Hybrid Opportunities in SPUG Areas using Homer

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Outline

- Introduction to NPC-SPUG
- PV-Diesel Hybrid Options for SPUG Areas
- Modeling SPUG areas with HOMER Pro
- Hybrid Implementation Arrangements
- Challenges in Hybrid Implementation
- Conclusion

About SPUG

The National Power Corporation Small Power Utilities Group (NPC-SPUG) is mandated by law (Philippines) to undertake the electrification of areas not connected to the main transmission grid, also referred to as Missionary Areas.

SPUG OPERATIONS as of December 2012

- NPC-SPUG operates 529 generating units with a total rated capacity of 283.06 MW in 233 areas. This nationwide operation is composed of 291 land-based power plants, 1 hydroelectric plant, 1 hybrid wind turbine farm and 11 barge-mounted power plants. It serves 233 island customers consisting of 41 electric cooperatives and 10 local government units.
- NPC-SPUG generated a total of 466,569,073.77 kWh with aggregate energy sales of 443,075,715.91 kWh.

Objectives

Use Homer Pro to explore hybrid options to:

- provide 24hours power to the Islands
- reduce energy production costs and subsidy requirement from the Universal Charge for Missionary Electrification (UCME)
- promote renewable energy generation and integration without compromising grid stability and generation cost

Target Operating Hours

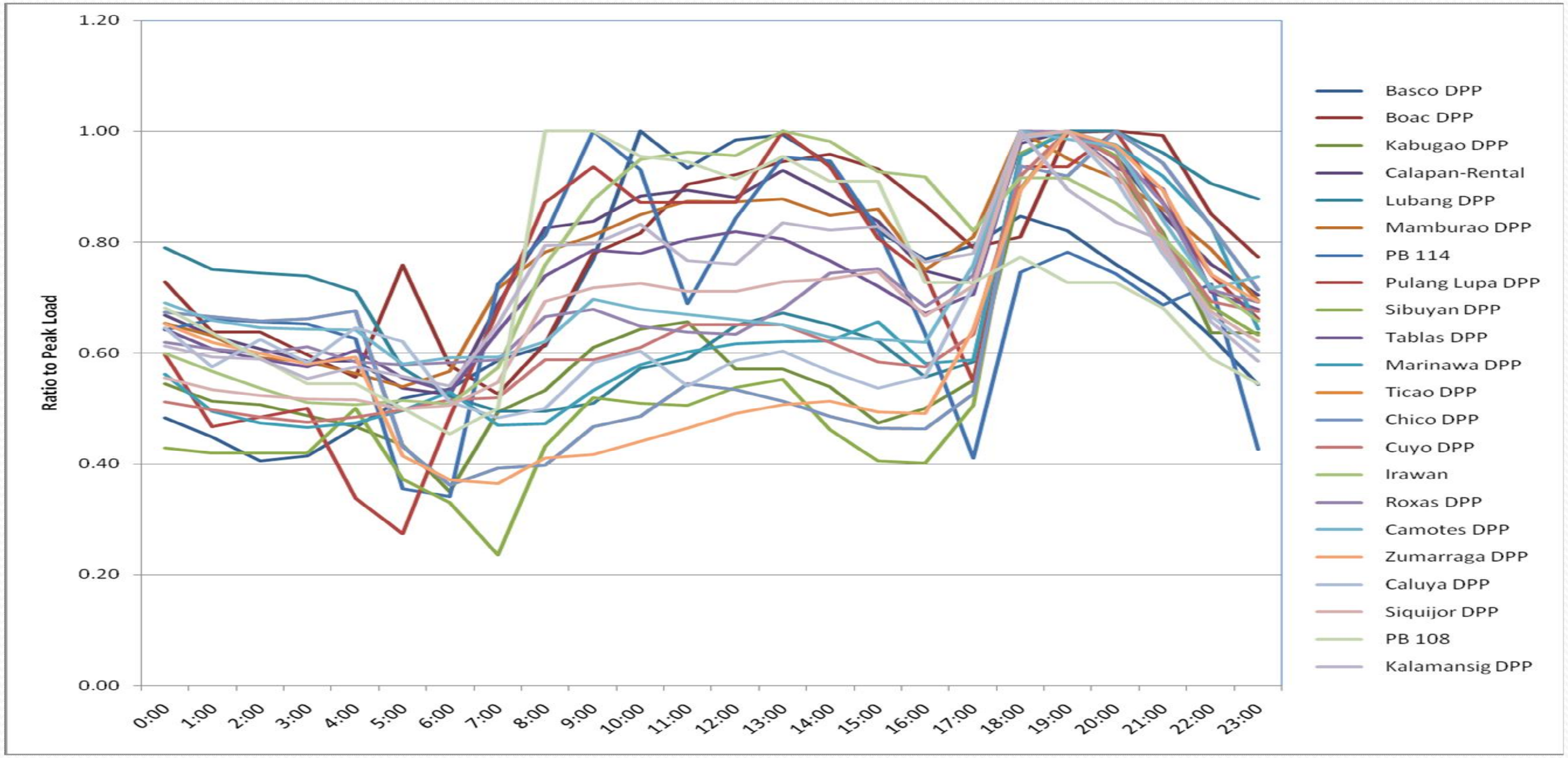
Year	2010	2012	2013	2014	2015	2016
24H	31%	35%	39%	37%	44%	44%
18-20H	9%	8%	4%	5%	8%	12%
12-16H	21%	30%	33%	41%	42%	42%
8-10H	28%	20%	20%	15%	6%	3%
6H	12%	8%	5%	1%	0%	0%
Average Running Hours	13.50	16.00	16.40	16.70	18.40	18.90

