

Small Wind Turbine Technology



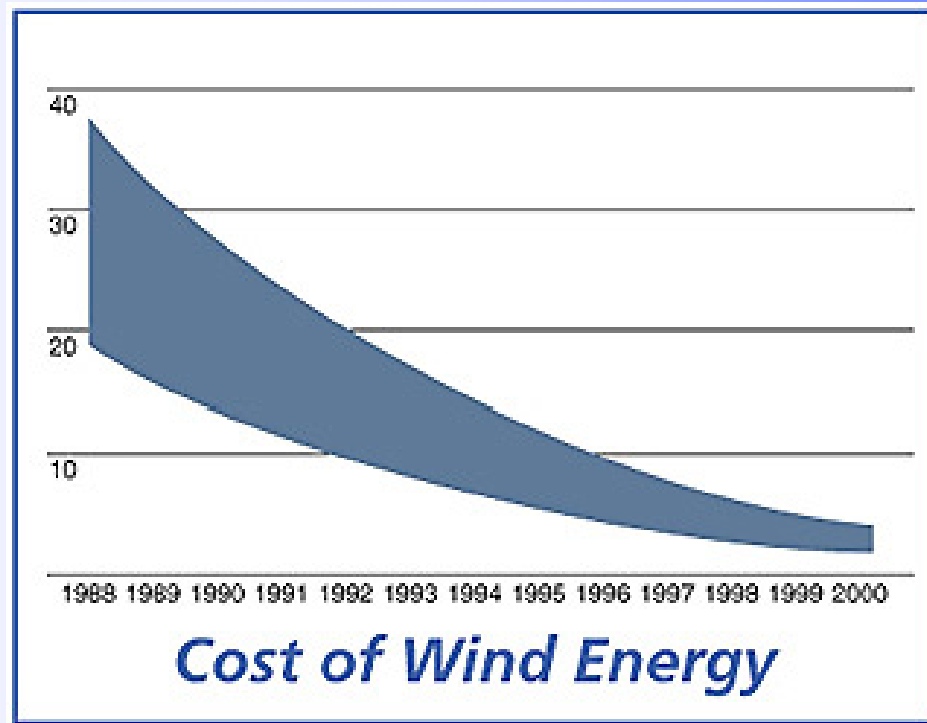
**501 Forrestal Road, Suite 211
Princeton, NJ 08540
p. +1-609-258-5994
f. +1-609-258-7329
www.princetonpower.com**

Definition of Small Wind

- US Department of Energy : < 100kW
- Other Definitions
 - 0 – 1,000 Watts : very small (mobile, etc)
 - 1 – 10 kW : residential, farm, urban
 - 10 – 100 kW : farm, small business
 - 100 – 1,000 kW : community wind



Why Wind?



Components of a Small Wind Turbine

- Turbine/Blades
- Drive Train
 - Gearbox (optional)
 - Generator
 - Inverter
- Tower/Mount
- Balance of Plant
 - Manual Disconnect
 - Electrical Panel
 - kWh meter

