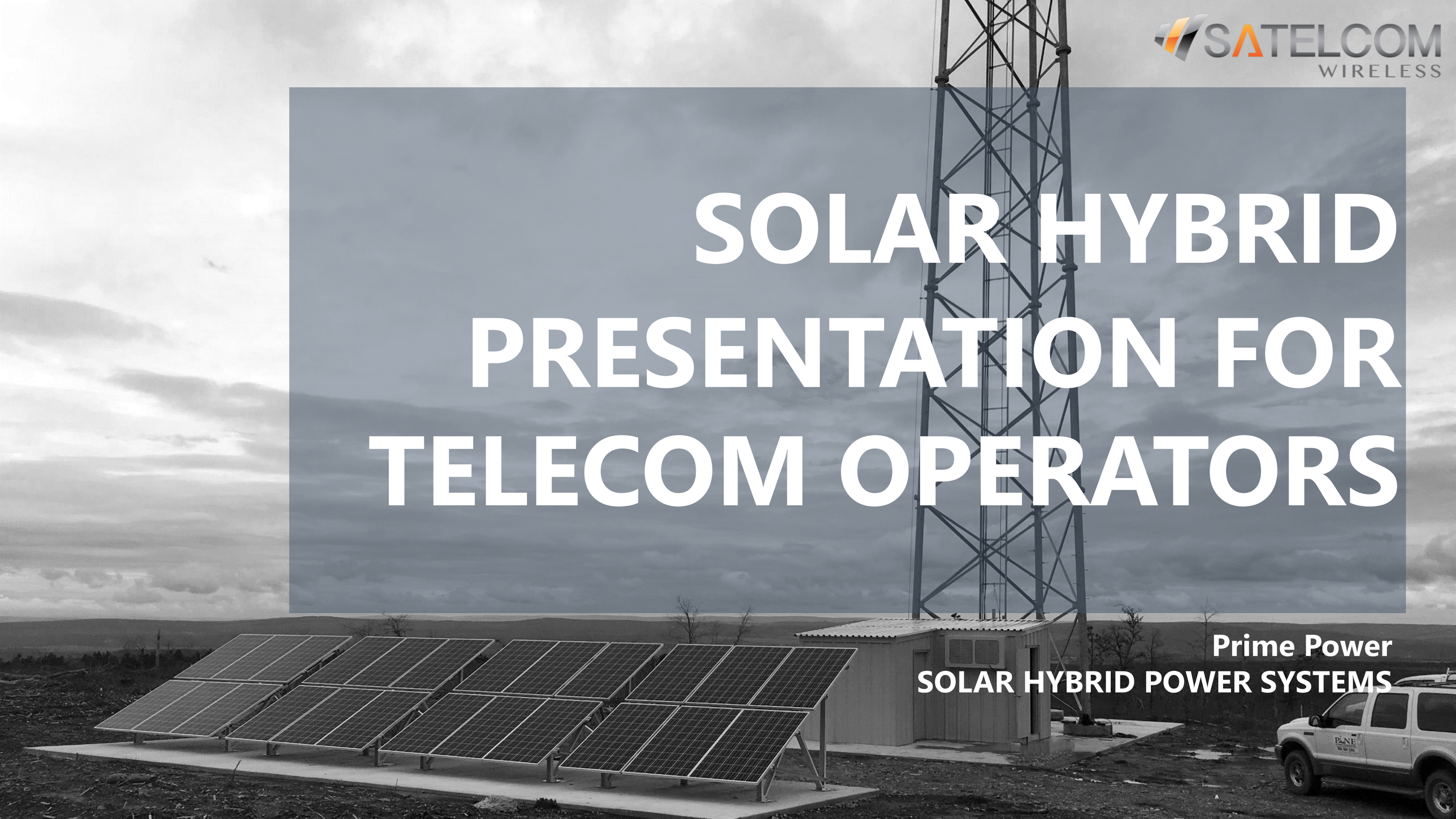
SATELCOM WIRELESS

SOLAR HYBRID PRESENTATION FOR TELECOM OPERATORS



Prime Power
SOLAR HYBRID POWER SYSTEMS

About Us

Founded in 1979, Polar designs, manufactures DC power and cooling systems for applications in:

- Telecommunication
- Military
- Electric vehicle charging
- Cogeneration and Distributed power
- Marine and RV
- Mining and Oil Field

Our Core Technologies and Capabilities include:

- Energy conversion
- Digital control systems
- System integration
- Manufacturing

Our greatest strength is taking the customers' technical needs and creating a solution.

20 years ago Polar started to provide DC generators to telecom companies for off-grid, prime power applications.

30 years ago Polar started to provide solar PV controls for off-grid microwave sites.

HYBRID SOLAR ENERGY SYSTEMS

Efficiently combining fuel with solar for reliable and low cost power

PRIME POWER SYSTEMS

Low maintenance systems for harsh and remote environments

TEMPORARY POWER AND RENTAL

Rapid deployment, fuel-efficient, installs on trailer, truck, or ground

BACKUP DC GENERATORS

Small footprint, quiet, lightweight, 72 hr. reserve, available in all fuels

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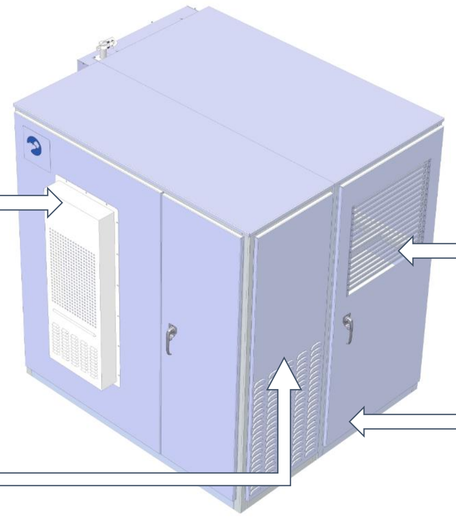
SUMMIT series
Hybrid Power System

- All-in-one integrated unit
- Aluminium light weight cabinet (IP 55)
- Small footprint (1,6m X 1,6m x 1,8m)
- DC Generator (Yanmar Engine)
- Scalable system
- Integrated fuel tank (750 litres)
- Monitoring and management of all major operating parameters: fuel consumption, battery, engine, alternator, loads, etc.
- Integrated Polar Supra digital controller and solar charge controllers
- Optional 220VAC output
- Battery capacity 800A (Narada REX C) or up to 900A Lithium-Ion
- Integrated free air cooling with optional air-conditioning system
- Metering System for multiple users

