

Small Wind Power For South Dakota

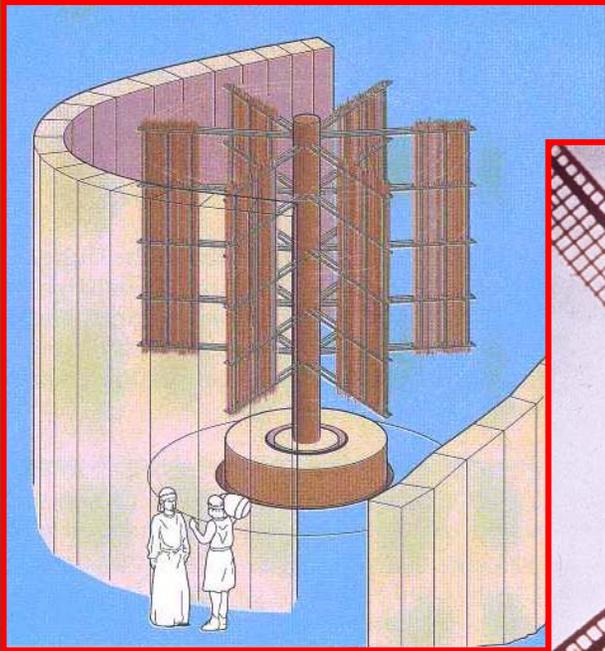


Jim Green

National Wind Technology Center



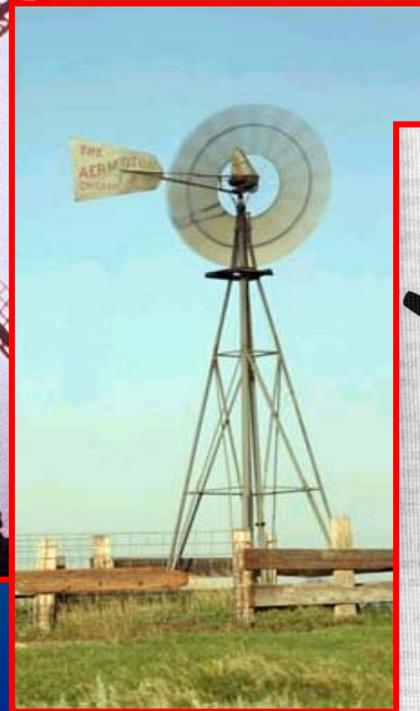
1400-1800 years ago,
in the Middle East



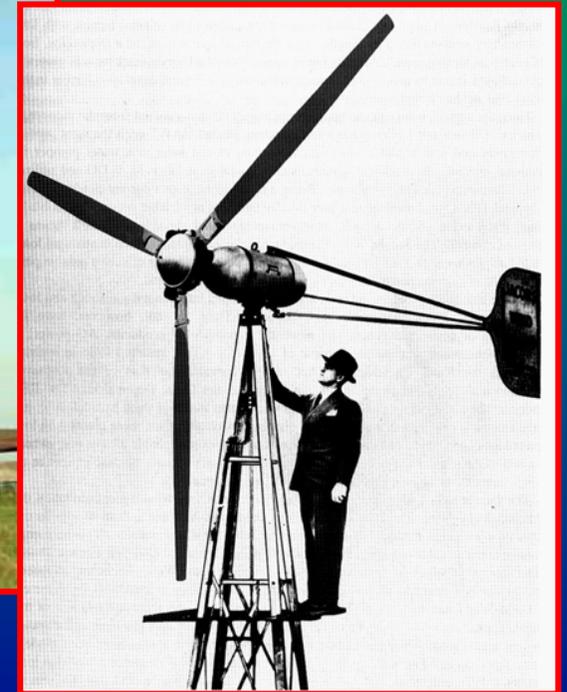
800-900 years ago,
in Europe



140 years ago,
water-pumping
wind mills



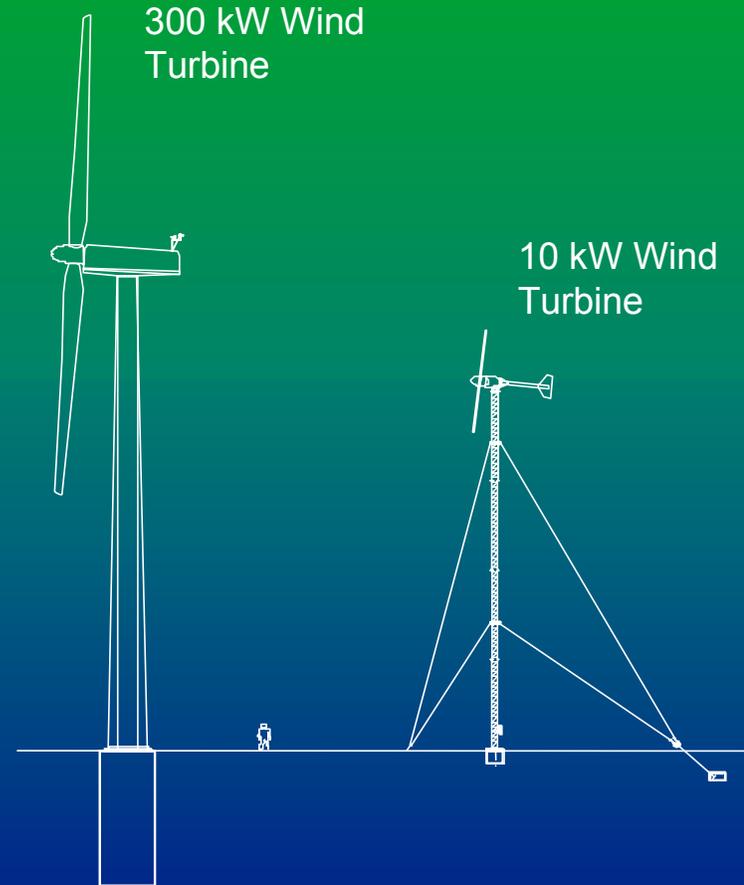
70 years ago,
electric power



Wind Power History

Small Wind Turbines are Different

- Large Turbines (600-1800 kW)
 - Installed in Windfarms, 10 - 100 MW
 - Provide Low Cost Power to the Grid
 - < \$1,000/kW
 - Require 6 m/s (13 mph) Average Wind Speeds
- Small Turbines (0.3-50 kW)
 - Installed Off-Grid or at On-Grid Facilities
