Institute for Energy and Environmental Research

CASH CROP ON THE WIND FARM:
A New Mexico Case Study of the Cost, Price, and Value of Wind-Generated Electricity

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Main findings

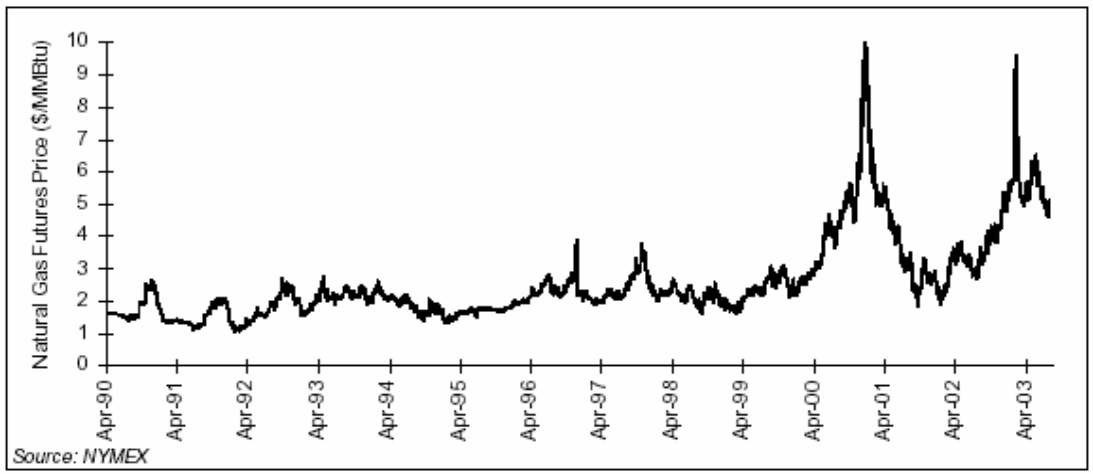
- At present, wind energy development is dependent on the federal tax credit. Current Power Purchase Agreements typically are in the $25 to $30 per MWh range – not enough to cover costs
- With the right policies and transmission infrastructure, large-scale development of wind without a federal production tax credit appears feasible
- That is, wind energy is economical today: consumer bills would be about the same if more wind-generated electricity from favorable areas is added to the mix of electricity
- Wind can be predicted, with some error. Cost of forecast errors can be modest and can be significantly reduced. This means wind can be accorded some capacity credit in the right circumstances.
- Integration of future wind planning with natural gas use, diversity in wind farm locations, and reducing forecast errors can greatly reduce the cost of high penetration levels and improve electricity system economics
- A renewable portfolio standard is necessary to achieve high wind energy penetration
- Main obstacles are not economic but lack of solid transmission infrastructure oriented to wind and insufficient national policy commitment

Main recommendations

- All states in the WGA should adopt a Renewable Portfolio Standard of 20 percent for wind energy to be achieved within about 15 years. Other renewable energy sources should be in addition to this target.
- WGA should advocate for the 20 percent RPS for wind at the national level.
- Integrate natural gas and water use in with electricity sector with new wind power planning development within states and regionally
- Western Interstate Energy Board's Wind Evaluation Team should undertake major study for 20 to 40 percent wind capacity penetration, including all costs and benefits
- Specifically, WEIB should evaluate development of a High Voltage DC transmission line linking high wind areas in the WGA region as a central artery for wind energy development
- Regulators should accord a capacity credit equivalent to several dollars per MWh to wind under suitable circumstances. Specific criteria should be developed for this.
- Major external costs of thermal power plants - water and CO_2 -should be internalized. These vary but could be ~ $5 per MWh.
- New Mexico should undertake a demonstration project to join wind energy, fuel cells, solar PV, and earth source heat pumps. Objectives: Show that natural gas use can be eliminated from commercial office buildings, and be freed for use in cars as compressed natural gas. Assess costs of large CO_2 reduction potential, security improvement, distributed grid configurations.

