



Small (Distributed) Wind Technology



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Presentation Outline

- Power in the wind – helping overcome climate change
- Overview of US wind resource
 - Rural/suburban small wind corollary to urban PV
- Overview of small wind technology – US products dominate world market
 - Pre-2000 – battery-charging, inverter added for on-grid
 - Post-2000 – on-grid
- Residential wind incentives and impact on economics
 - Average American electric home 10,000 kWh/ year = 5 kW wind turbine
- Overview of small wind CoE and economics
- Historic expansion of small wind markets
- Conservative estimates of market potential – 5,000 MW by 2020

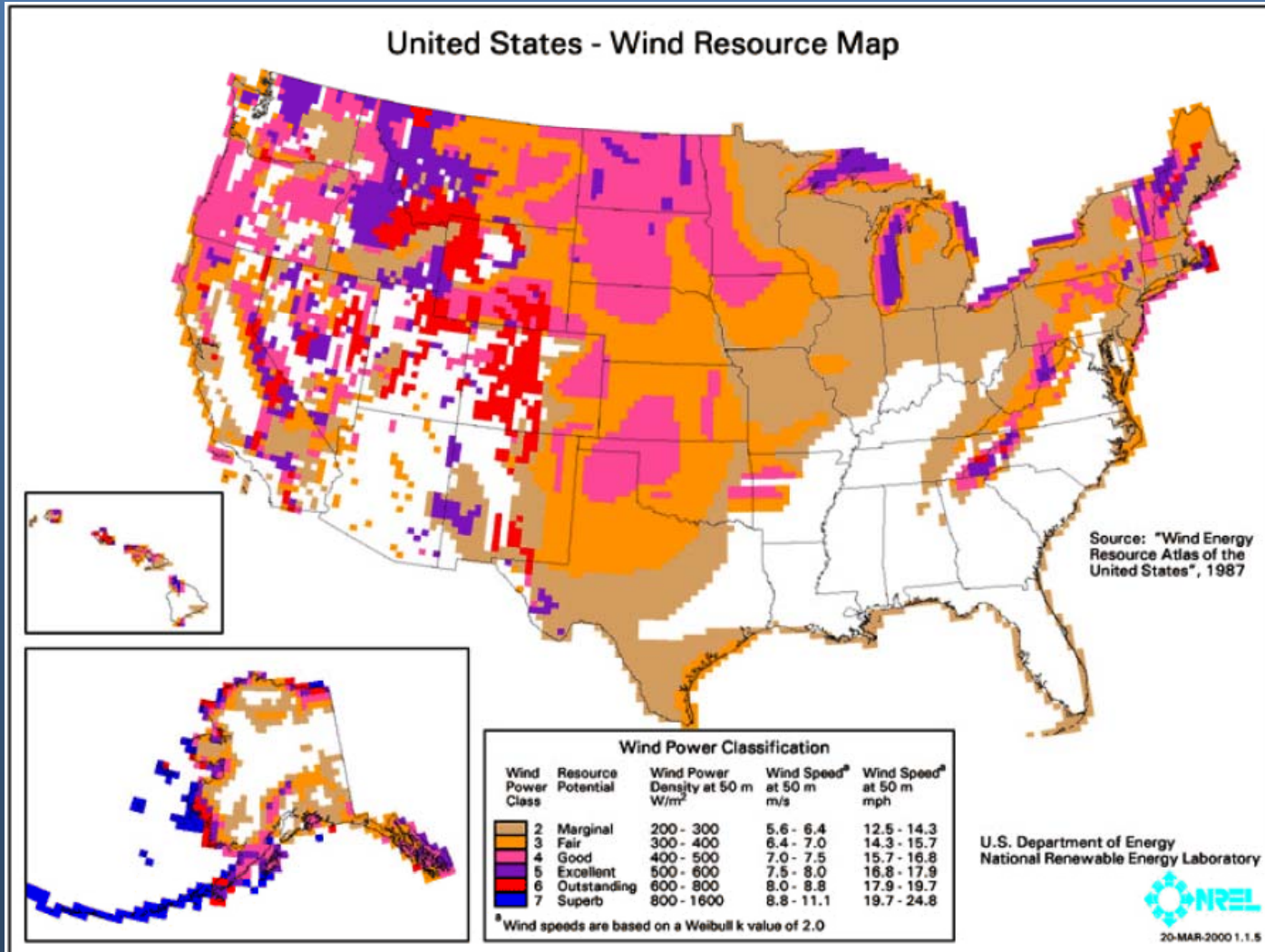


Calculation of Wind Power

- Power in the wind = $\frac{1}{2} \rho A V^3$
 - Effect of wind speed, V
 - Effect of rotor diameter on swept area, A
 - Effect of elevation and temperature on air density, ρ

