

Hybrid2

Status of the Hybrid Power System Simulation Model

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Wind-Diesel 2002 Workshop

September 23-24, 2002

Anchorage, Alaska

University of Massachusetts

Introduction

- Hybrid2 is an analysis tool to accurately model the performance and economics of hybrid power system designs
- Developed by:
 - Renewable Energy Research Laboratory (RERL) of UMass
 - National Renewable Energy Laboratory (NREL)

History

- First released June 1996
- Version 1.1 Released Winter 1998
 - 2nd mode rotary converters
 - Simplified dispatch strategy
 - Synchronous condenser
- Version 1.2 Released August 1999
 - Data gap filler incorporated

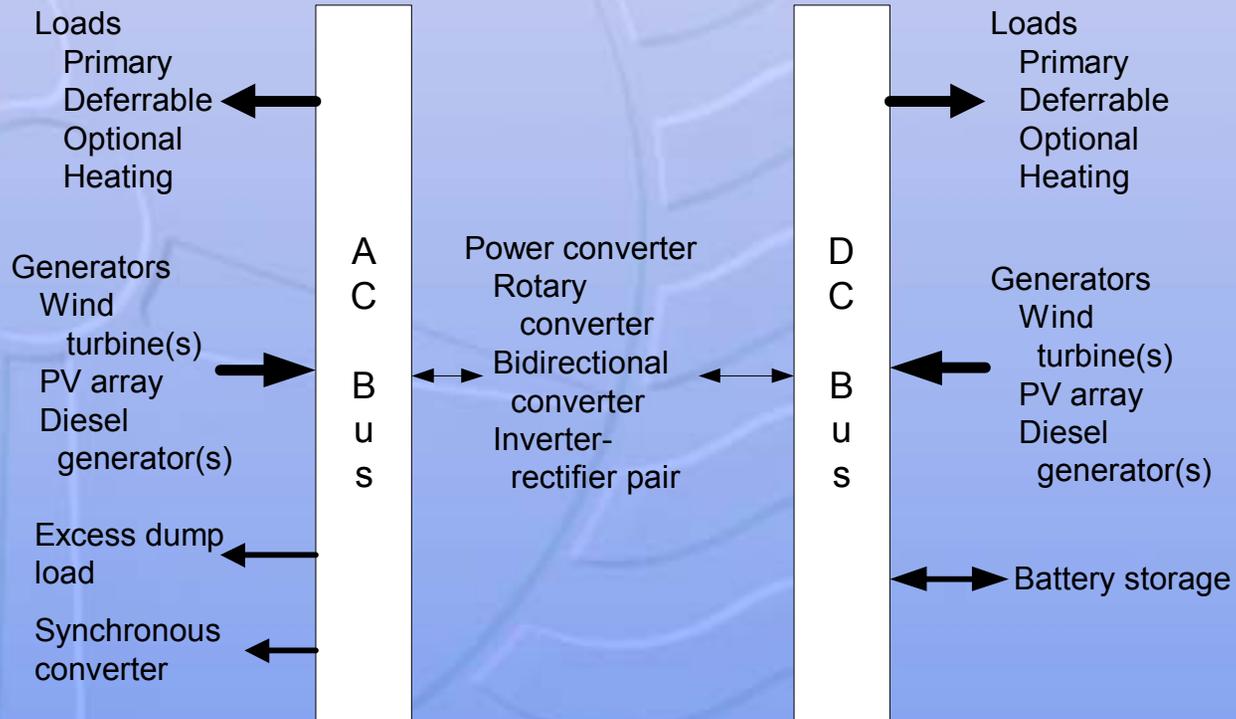
Current release

- Version 1.3
- Released Sept 2002
- <http://www.ecs.umass.edu/mie/labs/rerl/hy2/>

Description

- Time series/probabilistic model
 - Time series resource and load data
 - Statistical analysis within time steps
 - Manufacturers' component data
- Performance and economic simulation

System Model Schematic



System Model

- Loads
 - Primary
 - Deferrable
 - Optional
 - Heating
- Components
 - Wind Turbine
 - PV
 - Diesel
 - Battery bank
 - Power conversion

