

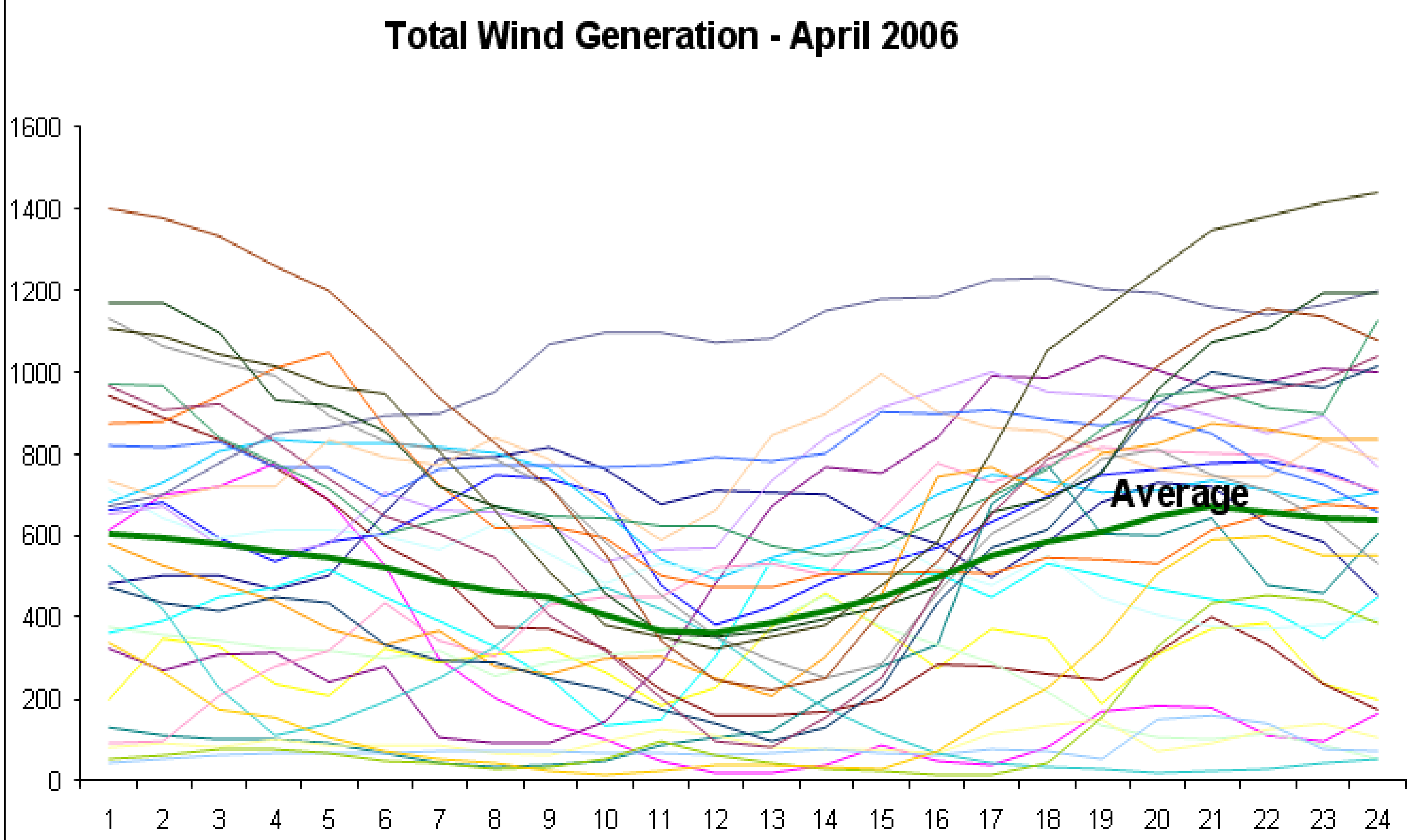
1. Understand wind/solar resource capabilities by using state-of-the-art forecasting to better understand unit commitments.