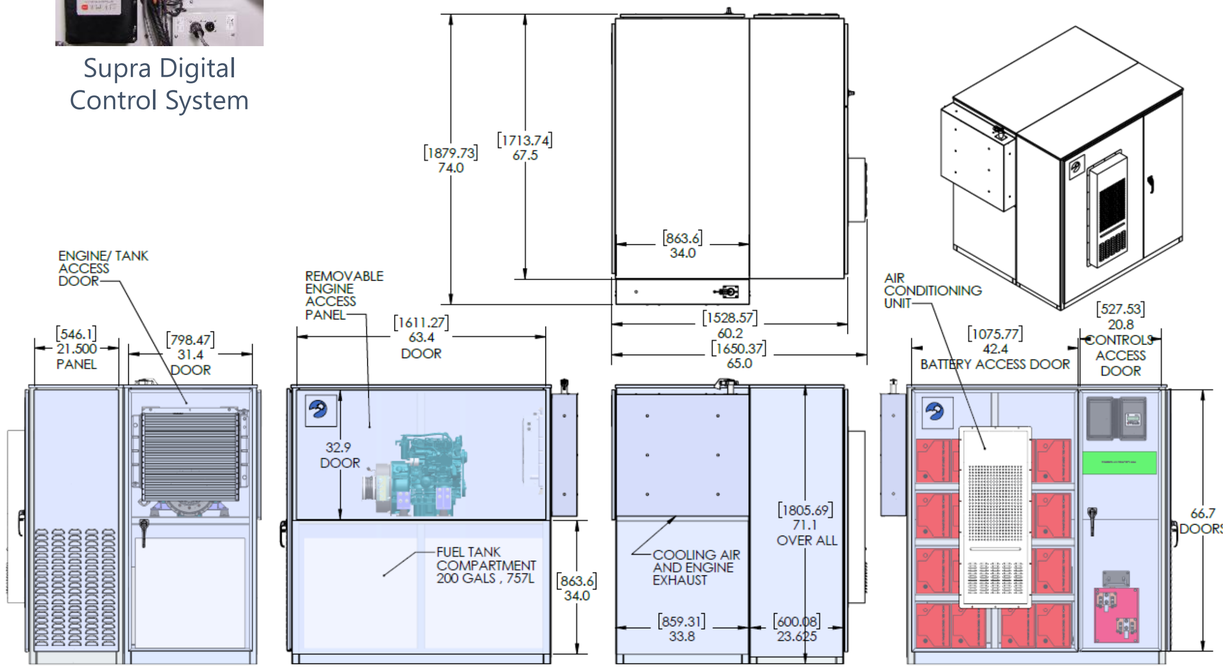
DC air con



15 kW Yanmar Hight efficiency DC generator

750 L integrated diesel fuel tank

Supra Digital Control System



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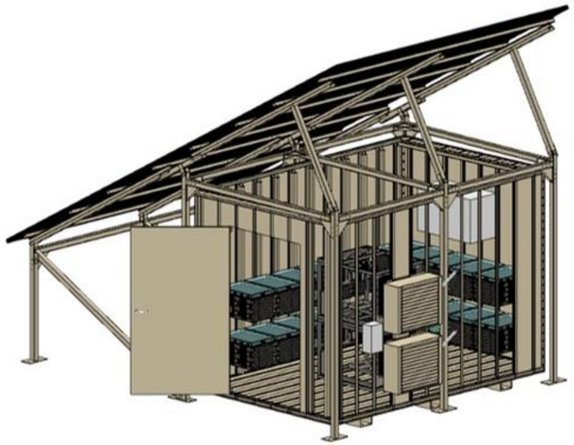
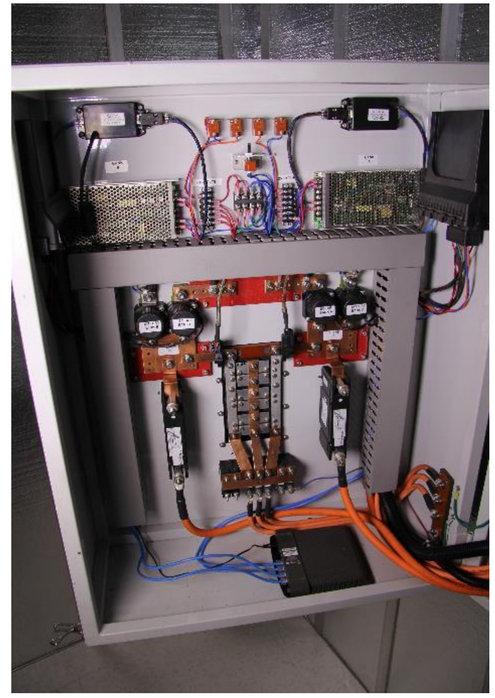
Dual Plane Configuration – Reliability Through Redundancy (N+1)

The dual plane (N+1) approach to a power system uses redundant components wired in parallel:

- Solar arrays and charge controllers
- Battery banks
- DC gensets
- Systems controls

A failure in a battery cell, solar controller, generator does not cause the site to go off air. The other plane assumes the load.





Open frame DC Generator

Primarily used for prime power systems including solar hybrid

- Designed for installations inside shelters. Locating the generator inside a walk in shelter facilitates maintenance at sites with weather extremes.
- Available in all fuels: propane, natural gas, and diesel.
- Can operate up to 6 - 12 months without maintenance or inspection.
- Engineered to provide 15 to 25 year service life with low maintenance.

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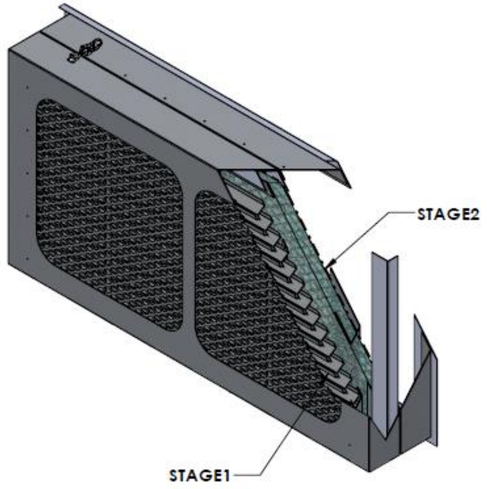
Advanced Cooling Solution

Brings advanced Air Conditioning technologies to Telecom Applications

DC Ambient Air-Cooling System

- Two stage filtration
  - First stage – particle separator
  - Second Stage – Conventional washable and replaceable filer
- Variable speed fan with the capability push up 1600CFM



DC Air-Conditioning System

- Models from 200W to 5000W (1.7T or 17,000BTU/hr)
- Spot cooling to save energy
- Remote monitoring of the system: refrigerant, compressor, heat exchangers, fans
- Designed for the both positive and negative ground 48Vdc
- Systems with low ripple or back EMF placed on the DC buss

DC GENERATOR FOR TELECOM MARKET

Main Features:

- Compact design, small footprint and light weight
- Long operational life and very low maintenance
- High efficiency with low fuel consumption
- 72 hr. reserves with Minimum fuel on site
- Automatic start/stop with remote control
- Combine the functions of a generator and battery charger

Continuous Power:

- 6 kW at 1800 RPM – 100 Amps at 56 V
- 10 kW at 2450 RPM – 180 Amps at 56 V
- 15 kW at 1800 RPM – 270 Amps at 56 V
- Operates with all fuels: Diesel, Propane, NG

Designed specifically for meeting all the needs of telecommunications

Combining fuel with renewable energy

- Hybrid systems combine the best features from various energy sources especially solar PV providing reliable power for off grid loads ranging from 0.5 kW up to hundreds kilowatts.

- Systems are configured to best match the local resources of site space, weather conditions & insolation, are local fuel availability.

Low cost DC generator (low CAPEX) + Renewable energy (low OPEX) = Reliable power solution

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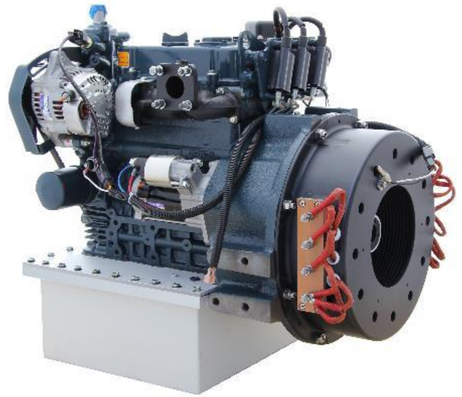
Prime power advantages

- Lower CAPEX cost
  - Typically a 5 to 15 kW DC genset can replace a 20 to 40 kVA AC genset
  - No transfer switches
  - No rectifiers or battery chargers
  - No additional system and monitoring controls are required
  - DC generators are compact and light in weight facilitating lower cost transport to the site and placement on the pad. Especially ideal for helicopter access site.
  - The higher reliability of the DC generator allows a reduction in battery bank size
- Lower OPEX cost
  - Elimination of AC genset over sizing - reduces fuel consumption
  - Elimination of AC to DC conversion – improves system efficiency.
  - Overall lower fuel consumption – up to 70% less fuel than the AC Generator.
  - Oversized fuel and oil filters reduce the maintenance cost
  - The Supra controller allows system recalibrations and software updates without the cost of traveling to the site
  - Increased reliability and durability – reduced visits to site for unscheduled repair



Horizontal DC Generator

Primarily used for prime power systems including solar hybrid

- Designed for weather extremes, especially hurricanes.
- All aluminum cabinet with stainless hardware, very corrosion resistant.
- Available in all fuels: propane, natural gas, and diesel.
- Can operate up to 6 - 12 months without maintenance or inspection.
- Engineered to provide 15 to 25 year service life with low maintenance.
- Very quiet operation.

