Challenges in Achieving High Penetration of Wind on the Grid

Asia Pacific Partnership –

Wind Electric Generation and Grid Integration Workshop

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Utility Wind Integration Group

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What is UWIG?

- Non-profit corporation established by 6 utilities in 1989 with support from EPRI and DOE/NREL
- Over 150 members, including utilities, developers, manufacturers, consultants, government organizations
- Focus on technical issues
- Mission: To accelerate the development and application of good engineering and operational practices supporting the appropriate integration of wind power into the electric system

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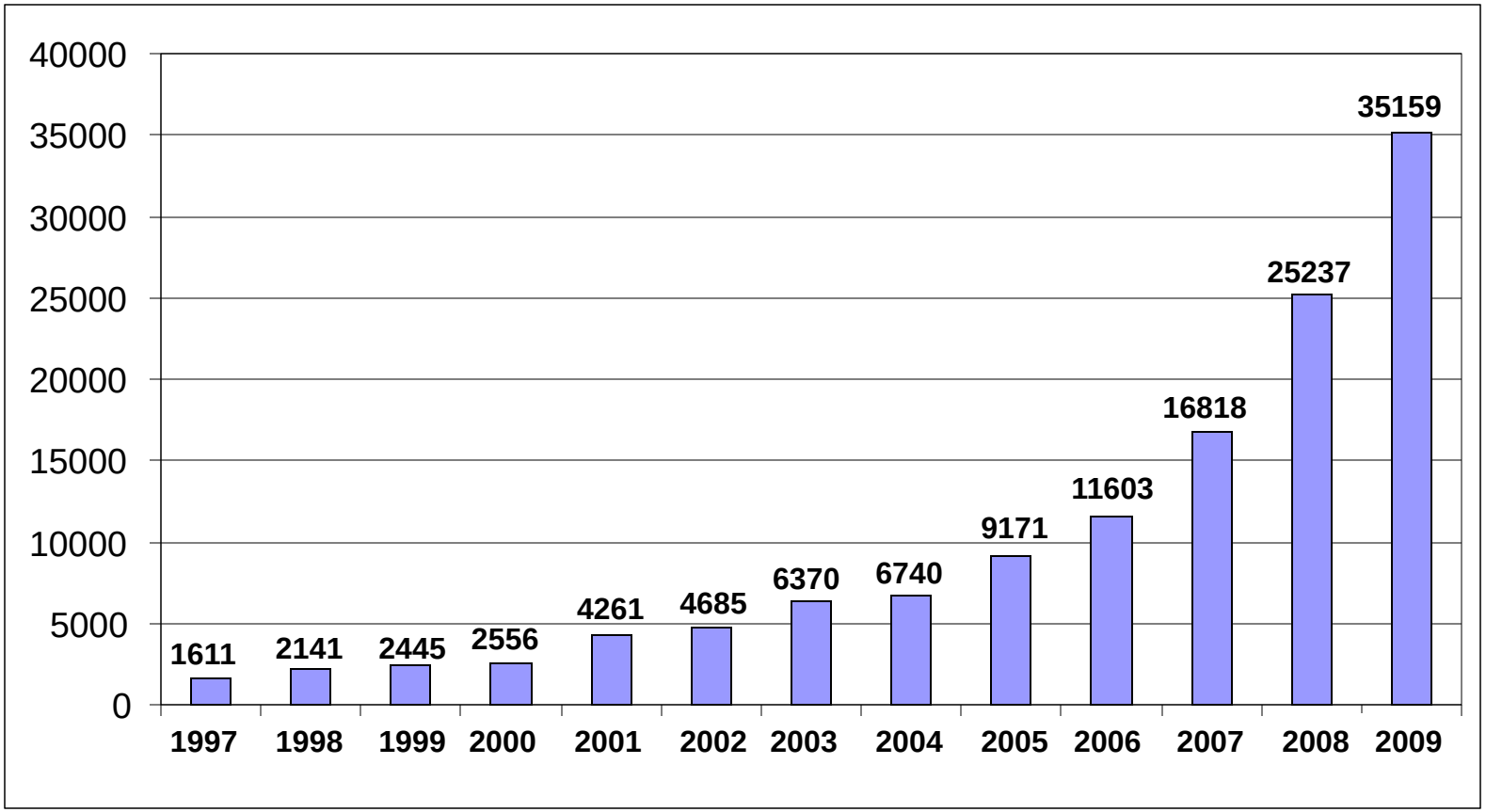
Outline of Topics