US Wind Resource Assessment Map

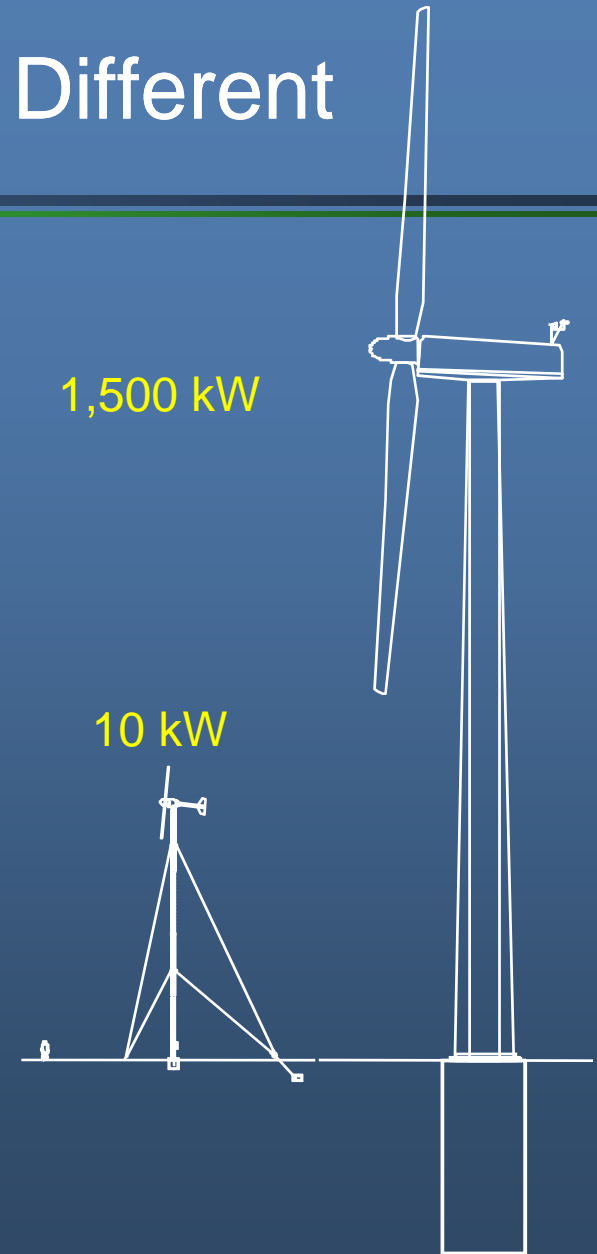
(Small Wind market = all colored areas+)





Small Wind Turbines Are Different

- Utility-Scale Wind Power
250 – 2,500 kW wind turbines
 - Installed on wind farms, 10 – 300 MW with professional maintenance crews
 - Installed as one to few turbines, 250 kW on up, need to acquire professional services
 - 13 mph (6 m/s) average wind speed
 - Benefits from Production Tax Credit
- Small Wind Power
300 W - 100 kW wind turbines
 - Installed at individual homes, farms, businesses, schools, etc.
 - On the “customer side” of the meter, or off the utility grid entirely
 - High reliability, low maintenance
 - 9 mph (4 m/s) average wind speed
 - Benefits from Investment Tax Credit & state incentives



Pre-2000 Small Wind Turbines

- **Configuration:** 2 or 3 blades aimed into the wind by the tail
- **Blades:** Fiber-reinforced plastics
- **Over-Speed Protection:** Furling (rotor turns out of the wind), no brakes
- **Generator:** Direct-drive, permanent magnet alternator (no brushes), 3-phase AC, variable-speed operation
- **Controller:** Electronic device that delivers
 - DC power for charging batteries
 - AC power for utility interconnection
- **Result:**
 - Simple, rugged design
 - Only 2–4 moving parts
 - Little regular maintenance required



