REGEN power
Sustainable Power Solutions

DC Hybrid-Gen

Variable Speed Generator

REGEN Sustainable Power Solutions power

Presented by

Regen Power Pty Ltd

Cooperated with

Daily Life Renewable Energy Pvt Ltd

Carbon Recycle Energy Technology Co. Ltd.

High Hope International Group

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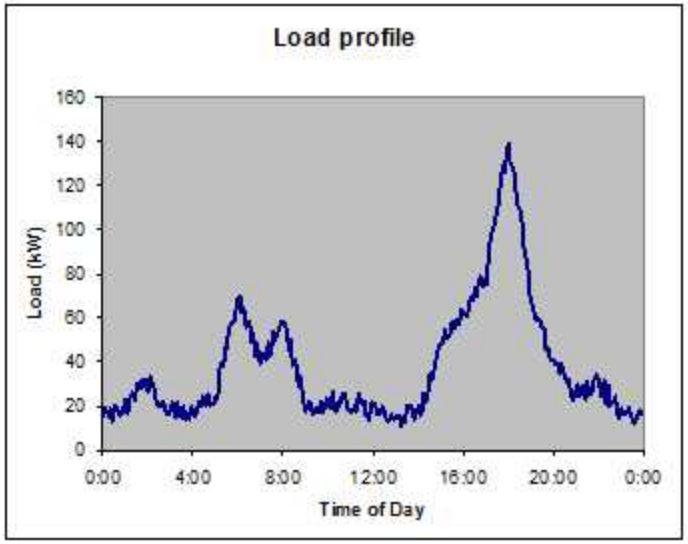
1. Background
2. Development of Hybrid-Gen
3. The New Model
4. Application in Telecommunication
5. Future is Now

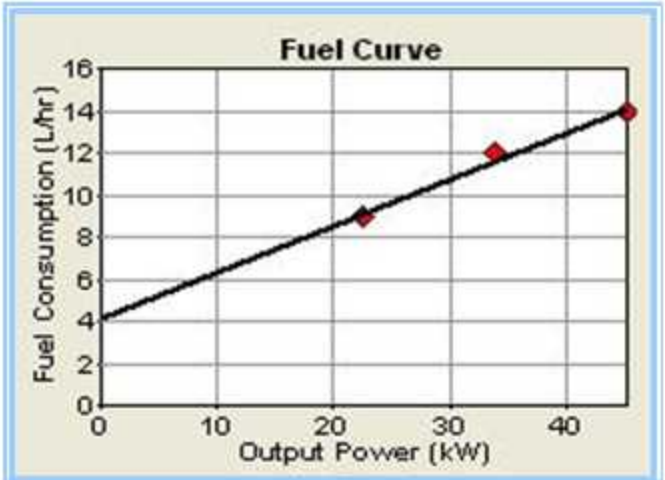
In the context of resources shortage and fuel pollution, it is everyone's duty to take the best endeavors to

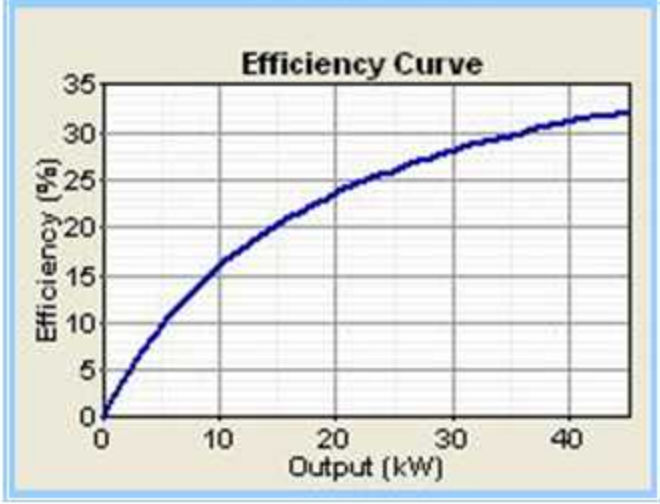
- Increase the efficiency in using traditional fuel
- Resort to clean and renewable energy sources
- Avail energy-storage media with high energy density

A Standard Diesel Generator runs at a constant speed to get constant voltage and constant frequency irrespective of the load on the generator.

However, the load usually varies, even dramatically, during a time cycle. The diesel generator should be selected to meet the peak input of the load, so when the load runs lower than rated, the diesel generator is working at low efficiency and a substantial percentage of fuel is wasted.



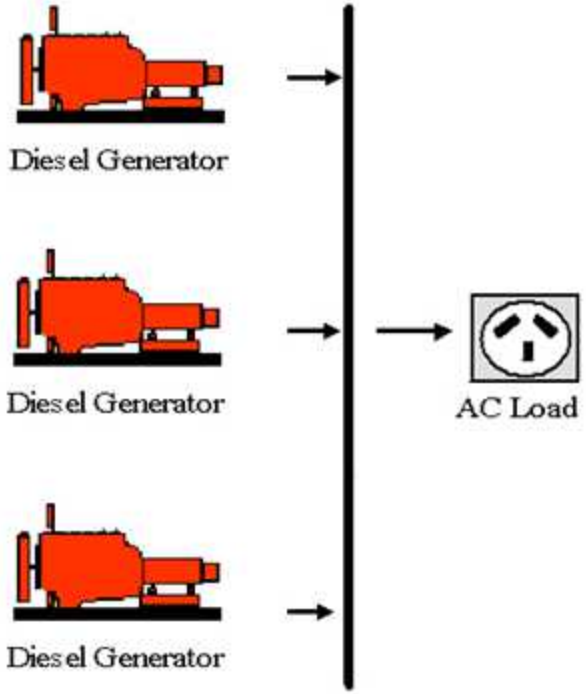




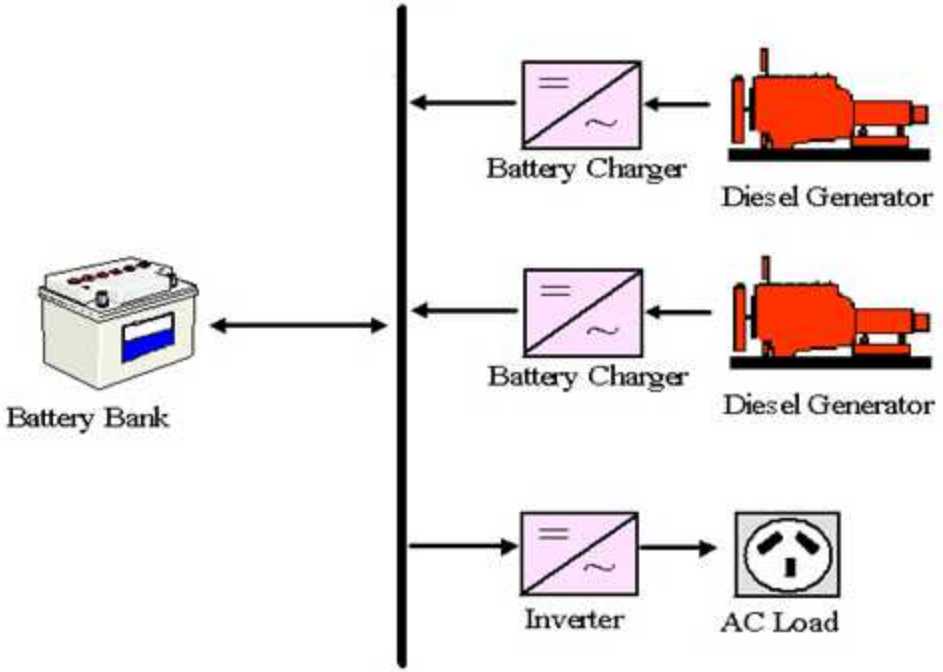
For a typical Diesel Generator:
50 KVA (Prime 45 KW)
Its fuel consumption goes up while efficiency goes down as the load decreases.

