Control of a Hybrid Energy System

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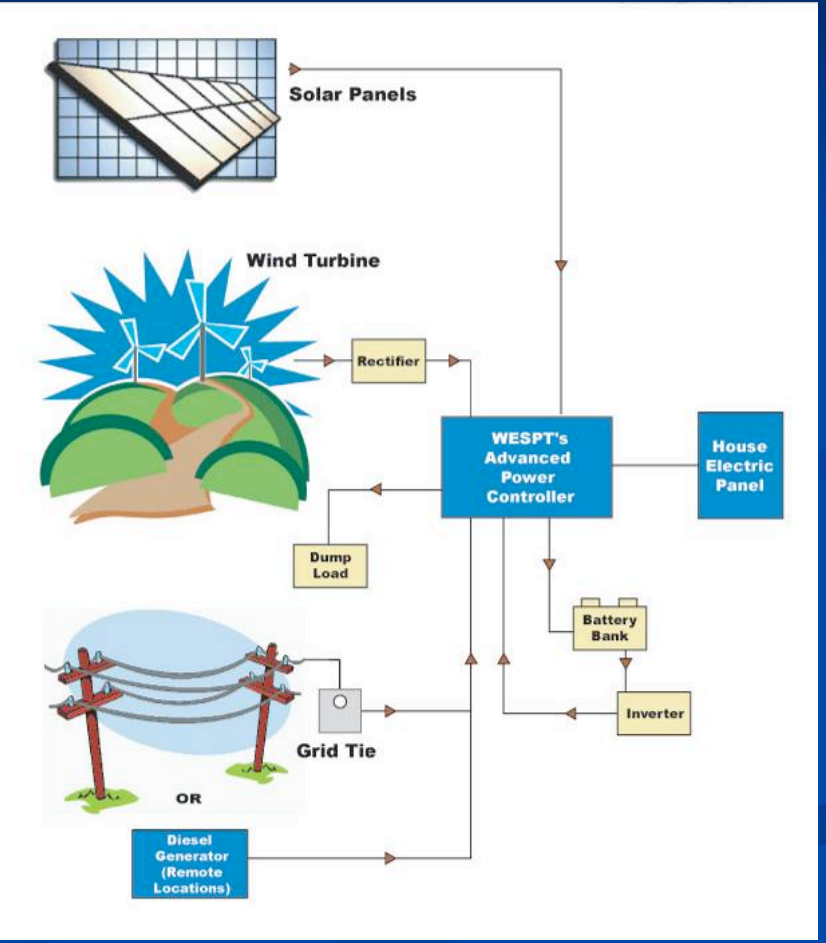
Outline

- Introduction
- Background
- Problem
- Design Methodology Research
- Design Overview
- Results
- Conclusions
- Recommendations

Introduction

- Effective way to combine multiple renewable energy sources
- What is a hybrid energy system?
  - Wind
  - Solar
  - Tidal
  - Micro-Hydro
  - Etc.



Introduction

Today's Hybrid System

UNSTABLE AC and/or DC Power …

Solar Panels

Wind Turbine

Grid Power

Requires STABLE AC Power

Net Metering

Cabin or Home or Boat Electrical Panel

Introduction

- Small wind less than 10kW
  - My research deals with micro small wind up to 1500watts and 1000 watts of solar
  - Most common for cabins, boats, peak shaving systems in residential locations, and total power production in developing nations

Background

- Increasing demand for alternative power
  - Energy shortage
  - Power distribution problems
  - Kyoto Protocol
  - Rising cost of fossil fuel
  - Incentives
  - Green Movement

Background

- Current solutions
  - Controllers that perform one function
  - Controllers that can do both wind and solar
    - Can only combine small amount of solar
    - Not entirely reliable
    - Will only work with one brand of turbine
    - Typically wind companies have built in some solar control
    - Solar companies have no wind control

Problems

- Many technical issues with hybrid systems
  - High variability in resource, e.g. wind, sun
  - Many components required
  - "Hybrid systems have a 65% or more failure rate, with failures due to components failing, poor maintenance, ..." (Vaughn C. Nelson, 2002)
  - Lack of monitoring of system
  - History logging
  - Remote communications

WIND TURBINE

BEFORE

AFTER

WT Control

Battery Bank

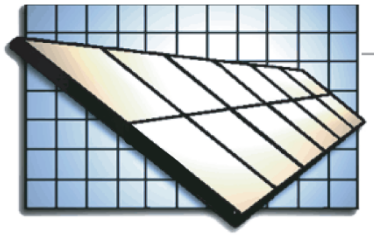
Charger

Solar Control

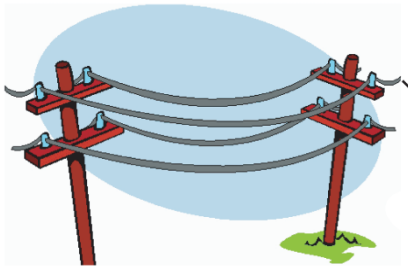
Dump Load

Monitor

HOUSE ELECTRIC PANEL



SOLAR PANELS



GRID

INVERTER

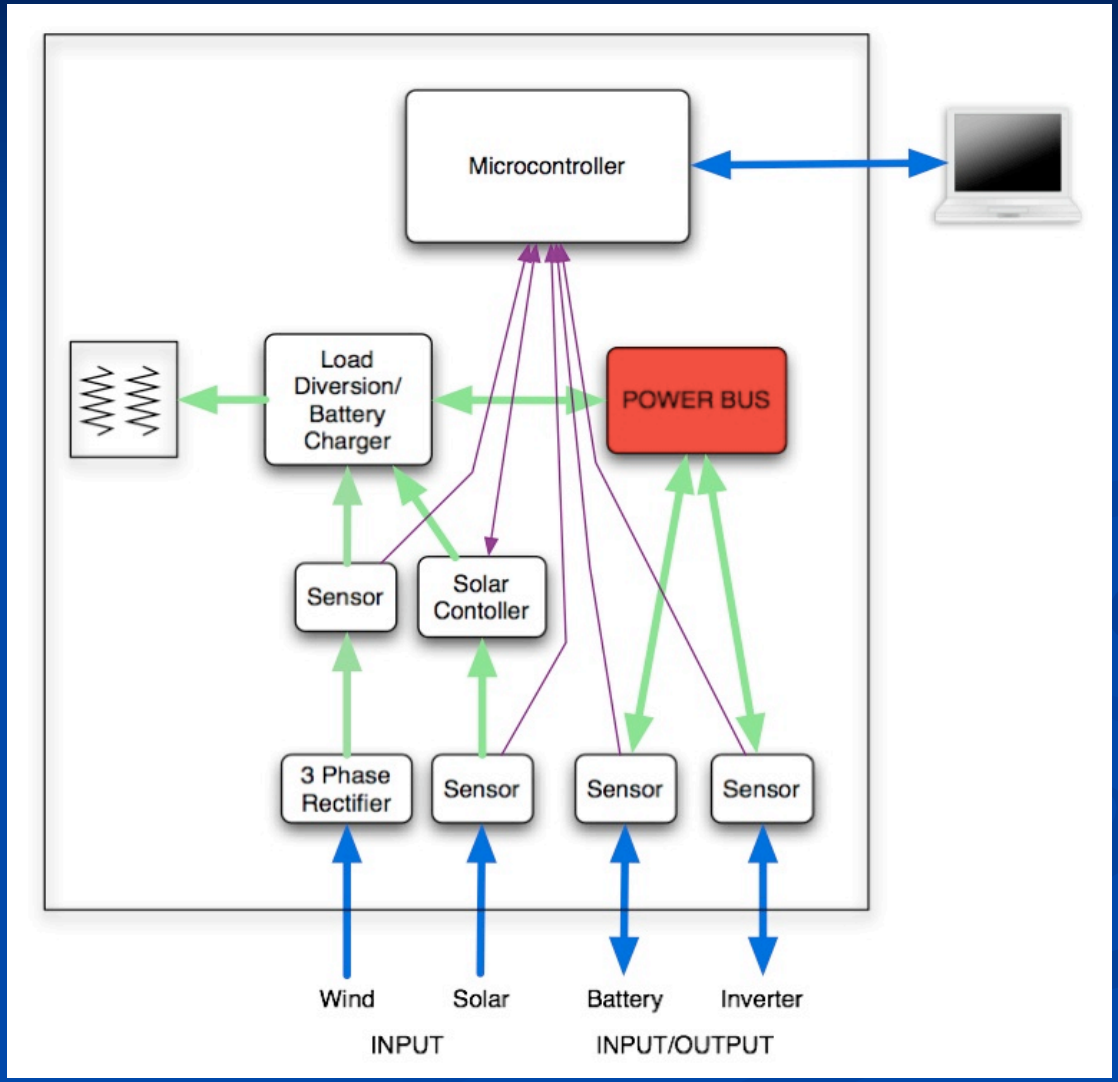
Diesel Generator (remote locations)

