

# Wind Power

## USDA/NCRS AG-DAY, Newcastle Colorado January 25, 2006



**Jim Green**  
National Renewable Energy Laboratory

# Why Renewable Energy?

- Renewable
- Clean, non-polluting
- Widely available
- Economic development
- Reduced price volatility
- Increases energy independence
- ***SUSTAINABLE!***



# Wind Energy History in Rural America



Water-pumping wind mills,  
from about 1860

“Wind-chargers” for electric power,  
during the 30’s and 40’s



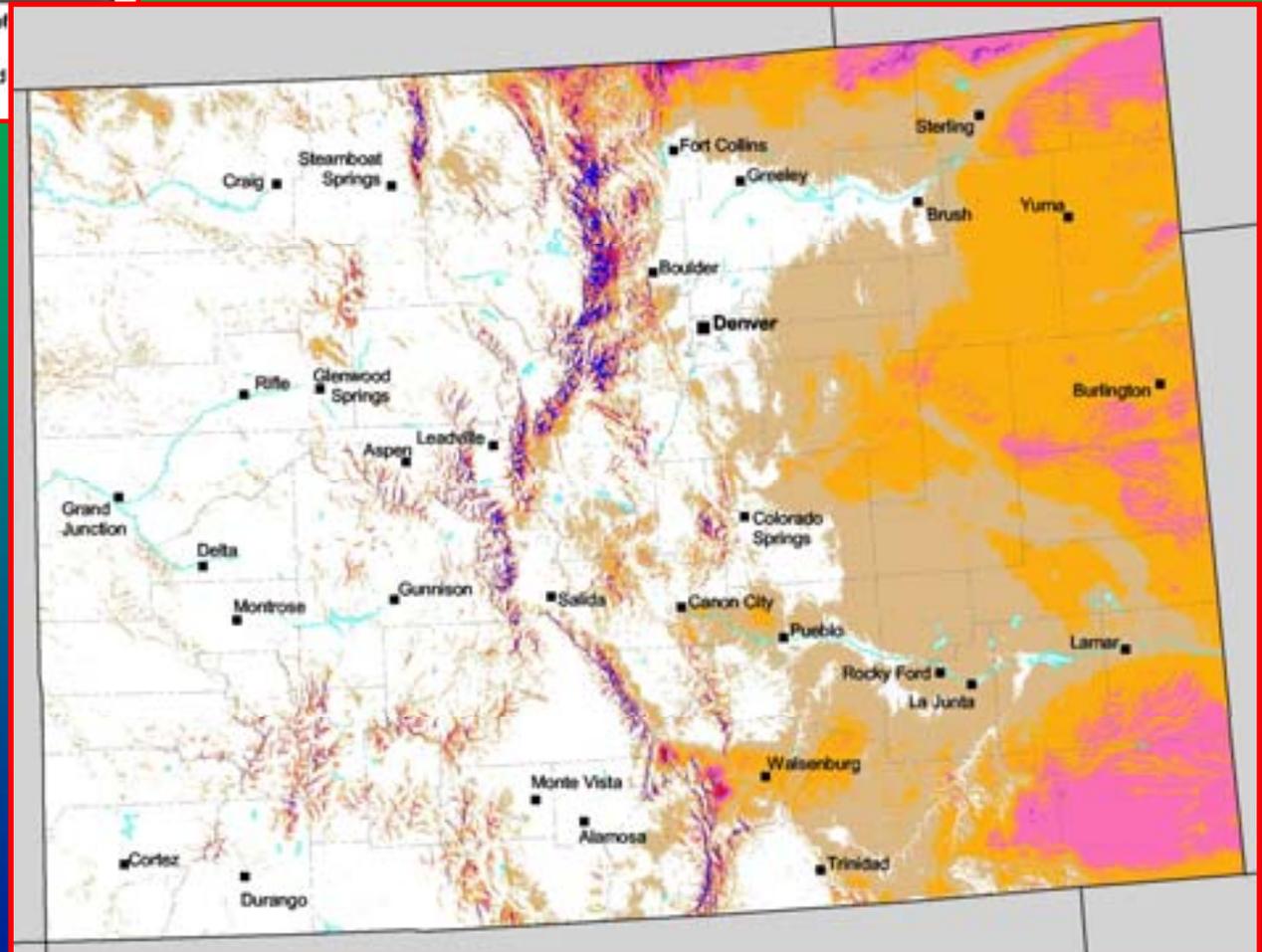
# Colorado Wind Resource Map

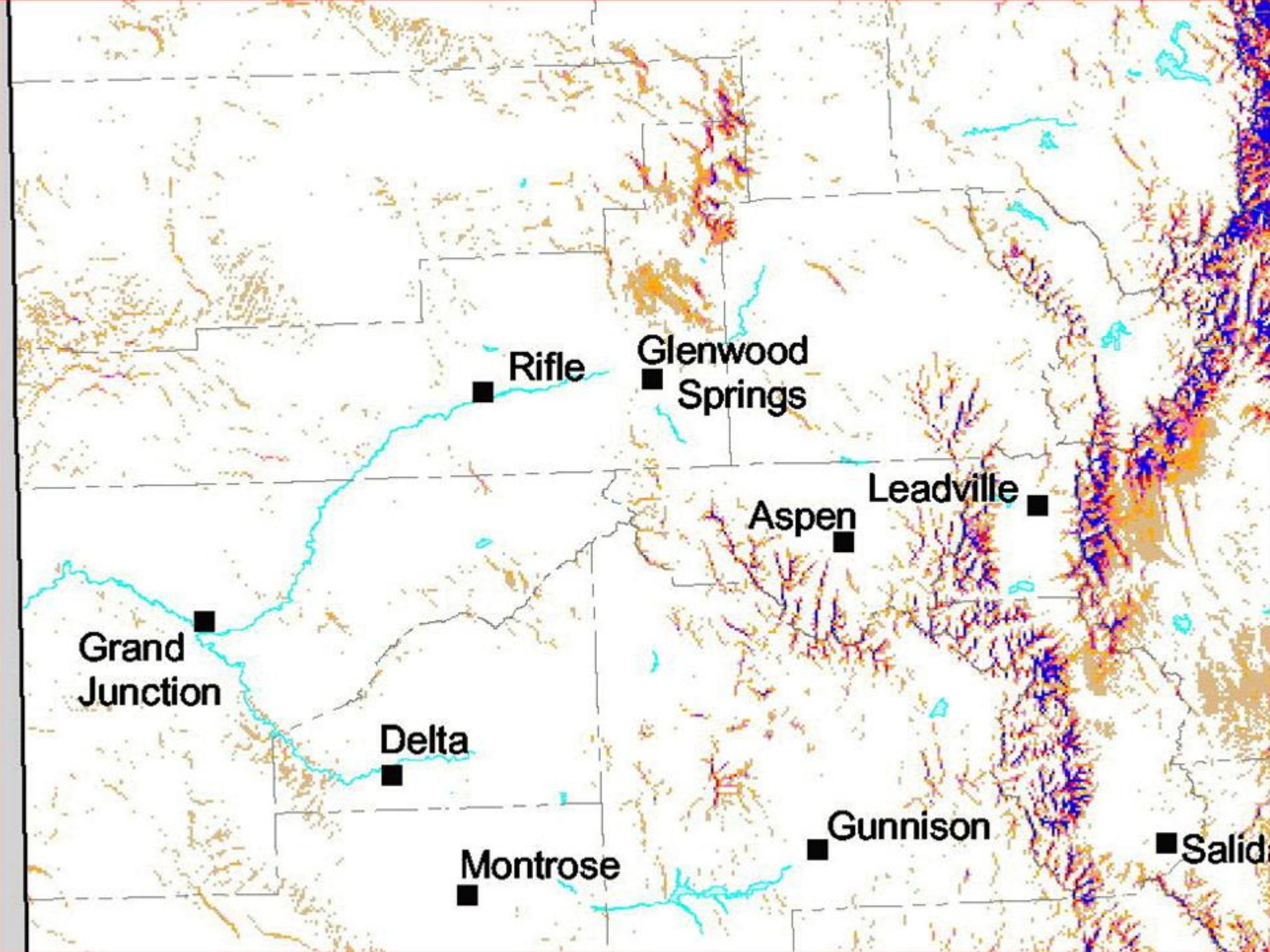
## Small Wind Turbine Productivity Estimates\*

Wind Power Class	Productivity per m <sup>2</sup> of swept area** (kWh/year)	Wind Power Density at 33 ft (10 m) (W/m <sup>2</sup> )	Wind Speed at 33 ft (10 m) (mph)	Wind Speed at 33 ft (10 m) (m/s)
1	< 350	<100	< 9.8	< 4.4
2	350 - 500	100 - 150	9.8 - 11.5	4.4 - 5.1
3	500 - 610	150 - 200	11.5 - 12.5	5.1 - 5.6
4	610 - 690	200 - 250	12.5 - 13.4	5.6 - 6.0
5	690 - 770	250 - 300	13.4 - 14.3	6.0 - 6.4
6	770 - 880	300 - 400	14.3 - 15.7	6.4 - 7.0
7	880 - 1170	400 - 1000	15.7 - 21.1	7.0 - 9.4

\* Estimates are based on different models and sizes of assuming a tower height of 80 ft (24 m).

\*\* For systems of different sizes, multiply the estimated the total swept area of the turbine.