Load (kW)	Fuel (L/kWh)	Efficiency (%)
45	0.317	32
40	0.325	31
35	0.343	30
30	0.366	28
25	0.401	26
20	0.450	24
15	0.466	20
10	0.602	17

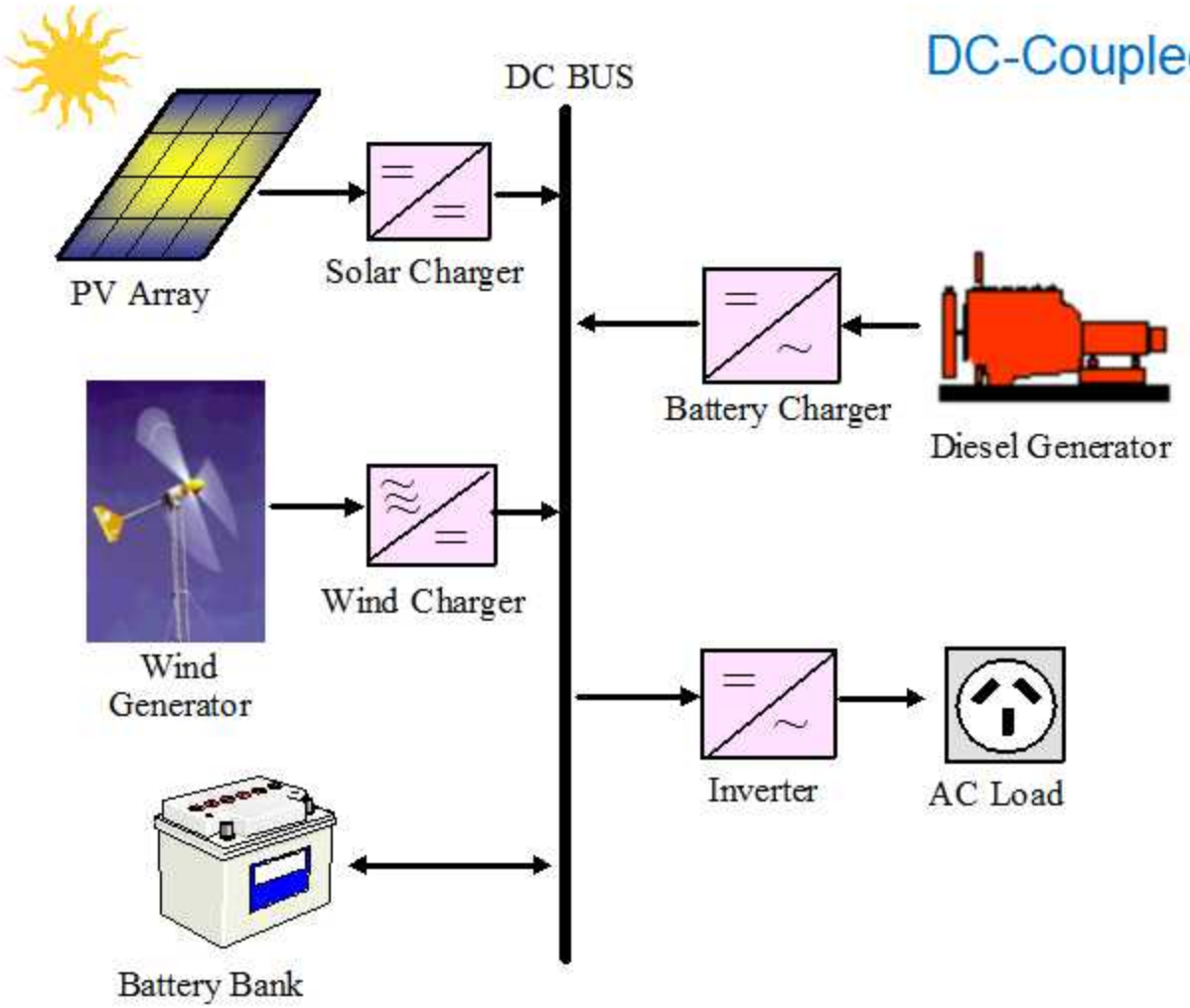
Generator Solution



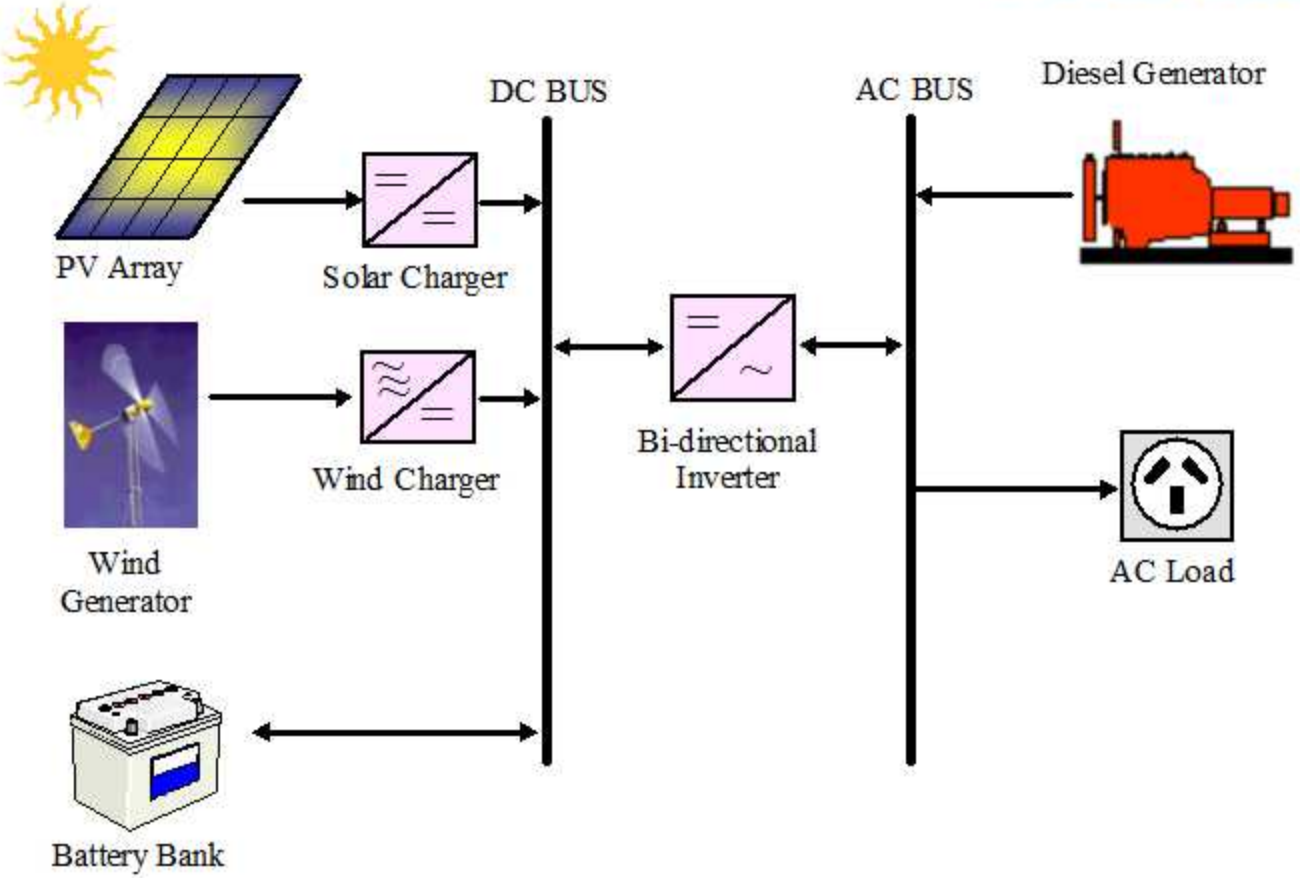
Battery Solution



DC-Coupled Solution



AC-Coupled Solution



Still problems:

- Large engine should be selected to meet both peak load & battery charging
- Fuel waste due to load variation is not avoided
- Fuel waste during battery's float charge is huge
- Battery's deep discharging is required to get good saving, so we need to compromise battery life or select bigger battery bank

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The founder & intellectual property owner of Hybrid-Gen is Professor Chem Nayar,

- BSc Elec Engg, MTech (IIT Kanpur), PhD (Wind Power), Univ. of Western Australia
- Professor of Electrical and Renewable Energy Engineering, Curtin University
- Visiting Professor –Hefei University, China University of Mining and Technology , United Arab Emirates University, Chiang Mai University (Thailand)
- 42 years teaching , research and industry experience
- Chairman, Regen Group Pty Ltd, Australia
- Director, Radiant Solar , Hyderabad, India
- Supervised /supervising 20 PhDs, 300 research papers, 8 million in research grants
- Winner of Sustainable Energy Industry Excellence Award 2011 : (1) The Ambassador Award and (2) Product and Technology Award