Source: NPC-SPUG 2016

Homer Data Requirements

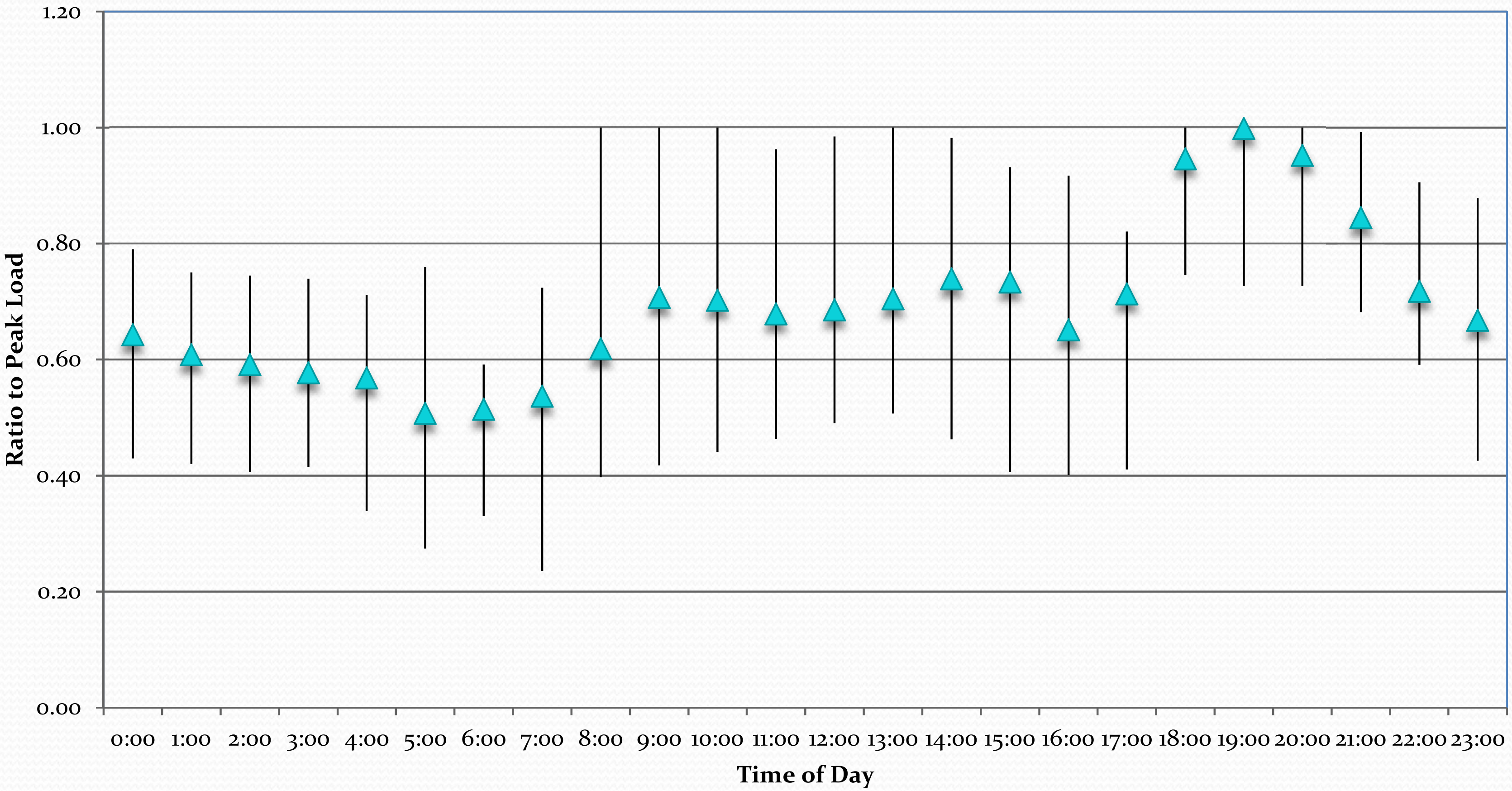
- Load Curve (Load profile – hourly demand data/24H)
- Technical configuration of existing power system
- Delivered cost of Diesel fuel
- Renewable Energy Source Data (solar, wind)
- Capacities and costs of renewable energy components

