ecomagination SM

Wind Technology

4 October, 2006

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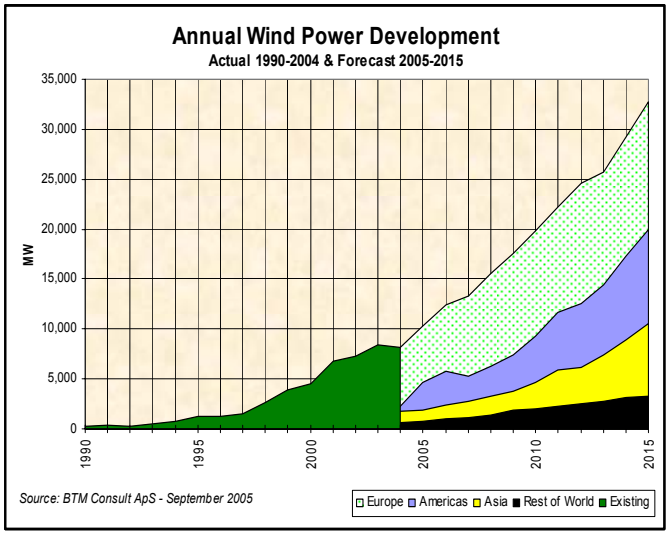
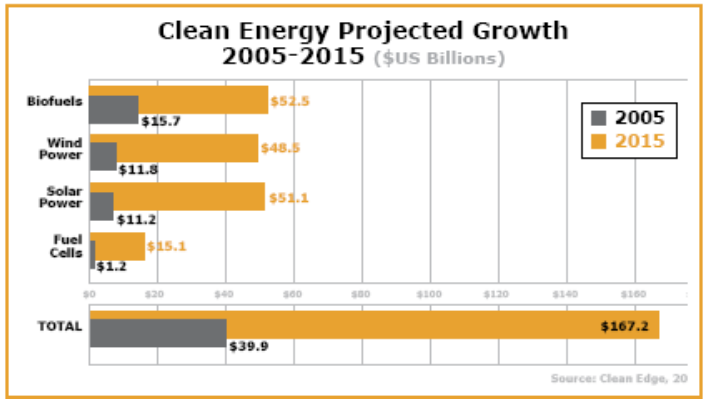
Wind Power Growth … Global Industry