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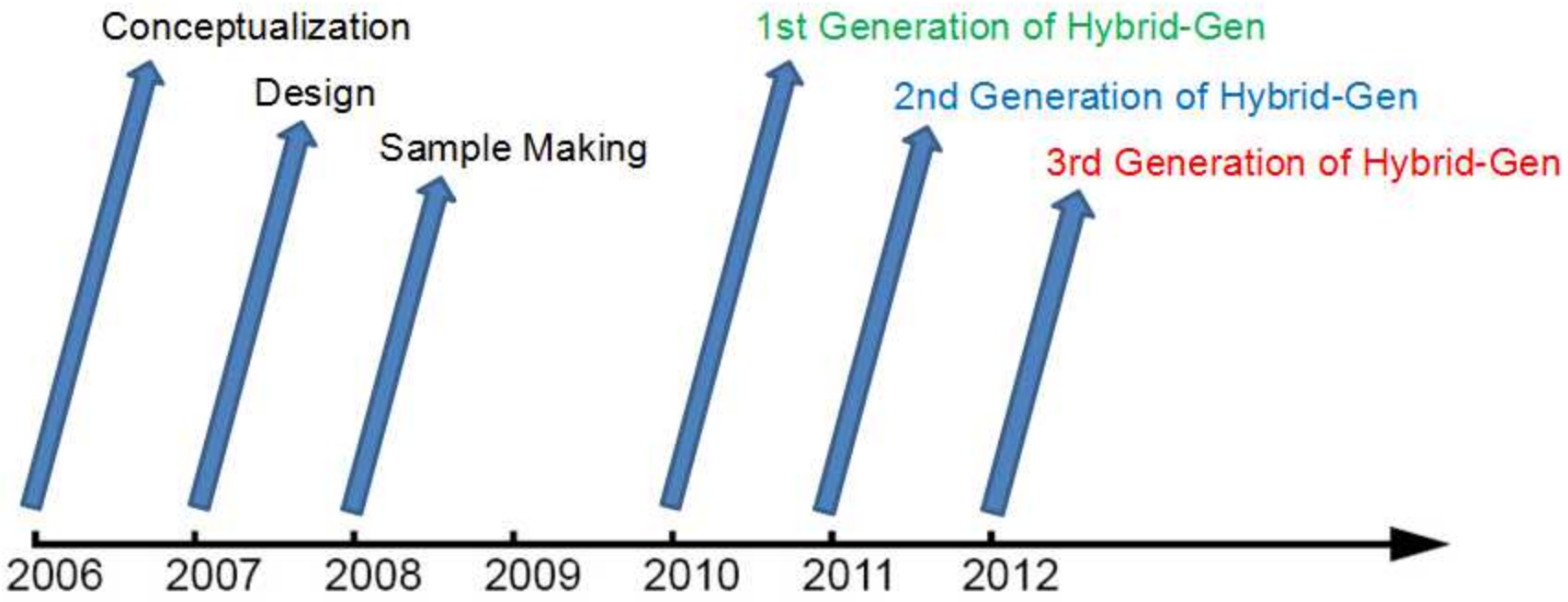
Brief Theory of DC Hybrid-Gen:

- For applications where DC power is required, there is no need to maintain the Frequency constant.
- By suitably controlling the generator output at different speeds, the output DC voltage can be maintained constant.
- DC Hybrid-Gen system generates the required DC voltage irrespective of the speed.
- The speed of the Diesel engine is varied in proportion with the output load.
- This helps in saving of the fuel at lower loads as speed can be decreased, compared to the normal generator which runs at the rated speed even at lower loads.


Conceptualization
Design
Sample Making
1st Generation of Hybrid-Gen
2nd Generation of Hybrid-Gen
3rd Generation of Hybrid-Gen
2006
2007
2008
2009
2010
2011
2012

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1st Generation

Item	Value
Max. Output	6.5 kW
Rated Voltage	48 V dc
Max. Current	120 A
Speed Range	800 ~ 1100 rpm
Battery Selection	200 ~ 800 Ah
Engine	Mahindra
Alternator	IEC
Management	Automatic
Monitoring	On-site

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2nd Generation

Item	Value
Max. Output	8.0 kW
Rated Voltage	48 V dc
Max. Current	140 A
Speed Range	800 ~ 1300 rpm
Battery Selection	200 ~ 1200 Ah
Engine	Mahindra
Alternator	IEC
Management	Automatic
Monitoring	Remote

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3rd Generation

Item	Value
Max. Output	8.0 kW
Rated Voltage	48 V dc
Max. Current	140 A
Speed Range	1070 ~ 1660 rpm
Battery Selection	200 ~ 1200 Ah
Engine	Perkins
Alternator	Stamford
Management	Automatic
Monitoring	Remote

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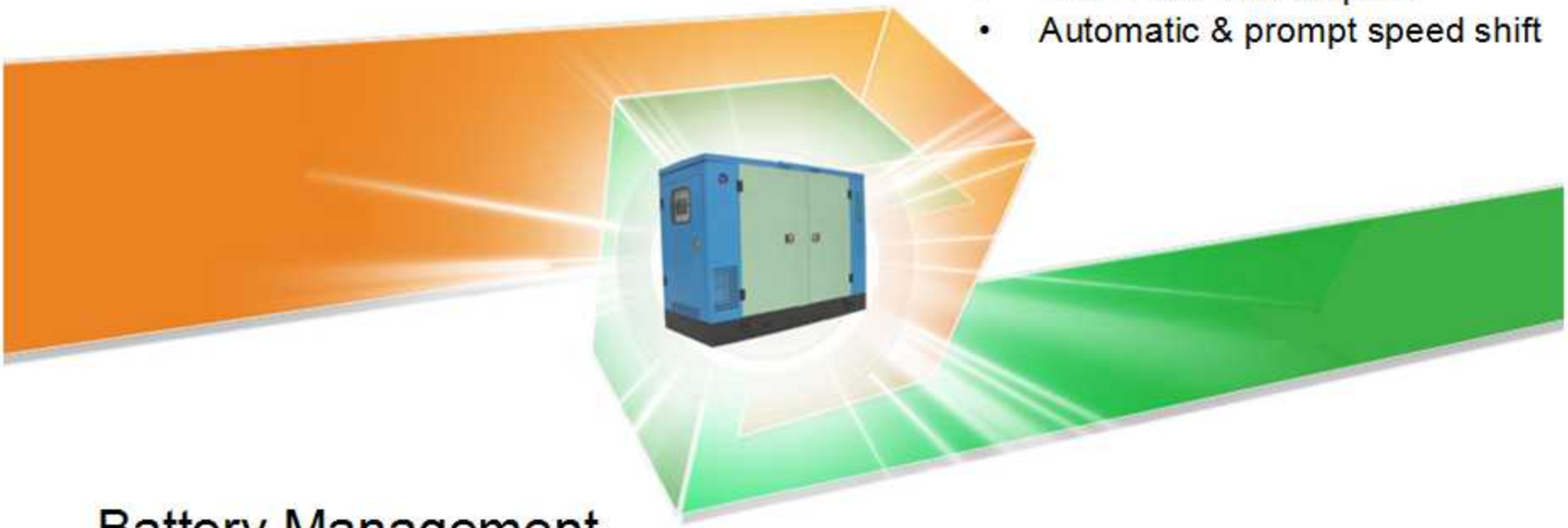
Variable Speed

- Smaller engine displacement
- Lower fuel consumption
- Automatic & prompt speed shift