 - \$2,000-6,000/kW
 - Designed for Reliability / Low Maintenance
 - Require 4 m/s (9 mph) Average



Small Wind Turbines

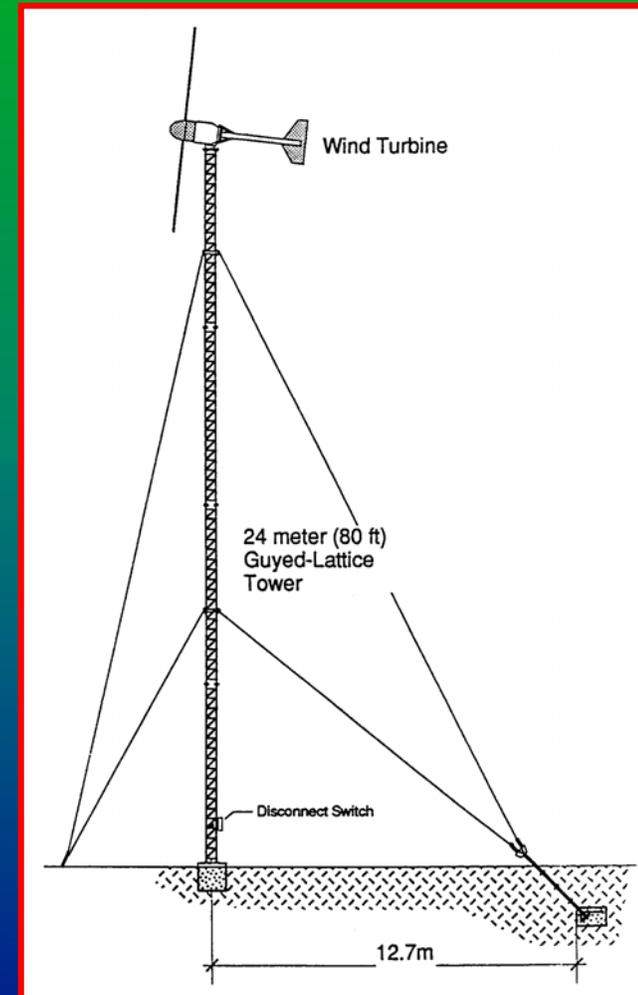
- **Configuration:** Up-wind, horizontal axis, 2 or 3 blades, aligned with wind by the tail
- **Blades:** Fiber-reinforced plastics, fixed pitch, either twisted/tapered, or straight (pultruded)
- **Generator:** Direct-drive permanent magnet alternator, no brushes, 3-phase AC, variable-speed operation
- **Overspeed Protection:** Passive furling (rotor turns out of the wind), no brakes
- **Result:**
 - Simple, rugged design
 - Only 2–4 moving parts
 - Little regular maintenance required