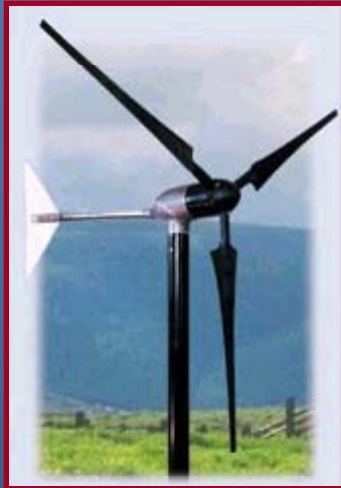
Bergey EXCEL, 10 kW



Small Wind Turbine Technology Evolution

(Southwest Windpower products)

Pre-2000



Battery-charging (International Market)
Overspeed - Furling
Heavier magnets – Heavier nacelle
Higher RPM – noisier
Inability to brake turbine – idle only

Post-2000

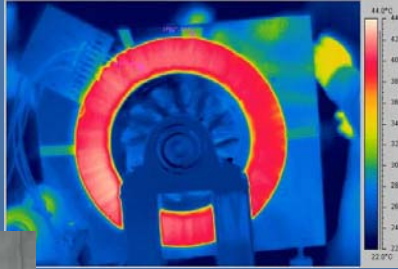


Grid-connected (Domestic market)
Overspeed with stall, brakes or blade pitch
Rare Earth Magnets – lighter turbines
Lower rotational speeds & quieter airfoils
Ability to brake rotor

Results in 4x production at 1/2 cost



DOE/NREL Public-Private Partnerships



- DoE/NREL has been a partner with Southwest Windpower since 2000
- Development of the Skystream wind turbine including analysis, design review, technology licensing, blade testing, and system field testing.
- Awards
 - Popular Science - Best of What's New 2006
 - Time Magazine - Best Inventions 2006
 - Sustainable Industries Association - Top 10 Green Building Products 2007

