The Economics of Wind Energy

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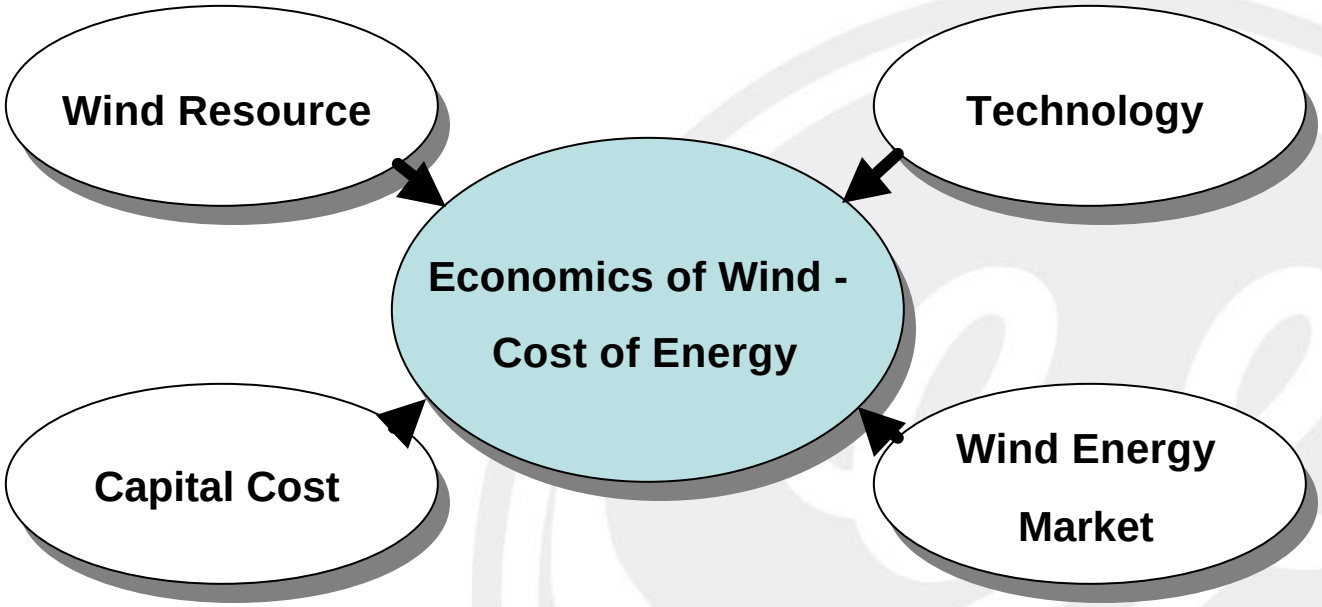
Background

Wind Energy
and the
Wind Industry
have come
a Long Way
due to
Wind Energy
Economics

Four Drivers of Wind Energy Economics

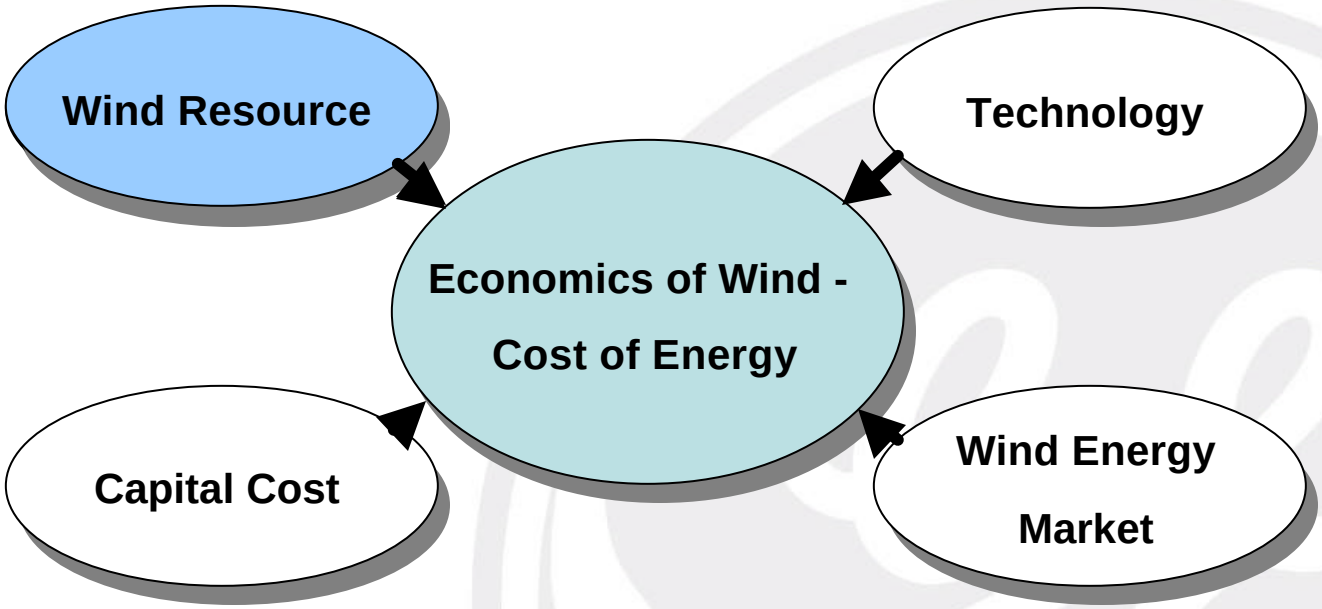


Definitions

Cost of Wind Energy: COE

- COE ($/MWh) = (Capital Recovery Cost + O&M) / MWh/year
  - MWh/year = Amount of Wind Resource and Production
  - Capital Recovery = Debt and Equity Cost
  - O&M Cost = Turbine design, operating environment