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Solution – designed for telecom applications

We engineered our telecom solutions using a “clean sheet of paper” approach. This means we can design, tool and manufacture components if they are not available or fail to meet our performance goals.

We started with the simplest approach to charge a battery.

DC was the best choice to simply the electrical system.

We started with the key component, **the Alternator:**

- **For reliability**, eliminate all the parts that can cause an alternator failure or require maintenance: bearings, exciters, and rotating electrical parts.
- **Make the alternator more efficient**, by reducing alternator inefficiencies including magnetic field generation, wind and bearing frictions. This will reduces: fuel consumption, fuel storage on site. Reducing fuel storage also reduces roof reinforcement.
- **Build a more compact and lightweight assembly**, this facilitates packaging into smaller generator enclosures and reduces the weight of the assembly. Takes up less space on site and reduces the need for roof reinforcement.

Solution: Permeant magnet alternator, 32 poles, pancake design that bolts on to the engine flywheel directly.

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Engineered prime power solutions specifically for Telecom applications

- **Eliminated the Starting Battery -** This is the number 1 reason why generators fail to start. System uses a Supercapacitor to start its telecom generators. Providing the highest amount of cranking amps during the coldest weather. Providing 15 to 20 years of reliable service in the hottest and coldest weather extremes.
- **Sealed electronics -** To ensure reliability during storms or flooding, all electrical connections and components are sealed and water tight.
- **No transfer switches -** DC generators connect direct to the battery (through fuses or CB)
- **NEMA 4 Storm resistant enclosures -** Designed to minimize the intrusion of rain and snow.
- **Corrosion Resistant -** The all aluminum is a unitized welded enclosure powder coated with stainless hardware for corrosion resistance and durability.
- **Remote monitoring and control** Real time access to operational status, fuel level, fault diagnosis and maintenance schedule of our products is critical to reliability and makes more efficient use of assets and vital human resources. Offers the capability of off loading management of power producing assets to out of state personnel or Satelcom.

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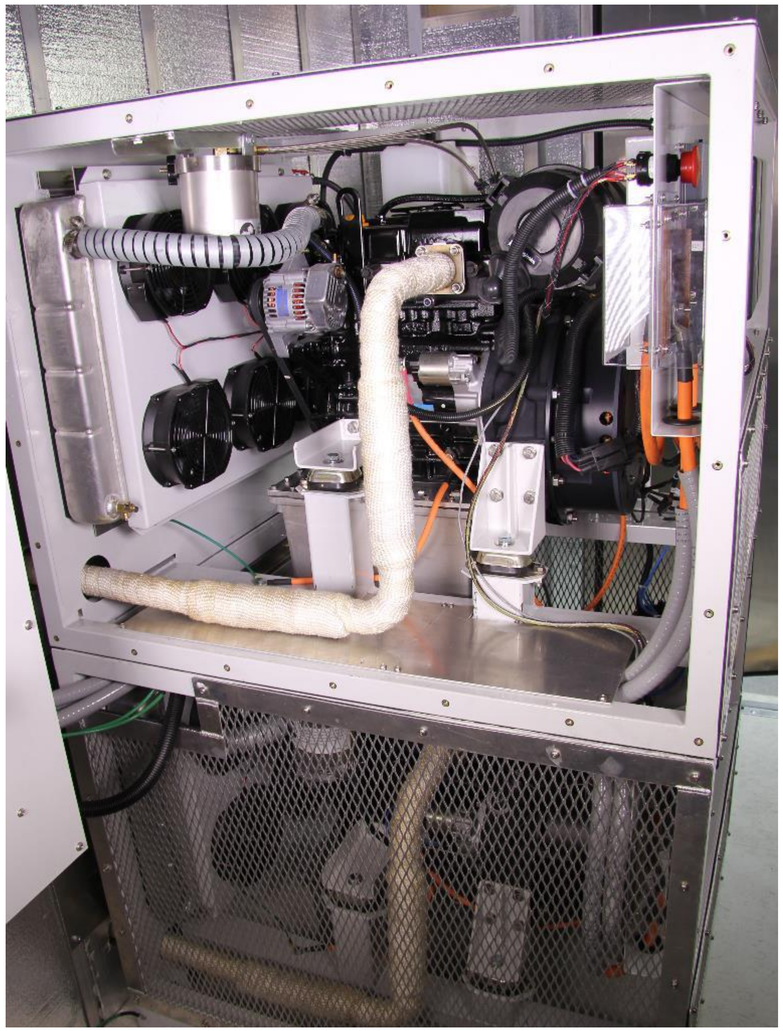
higher reliability and durability

- We use:
  - Heavy duty engines that have operational life of
    - 15,000 – 25,000 for Diesel
    - 20,000 – 40,000 hours for Propane and Natural Gas

- Made in USA
    - Corrosion resistant materials
    - High quality wiring
    - Sealed and gold plated connectors
    - Sealed Control modules from weather and biological
    - Military grade controls (without the additional cost)
    - Operation in High and Low Ambient Temperature (-55°C to 65°C)
- Communication and Monitoring
    - Complete remote monitoring and control through cell modem, Ethernet, and RS232
    - Support SNMP communications to a central station



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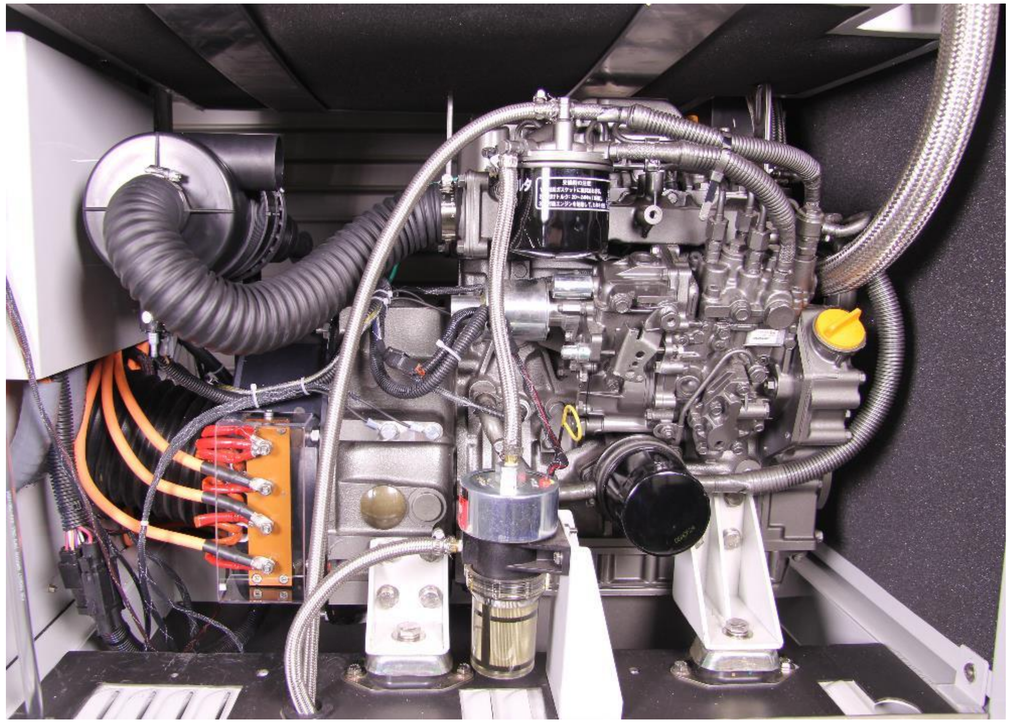
Enclosure and other features

Enclosure

- All welded aluminum construction for light weight, ruggedness, and corrosion resistance.
- Large insect and small rodent screens. These animals can chew wire and other plastic and rubber parts causing a generator to fail.
- Double louvers to keep the rain out and the noise in.
- Convenient to use junction box with pull fuse disconnect.
- Simple and convenient access to serviceable parts.

