



**Final Report -  
Avista Corporation Wind Integration Study**

Prepared for:  
Avista Corporation  
c/o Mr. Clint Kalich  
Manager of Resource Planning  
P.O. Box 3127  
J.A.I. East Edison Street  
Spokane, Washington 99220-3127

Prepared by:  
EnerNex Corporation  
1700 Warner Place, Boulevard  
Knoxville, Tennessee 37922  
Tel: (865) 691-5540 ext. 149  
Fax: (865) 691-5046  
[clint.kalich@enernex.com](mailto:clint.kalich@enernex.com)  
[www.enernex.com](http://www.enernex.com)

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# Defining Wind Integration & Overview of Avista Study

Clint Kalich  
Manager of Resource Planning & Power Supply Analyses  
[clint.kalich@avistacorp.com](mailto:clint.kalich@avistacorp.com)  
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# Outline of Presentation

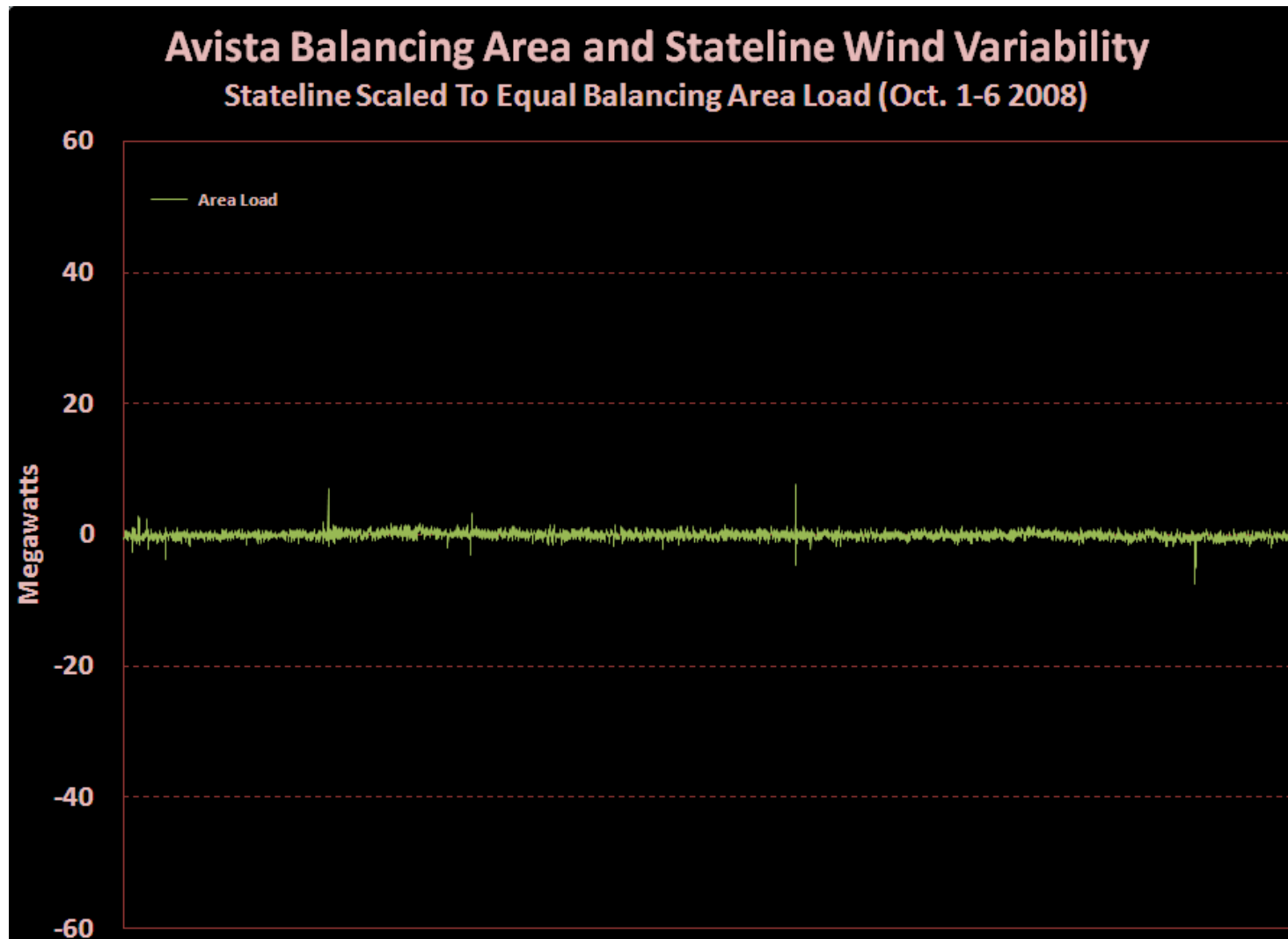
- **Defining Wind Integration**
- **Overview of Avista's System**
- **Evaluating Overall Cost of Wind**
- **Methodology Overview**
- **Wind Integration Cost Components**
- **Impact of Shorter Market Time Step**
- **Benefit of Wind Feathering**
- **Hydro Re-Dispatch Costs**
- **Next Steps/Modeling Enhancements**
- **Other Wind Integration Study Results**