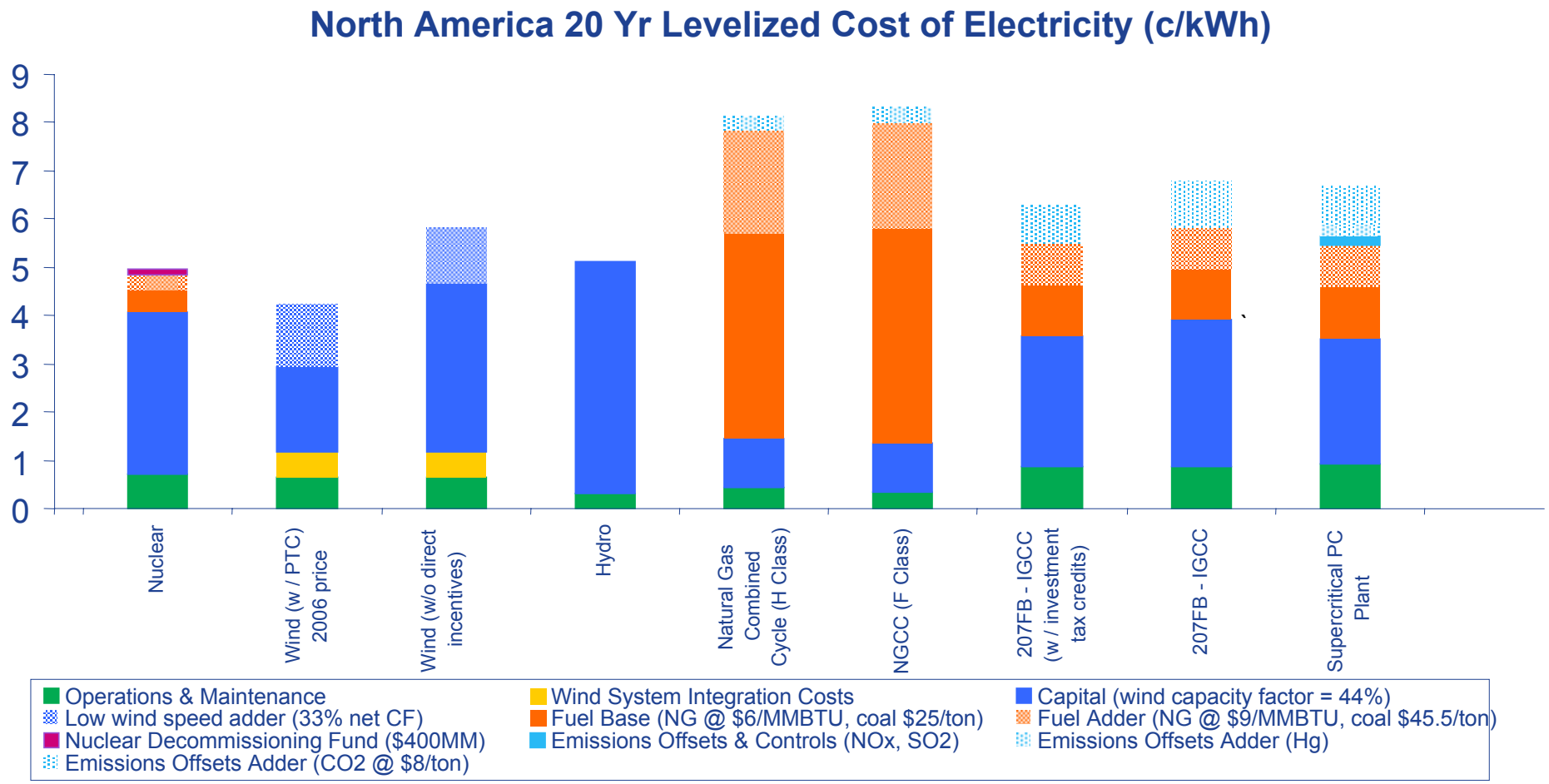
BTM Consult Wind Forecast



- Growth Dynamics Changing …
  - Onshore – Land Capacity Becoming Constrained (E.G. Germany, Spain)
  - Kyoto Protocol
  - EU Renewables Directive
  - Competitive Cost of Energy
  - UK Driving Offshore – 10GW by 2010
  - Government Incentives Accelerating Growth (Italy, UK, France, Poland, Japan, Australia)
- Biggest Offshore Segments Will Be UK, Netherlands, Germany, USA
- Emerging Onshore: Canada, China, India, Australia, Japan, Italy, Portugal, Norway, …