Load Curve

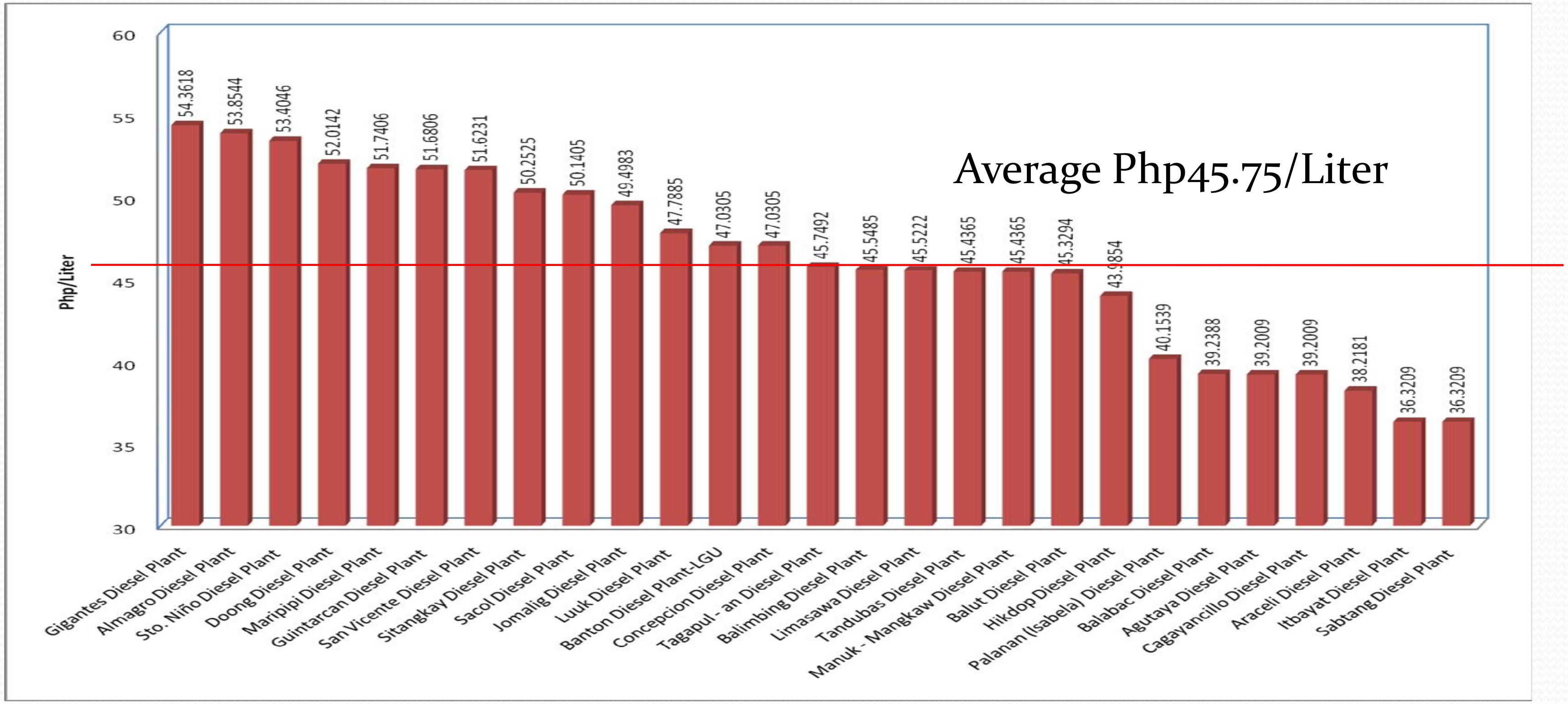


Source: SPUG.PH

Load Curve Model



Delivered Fuel Cost



Source: NPC-SPUG 2016

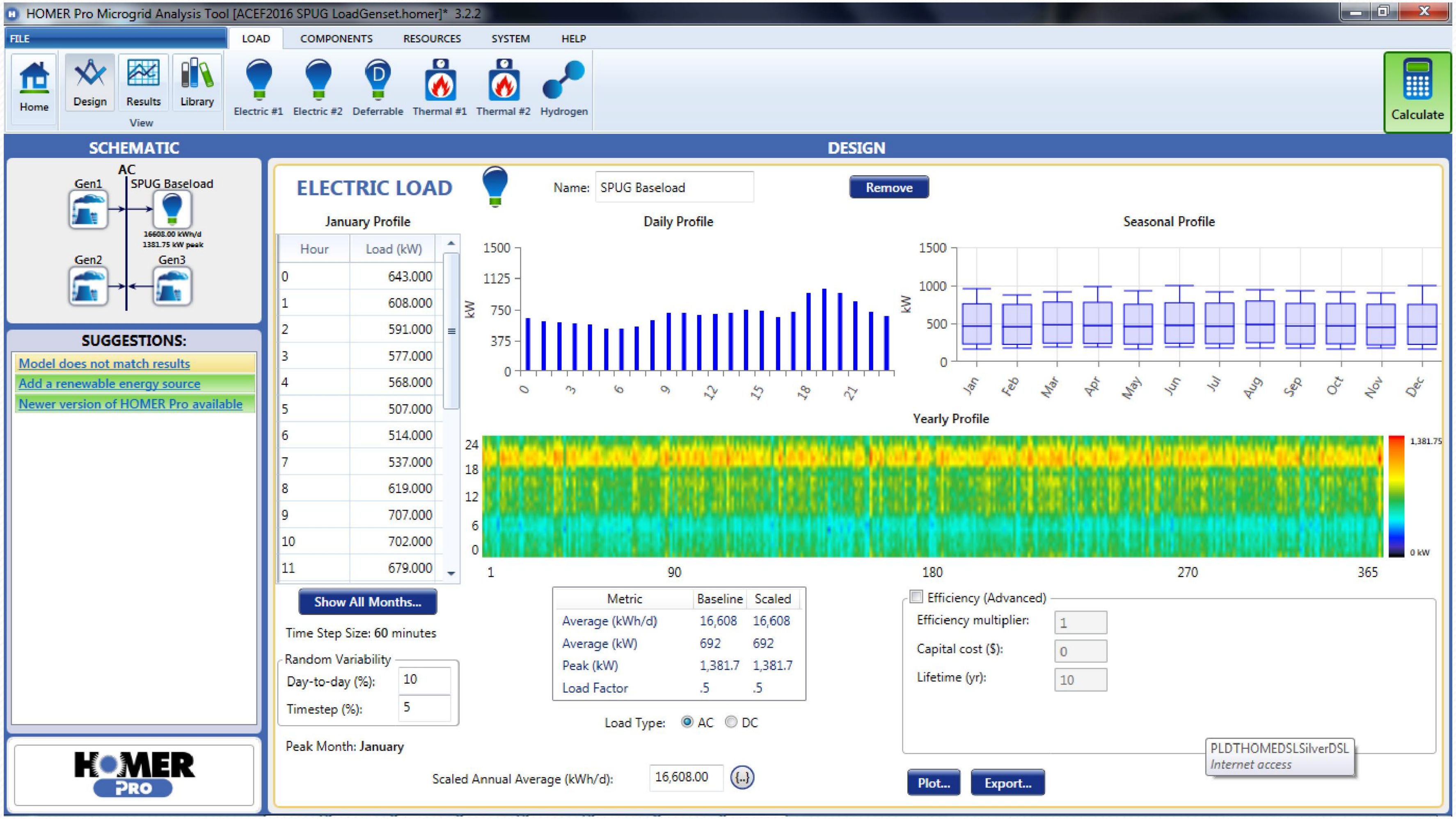
Fuel Conversion Rate Profile

Gross MWh (2011)	Plant Count	Fuel Rate (L/kWh)		Plant Use and Losses	
		Group Average	Weighted Average	Group Average	Weighted Average
<120	192	0.508	0.450	0.69%	3.16%
120 to 600	45	0.324	0.321	3.24%	3.56%
600 to 1,200	12	0.311	0.310	6.34%	6.22%
1,200 to 12,000	28	0.293	0.277	6.23%	5.93%
>12,000	10	0.283	0.281	4.67%	3.85%

