Mass Market Demand Response and Variable Generation Integration Issues: A Scoping Study

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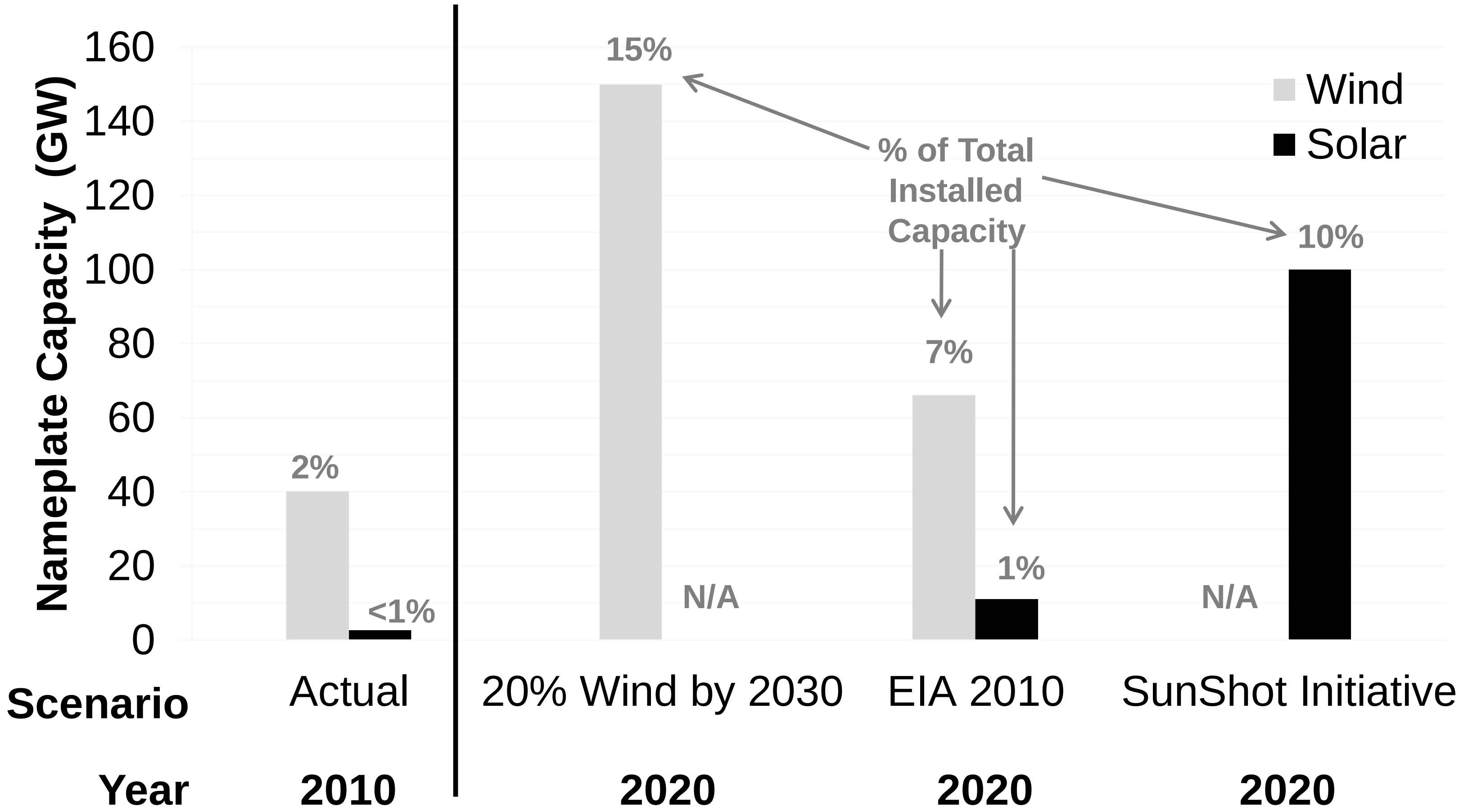
Presentation Overview