WGA member state (top nine)	Physical Resource, billion kWh/yr	Percent of 2003 U.S. electricity generation
North Dakota	1,210	31.5
Texas	1,190	30.8
Kansas	1,070	27.8
North Dakota	1,030	26.8
Montana	1,020	26.5
Nebraska	868	22.6
Wyoming	747	19.4
Colorado	481	12.5
New Mexico	435	11.3

Natural gas prices are volatile and high



Wind can replace natural gas generation at present gas prices

The marginal avoided cost for natural gas at $5 per million Btu fuel cost is:

- $40 per MWh for combined cycle plants
- $50 per MWh for duct firing of combined cycle plants
- $60 per MWh for single stage gas turbine
- Comparable wind costs are $37 to $45, at favorable New Mexico sites, including grid integration
- Wind energy is predictable enough to make seasonal commitments for displacement of natural gas
- Value of wind as a hedge for gas price volatility: difficult to assess, variable, may be ~ few dollars per MWh
- Value of water savings for natural gas combined cycle: variable. One estimate: ~$2.50 per MWh

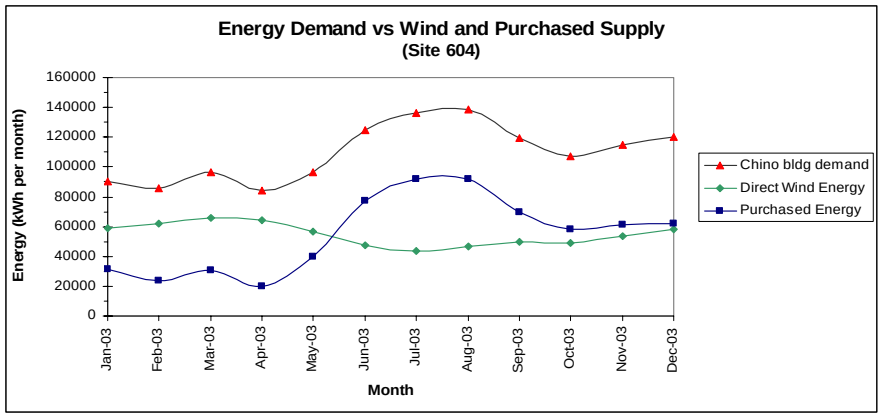
Water conservation value

- Water savings could be valued at ~$2.50 per MWh for combined cycle plants.
- Comparable figure for water savings for coal: $6 per MWh.

Internalization of cost of carbon dioxide emissions

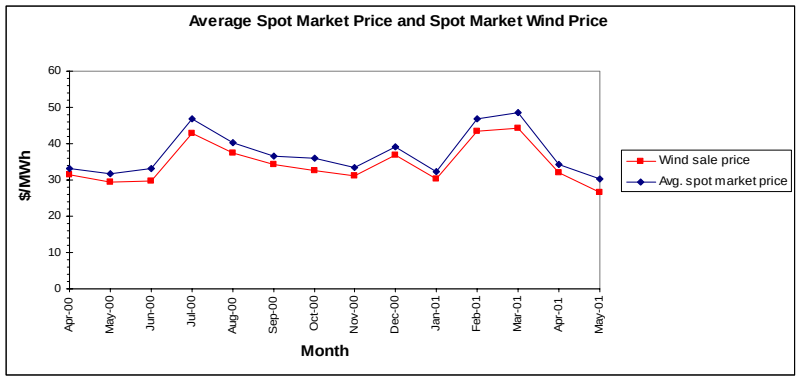
- Coal: value of CO_2 reductions is: 9 cents per MWh per dollar of cost attributed to one metric ton of CO_2 emissions; for CC natural gas: the figure is 3 cents
- For $25 to $50 per metric ton CO_2, coal cost internalization would be $2.25 to $4.50 per MWh. For CC natural gas, $0.75 to $1.50 per MWh

