Hybrid Generation Simulator
HybSim 3.3

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Agenda

- Introduction
- Hybsim Model
- Model Validation
- Current Work
- Future Work
- Acknowledgements
- Questions?

Introduction

HybSim Model

What – "Hybrid Simulator"; Tool designed to evaluate the economic and environmental benefits of adding renewable energy to the fossil fuel generation mix in remote and difficult-accessible locations.

Why – Benefits of energy storage, decision analysis, risk analysis, load growth issues, load management, economic analysis, planning (what-ifs)

Who - availability to coops, field techs, project managers, administrative personnel

Where – Remote villages, military installations, remote industrial systems; any climate

How - designed for simplicity of use, Windows OS, open MS Excel executables, imbedded libraries for batteries, gensets, PV systems, reports, modulated design for expansion – wind energy to be added in '06

Hybsim Model – What is it?

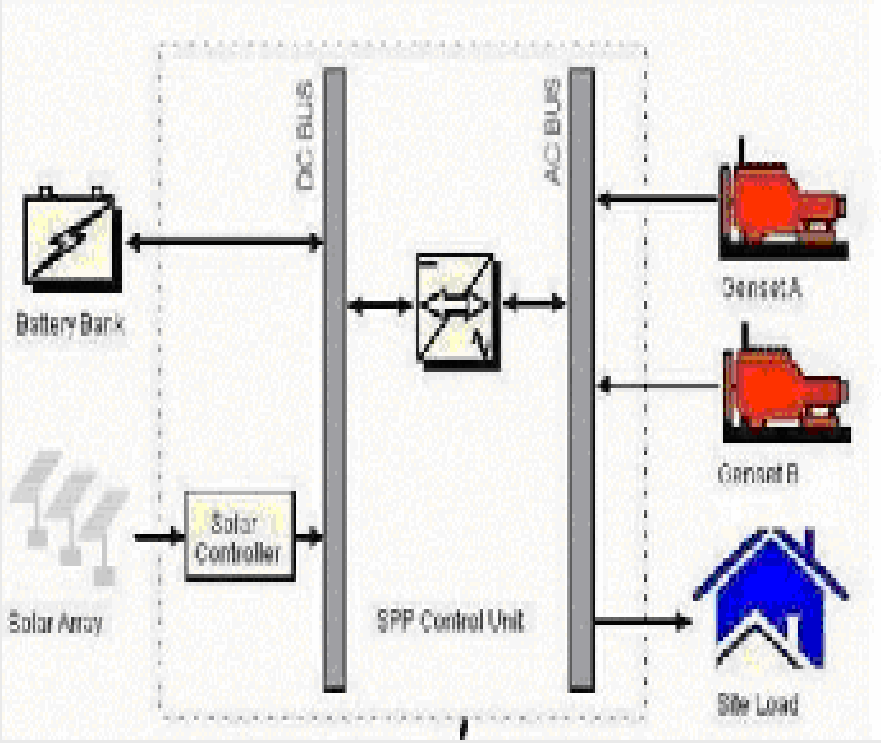
- Tool designed to evaluate the economic and environmental benefits of adding renewable energy to the fossil fuel generation mix in remote and inaccessible locations.
- Sophisticated macro embedded in the almost omnipresent Microsoft Excel.
- Inputs and outputs are spreadsheets.