**Grand Junction**

**Delta**

**Montrose**

**Rifle**

**Glenwood Springs**

**Aspen**

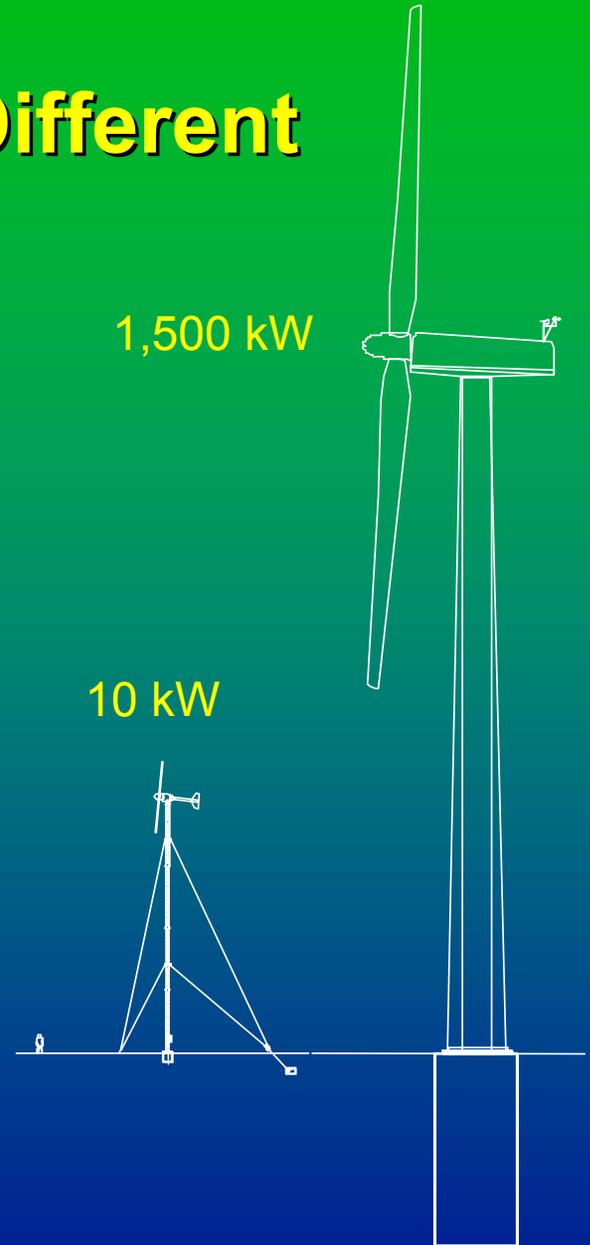
**Leadville**

**Gunnison**

**Salida**

# Small Wind Turbines Are Different

- Utility-Scale Wind Power  
600 - 1,800 kW wind turbines
  - Installed on wind farms, 10 – 300 MW
  - Professional maintenance crews
  - 13 mph (6 m/s) average wind speed
- Small Wind Power  
300 W - 250 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



# Colorado Green Wind Farm



Lamar, Colorado  
162 MW  
Commissioned 2003

# Utility-Scale Wind Energy is Becoming a New “Cash Crop”

Farmers and ranchers are earning \$2,500-4,000/year for each wind turbine on their land.



# Wind Power Provides Rural Economic Benefits

- 240 MW of wind in Iowa
  - \$640,000/yr in lease payments to farmers
  - \$2 million/yr in property taxes
  - \$5.5 mil/yr income from 40 long-term O&M jobs
  - Doesn't include multiplier effect
- 107 MW wind project in MN
  - \$500,000/yr in lease payments to farmers
  - \$611,000 in property taxes in 2000 = 13% of total county taxes
  - 31 long-term local jobs



# Key Factors for Wind Farm Development

- A good wind resource at 150-200 ft
- Proximity to a transmission line with excess carrying capacity
- Utility “Green Power” programs
- Policies that support wind power
  - Federal production tax credit extended through 2007
  - Colorado Amendment 37



# Farmer-Owned Wind Power



- 2x750 kW
- NEG Micon
- Farmer-owned
- Minnesota

- 2x2x900 kW
- NEG Micon
- Farmer cooperative
- Minnesota

For more information:  
<http://www.windustry.org>

# Case Study - School in Clarion, Iowa



This AOC 15/50 wind turbine on a farm in Clarion, Iowa save the Clarion-Goldfield Community School about \$9,000 per year on electrical purchase and provides a part of the school's science curriculum.

# “Green Power” in Colorado

- Over 20 utilities in Colorado now sell wind energy to residential and commercial customers through “green power” programs
- Get details on the Web at: [www.cogreenpower.org](http://www.cogreenpower.org)



# Wubben Case Study – Small Business



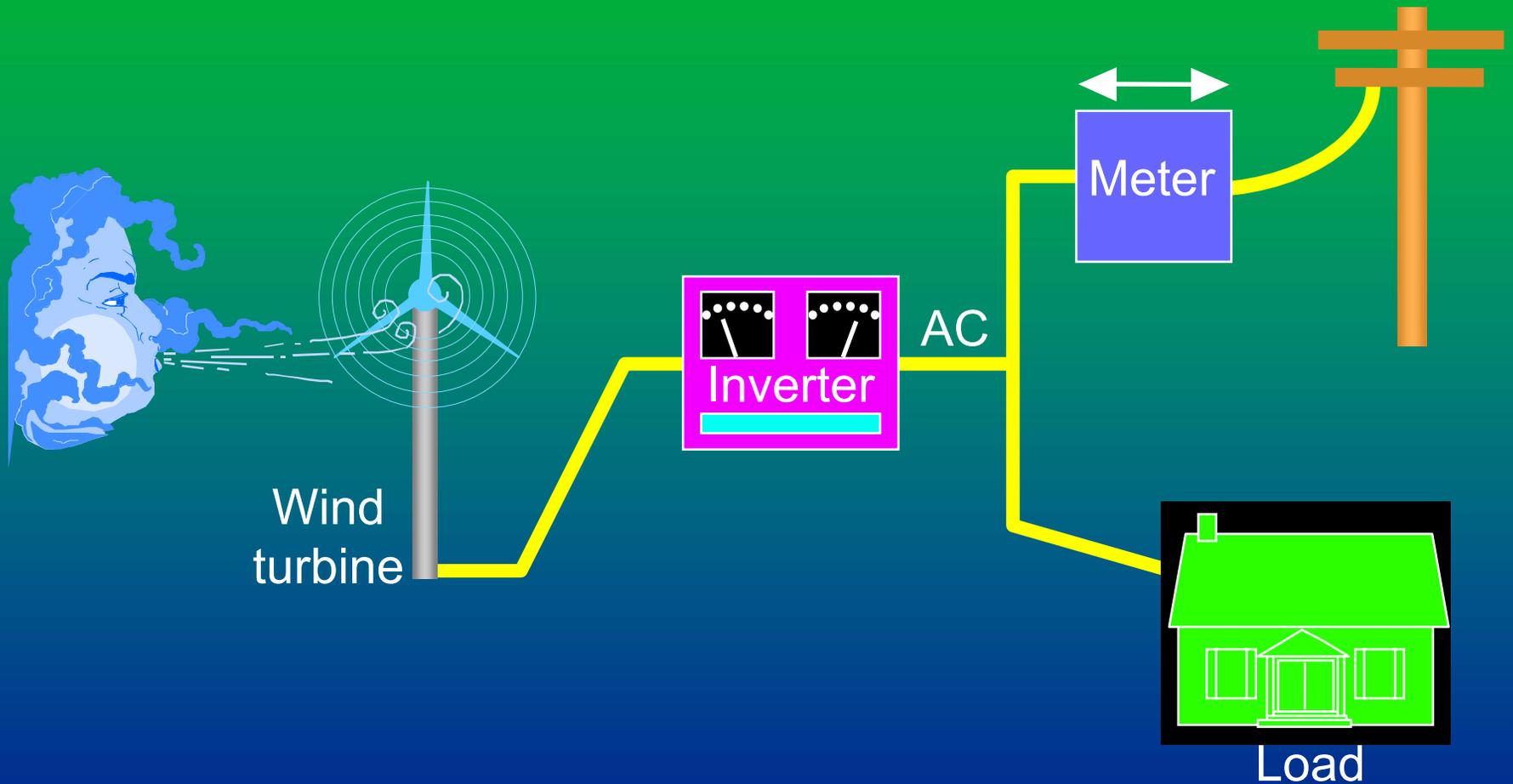
- Wubben business, Wisconsin - finished wood products
- 65 kW turbines, 110' towers, installed June 2004
- Payback in 12 years, \$85k per turbine
  - \$45k/turbine rebate from WI Focus on Energy
- Generation expected - 256,560 kWh/yr
  - 80% of business electrical consumption