Other Features

- The DC generator is supplied with braided fuel and coolant hoses or a braided cover, A/C are standard rubber hoses. Protect hose against rodents and temperature.
- Higher temperature, more weather resistant wire than AC generators. Increases generator life and increases reliability.
- Electric fuel pump to ensure reliable starting in all climates.
- UL 142 fuel tank.
- Electric fans on radiator to reduce acoustic noise and improve fuel efficiency.



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Alternator design

- Large diameter with 32 poles, and low weight of the alternator allows the engine to start at low speed, run at high efficiency, and have long service life.
- Lack of electronic components (diodes, etc.) and electrical connections inside the alternator.
- Absence of components that can short circuit, or vibrate freely inside the alternator.
- Lack of parts that rub, wear out or overheat under normal operating conditions.
- The output can be shorted for few minutes without causing damage.

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AC vs. DC

SIMPLICITY = RELIABILITY

AC GENERATOR
AC Model 42.2
Power: 16kW
Weight: 246 LBS
Length: 18 IN

3X Larger

DC GENERATOR
Alternator
DC Model 8220
Power: 22 kW
Weight: 49 LBS
Length: 5.5 IN

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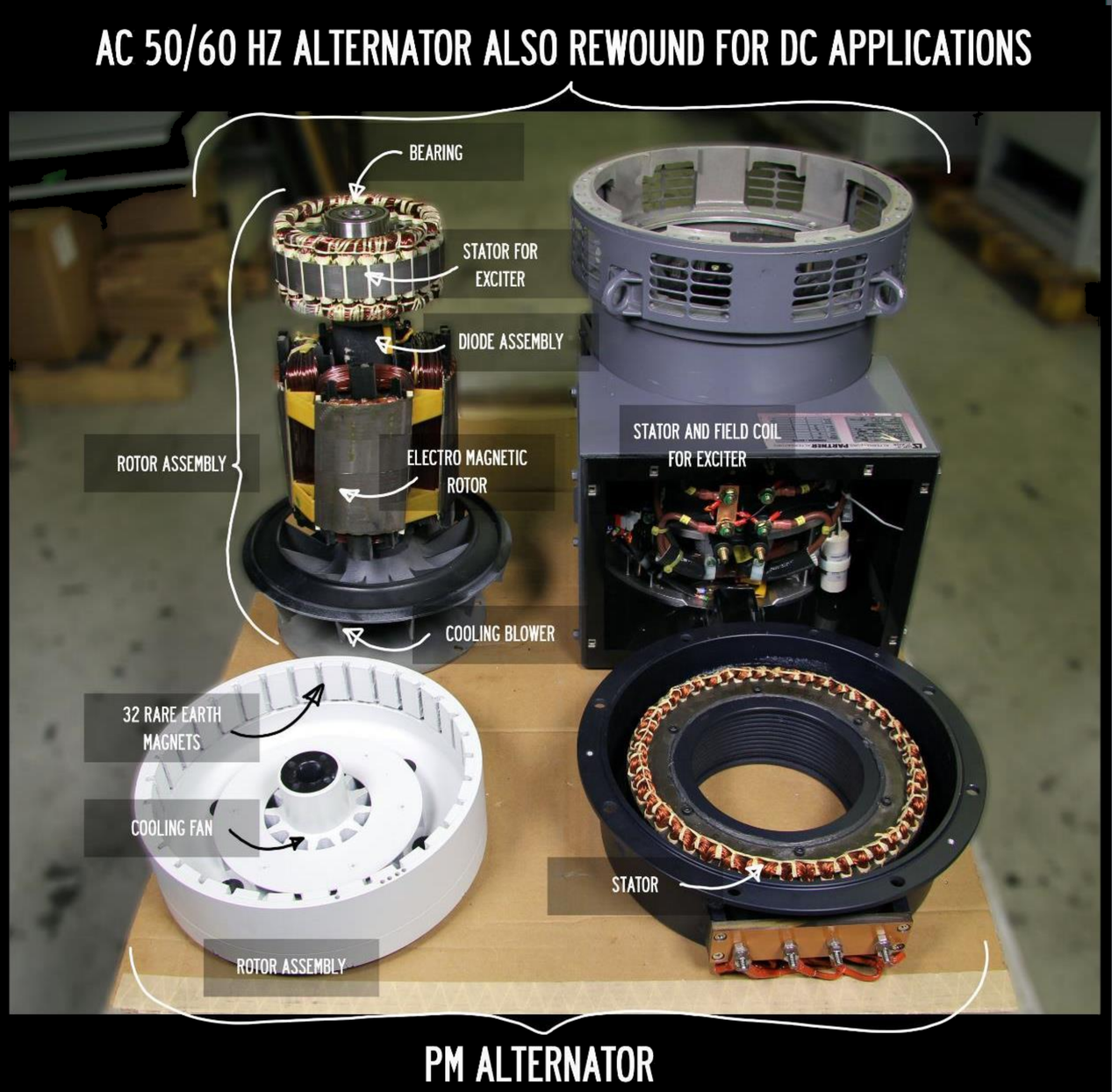

DC alternator

No maintenance, high reliability

- No bearings
- No Exciters
- No rotating diodes, electrical components, wires and laminations

Long life with no parts to wear

- 100,000+ hours

Very compact

- Reduces footprint of generator

Magnets increase efficiency

- Reduces fuel consumption
- Reduces the amount of fuel stored on site

Light weight

- Reduces cost to replace generator on site
- Less reinforcing of roof installations
- Very easy to service

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The efficiency of hybrid systems

For remote sites, the cost difference of different power supply options will vary depending on location conditions, power consumption, load balancing, availability of renewable energy, the price of fuel, and the transportation costs. As for the renewable energy, their use in rural areas, despite the higher cost of initial capital investment, in many cases is cost effective, given the low cost of operation and maintenance.

The critical factor in the decision-making process is the change in the price of fossil fuels, and consequently, the price of fuel on the national level. The sharp increase in crude oil prices, and continued depletion of this resource leads to long-term restrictions in the economic development in the world. Hybrid systems based on renewable energy, are independent of the oil price. Even if the systems include a diesel generator as backup, hybrid system provides 60 to 90% of required power.