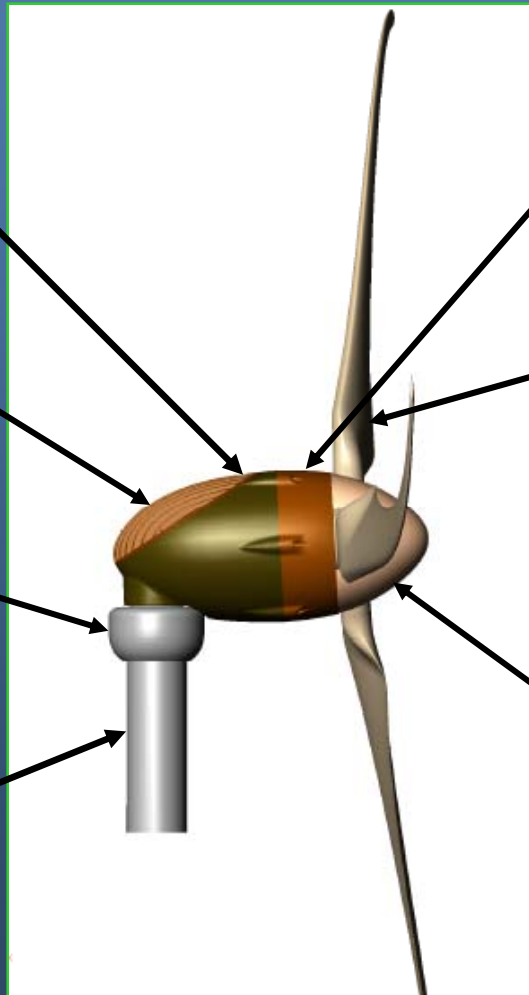
Skystream Innovative Features

Wireless display
and control

Fully integrated
universal inverter

Integrated tower
noise isolation

Monopole tower
without guy wires



Zero cogging
slot-less alternator

Low-noise, swept
fiberglass blades
using NREL airfoils

Patented stall
control provides
programmed speed
and power control
without noise

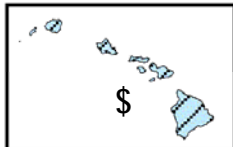
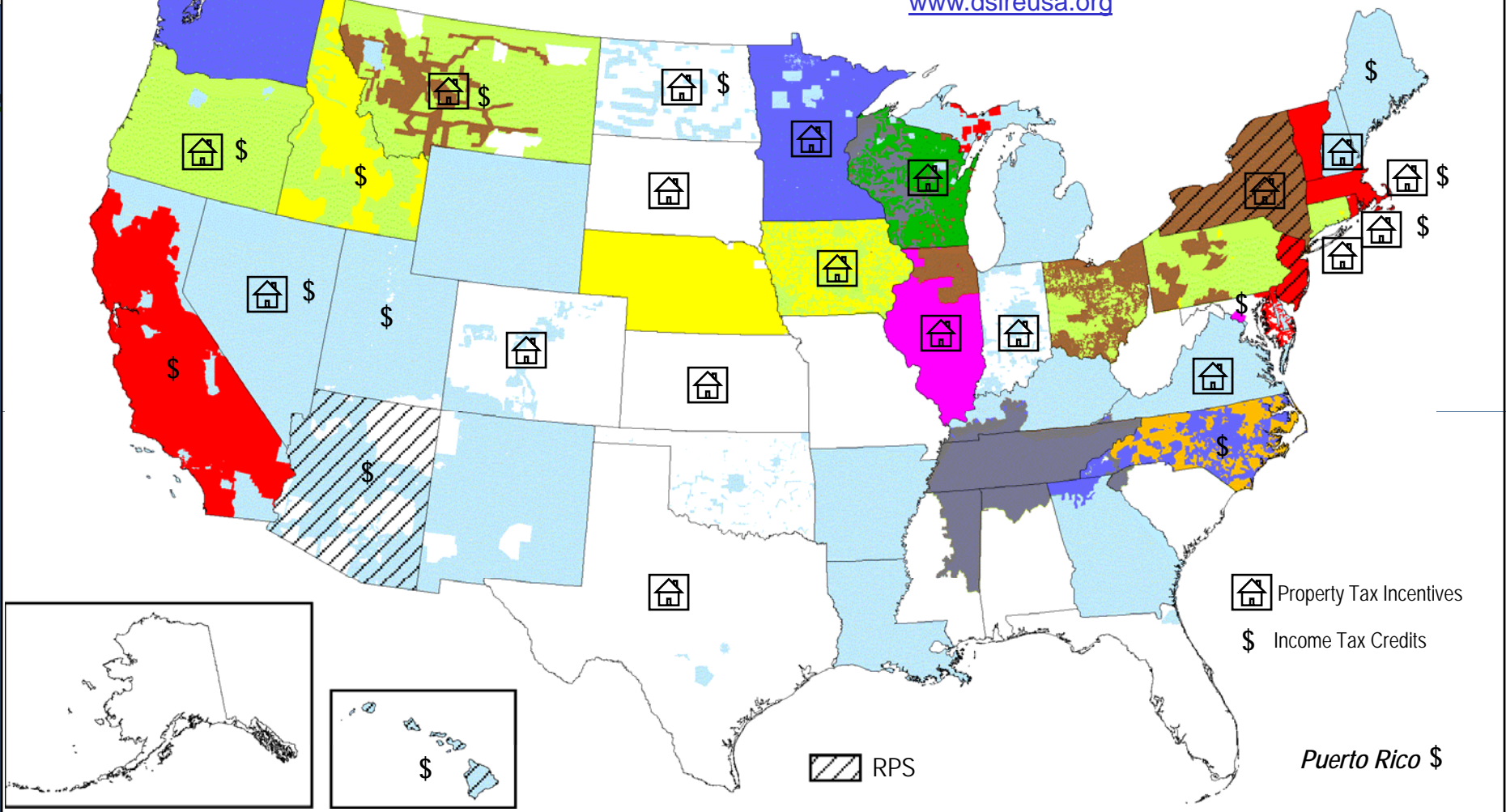
Growth of the Small Wind Industry

- In 2000 there were about 40 producers of small wind generators in the world
 - Last few years that number has doubled
- US small wind manufacturers dominate the world market with 22 manufacturers
- Non-US manufacturers anxious to come into US market