# Defining Wind Integration

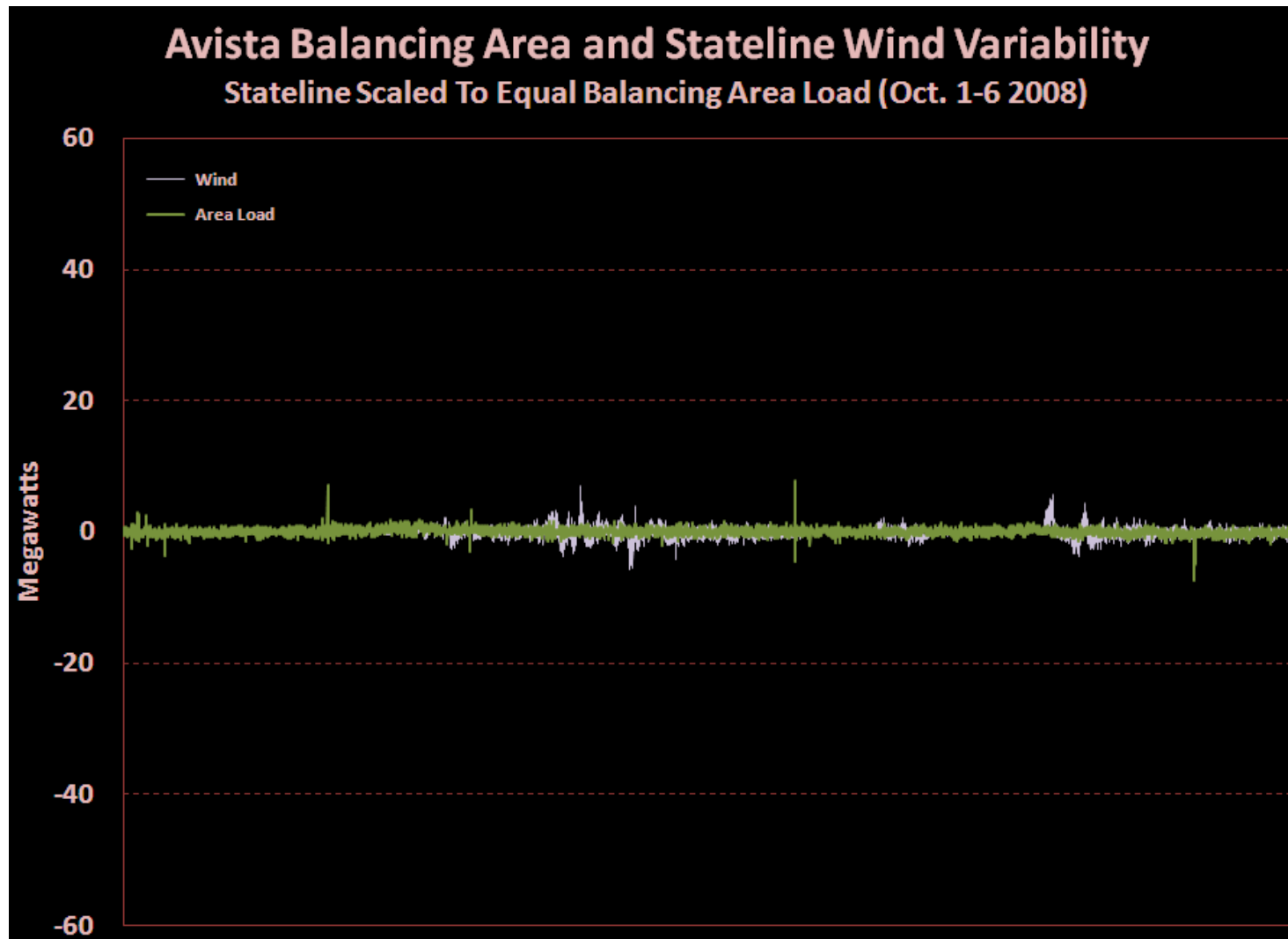
- **Incremental Reserves (Avista Study Method)**
  - Regulation (<1 minute)
  - Load following
    - covers timeframe from end of regulation up to next ramp (1 hour in WECC)
  - Forecast error
    - difference between forecast and actual generation
- **Other Things Sometimes Called Wind Integration**
  - Shape of delivered energy
  - Fuel savings from wind operations
  - Capital costs
  - Environmental attributes