# Case Study: On-Grid Farm

- Southwestern Kansas
- Utility bill reduction
- Bergey Windpower Excel turbine, 10 kW, 23-ft rotor, 100-ft tower
- Electricity production ~21,000 kWh/year
- Utility bill savings ~\$2,800/year
- Installed in early 1983, ~\$20,000
- Received federal tax credit
- Maintenance costs, \$50/year
- One lightning strike, one blade was replaced



# On-Grid Wind System without Storage

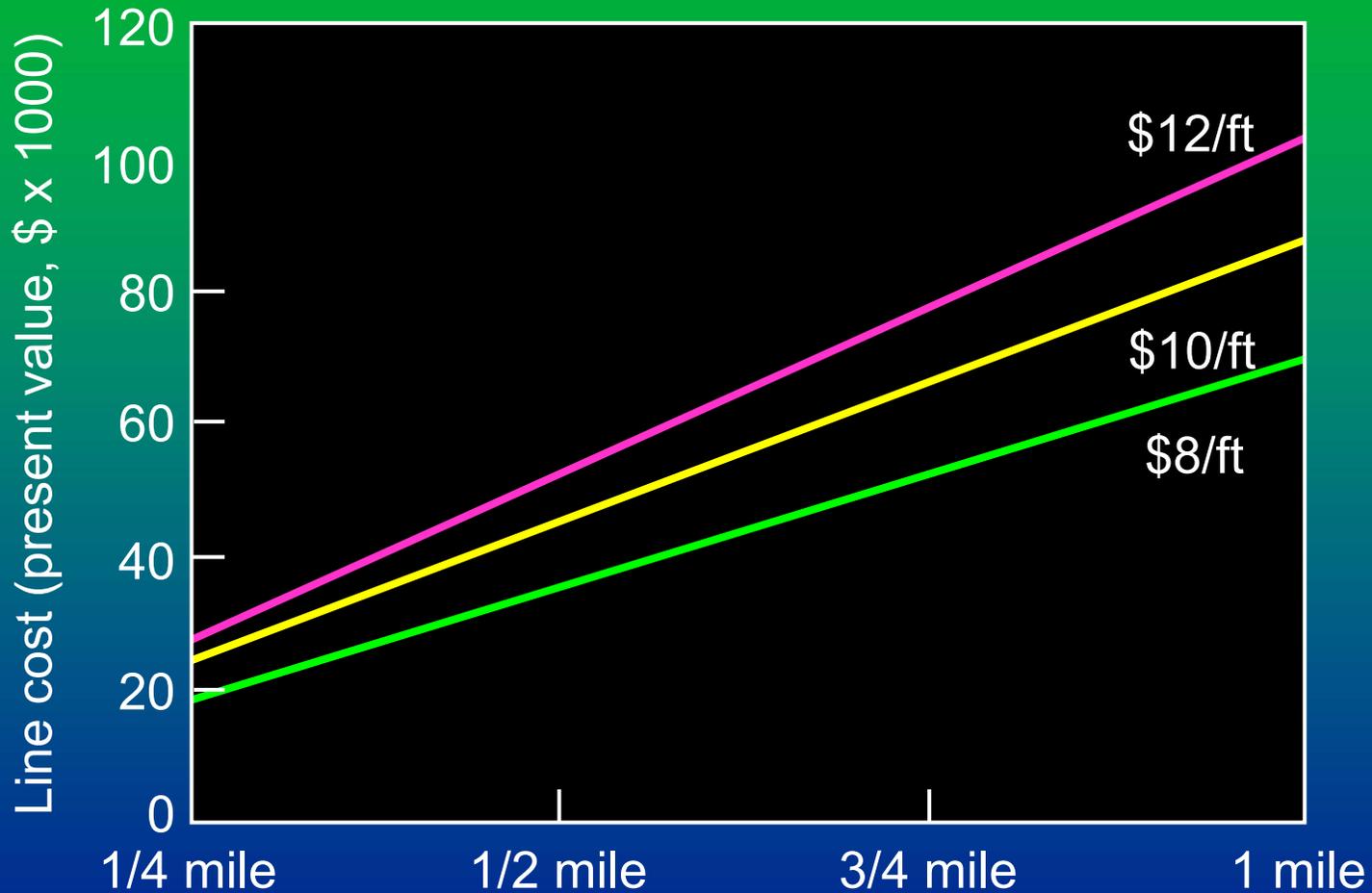


# Case Study: Off-Grid Office and Shop Building

- Wind farm maintenance shop and office, Woodstock, Minnesota
- Electric loads include lighting, PC, and shop tools
- Passive solar day-lighting, corn used for space heat
- Installed cost \$6,800 in 2001 (grid extension alternative: \$7,500)
- 1200 ft<sup>2</sup> shop, 900 ft<sup>2</sup> office
- Whisper H40 wind turbine, 900 W, 35-ft tower
- PV panels, 500 W
- 24 VDC battery, 750 Ah
- 4-kW inverter, 120 VAC single phase