Residential Small Wind Incentives

www.dsireusa.org



Property Tax Incentives
 \$ Income Tax Credits

RPS

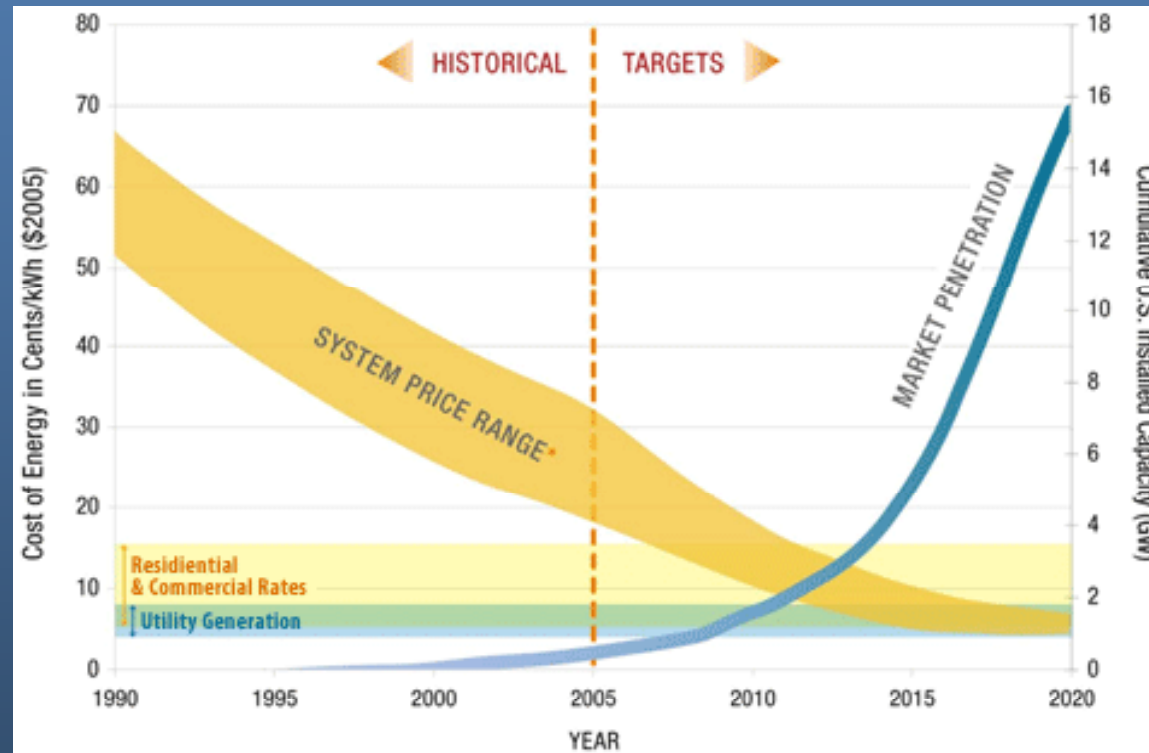
Puerto Rico \$

BUYDOWNS/GRANTS	PRODUCTIVITY INCENTIVES	MINOR INCENTIVES
Buydown/Grants	Productivity Incentives & Loans	Loans
Buydown/Grants & Net Metering	Net Metering, Loans & Prod. Incentives	Net Metering & Loans
Buydown/Grants, Net Metering, & Loans	Net Metering & Prod. Incentives	Net Metering

Yearly grants through the USDA farm bill are available for Illinois, Pennsylvania, Florida, Iowa, Wisconsin and Ohio.

Federal Incentives: Mainstay Energy – green tag purchase (CA excluded); USDA Federal Farm Bill Title 9006 – grant for rural areas

Finding the Tipping Point



GOAL: Continue to drive down the Cost of Energy while maintaining/improving reliability



Wind Turbine (pre-2000 technology) Installed Cost

Red highlights = Turbine System Cost

Updated: 5-Jul-07

Bergey Excel-S (10 kW)