Graphical User Interface

Power System Module - (test 10 minute)

Power System Description
test 10 minute Remove
test 10 minute Copy New Delete Insert

Notes

AC Generators:
Wind Turbine
PV Array
Diesel
Sync. Condenser
Dump Load

DC Generators:
Wind Turbine
PV Array
Diesel
Battery

Power Conversion:
Inverter
Rectifier
Bidirectional Inverter
Rotary Converter

AC Loads:
Primary
Deferrable
Optional

DC Loads:
Primary
Deferrable
Optional

Dispatch Strategy
Coupled Diesel
Input Units
Metric
English
OK

Loads Module - (test 10 minute)

AC Loads:
Primary test 10 minute Remove
Load Scale Factor 1
Deferrable None Remove
Optional None Remove

DC Loads:
Primary None Remove
Load Scale Factor 1
Deferrable None Remove
Optional None Remove

DC Primary Time Series | DC Deferrable | DC Optional | DC Primary Matrix
AC Primary Time Series | AC Deferrable | AC Optional | AC Primary Matrix

AC Primary Load Description
Block Island Load New Data Insert Plot Report
A large island off the coast of Rhode Island, USA. 1 year of data with a
Data Time Step (min) 60

Code for Fluctuations:
 Standard Deviation is in the file
 Constant Variability
 Constant Standard Deviation 0.1

AC Primary Load
Time Series Data

Minimum = 400.0 (kW) Average = 805.40 (kW)
Maximum = 2,350.0 (kW) # of points = 0704

OK

Bus Structure

- AC Bus
 - Constant voltage and frequency
- DC Bus
 - Voltage can vary
 - Can impact component performance
 - Batteries
 - Photovoltaic panels

Control Strategy

- Allows many different control strategies
- Dispatch configuration defined by:
 - Diesel dispatch
 - Battery dispatch
 - Diesel – Battery interaction

Performance Inputs

- Component description
 - Manufacturers' data
- Time series
 - Load
 - Resource
 - Wind speed
 - Solar insolation
 - Temperature

Time Series Input

Example: Primary Load

Loads Module - (test 10 minute)

AC Loads

Primary Primary

Matrix Matrix

Load Scale Factor Load Scale Factor

Deferrable Deferrable

Optional Optional

DC Primary Time Series DC Deferrable DC Optional DC Primary Matrix

AC Primary Time Series AC Deferrable AC Optional AC Primary Matrix

AC Primary Load Description

Data Time Step (min)

Code for Fluctuations

Standard Deviation is in the file

Constant Variability

Constant Standard Deviation

AC Primary Load

Minimum = 400.0 (kW) Average = 889.48 (kW)

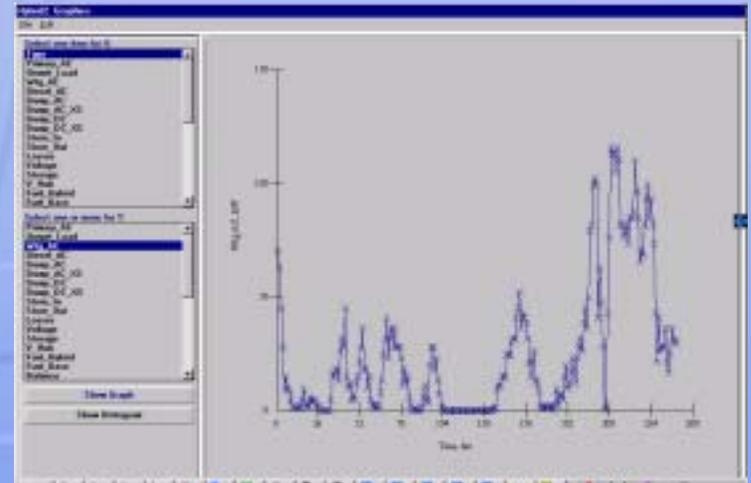
Maximum = 2,350.0 (kW) # of points = 8784

