Village Power Systems

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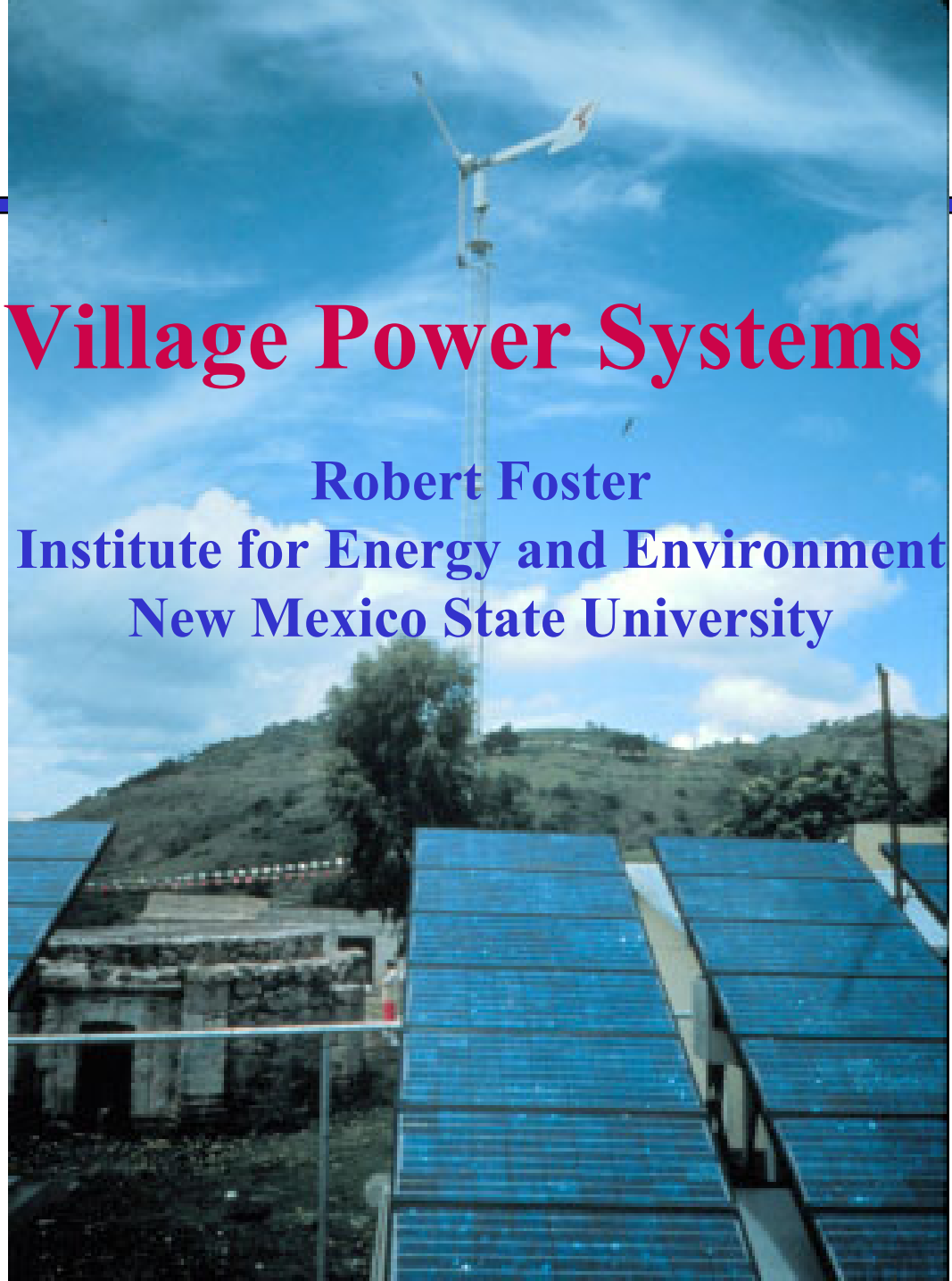