Bergey EXCEL, 10 kW

Small Wind Turbine Towers

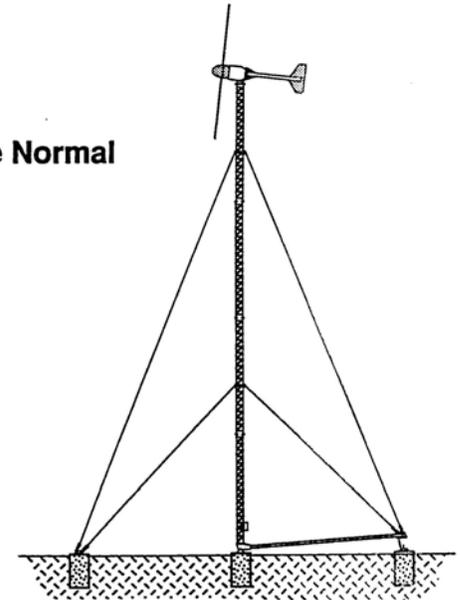
- Guyed lattice and tube towers are the least expensive and most commonly used towers for small wind turbines
- Adequate space is needed for the guy wires and their anchors
- Free-standing towers are used where space is limited



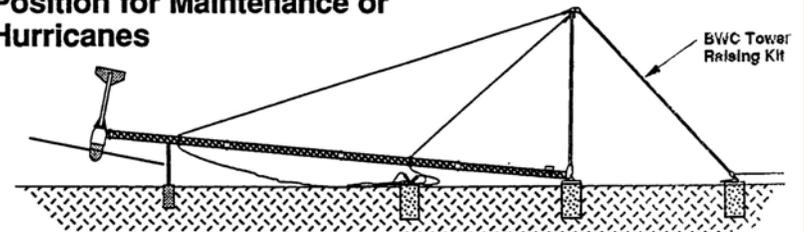
Tilt-Up Towers

- Tilt-up versions of guyed towers are available for easier installation and maintenance
- Uses 4 guy wires instead of 3

Tilt-up Tower in the Normal Operating Position

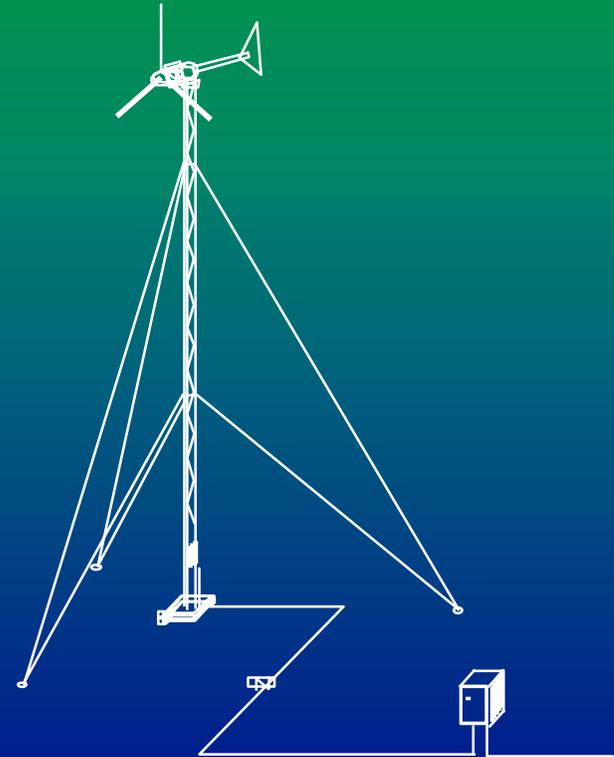


Tilt-up Tower in the Lowered Position for Maintenance or Hurricanes



The Wind Turbine Controller

- Battery-Charging
 - Converts AC power to DC for battery-charging
 - Regulates the battery voltage to prevent over-charging
- When the battery is fully charged:
 - Power is diverted to another load, or ...
 - The rotor is unloaded and allowed to “freewheel”
- Grid Interconnection
 - “Inverter,” converts the power to constant frequency 60 Hz AC
- UL label may be required



Small Wind Turbine Maintenance and Lifetime

- “Low maintenance” not “no maintenance”
 - Annual inspection and maintenance
 - Tightening bolts and electrical connections, inspecting slip rings, checking for corrosion, checking guy wire tension, inspecting/replacing leading-edge tape, etc.
 - Beyond 10 years: blade or bearing replacement may be needed
- Lifetimes of 10 to 20 years are possible with proper installation and annual maintenance
 - “A wind turbine will see as many operating hours in one year as an automobile will see in 200,000 miles!”*