ARCS1000

Design Methodology

- Goals to achieve
  - Reliability
  - Efficiency
  - Integration
  - Component number
  - Flexibility
  - Functionality
  - Convenience

Design Methodology

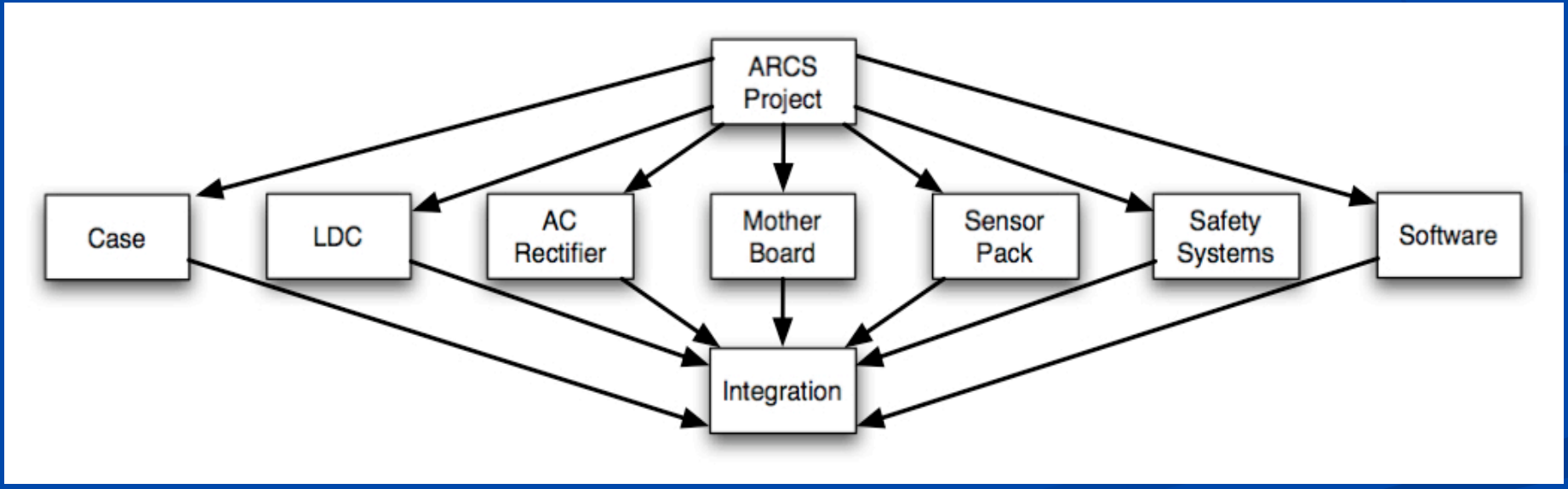


Design Methodology

- System design overview
- Design of each system block
- Implementation
- Testing
- Integration
- System testing

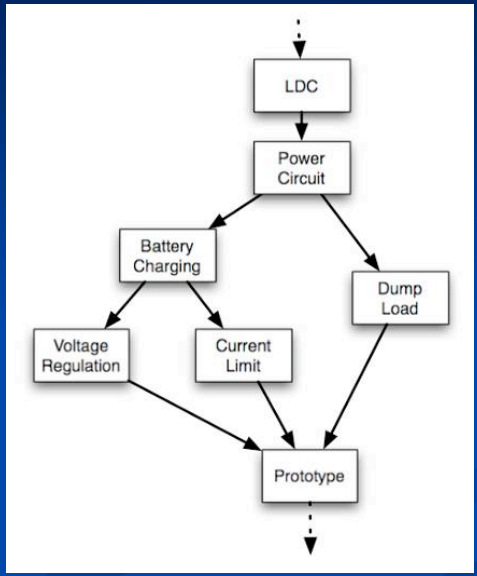
Design

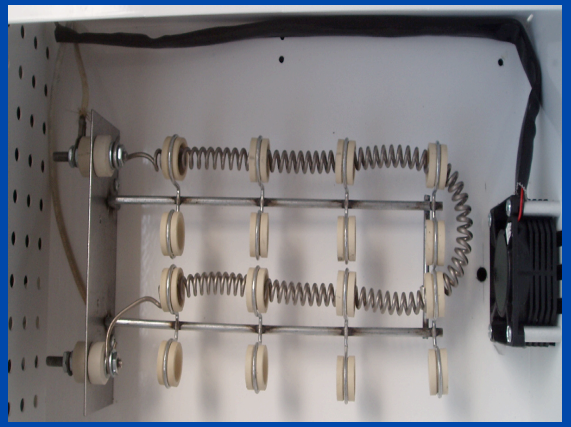
- ARCS (**A**utonomous **R**enewable **C**ontrol **S**ystem)

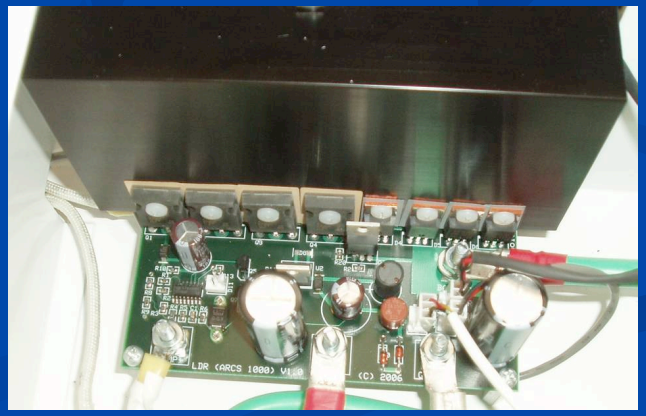


Design - LDC

- Load Diversion Control
  - Charge lead acid batteries
  - Keep wind turbine under control
    - Load at all times
  - Integrate solar energy