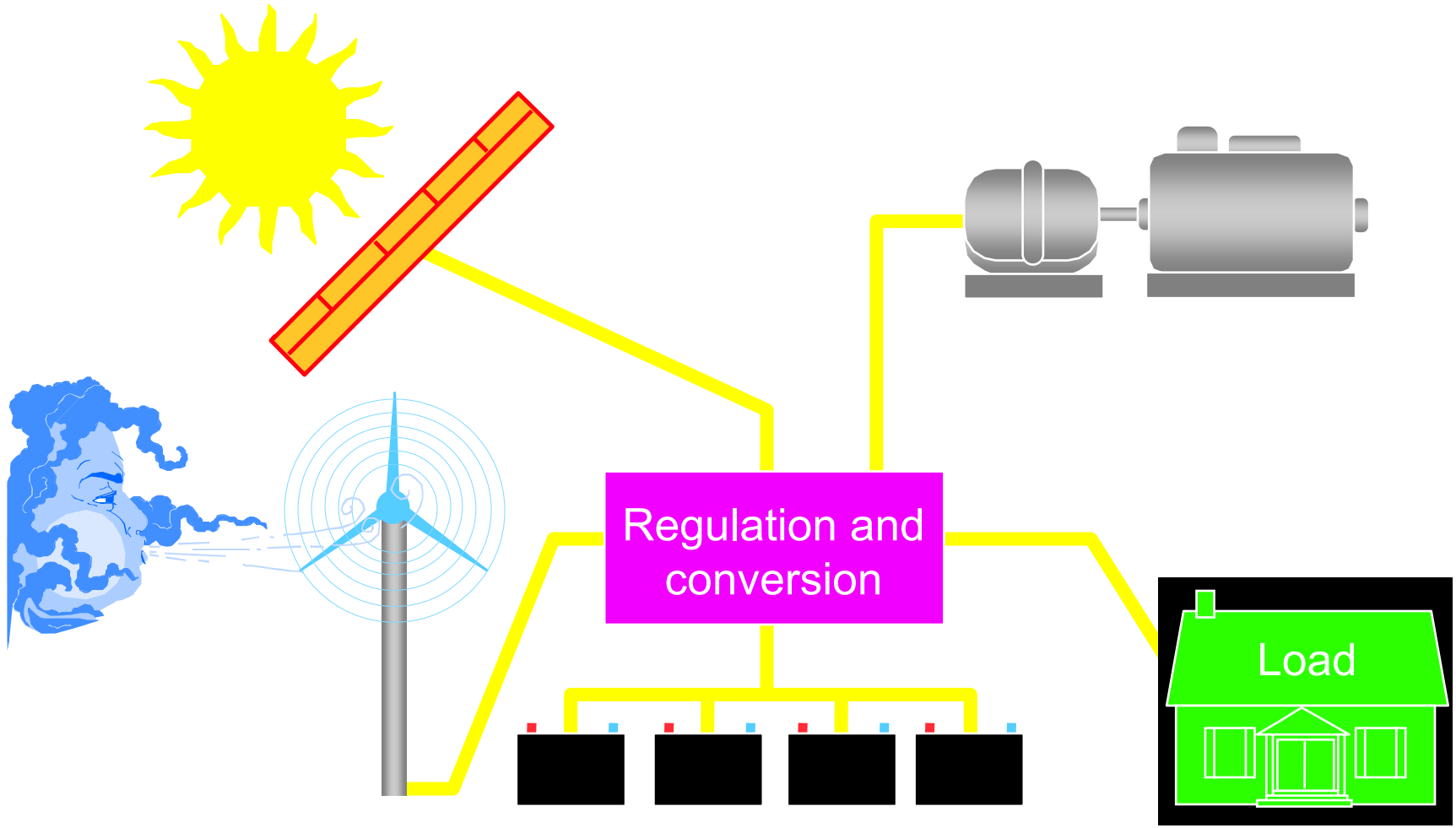
WEATS 2006
NREL-NWTC
August 8

Village Power Systems

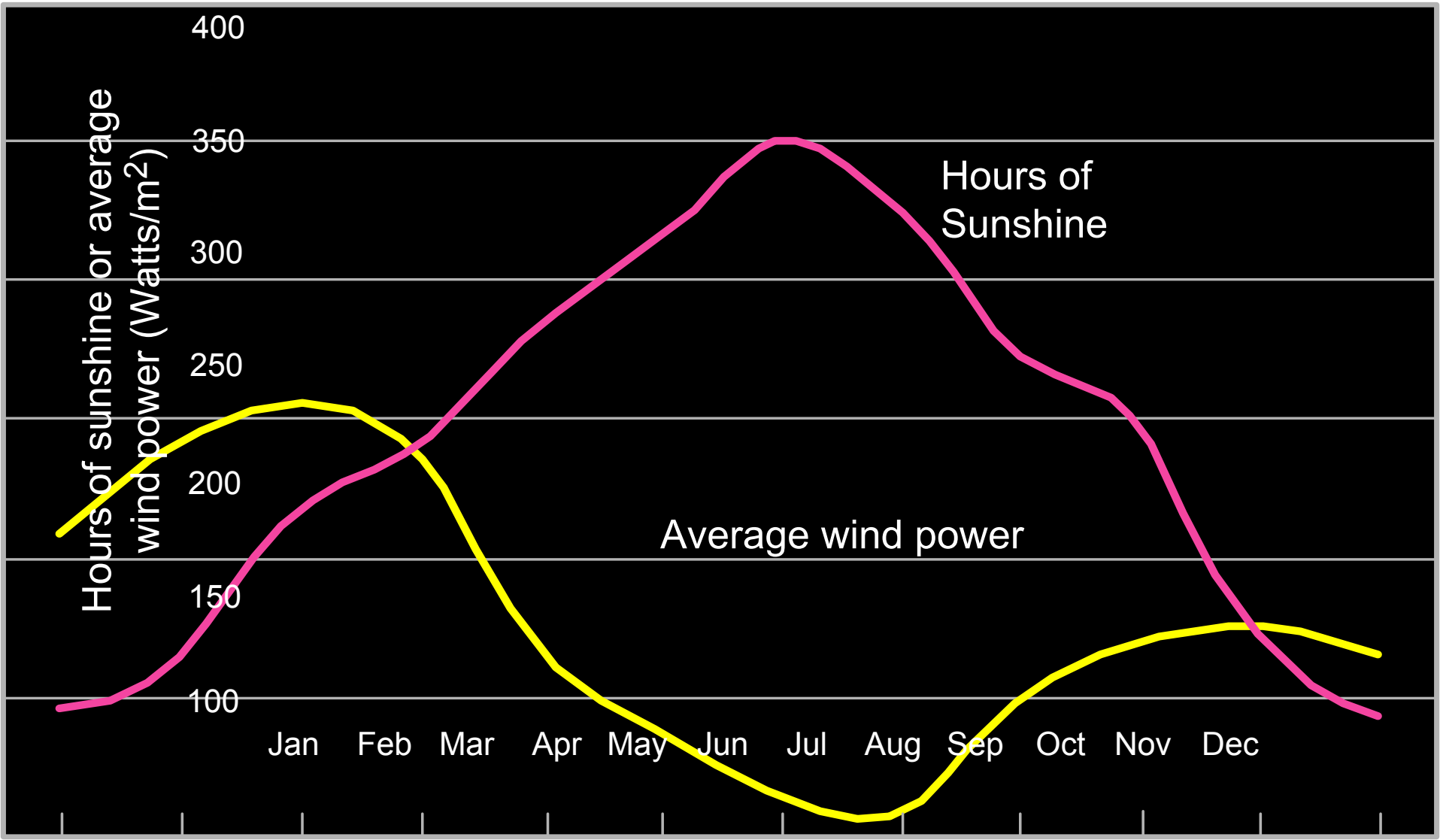
- **Village Power Systems:** Providing power to a whole community from a central production point.
  - Traditional means of providing power have been through expensive grid extension or diesel generators with expensive O&M, environmental, and volatile fuel costs.
- **Hybrid power systems** use local renewable resource to provide power.
  - Village hybrid power systems can range in size from small household systems (100 Wh/day) to ones supplying whole communities (10's MWh/day).
  - Combine different technologies to provide reliable power tailored to local resources and community.
  - Potential components include: PV, wind, micro-hydro, biomass, batteries, and conventional generators.
  - Centrally located and used by the whole community through a common distribution system
- Village power systems can further be distinguished by size.
  - Micro-grids (<100kWh/day load ~15 kWp) and Mini-grids