- **Variable Generation Resources and the Bulk Power System**
- **Demand Response Opportunities**
- **Demand Response as a Strategy to Integrate Variable Generation Resources**
- **Conclusions**

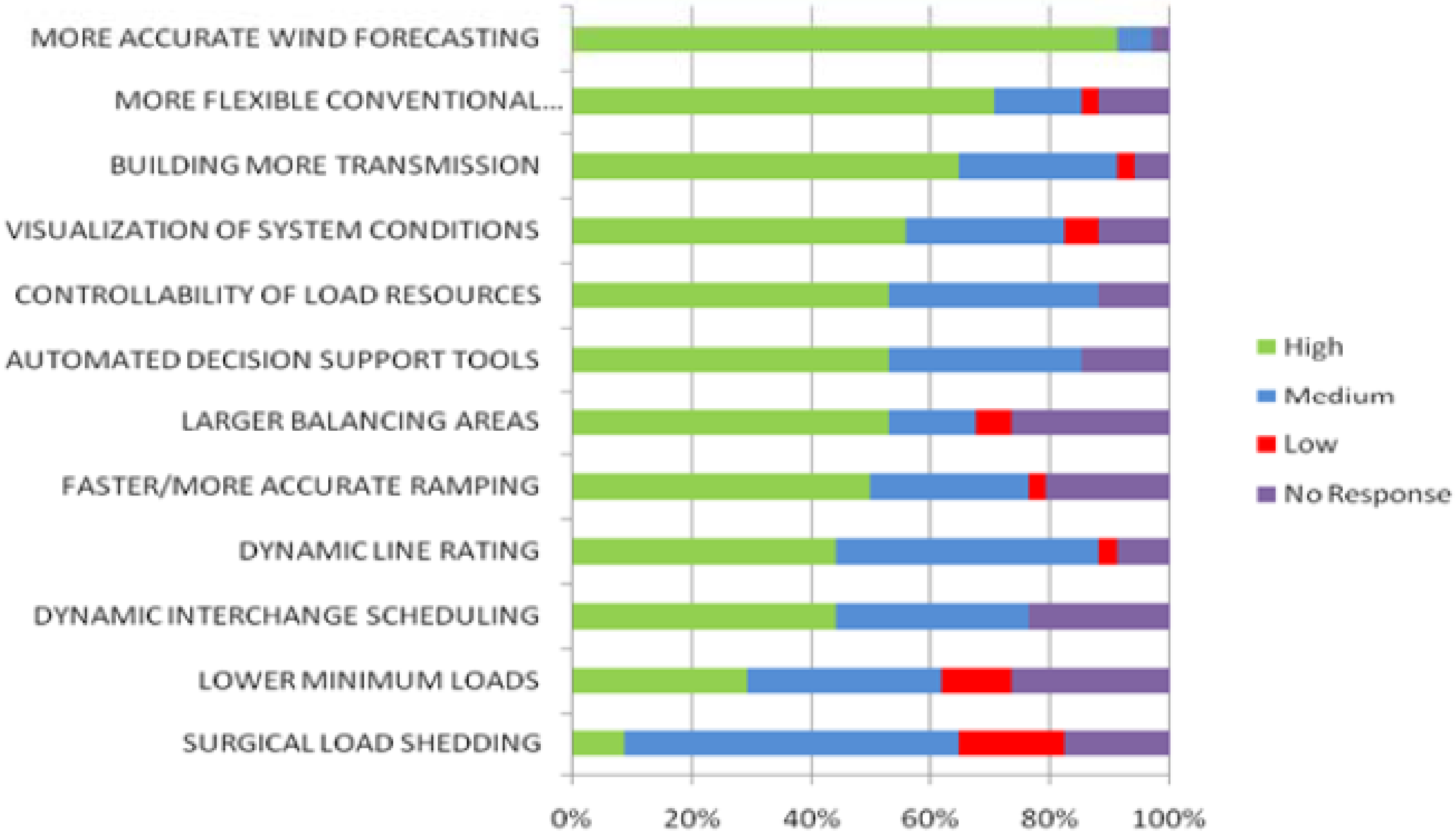
Large Forecasted Increase in Variable Generation Resources in the U.S. by 2020



