Microgrids Simplified

How the HOMER® Pro Software Can Improve the Design and Development of Clean and Sustainable Energy Projects

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Agenda

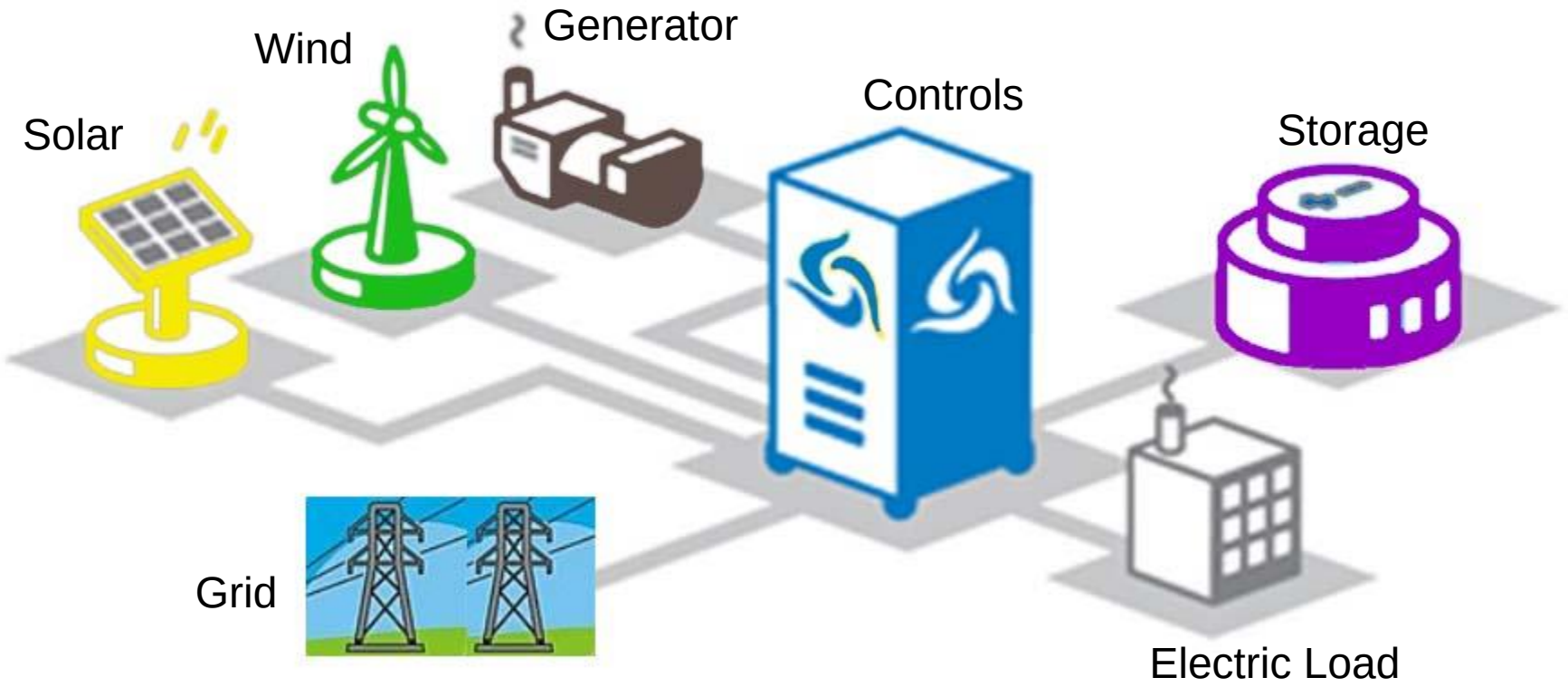
- Introduction to HOMER® Pro (Dr. Peter Lilienthal)
  - History
  - Purpose
  - What's New
  - How to get started
- Philippine Case Study (Silver Navarro)
- Insights from HOMER Pro (Dr. Peter Lilienthal)
  - Penetration levels
  - Tariff analysis
  - Sensitivity analysis
  - Unreliable grids

The Future of Power

Clean, distributed power with hybrid renewables and smart micro-grids

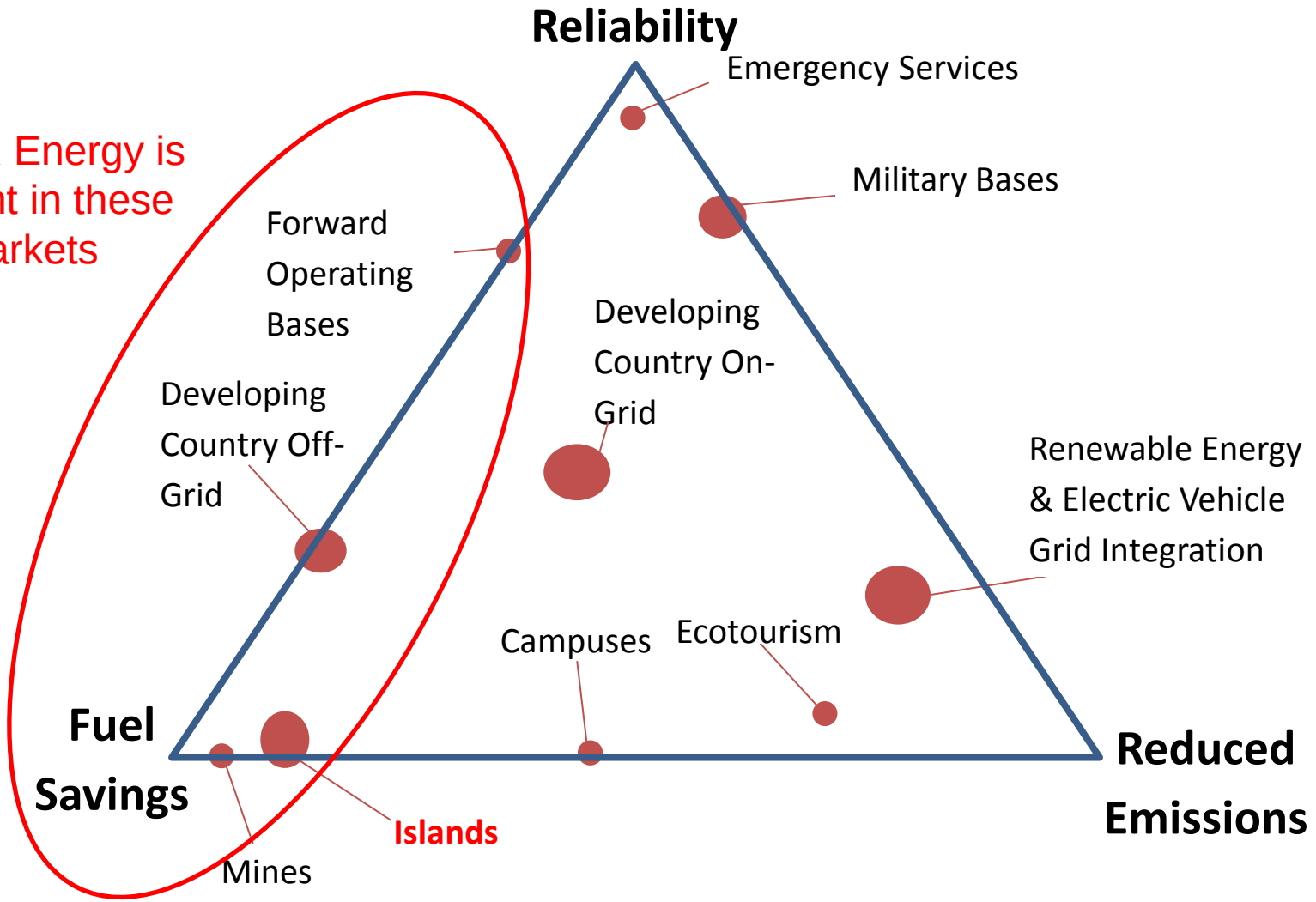
How do we get there?