2. Examine the value of stochastic unit commitment tools to develop a more robust unit commitment solution to further reduce wind/solar integration impacts.

3. Conduct technically rigorous regional integration operational impacts analysis based on current and emerging best practices:
   - Quantify net physical impacts based on multiple years of synthetic wind plant output time series data synchronized with load data from the same time period
   - Capture wind/solar resource geographic diversity through time synchronized weather simulation
   - Assess system contingencies – use wind/solar forecasting best practices and combine these forecast errors with other load/system forecast uncertainties.

Forecasting Problem – Wind

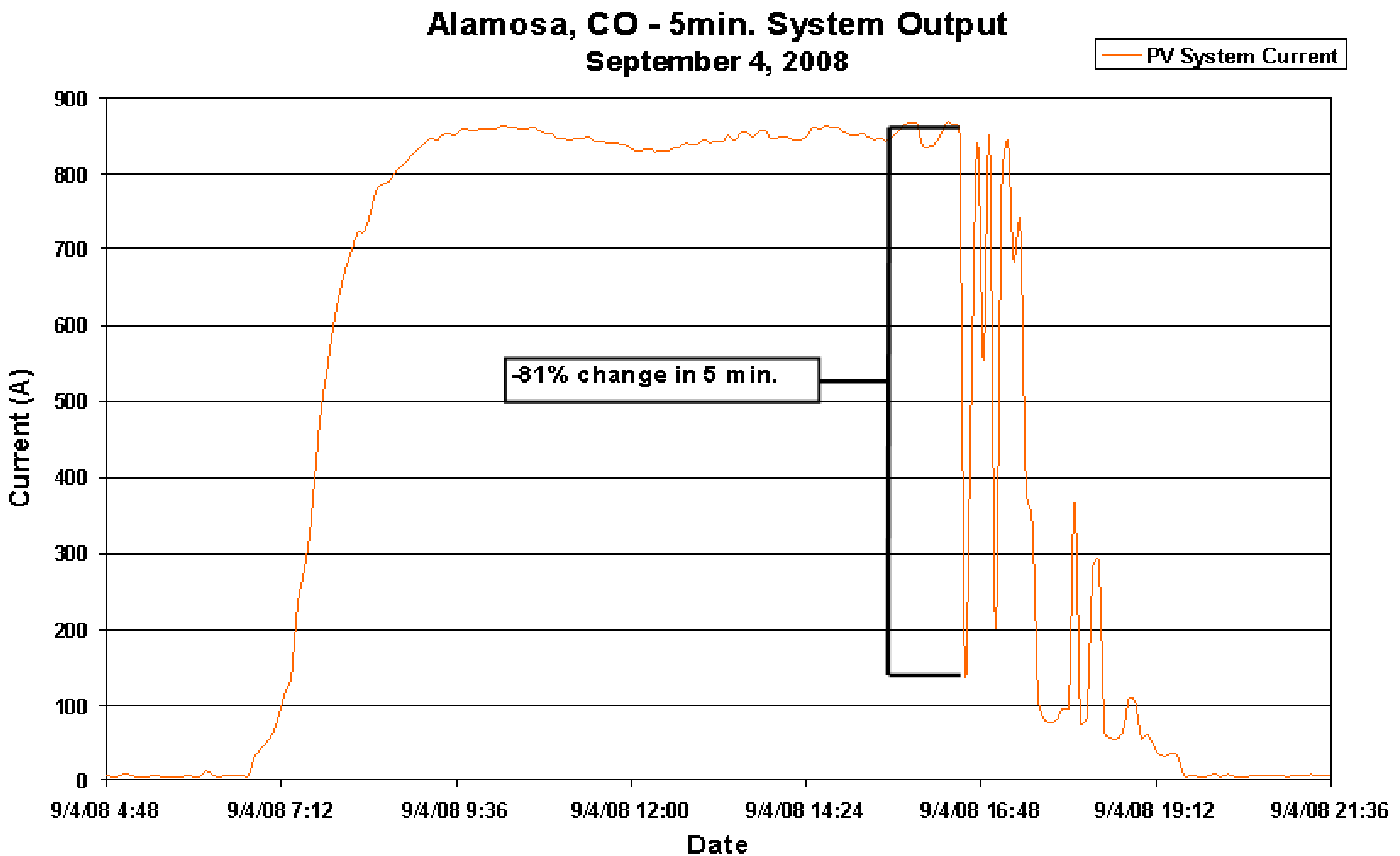
Each Colored Line is the output for a different Day.