Economics of Wind Energy



Wind Resource

Wind Energy = Wind Velocity^3

- The energy in wind varies with the Cube of the Wind Speed
- The most productive wind sites:
  - have high average wind speeds
  - are generally somewhat remote from population centers
  - integration with utility grid is generally challenging

Key Point: The Wind Resource is the #1 Driver of Wind Project Economics

Wind Resource

Approximate range of capacity factor:

~ 35% = Normal “Good” Wind Site

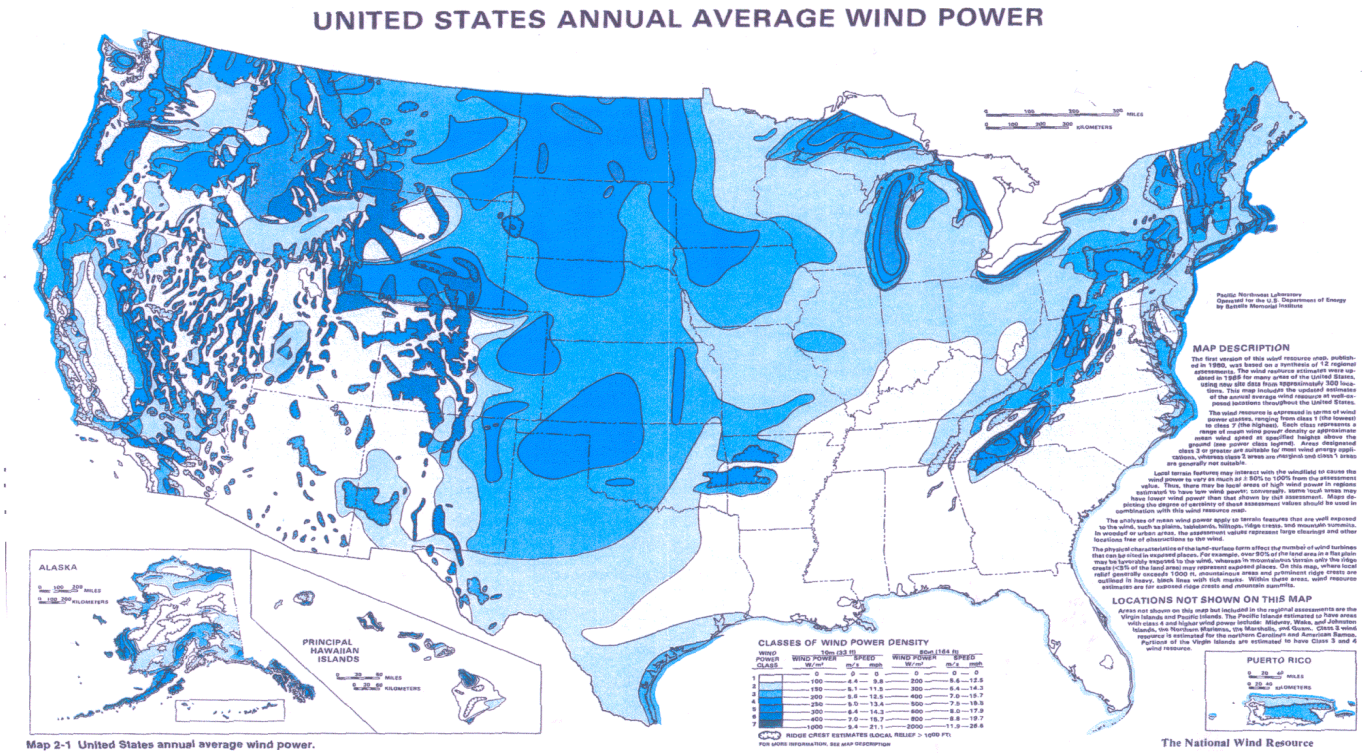
- Less production, economically works with greater power sale rate
- Pacific Northwest, Eastern States

Wind Resource

Upper end of capacity factor:

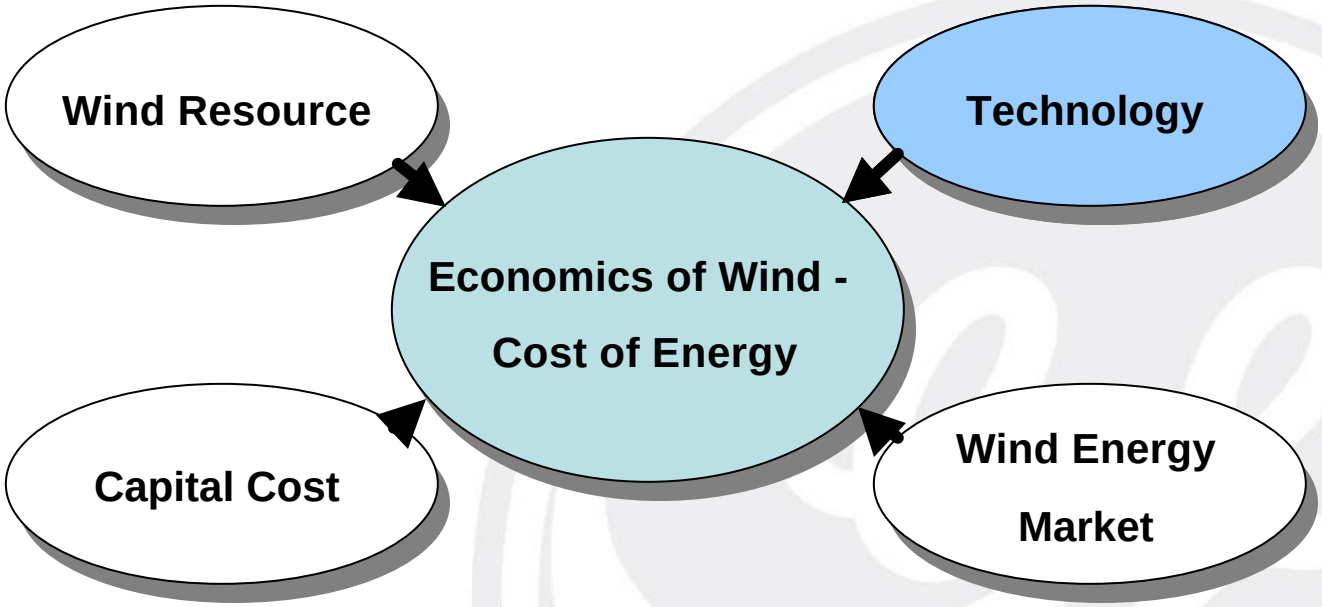
- >45% Capacity Factor = World Class Wind site
- Characterized by consistent, predictable, strong winds
- Great Plains, Hawaii, Select Mountain Passes, Select Off-Shore Sites

Wind Resource



Map 2-1 United States annual average wind power.

Economics of Wind Energy

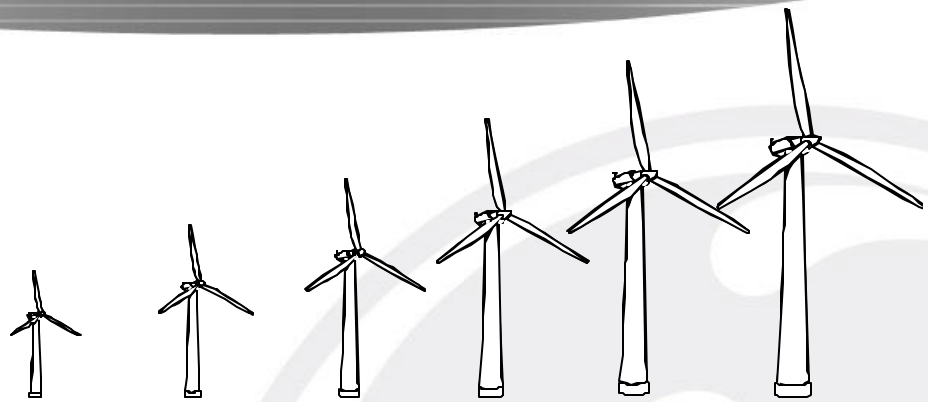


Wind Turbine Technology

Costs of Wind Energy Reduced through:

- Economies of Scale
  - Larger Turbines – up to 3.2MW
  - Larger Plant Size – up to 200MW
- Technological Advances
  - mitigate and control variable torque loads
  - integrate wind energy into a utility transmission / distribution system -- VAR and voltage regulation and support are important issues

20 Years of Wind Technology Development



	1981	1985	1990	1996	1999	2000
Rotor (Meter)	10	17	27	40	50	71
KW	25	100	225	550	750	1,650
Total Cost	$65	$165	$300	$580	$730	$1,300
Cost/kW	$2,600	$1,650	$1,333	$1,050	$950	$790
MWh	45	220	550	1,480	2,200	5,600

Bottom Line: 1981-1999 = 49x the power, 11x the cost;
1999-2000 = 2.6x the power, 1.8x the cost