Bottom Line: Be Careful When Assuming 2 Studies are “Apples-to-Apples”

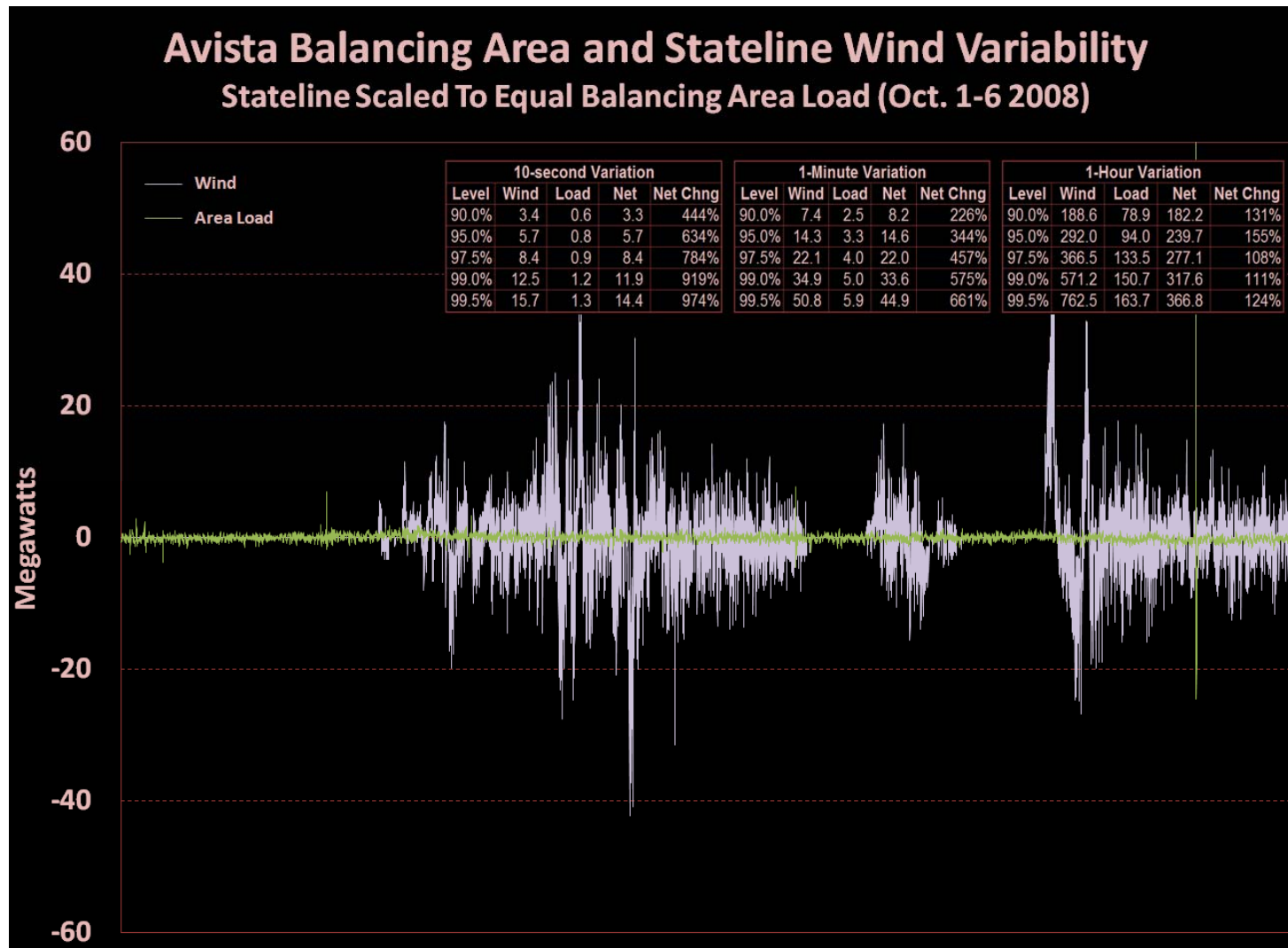
# Defining Wind Integration — A Graphical View



# Defining Wind Integration — A Graphical View



# Defining Wind Integration — A Graphical View



# Overview of Avista's System (2010)

- **2,200 MW Control Area Peak**
- **875 MW Minimum Load**
- **1,200 MW Hydro**
  - Very flexible with generous short-term storage
  - Provides majority of reserves for wind
    - regulation, spinning, supplemental
- **785 MW Gas Turbines**
  - 550 MW CCCT with 100 MW of spinning & supplemental reserves
  - 210 MW (4 units) provide only supplemental reserves
  - Remaining 7 (small) units cannot provide reserves