Hybrid Renewable Microgrids

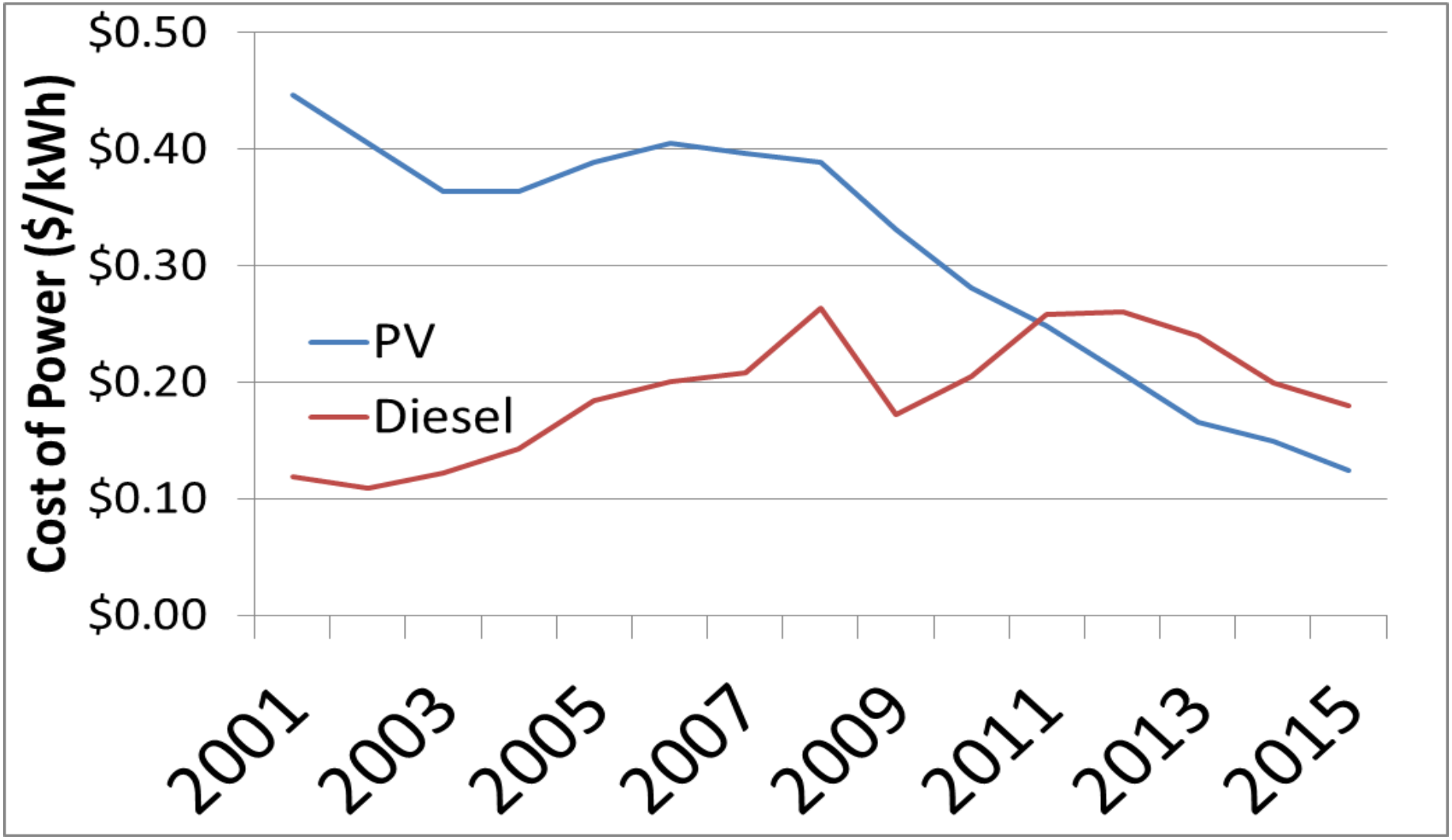


Provided by ZBB Energy Inc.

Microgrid Value Proposition

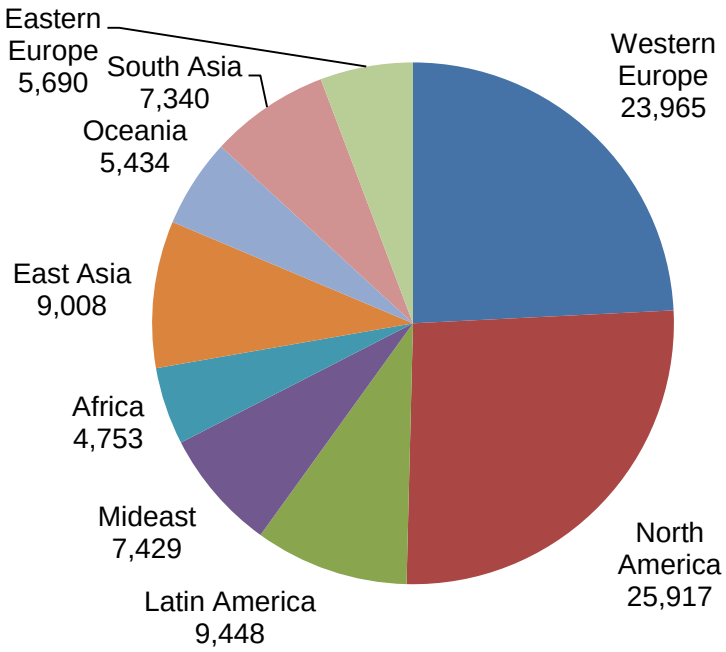


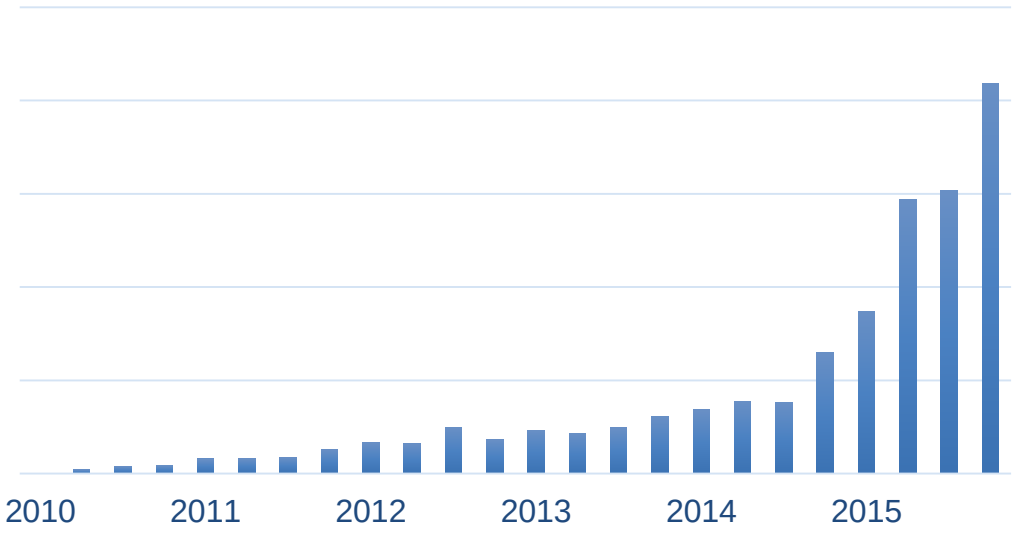
Unsubsidized Economics



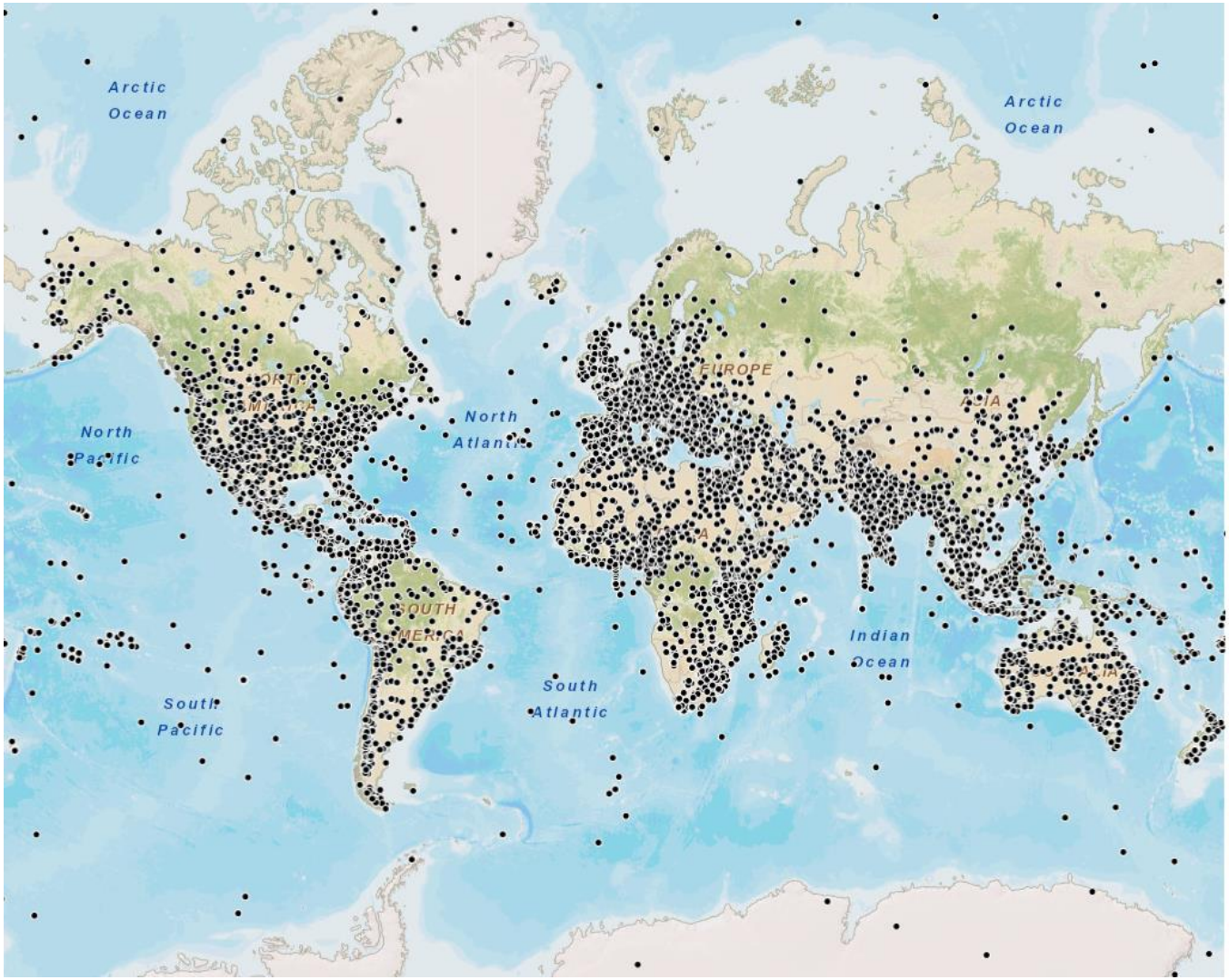
Who is HOMER?

- NREL: 1992-2008
- Original developers now at HOMER Energy
- 7 years of continuous, self-funded growth





160,000 users in 193 countries



15,000 projects in last 18 months

Too Many Choices

Solar

Wind

Hydro

Geothermal

Biomass

New Storage Techs.