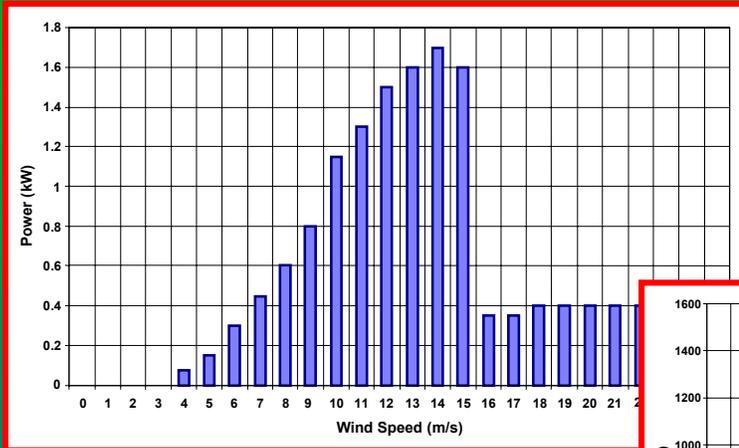
Small Wind Turbine Cost & Warranties

- Initial cost is between \$2,000 and \$6,000/kW for a small wind turbine, controller, and tower
- There is a trade-off between the incremental cost of a taller tower and increased wind turbine performance
- Buyers must make judgements between initial cost and rugged/durable design.
- Warranties
 - 5 years typical
 - Coverage of “materials and workmanship”

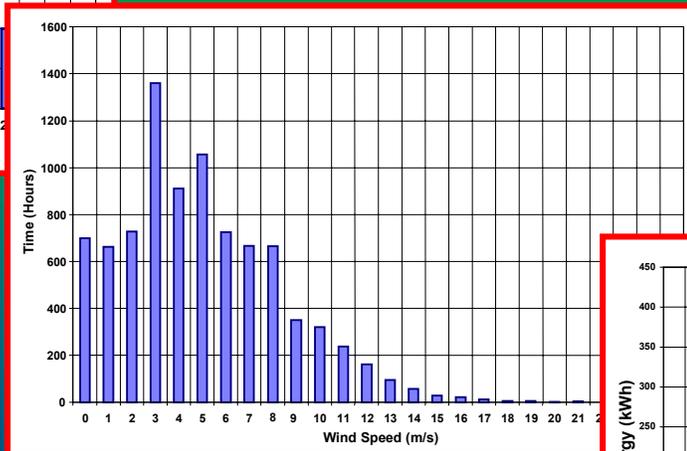
Zoning for Your Wind Turbine

- Short towers, 30–35 ft, can be installed with only a building permit
- Taller towers often require a “special use review” by the county commissioners
- Zoning issues include noise, obstruction of views, safety, and setbacks
- Zoning approval may be difficult or impossible to get for urban and suburban locations, is less a problem in rural locations

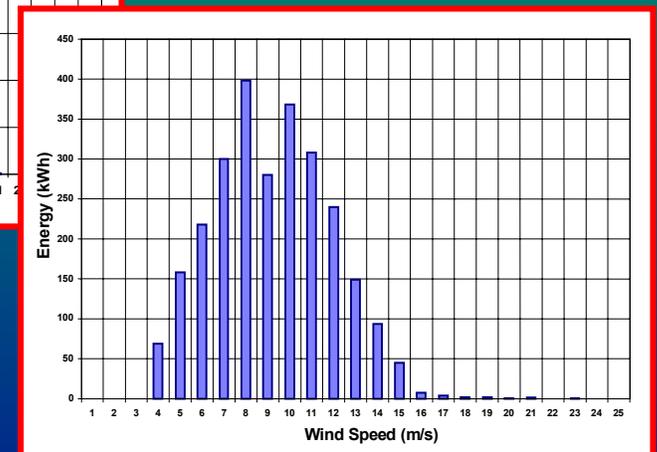
Estimation of Annual Energy Production



Power Curve



Frequency of Occurrence



Annual Energy Production

“Hot Tips” on Wind Energy

- **“Buy Reliability”**

“Based on experience, I side with the ‘school of heavy metal,’ those who believe that beefiness of components is directly related to the longevity of the equipment.” M. Sagrillo, small wind turbine expert