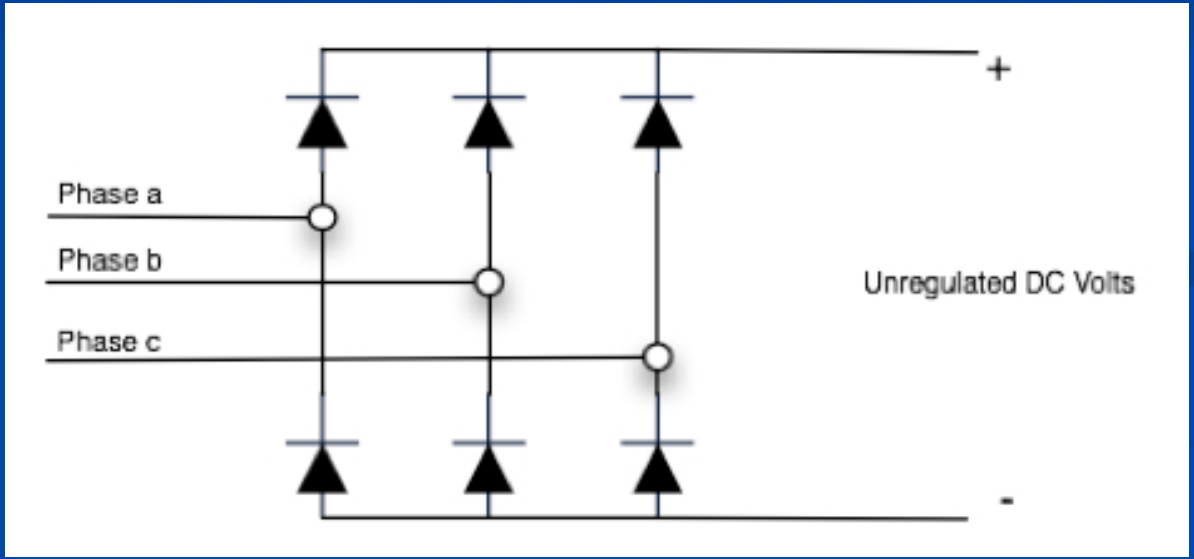


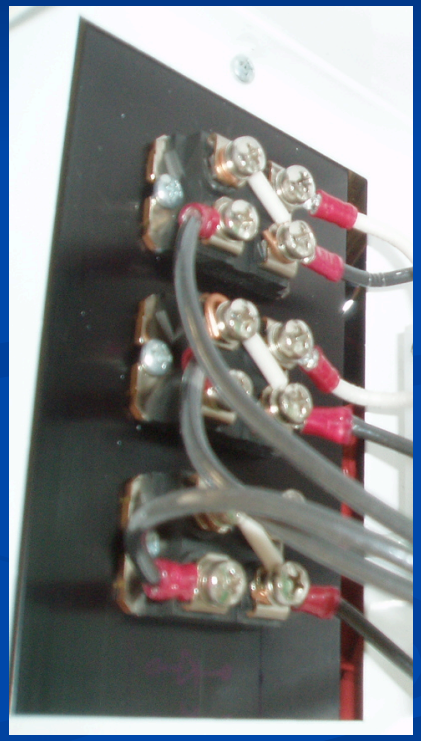




Design – AC Rectifier

- Three phase full bridge rectifier

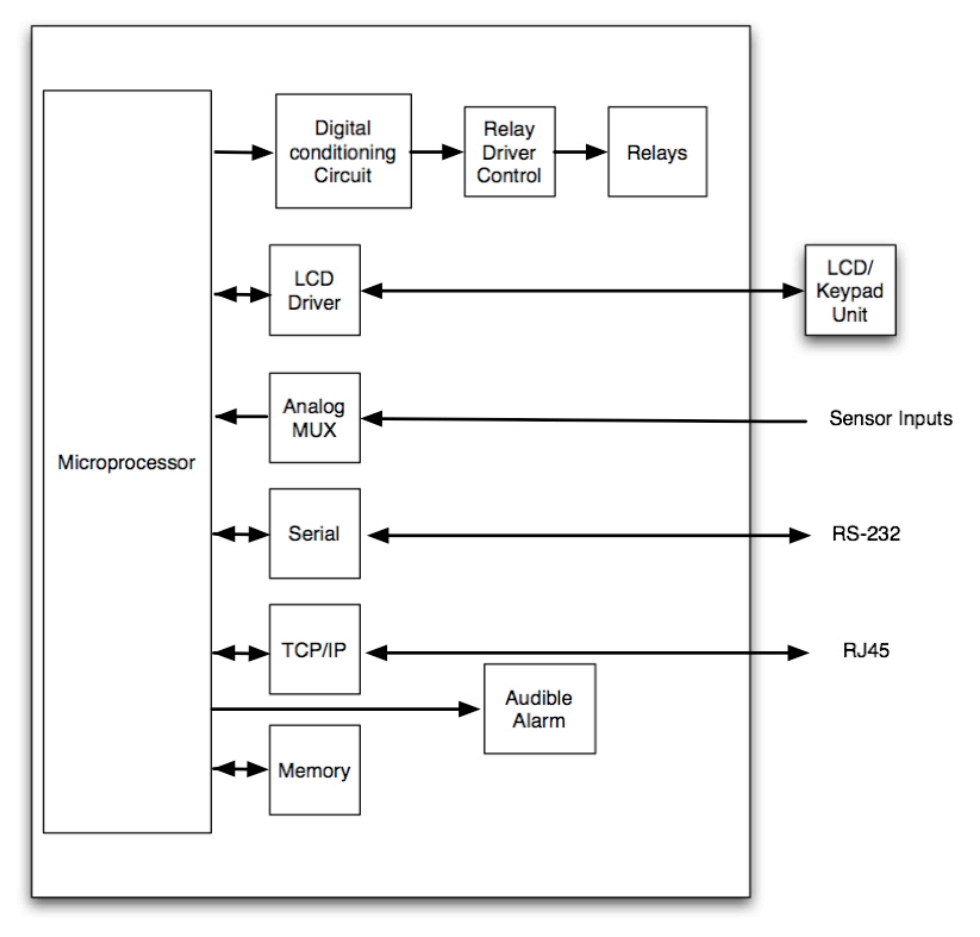




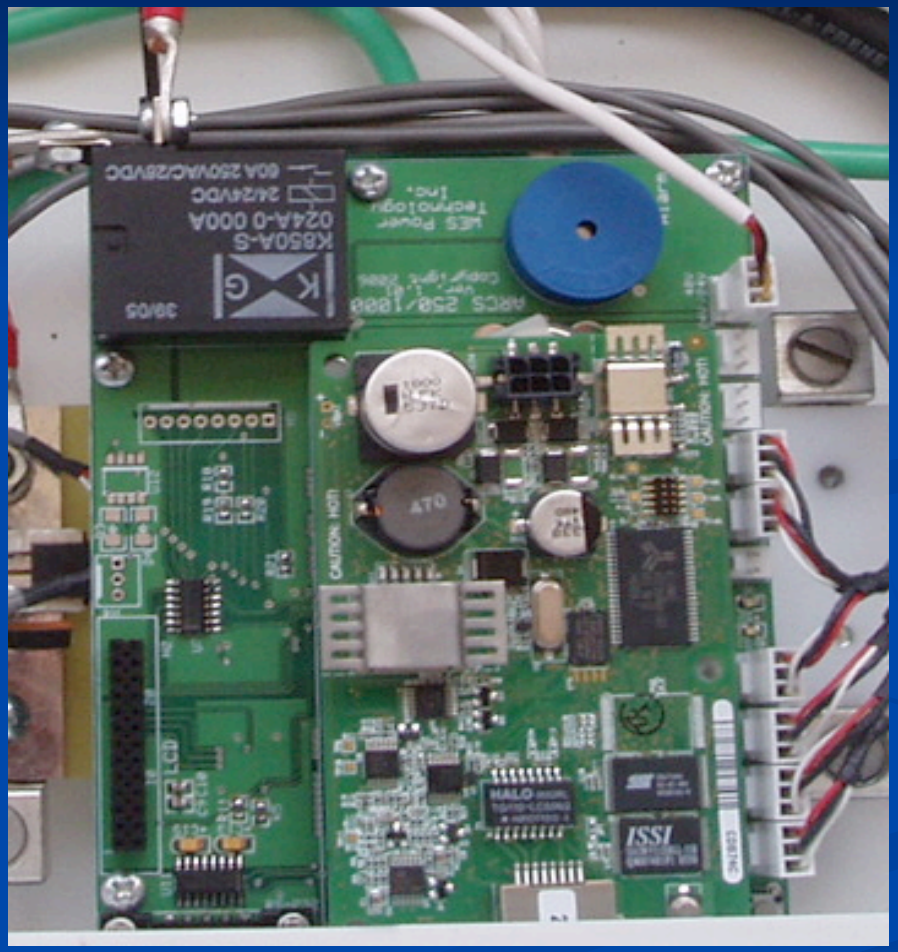
Design - Motherboard

- Data acquisition
- Storage
- User interaction
- Solar control
- LDC interaction