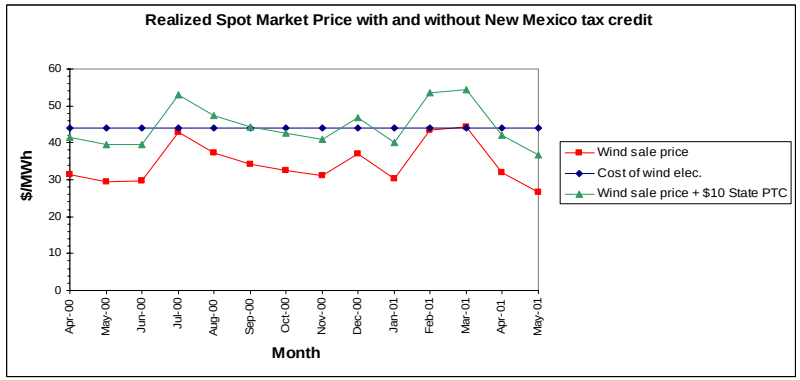
Joining Wind with the Grid – Chino Building Case Study



- Electricity Price for Chino building today: $64 per MWh for energy, plus demand charge
- Comparable price imputed to wind-generated electricity, NM Site 604, energy cost: $66 per MWh plus demand charge
- Actual comparison of final price of electricity, and hence cost to building depends on how capacity credit and demand charges are handled

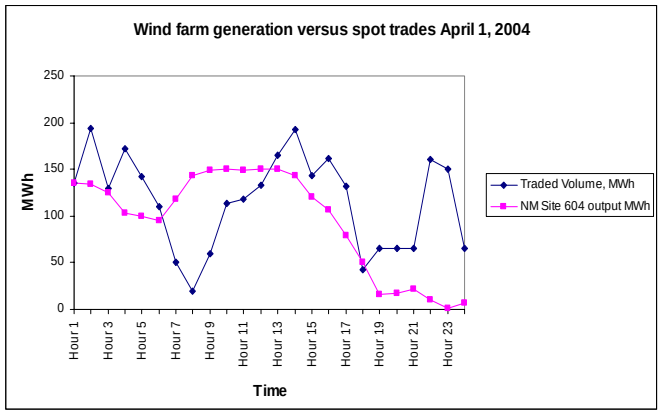
Spot market sales

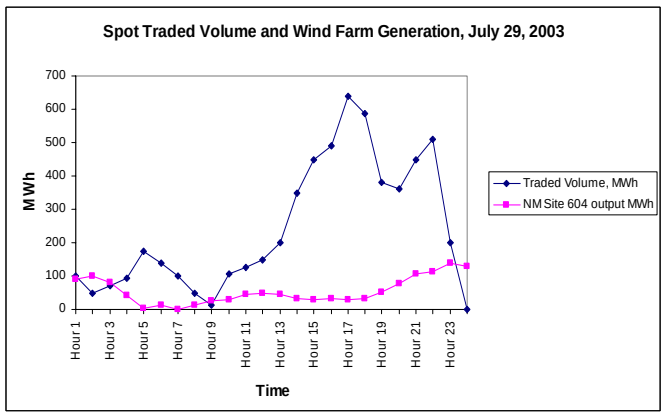




- Typical present PPA is $25 to $30 per MWh
- Results for spot market sales do not indicate wholesale advantage
- State-level Production Tax Credit of $10 per MWh may be enough in some cases