Bulk Power System Operations Required to Support Integration of VG Resources

Bulk Power System Operations	Operational Characteristics of Variable Generation Resources					
	1 minute to 5-10 minute variability	< 2 hour forecast error	Large multiple hour ramps	> 24 hour forecast error	Variation from avg. daily energy profile	Avg. daily energy profile by season
Spinning Reserves	●	●				
Supplemental Reserves		●	●	●		
Regulation Reserves	●					
Imbalance Energy	●	●	●			
Hour-ahead Energy			●	●	●	
Multi-hour Ramping			●	●	●	
Day-ahead Energy			●		●	●
Over-generation				●	●	●
Resource Adequacy					●	●

Multiple Strategies Have Been Proposed to Address VG Integration Issues



Source: Alstom, Jones and Clark - Successful Strategies for Renewables Integration Webinar, October 7, 2011.

Bars reflect the proportion of survey respondents who rated the solution based on their perceived level of importance.

Must Understand Perceived Risks, Benefits and Costs of Alternative Strategies

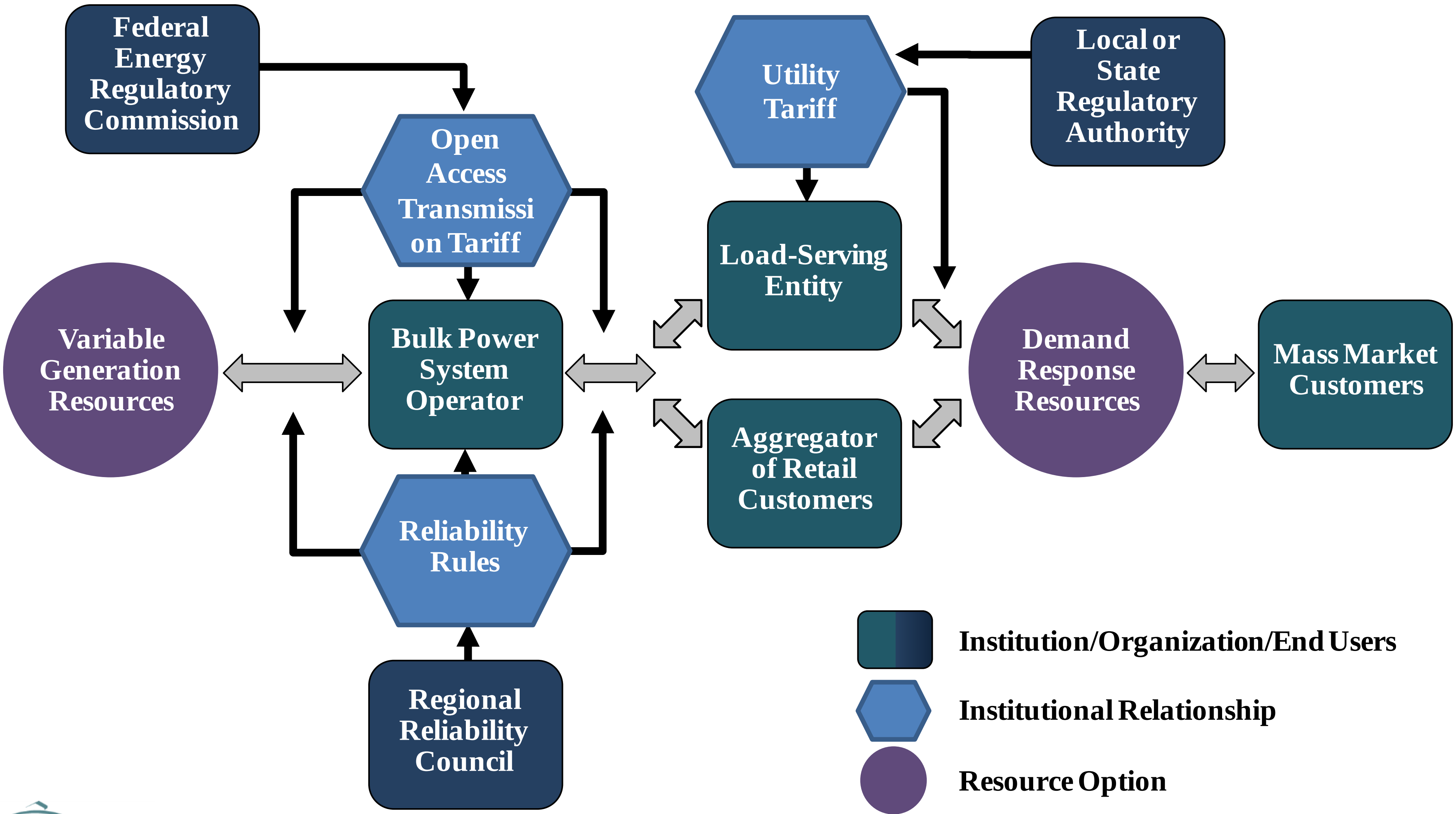
- ***More accurate forecasts***: **How much greater is the precision that reduces errors in scheduled VG supply relative to costs to integrate forecasts into existing scheduling algorithms?**
- ***Modify existing scheduling practices***: **Shorter scheduling periods provide more options for system operators attempting to balance the system but at what cost?**
- ***Increase flexibility of new fossil or renewable generation***: **Is it worth it to pay more upfront for a resource that can ramp faster, start quicker, and/or operate at lower loading levels?**
- ***Integrate demand response***: **Can existing DR opportunities be adapted to provide the necessary services or are new/different DR opportunities needed that attract new/different customers? Under what conditions is it worth the cost and effort to pursue each option? How reliable is the resource under each option?**