Electric Vehicles

Smart grids

Fuel Cells

Micro-turbines

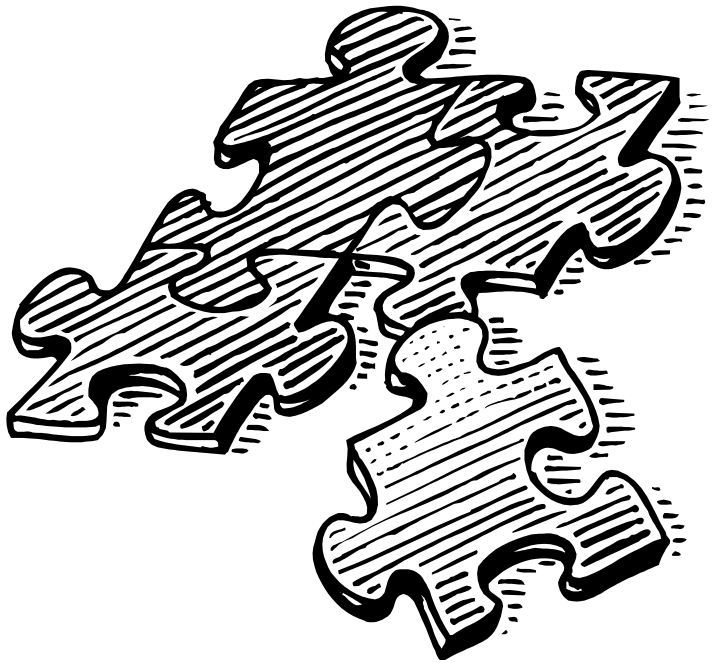
Micro-grids

Demand Response

Load Management

What is best?

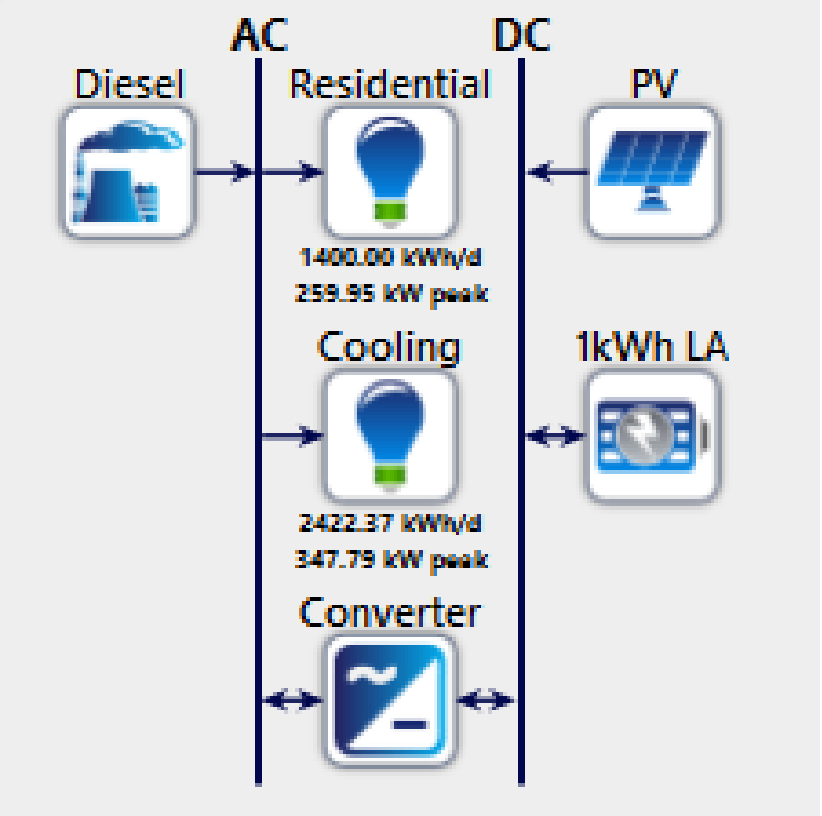
- It depends on:
  - Resources
  - Loads
  - Equipment prices
  - Equipment performance



- **A confused mind says “No!”**
- **HOMER fits the pieces together**

HOMER

- Industry standard for hybrid micro-grids
  - Conventional resources
  - Renewable resources
  - Storage
  - Load Management



HOMER Analysis Layers

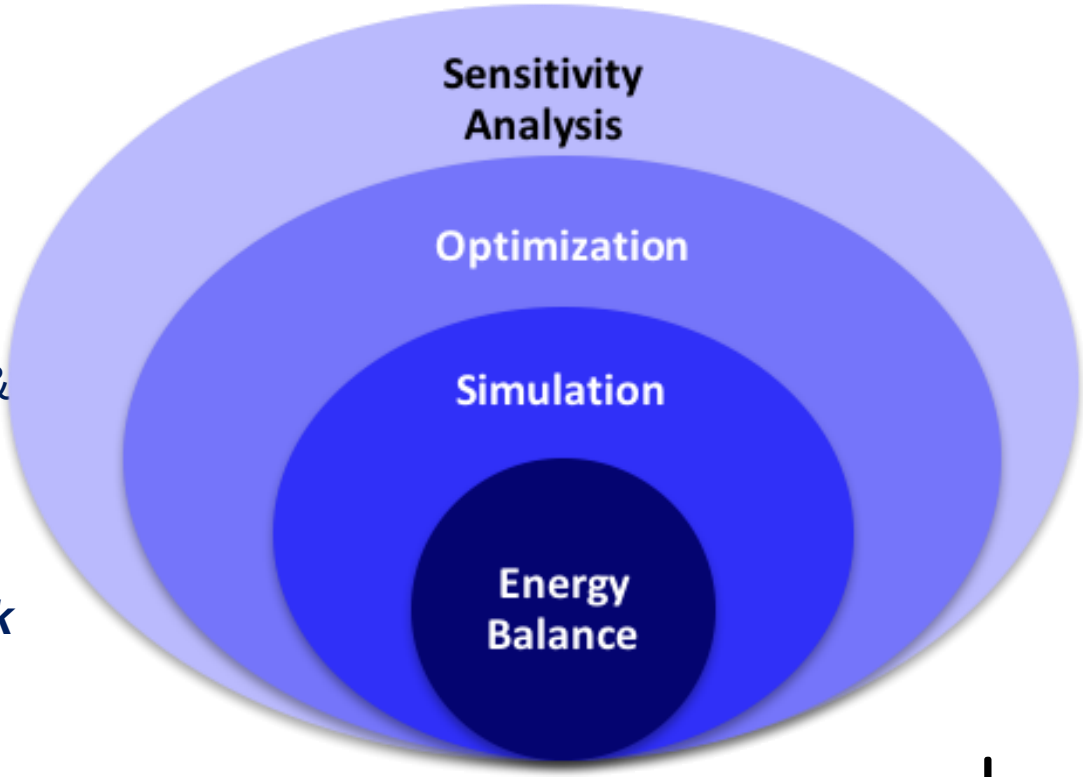
Design the most cost effective system by analyzing thousands of systems in minutes

Sensitivity Analysis -
Evaluates uncertain inputs: prices, weather, loads, ...

Optimization - LCOE, reliability, max. renewables, & resiliency

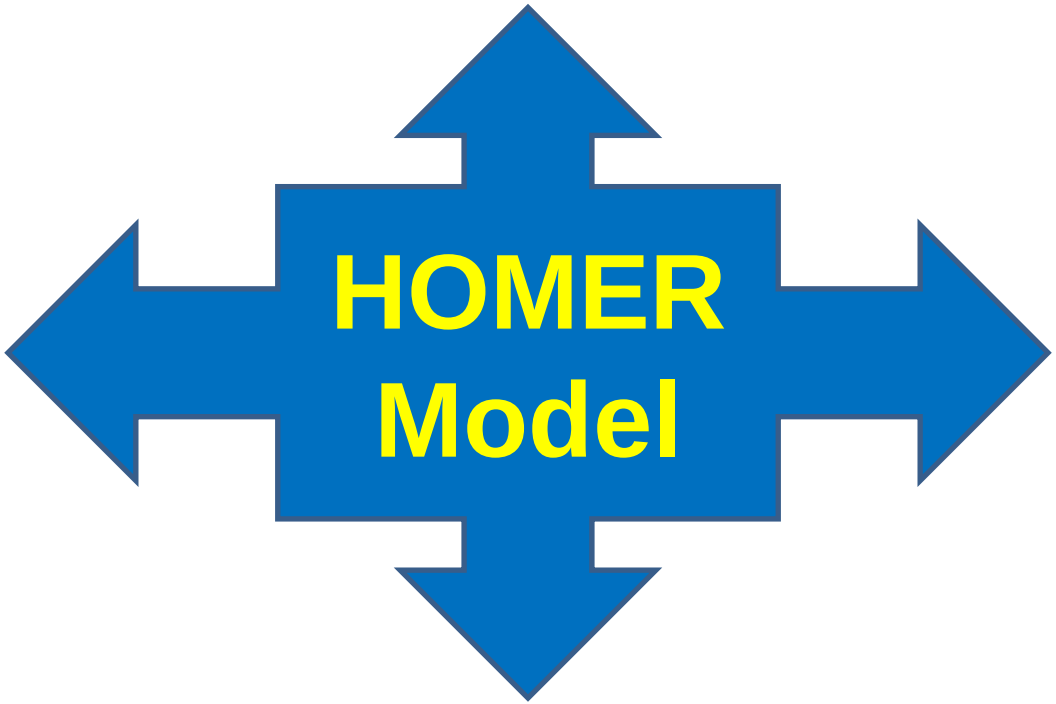
Simulation - Time varying loads & resources require chronological analysis for entire year

Engineering and economics work side by side to arrive at an ANSWER!