“Hot Tips” on Wind Energy

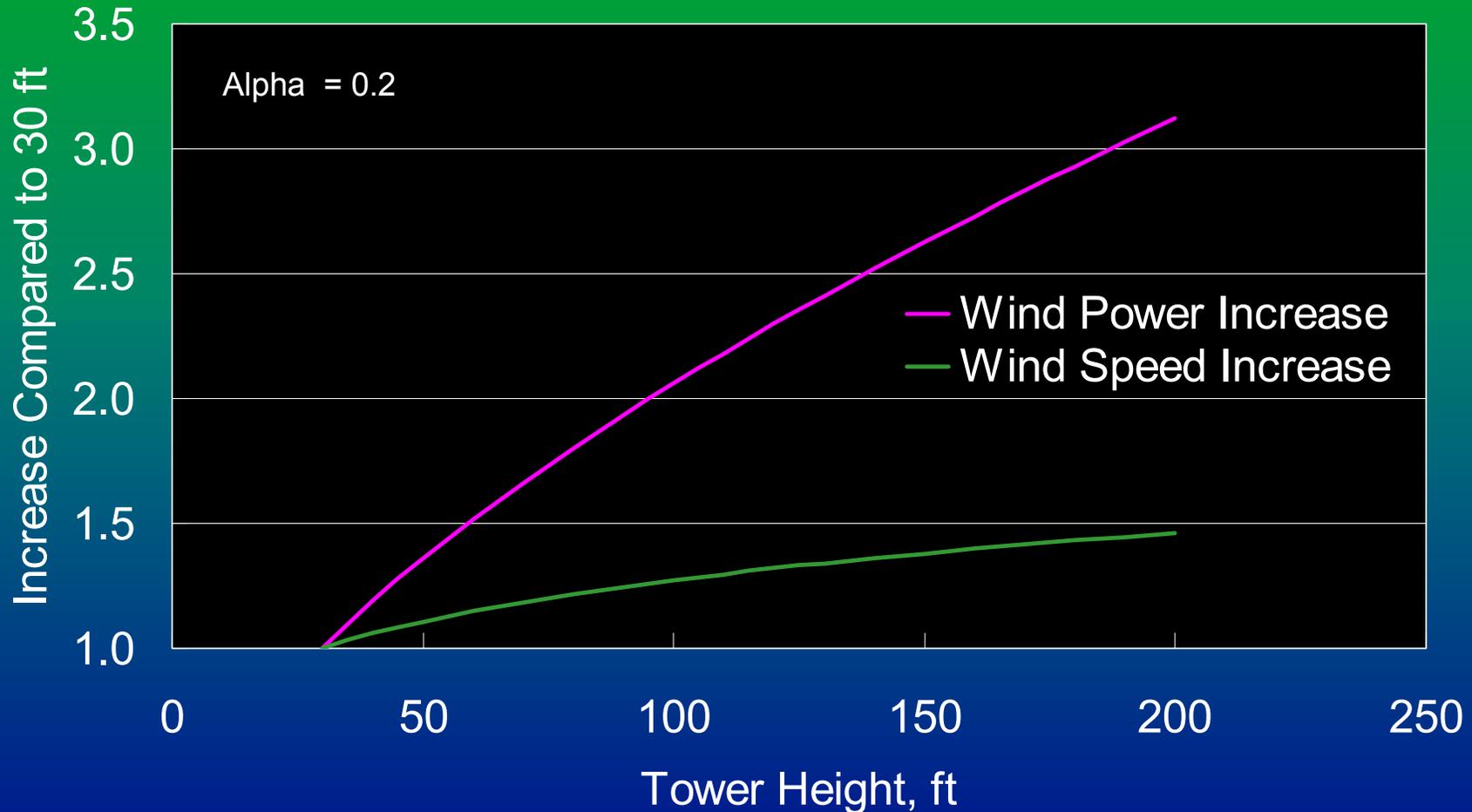
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- **“Taller is Better”**

Taller towers give better performance due to smoother wind and higher wind speeds