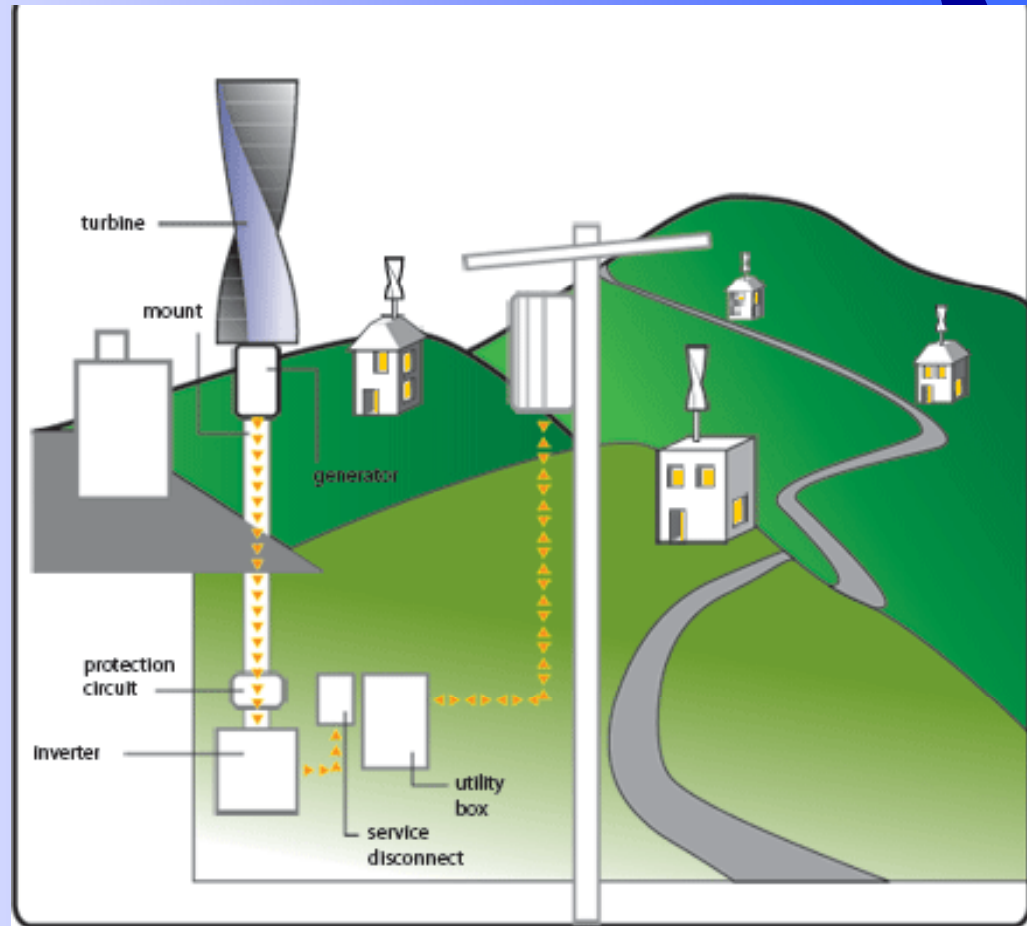


Image courtesy: Blue Green Pacific (bluegreenpacific.com)

Princeton Power Systems



- Commercial-scale inverters (100 – 500 kW)
- Small-scale inverters (3 – 50 kW)
- Systems Engineering

- Military/Government Background: US Army, US Navy, NASA, SAIC, General Dynamics

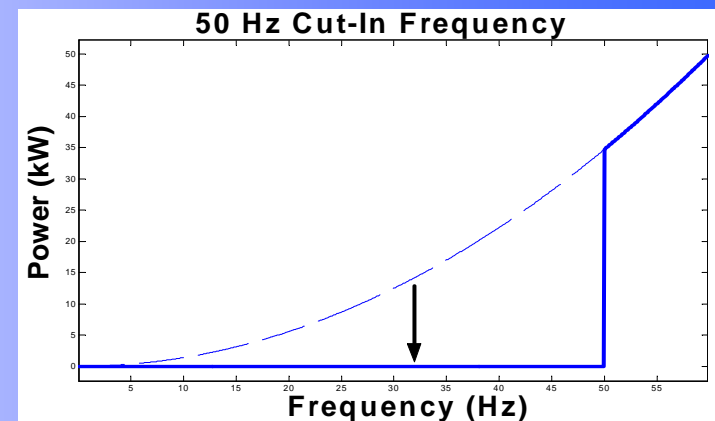
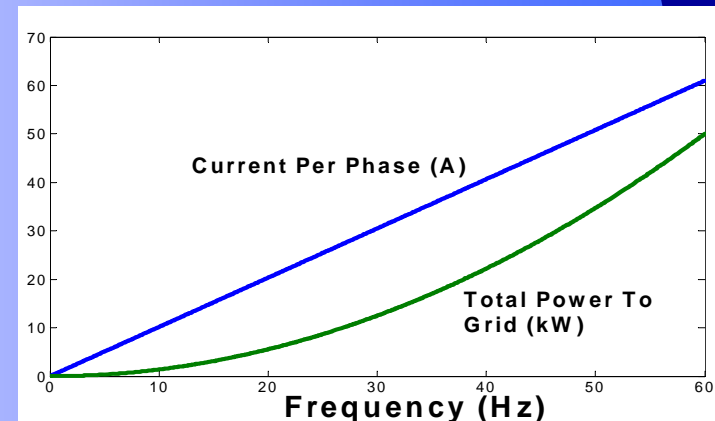
- Why Inverters?
 - Historically an unreliable, expensive part of wind systems
 - New materials technologies
 - Evolving grid-interconnect requirements
 - New turbine technologies



How a Turbine Works

Basic Electrical

- Wind turns the generator to create “wild” AC
- At high enough wind speed, inverter “cuts in”
- Inverter determines blade speed by controlling frequency and power draw



Technical Challenges

- Overspeed conditions
 - Cut-in “dump load”
 - Rate inverter to withstand voltage spike
 - Rate inverter to withstand brief power throughput
- Grid-interconnect standards (UL1741, IEEE1547)

Intermittency

- Utilities do not like unpredictable power sources
- Connection penalties
- Replaces “peaking” and “spinning reserves”
 - Mostly natural gas, diesel
 - Expensive, polluting
- Solution: energy storage
 - Utility can “demand” power (demand response)



Power Quality – Backup Power

- If the grid goes down, the power goes out
- Solution: energy storage
 - Inverter can supply loads “off grid”
 - Wind turbine charges the batteries

Bermuda: home
installation of solar, wind,
batteries



Future of the Technology

- Further integration with utilities
 - Demand response
 - Load shedding
- Many new turbine designs
 - Reliability?
 - Cost-effective?
- Greater penetration of intermittent resources:
problem for utilities



Key People

- **Darren Hammell** (dhammell@princetonpower.com : 609.258.9668)
 - Chief Executive Officer
- **Mark Holveck** (mholveck@princetonpower.com : 609.258.9678)
 - Chief Technical Officer
- **Erik Limpaecher** (elimpaecher@princetonpower.com : 609.258.9668)
 - Government Sales / Lead Controls Engineer
- **Independent Board Members**
 - Dr. Greg Olsen
 - Dr. Ed Zschau
 - Dr. Joe Stach
 - Dr. Rudy Limpaecher