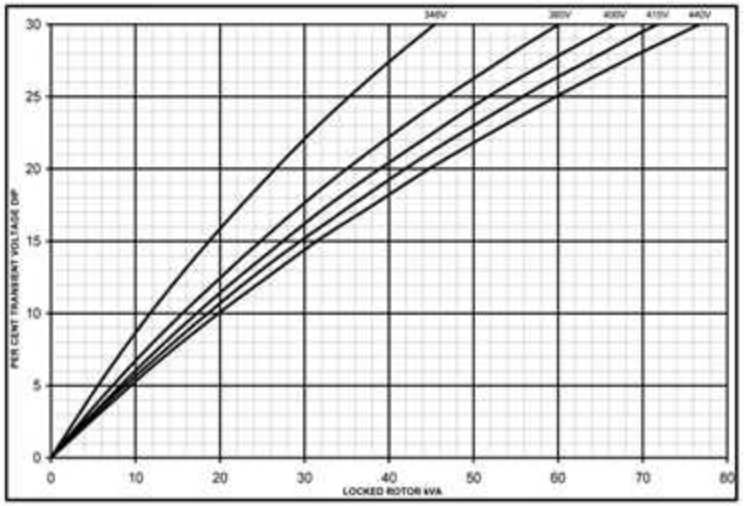
Battery Management

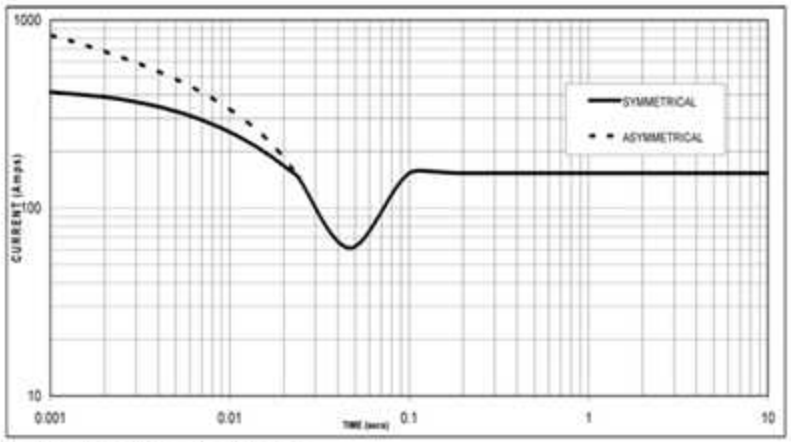
- Optimum energy use
- Smaller battery bank & longer life
- Automatic start & stop

Diesel Engine: 403D-15G

- Compact, clean, efficient power
- Lower operating cost
- Long-term power solution
- World-class product support

Engine Speed	Type of Operation	Typical Generator Output (Net)		Engine Power				Low Idle
				Gross		Net		
		kVA	kWe	kWm	bhp	kWm	bhp	
1500	Prime Power	13.0	10.4	12.2	16.4	12.0	16.0	n/a
	Standby Power	14.3	11.4	13.5	18.1	13.2	17.6	n/a
1800	Prime Power	15.8	12.6	14.7	19.7	14.4	19.3	n/a
	Standby Power	17.4	13.9	16.2	21.7	15.8	21.2	n/a

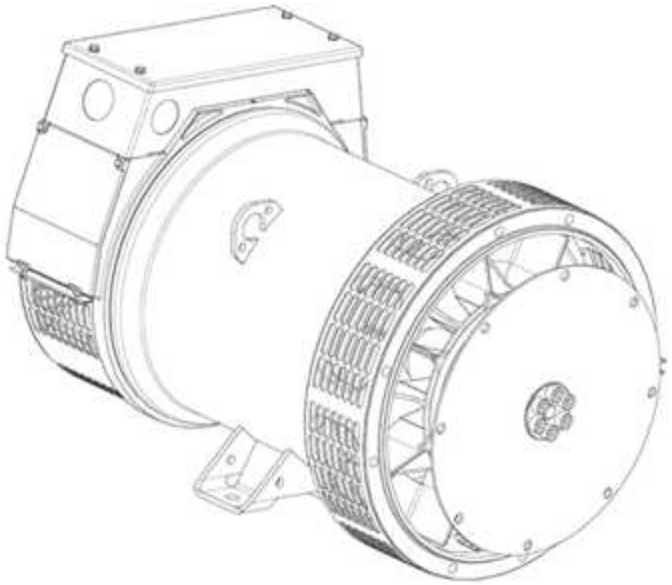


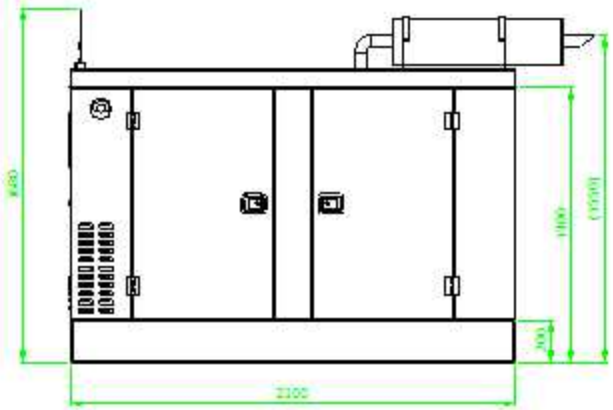


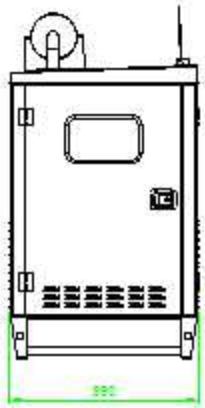
Sustained Short Circuit = 153 Amps

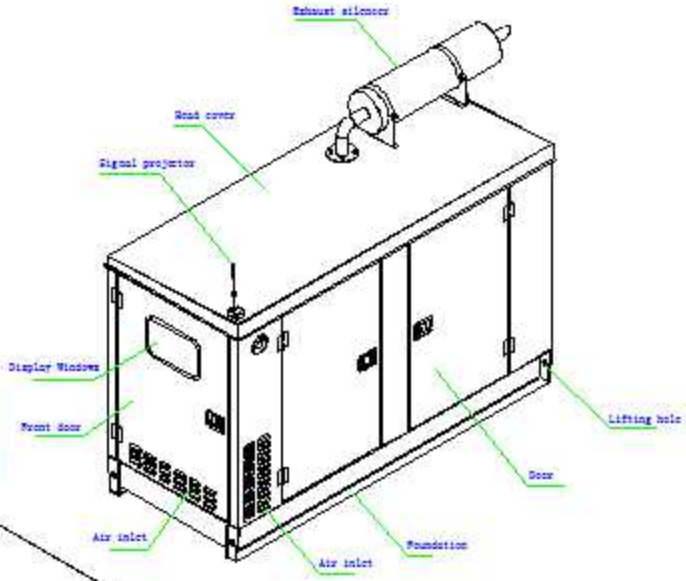
Alternator: PI144H

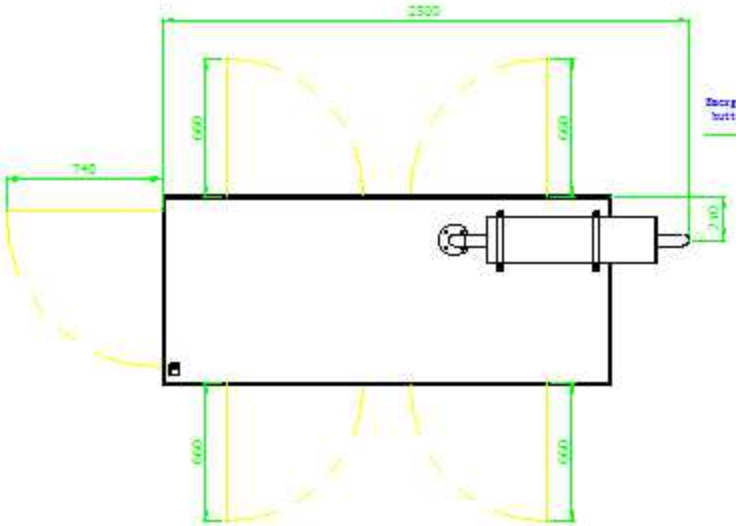
STAMFORD

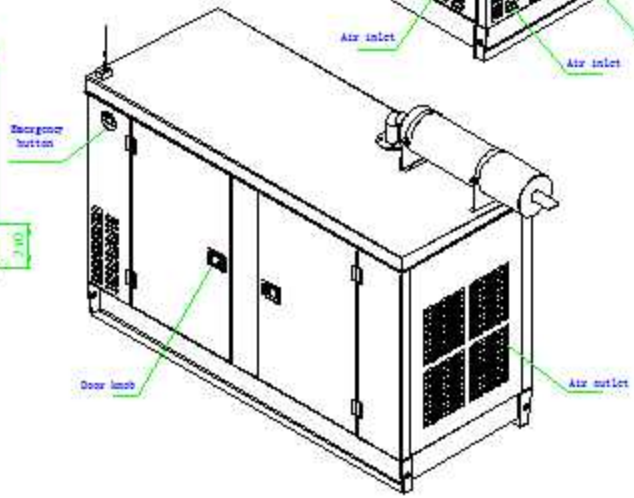



2100
990




Exhaust silencer
Hood cover
Signal projector
Display Windows
Front door
Lifting hole
Door
Air inlet
Air inlet
Foundation