- Current industry status
- Wind integration perspective
- Two recent wind integration studies
- Smart Grid
- Current national policy issues
- Conclusions

Wind Power is Growing

Expansion of Wind Energy in the United States



In the United States, 9,922 MW of wind energy was installed in 2009, bringing US wind energy capacity to 35,159 MW.

Source: AWEA

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Recent Industry Developments

- China sets all-time wind plant installation record in 2009 of 13,000 MW
- China poised to take lead in installed wind capacity in 2011
- Growing world-wide awareness of need for inertial response and governor response from wind turbines, and ability to provide it
- DOE funding for interconnection-wide transmission planning
- Europe recognizes need for significant transmission investment to enable single European electricity market by 2015
- European offshore grid plans moving forward, but hampered by lack of uniformity in political and regulatory frameworks among member states

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It's All About Dealing with Variability and Uncertainty

- Variability
  - Load varies by seconds, minutes, hours, by day type, and with weather
  - Supply resources may not be available or limited in capacity due to partial outages
  - Prices for power purchases or sales exhibit fluctuations
- Uncertainty
  - Operational plans are made on basis of best available forecasts of needs; some error is inherent
  - Supply side resource available with some probability (usually high)
- Key questions
  - How does wind generation affect existing variability and uncertainty
  - What are the costs associated with the changes
  - What does the future hold

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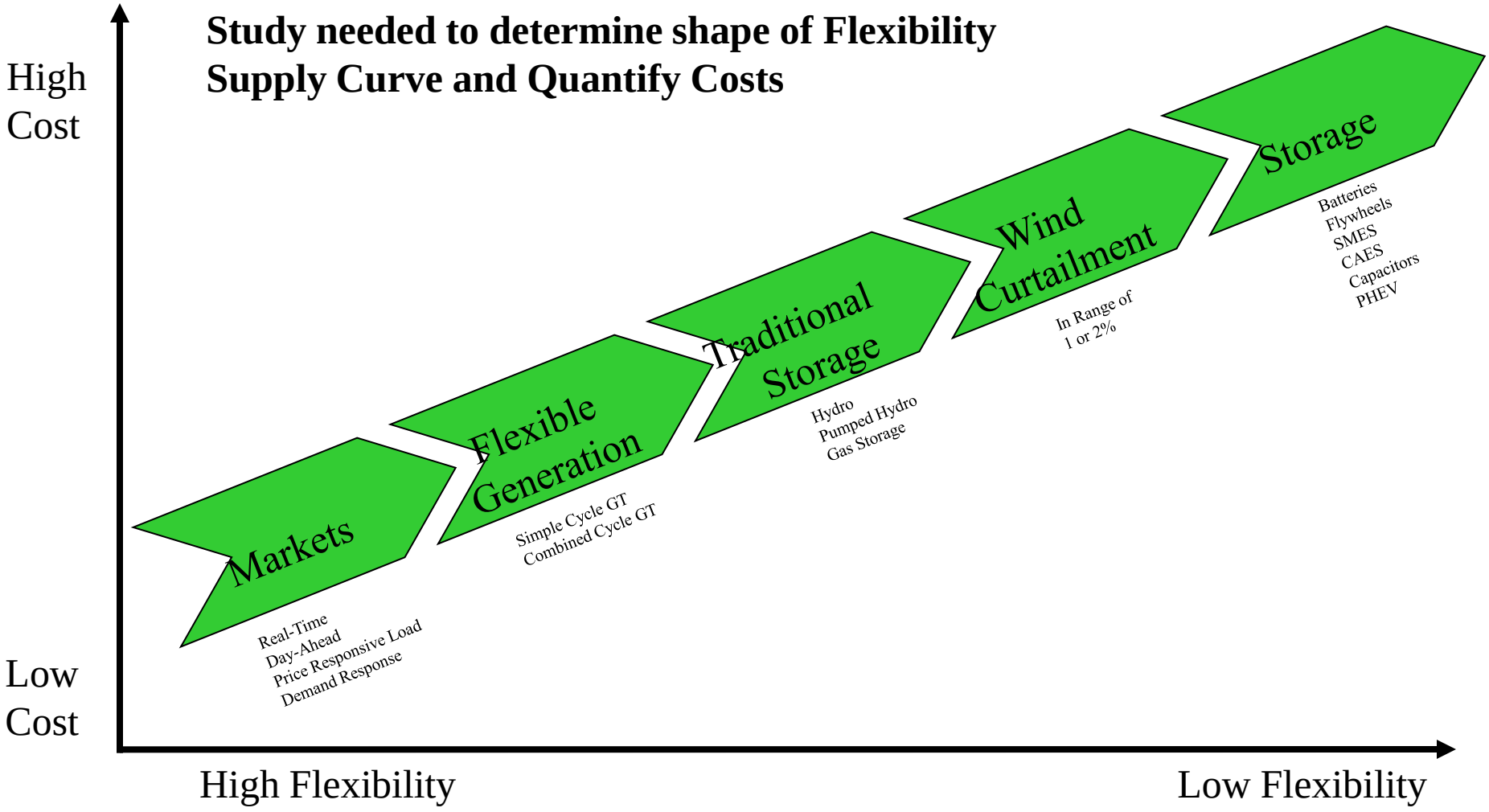
Flexibility Supply Curve