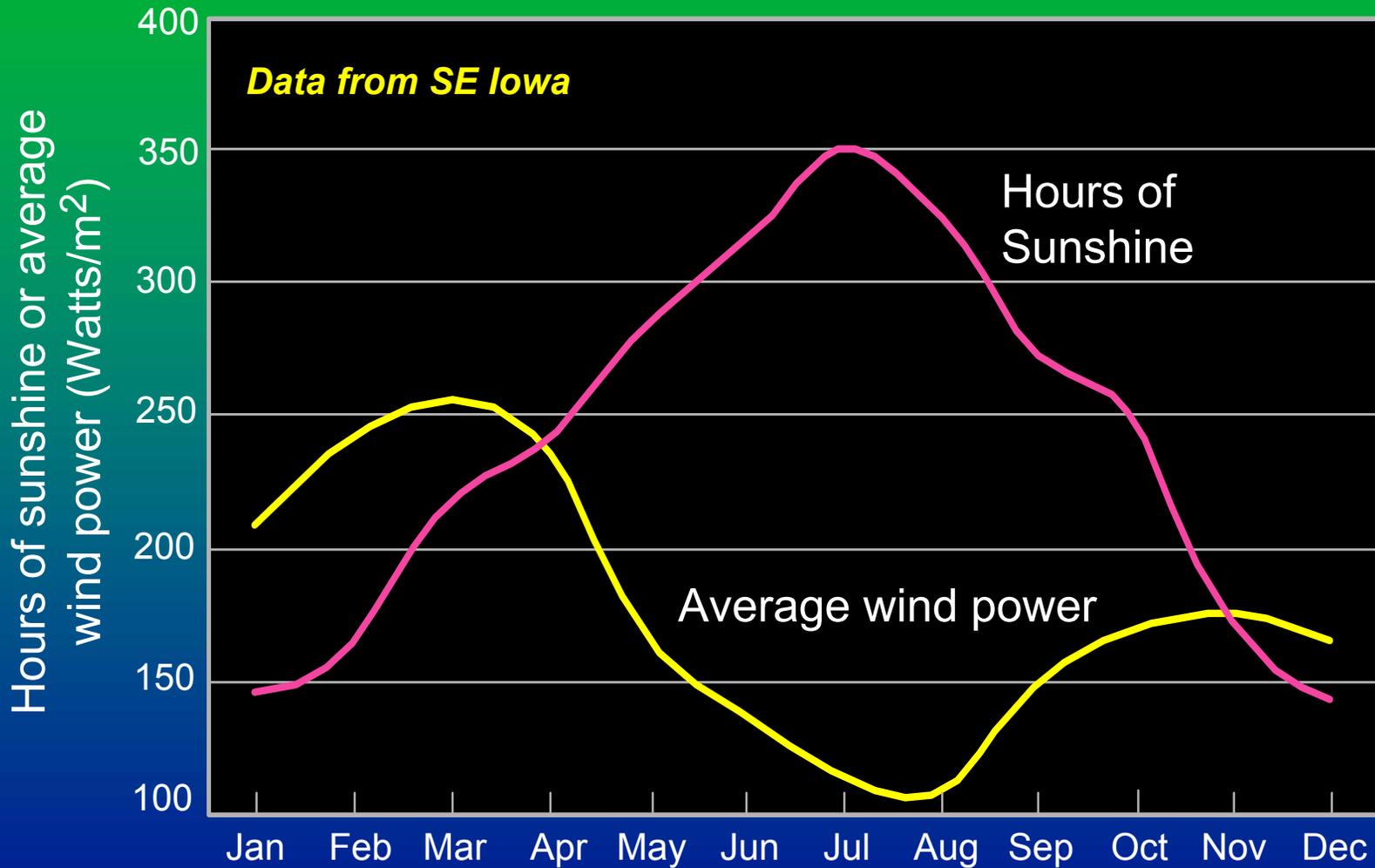
# Costs for Line Extensions



Source: PG&E



# Solar and Wind Resources are Complementary



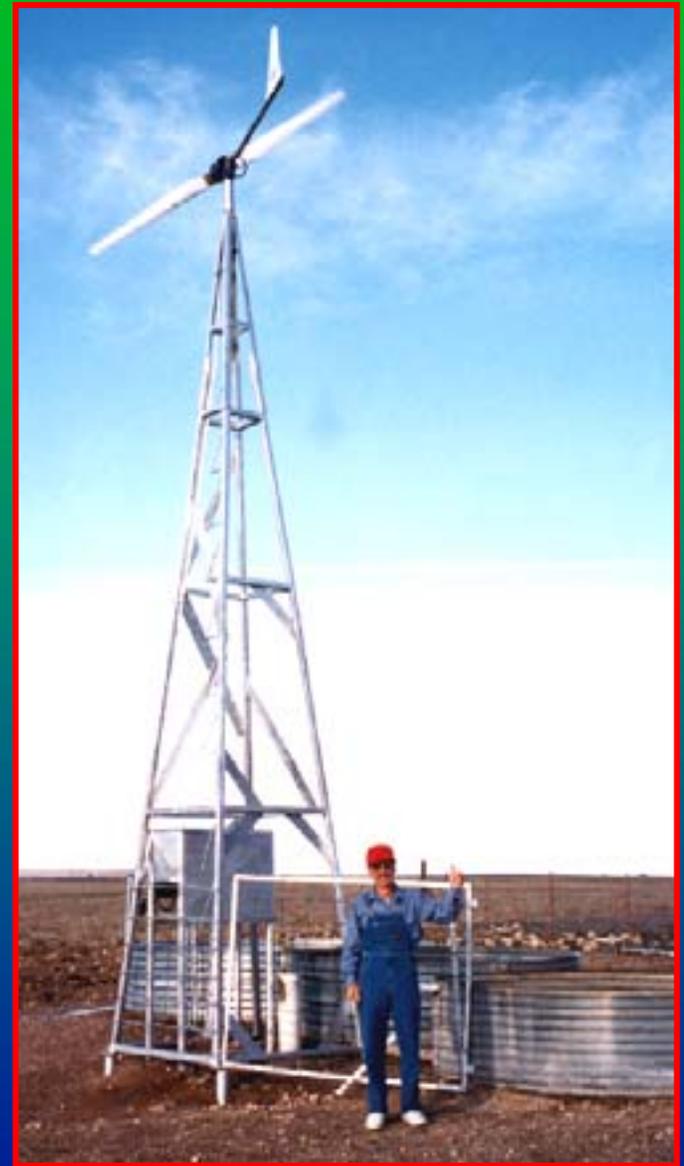
# Case Study: Off-Grid Weekend Cabin

- South Park, Colorado, at 9660 ft
- Southwest Windpower 503 wind turbine, 500 W, 5-ft rotor, 32-ft tower
- Off-grid cabin occupied 2–3 weekends/month
- Space heat from wood & propane
- Propane used for hot water, range, and refrigerator
- PV panels, 188 W
- 24 VDC battery bank
- Heart inverter, 2.5 kW, 120 V AC
- Installed cost in 1986–1992, ~\$7500
- Today's cost, ~ \$5,000



# Case Study: Off-Grid Water- Pumping

- Ranch near Wheeler, Texas
- Water-pumping for 120 head of cattle
- Whisper 1000 wind turbine, 1 kW, 9-ft rotor, 30-ft tower