HOMER as a Communication Tool

Renewable Advocates



Power Engineers

Financiers

Diesel Mechanics

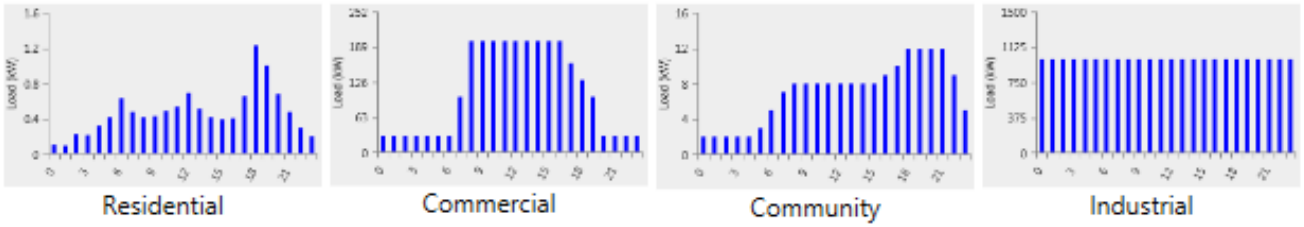
HOMER bridges different worlds

Levels of Input Detail

- $/watt or quantity discounts
- Synthesized or measured data
- HOMER Optimizer™ or defined search space
- Generic or specific components
  - Create your own components

New in HOMER Pro

- Optimizer
- Getting Started Wizard
- Unreliable Grid
- Advanced Battery
- Multi-year
- API’s
- Load Profiles



- Monthly Demand Limits

HOMER Energy's Services

HOMER® Software: Global standard for microgrid design

Education, Training, & Capacity Building

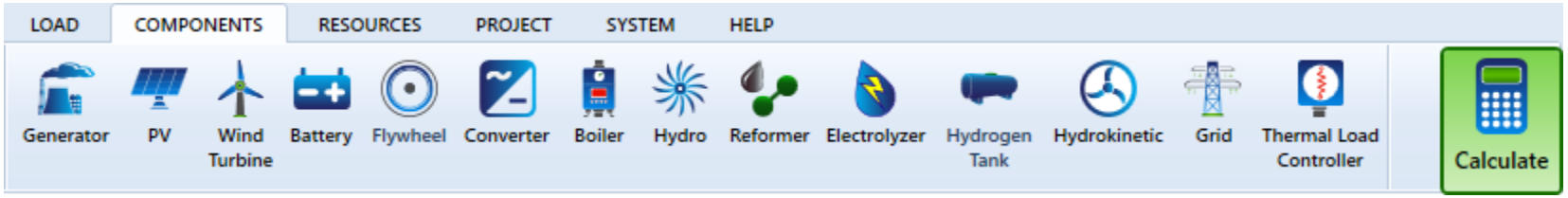
Consulting: Model reviews and strategic planning

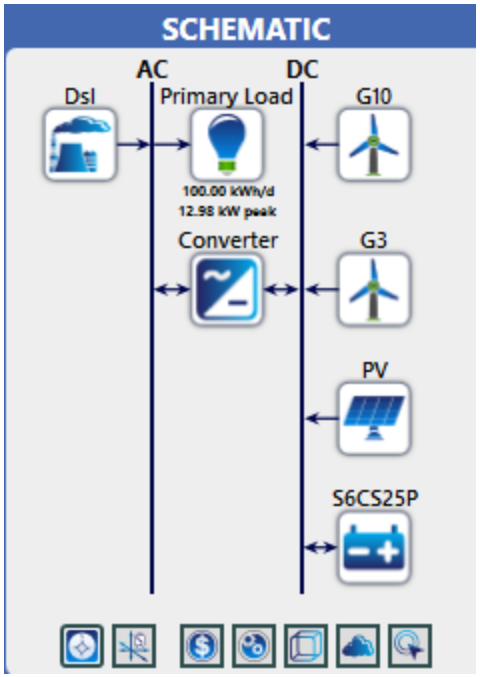
Market Access: Connecting suppliers with projects

Getting Started

- Help
- Tour
- Start Wizard

User Inputs

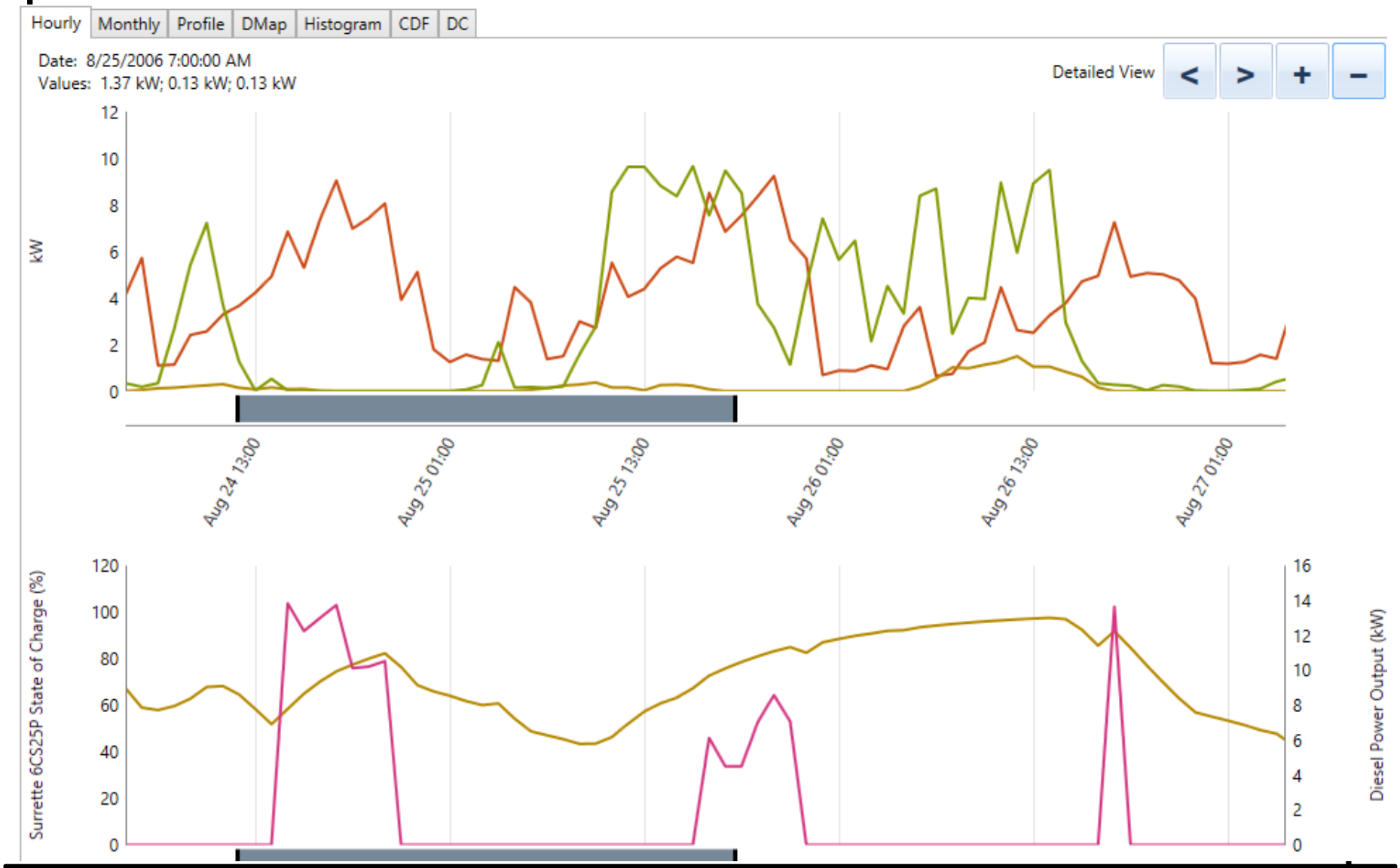

LOAD
COMPONENTS
RESOURCES
PROJECT
SYSTEM
HELP
Generator
PV
Wind Turbine
Battery
Flywheel
Converter
Boiler
Hydro
Reformer
Electrolyzer
Hydrogen Tank
Hydrokinetic
Grid
Thermal Load Controller
Calculate


SCHEMATIC
AC
DC
Dsl
Primary Load
G10
100.00 kWh/d
12.98 kW peak
Converter
G3
PV
S6CS25P


LOAD
COMPONENTS
RESOURCES
PROJECT
SYSTEM
HELP
Electric #1
Electric #2
Deferrable
Thermal #1
Thermal #2
Hydrogen


LOAD
COMPONENTS
RESOURCES
PROJECT
SYSTEM
HELP
Solar GHI
Solar DNI
Wind
Temperature
Fuels
Hydrokinetic
Hydro
Biomass

Chronological Simulation



Simulation Results

Simulation Results

System Architecture:			
	PV (2 kW)	Diesel (15 kW)	Converter (7 kW)
	Generic 10kW (1)	Surrette 6CS25P (12 strings)	Cycle Charging

Total NPC:	$211,555.00
Levelized COE:	$0.4112
Operating Cost:	$9,326.70

Cost Summary | Cash Flow | Electrical | Fuel Summary | Diesel | Renewable Penetration | Surrette 6CS25P | PV | Generic 10kW | Converter | Emissions

Production	kWh/yr	%
PV	3,235	6.67
Diesel	21,689	44.70
Generic 10kW	23,593	48.63
Total	48,516	100.00