Hybrid Power Systems

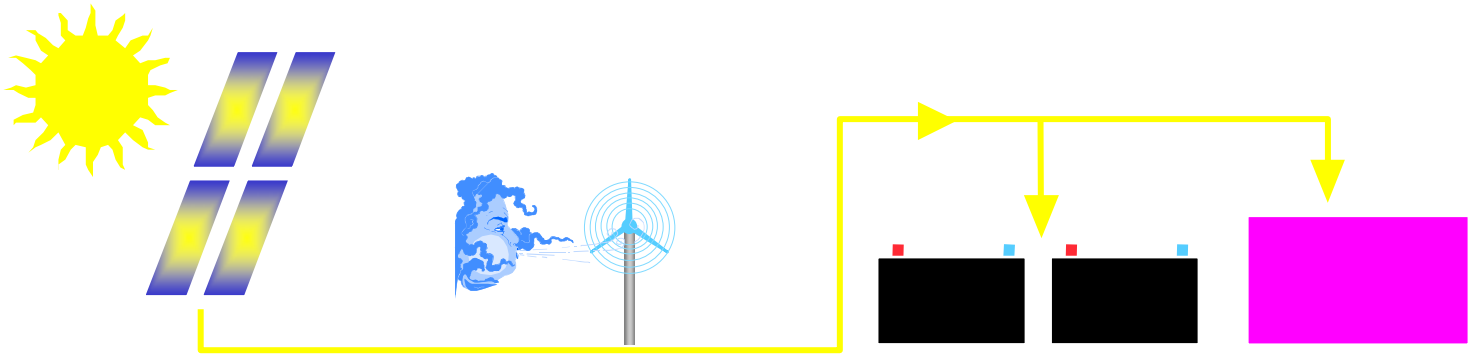
Combine multiple sources to deliver reliable electric power