From: CAISO

Forecasting Problem -- Solar

Output from an 8MW solar PV panel in Colorado on 9/4/08 (U.S. DOE)
-- Variability may be reduced by averaging sites across a geographic area --



Integration -- Implications of Studies

- Resulting regional integration analysis steps include:

1. Inventory current generating capability to see if more flexibility can be gained from existing generation
2. Encourage more flexible and maneuverable generation;
3. Increase responsive / non-spin reserves and operational flexibility
4. Near term:
   - Consider expanding demand response initiatives to provide flexible resources for variable renewable resource integration on the demand side.
5. Longer term (10 years out):
   - Consider potential role of plug-in hybrids and new technologies.
6. Minimize contractual obligations that limit system maneuverability (e.g. must-run QF contracts, flat block contracts, etc)

Additional Complexities

- For example, Eirgrid (Ireland) has an over-supply of wind when demand for electricity is low (6am on a summer weekend morning).
- With DR, if too much electricity is being created by wind, reduce the price of electricity (or send a signal) to the market to stimulate an increase in demand or storage – keeping renewables on-line.
  - The market gets cheaper electricity, from clean sources, investors are less wary of investing in wind so more wind farms are financed.
  - Regions stand a better chance of reaching their RPS targets from renewables.
  - Eirgrid get a more stable grid (as well as helping the gov't reach its RPS target)
- DR is also about increasing demand when energy is plentiful and additional consumption at the right time can help balance the grid. (CAISO, Clean Power, 8/31/2009)