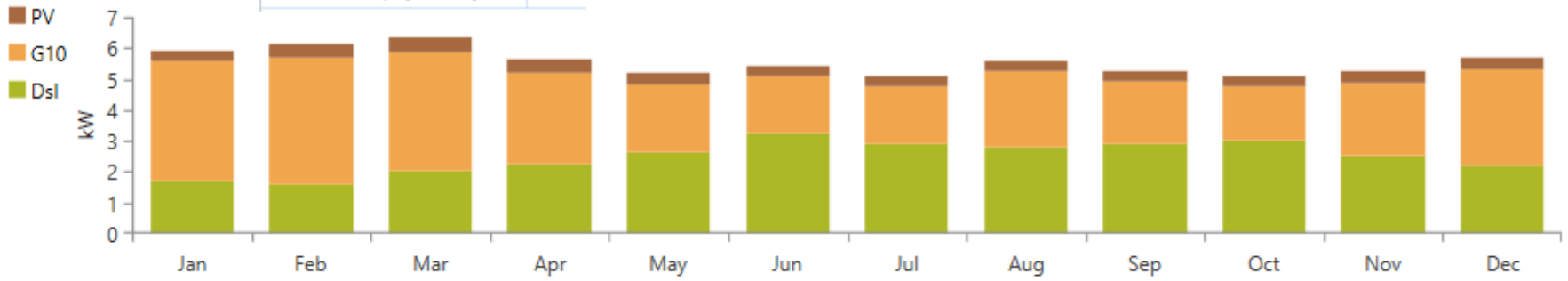
Consumption	kWh/yr	%
AC Primary Load	36,500	100.00
DC Primary Load	0	0.00
Total	36,500	100.00

Quantity	kWh/yr	%
Excess Electricity	6,389.3	13.2
Unmet Electric Load	0.0	0.0
Capacity Shortage	0.0	0.0

Quantity	Value
Renewable Fraction	40.6
Max. Renew. Penetration	1,599.8

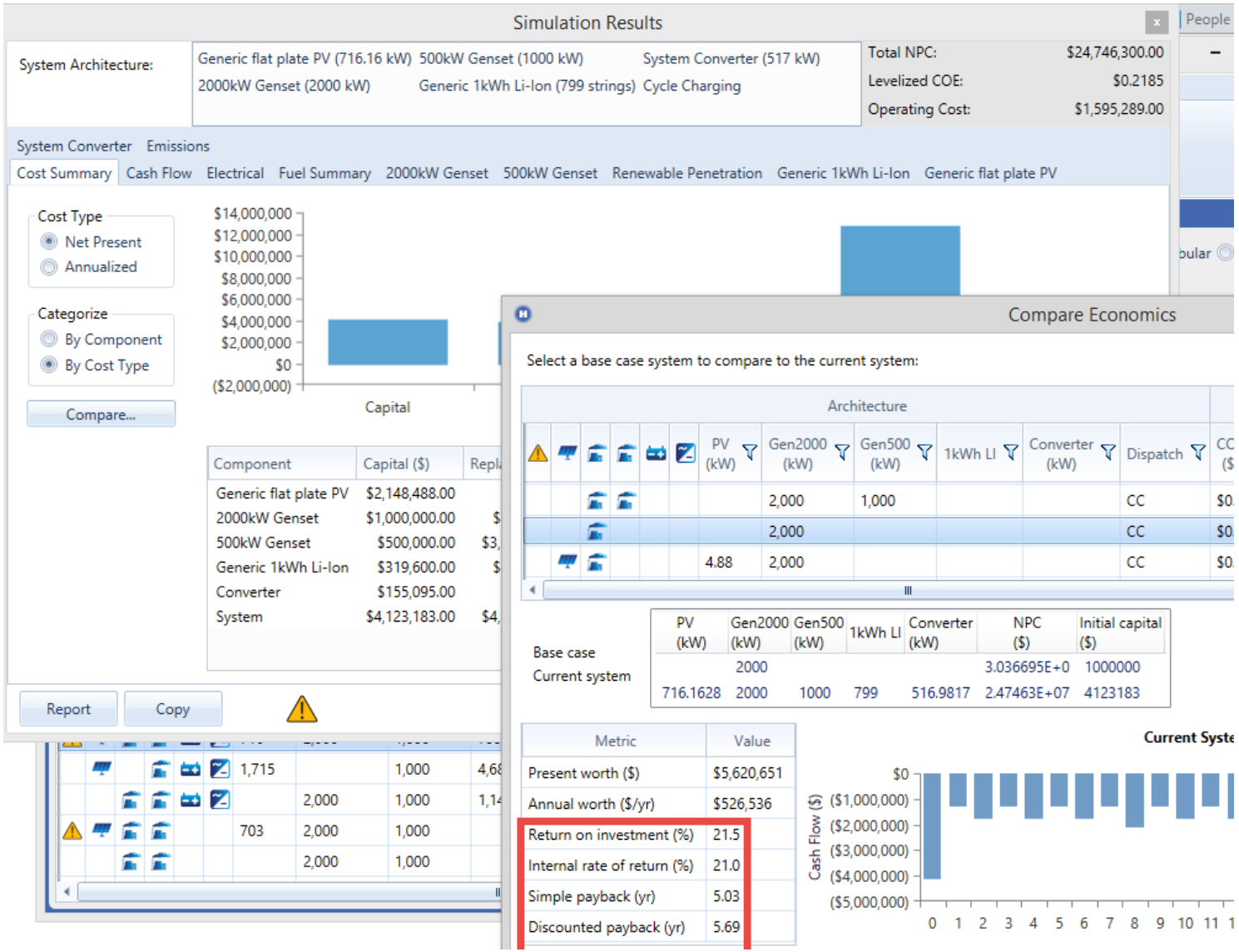
Return on investment (%)	12.2
Internal rate of return (%)	12.0
Simple payback (yr)	6.81
Discounted payback (yr)	8.64

Monthly Average Electric Production



Report | Copy | Time Series: | Plot... | Scatter Plot... | Delta Plot... | Table... | Export...

Compare Economics



Renewable Penetration: Definition

- 8 definitions
  - Based on capacity or energy
  - Instantaneous versus average
  - Allocation of excess energy
- Factor of 10 difference

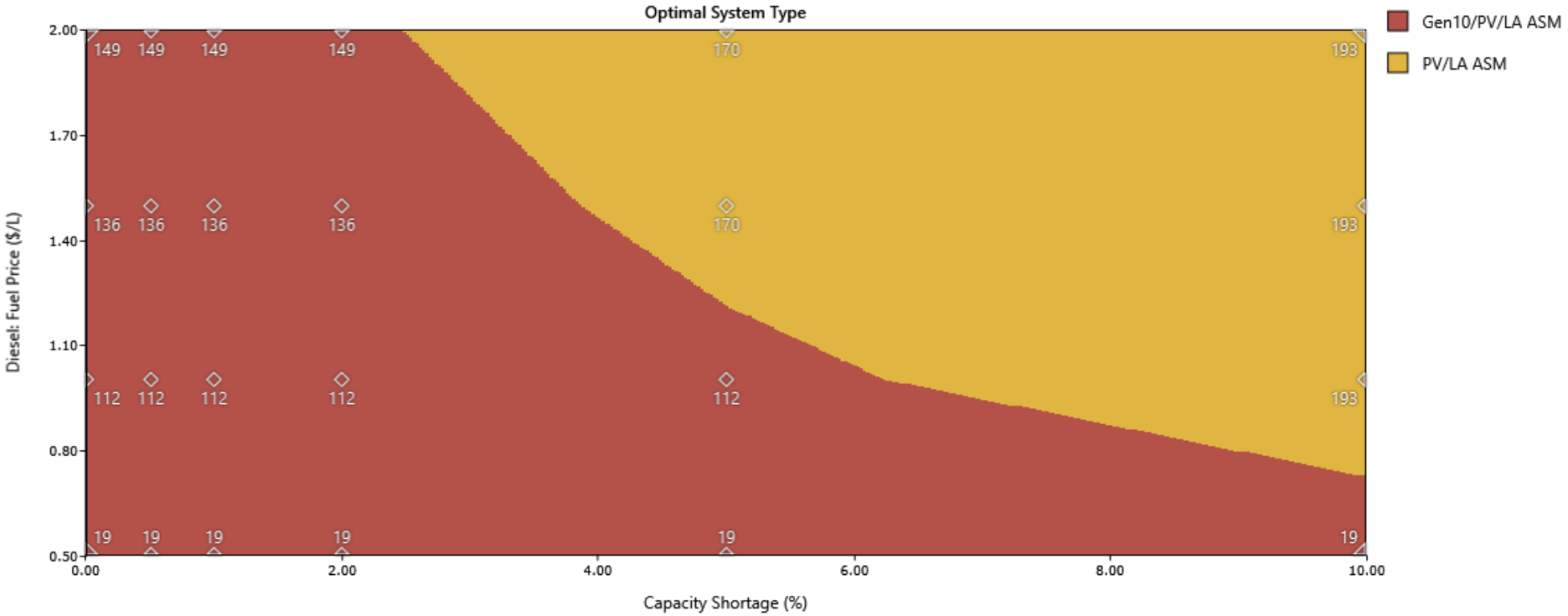
Taxonomy of System Designs

- Low penetration
  - RE variability comparable to load variability
- Medium penetration
  - Curtail renewables to protect diesels
- High penetration (large systems)
  - Re-dispatch diesels for O&M & greater fuel savings
- Very high penetration
  - Run diesel-off except during low resource periods
  - Requires grid-forming inverter

100% renewables without diesel backup

- Applicable for very small systems
- Advantages:
  - No fuel supply issues
  - Vastly reduced maintenance
- Disadvantages:
  - Unmet load
  - Battery management