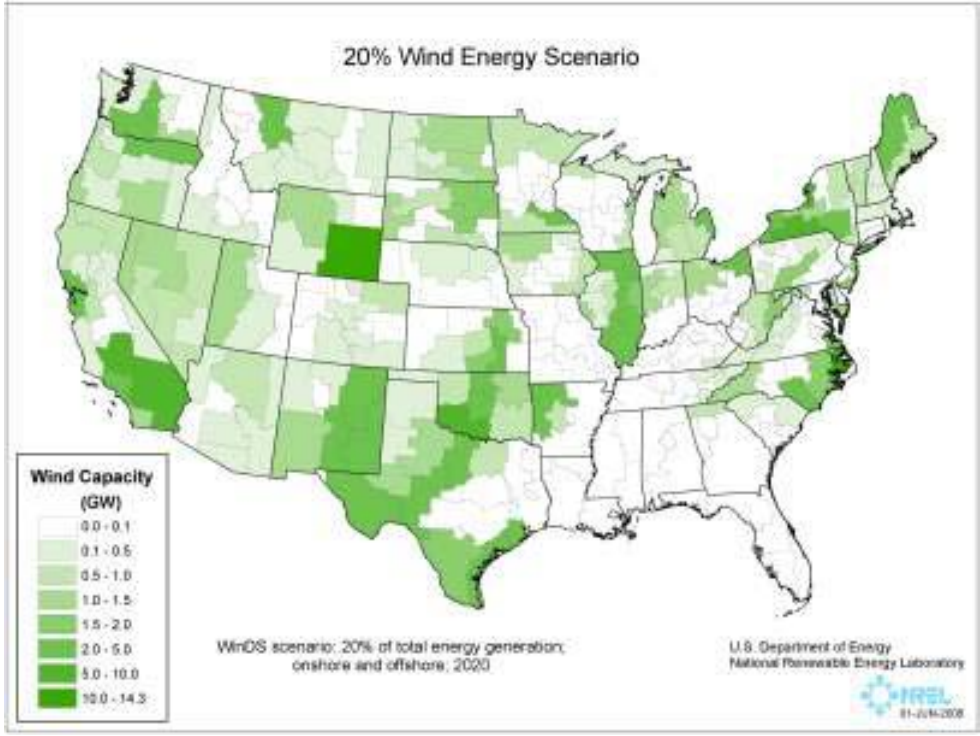
Wind Poised to Enter the Mainstream

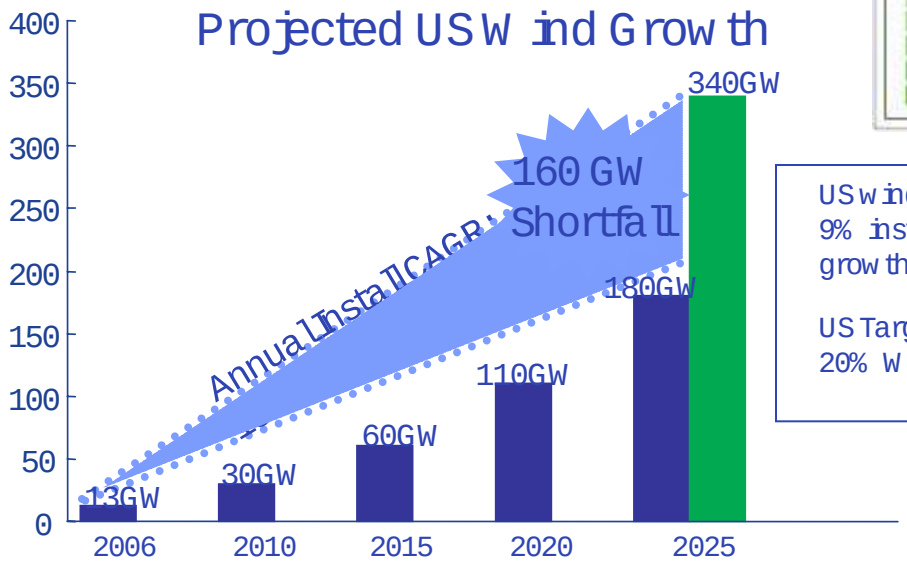
Generating Alternatives - COE



Wind - First Alternative with Competitive COE

20% Wind…
What does it mean?





US wind @ 9% install growth rate

US Target: 20% Wind

Great Plains Wind
Lamar, CO

A National Challenge

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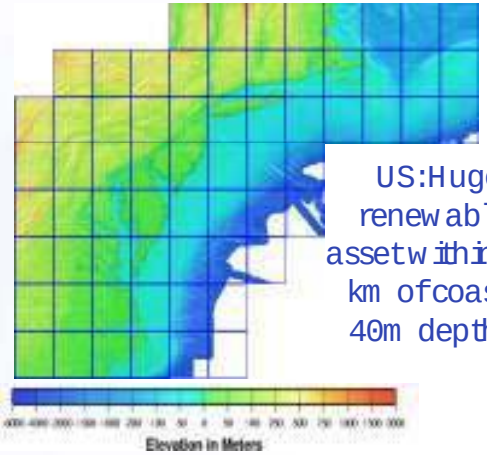
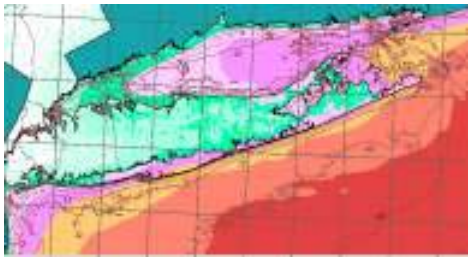
Offshore Wind … GW Scale Renewable



US: Huge renewable asset within 50 km of coast, 40m depths



VA to Boston – densest US population, highest electricity prices: 12-16 c/kw hr

- US East Coast, Great Lakes, UK, Germany, China, …
- Proximity to Population & Load Centers
- UK Targeting 10-15 GW next 5-10 years
- 5-6 MW machines coming, 10 MW ?

80 * 2MW Vestas V80 Horns Rev, Denmark

GE 3.6s Arklow Banks, Irish Sea

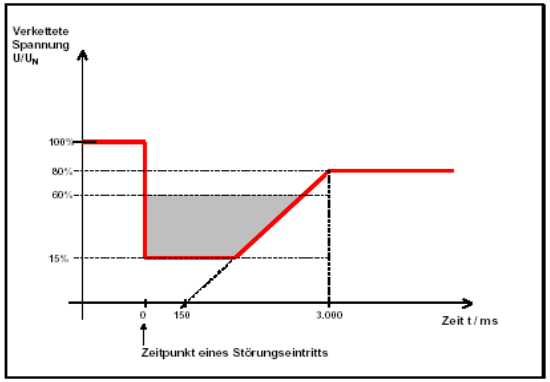
Utility Scale Wind Generation …
5-10% Penetration Easily Managed