Return to the Basics

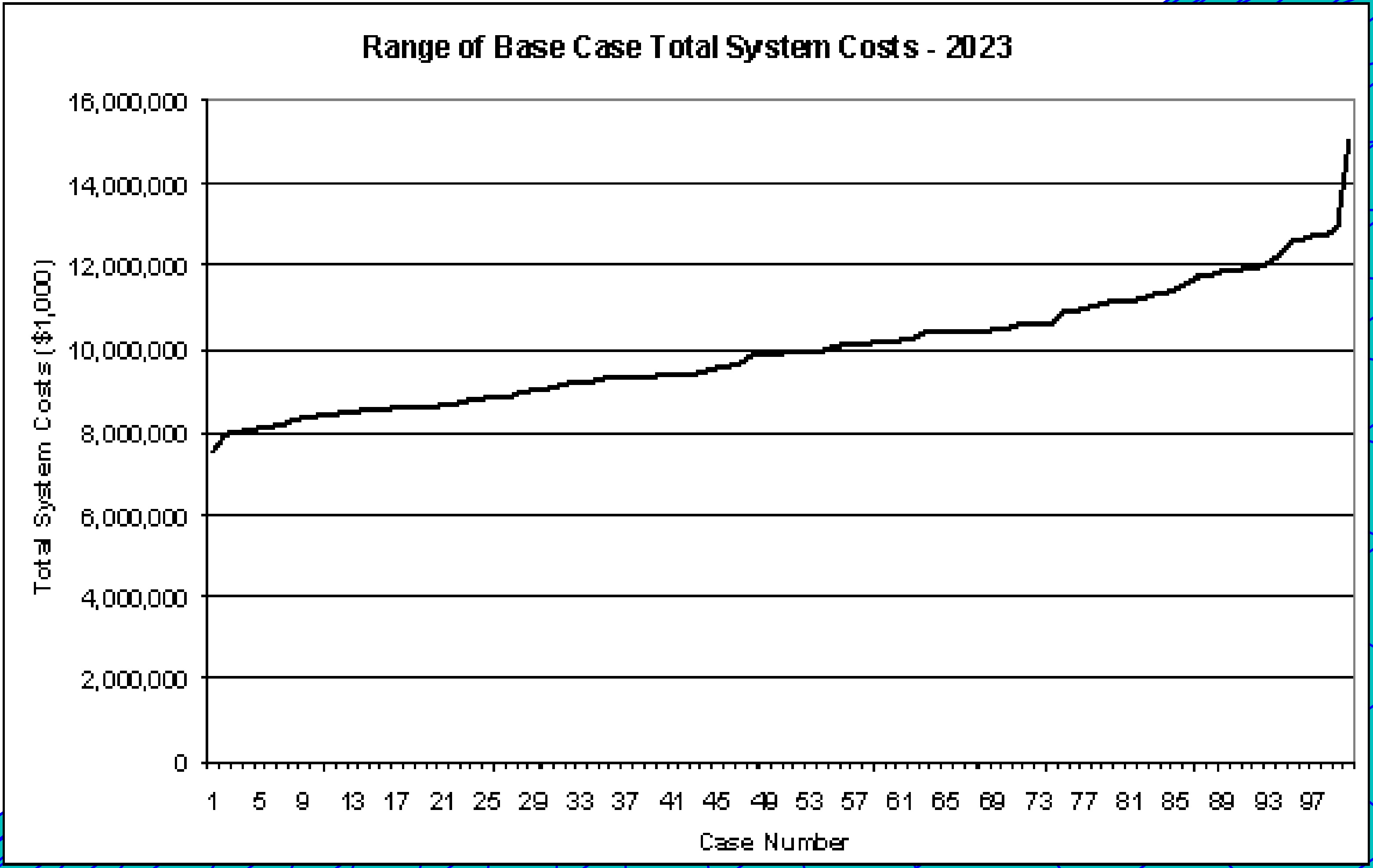
- Basics -- load duration curve analyses show that over 25% of distribution and over 10% of generation assets are needed less than 5% of the time ($100s of billions of investments)

- Uncertainty in managing a supply-side portfolio as driven by uncertainty in demand projections, fuel costs, capital costs, unit performance, and carbon mitigation is great.
  - Results in a plus/minus 100% range of revenue requirements (costs of supply) 15 years out.
  - Almost anything that can be done to reduce this uncertainty would seem to make sense.

- The economics for DR are compelling right now.

Uncertainty in Generation Costs Dimensioned – Range of System Costs

-- Range does not include carbon mitigation cost risks --



Ranges of System Costs by Year

- Generally, a 100% increase from low to high in the potential range of system costs for a given future year – without considering carbon mitigation uncertainties.

Ranges of System Costs for Select Years

Range of Total System Costs for Selected Years - Base Case ($ Billions)

Year			2015	2018	2020	2023
Maximum			10.2	10.3	12.4	15.0
Minimum			5.1	5.6	6.5	7.5
Range			5.1	4.6	5.9	7.5
Ratio	118.5%	118.8%	101.7%	82.2%	89.9%	99.3%

Does the anticipated increase in renewables double the market for DR?

- Texas Incident – NYT HEADLINE – *"Renewables push a gold mine for demand-response middlemen"* **– Is this a fact or a maybe?**
  - On a February night in 2008, the wind died in the usually blustery Texas Panhandle, and a forest of wind turbines there stopped whirring.
  - 1,700 megawatts of wind was cut to 300 megawatts in minutes.
  - DR provided in excess of 1,100 megawatts to the Texas grid.
- But the evolving economics of DR in a high renewables penetration scenario is complex.
  - There are many moving parts; and,
  - There is a need for the market participants to be educated about the economics of the different factors influencing renewable integration.

Research on Integration is Ongoing

1. New types of technologies are being developed to reliably and efficiently operate grids that have high levels of renewables.

2. Technical specifications that improve reliability and controllability of variable generation renewable resources are being examined.