Wind Speed and Power Increase with Height Above the Ground



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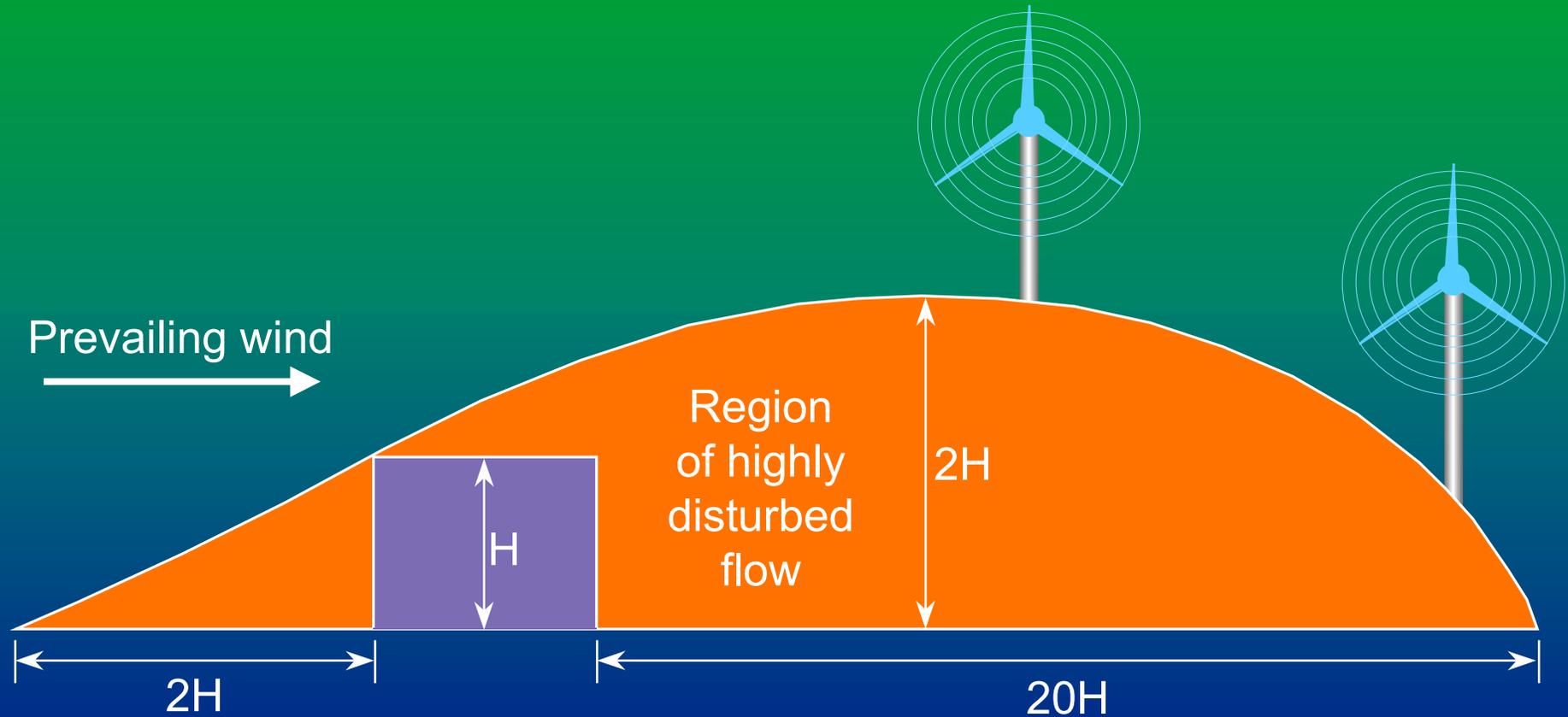
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- **“Pay Attention To Micro-Siting”**

For best performance, locate wind turbines above and away from obstructions to the wind

Micro-Siting Example: Obstruction of the Wind by a Building



Questions?





Off-Grid Wind Water-Pumping

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

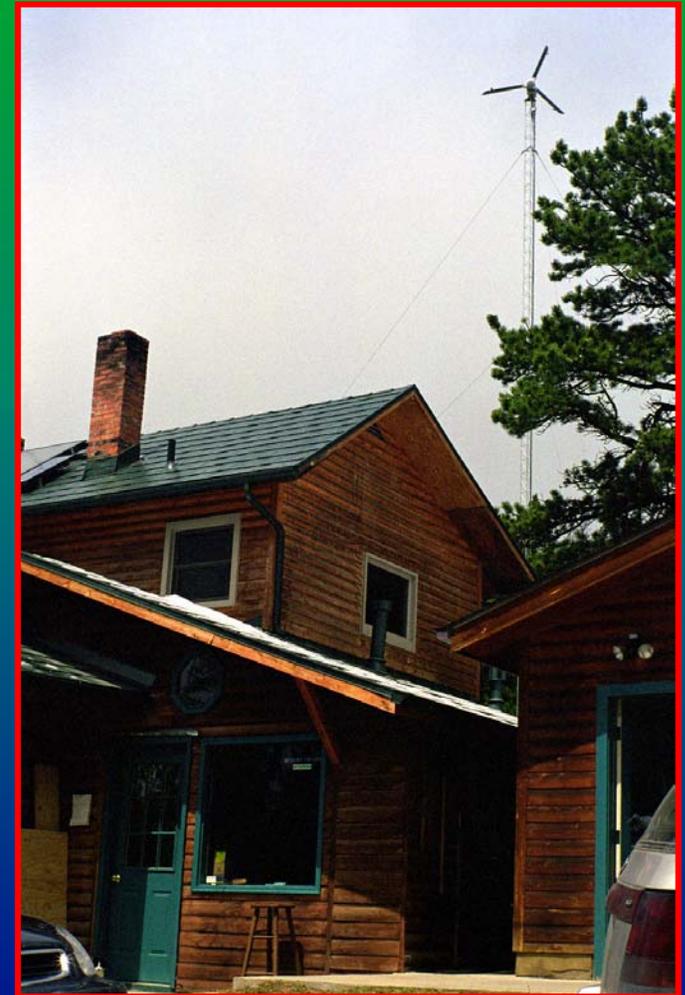
Case Study: Off-Grid Stock Tank Heating with Wind

