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Energy
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Welcome to
ON SITE WIND GENERATION –
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2004
Energy
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Rochester, New York
Wind Turbines are "Taking Off"
in Distributed Generation
Applications
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Lorax Energy Systems, LLC
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Block Island, RI 02807
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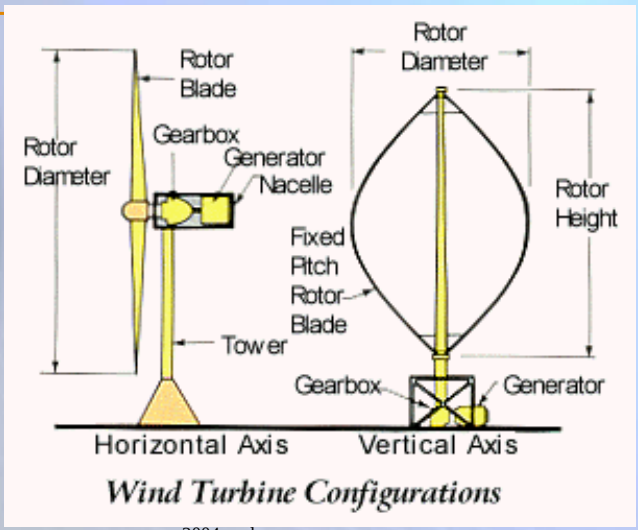
Wind Energy Today

- Fastest Growing New Source of Energy
  - 39,000 MW global wind power capacity
  - Increase of 8,000 MW over 2002, up 26%
    - Mostly in Europe, 5,670 MW up to 28,706 MW
    - United States, 1,687 up to 6,374 MW in 20 States
  - Each MW powers about 300 homes which means that about 2,000,000 homes are now powered in the US by wind energy