Economic Inputs

- Performance simulation output
- Component Cost
- System Cost
- Economic Parameters
 - Financial (Inflation, discount rate)
 - Loan (Interest, Period, Down Payment)
 - Price of Power (Primary, Deferrable, Optional)
 - Taxation (Corporate Rate, Tax Incentive)

Outputs

- Summary information
- Time series



For both performance and economic simulation

Additional tools

- Data synthesizer
 - Wind speed, solar insolation, primary load
 - Rayleigh and Weibull distribution
 - Diurnal and long cycle scaling
- Gap filler
 - Long cycle (wind speed, load, temperature) and diurnal (solar insolation) data

Applications

- Detailed analysis of various wind/diesel and hybrid system configurations
- Base case analysis
- Control strategy comparison
- System performance – component sizing
- Grid inter-tie comparison (special application)

Grid Inter-Tie Comparison

(Special Application)

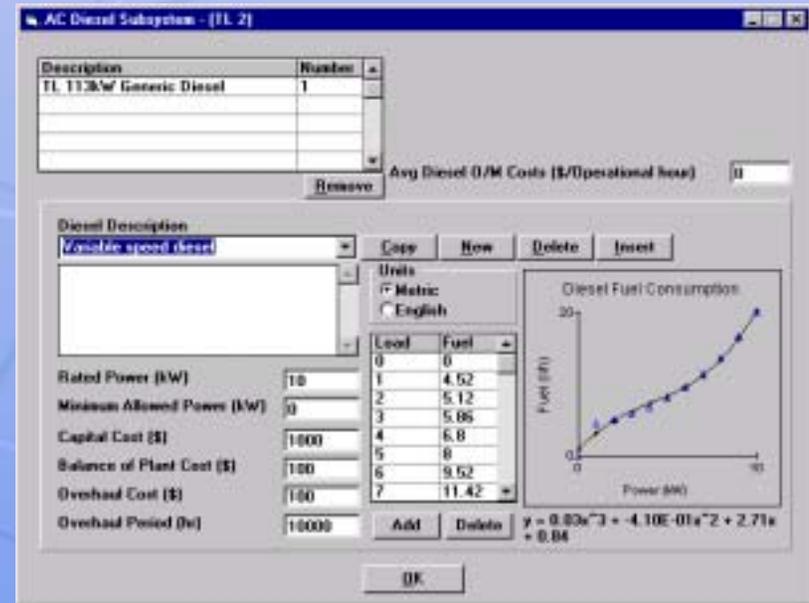
- Currently available only with special adaptations of available components
- Conducted for Thompson Island, MA power plant option investigation
 - Submarine cable replacement vs. hybrid system
- Future development of Hybrid2 will have this available

Version 1.3 enhancements

- Variable speed diesel
- Space heating load
- Thermal storage

Variable speed diesel

- Allowed to run at lower speeds to match load
- 4th degree polynomial diesel fuel curve
- Better simulation of diesel generators at different speeds



Heating Load

- Additional optional load; utilizes excess energy after deferrable and other optional loads are met
- Useful when temporal mismatch exists between renewable source and primary load while heating load is present

Heating Load

- Calculated from
 - Ambient temperature
 - Base temperature
 - UA value
- UA value can be reverse calculated from current heating fuel consumption

Thermal Storage

- Idealized storage of heat energy
- Constant rate input and output
- Potential improvement
 - Input and output rate dependent on storage level and ambient temperature
 - Losses due to length of time, storage temperature (level) and ambient temperature

Vision for Future

- Enhanced flexibility for new concepts
 - Open architecture
 - Object oriented coding
- Explicit AC & DC electrical models
 - Short time step option (~1 second)
- Distributed generation
 - Interconnected hybrid systems
 - Weak grids
 - Congestion pricing, RPS certificates

Near-Term Future Developments

- Grid inter-tie, cable connection
- Variable frequency, variable voltage components
- Complex battery model

Related Activities at RERL

- Distributed multi-unit secondary thermal loads
 - Paper at AWEA '02
- Conceptual design of “Plug & Play” Hybrid Power System
 - Subject of Ph.D. dissertation