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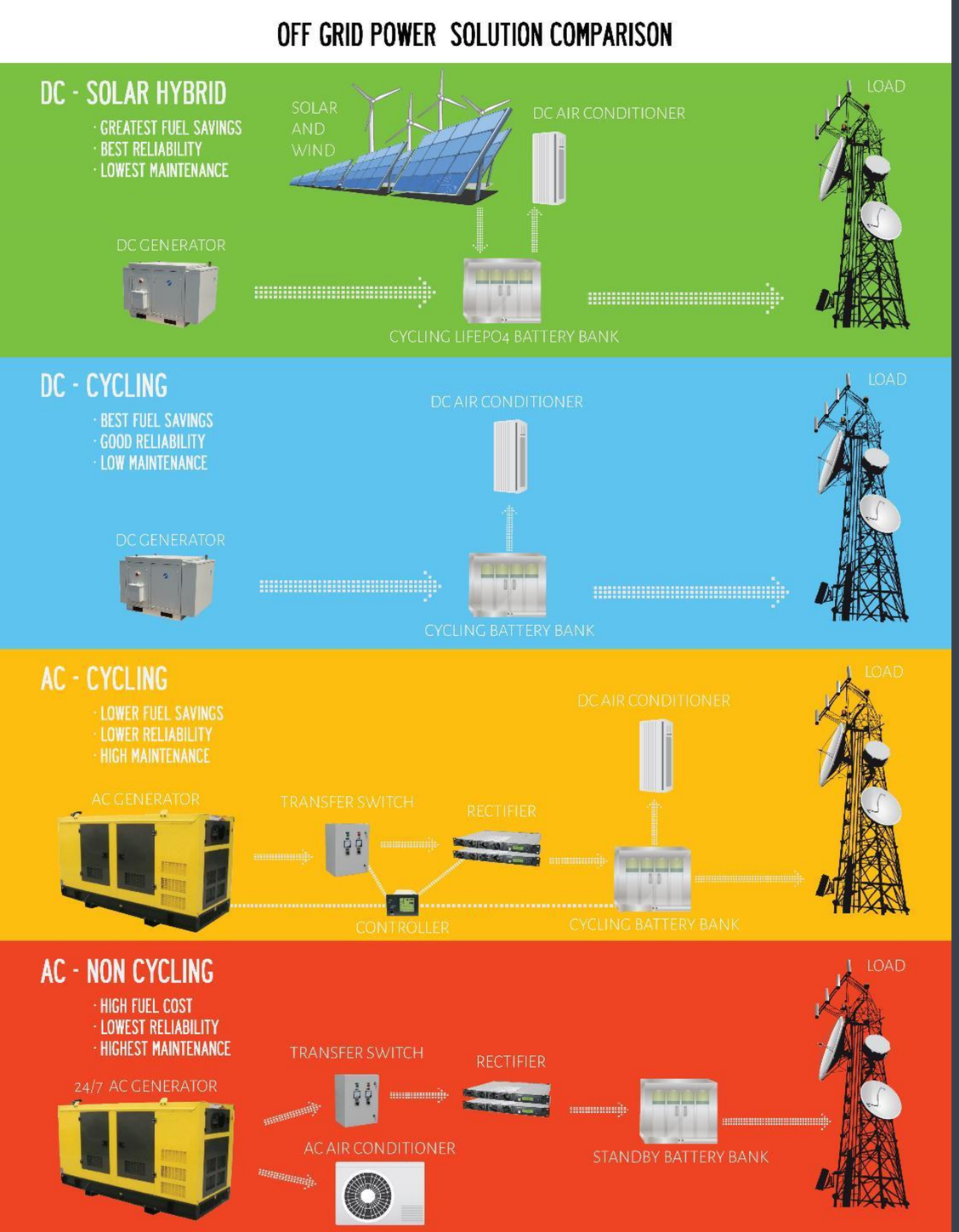

- Fuel saving has been the most important reason for choosing DC systems . We can reduce fuel saving by up to 70% over typical AC installations.
- Our DC Hybrid systems reduces field maintenance and refueling from 1 to 4 times a month for traditional technologies to as long as 12 months.
- The CAPEX for an installed DC Hybrid system is typically lower than an AC based system.
- Our products are specifically engineered for Low maintenance and long life in prime power applications; thereby reducing OPEX costs. Typically 20 kW AC generators and smaller are engineered for a low cost applications, and not prime power; increasing the OPEX cost.
- Ease of transportation to remote sites.
- Remote monitoring and control.
- Built in battery charging algorithms.
- Truly a disruptive technology.

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Diagram of a Solar Hybrid System

Remote monitoring and control of sites from anywhere in the world

Reduces maintenance costs

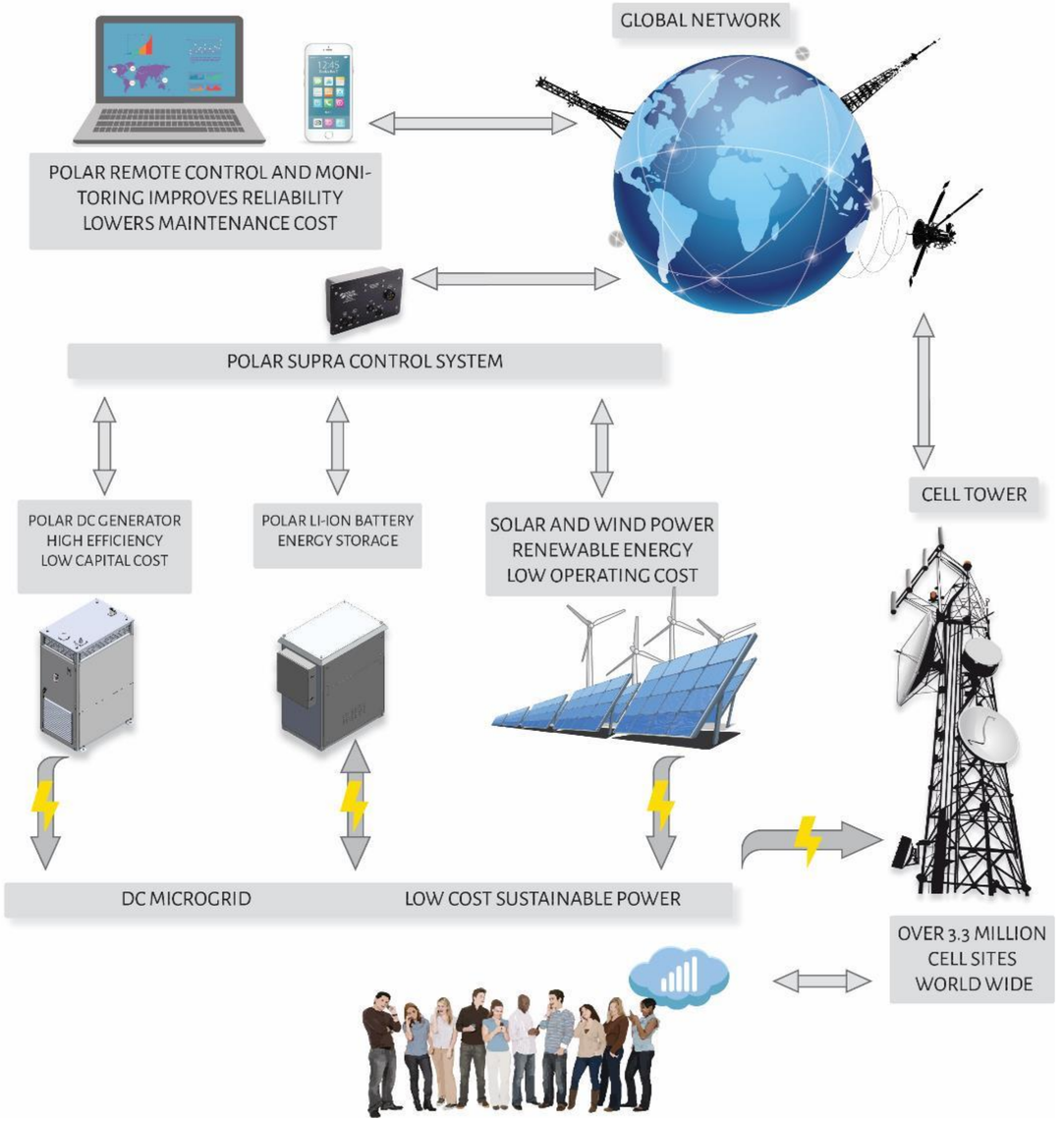
Improves reliability

Foundation for Rental / Micro-Utility / OPEX

Designed to support 99.9% network up-time

Hybrid system cuts diesel-related costs by up to 70%.

Combines a low CAPEX fuel energy source with a low OPEX renewable energy for low cost sustainable power



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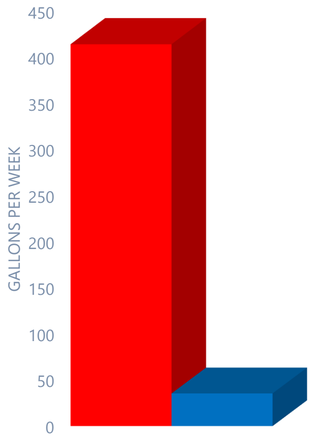
DC Solar Hybrid power systems

Average fuel consumption a week



Red – Solar Hybrid site using a LPG AC genset with a large solar array and 10 days of autonomy from lead acid battery bank. The AC generator ran for an average of 103.7 hours a week, consuming 4 gal/hr. of propane, requiring a total of **414.8** gallons per week.

Blue – Same site with a LPG DC generator with 1 day of autonomy from Li-Ion battery. With this upgrade the DC generator ran for 25.6 hrs./week, using 1.4 gal/hr., averaging **35.9** gal/week.