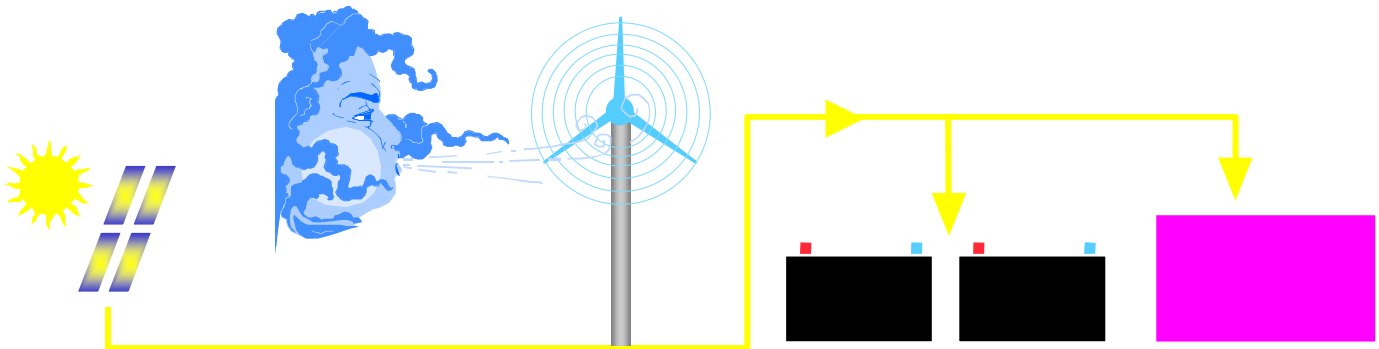


Solar and Wind Resources Often Complimentary

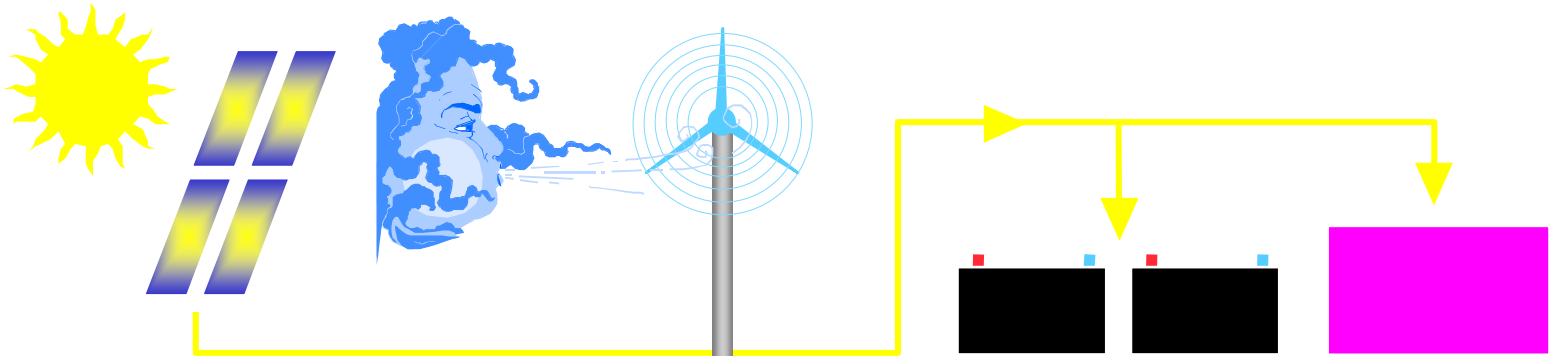


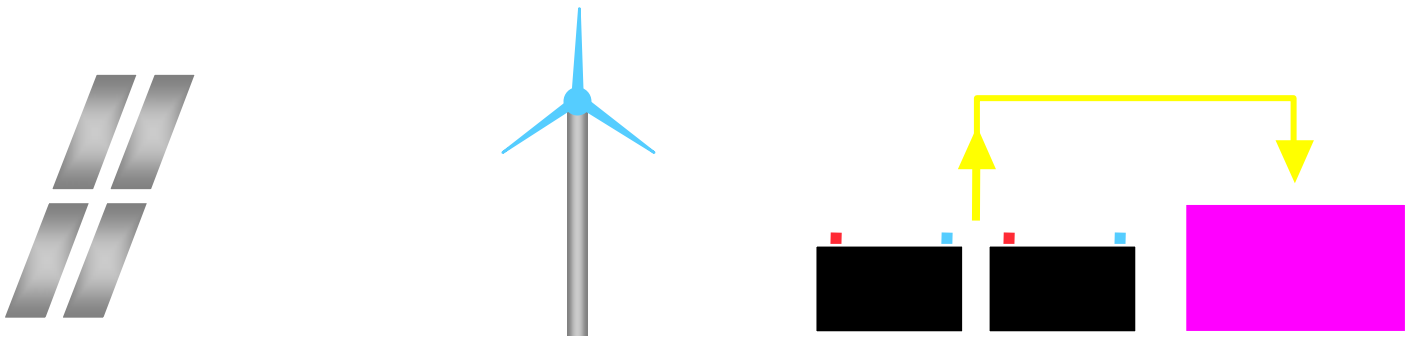
The Effect of Seasons on Hybrid Power Systems





The Role of Storage in Hybrid Power Systems





Why Use a Backup Generator?

- Renewable energy sources (wind and PV) and generators have complementary characteristics:

Characteristic	Renewable	Generator
Capital cost	High	Low
Operating cost	Low	High
Maintenance requirements	Low	High
Available on demand?	No	Yes

- In combination, they provide a more reliable and cost-effective power system than is possible with either one alone

Micro-Grids: Isla Tac, Chile

- Powers a health post, school and 82 homes
- Power System:
  - 2x7 kW wind turbines
  - Flooded battery
  - 2 x 4.5 kW inverter
  - 16 kW backup gas generator

Wind-Diesel Power Systems

- Larger systems with demands over ~ 100 kW peak load to MW
- Based on AC bus configurations
- Batteries, if used, store power to cover short lulls in wind power
- Both small and large renewable penetration designs available
- Provide AC power