Variability is Expensive: Regulation Is The Most Expensive Ancillary Service

	2002	2003	2004	2005	2006	2007	2008
				Annual Average $/MW-hr			
California (Reg = up + dn)							
Regulation	26.9	35.5	28.7	35.2	38.5	26.1	33.4
Spin	4.3	6.4	7.9	9.9	8.4	4.5	6.0
Non-Spin	1.8	3.6	4.7	3.2	2.5	2.8	1.3
Replacement	0.90	2.9	2.5	1.9	1.5	2.0	1.4
ERCOT (Reg = up + dn)							
Regulation		16.9	22.6	38.6	25.2	21.4	43.1
Responsive		7.3	8.3	16.6	14.6	12.6	27.2
Non-Spin		3.2	1.9	6.1	4.2	3.0	4.4
New York							
Regulation	18.6	28.3	22.6	39.6	55.7	56.3	59.5
Spin	3.0	4.3	2.4	7.6	8.4	6.8	10.1
Non Spin	1.5	1.0	0.3	1.5	2.3	2.7	3.1
30 Minute	1.2	1.0	0.3	0.4	0.6	0.9	1.1
New England (Reg +"mileage")							
Regulation			54.64	30.22	22.26	12.65	13.75
Spin					0.27	0.41	1.67
10 Minute					0.13	0.34	1.21
30 Minute					0.01	0.09	0.06

Source: Brendan Kirby, UWIG 2009 Spring Workshop

Interestingly – Generators Do Not Appear To Command A Premium For Sub-Hourly Response