Design - Motherboard

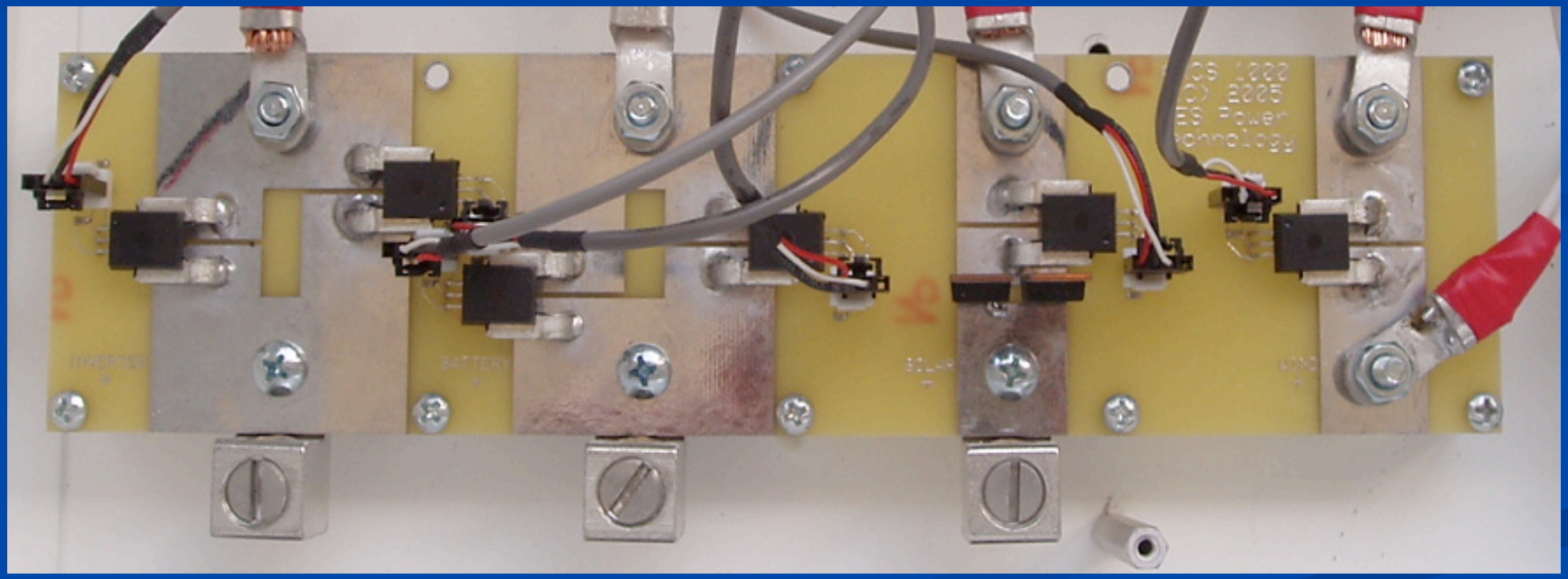


Design - Motherboard



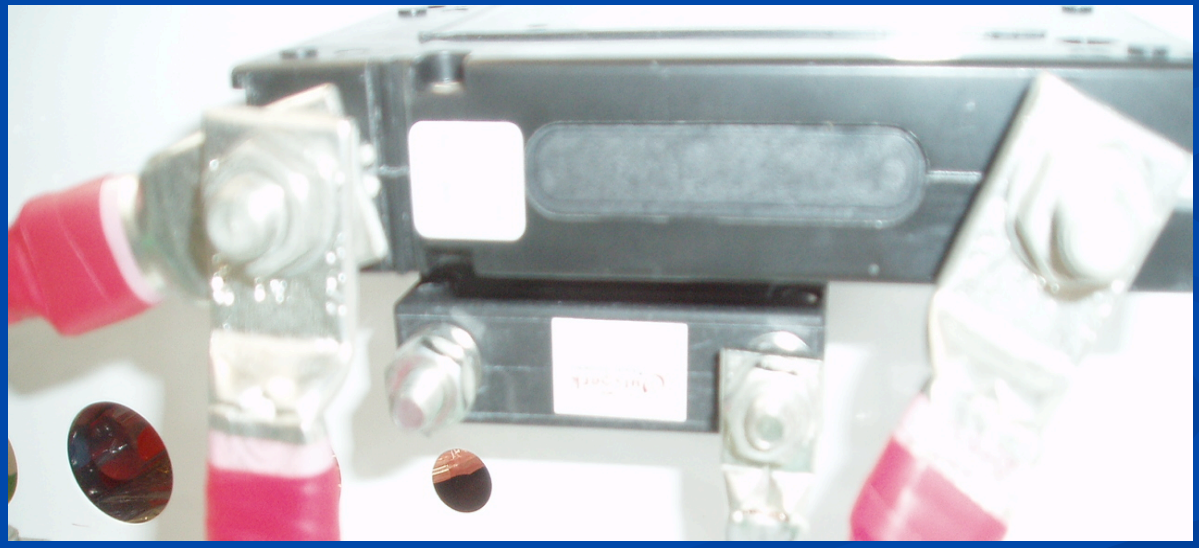
Design – Sensor Pack

- Measures current of all components of system

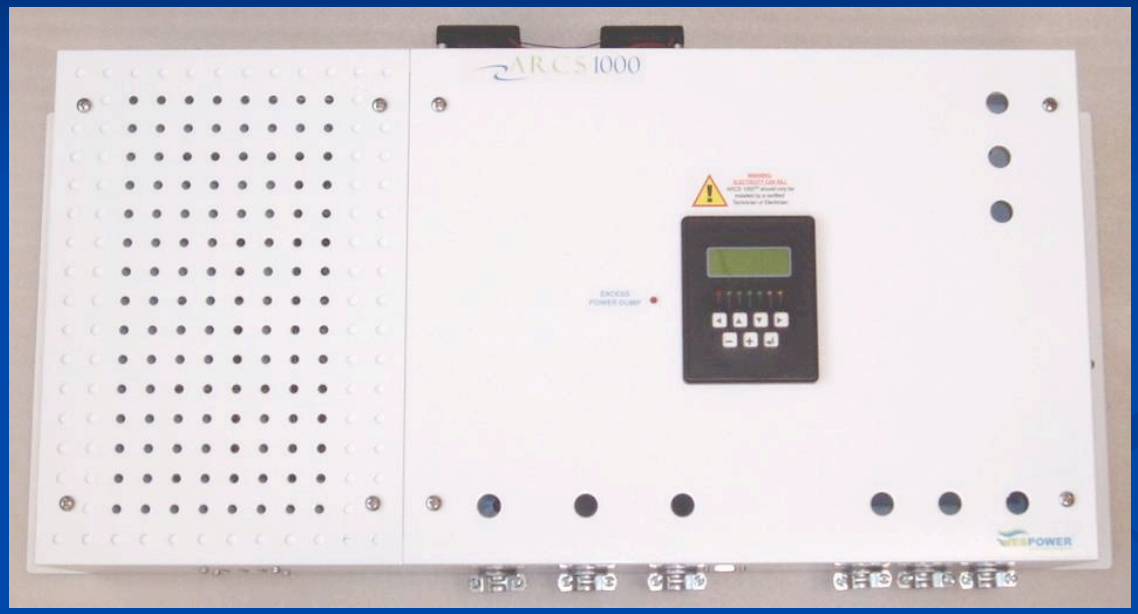


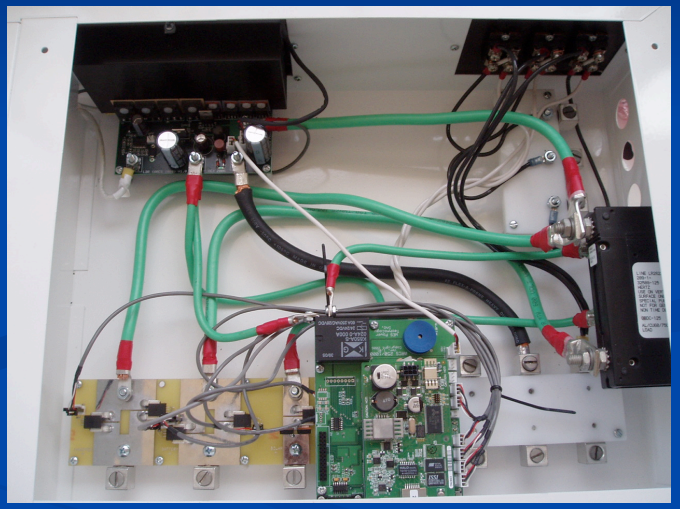
Design - Safety

- Safety systems are critical for all electrical systems
  - Breakers for over current protection
  - Circuitry for voltage protection