2500
740
660
660
660
660


Emergency button
Door knob
Air outlet

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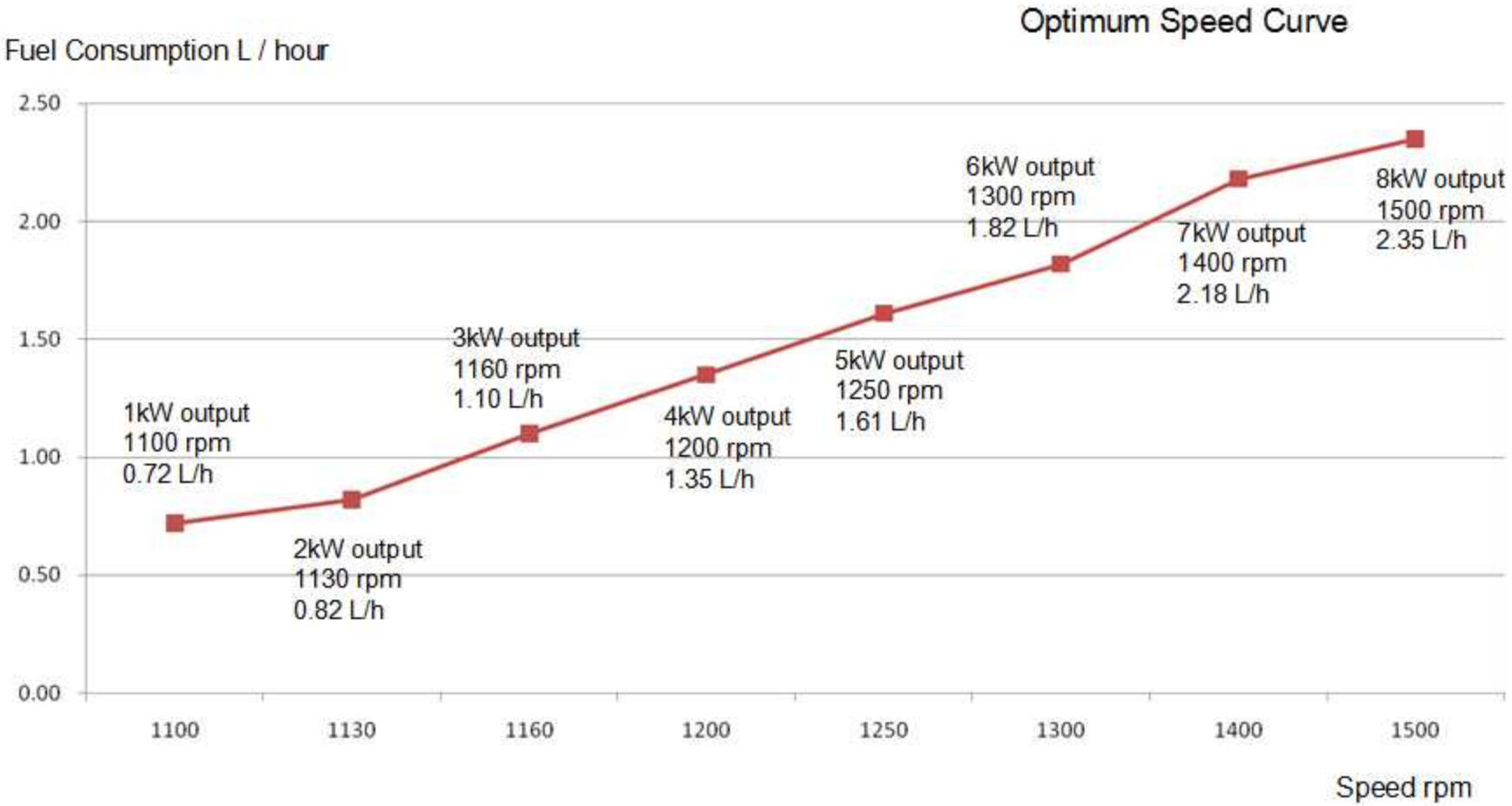
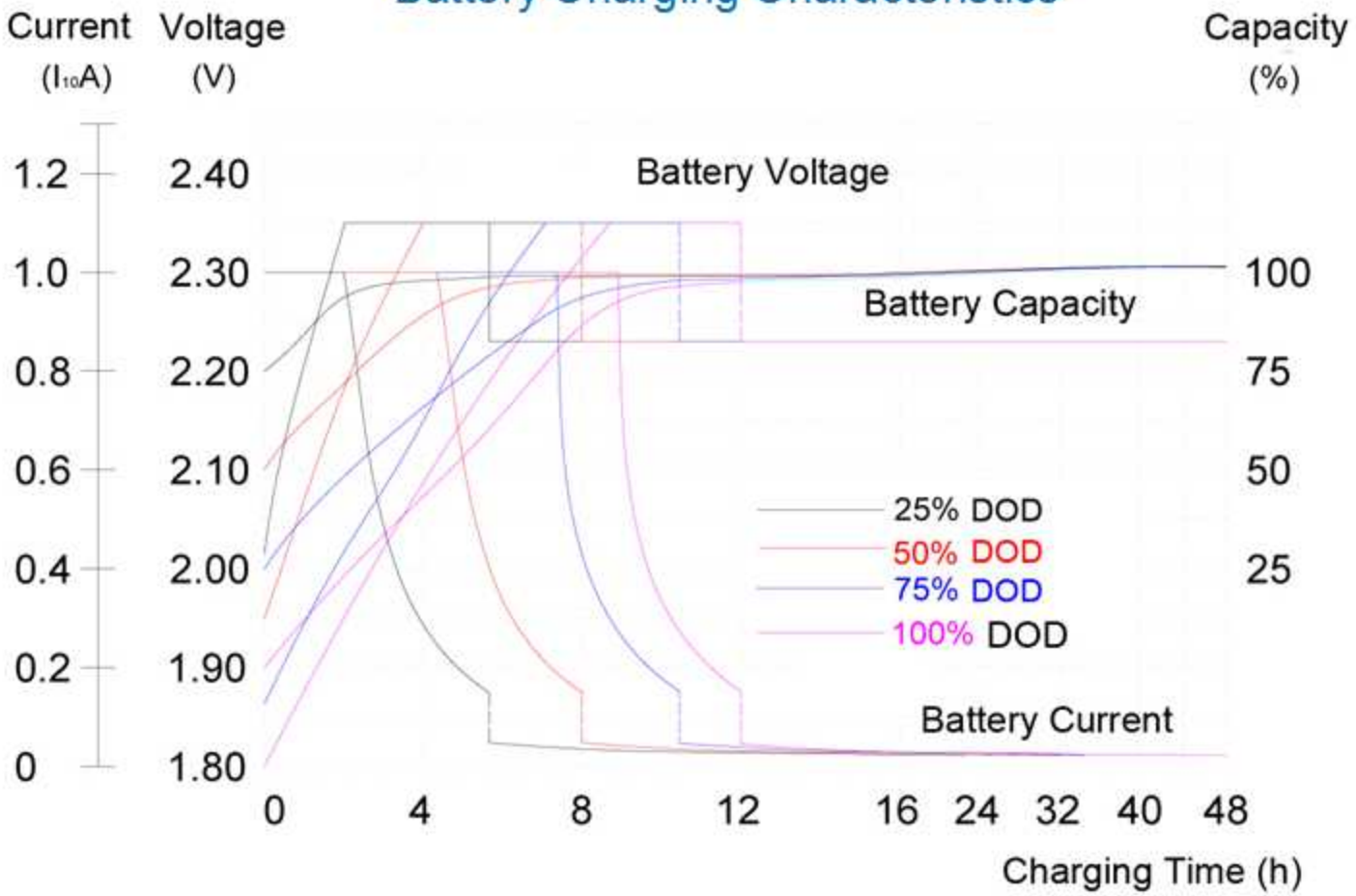
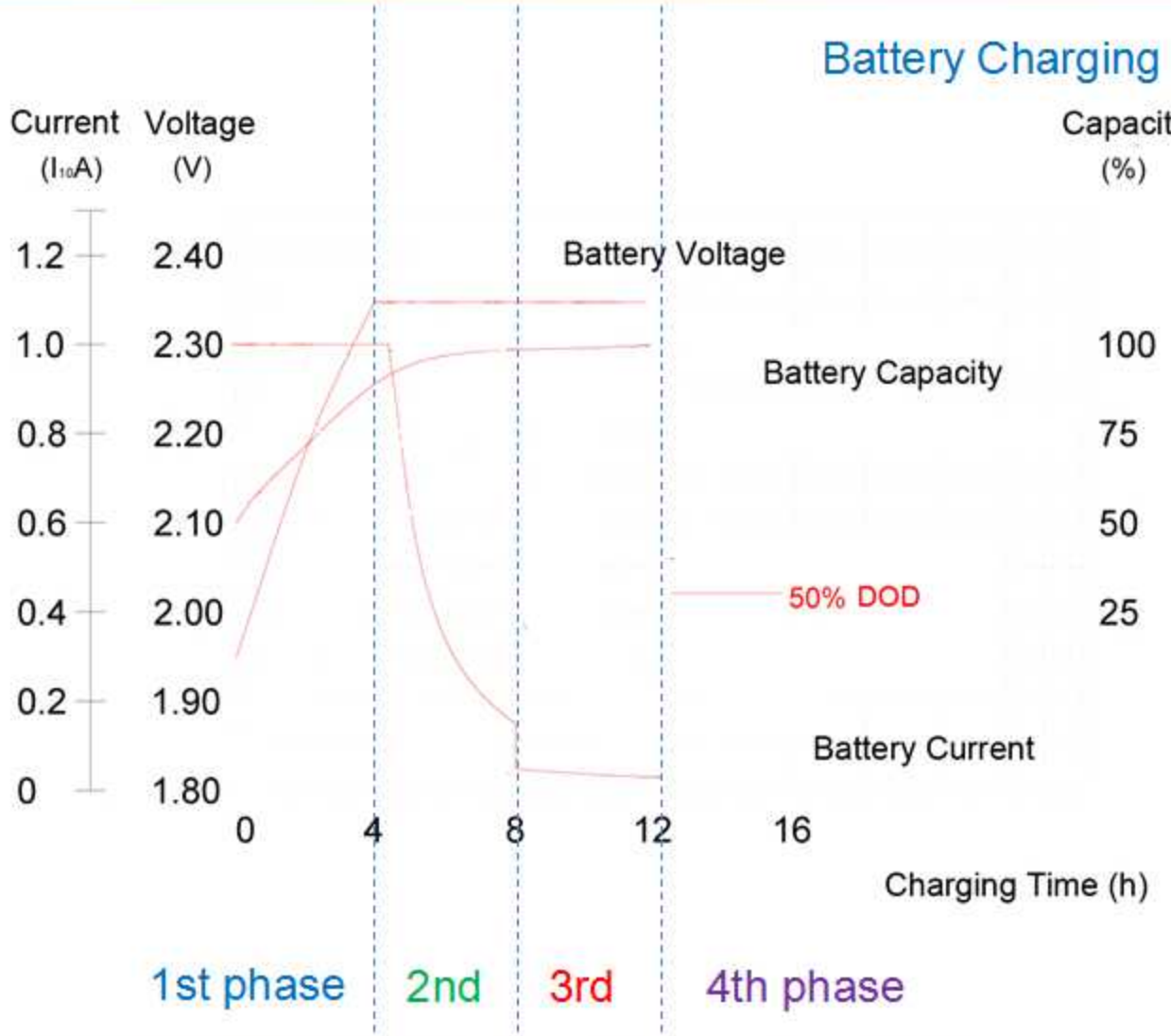
Optimum Speed Curve