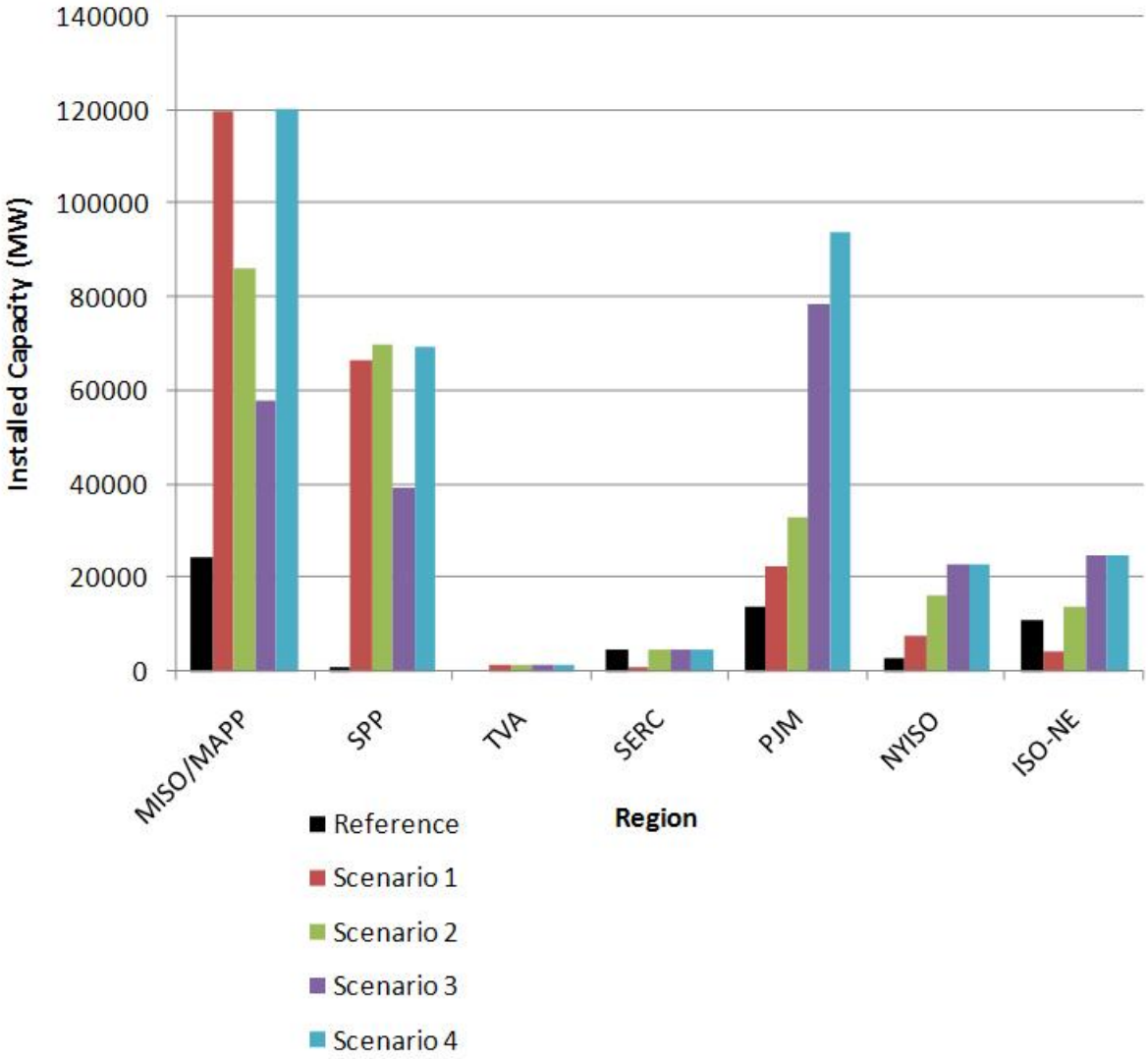
ISO	Day-Ahead $/MWH	Hour-Ahead $/MWH	5-Minute $/MWH	Average Within-Hour 5-Minute Range $/MWH
NYISO	$67.70	$64.93	$63.31	**$91.18**
ISO-NE	$81.38	$80.76	$81.22	**$24.40**
CAISO		$69.78	$68.32	**$59.87**
ERCOT[1]			$71.69	**$40.00**
MISO	$49.99	$48.62	$48.71	**$67.75**

[1]ERCOT currently operate a 15 minute sub-hourly market rather than a 5 minute market.