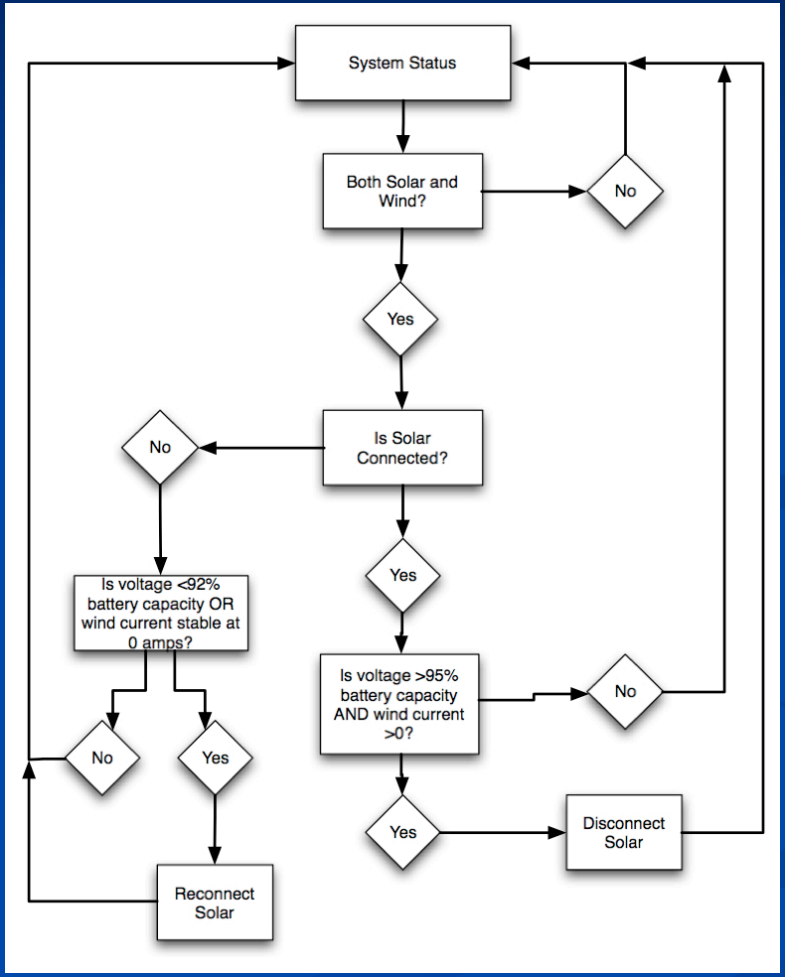


Design - Case





Design – Solar Algorithm



Design - Software

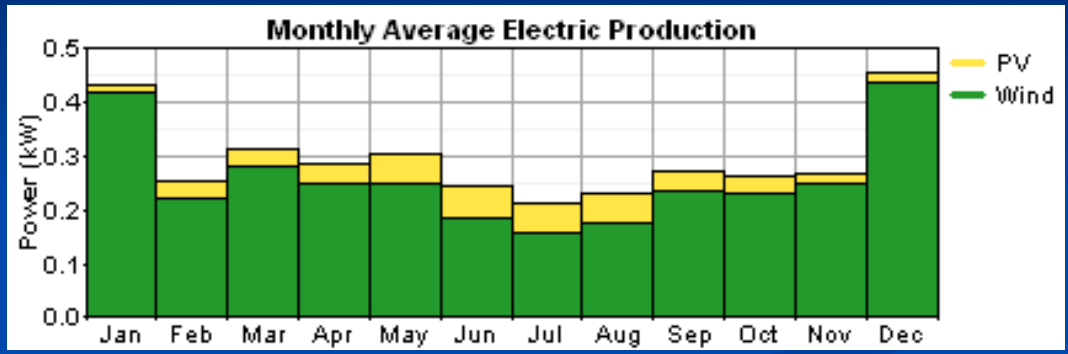
- Control algorithms
- User interaction
- Graphical user interface for unit and PC
- Firmware/ Software

Test System

- Southwest Windpower - Whisper 200
- Evergreen Solar – two 110 watt panels
- Xantrax – SW5548 inverter
- Nautilus lead acid batteries