Battery Charging Characteristics



Battery Charging Management



Phase	Charging Mode	Trigger Constraints	Power Input	Power Output	Battery Voltage	Battery Current	Battery Capacity	Generator Speed
1st	Constant Charging	a) Bat. DOD > 50% b) Bat. volt < 1.80V	Load & Battery	Gen-set	? ~ 2.3V	0.15C	50% ~ 90%	High
2nd	Variable Charging	a) Bat. volt > 2.3V b) Bat. cur. falls	Load & Battery	Gen-set	2.3V	0.15C ~ 0.04C	90% ~ 110%	Decreasing
3rd	Float Charging	a) Bat. cap. > 110% b) Bat. cur. < 0.04C c) 2nd charge > 4 hr	Load & Battery	Gen-set	2.2V	0.04C ~ 0.01C	110%	Low
4th	None Charging	1 hour after float charging	Load	Battery	2.2V ~ ?	(-) Load current	110% ~ 50%	None

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Daily Fuel Consumption: 1.0kW Load, 50% Battery DOD

Battery Bank	Dis-charge Time	1st Phase Charge			2nd Phase Charge			3rd Phase Charge			Whole Cycle		Daily Fuel Usage
		Output	Time	Fuel	Output	Time	Fuel	Output	Time	Fuel	Time	Fuel	
48V 200Ah	4.95 h	2.68kW	2.48 h	2.21 L	1.84kW	2.48 h	1.82 L	1.42kW	1.00 h	0.70 L	10.91 h	4.73 L	10.41 L
48V 300Ah	8.41 h	3.52kW	3.00 h	3.51 L	2.26kW	3.00 h	2.45 L	1.64kW	1.00 h	0.72 L	15.41 h	6.68 L	10.40 L
48V 500Ah	20.54 h	5.20kW	3.19 h	4.78 L	3.10kW	3.19 h	3.28 L	2.06kW	1.00 h	0.76 L	27.92 h	8.82 L	7.58 L
48V 800Ah	36.70 h	7.72kW	3.16 h	9.16 L	4.36kW	3.16 h	3.54 L	2.70kW	1.00 h	0.92 L	44.02 h	13.62 L	7.43 L
48V 1000Ah	42.00 h	8.00kW	4.00 h	9.51 L	4.50kW	4.00 h	5.62 L	3.12kW	1.00 h	1.04 L	51.00 h	16.17 L	7.61 L
48V 1200Ah	45.49 h	8.00kW	5.10 h	12.12 L	4.50kW	4.00 h	5.62 L	3.54kW	1.00 h	1.18 L	55.59 h	18.92 L	8.17 L

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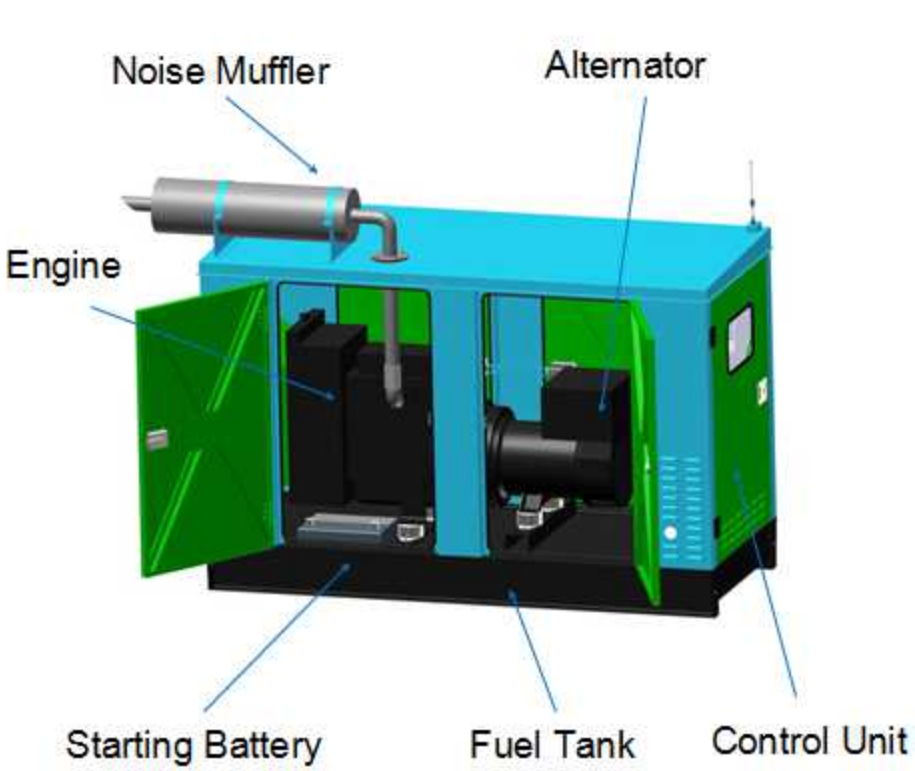
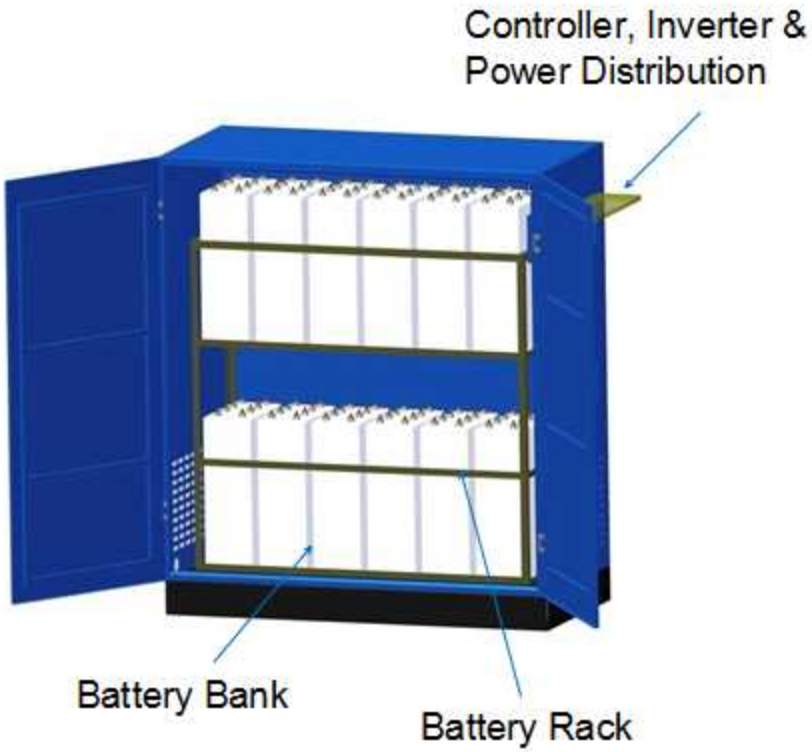
Daily Fuel Consumption: 2.0kW Load, 50% Battery DOD