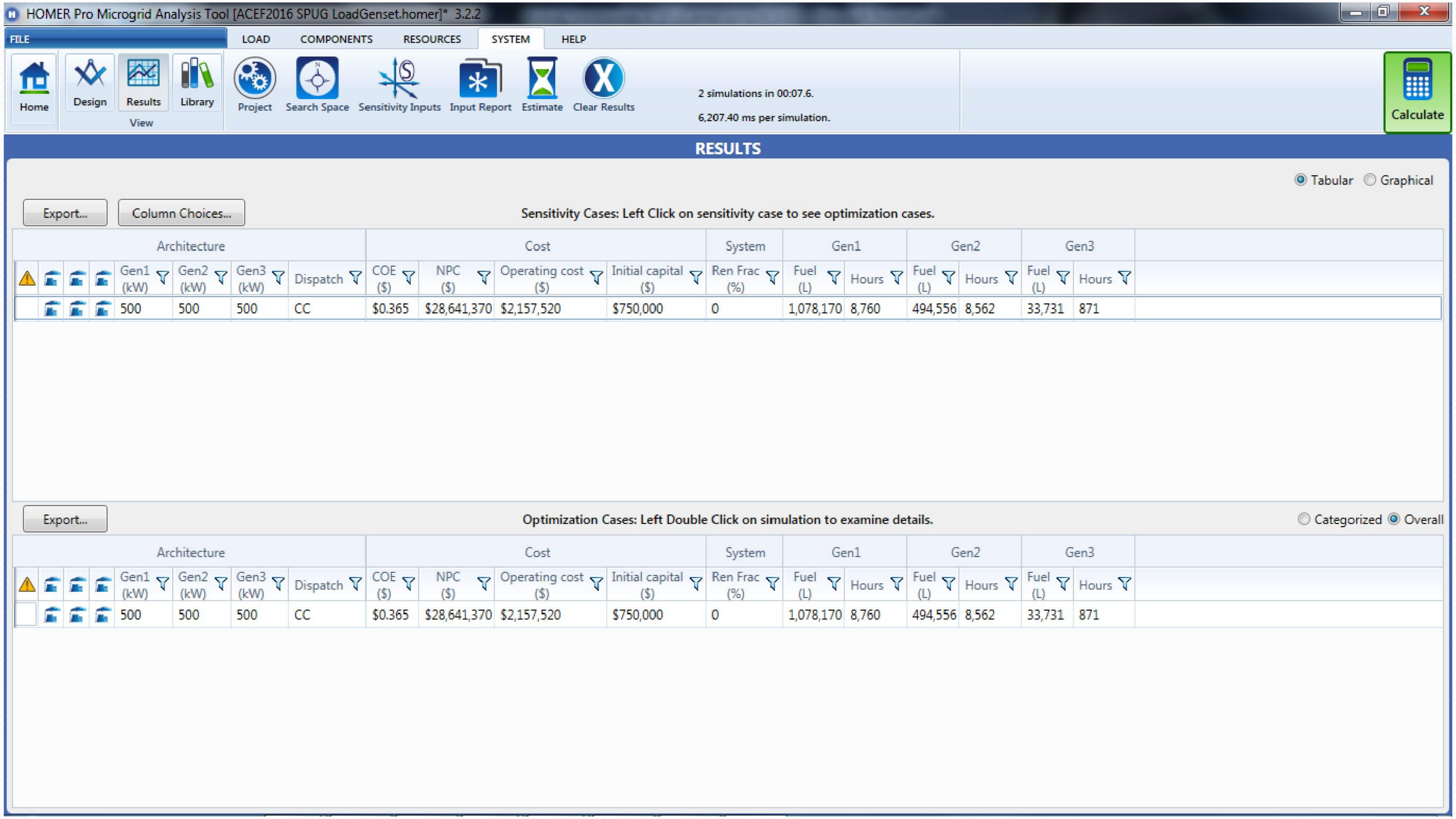
Source: MEDP 2012

Diesel PV Hybrid Options

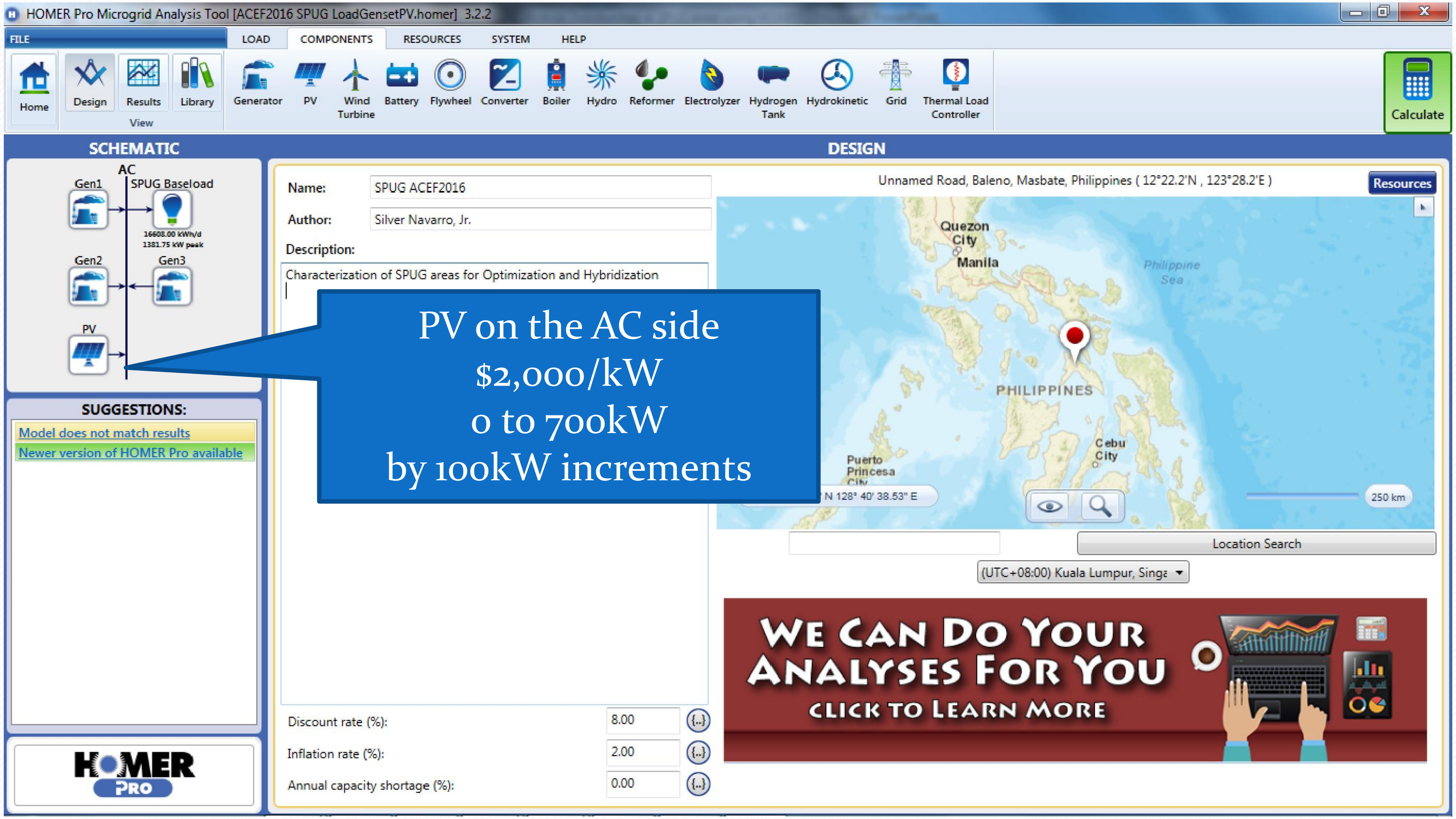
- Integrate solar PV without batteries
  - Use grid-connected PV inverters
  - Consider the minimum genset load ratio requirement
  - Consider the genset capacity reserve due to variable PV output and changing load demand
  - Use hybrid controller for maximum PV penetration
- Integrate solar PV with batteries
  - Higher renewable energy fraction/penetration
  - Gensets can be turned off using grid forming inverters
  - Battery chemistry, capacity, depth of discharge, cycle life