Example of an upgraded site in New Mexico, replaced the AC generator and lead acid batteries with DC generator and Lithium-Ion batteries. The engineering practice of 5 to 10 days of battery autonomy had severely impacted the systems efficiency. Long autonomy is standard practice because of the lower reliability of the AC generator and lead acid batteries.

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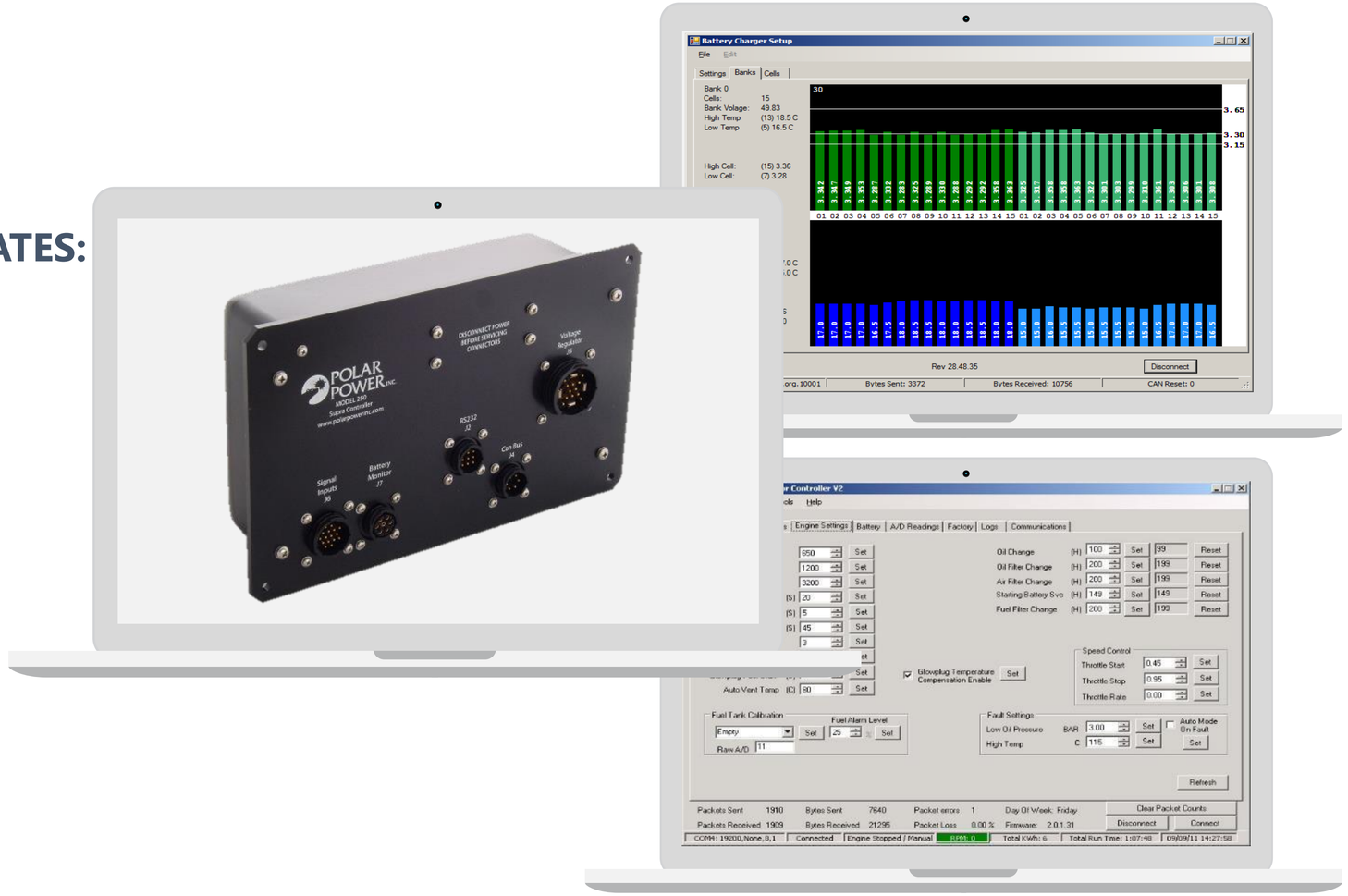
Supra Digital Control system

REMOTE CONTROL AND MONITORING IMPROVES:

- Reliability
- Serviceability
- Lowers maintenance cost

PROPRIETARY DIGITAL CONTROL SYSTEM INTEGRATES:

- Remote monitoring & control (including fuel monitoring)
- Complete alternator & engine control
- Controls battery charging from multiple power sources
- Connectors providing Plug and Play troubleshooting and repair
- Very simple wire harness for ease of repair / replacement



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DC generator advantages: prime power

- Fuel Efficiency
  - Can consume less than 1/2 the fuel of the planned 20 kVA – 40 kVA AC Generator.
  - High fuel efficiency provides longer reserve time with minimum fuel storage on site.
- Lower Acoustic noise
  - DC generators are typically quieter than most AC generator systems.
- More Reliable Starting with a DC Generator with the Supercapacitor Option
  - A super capacitor provides no maintenance for up to 20 years and reliable starting at temperature extremes.
  - Battery, engine block, oil heater are not required.
- Smaller footprint
  - DC power systems are typically 1⁄2 the footprint of a conventional AC unit.

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Weather extremes

Hybrid solar power system in desert on the USA-Mexico border. Summer temperatures reach 48.8°C

Provides power for cell service to Border Patrol 24/7/365

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Weather extremes

Solar hybrid power system in Alaska. Winter temperature reaches -45.5°C.

Provides power for cell service 24/7/365

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Hybrid Application: Replace Lead Acid with Li-Ion Batteries

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Comparison of Lead Acid and $LiFePO_4$

Lead – Acid batteries	Lithium Batteries
1) Need replacement once every 18 months to 2 years. Rated at 1,200 cycles	1) Need replacement once every 4 to 8 years. Rated at 5,000 cycles
2) Up to 20 % loss in charge	2) Charging loss very minimal
3) Needs air-conditioning	3) Does not need air-conditioning
4) Occupies a lot of space and is heavy	4) Significantly compact and light weight. This reduces site foot print and eliminates need of material handling equipment
5) Depth of discharge 15% to 50 %	5) Depth of discharge 70 to 80 %

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FUTURE POWER REQUIREMENTS

Our standard 8000 series alternators takes us up to 26 KW

Polar manufactures its own alternators and control electronics, we can engineer DC generators of any power capacity.

The larger the load the more noticeable the performance difference between DC and AC.

FYI, Polar is currently working to produce a 200 kW DC generator for data centers.

DC Generator Financial advantage

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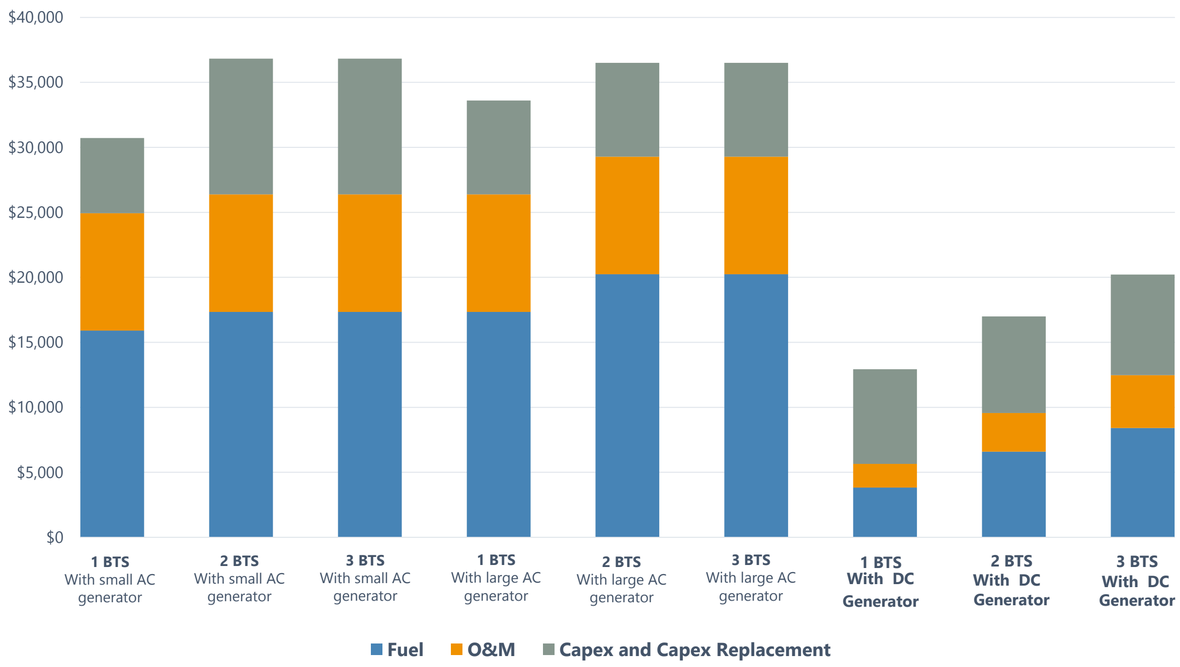
Estimated annual savings genset