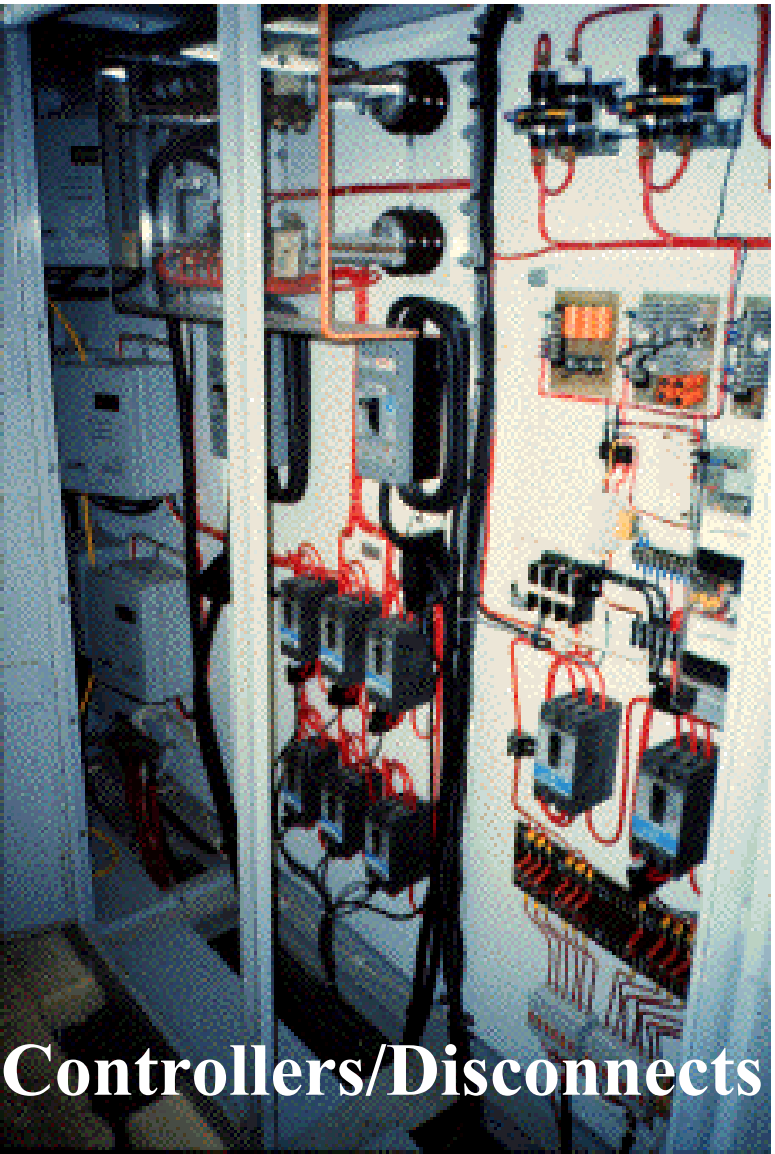
San Juanico, Mexico

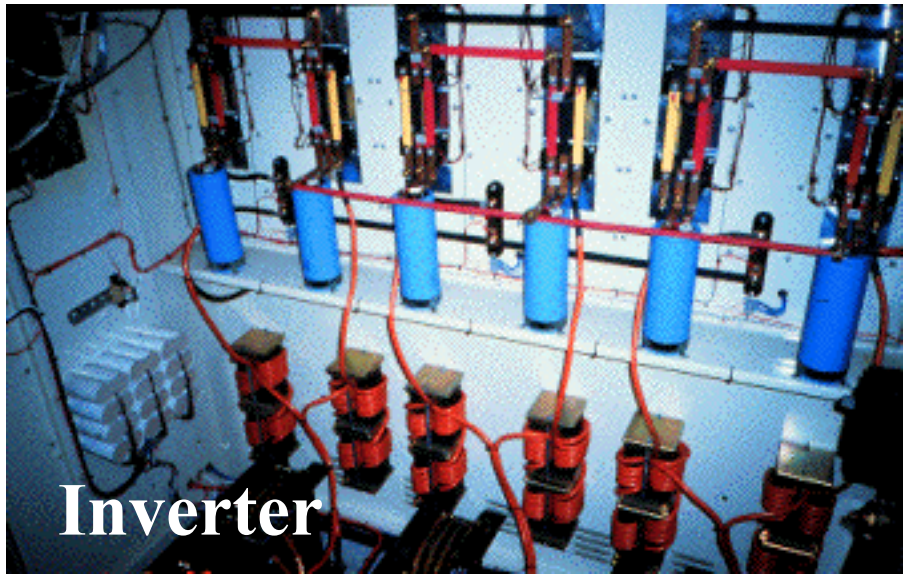
Remote fishing & tourism community of 400 people

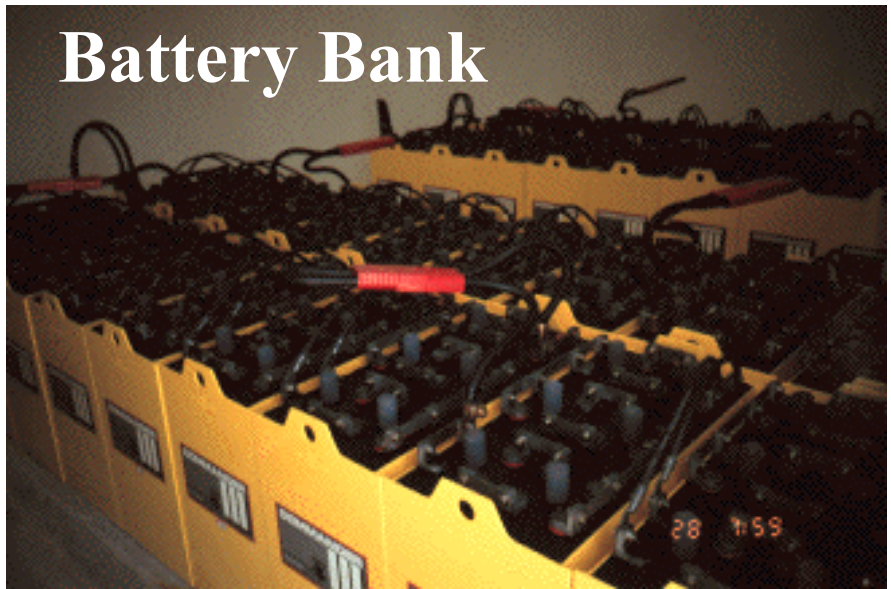
Power System

- 17 kW PV
- 70 kW wind
- 80 kW diesel generator
- 100 kW power converter/controller
- Advanced monitoring system