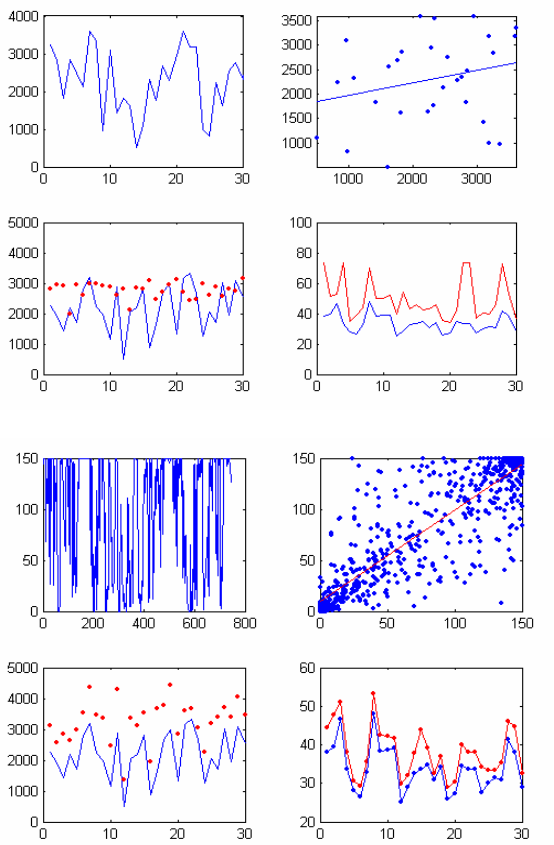
Market maturity assessment





- Four Corners hub does not have a well-developed market
- 150 MW wind farm would greatly perturb prices

Day-ahead and hour-ahead spot sales contracts

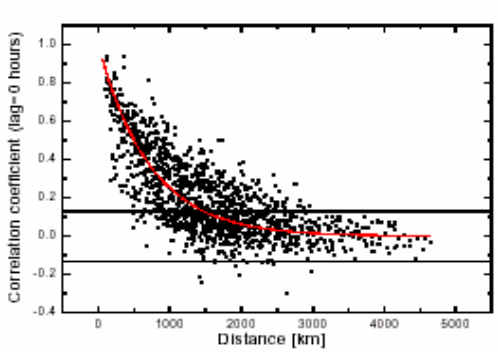


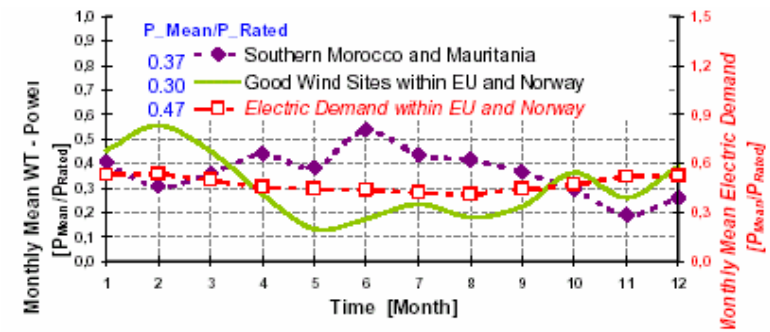
- Day-ahead forecasts (top charts) have high error, but based on limited data for forecasting
- Same limited data yields better results for hour-ahead sales (bottom charts)
- Clockwise from top left for each set: output, model fitting, sales contract vs. actual output, average spot price (upper curve) vs. wind price realized.

Hour-ahead spot sales – net price estimation

Month	Actual Revenue ($*1K)	Actual output (MWh*1K)	Value of actual output ($*1K)	Average sale price ($/MWh)	Oracle Average sale price ($/MWh)	Unsold actual output (MWh*1K)	Nominal value of unsold actual output ($*1K)
April, 00	2059.48	65.47	2, 172.86	31.46	33.19	1.76	43.71
May, 00	1811.8	61.5	1, 944.89	29.46	31.62	1.75	48.47
June, 00	1483.36	50.01	1, 655.72	29.66	33.11	2.41	62.05
July, 00	1815.07	42.23	1, 977.37	42.98	46.82	1.17	46.59
Aug., 00	1872.89	50.17	2, 021.02	37.33	40.28	1.37	43.78
Sept., 00	1865.94	54.36	1, 995.11	34.33	36.7	1.54	46.37
Oct., 00	1371.26	42.2	1, 516.29	32.49	35.93	1.34	37.37
Nov., 00	1755.01	56.48	1, 884.03	31.07	33.36	1.83	48.55
Dec., 00	2428.72	65.75	2, 529.51	36.93	39.19	1.66	50.36
Jan., 01	1524.89	50.26	1, 657.95	30.22	32.4	1.32	27.84
Feb., 01	2, 349.80	53.93	2, 532.76	43.57	46.88	2.18	78.65
March, 01	2159.16	48.68	2, 332.30	44.41	48.46	1.38	45.31
April, 01	1761.38	54.9	1, 882.57	32.09	34.29	1.75	47.23
May, 01	1204.58	45.15	1, 369.77	26.68	30.34	1.99	55.85