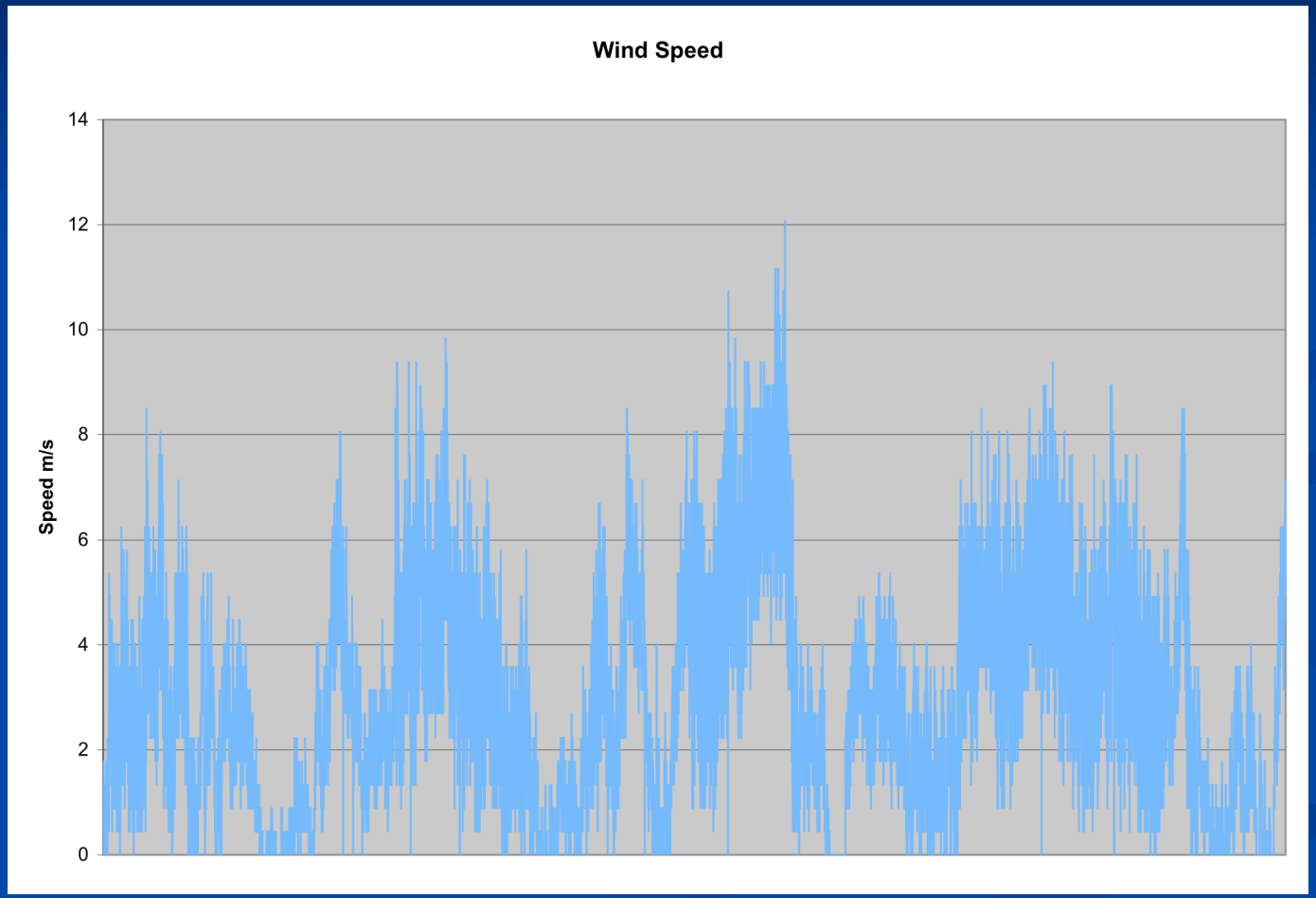
Results

- Average expected monthly production

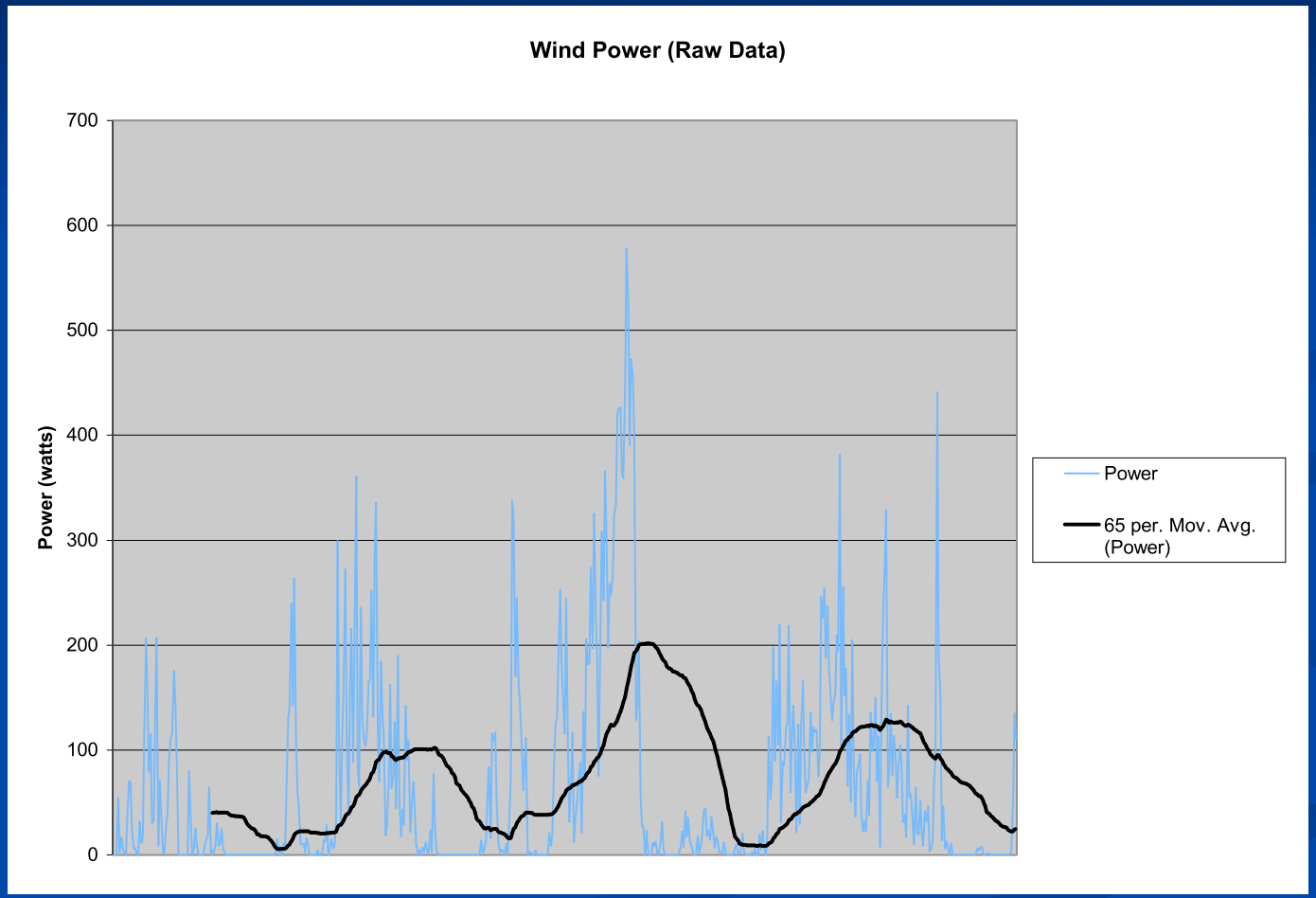


Component	Production (kWh/yr)	Fraction
PV array	328	13%
Wind turbine	2,266	87%
Total	2,594	100%