Hybsim Model – Application

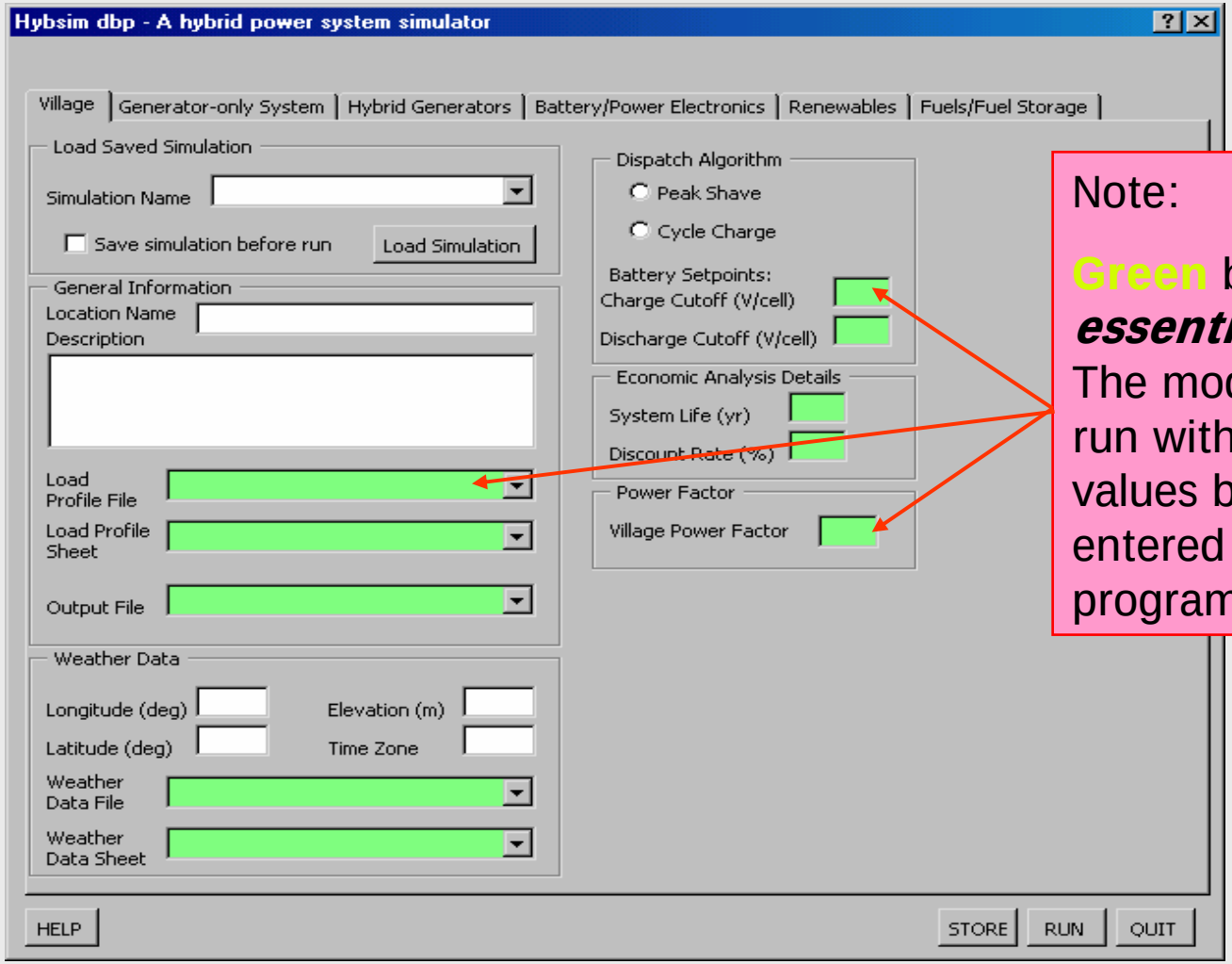
- Primarily established to help technical and non-technical personnel <u>reduce</u> the "guess work" on the benefits of energy storage and other hybrid options for existing or new systems.
- <u>Not</u> intended to <u>emulate the exact response</u> of the components.
- Variance in component response expected.