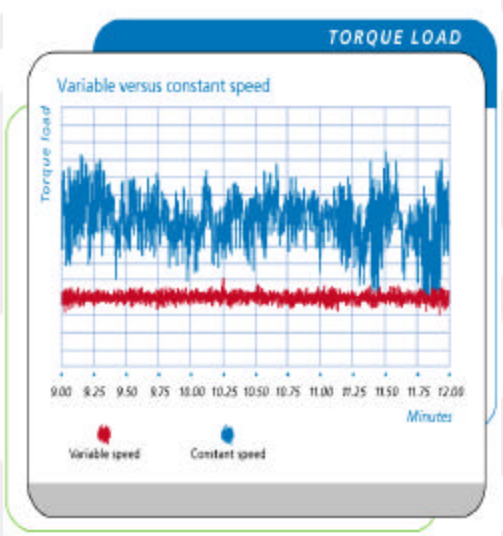
Wind Turbine Technology Advances

Variable Speed Constant Frequency

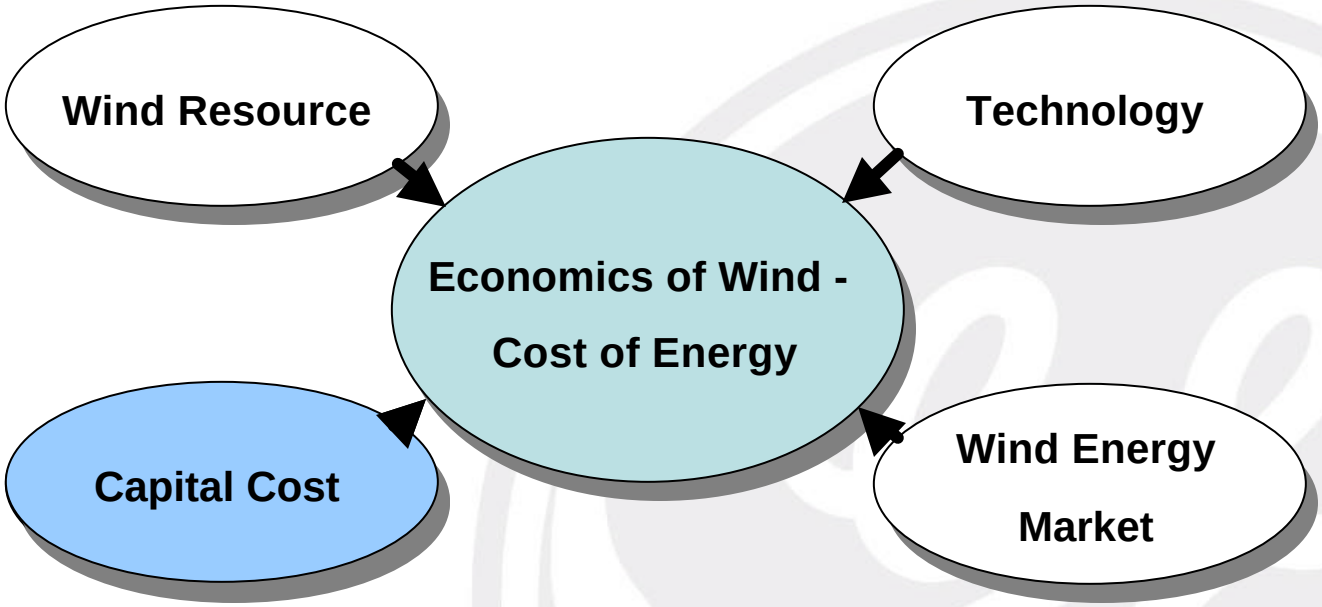
- Key Cost Reducing Technology
- Variable speed operation limits power / torque excursions
- Rotor operates at maximum aerodynamic efficiency from cut-in to rated capacity

Benefits:

- Lowers load → reduces component cost
- Increases power output
- Enables dynamic VAR control, remote control of voltage and power factor for utility grid integration
- Stabilizes weak grids, provides utility system benefits



Economics of Wind Energy



Total Capital Costs

Approximate Installed Cost of Wind Energy Facility = $1 Million / MW

- Turbine (~ 70% of Total Cost)
- Installation
- Balance of Plant
- Financing
- Legal
- Permitting
- Site Acquisition

Capital Costs

Typical Revenue Streams from a U.S. Project:

- Power Sale: $.03 - $.045 / KWh Levelized
- Production Tax Credit: $.018 / MWh
- “Green Credit” Sale: New Market, Values Vary

Capital Costs

Typical Current U.S. Project Finance and Capital Structure:

Construction Finance	$100% of Total Cost
Repaid by:	
• Long Term Debt:	50%
• Equity:	50%

Capital Costs

Long Term Debt

- Longer Term = Lower COE due to lower debt payment amount
  - Term in years varies with certainty of power sale rate over time
  - 20+ year term fixed price PPA = 20+ year term

- Loan Amount: Lower debt service coverage ratio (DSCR)
  = Greater debt amount
  = Lower COE as debt cost is less than equity cost

- Long term fixed price PPA = 140% DSCR
  - Operating cash flow / debt payment = 1.40

Capital Costs

Equity

- Return requirements vary with risks
- Returns are evaluated on after tax basis
  - Wind Project ~ Low teens
  - Housing ~ high single digits
  - Venture capital ~ 30% +
- Production tax credit helps to provide an adequate after tax return to the equity owner with a lower cash price for wind energy