# Overview of Avista's System, Cont

- **230 MW Coal & 50 MW Biomass**
  - Do not provide reserves
- **35 MW of Stateline Wind**
- **~750 MW Contracts Rights**
  - 350 MW for “native load”
  - 400 MW 3<sup>rd</sup> party resources to serve 3<sup>rd</sup> party loads in control area
  - No reserve capabilities
- **~200 MW Capacity Contract Obligations**
  - Sales of AGC and spinning reserves for 3<sup>rd</sup> party load and wind

# Evaluating Overall Cost of Wind

- **Commodity Value of Energy**
  - Consider hourly pattern
  - Wind doesn't generate flat or at the operator's control
- **Transmission Cost ~ 3 Times Traditional Resources**
- **Impact on Operation of Other Owned Resources**
  - Fuel savings and/or impact on market sales & purchases
- **Incremental Reserve Obligations**
  - Avista definition of wind integration
  - Regulation, load following, forecast error
    - load following and forecast error are greatly affected by spot market timeframe
- **Capital Recovery and Operation Costs**
- **Environmental Attribute Values (green tags, reduced CO<sub>2</sub>)**
- **Capacity Contribution (or lack thereof)**

# Methodology Overview

- **Develop Hourly LP Model Of Avista System**
  - Model of both Real-Time and Pre-Schedule timeframes
    - pre-schedule commitment and market transactions “honored” in Real-Time
  - Represent inherent flexibility and constraints
    - hydro storage and minimum flow
    - minimum up/down requirements
    - reserve capabilities and ramping rates
    - transmission paths
    - hydro spill and wind “feathering”
  - Access to energy market for balancing and optimization
    - pre-schedule and real-time markets

# Methodology Overview (Cont.)

- **Run Model With and Without Wind Variability**

- Over same historical timeframe (2002-04)
  - using actual loads
  - wind is priced in each hour at market
  - eliminates potential for wind shape to bias result
  - carry additional reserves in “With Wind” case

- **Compare System Values**

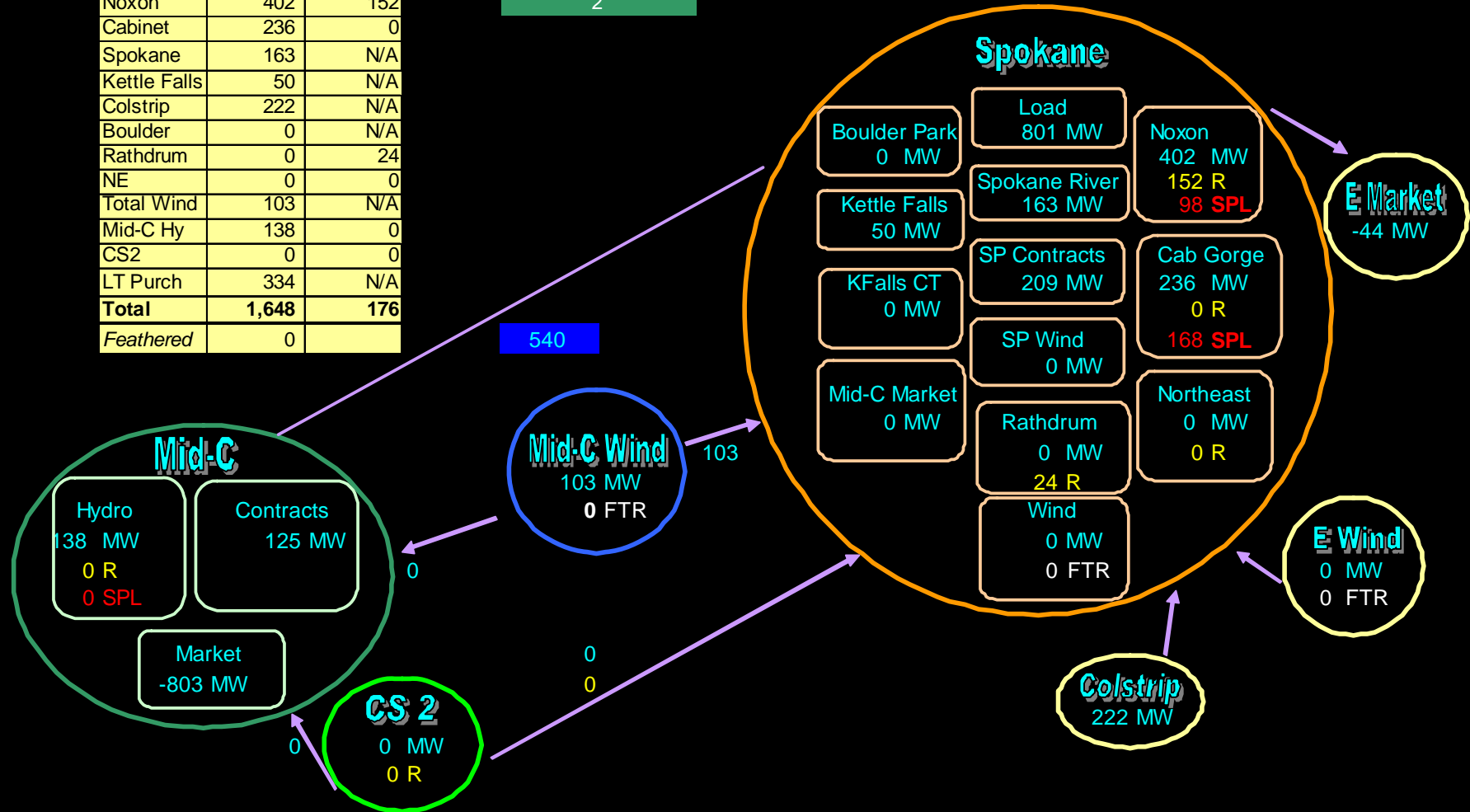
- Change is spread over wind deliveries to arrive at an integration cost
  - per MWh (absolute or % of market price)
  - per kW-month (absolute or % of market price)