Hybsim Model – Components

- **Hybrid System = Generator(s) + Battery + Photovoltaic Panels**



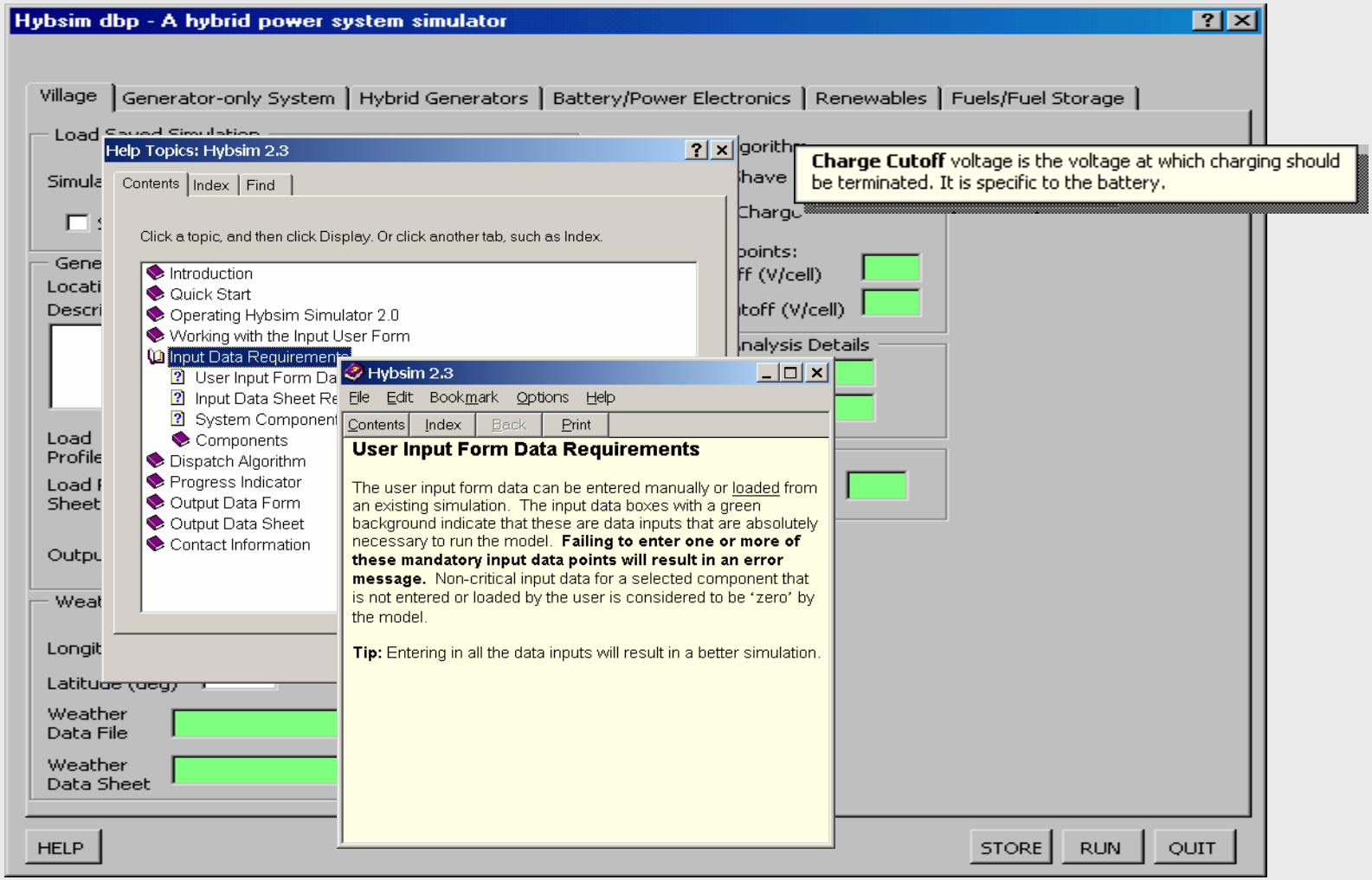
Hybsim Model – User GUI



Note:

Green boxes are ***essential data***. The model will not run without these values being entered into the program.

Hybsim Model – Help Feature



Model Validation – Approach

- Validate against a real system.
- Compare the real system vs. simulated system w.r.t. the response of each component in the two systems.
- Ideal site – System comprised of Diesel Gens, PV Panels and Battery Bank located in a remote location.

Model Validation – Site Description

- Carol Springs Mountain, Arizona
- System Components:
  - Diesel Gen - 50 kW
  - PV Panels - 24.6 kW
  - Battery Bank - 2880 A-hr
  - Inverter - 30 kVA
- Charge Regime
  - Dispatch Algorithm - Cycle Charge
  - Depth of Discharge - 50%