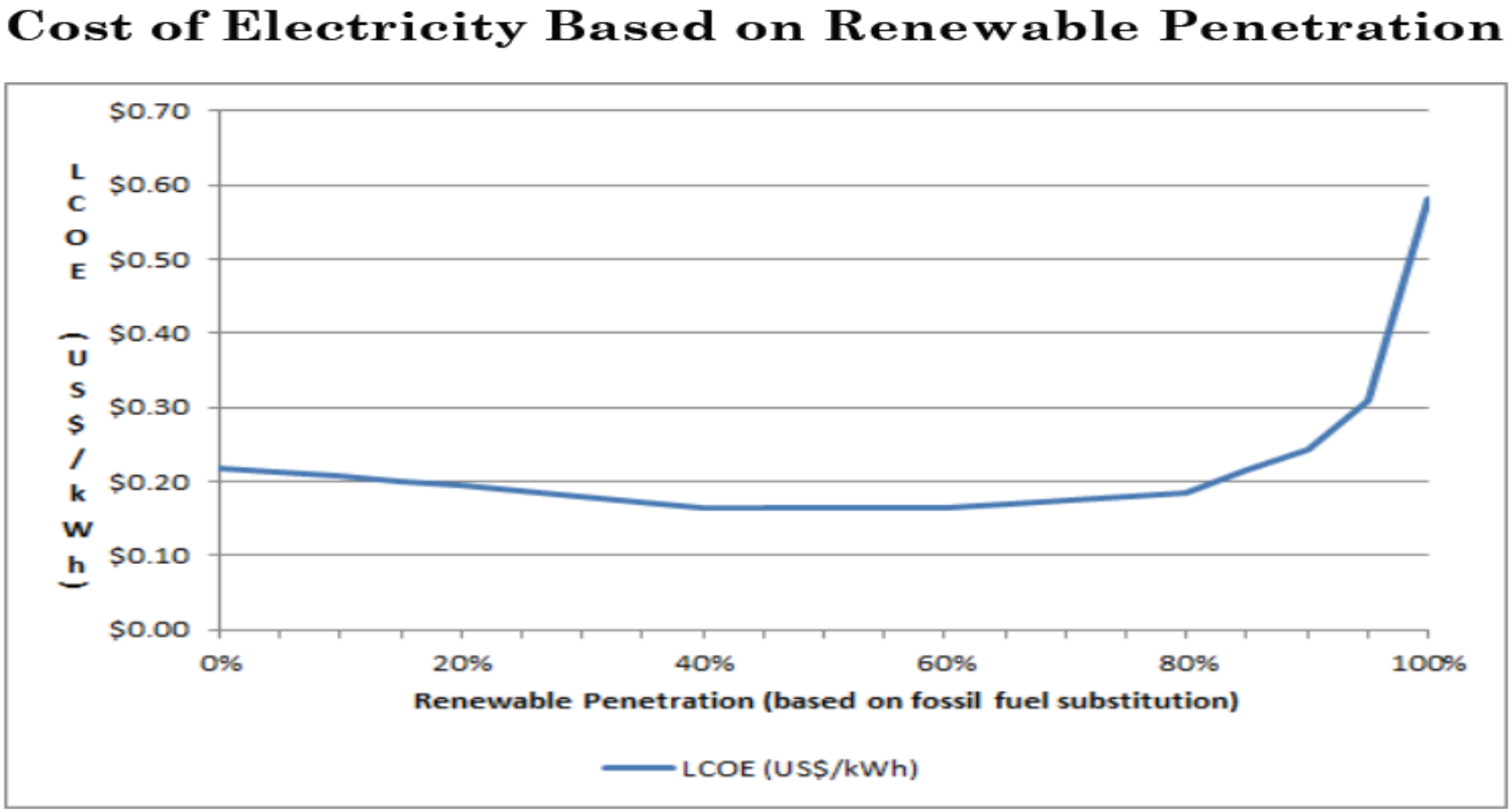
Capacity Shortage without backup



Large Systems

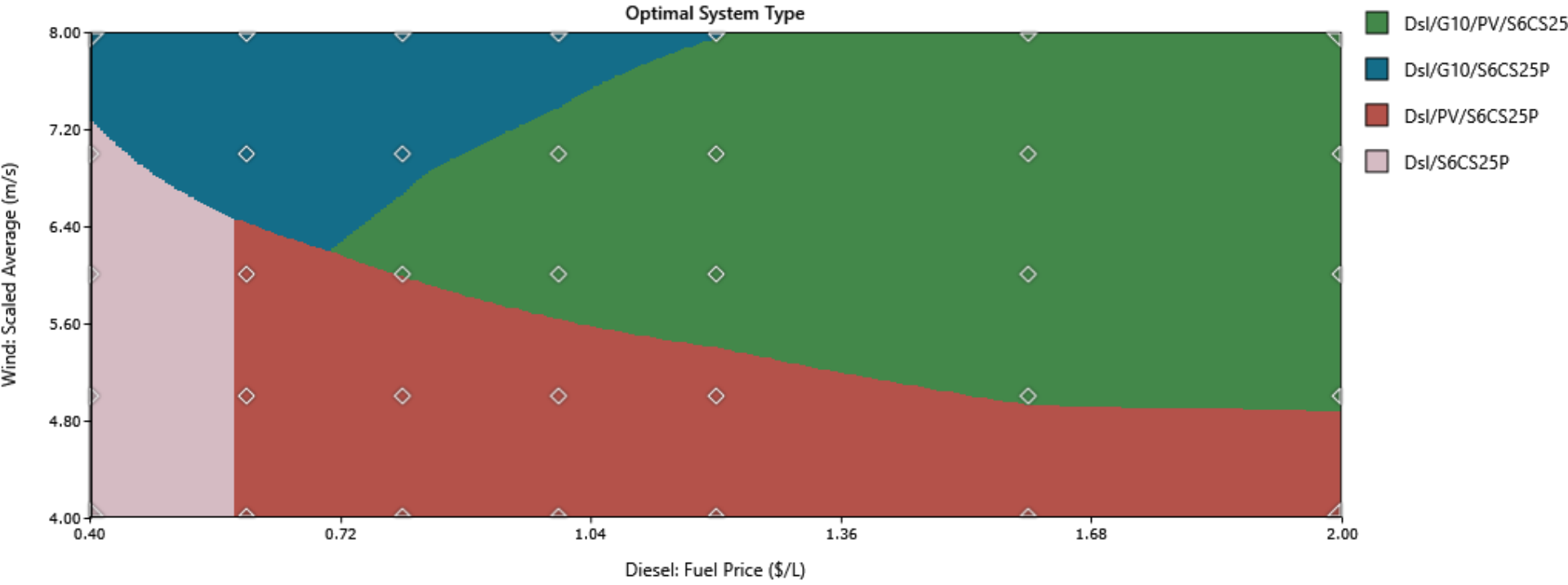
- Multiple Gensets
- Operating (Spinning) Reserves
- Minimum Loading
- Ramp rates
- Special issues for diesel-off operation

Penetration Analysis from HOMER



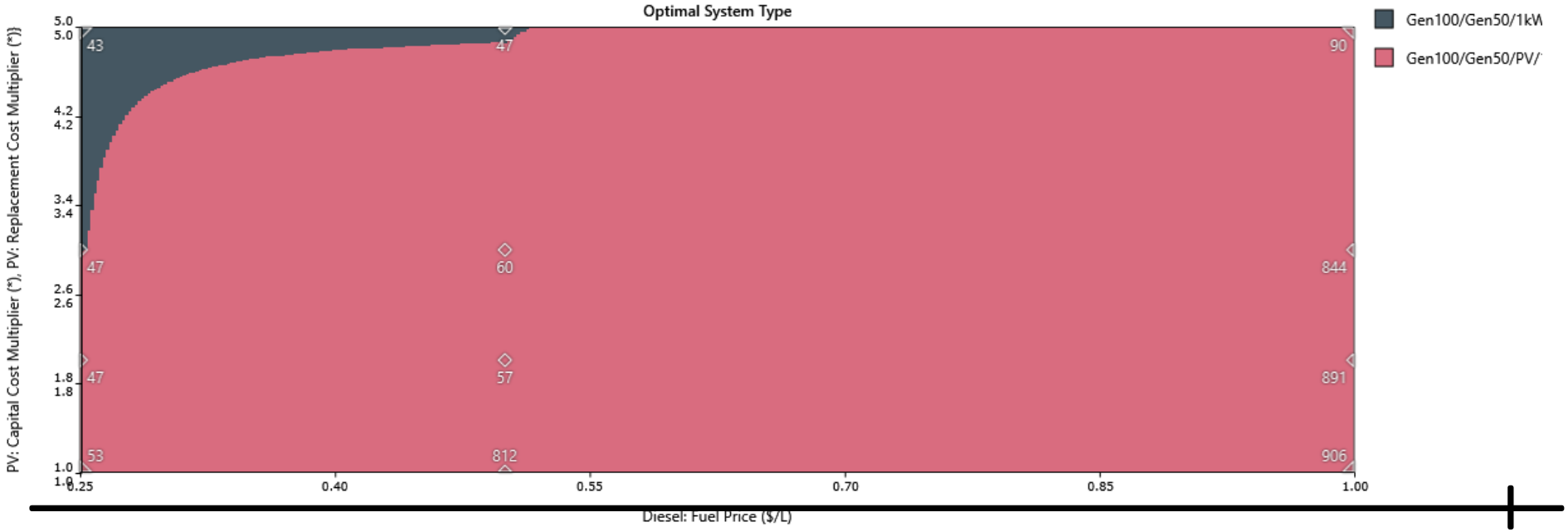
Aruba: > 100 MW peak load

Sensitivity Analysis

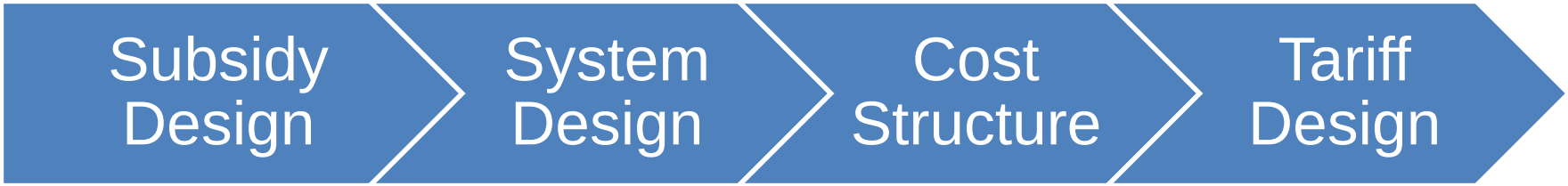


Battery sizing

- 124 kW Peak, multiple generator, $400/kWh batt.
- PV still very cost-effective
- Large range in optimal battery size