# Example: Off-Grid Water Pumping with PV System

- PV powered water pumping for stock tanks. Cost is \$4705 for 100 foot well and 1500 gpd
- Systems are owned or can be leased to ranchers for \$16 to \$52 per month, depending on size
- Systems can be moved to different wells



# Off-Grid Small PV Powered Applications

- Electric fence charger with PV module. Total cost is around \$170.
- Electric lights recharged by PV module. Total cost is between \$100 and \$160.



# Case Study: On-Grid Jess Alger's Ranch - Stanford, MT



# Case Study:

## Jess Alger's Ranch - Stanford, MT

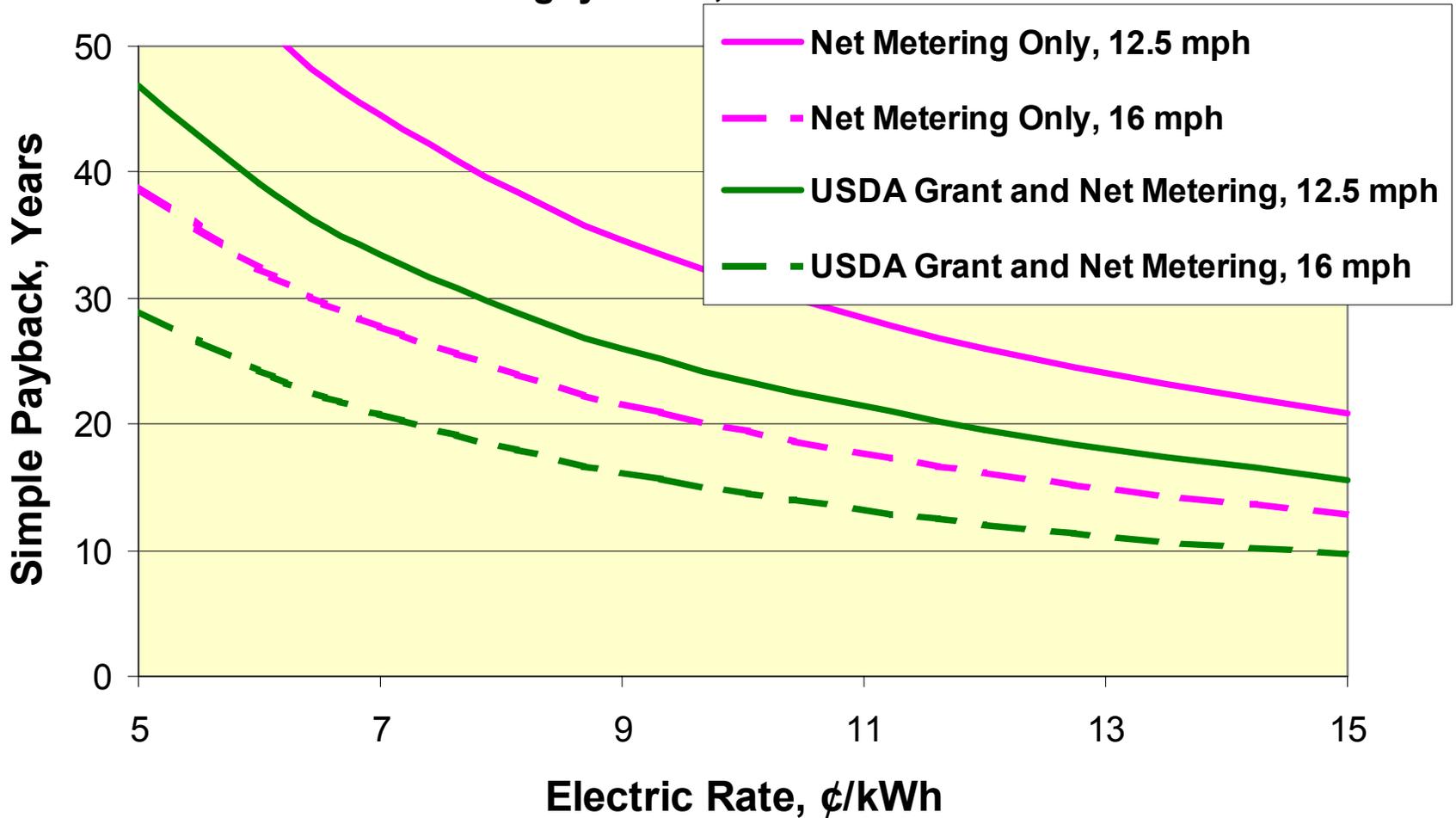
- Fourth generation Montana farmer
- 1,200 acre cattle ranch and wheat farm
- Wind used to offset electricity consumed by home and farm operations
- Turbine installed September 2003
- 12 mph annual average wind speed (Class 3)
- 100 foot tower