150 MW Trent Mesa, TX

Utility Windfarms

100-500 MW Farms Being Developed

- Grid Codes Rapidly Evolving
- Transient Voltage Performance



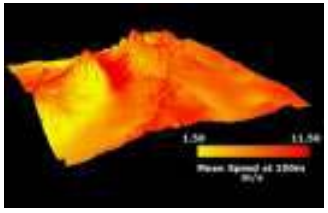
e-on Low Voltage Ride-Thru

Danish Transmission Grid w/ Interconnects & Offshore Sites

Jutland - Western Denmark

3000 MW Wind Capacity Out of 6800 MW Total

- 20+% of Average Demand Supplied by Wind
- Max 1 Hr Penetration Is 80%, max 20% change per hour
- HVDC Link to Norway, Hydro As Virtual Storage

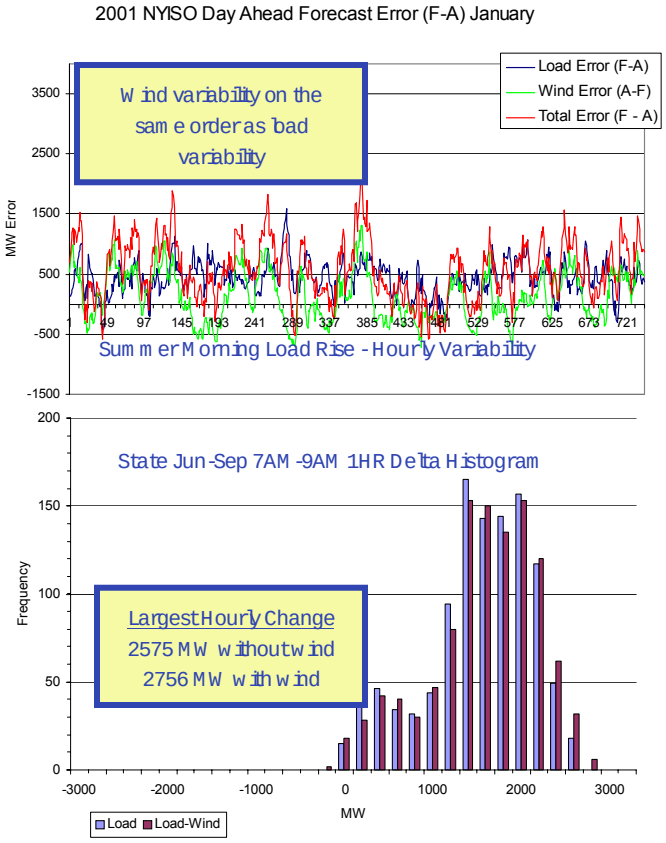


Wind Site Forecasting

Managing a Variable Resource

- 1 to 48 Hour Wind Forecasting
- Coordinated Economic Dispatch of Hydro, GT, …

Wind in New York



AWS Truewind

NYISO Study

- RPS 25% renewables by 2013 (15% existing hydro)
- 10+% wind 3.3 GW achievable w/ minor changes in operations
- Day-ahead uncertainty w/ wind similar to load forecast
- Wind improves post-fault response of interconnected grid

	With Day-Ahead Wind Forecasting	Without Wind Forecasting
Total variable cost reduction *(includes fuel cost, variable O&M, start-up costs, and emission payments)*	$ 430M	$ 335M $ 95M
Total variable cost reduction per MW-hour of wind generation	$48 / MWh	$38 / MWh
Wind revenue	$ 315M	$ 305M
Non-wind generator revenue reductions	$ 795M	$ 960M
Load payment reductions *(calculated as product of hourly load and the corresponding locational spot price)*	$ 515M	$ 720M

Annual Operating Cost Impacts for 2001 Wind and Load Profiles

NYS Benefits

- $48/MWhr of Wind Energy Production Cost
- $50/MWhr Reduction in Wholesale Generation Costs

RPS with 10% Wind both Feasible & Economic

H_2 Production - Pipeline Delivery (Tug Hill-Syracuse)

500 MW
$1600/kW
η ~ 40%

200 MW

200 MW
$1000/kW
η ~75%

O_2 Gas

3 gal/kg H_2

4500kg (150 MWh)
$100/kWh
η ~ 99%

Hydrogen
Buffer Storage

350 bar

6 MW
$1000/kW
η ~80%

4500 kg/hr, 25 bar

H_2 production:
108,000 kg/day
@ $5.4/kg

Plateau-Syracuse: 30 miles
Hydrogen pipeline
10" Diameter, 25 bar
$1MM /mile
η ~99% (30 miles)

H_2 production:
107,000 kg/day
@ $5.6/kg

Water Consumption
324,000 gal/day

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