Key Point: Production Tax Credit is critical to project economics

Costs – Operating Costs

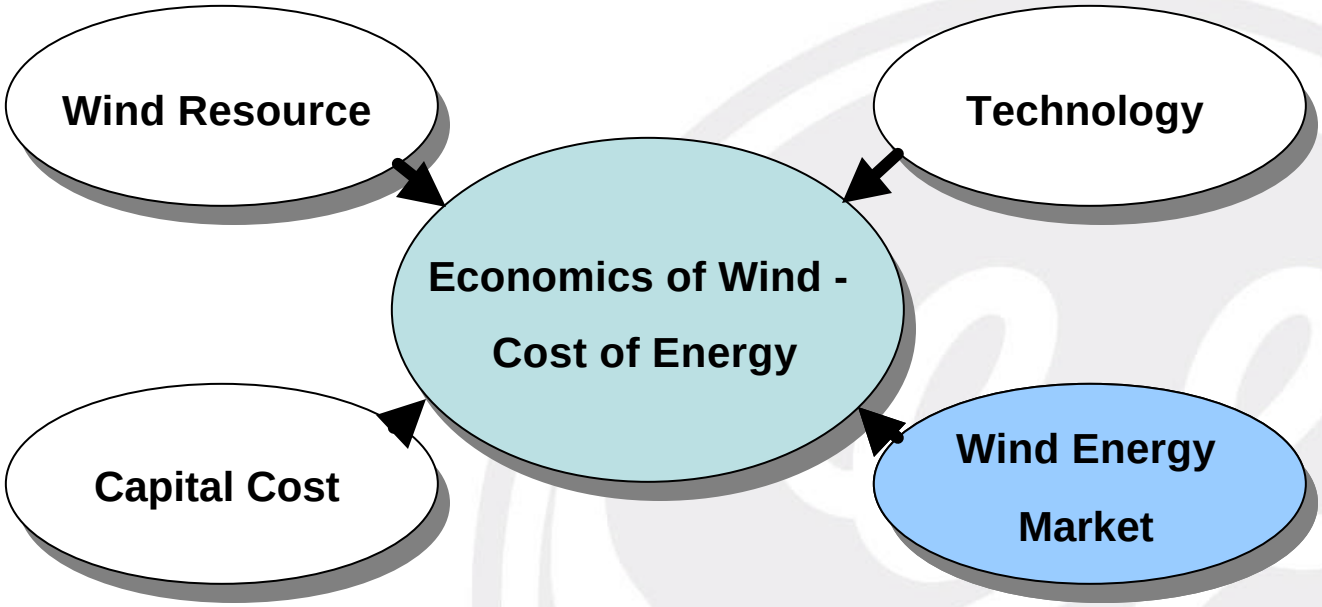
Project Specific Costs

- Local Taxes
- Insurance
- Land Use Rights
- Power delivery costs
  - Interconnect
  - Transmission
- Operations and Maintenance