What Role Can the Smart Grid and Mass Market Customers Play in this Effort?

- **Greatest overall potential for increasing the size and scope of DR opportunities in the U.S. is with residential and small commercial (i.e., mass market) customers, but to do so will require massive investments in interval meters and/or control/automation technology**
- **By 2020, the electric power sector is expected to add ~65 million advanced meters (which would reach ~47% of U.S. households) as part of smart grid and AMI deployments.**

In the near-term, what role can the smart grid and mass market customers play in helping to integrate greater penetration of variable generation resources?

Entities & Institutions that Influence Relationship between VG and DR Resources



Typology of Existing Demand Response Opportunities

- **DR customers alter electricity consumption over some time period based on DR Signal provided by a Load Serving Entity (LSE) or Aggregator of Retail Customers (ARC)**
- **Time-Based Retail Rates send price signals while Incentive-Based DR Programs utilize system state signals to induce a decrease in electricity usage, with some signal seeking to increase consumption**

Time-Based Retail Rates ***DR Signal: Price Level***	**Incentive-Based DR Programs** ***DR Signal: System State***
Time-of-Use (TOU)	Direct Load Control (DLC)
Critical Peak Rebate (CPR)	Interruptible/Curtailable (IC)
Critical Peak Pricing (CPP)	Emergency DR Resource
Day-Ahead Real-Time Pricing (DA-RTP)	Capacity Resource
Real-Time Real-Time Pricing (RT-RTP)	Energy Resource
	Ancillary Services Resource

Limited Ability for Time-Based Rates to Affect VG Integration Issues

Variable Generation Integration Issue	TOU	CPR	CPP	DA-RTP	RT-RTP
1 min. to 5 – 10 min. variability					
<2 hr. forecast error					○
Large multiple hour ramps					○
>24 hr. forecast error					○
Variation from avg. daily energy profile		◉	◉	○	○
Avg. daily energy profile by season	◉			○	○

	Currently not offered and unlikely to be offered in the future
○	Currently not offered or offered only on a very limited basis but could be offered more in the future
◉	Currently offered on a limited basis and could be expanded in the future
●	Currently offered on a wide-spread basis and could be continued in the future

- **Granularity of pricing signals (e.g., hourly, multiple-hourly) will dictate the efficacy and ability of time-based rates to manage VG integration issues**
- **Need political support for exposing mass market customers to greatest time-differentiation in pricing (e.g. RTP) or at least to more flexible rate designs (e.g., variable length CPP/CPR events) coupled with automation/control technology in order to enhance ability of DR to affect VG integration issues**