# Alger's Estimated Cost and Production

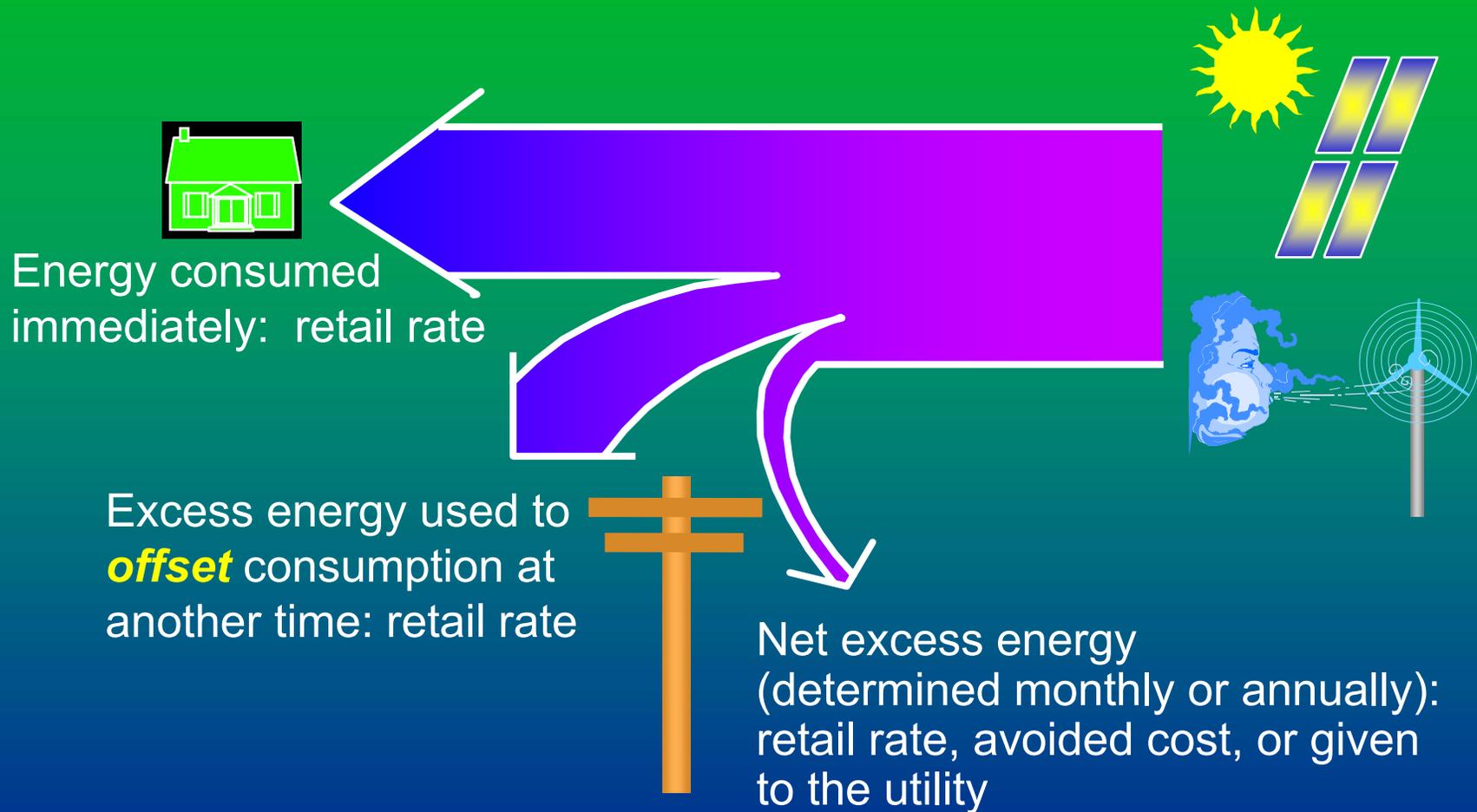
- Installed Turbine System - \$36,850
  - Lower than typical
    - Turbine system costs only, no dealer payment
    - Site preparation done by J. Alger
- USDA RESG (25% grant) - \$7,696
- Montana NCAT USB Funds - \$12,500
- Estimated electricity used 14,200 kWh/yr
- Estimate electricity produced 18,000 kWh/yr (based on Class 3 wind site)

# Small Wind Economics

Simple Payback  
Bergey Excel, 100 ft Tower



# Net Metering of Renewable Energy



# Colorado Incentives

- State of Colorado anemometer loan program: [www.state.co.us/oemc/programs/renewable/anemometer.htm](http://www.state.co.us/oemc/programs/renewable/anemometer.htm)
- Net Metering:
  - Xcel Energy
  - Aquila
  - Ft. Collins Utilities
  - Aspen Electric
  - Gunnison County Electric
  - Holy Cross Electric
- Database of incentives - [www.dsireusa.org](http://www.dsireusa.org)