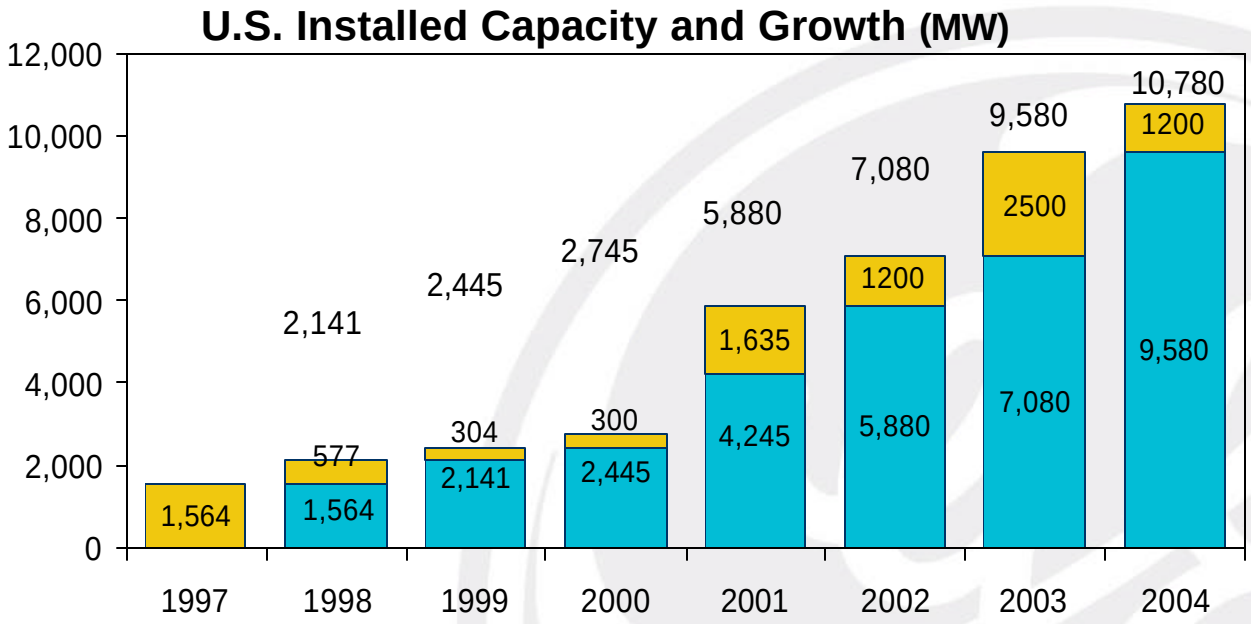
Capital Costs

Example Values:	
Capacity Factor:	40%
All in Cost:	$1,000,000 per installed MW
Capital Recovery Factor:	10%
O&M Cost:	($20,000 / MW / year / capacity factor)
Example Calculation:	
COE = ((All in Cost x Capital Recovery Factor) + Annual O&M Cost) / MWh/year	
COE = (($1,000,000 x 0.10) + ($20,000 / 0.4)) / (1 x 8,760 x 0.4)	
COE = (($100,000) + (50,000)) / 3,504	
COE = 150,000 / 3,504	
COE = $.0428 / KWh	
COE = ($.0428-$.01) = $.0328 w/PTC value subtracted from cash	