Basic Concepts

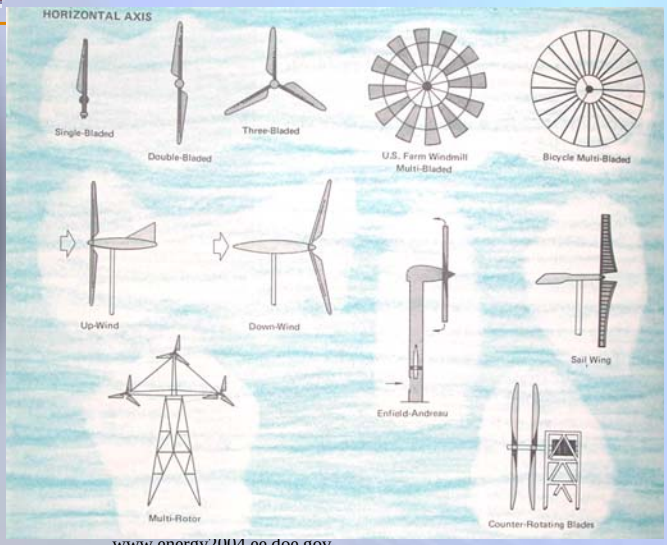


Wind Turbine Configurations

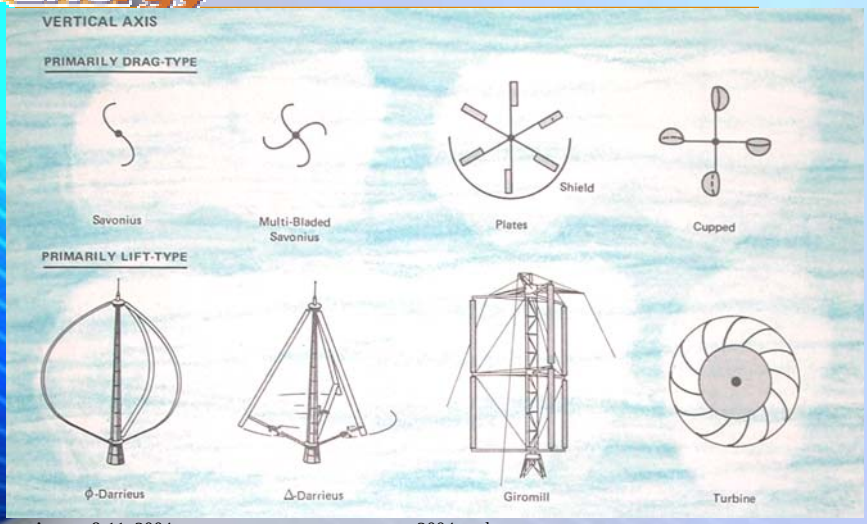
A Little History

- First wind machines in Persia 3000 BC
  - Vertical axis, Savonious type
- Middle Ages
  - Dutch type wind mills changed the face of Europe
- 1800s
  - American Multi-bladed farm wind mills pump water
- 1900s
  - Rural DC Electric battery chargers before the REA
  - Modern "Danish Design" 3 bladed upwind machine (wind turbine) for generating electricity

Horizontal Axis Wind Turbine Types



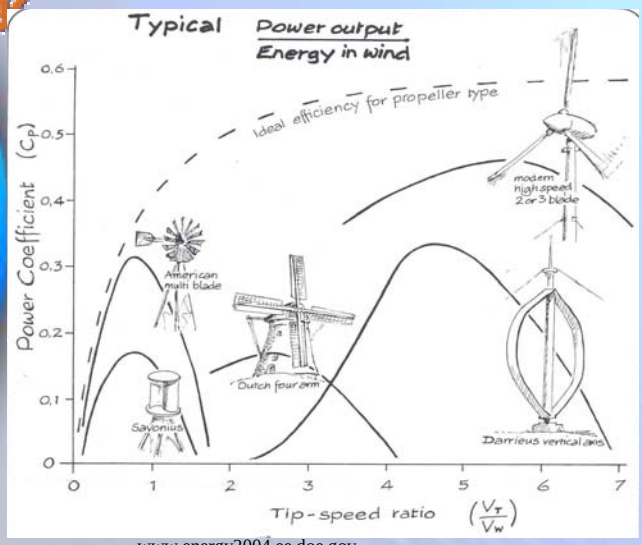
Vertical Axis Wind Turbine Types



Vertical or Horizontal Axis?

- VAWT Advantages
  - Generator, Gearbox can sit on the ground
  - Omni Directional, no active yaw mechanism required
- VAWT Disadvantages
  - Not much wind near the ground, towers will help
  - Often requires guy wires
  - Less Overall efficiency
  - Sinusoidal power pulses from rotor to drive train
  - Main bearing change means dismantling entire machine
  - Not Self Starting
- HAWT Advantages
  - Taller towers provides better exposure to the wind
  - Overall better efficiency
  - Power from rotor does not come in short pulses
  - Small system footprint
- HAWT Disadvantages
  - Large wind turbines require very large cranes to erect
  - All maintenance must be done in the tower or machine must be removed
  - Yaw system required

Wind Turbine Efficiency



Mid-Sized Wind Turbines for Distributed Generation Applications

Fuhrländer FL 250 at Harbec Plastics in Ontario, New York

- Located at the facility "after the meter" where retail power can be displaced
- Reduces facility monthly utility energy bill
- Sells excess power back to utility during off-shift and/or during windy periods.
- May provide additional benefits: Visual evidence that the facility generates and uses green power

Factors Determining Wind Turbine Size and Cost

- Advances in technology has driven dramatic wind turbine size increases
  - Doubling the size of a wind turbine quadruples the rotor area and energy capture (Square rule)
  - Doubling the size of the wind turbine does not double the cost
  - Cost per kWh varies from $.30 for a 1 kW WT to <$.04 for 1 MW WT
- This has caused a giant "gap" between the largest residential size and the smallest utility size wind turbines

Nordex 1MW wind turbines in Palm Springs, CA

Why does Wind Power make sense for Distributed Generation applications?