Portfolio of Incentive-Based DR Programs Can Manage Multiple VG Integration Issues

Variable Generation Integration Issue	DLC	Emergency	Capacity	Energy	Ancillary Services
1 Min. to 5 – 10 Min. Variability	○				○
<2 hr Forecast Error	◉	○		○	○
Large Multi-hour Ramps	◉			○	
>24 hr Forecast Error	○			○	
Variation from Avg. Daily Energy Profile		○	○	○	
Avg. Daily Energy Profile by Season					

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- Incentive-based DR programs have significant potential to manage many variable generation integration issues if residential customers are willing to participate in programs whose designs feature short duration and frequent demand response events
- Mass market customers' acceptance of the types of control technology required will dictate DRs ability to expand its role in mitigating VG issues

Key Activities that will Influence Near-term Penetration of Mass Market DR Opportunities

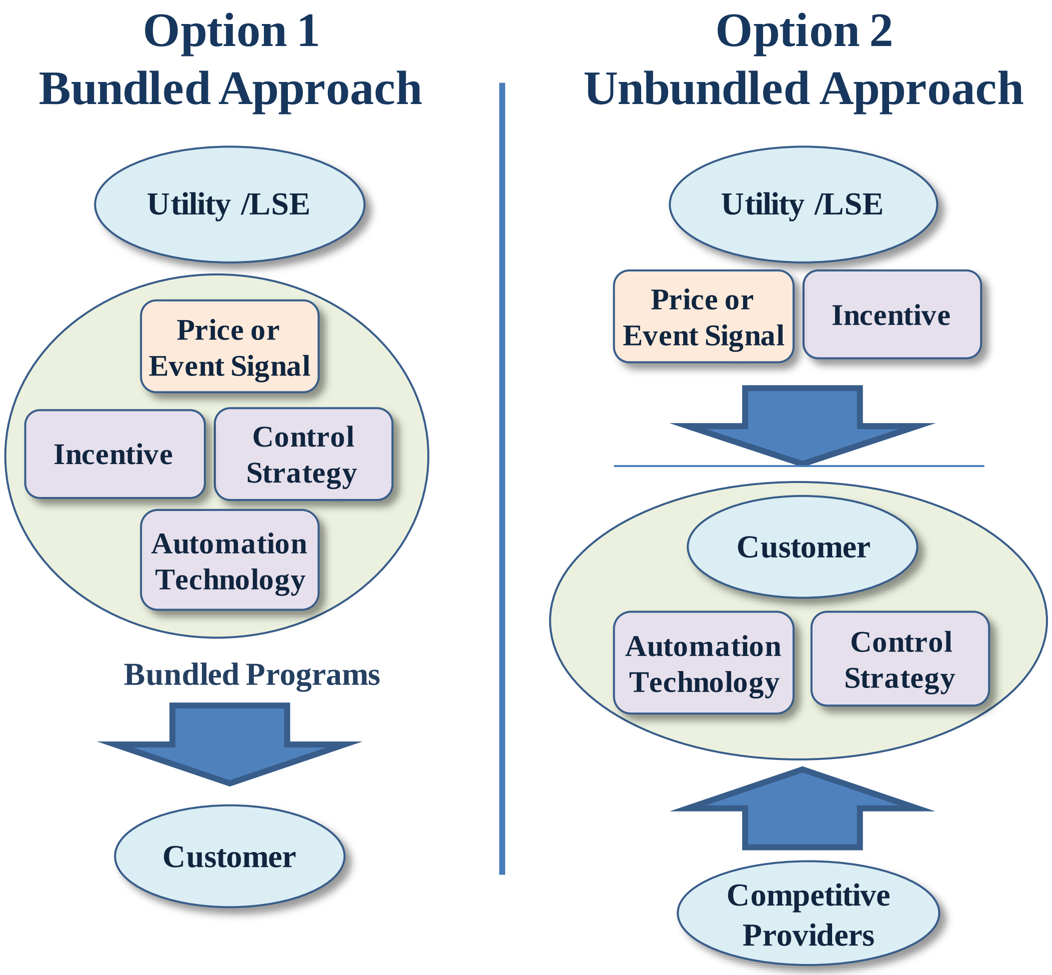
AMI Deployment
Scope of deployment of advanced meters with two-way communication capabilities to mass-market customers