Economics of Wind Energy

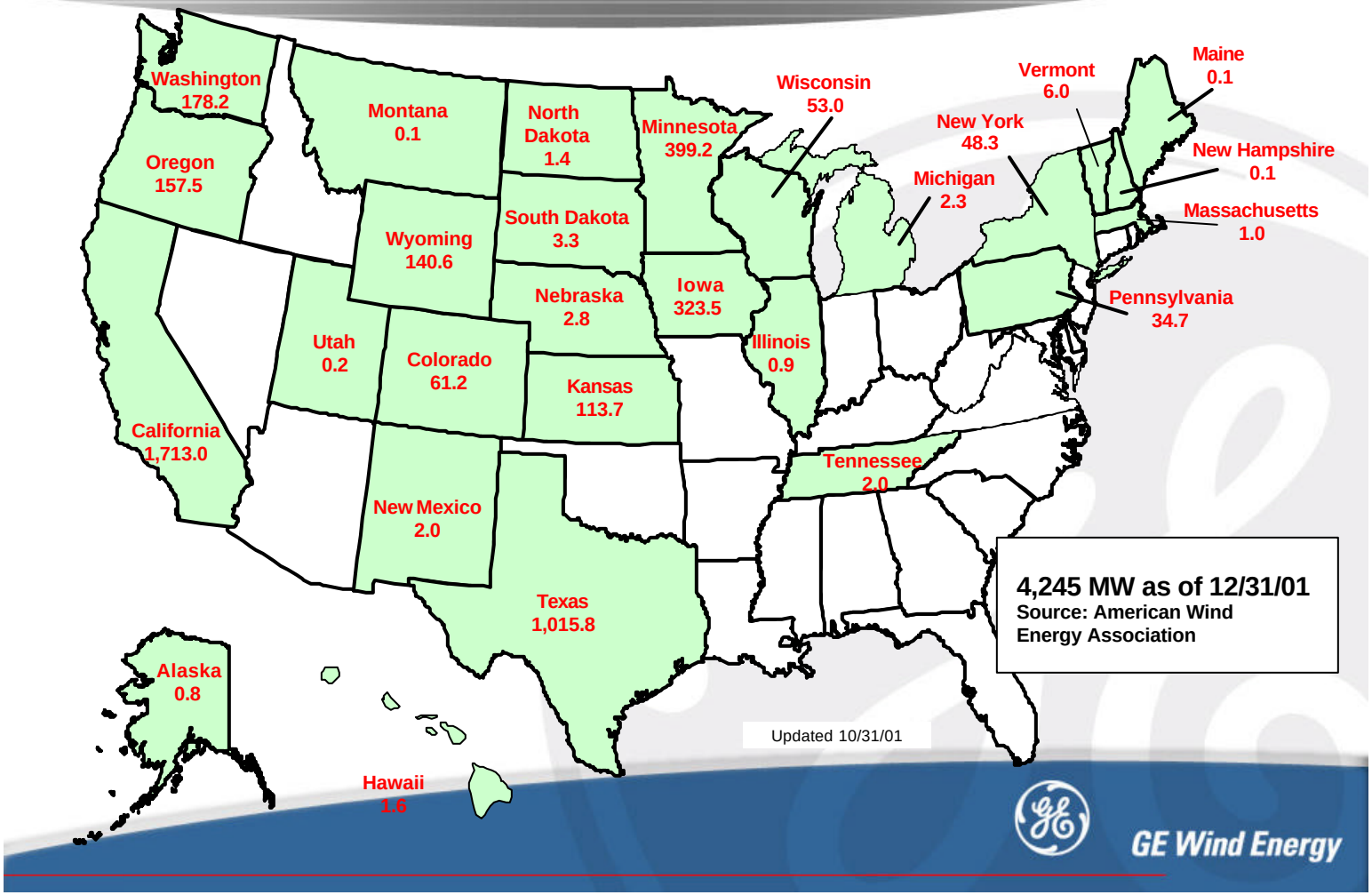


Wind Energy Market



Source: BTM Consult 2001

Wind Energy Market



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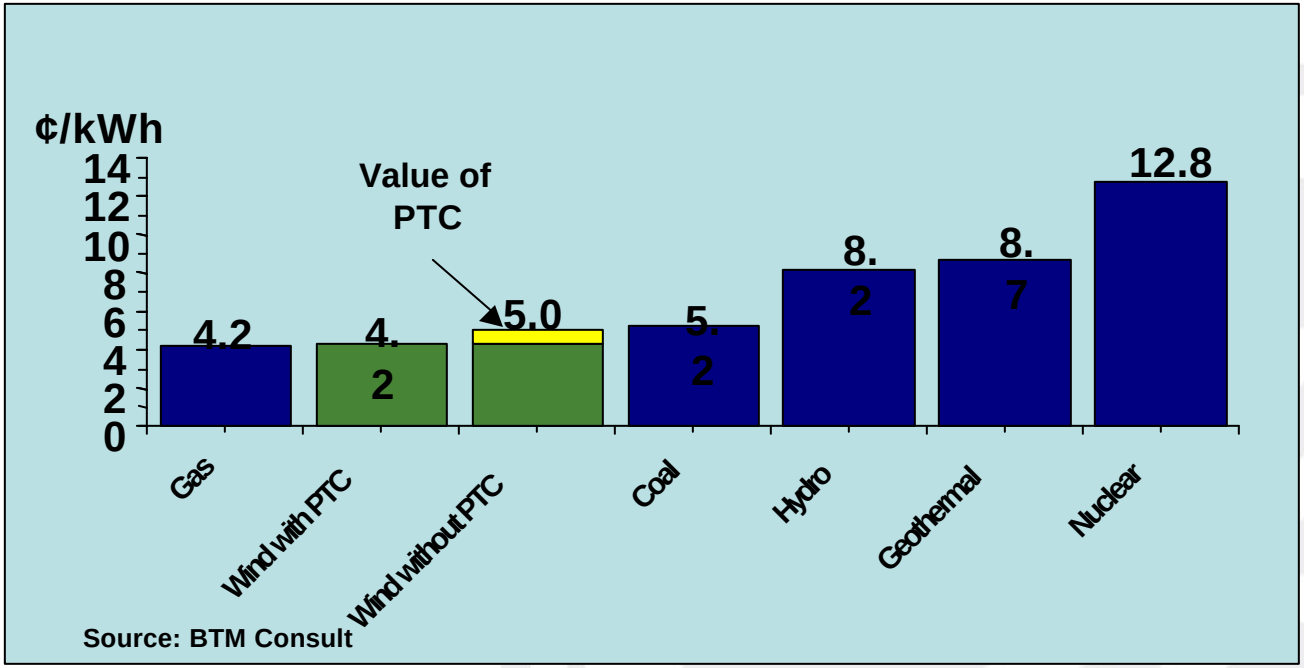
Wind Energy Market

Wind Energy Cost Competitiveness



Wind is competitive with gas and coal, less costly than other new resources

Wind Energy Market

Values Associated with the Economics of Wind:

- Energy Sale
- Tax Credit
- “Green” Credit / Emissions Credit
  - Cash
  - Regulatory compliance value
- Unpriced Values
  - Real Option Value
  - Hedge value
    - Fuel costs increase risk
    - Pollution / CO2 tax risk
  - Fuel diversity value

Green Power

- Challenge: How can individuals, companies, private organizations, State and Federal Agencies use Green Wind Power?

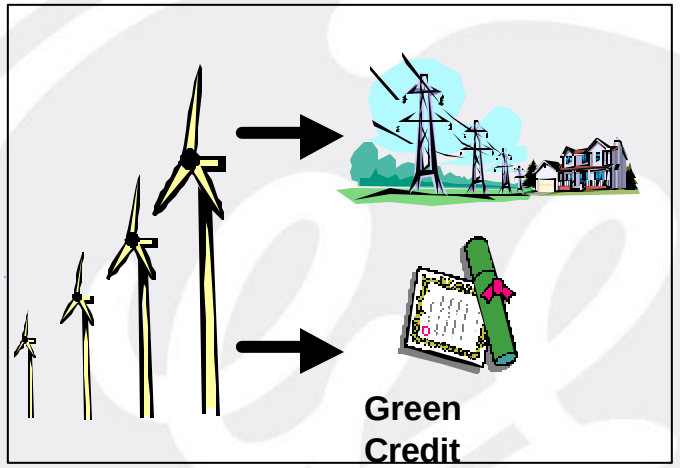
- Limited Solution: Build a wind project, connect wind power directly to load impractical on an economic scale basis

Building a Wind Project is not always economically viable given your location but …

Green Power

Favored Solution: *De-Aggregate* the Energy and the Renewable Attribute!

1. Developers build the most economic wind sites
2. The physical product (electron) is separated from the renewable attribute (green credit)
3. The green credit is purchased as an identifiable product
4. Demand for the renewable attribute stimulates additional wind development



… buying Green or Emission Credits is an economic solution.