3. Energy storage that adjusts rapidly in response to the variability of renewable energy output to take advantage of the potential surplus of in off-peak hours to store for release during peak hours.

4. DR also counts -- load shifting and demand response capabilities are needed to respond to varying output from renewables.
   – Improved coordination and control of these demand side and storage capabilities may be needed.

5. Advanced operational transmission technologies and infrastructure, such as those envisioned as part of a “smart grid.”

CAISO Integration of Renewable Resources (IRRP)

CAISO has suggested operational studies for 2009.

- Ramping and ancillary services evaluation -- simulation
- Fleet characteristics analyses – conventional generation and renewables:
  - Accurate assessments of the operational impacts of intermittent renewables are needed.
- Over-generation issues.
- Additional Studies:
  - Fast Regulation
  - Wide Area Energy Storage and Management System
  - Evaluation of Inter-hour Scheduling at Inter-ties
  - Impact on Gas Transmission and Storage

www.caiso.com -- CAISO Integration Working Group January 13, 2009

Components of a Renewables Integration Plan

1. New wind/solar forecasting tools need to be a focus.
2. New tools that take the forecast information and allow grid operators to anticipate changes in output are needed.
3. Adapt or develop new conventional generation with greater flexibility.
4. New wind/solar power management procedures, e.g., better manage ramp rates.
5. New transmission upgrades and regional transmission plans.
6. Increase the magnitude of flexible DR resources that can help with intermittency and ramp rates of renewables.
7. Continue investment in R&D will help create new solutions.

Resources Needed for Renewables Integration

1. <u>Generation Portfolio</u>
   – Quick Start Units
   – Fast Ramping
   – Wider Operating Range
   – Regulation capability

- <u>Demand Response</u>
  – Price sensitive load
  – Responsive to ISO dispatches
  – Frequency Responsive
  – Responsive to Wind Generation Production

- <u>Storage</u>
  – Shift Energy from off-peak to on-peak
  – Mitigate "Over Generation"
  – Voltage Support
  – Regulation capability

Integration of DR and Renewables

Sets the stage for the development of the Smart Grid

- Greater reliance on demand and renewable resources will increase complexity of bulk power system management
- From a grid operator perspective, balancing a diverse set of technologies and resources requires controllability and visibility
- Smart Grid technologies and applications will provide enhanced controllability and visibility:
  - Advanced metering
  - Storage technologies
  - Advanced grid simulator tools
  - Various other technologies and software applications

Momentum -- Integrating EE and DR into Smart Grid Investments

- Substantial progress is being made on better defining smart grid investments and the road map for reaching the smart grid.
  - The Energy Independence and Security Act (EISA) of 2007 states that support for creation of a smart grid is the national policy.
  - EISA directed NIST to coordinate development of a smart grid framework and roadmap.
  - The funding for smart grid investment through the American Recovery and Reinvestment Act (ARRA) has led to some detailed project specification.
- These efforts are beginning to focus the smart grid vision and define a path towards attaining that vision.
- Now, what is the role of DSM/DR professionals – the hands on practitioners and planners that make EE and DR work?

The Smart Grid Vision

- Elements to this vision include:
  1. The Smart Grid will be characterized by a two-way flow of electricity and information to create an automated, widely distributed energy delivery network.
  2. The grid incorporates the benefits of distributed computing and communications to deliver real-time information and enable the near-instantaneous balance of supply and demand at the device level.
  3. A common (and interoperable) pricing model is a key element of a smart grid. A pricing model/construct is needed for dynamic pricing in all its forms, demand-response systems, and trading.
  4. The Smart Grid is a network of networks cutting across control areas which emphasizes interoperability.
- This is an ambitious vision.

What makes the Grid "Smart"

- To assess progress of deployments, DOE is tracking activities by six chief characteristics of the envisioned Smart Grid:

1. Enables informed participation by customers;
2. Accommodates all generation and storage options;
3. Enables new products, services, and markets, i.e., innovation;
4. Provides the power quality for the range of needs;
5. Optimizes asset utilization and operating efficiently; and
6. Operates resiliently to disturbances, attacks, and natural disasters.