Model Validation – Aerial Site View

Model Validation – Component View

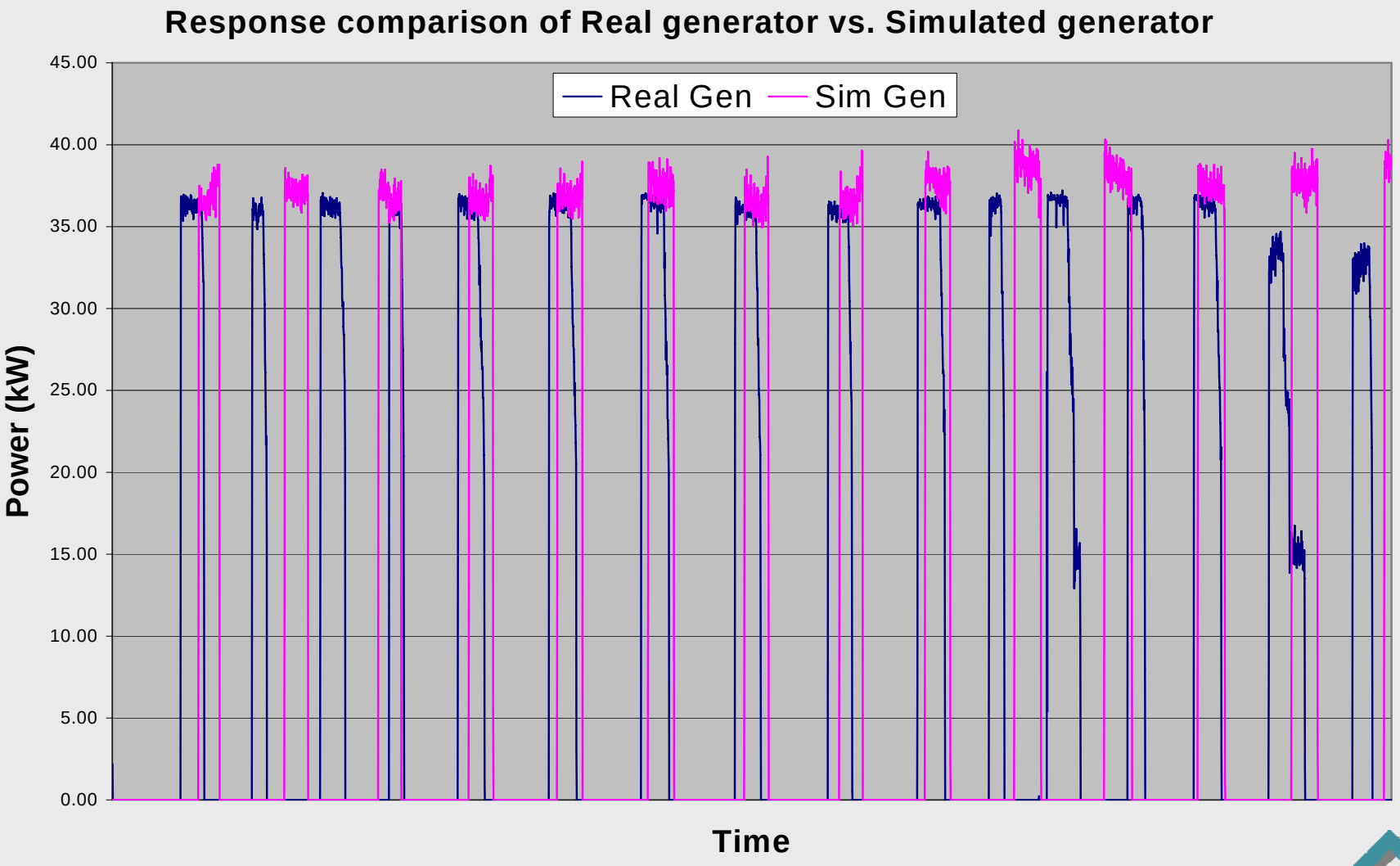
Model Validation – CSM Data

- 10 minute interval data for the month of June.
- Specifications for the real system components were used in the model.
- Data modified to begin when the battery is fully charged.
- Real battery was limited to 50% DOD and operated between 2.35 – 2 V/cell.