- University of Wyoming
- Bergey Windpower 1500 wind turbine, 1500 W, 10 ft rotor

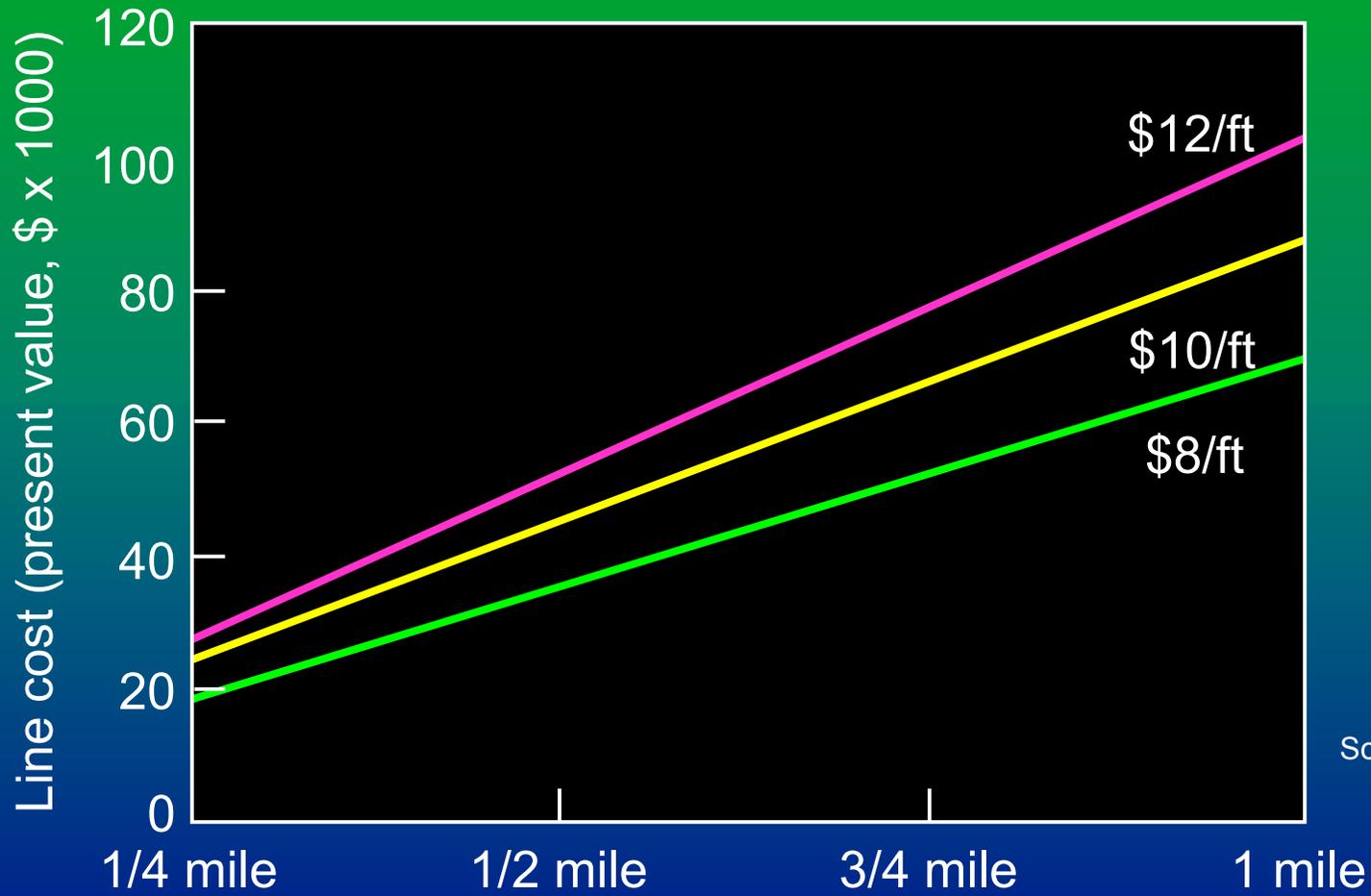


Case Study: Off-Grid Home with Wind/PV System

- West of Boulder, CO, at 9,000 ft
- Bergey 1500 wind turbine, 1.5 kW, 70 ft tower
- Solarex PV panels, 480 W
- 24 VDC battery, 375 Ah
- Onan generator, propane-fueled, 3 kW (at altitude)
- Trace inverter, 120 VAC, 1 phase
- Propane used for range, refrigeration, space heat, hot water (w/solar pre-heat)
- First wind turbine installed in 1978, fourth wind turbine now in service
- PV installed 1984 w/ tax credits
- System cost about \$20,000