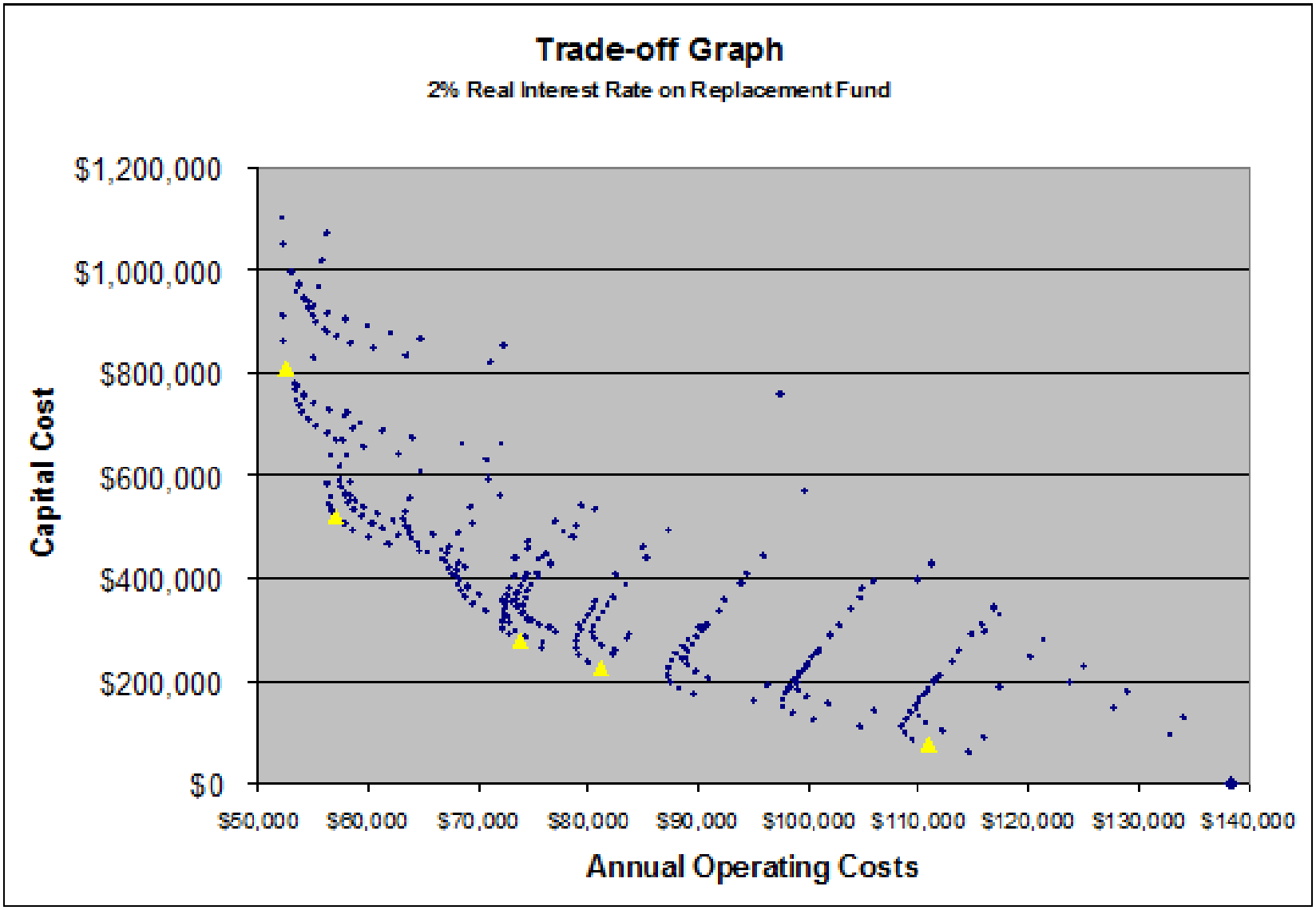


Tariff Design



- Diesel systems
  - Low capital cost, high operating cost
    - Need for continuing subsidies
- Solar Systems
  - High capital cost, low operating cost
    - Need attractive financing
- Hybrid Systems
  - Optimize the tradeoff

Capital / Operating Cost Tradeoff



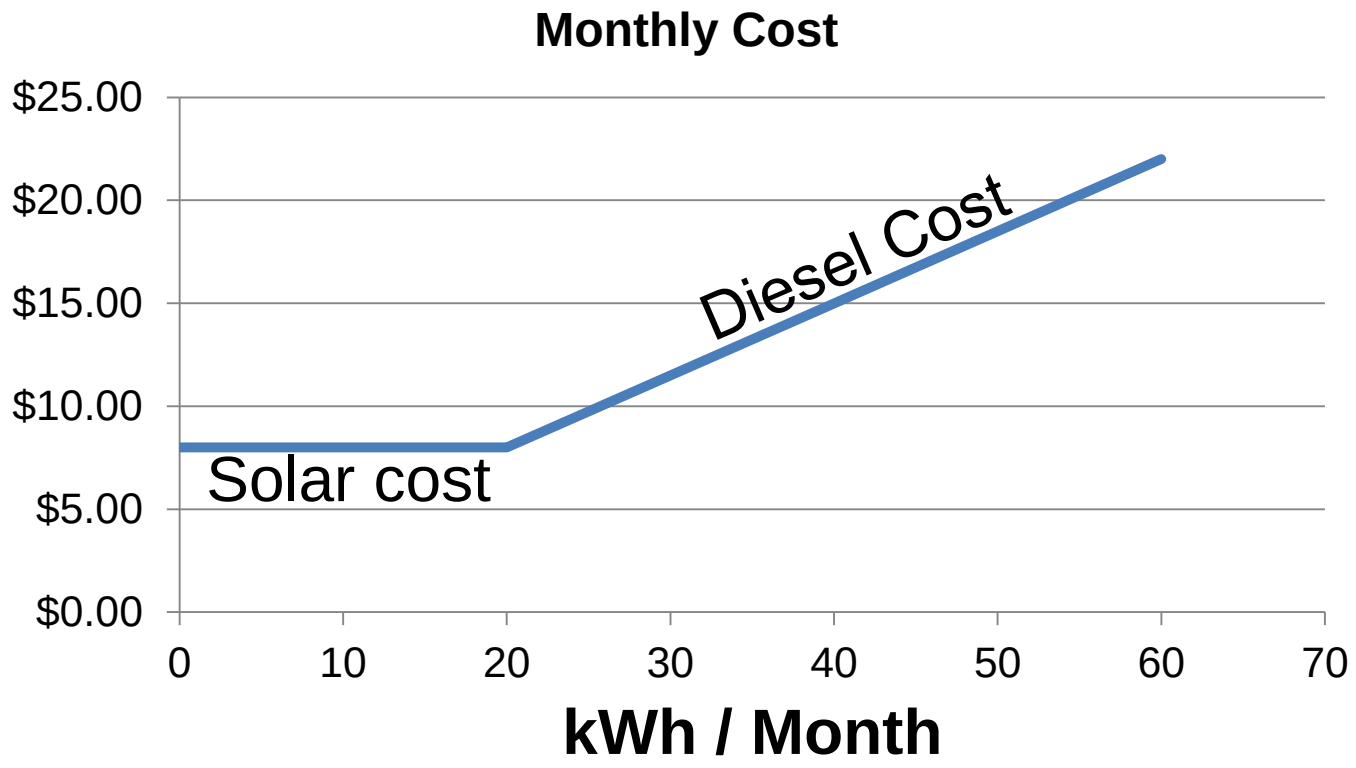
Sustainable Tariffs

- Affordable
  - Consumers
  - Producers
  - Government
- Equitable
  - Subsidy goes to poor
- Efficient
  - Incentive to use most efficient appliances

Tariff Design

- What's wrong with a flat rate:
  - Wealthy households with more appliances get more subsidy
  - Subsidy grows faster than economy
  - No incentive for energy efficiency
- Two-part tariff
  - Subsidy goes to the poor
  - Limited fiscal burden
  - Maintains incentive for energy efficiency