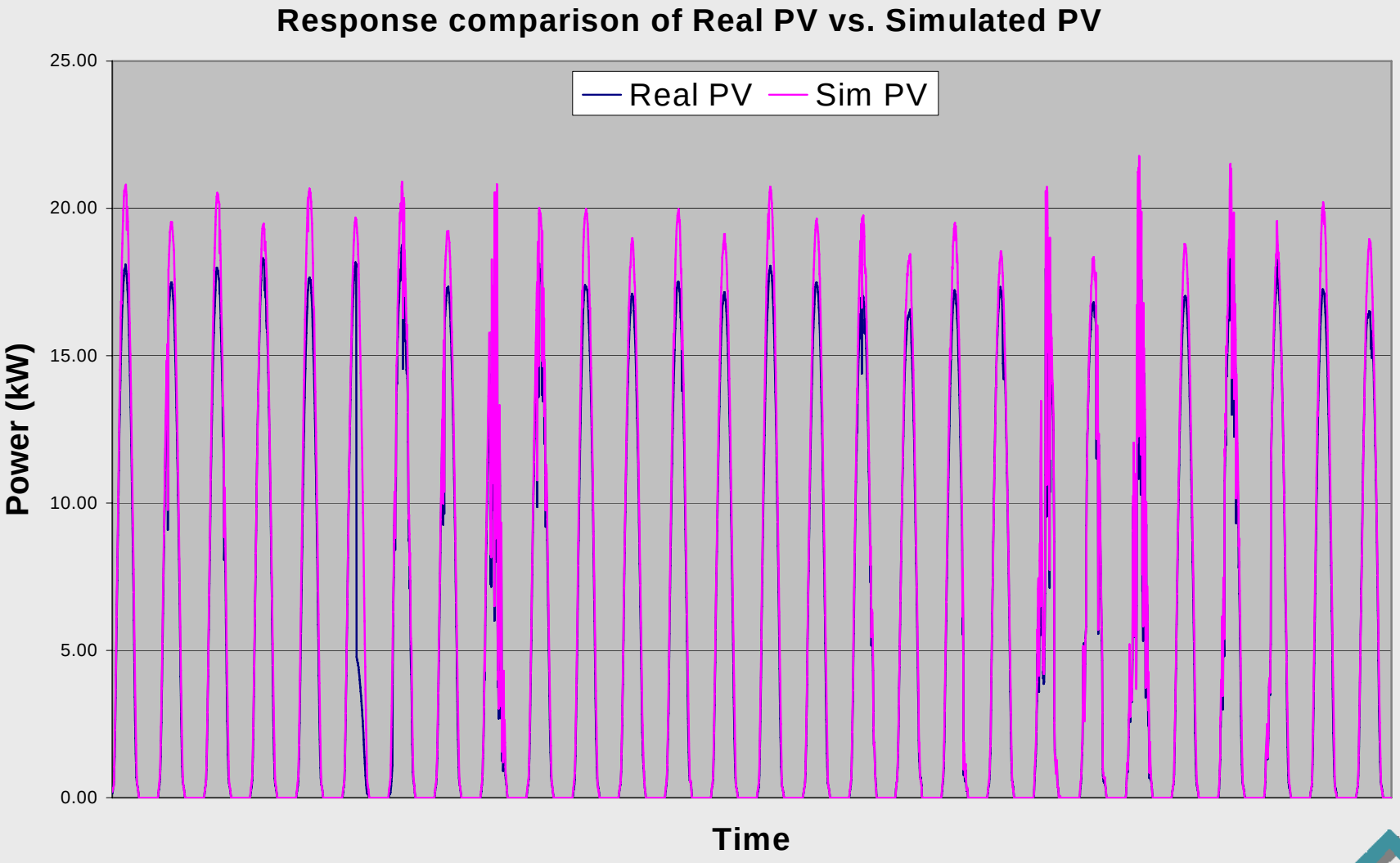
Model Validation – Real vs. Sim Data

Component	Real (kWhr)	Sim (kWhr)	% Diff
PV	20700.20	23040.71	11.31%
Generator(s)	40058.70	38413.43	-4.11%
Batt – Charging	-27646.30	-30509.47	10.36%
Batt – Discharging	25563.68	-30833.86	20.62%