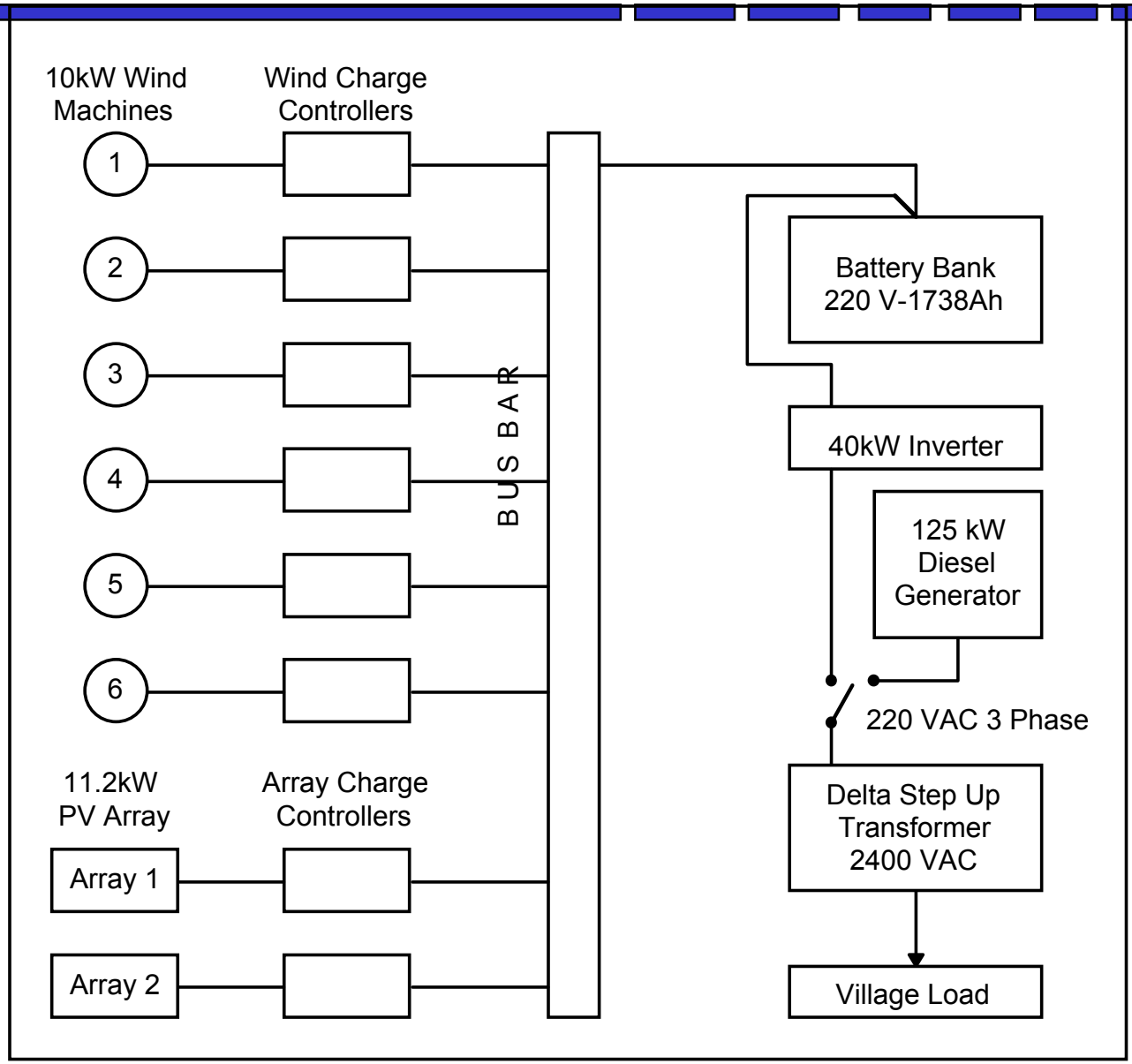
Hybrid System Components







Hybrid Schematic

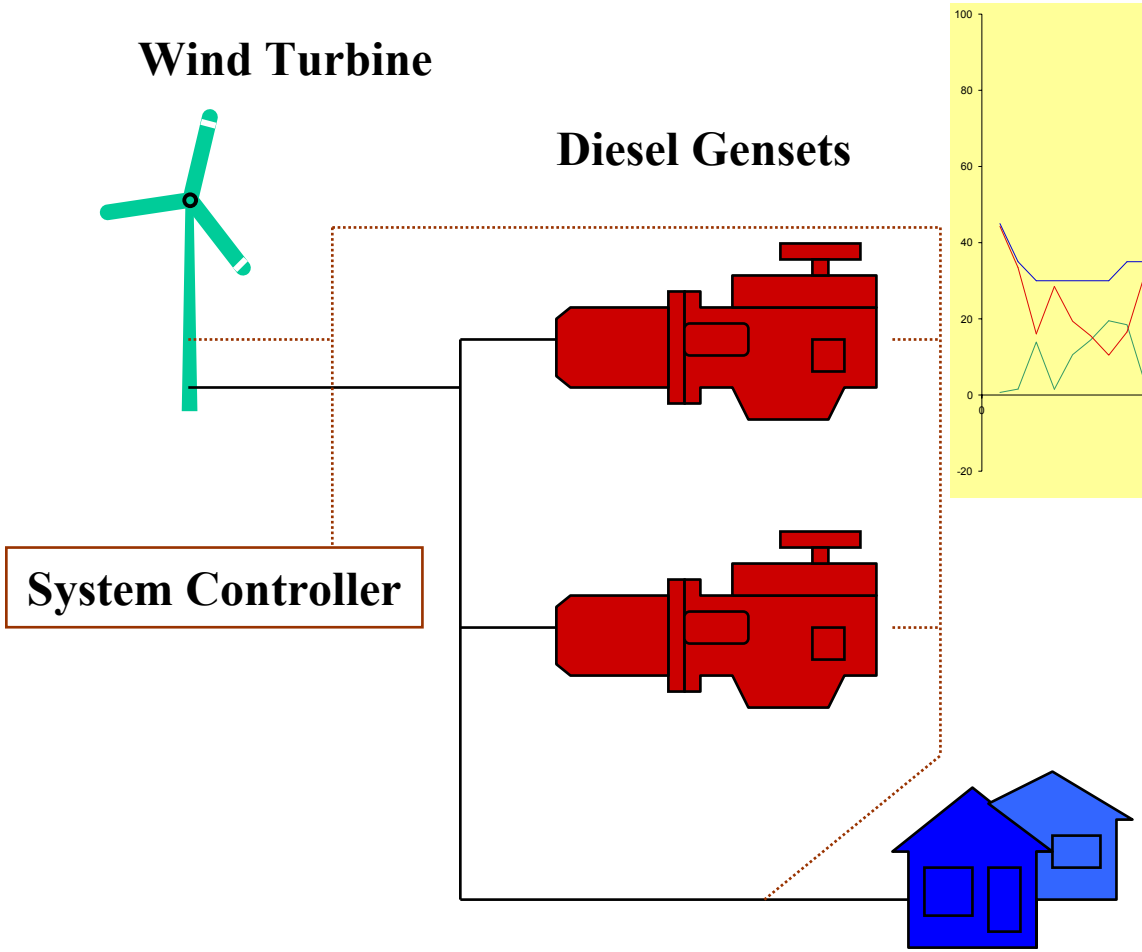


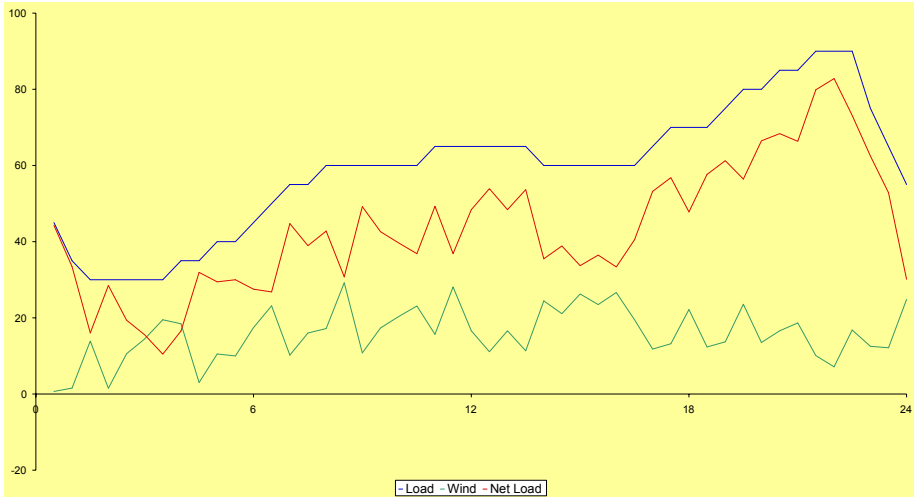
Wind-Diesel Low Penetration

- Capital cost of between $1,000-1,500/ per kW of wind capacity, excluding diesel units and plant BOS
- Easy integration with existing diesel system, little or no diesel modifications required
- Very little plant modifications necessary
- little or no equipment other than wind turbine(s) required
- Modest fuel savings of up to ~20% possible.
- System support requirements:

  Wind turbine maintenance

Low Penetration wind/diesel system





Time

Ascension Island

- U.S. Air Force installation on British island in mid-Atlantic ocean.
- Prime diesel generation with rotary interconnect to British 50 hertz system

Four NEG-Micon 225 kW turbines installed in 1996

Wind-Diesel Medium Penetration

- Capital cost of between $1,500-2,500 per kW of wind capacity, excluding diesel units and plant BOS.
- Some diesel controls modifications necessary
- Automated diesel operation desirable
- Usually must install/integrate secondary loads to regulate minimum diesel loading.
- Requires relatively simple supervisory control
- Rudimentary control of wind turbine output recommend