Battery Bank	Dis-charge Time	1st Phase Charge			2nd Phase Charge			3rd Phase Charge			Whole Cycle		Daily Fuel Usage
		Output	Time	Fuel	Output	Time	Fuel	Output	Time	Fuel	Time	Fuel	
48V 200Ah	2.06 h	3.68kW	2.48 h	3.06 L	2.84kW	2.48 h	2.37 L	2.42kW	1.00 h	0.85 L	8.02 h	6.28 L	18.79 L
48V 300Ah	3.62 h	4.52kW	3.00 h	4.22 L	3.26kW	3.00 h	3.26 L	2.64kW	1.00 h	0.91 L	10.62 h	8.39 L	18.96 L
48V 500Ah	7.05 h	6.20kW	3.19 h	5.45 L	4.10kW	3.19 h	4.33 L	3.06kW	1.00 h	1.00 L	14.43 h	10.78 L	17.93 L
48V 800Ah	10.36 h	8.00kW	3.25 h	7.73 L	5.00kW	3.25 h	4.75 L	3.70kW	1.00 h	1.24 L	17.86 h	13.72 L	18.44 L
48V 1000Ah	20.95 h	8.00kW	4.60 h	10.93 L	5.00kW	4.00 h	5.85 L	4.12kW	1.00 h	1.36 L	30.55 h	18.14 L	14.25 L
48V 1200Ah	27.89 h	8.00kW	5.80 h	13.79 L	5.00kW	4.00 h	5.85 L	4.54kW	1.00 h	1.41 L	38.69 h	21.05 L	13.06 L

Load	Battery	DOD	Hybrid-Gen Daily Fuel	Normal Gen-set Daily Fuel	Annual Fuel Saving	Annual Cost Saving
1.0kW	48V 500Ah	50%	7.58 L	14.59 L	2500 L	USD 2500
2.0kW	48V 1000Ah	50%	14.25 L	20.43 L	2200 L	USD 2200

- Hybrid-Gen can substantially save fuel through variable speed.
- Hybrid-Gen can increase fuel efficiency through battery management.
- Hybrid-Gen can further save fuel if the load regularly shifts.
- Hybrid-Gen can optimize power solution by adding renewable energies.


Noise Muffler
Alternator
Engine
Starting Battery
Fuel Tank
Control Unit


Controller, Inverter &
Power Distribution
Battery Bank
Battery Rack

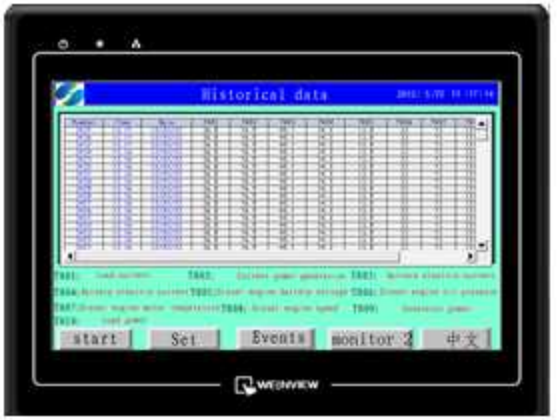
Control Cabinet

- GPRS based remote monitoring
- Automatic engine management
- Adjustable battery management
- Data logger
- Emergency protection
- Expandable to renewable energies

Real-time monitoring

System Start-up

Parameter Setting



Historical Data

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Sri Lanka Case

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Star Hub Case

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Replacement of normal gen-set at established site

Site Installation

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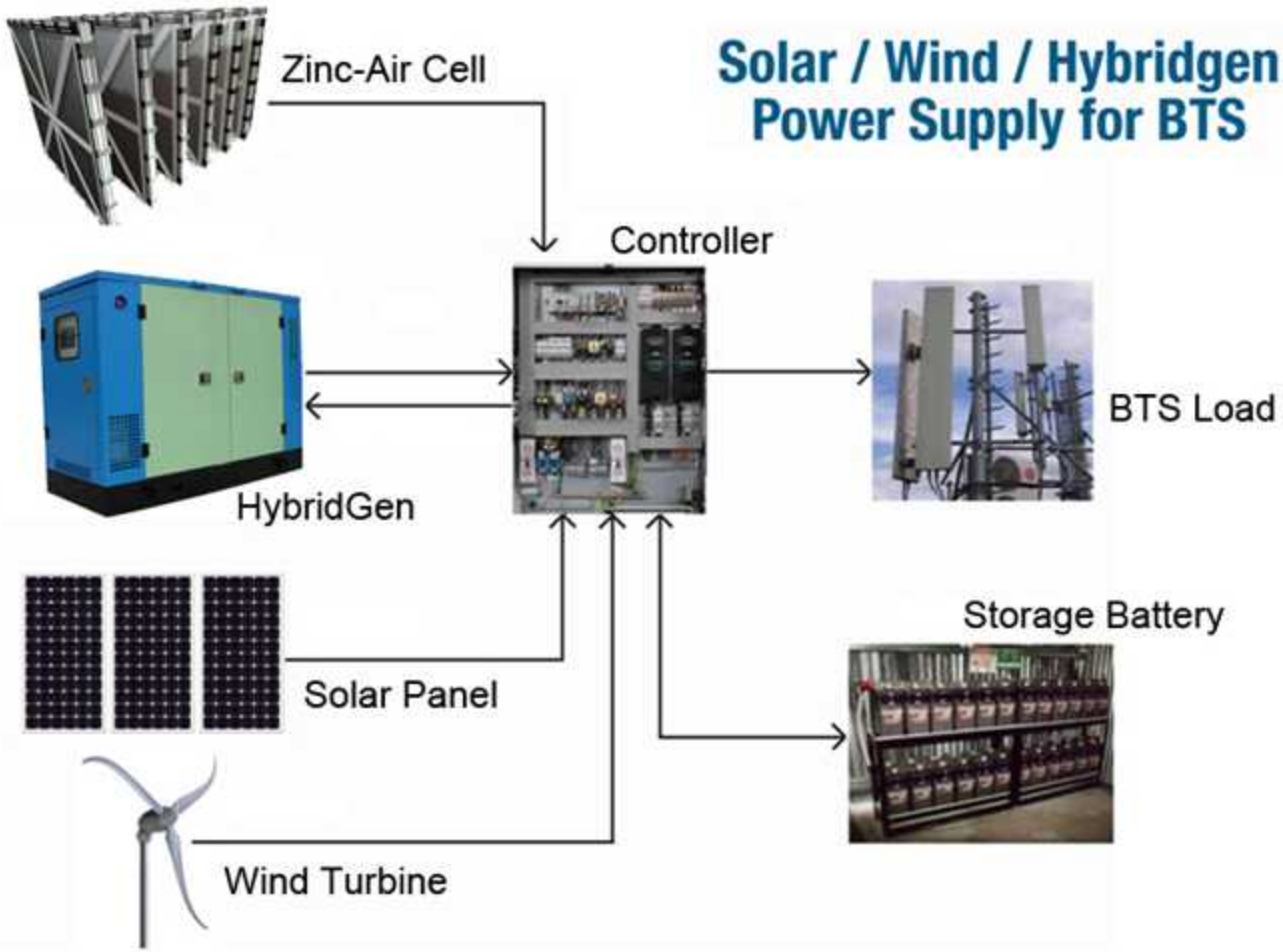
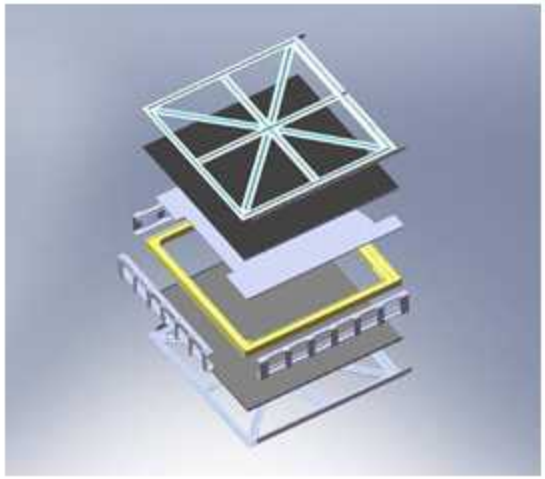
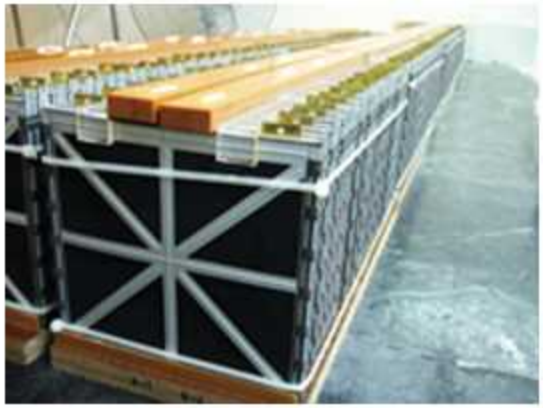
Solar / Wind / Hybridgen Power Supply for BTS