# USDA Farm Bill Section 9006

[www.rurdev.usda.gov/rbs/farbill](http://www.rurdev.usda.gov/rbs/farbill)

- Renewable Energy & Energy Efficiency:  
wind                      solar                      biomass  
geothermal              hydrogen              energy efficiency
- For farms, ranches, small businesses (not for residential systems)
- Grants (up to 25% of project cost), or Loan Guarantees (up to 50% of project cost)
- In 2005, a total of \$21 million in grants were distributed to 150 projects in 32 states.
- Work with rural energy coordinators at your USDA State Rural Development Office
- Simplified application in 2006 for projects < \$200,000

# USDA Farm Bill Section 6401

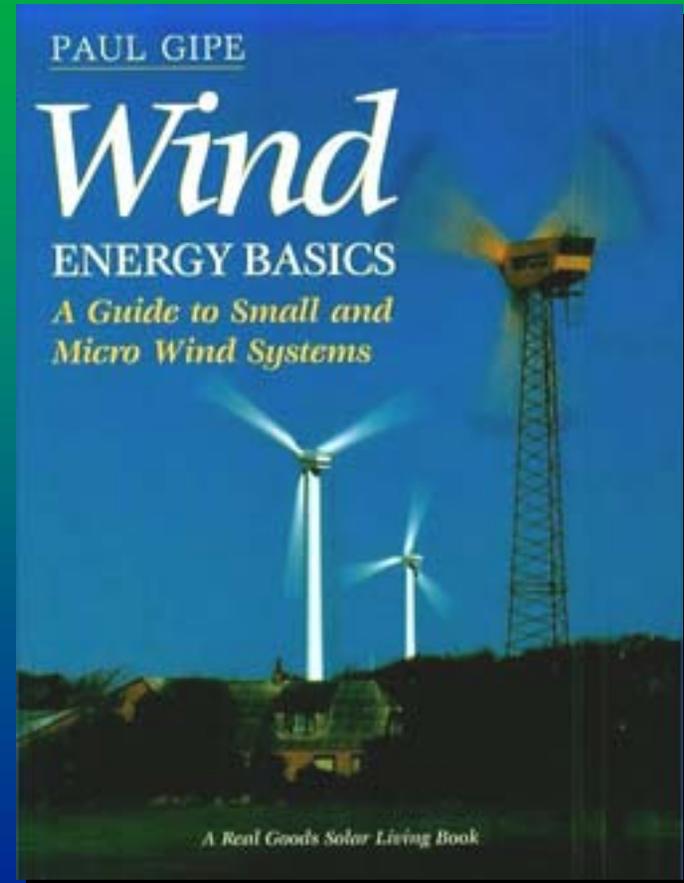
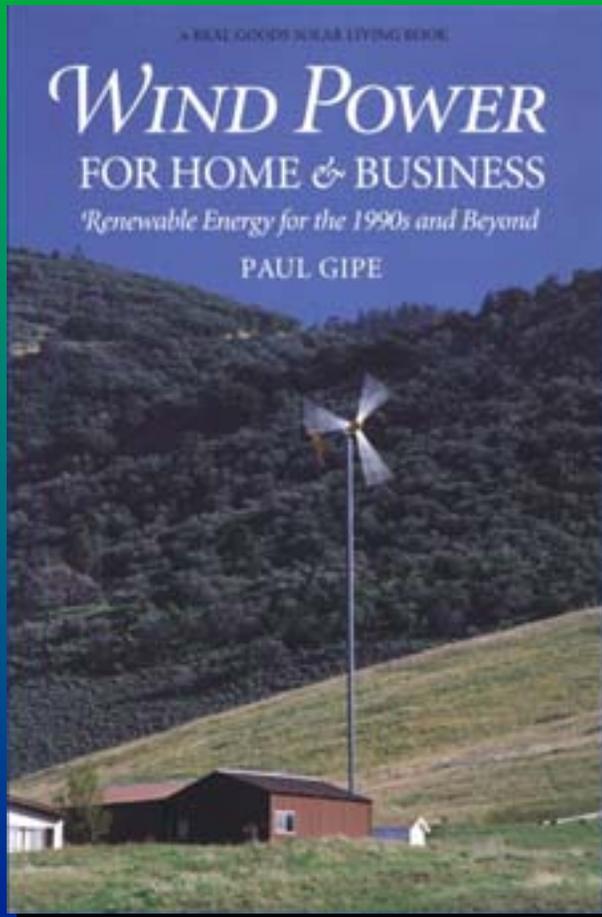
[www.rurdev.usda.gov/rbs/coops/vadg.htm](http://www.rurdev.usda.gov/rbs/coops/vadg.htm)

- Value-Added Producer Grants for wind, hydro, and biomass digesters
- Grants (up to 50% of project cost) may be used for wind resource assessment, but not for buying a wind turbine.
- For independent producers, producer cooperatives, and producer groups
- \$19.5 million available in 2006
- Work with rural energy coordinators at your USDA State Rural Development Office
- Applications due March 31, 2006

# Books by Paul Gipe

Available from Chelsea Green Publishing Co.

[www.chelseagreen.com](http://www.chelseagreen.com)



# Small Wind Consumers Guide

A U.S. guide and about 30 state- and region specific guides are available from the National Renewable Energy Laboratory:

[http://www.windpoweringamerica.gov/small\\_wind.asp](http://www.windpoweringamerica.gov/small_wind.asp)

## Small Wind Electric Systems

A U.S. Consumer's Guide



U.S. Department of Energy





*Carpe Ventem*

[www.windpoweringamerica.gov](http://www.windpoweringamerica.gov)