High Cost

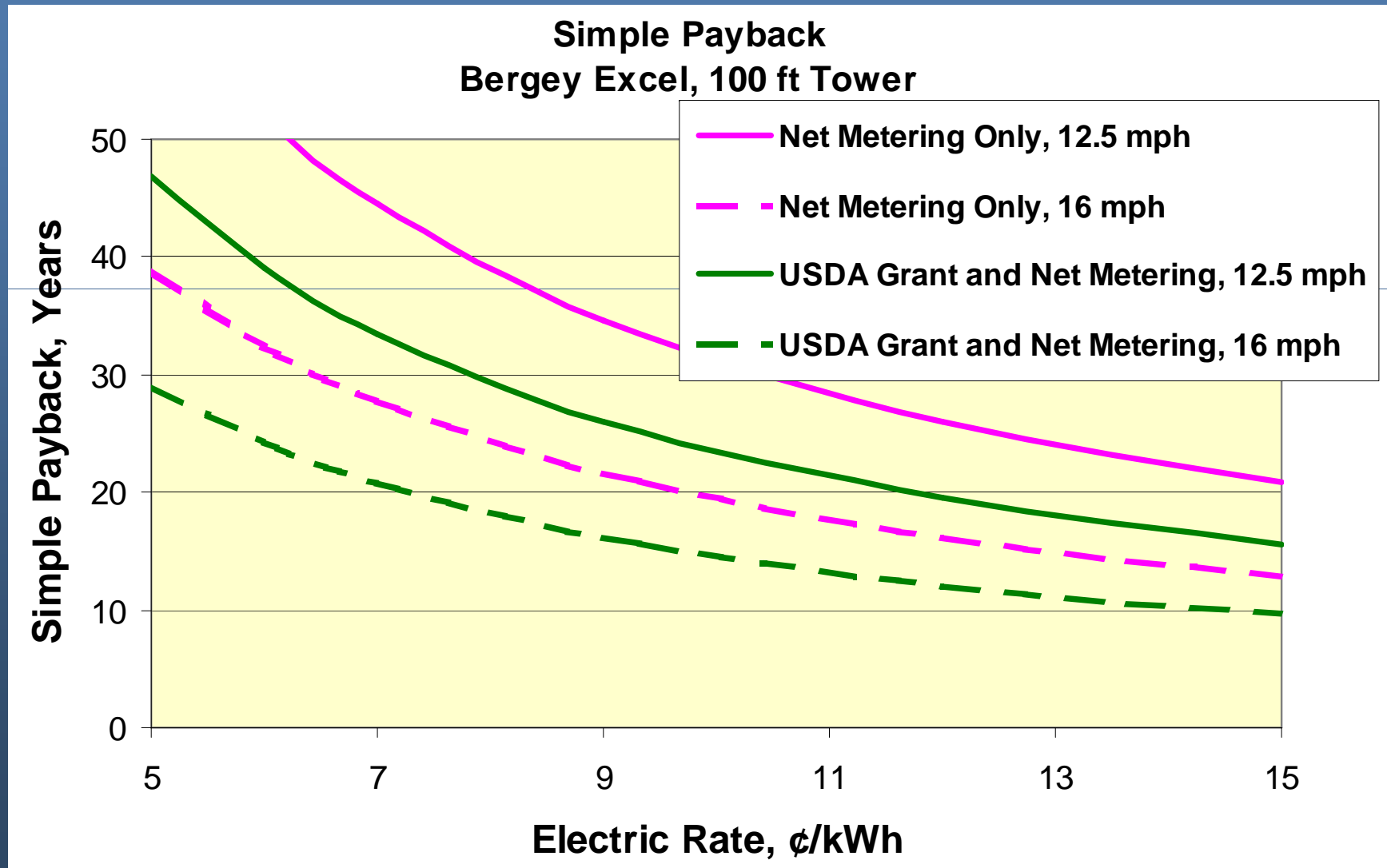
Low Cost

Wind turbine & inverter	\$27,900	\$27,900	\$27,900
Tower (100 ft guyed)	\$9,200	\$31,950	\$7,400
Tower Wiring Kit	\$1,000	\$1,140	\$860
Shipping	\$1,500	\$2,000	\$1,000
Installation	\$8,000	\$18,000	\$2,000
Permits/Fees	\$500	\$6,000	\$0
Sales Tax, 2%	\$952	9%	none
Total	\$49,052	\$94,279	\$39,160