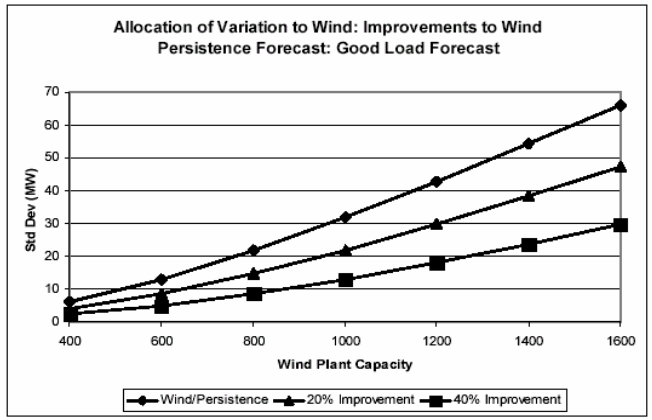
Diversity can reduce costs





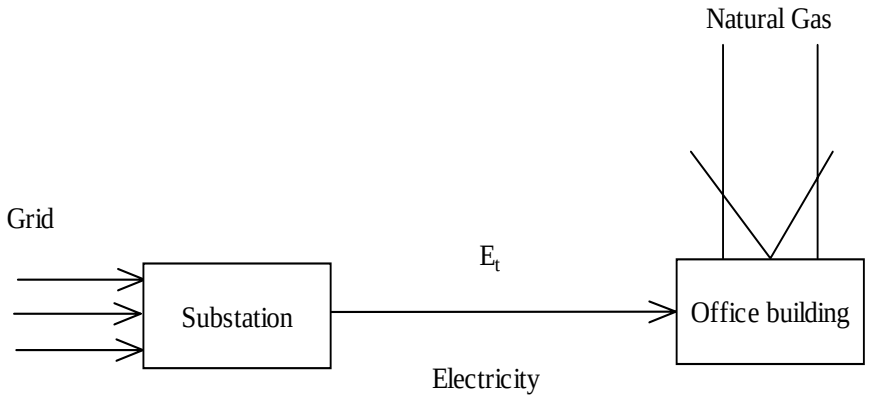
- Large scale regional integration of wind-generated electricity can increase reliability and reduce costs by reducing wind uncertainty
- Europeans are considering a Sahara wind farm with a 4,000 km HVDC line to Central Europe.