Fuel Savings ($ per annum)

	Smaller AC Generator	Larger AC Generator	DC Generator
1 kW Load	15,899	17,345	3,824
2 kW Load	17,345	20,236	6,591
3 kW Load	17,345	20,236	8,412
Average	16,863	19,272	6,276
Savings	***10,587***	***12,996***	

O&M ($ per annum)

	Smaller AC Generator	Larger AC Generator	DC Generator
1 kW Load	9,040	9,040	1,826
2 kW Load	9,040	9,040	2,968
3 kW Load	9,040	9,040	4,060
Average	9,040	9,040	2,951
Savings	***6,089***	***6,089***	

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Where do the savings come from?

		Smaller AC Generator	Larger AC Generator	Hybrid
	Service Interval (hours)	500	500	500
	Run hours per year	*8760*	*8760*	*2330*
	No. Times serviced per year	*17.5*	*17.5*	*4.7*
Oil	Oil (L) per 500 operating hours	9	9	3
	Oil per year (L)	*158*	*158*	*14*
	Cost per litre	4	4	4
	Oil cost per year	**631**	**631**	**56**
Parts	Parts cost per service ($)	300	300	200
	Parts cost per unit per year	**5,256**	**5,256**	**932**
Labour	Labour hours per service	4	4	4
	Labour cost per hour ($)	35	35	35
	Labour cost per unit per year	**2,453**	**2,453**	**652**
Mileage	Mileage per service ($)	80	80	80
	Cost per mile ($)	0.50	0.50	0.50
	Mileage cost per unit per year	**701**	**701**	**186**
	Total O&M cost per unit per year	**9,040**	**9,040**	**1,826**

***Mainly* due to lower running hours -> Less Fuel / Fewer services**

Also less oil required

And fewer / cheaper parts

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Installation, maintenance and warranty

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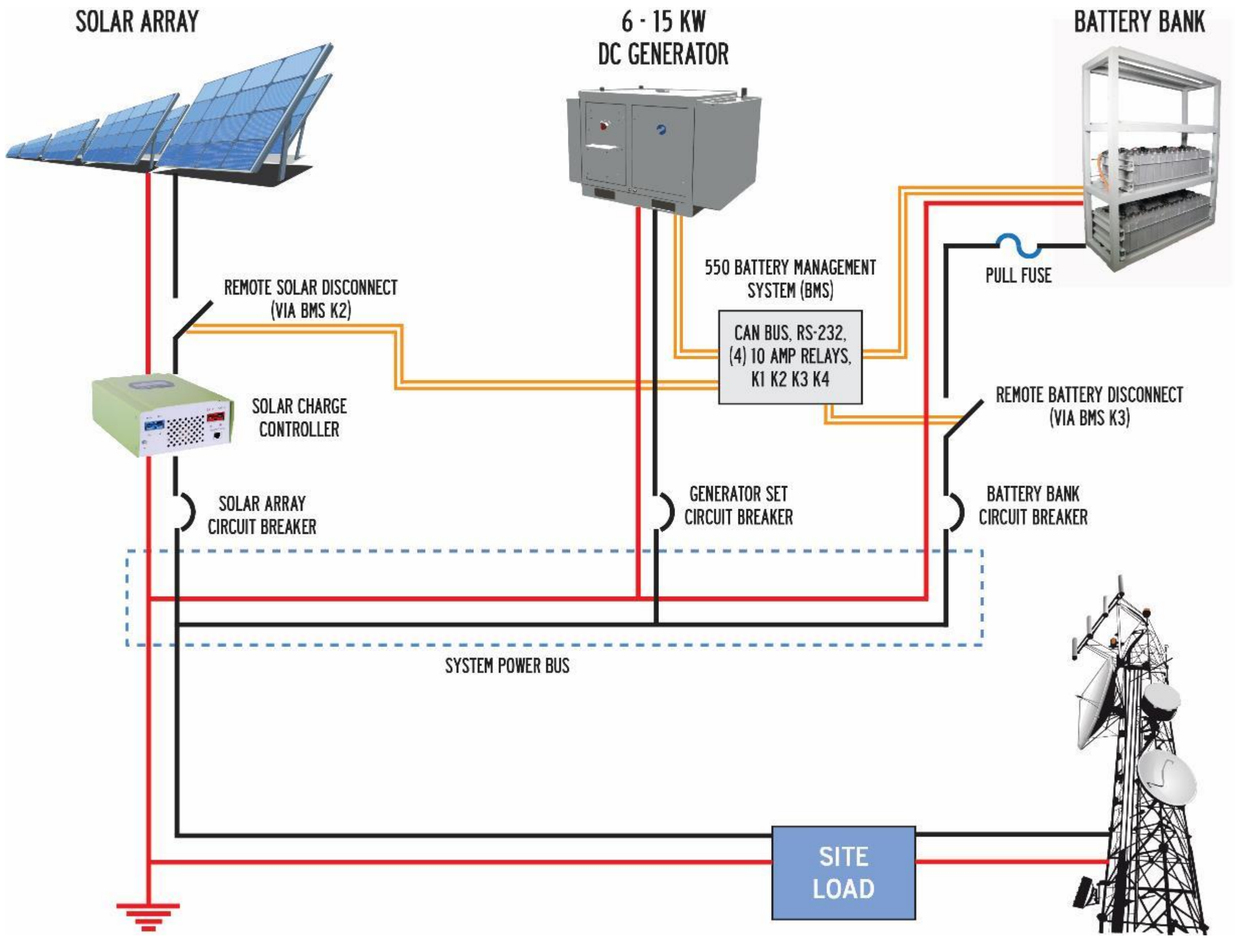
Installation



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Maintenance and warranty

- System offers a 2 **year full warranty** for off grid generators

- Maintenance is offered through local partnering companies

- Maintenance for Prime/Hybrid Power application (with additional 14 liters oil sump):
    - Scheduled visits to change oil every
    - **For diesel fueled unit:**
        - Using petroleum based oil – 1500 hr.
        - Using synthetic oil based oil – 2000 hr.
    - **For LPG/NG fueled unit:**
        - Using petroleum based oil – 1500 hr.
        - Using synthetic oil based oil – 3000 hr.