- *Average* day-ahead, hour-ahead, and 5-minute prices are nearly equal
  - 5-minute price is often slightly lower
  - No premium for flexible generation
- *Within hour* 5-minute price *range* is very large
  - Marginal generators receive a strong signal to move within the hour

Source: Brendan Kirby, UWIG 2009 Spring Workshop

Eastern Wind Integration and Transmission Study (EWITS) Scenarios



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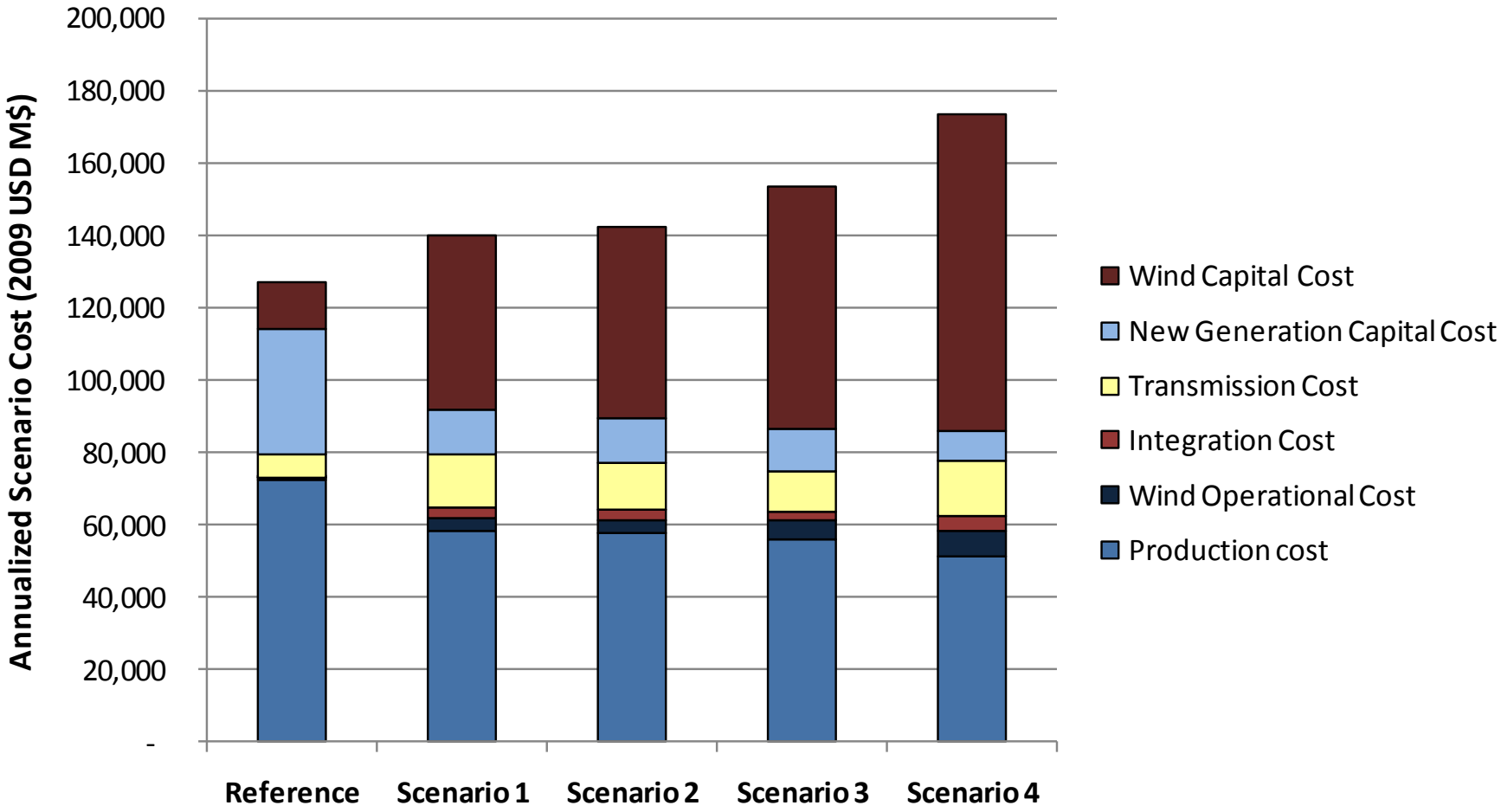
Total Scenario Cost