- Technology improvements have dramatically lowered costs and increased reliability
- US State and Federal incentive programs are making wind projects economically attractive
- Much more economic than other renewable technologies in most places
- Increasingly positive public perception is making siting and permitting easier
- Other benefits of clean energy technology is increasingly in demand by Corporations, Schools, Governments, and other end users.

Key Ingredients for a Successful Distributed Generation Project

- Suitable Sites
  - Good Wind Resource
  - High Utility Power Cost
  - State Incentive Program
  - Permitable (allowed with zoning variance)
  - Connectable (Utility Interconnection Agreement)
- Mid-Size Wind Turbine Availability
  - Mid Sized wind turbine production in decline
  - Large Manufacturers are too busy with large projects

Examples of Small-Mid Size Wind Turbines for Distributed Generation

Fuhrlaender FL 30

Farm, Office or School Use
30,000 - 75,000 kWh/yr
30 meter tower
Typical $130,000 cost ($4.33 /W)
Typical 27 year payback
(19 years with incentives)

Fuhrländer FL 250

Factory, Farm, School Use
350,000 – 550,000 kWh/ yr
40-50 meter tower
Typical $475,000 cost ($1.90 /W)
Typical 9 year payback
(6 years with incentives)

Fuhrländer FL 100

Factory, Farm, School
150,000 – 250,000 kWh/ yr
35 – 40 meter tower
Typical $380,000 cost ($3.80 /W)
Typical 22 year payback
(17 years with incentives)

Fuhrländer FL 600

Factory or Water Treatment Plant
1.0 - 1.75 million kWh/yr
50-75 meter tower
Typical $975,000 cost ($1.63 /W)
Typical 6 yr payback
(4 years with incentives)

Inside a Mid Size Wind Turbine

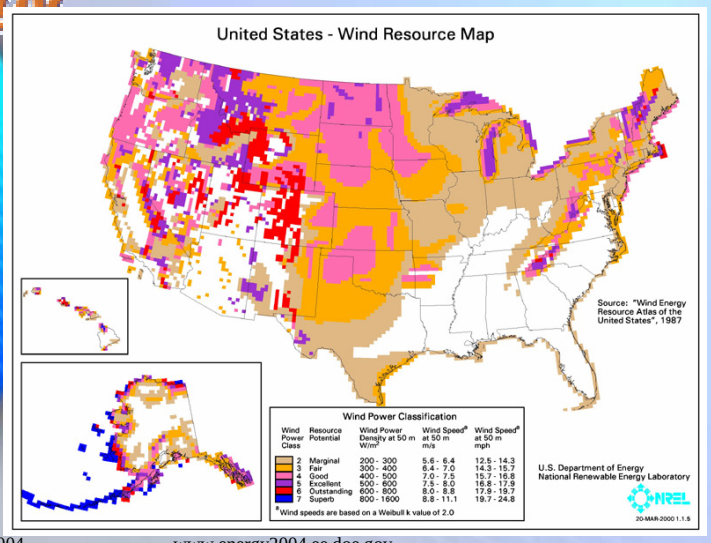
Evaluating Potential Sites

- Site Qualifying Factors to Consider
  - Wind Resource Availability
    - Area and local winds suitable for wind power generation
  - Location Suitability
    - Obstructions to wind resource
    - Set backs from neighbors in appropriate neighborhood
    - Permitable (zoning, cultural, coastal, wetlands, FAA)
    - Suitable soils for foundation
    - Access for crane and lay down area
  - Economic Viability
    - Good State incentives, high power cost, green tags all help