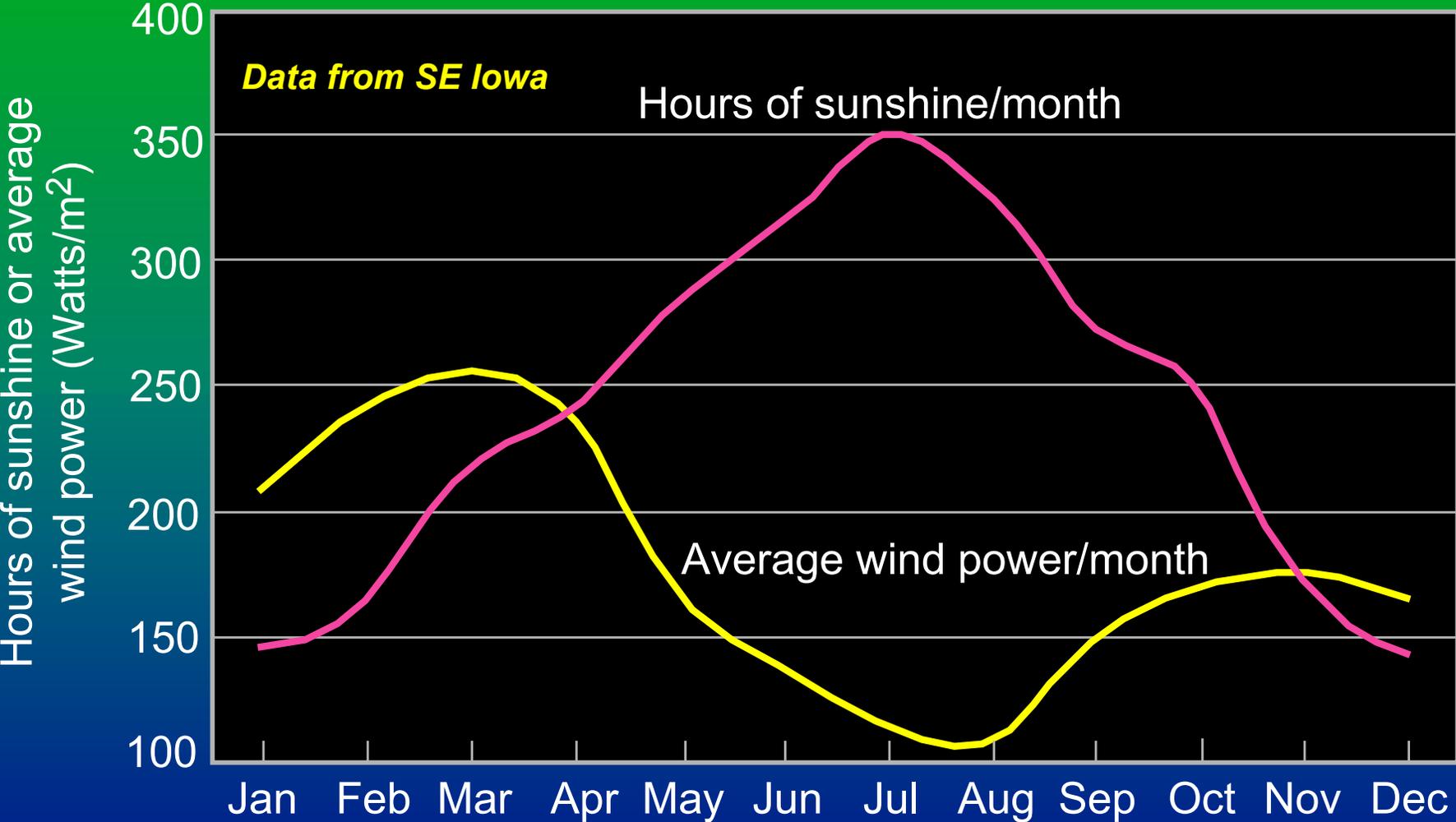


Costs for Line Extensions



Source: PG&E

Solar and Wind Resources are Complimentary



Do I Use Wind or PV?

- Optimal system in central Kansas: wind/generator hybrid, no PV
- Analysis done with HOMER software

Kansas Solutions			
Large 7.519 kWh/d	Optimal	First PV-only System	Difference (PV/Opt.)
PV (kW)	0.0	1.0	
BWC XL.1 (#)	2	0	
Diesel (kW)	1	1	
Battery (kWh)	18	18	
Inverter (kW)	2	2	
Renewable %	89%	48%	
Generator Run Time	729	2015	176%
Diesel Fuel Usage	386	1074	178%
Total NPC	\$20,940	\$28,349	35%