WWSIS Scenario Overview

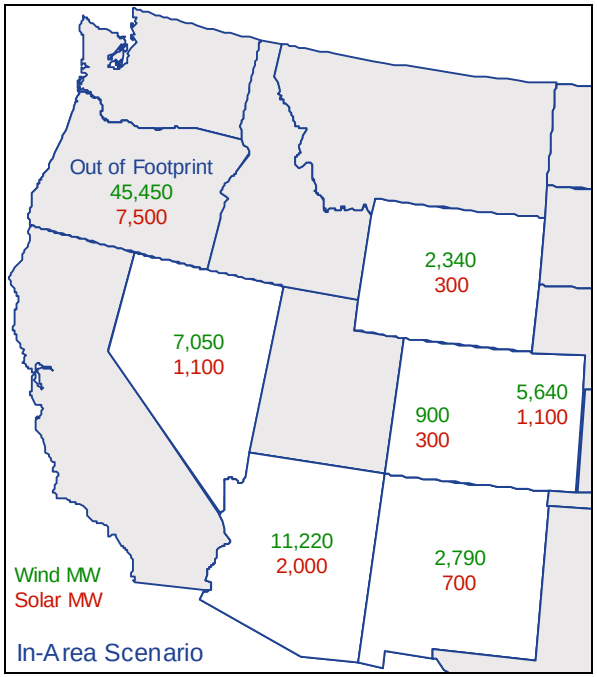
- 2017 Study Year
- 2004, 2005, 2006 Load Shapes Escalated to 2017
- Wind and Solar Penetration Levels (% Energy)

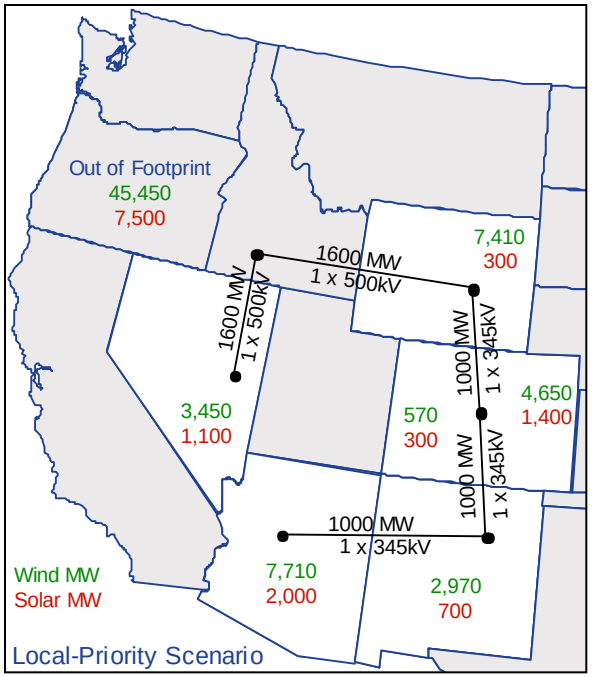
In Footprint		Rest of WECC	
Wind	**Solar**	**Wind**	**Solar**
10%	1%	10%	1%
20%	3%	10%	1%
20%	3%	20%	3%
30%	5%	20%	3%

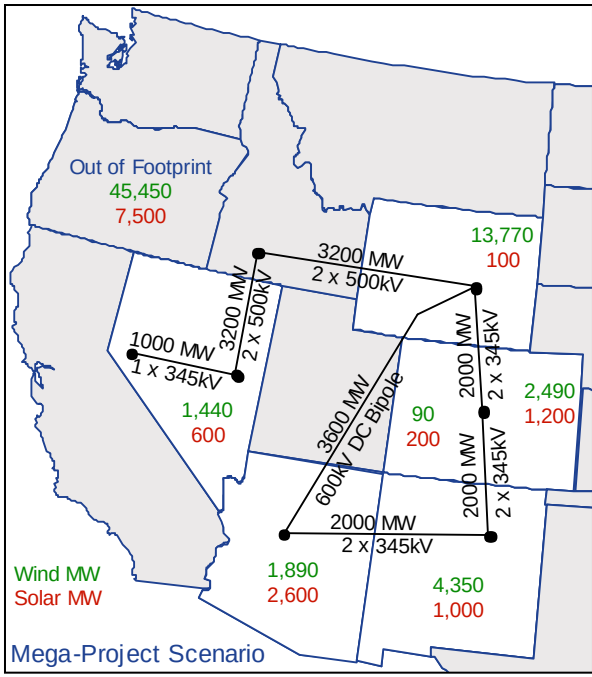
- Solar Mix
  - 70% Concentrating Solar Plant with Storage (CSP w/S)
  - 30% Photo-voltaic (PV)