Technology Acceptance
Customer willingness to accept technology depends on alleviating privacy concerns and developing a value proposition

Time-based Rate Acceptance
Willingness of regulators and utilities to offer time-based retail rates to mass market customers and degree of customer acceptance

Ability to Provide Services
Market designs and reliability rules that encourage DR service providers (i.e., LSEs or aggregators) to provide most bulk power system services

Expanding DR Program, Technology and Service Offerings through Regulatory/Market Framework Changes



- **Historic "bundled approach" where utility is "one-stop shop" may not be optimal or necessary with smart grid**
- **Alternative approach takes advantage of smart grid by creating a market for the offer and support of automation/ control equipment and services**

Expanding Customer Aggregation through Retail Market Regulatory Changes

- **ARCs are pushing for expanded opportunities to provide bulk power system services by acting as third-party providers of DR programs, which may require regulatory approval**
- **State PUCs (and utilities) should consider new tariffs or modifying existing tariffs to allow the differential dispatching of DR resources**
  - **Would allow utility and any third-party provider greater flexibility in addressing such issues as variable generation integration**
- **Remains to be seen if utilities provided with such tariff changes will take advantage of this opportunity by:**
  - **Investing in the necessary infrastructure to dispatch their own DR resources as a portfolio; or**
  - **Partnering with third-party service providers that already have this capability**

Expanding Customer Aggregation through Wholesale Market & Reliability Rule Changes

- **Historically, rules for wholesale markets and reliability were designed under a "generator-only" paradigm**
- **Capturing full value of DR opportunities requires changes to reliability rules and access to wholesale power markets**
  - **Some ISO/RTOs and reliability councils have expanded product definitions and addressed necessary technical issues to allow DR resources to provide ancillary services**
- **Definitions of bulk power system services may have to be altered to access balancing services from demand response (along with other new resources like storage)**
- **Experience with DR must be sufficient for system operators to gain confidence that customer resources can perform well and/or predictably during times of need**

Conclusions

- **Mass market DR (enabled by smart grid/AMI) must address the following challenges in order to facilitate the integration of variable generation resources:**
  - **Garner regulatory/stakeholder support for time-based rates with the greatest potential to address VG integration issues (i.e., RTP)**
  - **Establish price/event response strategies at the customer level that will likely rely on automation/control technology**
  - **Gain ratepayer acceptance of directly-integrated end-use control technology that would be used frequently ("set-it-and-forget-it")**
  - **Consider alternative regulatory/market framework: bundled utility DR program, technology and service offering vs. utility provision of DR incentives and price/event signals while competitive market provides controls technology and DR services**
  - **Address retail market restrictions, wholesale market designs, and reliability rules to access the customer diversity/flexibility**
  - **Show that DR is a cost-effective strategy with manageable risk**

Conclusions (2)

- **It is likely that combination of strategies will be utilized to address VG integration issues**
- **The mix of strategies will depend in part on the specific VG integration issues that each grid operator needs to solve (e.g. multiple hours of ramping vs regulation), which depends in part on the characteristics of their particular power system and market structure/design**