# Pre-Schedule Wind Model Delivery Schematic

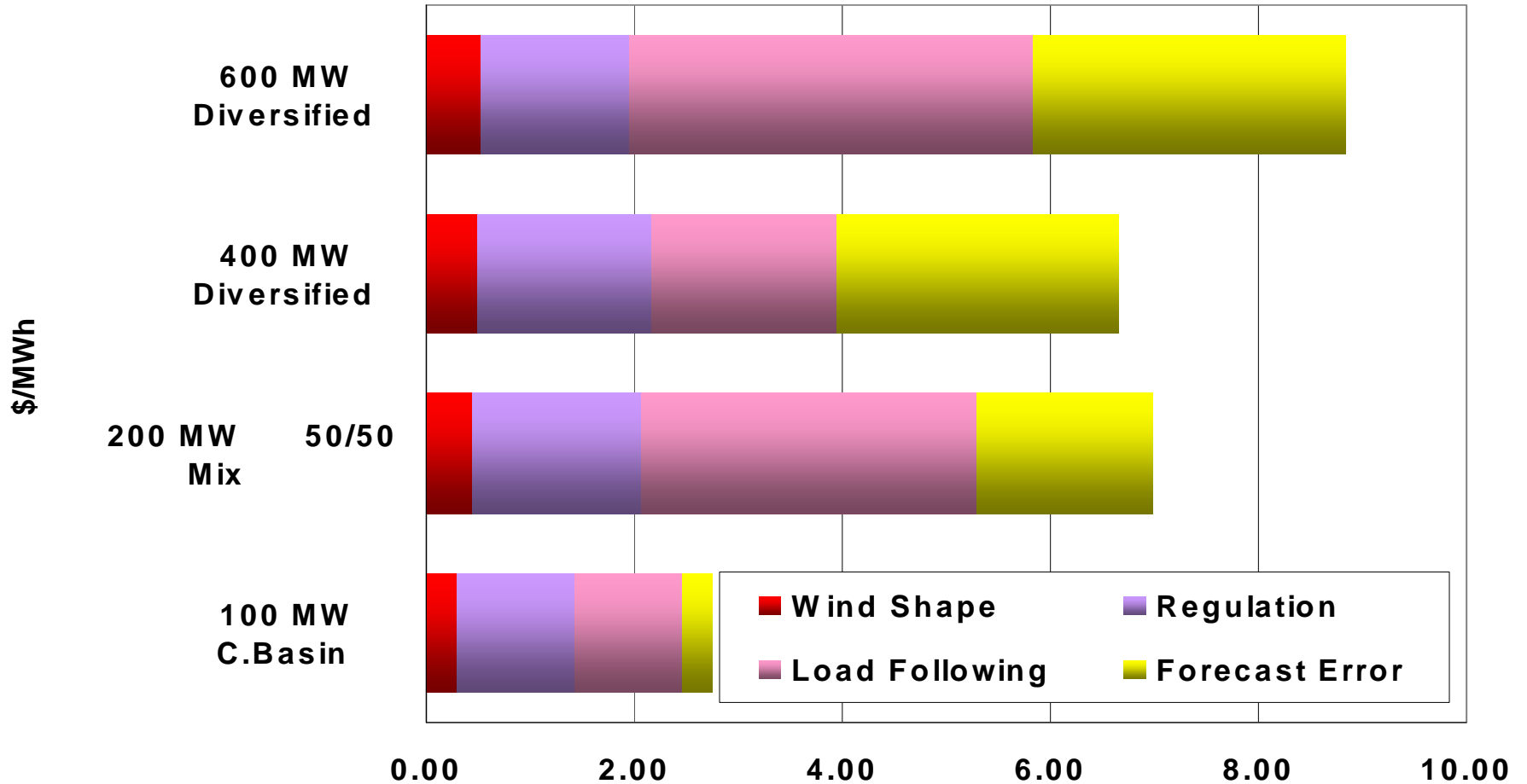
## Generation Summary

Resource	Power	Res
Noxon	402	152
Cabinet	236	0
Spokane	163	N/A
Kettle Falls	50	N/A
Colstrip	222	N/A
Boulder	0	N/A
Rathdrum	0	24
NE	0	0
Total Wind	103	N/A
Mid-C Hy	138	0
CS2	0	0
LT Purch	334	N/A
<b>Total</b>	<b>1,648</b>	<b>176</b>
Feathered	0	