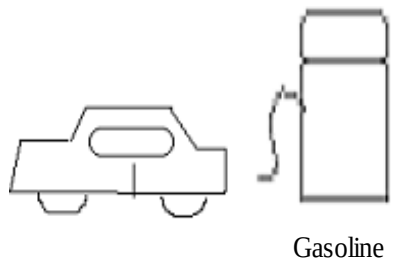
Value of improving meteorology



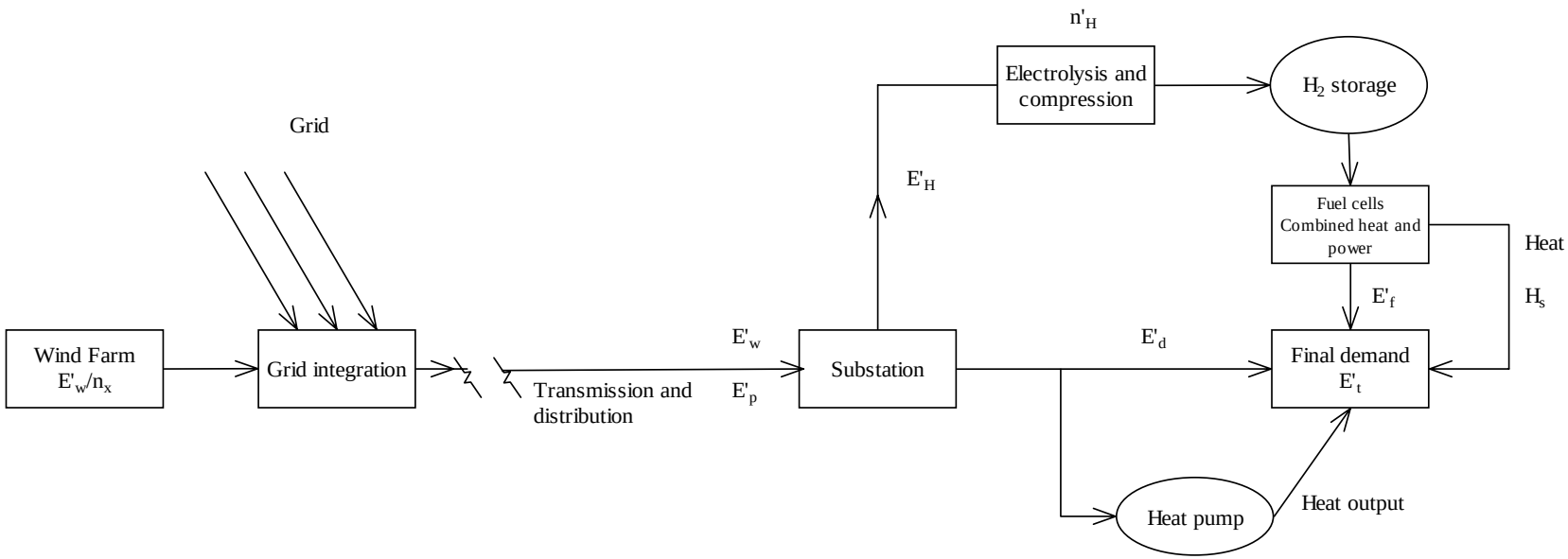
- Costs for wind integration can be reduced greatly by increasing wind forecasting accuracy
- Standby capacity can be reduced by about half at high penetration levels, for 40% reduction in forecasting error

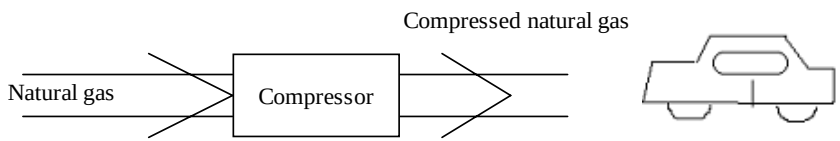
Present day building and transportation energy supply





Santa Fe Secure and Sustainable Energy Demonstration Project





New Mexico demonstration project goals

- Join wind energy, fuel cells, solar PV, and earth source heat pumps
- Evaluate distributed grid configurations
- Assess potential for eliminating natural gas in buildings for use in cars as compressed natural gas
- Assess costs of large CO_2 reductions (50 percent or more) for different efficiency, renewable energy configurations
- Assess water benefits
- Evaluate energy system security improvements
- Evaluate how the fine scientific and technical resources of the state can work together in practical projects to make the state a leader in sustainable energy

Final remarks

- Wind energy costs are low enough that large-scale investments in generation and wind-oriented transmission are warranted
- Financial and regulatory policies that encourage region-wide construction of wind-oriented transmission are needed. HVDC transmission artery linking high wind states should be examined
- Wind-generated electricity could play a very major role in helping address the multi-sided crisis in energy – climate change, water use in thermal plants, natural gas prices
- A 20 percent Renewable Energy Portfolio for wind-generated electricity is essential
- New wind capacity should be integrated with considerations of natural gas and water conservation issues
- Demonstration projects joining efficiency and renewables that can displace natural gas use for space heating and free it for vehicular use could show the way to a new energy system