Questions/Comments

BACKGROUND SLIDES

System Requirements for Bulk Power System Operations

Bulk Power System Operations	Time Scale				
	Procurement or Schedule	Control Signal	Advance Notice of Deployment	Duration of Response	Frequency of Response
Spinning Reserves	Days ahead	<1-min	~1-min	~30-min	~ 20-200 times per year
Supplemental Reserves	Days ahead	<10-min	~10-30 min	~ Multiple hours	~ 20-200 times per year
Regulation Reserves	Days ahead	~1-min to 10 min	Automatic	< 10-min in one direction	Continuous
Load Following/ Imbalance Energy	5-min to 1-hr	5-min to 1-hr	5-min to 1-hr	5-min to 1-hr	Depends on position in bid stack
Hour-ahead Energy	1-2 hour	5-min to 1-hr	1-2 hour	>1 hr	Depends on position in bid stack
Multi-hour Ramping Capability	None	5-min to 1-hr	Days ahead to 30 min	1-4 hrs	As frequent as daily
Day-ahead Energy	24-36 hours	1-hr	24-36 hours	>1 hr	Depends on position in bid stack
Over-generation	None	1-hr	Day to multiple hours ahead	1 to multiple hrs	Seasonal
Resource Adequacy	Years	1-hr	Day ahead	Multiple hrs	Seasonal

Demand Response Opportunities: Characteristic Features

Demand Response Opportunity	Time Scale		
	Advance Notice	Duration of Response	Frequency of Response
Time-Based Retail Rates			
TOU	>6 Months	Length of Peak Period (e.g., ~4-15 hours)	Daily, seasonal, etc.
CPR/CPP	2 – 24 Hours	Length of Critical Peak Period (e.g., ~2-8 hours)	Typically <100 Hours/year
DA-RTP	~24 Hours	Depends upon price level (e.g., ~2-8 hours)	Depends upon price level
RT-RTP	~5 min – 1 Hour After	Depends upon price level (e.g., ~2-8 hours)	Depends upon price level
Incentive-Based DR Programs			
Direct Load Control	None	5 – 60 Minutes	Sometimes limited in Tariff
Interruptible/Curtailable	30 - 60 Minutes	Depends on contract	Sometimes limited in Tariff
Emergency DR Resource	2 – 24 Hours	2 – 4 Hours minimum	Typically <100 Hours/year
Capacity Resource	2 – 24 Hours	2 – 4 Hours minimum	Typically <100 Hours/year
Energy Resource	~5 Minutes – 24 Hours	Depends upon price level	Depends upon price level
Ancillary Services Resource	~5 Seconds – 30 Minutes	10 Minutes – 2 Hours	Depends upon reliability level

Opportunities for Incentive-Based DR to Provide Bulk Power System Services

Bulk Power System Service	DLC	Emergency DR	Capacity	Energy	Ancillary Services
Spinning Reserves	○				○
Supplemental Reserves	○	○			○
Regulation Reserves					○
Imbalance Energy	◉			○	
Hour-ahead Energy	◉			○	
Multi-hour Ramping	○				
Day-ahead Energy	◉			○	
Over-generation	○				
Resource Adequacy	●		○		

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- **Significant potential exists to provide bulk power system services if mass market customers are willing to participate in programs whose designs feature short duration and frequent demand response events.**

Opportunities for Time-Based Retail Rates to Provide Bulk Power System Services

Bulk Power System Service	TOU	CPR	CPP	DA-RTP	RT-RTP
Spinning Reserves					
Supplemental Reserves					
Regulation Reserves					
Imbalance Energy					○
Hour-ahead Energy					○
Multi-hour Ramping				○	○
Day-ahead Energy				○	○
Over-generation				○	○
Resource Adequacy	○	◉	◉	○	○

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- **RT-RTP with customer controls has most potential among time-based rates**
- **Rates like CPP/CPR currently have more regulatory and stakeholder support but have very limited potential to provide these bulk power system services**

Operational Characteristics of Variable Renewable Generation

- ***1 minute to 5-10 minute variability***: **Changes in aggregate output from wind facilities over very short time horizons**
- ***Less than 2-hour forecast error***: **Errors in short-term forecasts of VG that occur over the next ten to 120 minutes**
- ***Large multiple hour ramps***: **Sustained and unexpected changes in the output of VG over multiple hours**
- ***Greater than 24 hour forecast error***: **Wind and solar forecasts of the expected hourly production for a horizon of multiple hours to multiple days are less accurate than very short-term forecasts.**
- ***Variations from average daily energy profile***: **Actual energy production that is forecast may be very different from the average daily profile for that season**
- ***Average daily energy profile by season***: **Daily trends of variable generation production**