Micro Wind for Remote Sites

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My Definitions

Micro Wind

- 1,000 watts or less nominal power output

Remote Sites

- Inconvenient to access locations

Keys to Success: Use Solar

- Solar!
  - Reliable
  - Cheap
  - Easy
- Use wind when you can't get enough solar

Keys to Success:
Quality

- Buy darn good stuff
- Purchase price is always going to be cheaper than service cost or downtime

Keys to Success:
Plan for Stuff to Break

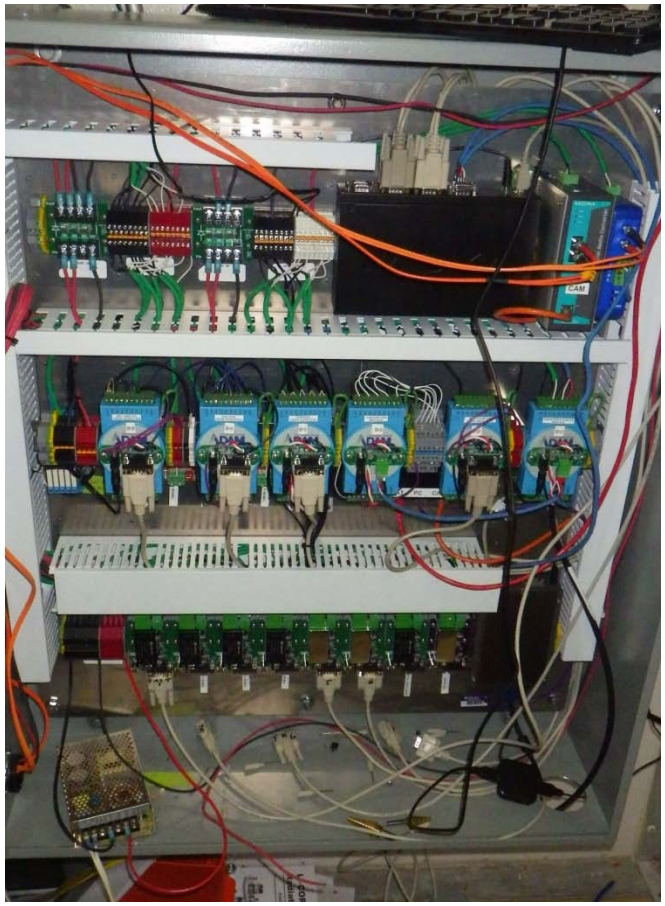
- Design with redundancy
  - but not the same components that break the same!
- Minimize single points of failure
- Don’t go overboard!

Keys to Success:
Die Gracefully

- When everything fails, don't destroy the battery bank
- Always incorporate low voltage disconnects
- Keep LVD power consumption ≈ battery self discharge rate

Keys to Success:
Keep an eye on things

- Monitor
  - system
  - environment
  - but don't go overboard
- Maintain
  - do preventative maintenance