Model Validation – Gen Comparison



Model Validation – PV Comparison



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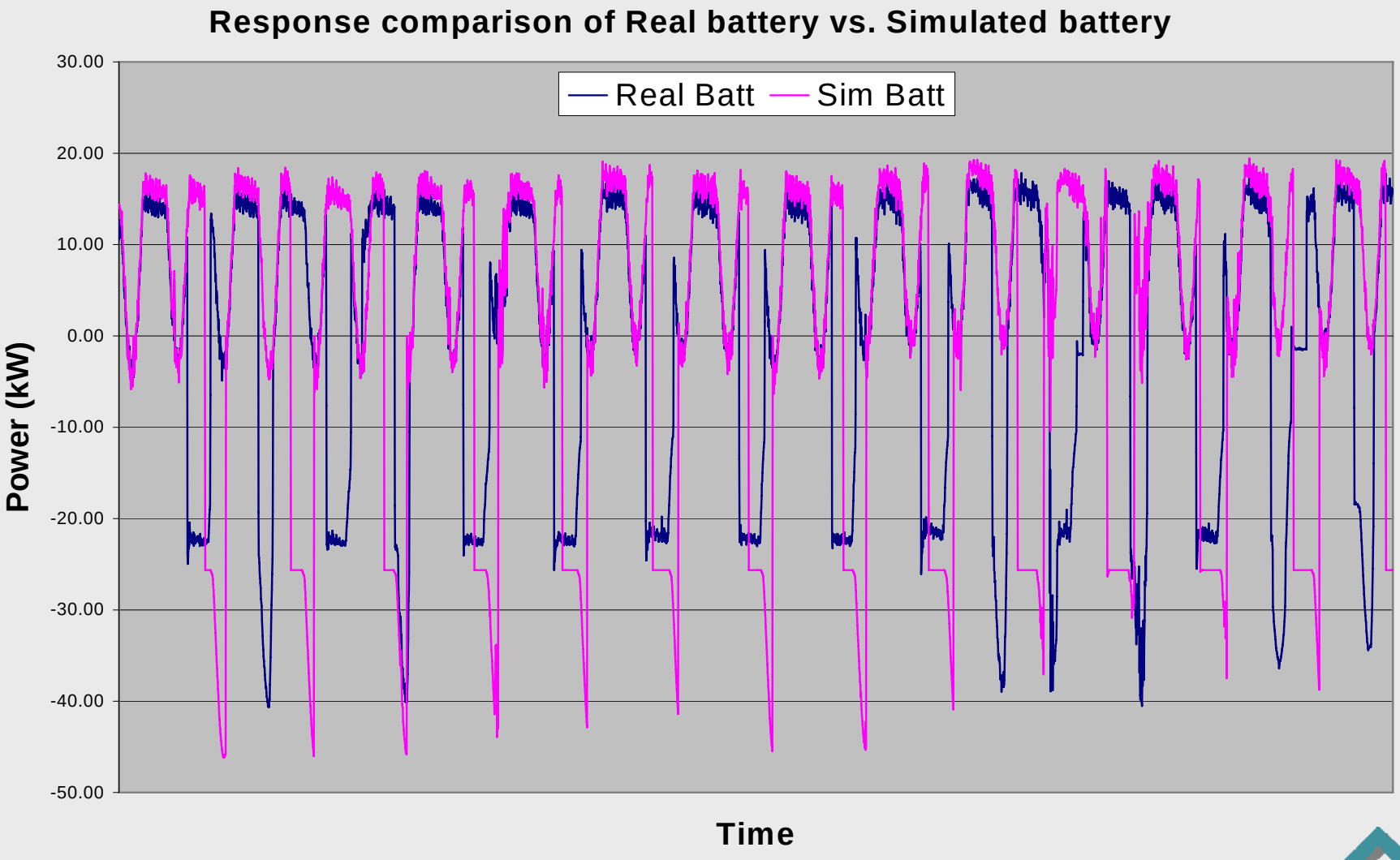
Model Validation – Batt Comparison



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Model Validation – Valid or not?