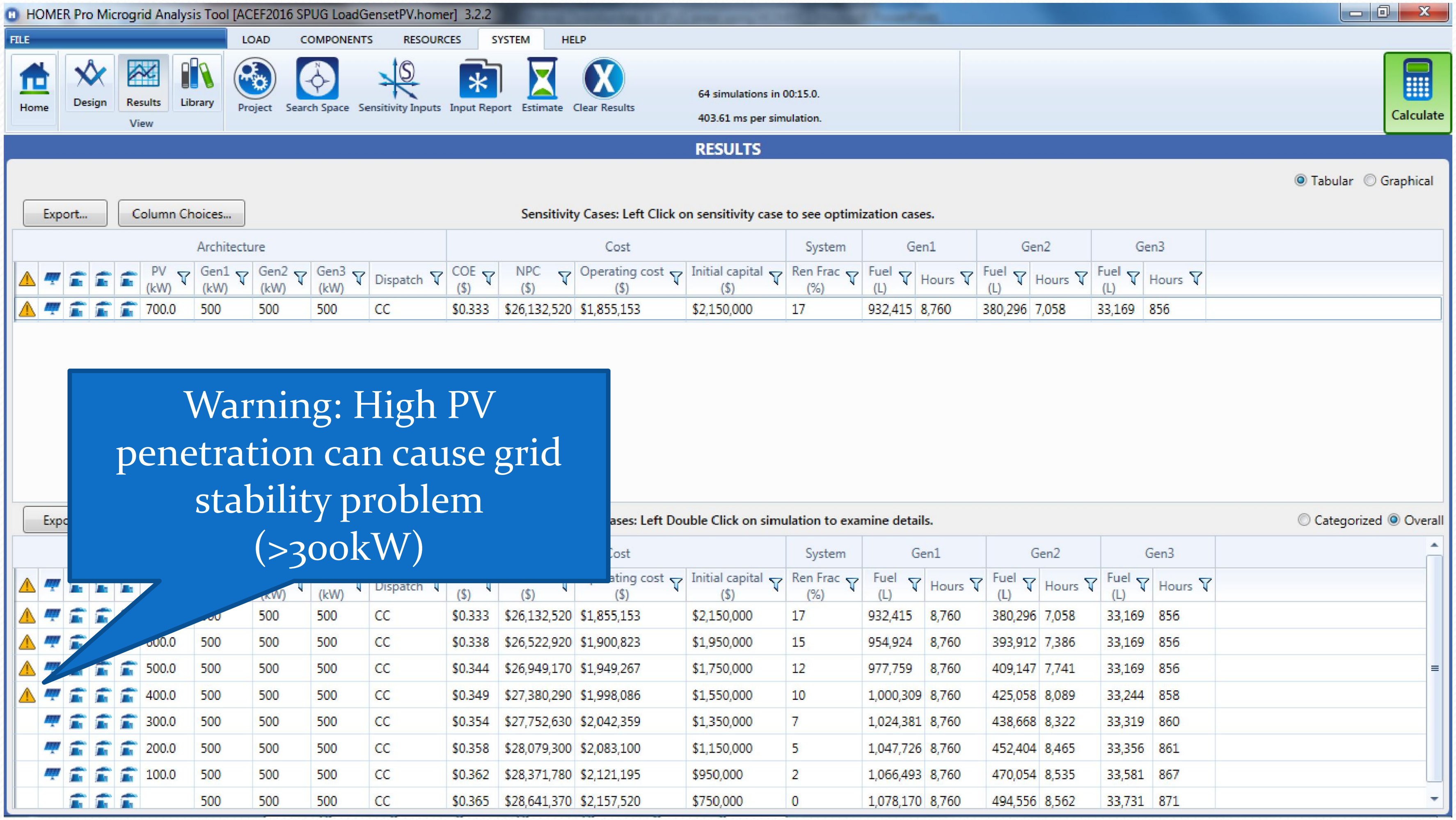
Baseline: Base load + 3 x 500kW Diesel Gensets



Baseline: Base load + 3 x 500kW Diesel Gensets (Initial Result)



PV Diesel Hybrid: Base load + 3 x 500kW Diesel Gensets + PV(0 to 700kW)



Sensitivity cases:

PV (kW)	Gen1 (kW)	Gen2 (kW)	Gen3 (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Gen1 Fuel (L)	Gen1 Hours	Gen2 Fuel (L)	Gen2 Hours	Gen3 Fuel (L)	Gen3 Hours
700.0	500	500	500	CC	$0.333	$26,132,520	$1,855,153	$2,150,000	17	932,415	8,760	380,296	7,058	33,169	856

Optimization cases:

PV (kW)	Gen1 (kW)	Gen2 (kW)	Gen3 (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Gen1 Fuel (L)	Gen1 Hours	Gen2 Fuel (L)	Gen2 Hours	Gen3 Fuel (L)	Gen3 Hours
[illegible]	[illegible]	500	500	CC	$0.333	$26,132,520	$1,855,153	$2,150,000	17	932,415	8,760	380,296	7,058	33,169	856
600.0	500	500	500	CC	$0.338	$26,522,920	$1,900,823	$1,950,000	15	954,924	8,760	393,912	7,386	33,169	856
500.0	500	500	500	CC	$0.344	$26,949,170	$1,949,267	$1,750,000	12	977,759	8,760	409,147	7,741	33,169	856
400.0	500	500	500	CC	$0.349	$27,380,290	$1,998,086	$1,550,000	10	1,000,309	8,760	425,058	8,089	33,244	858
300.0	500	500	500	CC	$0.354	$27,752,630	$2,042,359	$1,350,000	7	1,024,381	8,760	438,668	8,322	33,319	860
200.0	500	500	500	CC	$0.358	$28,079,300	$2,083,100	$1,150,000	5	1,047,726	8,760	452,404	8,465	33,356	861
100.0	500	500	500	CC	$0.362	$28,371,780	$2,121,195	$950,000	2	1,066,493	8,760	470,054	8,535	33,581	867
	500	500	500	CC	$0.365	$28,641,370	$2,157,520	$750,000	0	1,078,170	8,760	494,556	8,562	33,731	871

PV Diesel Hybrid: Base load + 3 x 500kW Diesel Gensets + PV(0 to 700kW) Result

Compare Economics

Select a base case system to compare to the current system:

Categorized Overall

Architecture						Cost				System	Gen1		Gen2		Gen3	
PV (kW)	Gen1 (kW)	Gen2 (kW)	Gen3 (kW)	Dispatch		COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Fuel (L)	Hours	Fuel (L)	Hours	Fuel (L)	Hours
300.0	500	500	500	CC		$0.354	$27,752,630	$2,042,359	$1,350,000	7	1,024,381	8,760	438,668	8,322	33,319	860
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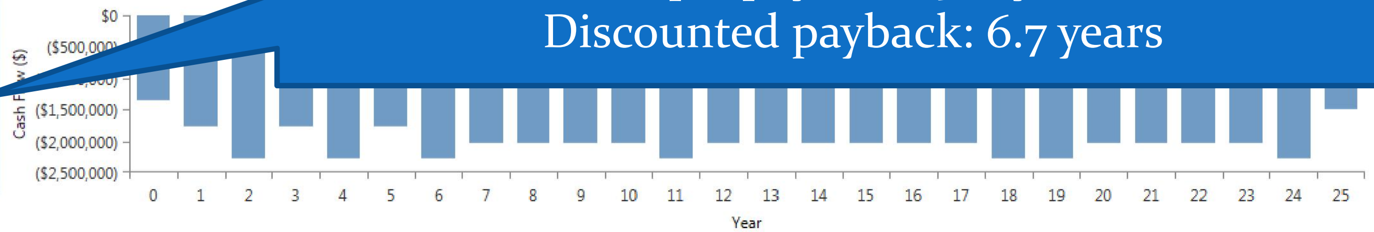
	PV (kW)	Gen1 (kW)	Gen2 (kW)	Gen3 (kW)	NPC ($)	Initial capital ($)
Base case		500	500	500	2.864137E+07	750000
Current system	300	500	500	500	2.775263E+07	1350000