WWSIS Capital Costs: Wind, Solar, Transmission

Scenario	Wind MW	Solar MW	Transmission (GW-mi)	Wind Cost ($B)	Solar Cost ($B)	Transmission Cost ($B)	Total Cost ($B)	Delta ($B)
In-Area	29,940	5,800	0	59.9	23.2	0.0	83.1	
Local-Priority	26,760	5,800	2,100	53.5	23.2	3.4	80.1	-3.0
Mega-Project	24,030	5,700	6,900	48.1	22.8	11.0	81.9	-1.2







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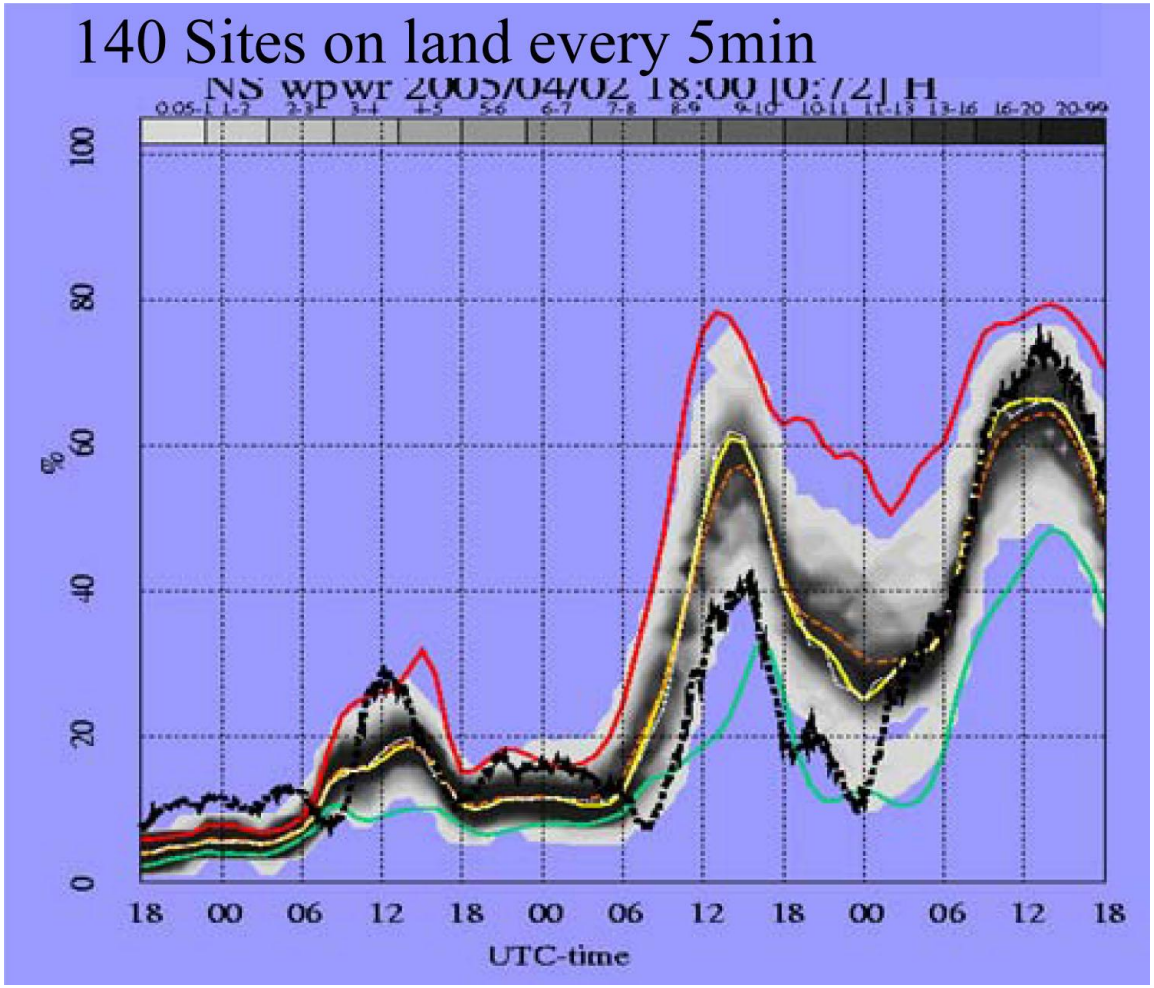
Forecasting and Balancing Markets Reduce Impacts