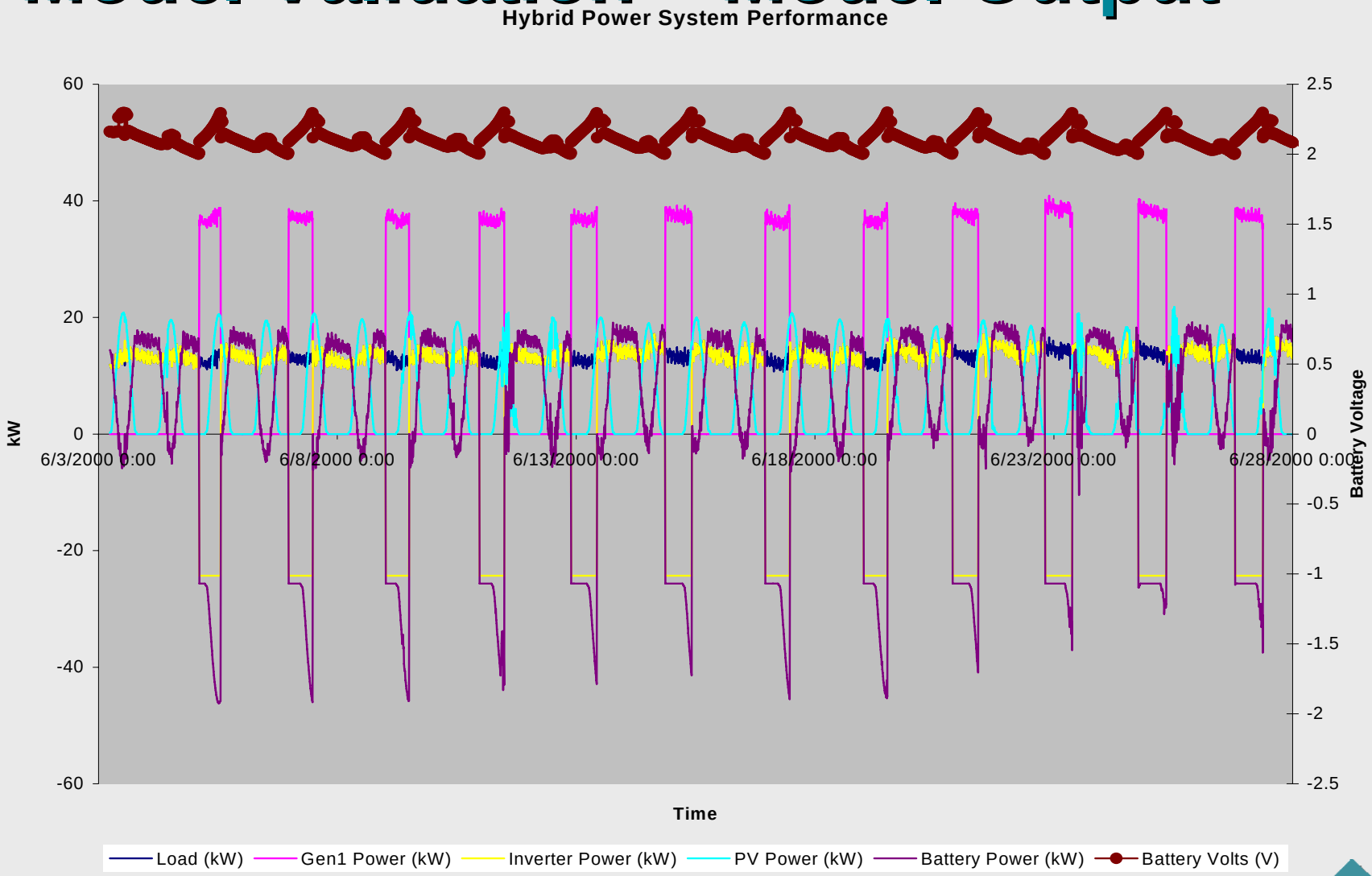
- Variance in Model acceptable? - YES
  - Temperature compensation
  - Battery equalization frequency
- Model may not always match up well to real system due to:
  - Inaccurate readings
  - Poor maintenance
- Is it good for analysis? - YES

Model Validation – Real vs. Sim Data

Criteria	Real Hybrid	Sim Hybrid	Gen-Only
Diesel Consu. (gal/day)	12.56	13.62	27.78
Diesel $ Avoided ($/day)*	-	-	35.40
NO_x(kg)	-	1,125.70	-
SO_x(kg)	-	12.80	-
CO(kg)	-	299.00	-
PM-10(kg)	-	35.20	-
CO_2(kg)	-	57,576.00	-

* Assuming $2.50/gallon of Diesel

Model Validation – Model Output



Current Work

- Model validation
- Incorporate Load Growth data & graph
- Expand battery library included in the model
- Improve financial calculations for better projections

Future Work

- Add wind energy technologies as an option – size <u>restricted to less</u> than 100 kW
- Copyright
- Distribution
  - Alaska users, utilities, coops, project managers, universities

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Questions?

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