Green Power

- Benefits of Buying Green Credits:
  - Promotes the development of most economical wind sites
  - Promotes economies of scale in large wind projects
  - Easy to implement: structures already exist in Pennsylvania, California, Texas for the purchase and sale of “Renewable Energy Credits,” “Green Tags,” etc.
  - Quick implementation: buyer creates demand now
  - Easy auditing: certified renewable energy credits

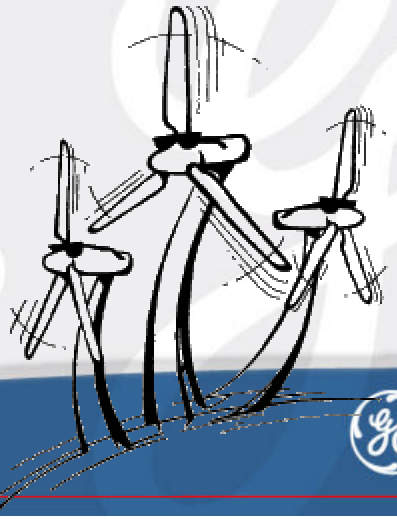
Summary

Economics of Wind are Reasonably Certain and Highly Favorable:

- Wind resource is statistically predictable
- Today's wind turbines technology is reliable
- Capital costs can be fixed at the start of a project
- There is no fuel cost risk
- The price of wind energy is competitive in today's energy market
- Green Credit initiatives directly impact development of renewables

Economics of Wind Energy

SUCCESSFUL WIND DEVELOPMENT MAKES EVERYONE HAPPY!



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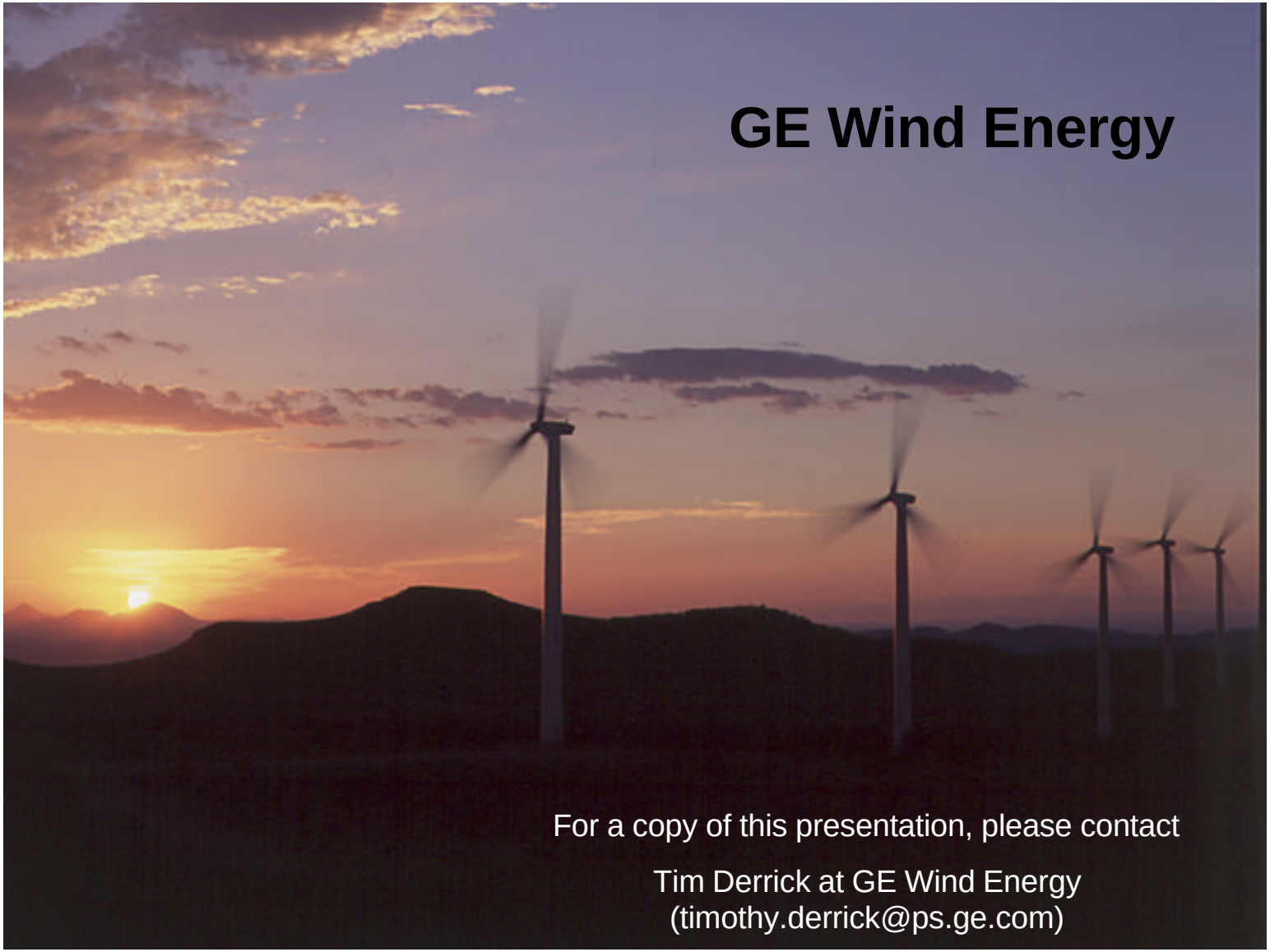
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