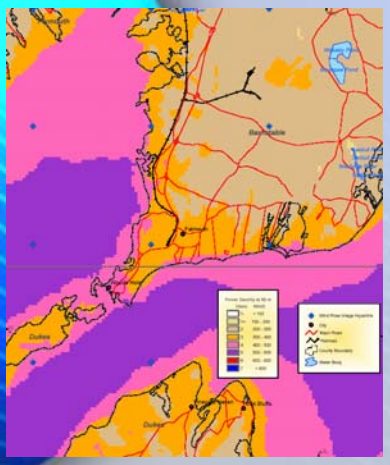
Local Wind Resource Assessment

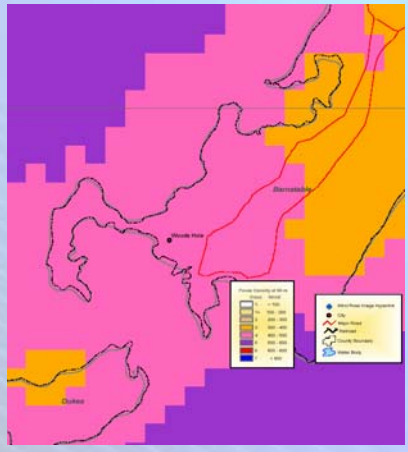
- Wind Maps
  - Available for many US states.
  - Typically mapped at 200 meter square resolution
- National Weather Service Data
  - From the Web or for purchase
- Anecdotal Evidence
- On Site Wind Measurements (if warranted)
  - Wind Monitoring Equipment
  - DOE Anemometer Loan Program

Wind Resource Map of the United States



Wind Resource Map Depicting Woods Hole, MA





Economics: State Benefit Programs

- System Benefit Charge Funded Programs
  - Capital Cost Buy Down (up to 75%)
  - Production Credit (by solicitation, up to 3 cents kWh)
- State Tax Incentives
  - State tax Credits (up to 35%)
  - State Sales Tax exemption (up to 7+%)
- Other State Indirect Incentives
  - Net Metering (depends on size and use, offers protection against adverse standby charges)
  - Renewable Portfolio Standard
  - Local Property Tax exemption
- Green Energy Certificates Sales (from 1 to 4 cents / kWh!)

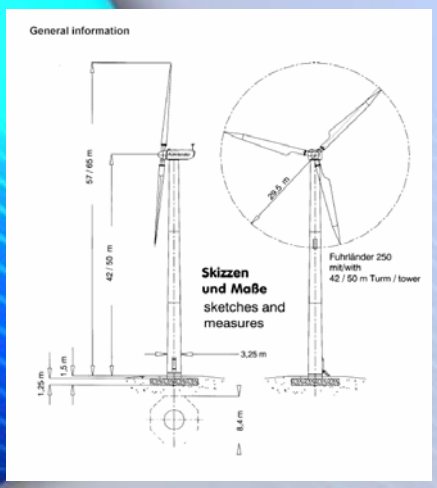
States with Favorable Programs

State	Funds	Buy Down	Income Tax Credit	Sales Tax Ex	Net Metering	Production Credit	RPS
CA	$20 M 2003	50%	7.5% up to 200 kW	No	CO Metering < 1 Meg	No	Yes
IL	Yes	60%	No	No	40 kW	No	No
NJ	120MA	30%	No	Yes	2 MW!	B/S	Yes
NC	Yes	No	35%	No	No	TVA $.15!	No
MA	150M	30%	Yes	Yes	60 kW	No	Yes
RI	Yes	30-50%	Yes	Yes	25 kW	$.03 B/S	No
NY	Yes	15-50%	No	No	25/125 kW	No	Pend-ing

Typical Industrial Wind Power Project

- Facility: Seafood Processing Facility in NJ
  - Uses 1.5 M kWh per year, Electricity Cost $160 k
  - Energy charge $ 0.075 per kWh
  - Green Energy Credits available: $.02 per kWh
  - Peak Load 400 kW, Min Load 200 kW
- Wind Turbine: Fuhrländer 250 kW Machine
  - Class 3+ power output 500,000 kWh annually
  - Total Installed Cost $475,000
  - Value of Electricity Displaced: $47,500 (first year)
  - 20 year Cumulative Savings: $895,000