<u>Note</u>: The Modern Grid Initiative adds a 7th Smart Grid characteristic:

7. Anticipate and Respond to System Disturbances (Self-heal).

[These seven characteristics represent a consensus regarding what capabilities a smart grid should have -- reached among Modern Grid Strategy, GridWise Alliance, Galvin Initiative, and EPRI IntelliGrid]

Implications of this Vision

- The Smart Grid will affect every person and every business in the United States – there is a need to understand and address the requirements of all these stakeholders (NIST).
  - Key research is needed. DR professionals have experience working with customers.
  - Regulatory models that allow for value propositions under dynamic pricing will be needed – history has shown this poses many challenges.
  - Assessing the behavioral issues will be a key component: How will customers interact with the grid? What enablers are needed? How to make it simple enough?
- The smart grid will require gradual transition and the long coexistence of diverse technologies.
- The smart grid is an evolving goal. All that the Smart Grid is, or can be, is not known at this time (NIST).
- The smart grid will require continuing R&D to assess the evolving benefits and costs, and to anticipate the evolving requirements.

VISION – Pricing in the Smart Grid

- A common specification approach for determining prices is critical for the Smart Grid – actions in the NIST Framework and Roadmap are designed to produce a common dynamic specification for prices.
  - Businesses, homes, electric vehicles, and the power grid will benefit from automated and timely communication of energy prices, characteristics, quantities, and related information.
  - Price also is used to assess abundance, scarcity, and other market conditions.
  - A common price model will define how to exchange data on energy characteristics, availability, and schedules to support efficient communication of information in any market
- **<u>ACTION by NIST</u>**: Develop the common pricing approach/model by working with other relevant Standards Organizations that span the entire value chain – generators, transmission, distribution, retail, and regulatory.

VISION -- Smart Grid Pricing Model

<u>Questions regarding a common price specification process</u>:

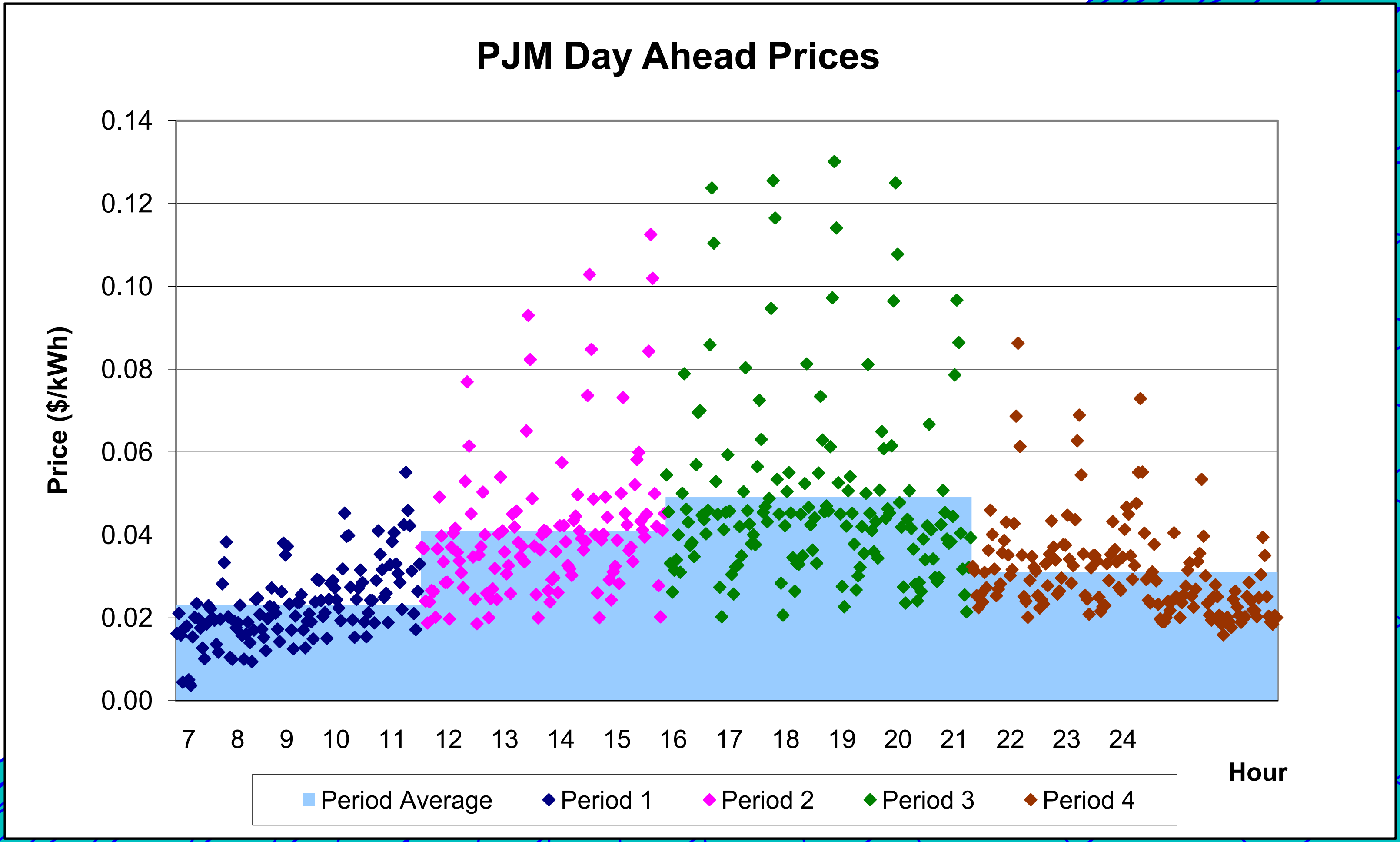
- Likelihood of state regulator and other stakeholder acceptance.
- Response of different customer groups to dynamic prices from this model, i.e., what are the behavioral issues that need study?
- Development of enabling equipment and creating an easy, hands-off response capability for customers – Innovation is needed here.
  - Simple approaches may be needed.
  - Setup of equipment will reflect user preferences
  - The use of navigation equipment in cars is now common and viewed as a benefit, but it was viewed as complicated at first.
- What level of geographic disaggregation in pricing is appropriate?
- How accurate is accurate enough in pricing?

Dynamic Pricing -- Issues

- Arguments are made that true dynamic pricing may not be acceptable to customers and/or regulators:
  - Too complex, i.e.., customers won't take the time to understand and respond to hourly pricing.
    - But, through innovation, they can respond to packages that are set up for customers with enabling technology?
    - Equity – Even if customers don't change their energy use, is it more equitable for those customers that use the most electricity during periods of high prices to pay more?
  - Some customers might see large increases in bills.
    - But, simulations have shown that for most customers (90% plus) the annual expenditure on electricity will not vary much (less than 5%).
    - If some customers do experience large changes in bills (e.g., 5% or more), these customers can have the billed phased in over 2 years.
  - How accurate is accurate enough – TOU, TOU/CPP or PTR, or RTP?

Comparison of TOU prices with RTP

- Four TOU day-time periods are compared to RTP. TOU leaves quite a bit of potential price response unaccounted for, and CPP or PTR may not make this up.



Conclusion

- Higher penetrations of intermittent renewables can help create a market for DR.
  - However, it is not entirely clear how the much the market will increase (2X?) over that based on the favorable economics that already exist.
  - DR may become more focused on applications where it has the most favorable economics.
  - Renewables that provide power off-peak will increase the need for peak resources – DR is well positioned to addressed this need.
- The role of DR in a smart grid environment with renewables will evolve over time.
  - The smart grid vision is based on appropriate pricing – planning for dynamic pricing with customers can start now.
  - Understanding the moving parts of renewables integration will be important for those in the DR industry as this future unfolds.