Two-part Tariff

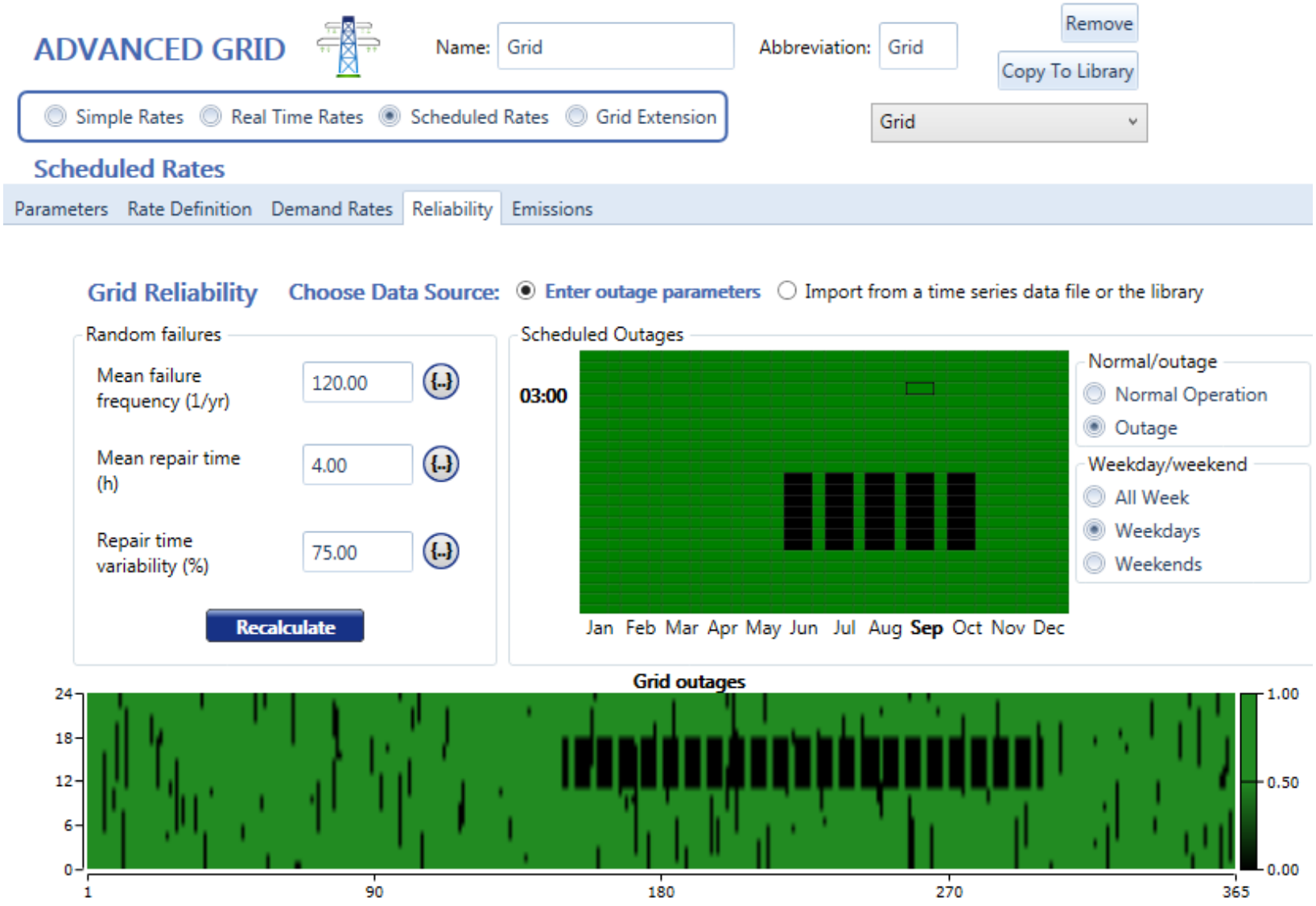


- 2-part tariff
  - Lifeline rate for basic needs
  - Full cost recovery for increased load
    - Pays for system expansion

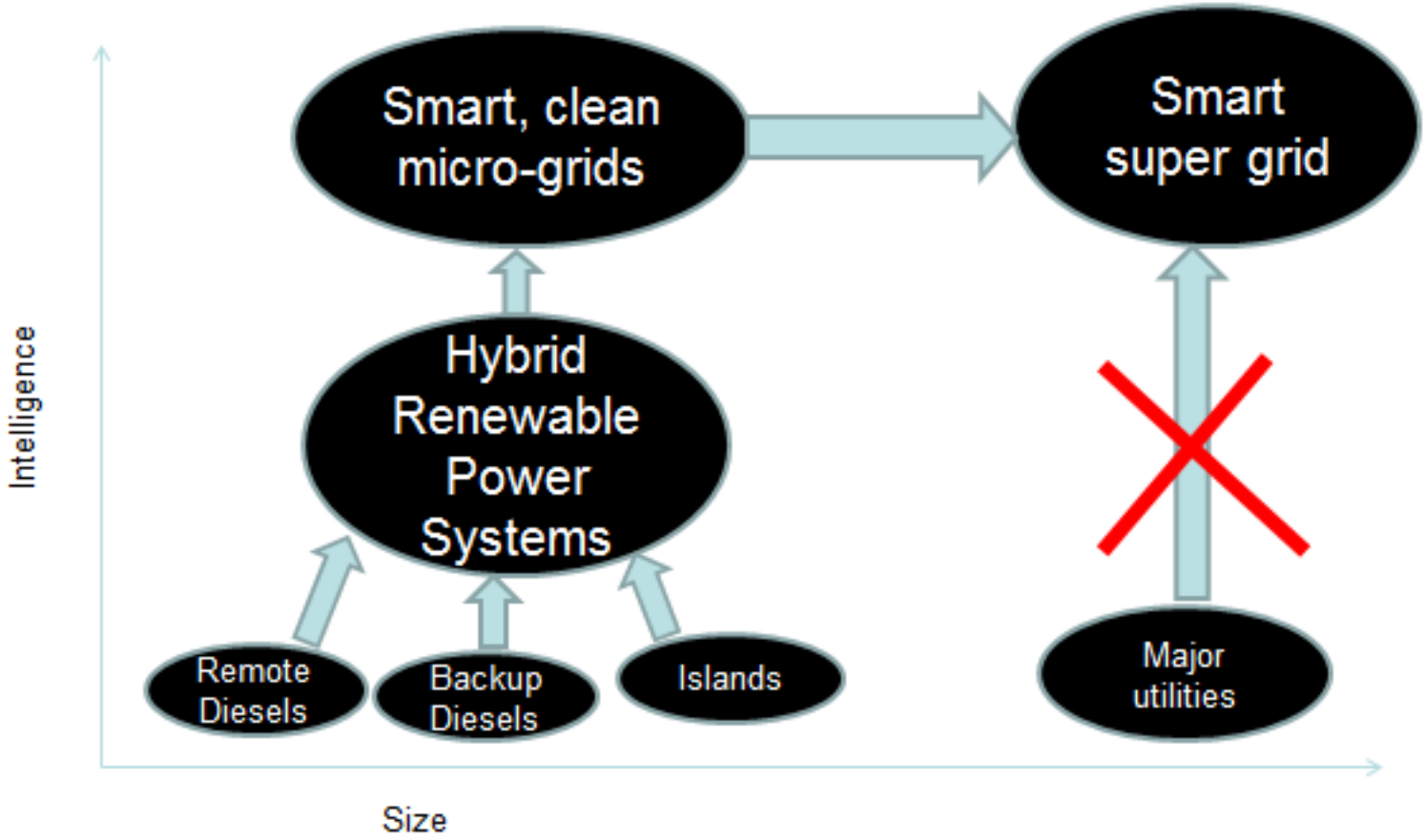
Two-part Tariff

- Also called Lifeline Rate, Social tariff
- Fixed monthly charge
  - Covers basic consumption
  - Based on PV for daytime power
    - PV + Batteries for evening power
- Above threshold, based on diesel power

Modeling Unreliable Grids



Clean Power Evolution



- Smaller systems
  - Liquid fuels from oil
  - High renewable penetrations
- Large utilities
  - Security obstacles
  - Regulatory obstacles

Storage and Load Management

- Load management is mostly ICT
  - Less expensive but more complex than storage
  - Store water, ice, even laundry
- Storage technologies are improving
  - New technologies for stationary applications
- Small systems – use solar power at night
- Large systems – provide spinning reserve
  - Avoid running diesels at low load

Using Exported Data

Sensitivity/Electric Load #1 Scaled Average (kWh/d)	Sensitivity /Electric Load #2 Scaled Average (kWh/d)	Sensitivity /Deferrable Load Scaled Average (kWh/d)	Architecture/PV (kW)	Architecture/LA ASM	Architecture/Converter (kW)	Cost/COE ($)	Cost/NPC ($)	Cost/Operating cost ($)	Cost/Initial capital ($)	PV/Capital Cost ($)	PV/Production (kWh)	LA ASM/Autonomy (hr)	LA ASM/Annual Throughput (kWh)	Converter/Inverter Mean Output (kW)
100	100	100	120	300	90	0.427813	600953.7	9588.359	477000	360000	186992.6	19.6961	29881.7	12.40417
100	100	110	120	300	90	0.415627	601299.4	9615.105	477000	360000	186992.6	19.06074	30047.8	12.7752
100	110	100	120	300	90	0.418033	605747.4	9959.172	477000	360000	186992.6	19.06074	31007.23	12.79566
100	110	110	120	300	90	0.406493	606218.4	9995.613	477000	360000	186992.6	18.46509	31207.59	13.16914
110	100	100	120	300	90	0.420639	609510.8	10250.29	477000	360000	186992.6	19.06075	31977.57	12.79537
110	100	110	120	300	90	0.408479	609020.9	10212.39	477000	360000	186992.6	18.4651	32009.22	13.16565
110	110	100	120	300	90	0.410812	613161.6	10532.7	477000	360000	186992.6	18.46509	33013.6	13.17992
110	110	110	120	300	90	0.400442	614256.9	10617.43	477000	360000	186992.6	17.90554	33220.91	13.54537
Residential	0.181351													
Commercial	0.1015926													
Waterpumping	0.0073277													

Incremental cost of different load types

Conclusions

- No “one-size-fits-all” solution
- HOMER Pro has multiple uses
  - Conceptual or prefeasibility analysis
  - Detailed analysis
- Analyze systems of various sizes
- Multiple technologies
  - Especially hybrids
- Off-grid or grid-connected
- Tariff analysis
  - Load growth
- 30 day free trial