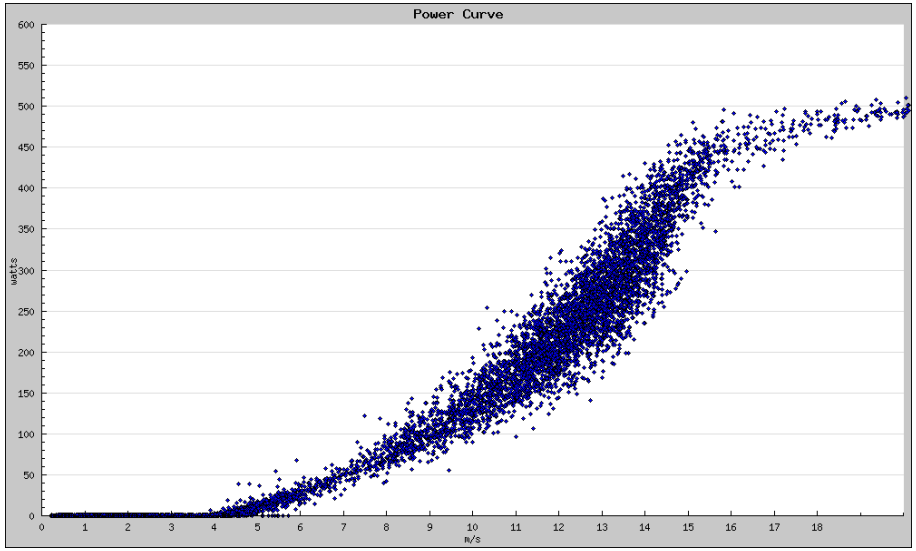


Keys to Success:
Design for Installation & Maintenance

- Minimize field time
- Keep records
- Bring the correct tools

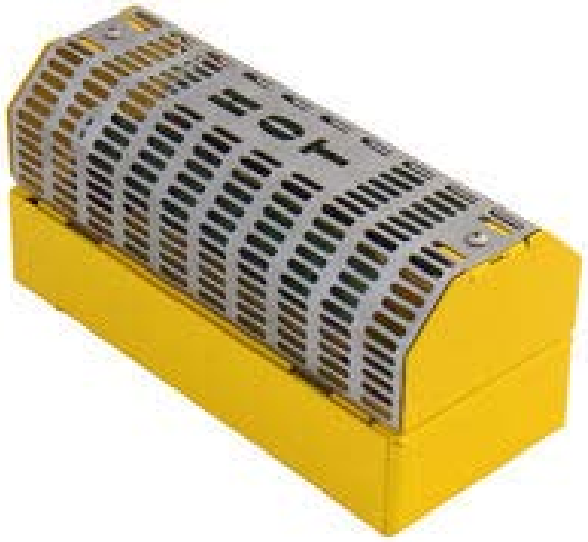
10 Second Technical: Turbine Selection

- Site wind speeds versus cut-out speeds
  - be sure to look at all time periods, not just annual averages
- Icing, salt water, extreme temperatures, etc
- Keep active electronics out of the turbine!



10 Second Technical: Make Use of Excess Power

- Indoor dump load and outdoor dump load
  - Heat building when needed
  - Satisfy redundant dump controller requirements
- Intelligent load control
  - turn on heaters, compress air, fill water tanks, upload data, etc
  - add useful loads
    - generator block & fuel
    - battery bank



Design for Transportation

- Select *economically* transportable components
  - Observe ATV, snow machine, helicopter, etc weight and size limits
  - If at all possible, use your customer's normal modes of site access.

Work in the easiest place possible

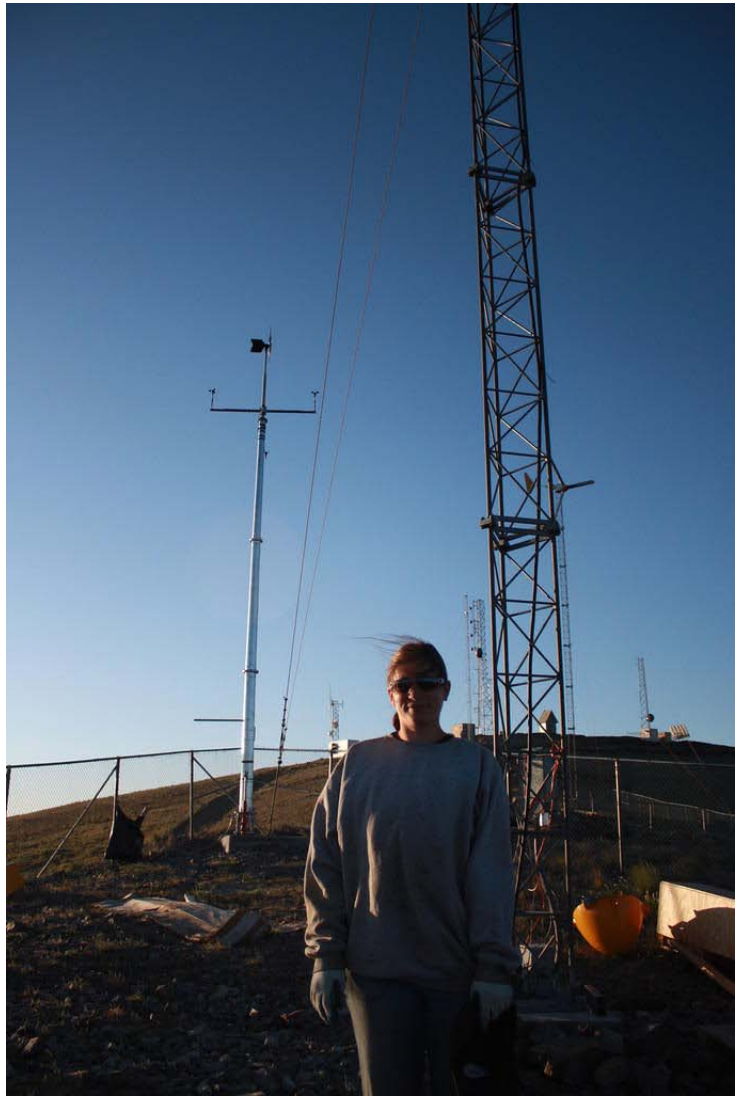
- Pre-build as much as you can in *your* shop
  - sub assemblies, wire harnesses, anything that requires small parts
  - select vendors that make easy to install products!
- Re-package parts and assemblies so they are easiest to handle in the field
  - packing peanuts or shredded paper at a wind site?
- On-site time is the most expensive time