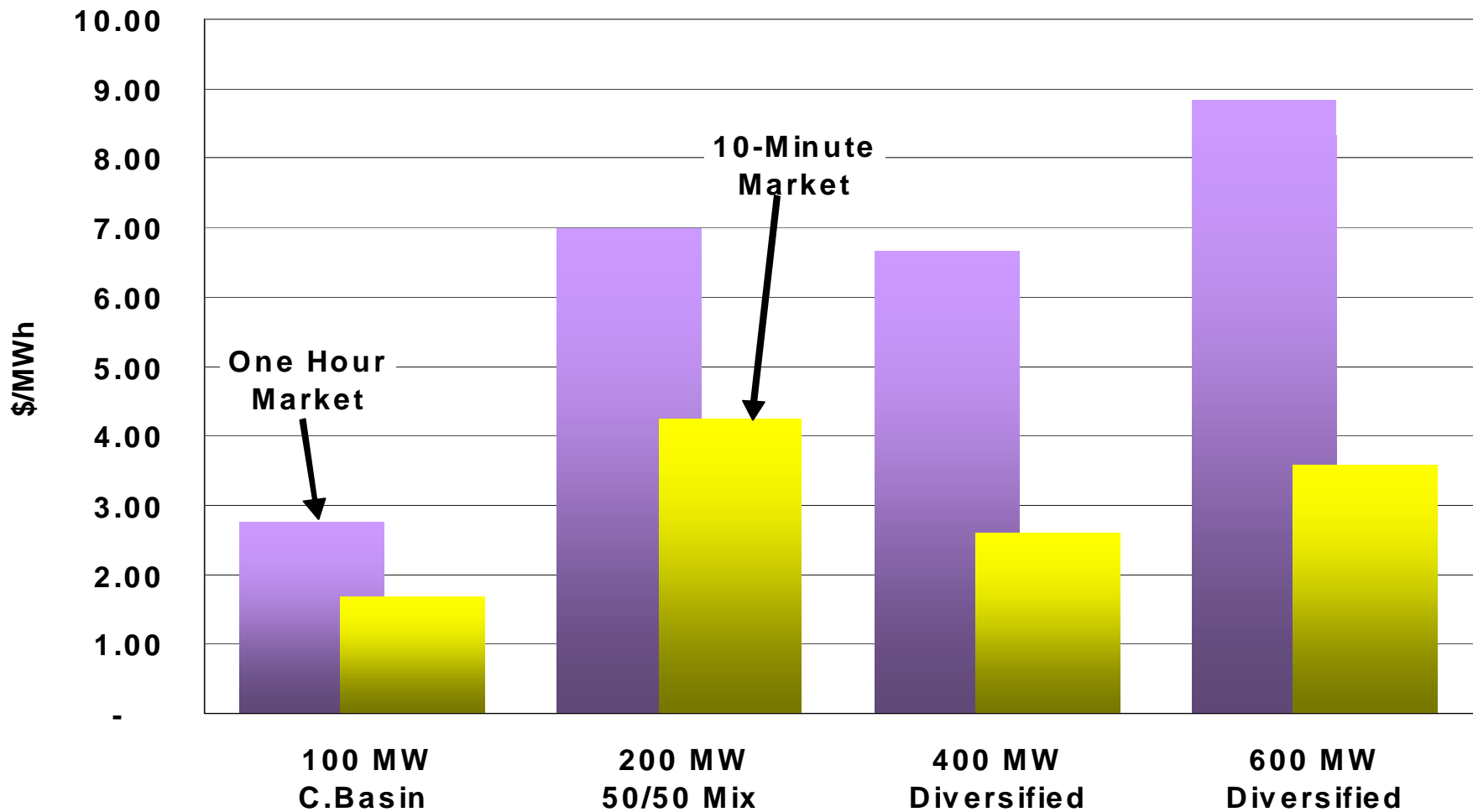
Modeled Hour  
2



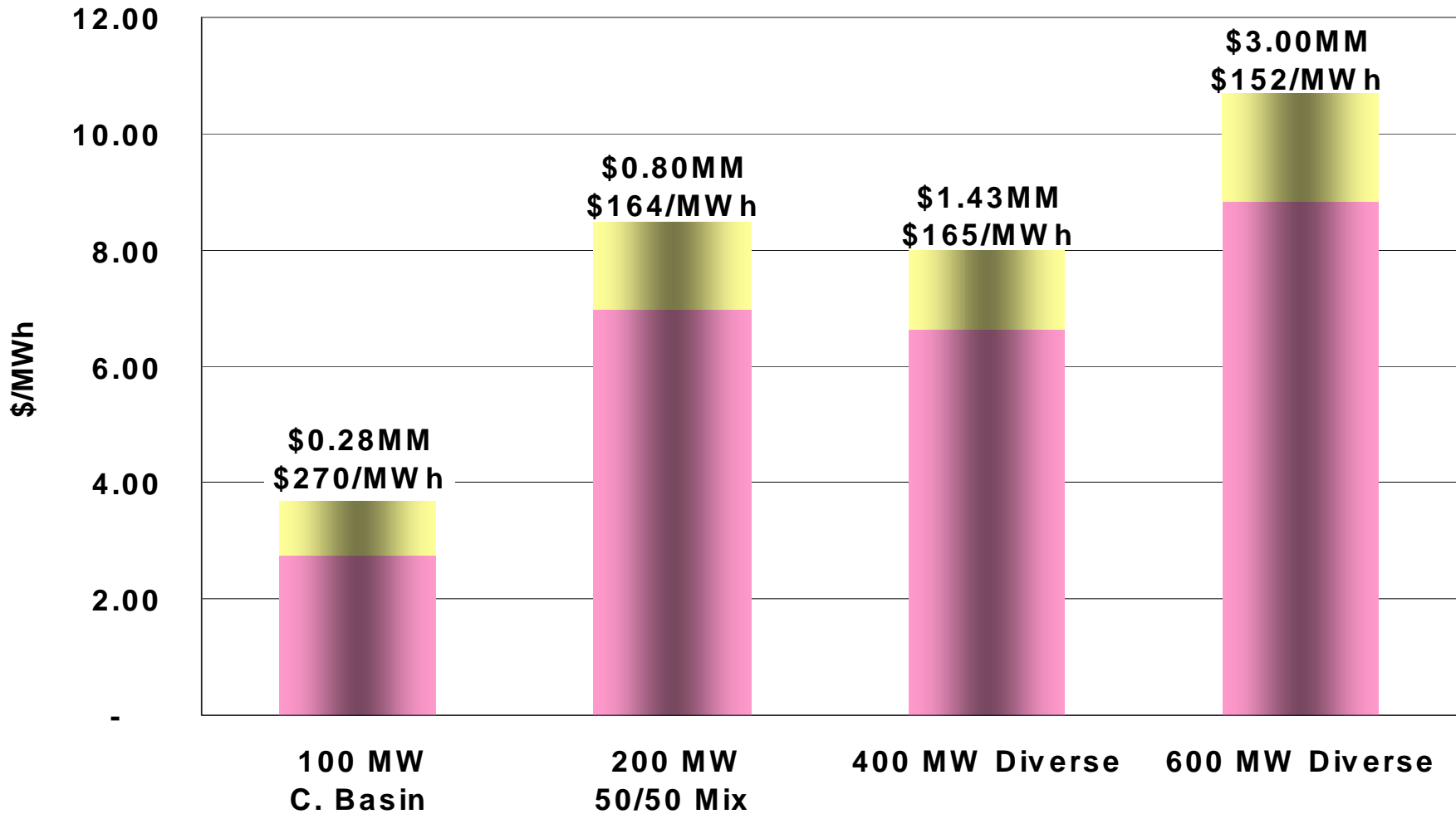
# Wind Integration Cost Components



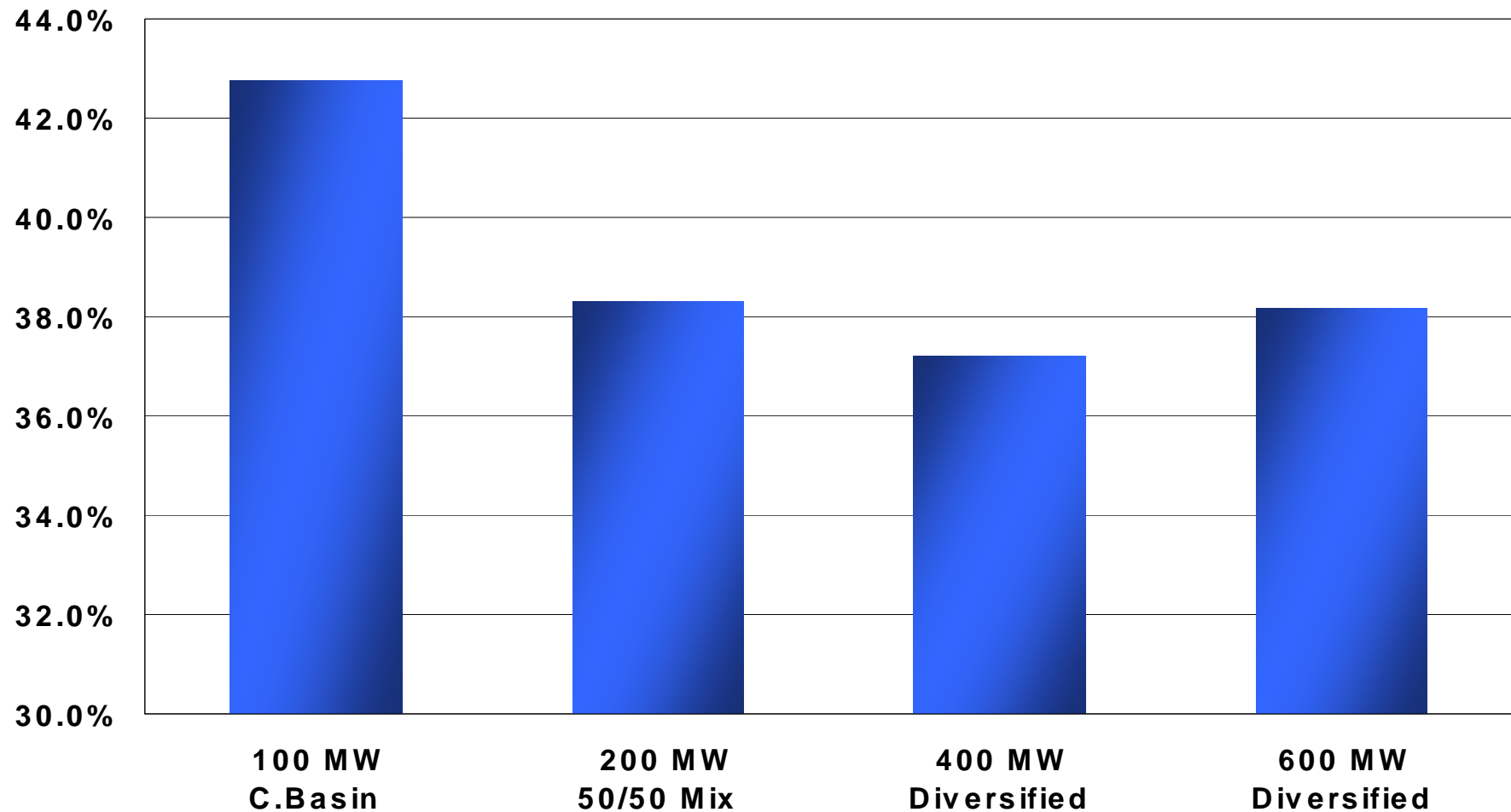
# Impact of Shorter Market Time Step



# Benefit of Wind Feathering



# Hydro Re-Dispatch Costs



# Next Steps/Modeling Enhancements

- **Update With Latest Data**
  - Augment limited NW data sets with data from outside the NW
  - Update to data through 2006
  - Use NPCC/BPA 3-Tier meso-scale wind data when available