How Can Smart Grid Technologies Help?

- How do we deal with increased uncertainty?
  - IMPROVED FORECASTING
- How do we deal with increased variability?
  - INCREASED FLEXIBILITY
- Is there an opportunity to provide for
  - IMPROVED FORECASTING and
  - INCREASED FLEXIBILITY
  - with SMART GRID?
- YES

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How Can Smart Grid Technologies Help?

- Improved wind plant output forecasting
  - Individual turbine data acquisition
  - Line loading and curtailment monitoring
- Increased sources of system flexibility
  - Demand side management
  - Price responsive load markets
  - Plug Hybrid Electric Vehicles
- Smart Grid functions in common
  - Distribution Automation
  - Communications, monitoring and control
  - Smart metering

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Current Policy Issues

- Carbon policy
- Renewable portfolio standard
- Transmission policy
- Wind integration charges
- BA cooperation
- Sub-hourly scheduling
- Role of wind plant output forecasting
- Market design
- Interconnection-wide planning

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Current Operational Issues

- Wind plant aggregation
- Transmission for remote resources
- Forecasting implementation
- Rapid change in wind plant output
- Role of energy storage
- Greater real and reactive power control
- Dynamic response
- NERC IVGTF variable generation activities

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National Transmission Policy

- National policy debate stimulated by two activities:
  - Success of Texas CREZ process
  - Growing recognition that RPS goals cannot be met without significant transmission build-out
- Three major transmission bills proposed in US Senate in 2009
- All different, but all have three common elements:
  - Interconnection-wide transmission planning
  - High voltage backbone with broad cost allocation
  - Federal backstop siting authority
- Growing recognition of critical need for transmission

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NERC IVGTF Report Recommendations

- Broad based industry effort with participation of utilities, ISOs, turbine manufacturers, project developers, research organizations, consultants, trade associations
- Requested by OC/PC in recognition of the increasing large role wind power will play
- Report released mid-'09
- Phase 2 work leading to a review and likely update of NERC standards

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The Big Enchaladas

- Dynamic models
- Grid codes
- Probabilistic planning
- Incorporating need for flexibility in G&T planning
- PHEV and DSM as sources of flexibility
- Need for forecasting
- Large balancing areas
- Faster markets
- Remove barriers to transmission

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FERC Notice of Inquiry

- Integration of Variable Energy Resources
- Issued January, 2010
- Policy Issues
  - Wind forecasting and required data
  - Generation scheduling flexibility
  - DA market participation and reliability UC
  - Balancing Authority Area coordination
  - Non-spinning and supplemental reserves
  - Integration of DR and storage into markets
  - Capacity market evolution
  - Integration charges

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and the conclusion is…

- There are no fundamental technical barriers to the integration of 20% wind energy into the electrical system, but…
- It won't be achieved under a "business as usual" scenario
- There needs to be a continuing evolution of transmission planning policy, system operation policy and market development for this to be achieved

For More Information

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