- Greater fuel savings possible, up to ~40%
- Additional support requirements:
  - Wind turbine maintenance
  - Secondary load and minimal control.

Coyaique, Chile

- Isolated Community
- Private Utility
  - 2 MW Wind, 4.6 MW Hydro, 16.9 MW Diesel
- Remote installation

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LA LUZ DEL SUR

High Penetration

- Capital cost between $2,500-4,000 per kW of wind capacity, excluding diesel units and plant BOS
- Significant diesel controls modifications may be necessary and new diesel control panels highly recommended
- Must install integrated secondary loads
- Requires sophisticated supervisory control system
- Some control of wind turbine output recommend
- Highest fuel savings possible, up to ~70%
- Additional support requirements:

  Active assessment to insure system maintains adequate control of system power quality.

  Wind turbine maintenance

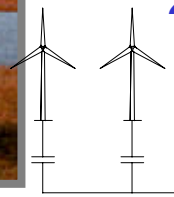
  Secondary load maintenance

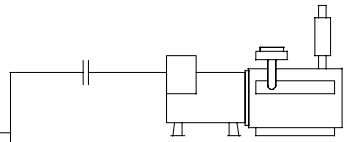
Wales Alaska Wind-Diesel System

- High penetration system
- 80kW average load with 130kW of wind power
- Short term battery storage
- Resistive loads used for heating and hot water

Wales Alaska

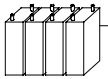
Wind Turbines
(Induction, Stall-Regulated)
2 X 65 KW = 130 KW