Metric	Value
Present worth ($)	$888,742
Annual worth ($/yr)	$83,256
Return on investment (%)	19.2
Internal rate of return (%)	18.7
Simple payback (yr)	5.41
Discounted payback (yr)	6.67

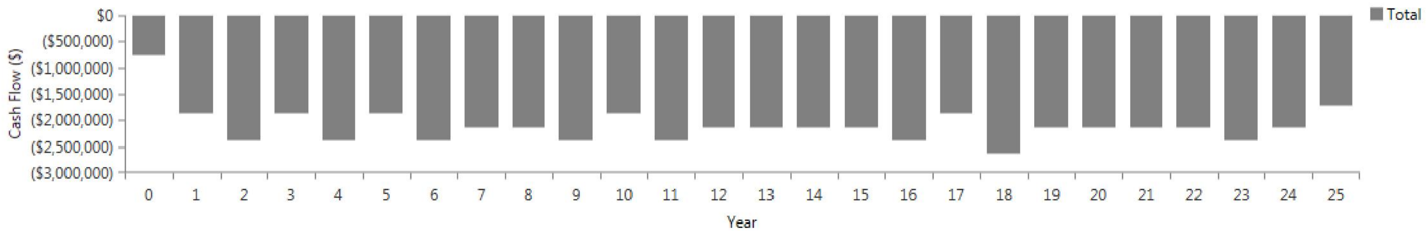
Comparison to Baseline: ROI 19.2,% IRR 18.7%
Simple payback: 5.41years
Discounted payback: 6.7 years



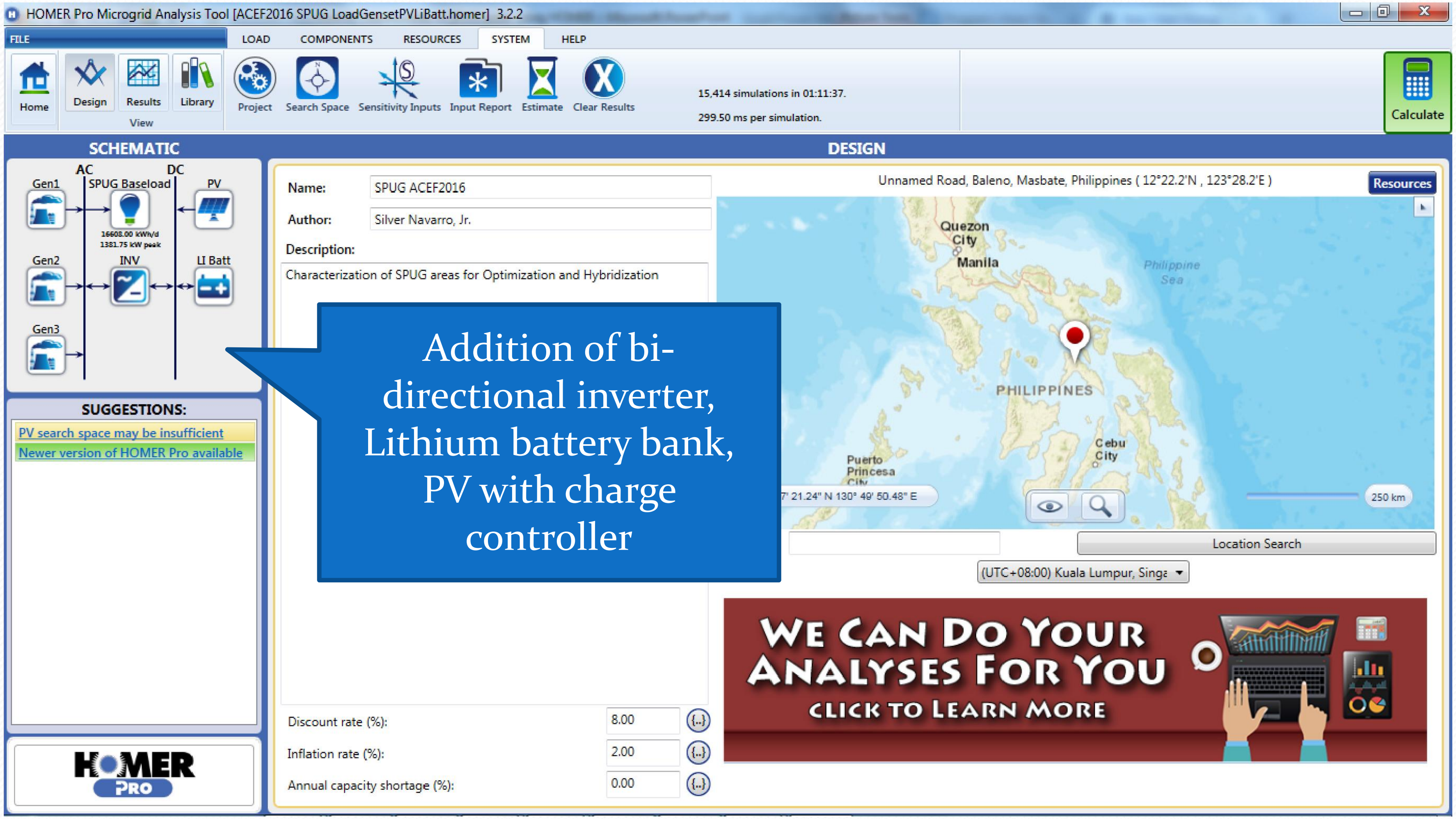
Display:

Graph / Table
Both / Difference
Annual / Cumulative
Nominal / Discounted

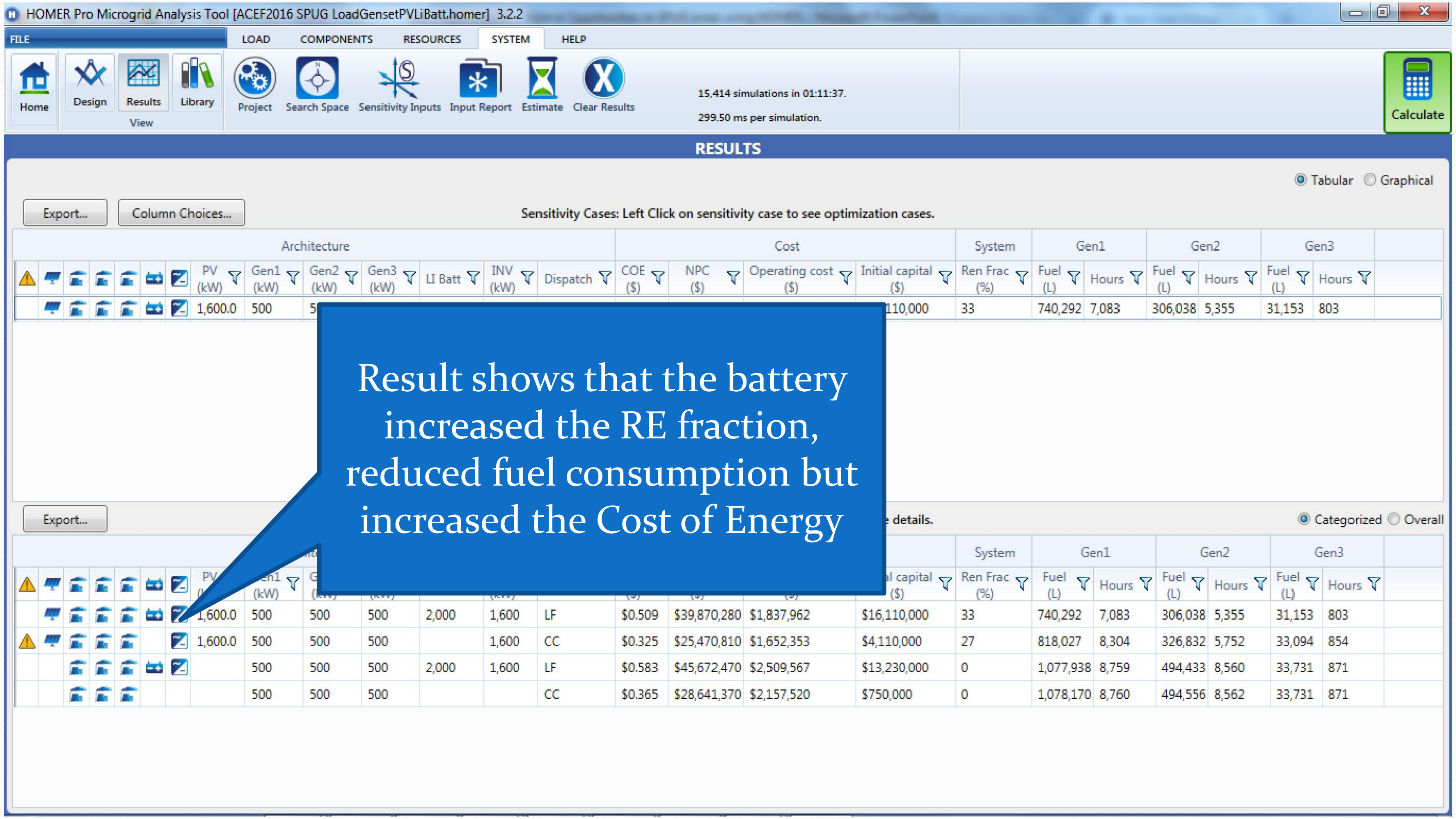
Base Case - Nominal



Comparison of Baseline vs300kW PV Hybrid



PV+Battery Diesel Hybrid: baseload + 3 x 500kW Diesel Gensets + PV+ Battery



PV Diesel Hybrid: Base load + 3 x 500kW Diesel Gensets + PV + Li Battery Result

Possible Hybrid Implementation Arrangements

- Hybrid implementation by SPUG through Competitive Selection Process (CSP)
- Hybrid implementation by New Power Producer (NPP)
- Hybrid implementation by Qualified Third Party (QTP)
- Implementation by Distribution Utilities (DU), Electric Cooperatives (EC), Local Government Units (LGU), private sector for own use

Hybrid Implementation Challenges

- Low oil prices slows down interest in Hybrid projects
- NPC-SPUG cannot borrow capital and relies only on internally generated cash to do RE projects
- Loss of market of existing NPPs to be displaced by RE generation
- There is a limited number of private sector participants that are selective to only develop areas with high true cost of generation and with significant scale
- Administrative requirements on permitting , service contract, financing, others.

Conclusion

- Homer can be used by NPC-SPUG in optimizing hybrid configurations on its diesel plants to provide 24h supply
- Homer demonstrated how to size hybrid components that results to the least cost of energy generation without compromising the grid stability
- Homer can be used to validate hybrid proposals submitted to SPUG for implementation