- **Evaluate Regulation, Load Following, Forecast Errors Using Root-Mean-Squares Method**
- **Search For Better Wind Forecasting Algorithms**
- **Enhance Start-Up Cost Logic For Thermal Plants**
- **Model Reserve Capabilities of Coal-Fired Plants**
- **Evaluate Real-Time to Pre-Schedule Relationships**

# Other Integration Study Results

Wind Integration Study Costs (\$US/MWh)					
Entity	Low	High	Entity	Low	High
APS 2007	0.91	4.08	Maritimes (E. Canada) 2007	3.66	6.13
Avista 2007	2.75	9.00	Minnesota 2004	2.25	5.25
BPA 2007	1.90	4.60	Minnesota 2006	3.45	5.10
BPA 2008			Nordic 2004	1.50	3.15
California	0.45		Norway (Greennet)	0.30	0.68
Colorado 2007	4.00	8.00	PacifiCorp 2006	1.86	5.94
Denmark (Greennet)	0.60		Puget Sound Energy	3.73	4.06
Finland (Greennet)	0.30	2.10	Sweden (Greennet)	0.38	0.90
Finland 2004	3.00	4.50	UK 2002	5.10	6.08
Germany (Greennet)	3.23		UK 2007	2.10	5.10
Idaho Power 2007	6.00	9.00	WeEnergies 2003	1.90	2.90
Ireland	0.38	0.75			

**The End**