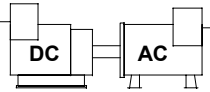


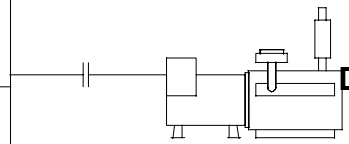


Diesel #1
142 kW

Battery Bank



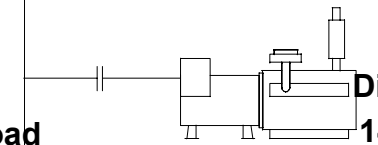




Diesel #2
75 kW

240 VDC, 130 Ah
~30 kWh

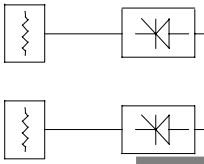
Rotary Converter
156 kVA



Diesel #3
148 kW

Secondary Load Controllers

School Heating System



Resistance Heaters

Diesel Plant Hydronic Loop

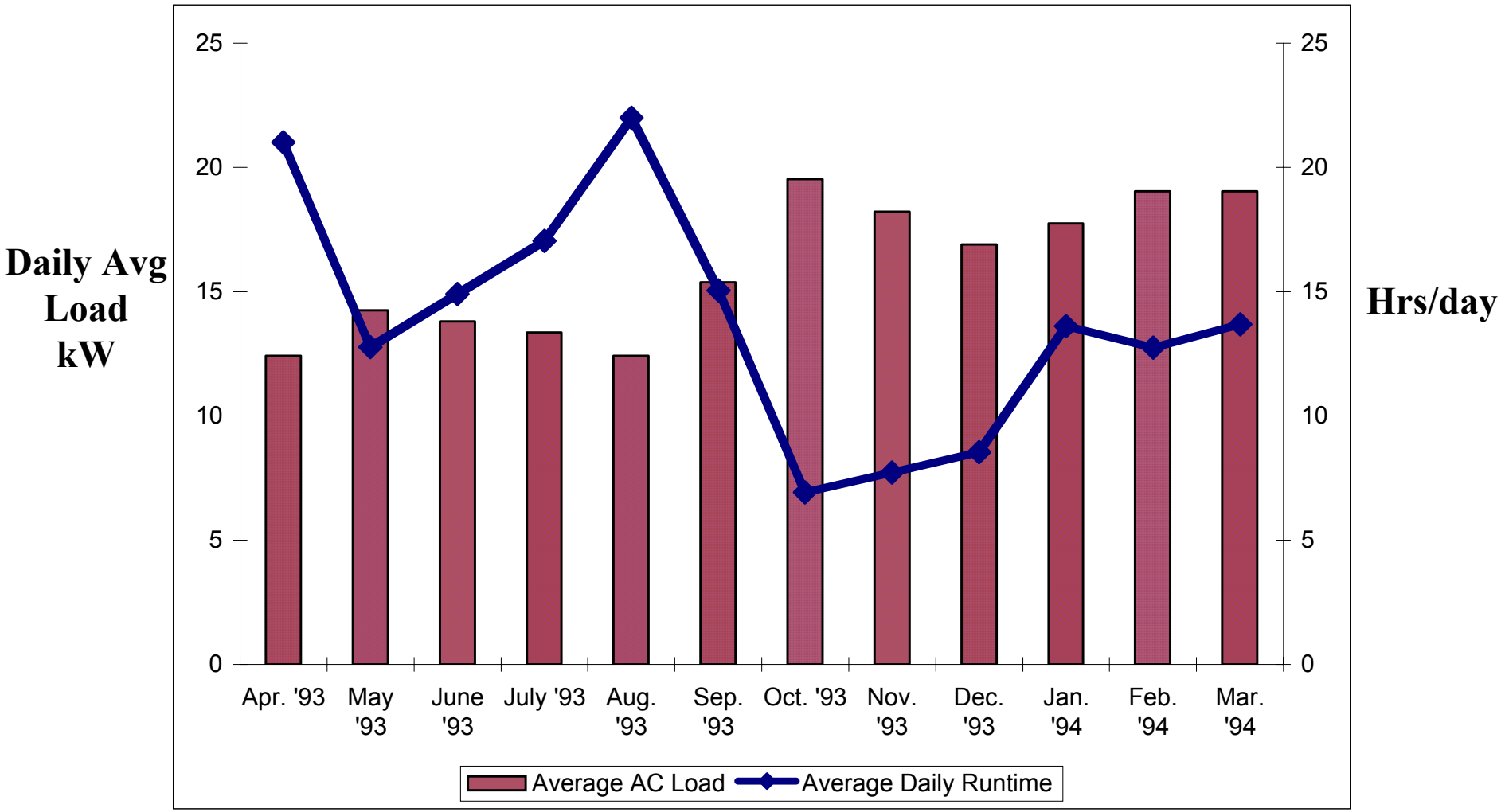
Primary Village Load
40-120 kW

Village Power Challenges

- COST, Subsidies (Who, How Much)
- Operation, Performance and Reliability Issues
- O&M and Payment for kWh
- Extreme Environments
- Manufacture/Sales Support
- Regional Infrastructure
- Lack of Institutional Oversight
  - Non payments
  - Illegal Connections
  - Inadequate or non-existent tariffs
  - Unchecked load growth
- Maintenance Ignored
  - Corrosion
  - Batteries

New System Load Growth

- Xcalak village load grew 53% in the first year of operation



Operational Challenges

- Long response time to component failures
  - Remote site – difficult access
  - Institutional issues - availability of qualified personnel
- Extreme Climates
  - Turbine Icing
  - Corrosion from salt spray
    - Dampers
    - Fuses
    - Guy Cables
  - Hurricanes
- Turbine problems
  - Tip brakes
  - Control twist cable connection
- Diesel plant problems
- Controller problems (CPU)
- Poor communications with Plant Operator
- Lightning (proper grounding)

Integrated Village Power Approach

Rural Situation	Application/ Productive Uses	Resource Characterization
Analysis of Options	Regional Pilot Project	Institutional Delivery
Capacity Building	Policy	Financing

Possible Institutional Pathways

- **Retailers, Individual Entrepreneurs** (manufacturer-linked?)
- **"McWind"** (Franchise Model)
- **Traditional Rural Electric Cooperatives** (member owned)
- **Local or Municipal Power Association**
- **Rural Energy Service Companies** (very small to very large)
- **National Utility – Diesel Group**
- **Non-Government and Private Voluntary Organizations**

Institutional Solutions

Maintenance Is Critical

Ownership, Responsibilities Need to be Determined Early

Metering, Equitable Tariff

Local Village Support, Training

Long Term Planning

Battery Charging from Generator

Village Power Summary

- Village renewable power systems can help supply energy to rural communities in a clean, cost-competitive way that does not burden national economies
- Renewable based rural power systems have many uses in a "non-traditional" sense
- Configuration depends on many factors
- Social issues dominate over technical issues
  - Planning
  - Ownership
  - Metering
  - Tariffs
  - Responsibilities