As an innovative and useful component of BTS power system, Zinc-Air cell can serve as ideal UPS due to its high energy-density.

- ZOE UPS employs the heritage of ZOE – high energy density, safe, and economical
- A 50-piece system could generate a nominal voltage above 48V with minimal 20A discharge, well enough for a 1kW system and recharging the backup VRLA batteries.
- No emission, No sound, Light weight, Small footprint, Environmentally friendly, best suited for urban areas UPS diesel generator set replacement





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Parameter	Value
Open-Circuit Voltage	1.30 ~ 1.45 V
Operating Voltage	1.1 V
Output Current	20 ~ 40 A
Capacity	140 Ah
Total Energy	154 Wh
Operating Temperature	- 15 ~ 60 ℃
Dimension per Cell	205 * 195 * 11 mm
Air Electrode Area	203 * 188 mm
Cell Bank Weight	1630 g

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Storage Technologies	Main Advantages (relative)	Disadvantages (Relative)	Power Application	Energy Application
Pumped Storage	High Capacity, Low Cost	Special Site Requirement		●
CAES	High Capacity, Low Cost	Special Site Requirement, Need Gas Fuel		●
Flow Batteries: PSB VRB ZnBr	High Capacity, Independent Power and Energy Ratings	Low Energy Density	◑	●
Metal-Air	Very High Energy Density	Electric Charging is Difficult		●
NaS	High Power & Energy Densities, High Efficiency	Production Cost, Safety Concerns (addressed in design)	●	●
Li-ion	High Power & Energy Densities, High Efficiency	High Production Cost, Requires Special Charging Circuit	●	○
Ni-Cd	High Power & Energy Densities, Efficiency		●	◑
Other Advanced Batteries	High Power & Energy Densities, High Efficiency	High Production Cost	●	○
Lead-Acid	Low Capital Cost	Limited Cycle Life when Deeply Discharged	●	○
Flywheels	High Power	Low Energy density	●	○
SMES, DSMES	High Power	Low Energy Density, High Production Cost	●	
E.C. Capacitors	Long Cycle Life, High Efficiency	Low Energy Density	●	◑

● Fully capable and reasonable

◑ Reasonable for this application

○ Feasable but not quite practical or economical

None Not feasable or economical

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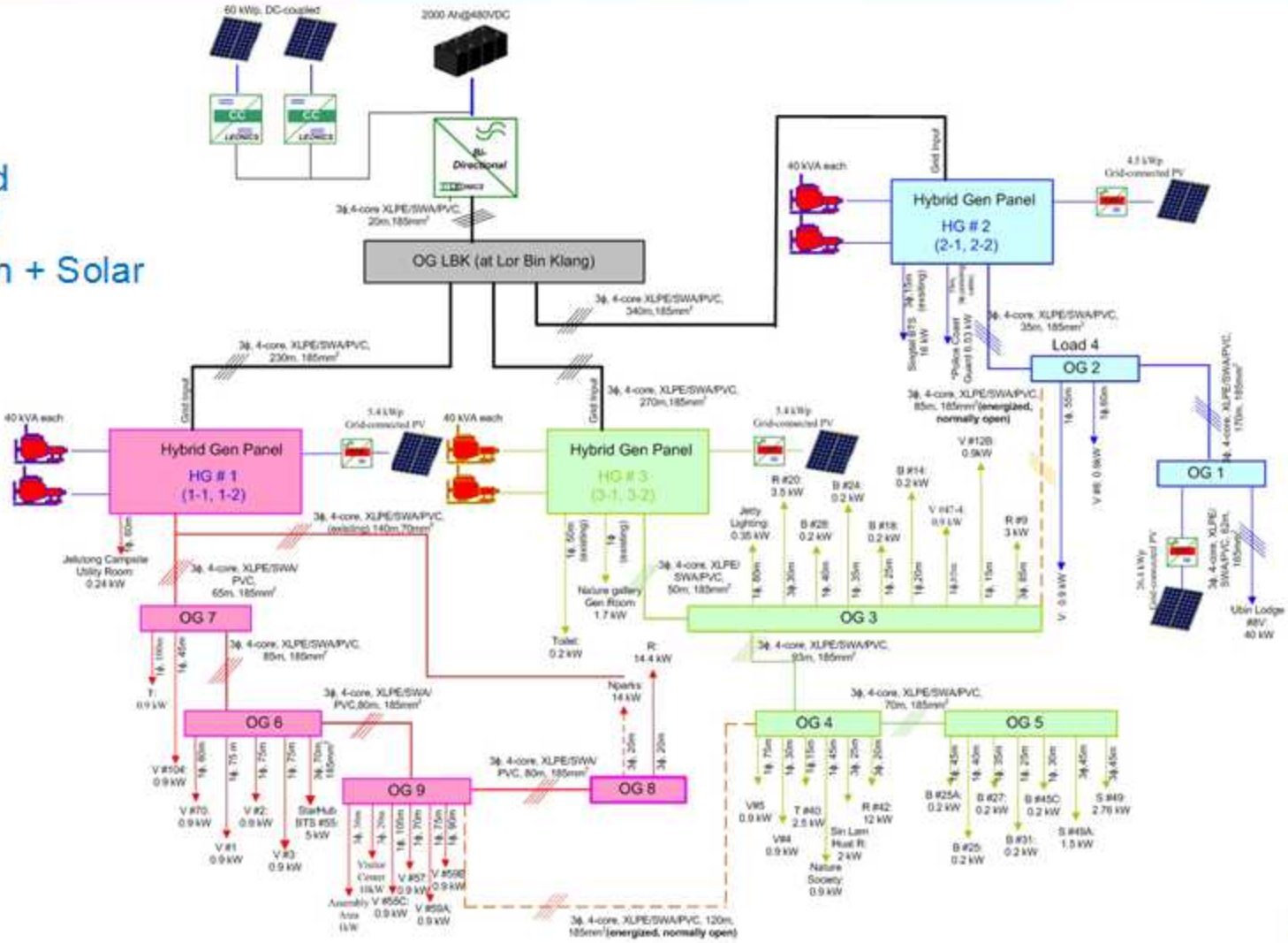
Ubin Island Micro-Grid Hybrid-Gen + Solar



Mobile Water Treatment Plant powered by Hybrid-Gen

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DC Hybrid-Gen

Variable Speed Generator

Your Power Solution