Wind Turbine Selected



Wind DG Economics

Wind Tubine Simple Payback Analysis, by Size Without State Incentives

20 Year Averages	10 kW	30 kW	100 kW	250 kW	600 kW
	No Incentives	No Incentives	No Incentives	No Incentives	No Incentives
[1] Capital Cost of Wind Turbine Generator	$45,000	$130,000	$385,000	$475,000	$875,000
[2] Annual System Power Generation (kWh)	12,000	60,444	201,480	503,700	1,208,880
[3] Annual Power Displaced from Electric Company	$1,340	$6,750	$22,499	$56,247	$134,993
[4] Annual Value of Green Tag Sales	$240	$1,209	$4,030	$10,074	$24,178
[5] Annual Operating Costs for Wind Turbine	-$675	-$3,250	-$9,625	-$11,875	-$13,125
[6] Annual System Savings [3]+[4]-[5]	$905	$4,709	$16,903	$54,446	$146,046
[7] Simple Payback (Years) [1]/[6]	49.7	27.6	22.8	8.7	6.0
[8] 20 Year Power Generated Cost ($/kWh)	$0.161	$0.143	$0.143	$0.071	$0.047

NOTES:
[1] Capital cost is estimated from best available information.
[2] Annual Power Generation is calculated using a 23% capacity factor. (18% for 10 kW wind turbine)
[3] Annual Electric power costs calculated using a $.075 cost increasing at 4% a year
[4] Annual Renewable Energy Credits at $.02 per kWh
[5] Annual operating costs are estimated to be 2.5 percent of capital (1.5% for 10 kW and 600 kW)

Wind DG Economics

Wind Tubine Simple Payback Analysis, by Size with Incentives

20 Year Averages		10 kW	30 kW	100 kW	250 kW	600 kW
		30% buy down	30% buy down	30% buy down	30% buy down	30% buy down
[1] Capital Cost of Wind Turbine Generator		$45,000	$130,000	$335,000	$475,000	$875,000
NJ State Program Rebate	30%	$13,500	$39,000	$100,500	$142,500	$262,500
New Capital Cost of Wind Turbine Generator		$31,500	$91,000	$234,500	$332,500	$612,500
[2] Annual System Power Generation (kWh)		12,000	60,444	201,480	503,700	1,208,880
[3] Annual Power Displaced from Electric Company		$1,340	$6,750	$22,499	$56,247	$134,993
[4] Annual Renewable Energy Credit		$240	$1,209	$4,030	$10,074	$24,178
[5] Annual Operating Costs for Wind Turbine		-$675	-$3,250	-$8,375	-$11,875	-$13,125
[6] Annual System Savings [3]+[4]-[5]		$905	$4,709	$18,153	$54,446	$146,046
[7] Simple Payback (Years) [1]/[6]		34.8	19.3	12.9	6.1	4.2
[8] 20 Year Power Generated Cost ($/kWh)		$0.244	$0.161	$0.125	$0.071	$0.047

NOTES:

[1] Capital cost is estimated from best available preliminary information.

[2] Annual Power Generation is calculated using a 23% capacity factor. (18% for 10 kW wind turbine)

[3] Annual Electric power costs calculated using a $.075 cost increasing at 4% a year

[4] Annual Renewable Energy Credit at $.02 per kWh

[5] Annual operating costs are estimated to be 2.5 percent of capital (1.5% for 10 kW and FL 600)

Typical Installation

Typical Installation

Harbec Plastics, FL 250, view showing reinforcement around tower foundation insert

Typical Installation

Typical Installation

Typical Installation

Typical Installation

Typical Installation

Typical Installation

Finished Installation

In Summary:

- Mid-Sized wind turbines can be economic in distributed generation applications given the right combination of factors:
  - Windy Location
  - State and / or Federal Economic Incentives
  - Relatively High Power Cost
  - Good Load Match with the Facility (or net metering)
- Other benefits may be available as well

Mid-Sized Wind Turbine Resources

- American Wind Energy Association
  - www.awea.org
- Wind Powering America
  - www.eren.doe.gov/windpoweringamerica/
- US DOE National Wind Technology Center
  - www.nrel.gov/wind
- Danish Wind Industry Page
  - www.windpower.dk
- New Jersey DEP Clean Energy Program
  - www.njcep.com/
- Database of US State Renewable Energy Incentives
  - www.dsireusa.org/