This is no fun at 0°

More Tower? More Power? More $$$?

- Unique sites and unique considerations!

- What is wind shear coefficient here?

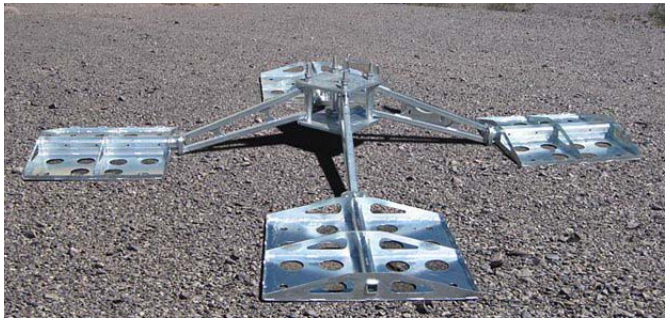


10 Second Technical: Towers

- Tower and foundation cost typically 2 to 10 times price of turbine
- Install time typically 20 to 100 times the install time of the turbine
- Consider mounting to existing towers or even roof mounting
- Optimize your tower selection!

10 Second Technical: Foundations

- Use what the site already has!
- anchor to existing concrete slabs or rock
  - acrylic adhesive is my favorite
- Consolidate available site materials into ballast for ballasted tower
  - rocks in a super sack
  - but do some math first



10 Second Technical: Controller Interactions

- Make sure multiple charge sources aren't fighting
  - don't allow fossil fuel generator to trigger wind dump load
  - don't dump while equalizing

10 Second Technical: Low voltage disconnects: use them!

- Use low voltage disconnects to prevent damage to your batteries in the event of power source failure
- Some turbines require no standby power and can be used to bring up a discharged battery
- Turbines with MPPT or other active controllers typically require battery power to operate and cannot charge a discharged battery.
  - make provisions for some other source to be able to bootstrap things

10 Second Technical: Telemetry

- Put remote monitoring provisions into your system
- Basic state of health data as minimum
- Consider “web” IP camera view of turbine and PV
  - decent quality outdoor web cameras are now <$500