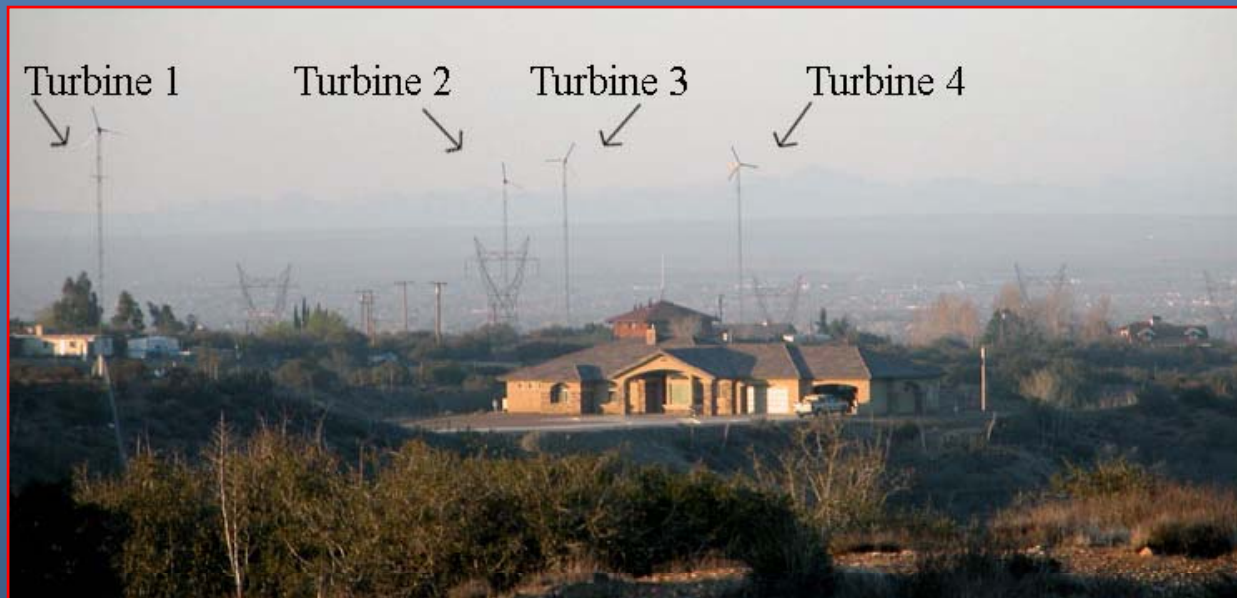
Small Wind Economics

Bergey Excel on 100ft Tower





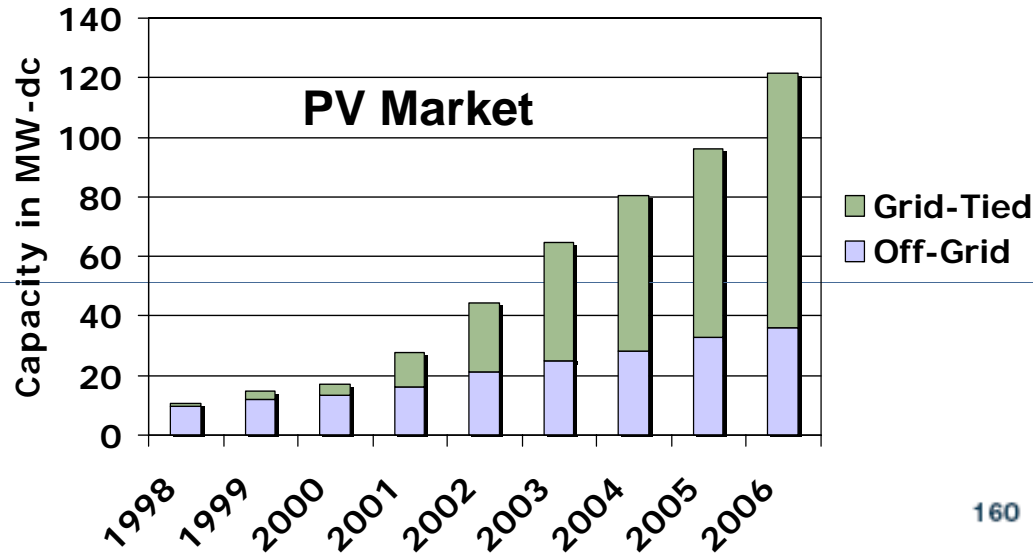
Localized Growth San Bernardino County, CA



- Guasti Construction – started in 2000 with first small turbine installation
 - 1/2 Full Time Equivalent (FTE)
- Worked the local zoning and interconnection issues
- As of 12/07 – installed 116 turbines (114 in San Bernardino County)
 - 6 3/4 FTE

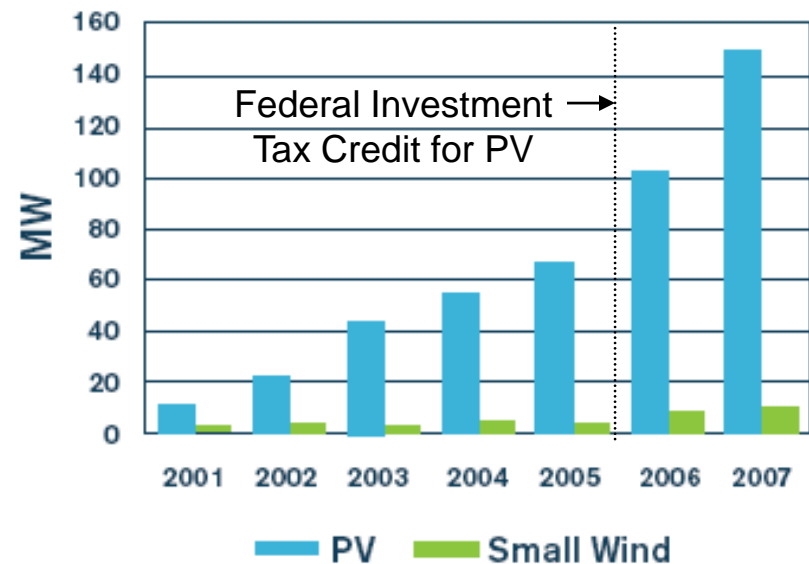
Building a module that will work with Jobs, Economic Development Impact (JEDI) tool – in development