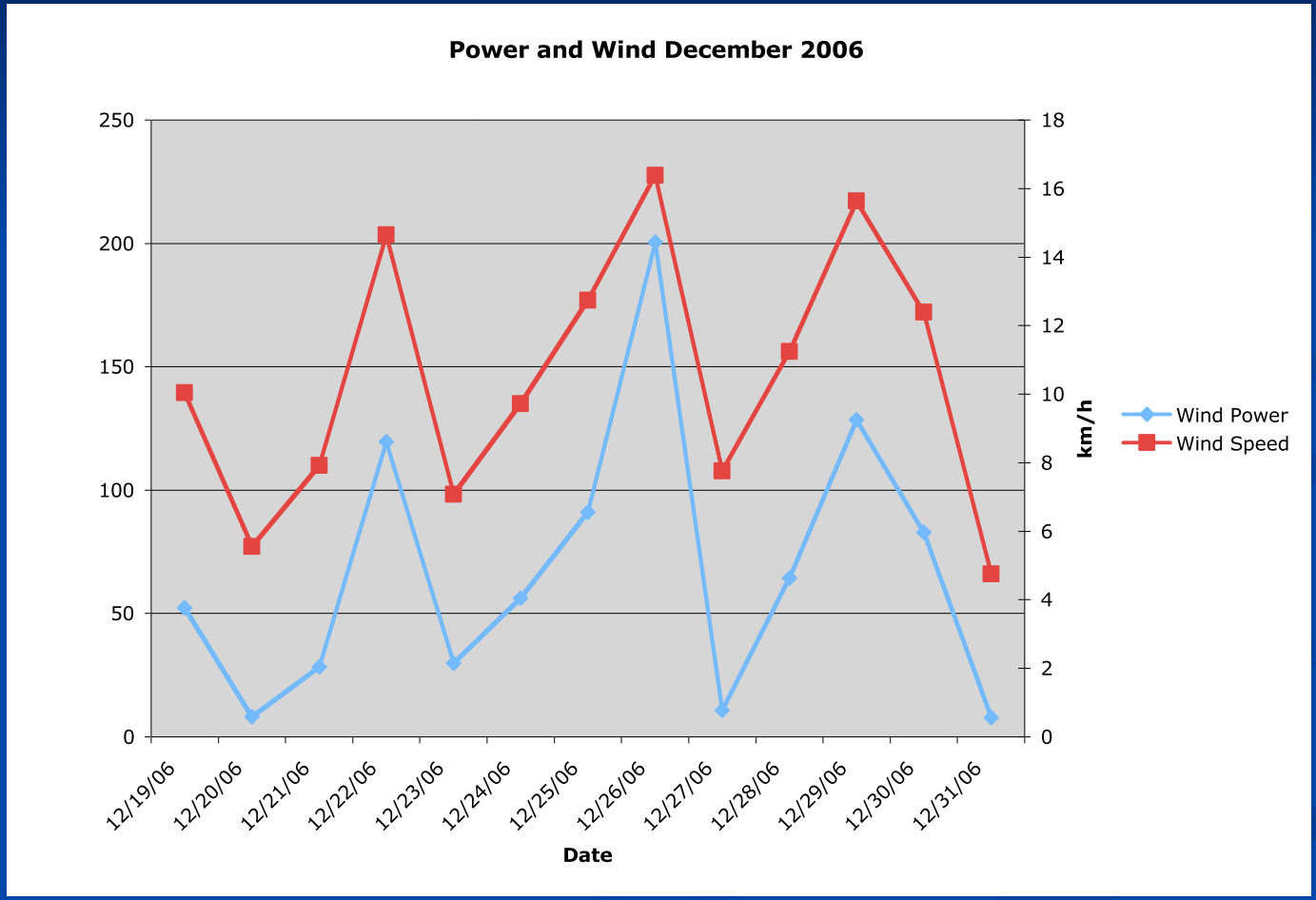
Results



Results

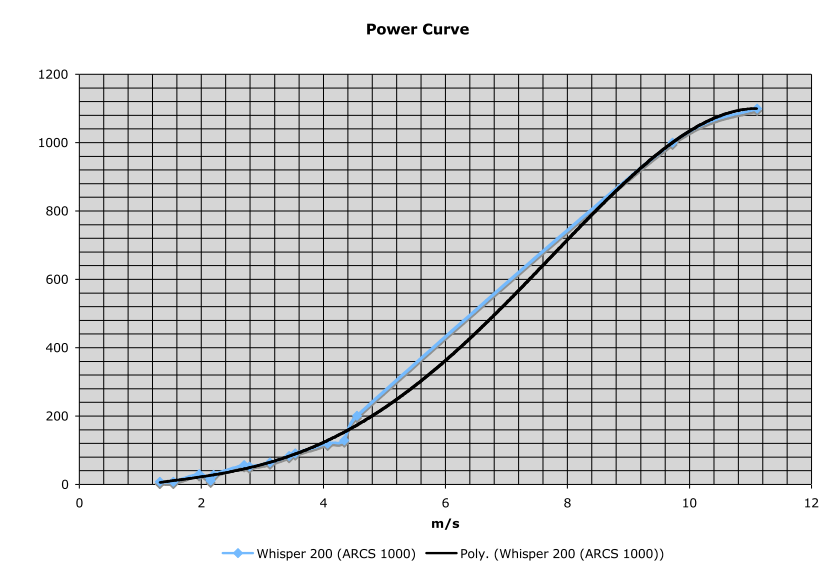


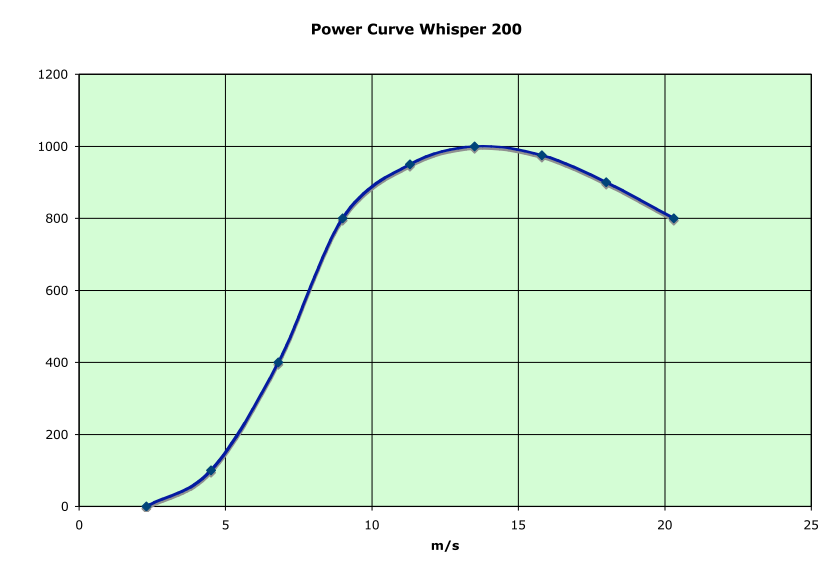
Results



Results

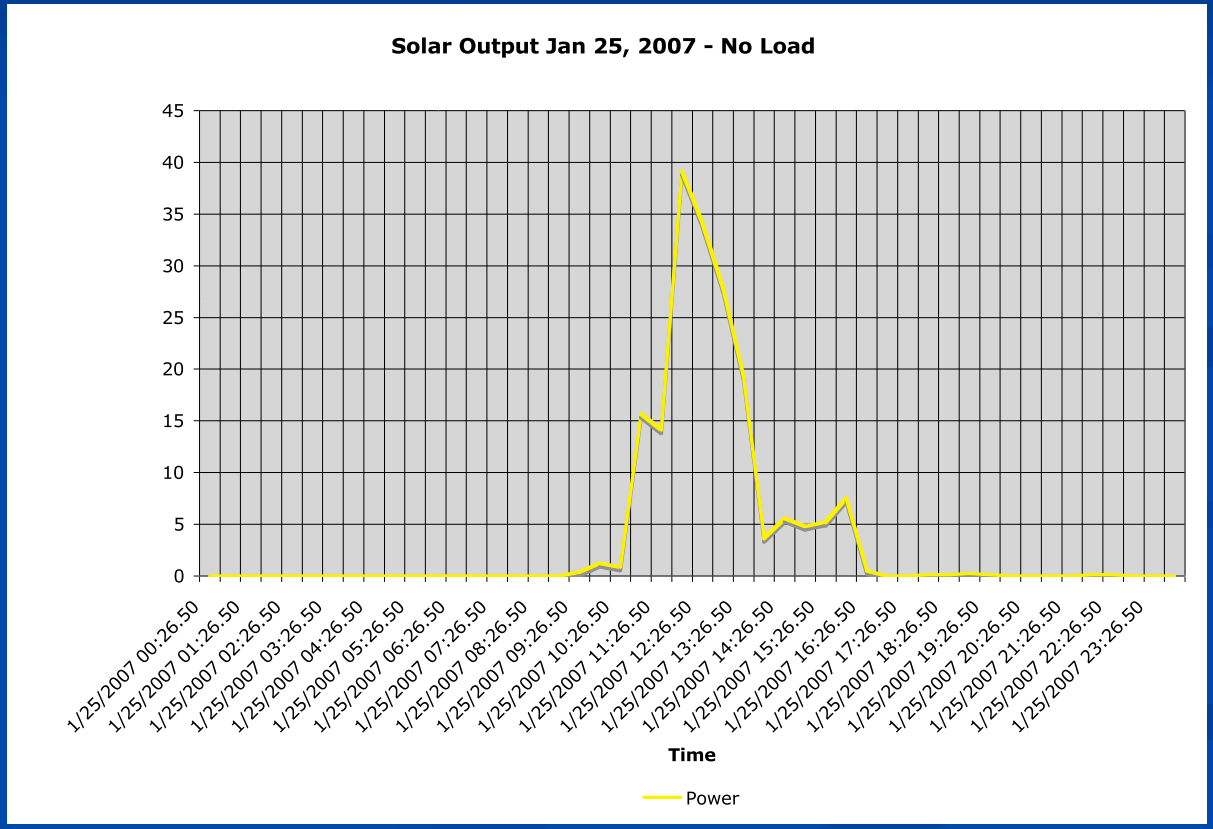
- Power Curve Measured vs. factory





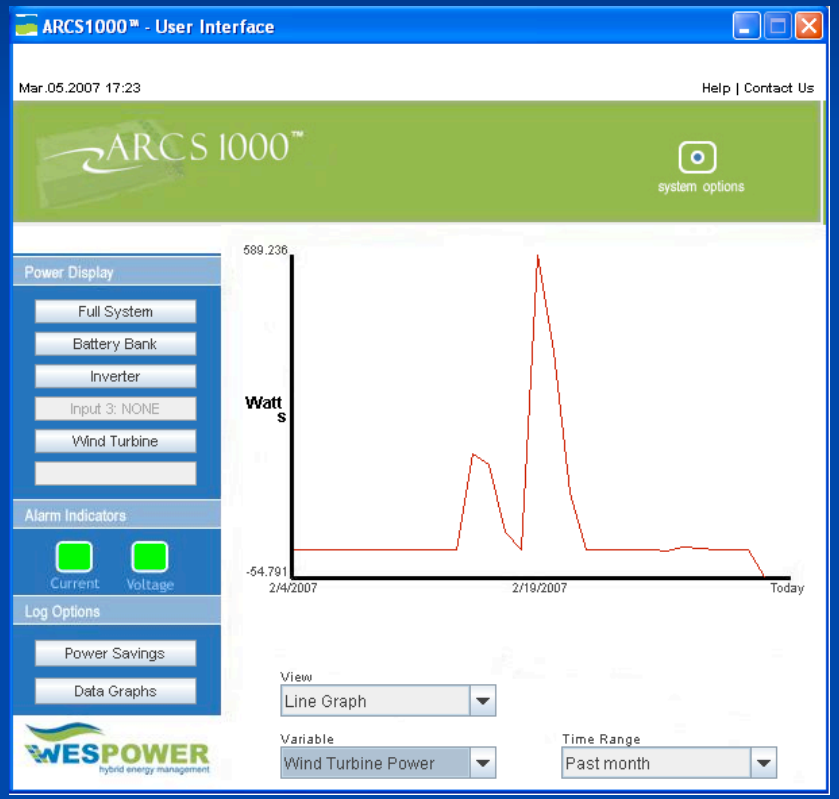
Results

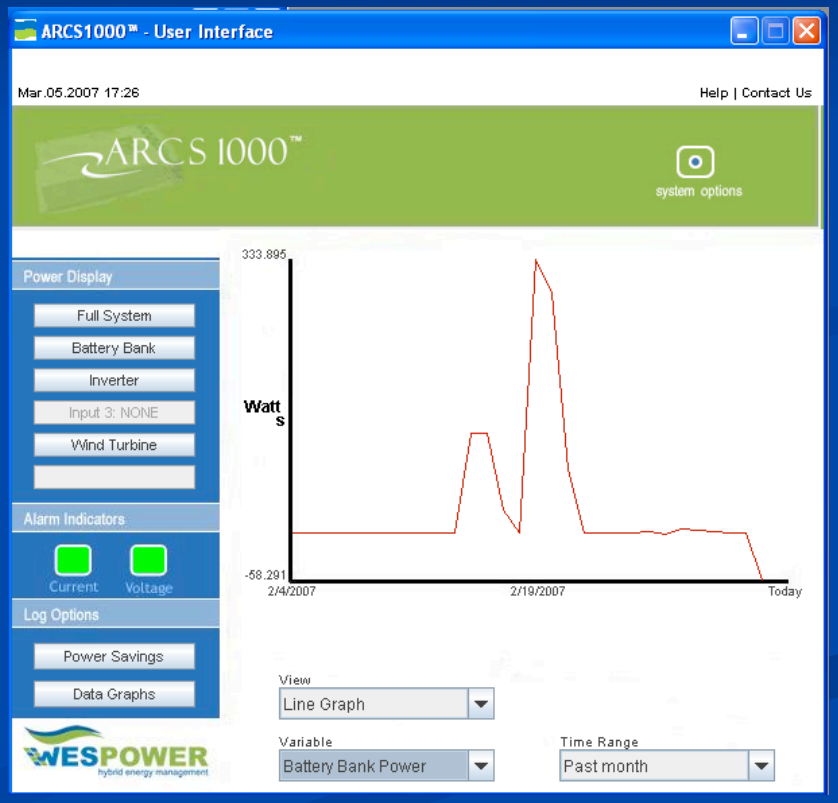
- Solar Data



Results

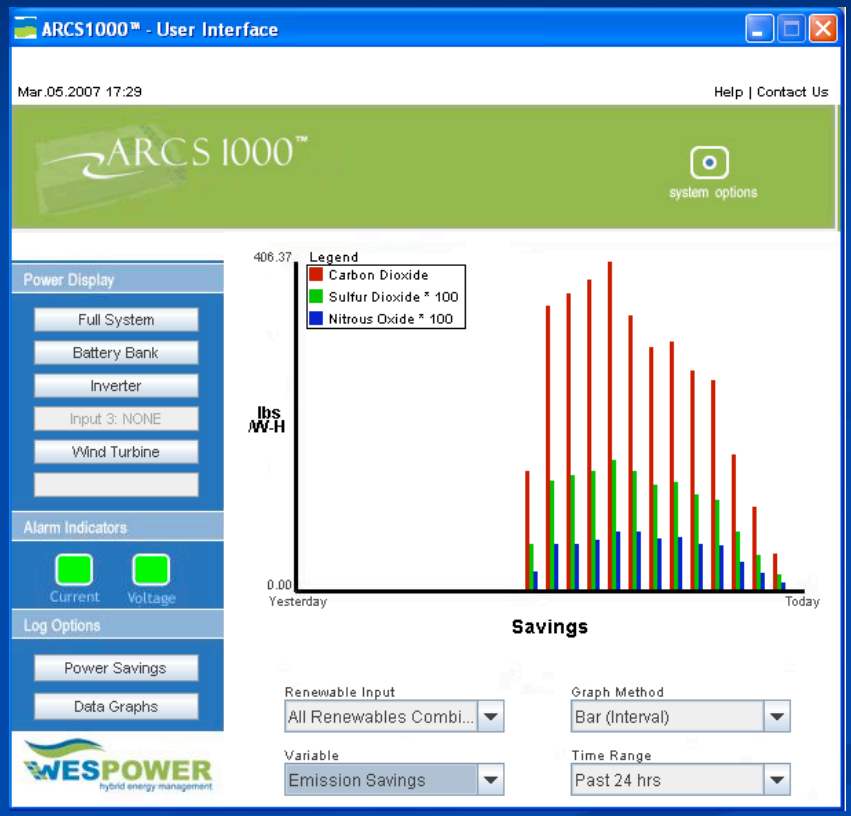
- Wind Power and Battery Power





Results

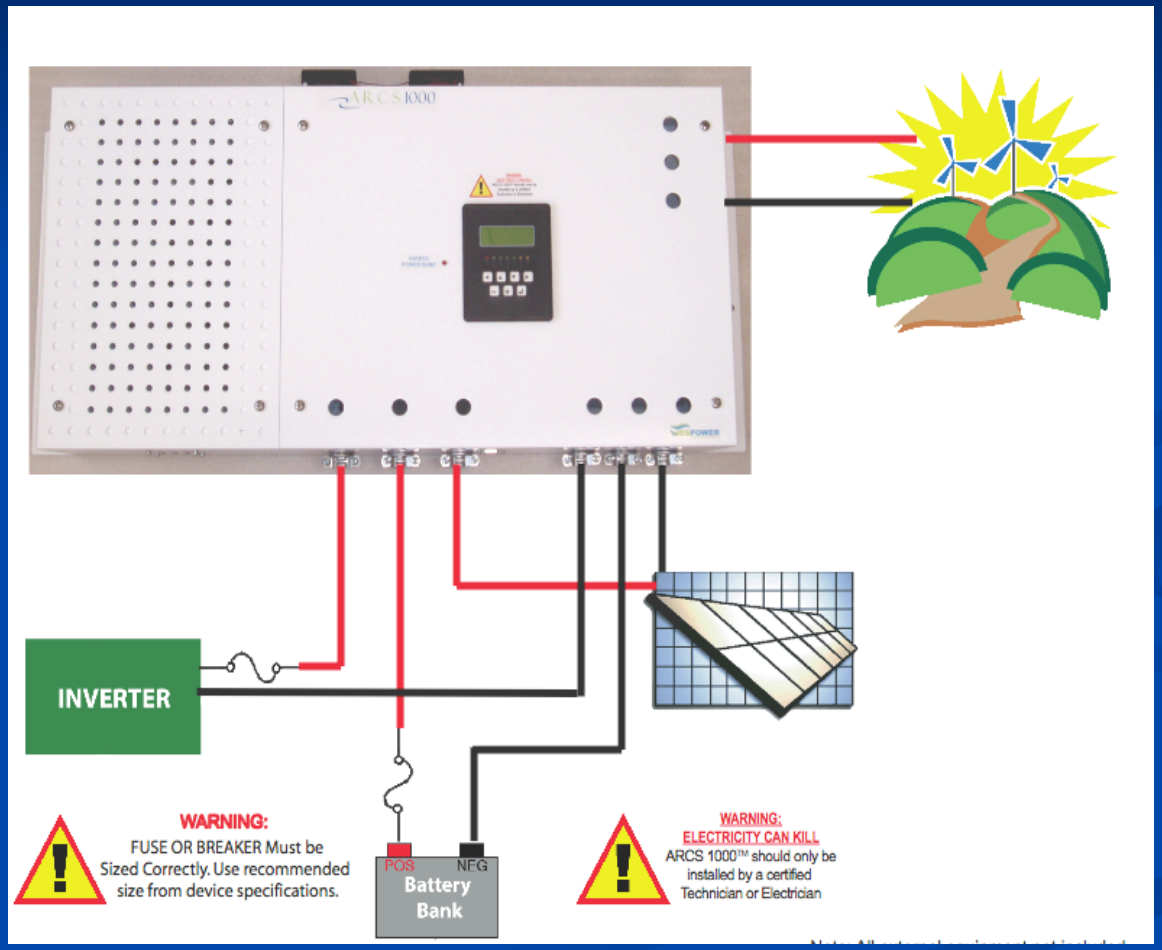
- Track power production, cost savings, GHG emission savings



Conclusions

- Effectively combined wind and solar
- Increased power curve of wind turbine
- Allowed significant addition of solar power
- Increase reliability
- Tracked history and made data portable
- Increase in safety and usability

Conclusions



Recommendations

- Interaction with the grid
- Different turbines and solar arrays
- Multiple control schemes

Many thanks to:

Dr. Neil Bose, Tariq Iqbal, Philip Crowley, David Green, MUN, WES Power Technology Inc., and NRC

Thank you

Questions/Discussion