IP Camera Example

6:09PM

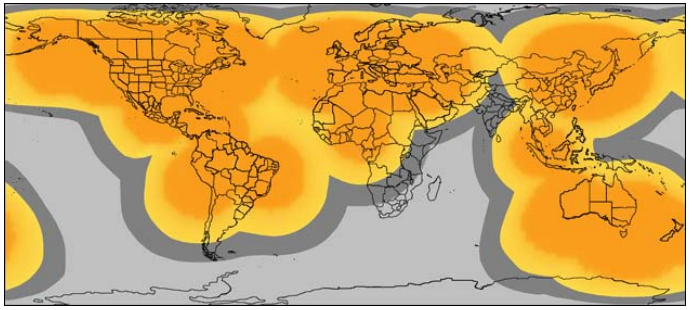
6:10PM

IP Camera Example, Continued

What I found

Telemetry - Satellite

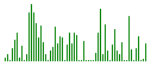
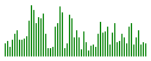
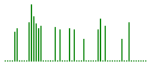
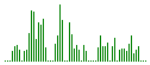
- APRS World / SPOT Satellite Telemetry
  - Globalstar network
  - Low cost SPOT network
  - <$400 hardware & <$100 year data
  - 6 hour highly compressed message with
    - Wind speed / gust / average
    - Turbine RPM / average RPM / current
    - Temperature
    - Dump Load kWh, duty cycle, battery temperature
    - Battery Voltage



Satellite Telemetry Data Website

Example of "live" data:

Data Date:	2013-04-02 00:01:07 UTC Report received 04:40:49 (hours:minutes:seconds) ago.
Historical Data:	All Historical Data
Dump Load **All values are reported by TriStar and not independently measured.**	
Battery Voltage:	24.4 
kWh Dumped:	38 
Duty Cycle:	0% 
Battery Temperature:	16°C / 60°F 

Environmental	
Wind Speed from Anemometer 0:	4.2 m/s / 9.4 MPH 
Wind Speed from Anemometer 1:	0.0 m/s / 0.0 MPH
Wind Gust from either Anemometer:	8.4 m/s / 18.8 MPH 
Turbine RPM:	0 RPM 
Turbine Gust RPM:	0 RPM 
Turbine Current:	1.8 amps 
Outdoor Ambient Temperature:	10°C / 50°F 

Example of historical data:

February 2013										
Date (UTC)	**Dump Load**				**Environmental**					
	Voltage	**kWh Dumped**	**Duty Cycle**	**Battery Temp**	**AN0**	**AN1**	**Gust**	**RPM**	**Max RPM**	**Outdoor Temp**
2013-02-10 12:06:35	30.2 VDC	34 kWh	55%	1°C / 33°F	8.8 m/s / 19.6 MPH	0.0 m/s / 0.0 MPH	28.9 m/s / 64.7 MPH	1061 RPM	3870 RPM	-7°C / 19°F
2013-02-10 00:00:37	29.9 VDC	34 kWh	72%	6°C / 42°F	17.2 m/s / 38.5 MPH	0.0 m/s / 0.0 MPH	25.0 m/s / 56.0 MPH	2033 RPM	3636 RPM	-5°C / 22°F
2013-02-09 06:00:37	25.9 VDC	34 kWh	0%	4°C / 39°F	0.5 m/s / 1.2 MPH	0.0 m/s / 0.0 MPH	12.3 m/s / 27.5 MPH	0 RPM	1132 RPM	-1°C / 29°F
2013-02-08 18:00:37	28.5 VDC	34 kWh	1%	5°C / 41°F	4.1 m/s / 9.1 MPH	0.0 m/s / 0.0 MPH	13.1 m/s / 29.4 MPH	805 RPM	1212 RPM	8°C / 46°F
2013-02-08 12:00:38	24.9 VDC	34 kWh	0%	-1°C / 30°F	0.0 m/s / 0.0 MPH	0.0 m/s / 0.0 MPH	4.1 m/s / 9.2 MPH	0 RPM	0 RPM	-5°C / 22°F
2013-02-08 06:06:35	25.0 VDC	34 kWh	0%	4°C / 39°F	1.7 m/s / 3.9 MPH	0.0 m/s / 0.0 MPH	4.1 m/s / 9.2 MPH	0 RPM	0 RPM	-4°C / 24°F

MRO

- Do regular scheduled maintenance
- Consider pre-emptive replacement of batteries and micro turbines

Conclusions

- Use solar!
- Use the best parts with best track record
- Monitor and maintain system
- Plan, plan, plan

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