PV & Small Wind Market growth rates



Per AWEA Market Study – 14% small wind growth in 2007

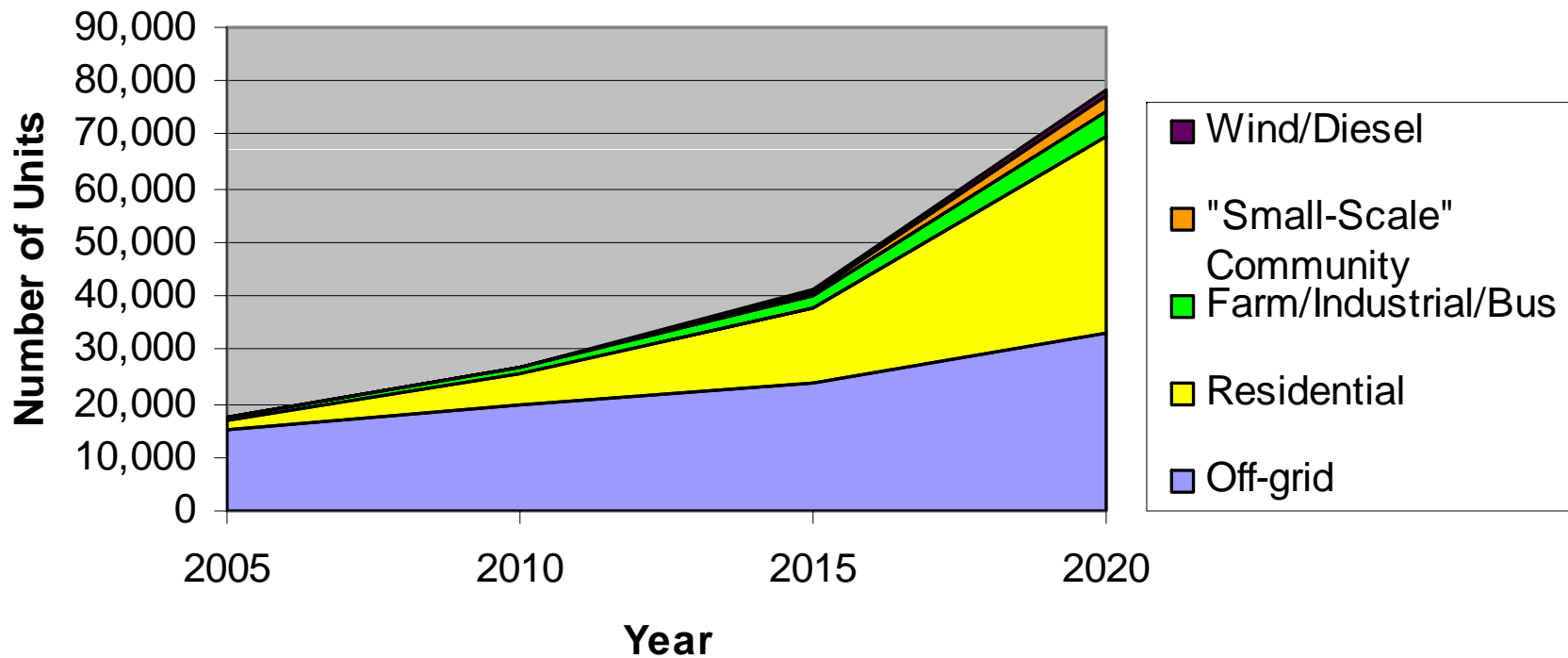
US PV & Small Wind Installed Annually



Source: Larry Sherwood of IREC

Conservative US Market Potential

Preliminary Domestic Market Assessment



In addition to a very strong international market



For More Information

- Wind Powering America – www.windpoweringamerica.gov
 - Small Wind **tab**
- American Wind Energy Association – www.awea.org
 - Small Wind tab
- American Solar Energy Society – small wind division
 - www.ases.org
- Incentives – www.dsireusa.org