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Periodic inspection for prime power

With Extended Oil Sump and Refining Pack Filtration System

Classification	Item	Commission	Maintenance Period						
			50 Hours Burn in	Every 250 Hours or 6 months	Every 500 Hours or 6 months	Every 1000 Hours or one year	Every 1500 Hours or one year	Every 2000 Hours or two years	Every 3000 Hours or two years
Whole	Visual check around generator set and engine	©	○	○	○	○	○	○	○
Fuel/Oil System	Fuel tank level check and fuel supply	©							
	Fuel tank draining / cleaning	As needed							
	Fuel/water separator drain/replace			○Ⓟ					
	Water separator cleaning			○					
	Leak check			○					
	Fuel filter replacement				○Ⓟ				
Lubricating Oil System	Lube oil check	©	○	○					
	Lube oil filter replacement		○	○Ⓟ					
Lube oil change									
Diesel Fueled Unit	Using Petroleum Based oil		○				○		
	Using Synthetic Based oil		○					○	
LPG/NG Fueled Unit	Using Petroleum Based oil		○					○	
	Using Synthetic Based oil			○ Burn in					○
Coolant System	Coolant level check	©	○	○					
	Radiator fin cleaning	As needed							
	V-belt tension check		○	○		○Ⓟ			
	Coolant replacement					○Ⓟ			
	Coolant flush and maintenance							●Ⓟ	
	Coolant / Fuel inspection / maintenance	©		○		Ⓟ			
Rubber Hoses	Inspection, run engine under load	©							
Governor	Air cleaner / element inspect / clean	©				○			
Air Intake	Air cleaner / element replacement					○			
Electrical System	Instrument Function check	©							
	Check battery terminals	©			○				
	Secure connections + fastners	©				●			

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Additional slides

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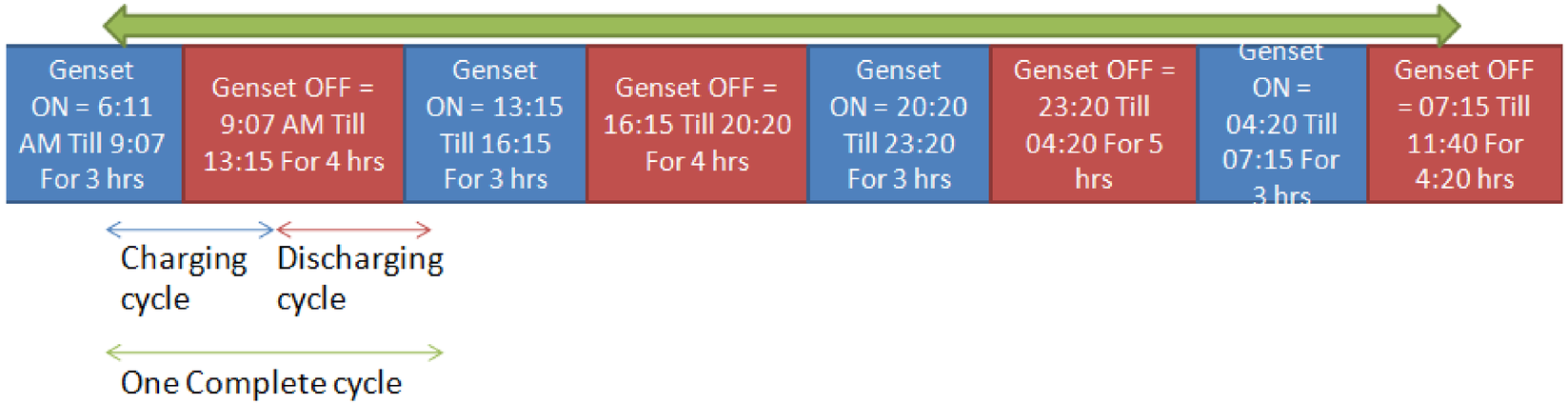
Field trial – Warid Telecom, Pakistan

DC DG Charging/Discharging cycle



Genset Running In Complete Duty Cycle : 12 Hours

Genset Stop Position In Complete Duty Cycle : 17:20 Hours

Description	A/C Gen	D/C Gen	DC Genset Savings
Engine Running Hours / Day	24	10	14
Average Fuel Consumption	2 L/H	1.9 L/H	-
Total Fuel Consumption	48 L/Day	19 L/Day	29 L/Day
Interval Of Maintenance	After 10 Days	After 25 Days	15 Days
Interval Of Fuel Refilling (With 500 Liter Tank Capacity)	After 11 Days	After 27 Days	Up to 16 Days

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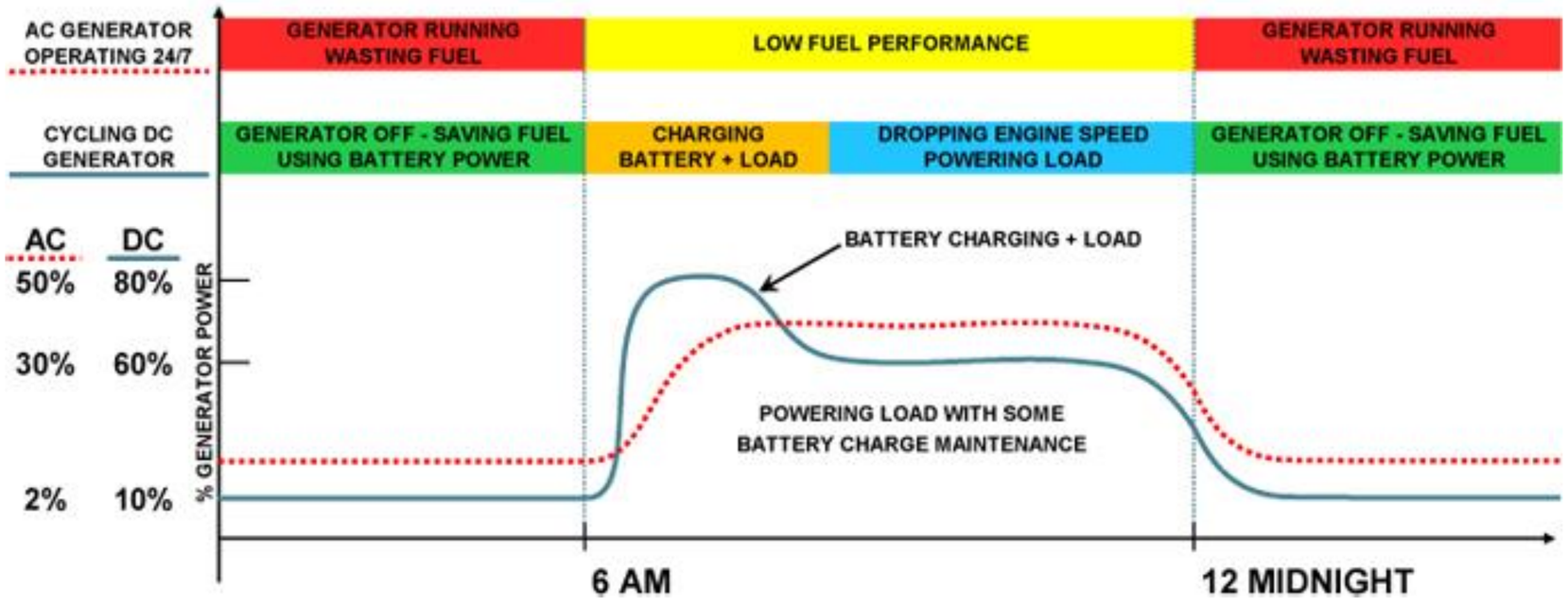
AC vs. DC Generators Daily Operation



Field trials have shown 20 to 70 % fuel reduction for DC generators over conventional AC generators operating 24/7

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Field trials – GTL, India

Date	Dg run hours	Load - KWH				Diesel filling (Lts)
		Aircel	Docomo	Aircon	Battery Bank	
22-Nov-11	6.12	33.3	40.7	0.4	9.7	93
23-Nov-11	11.08	16.1	19	3.7	21.7	
24-Nov-11	10.1	16.2	19	1.8	21.3	30
25-Nov-11	11.14	16.2	19	0	21.9	
26-Nov-11	12.36	16.3	18.8	4.4	24.2	
27-Nov-11	12.5	16.4	18.9	6.1	25	
28-Nov-11	5.17	16.3	19.1	4.4	19.6	
Total	**69.43**	**130.8**	**154.5**	**20.8**	**143.4**	**123**
29-Nov-11	10:06	15.5	18.1	6.5	29	
30-Nov-11	12:02	16.2	19.1	7.9	23.3	93
1-Dec-11	13:08	16.4	19.4	9.4	21.5	
2-Dec-11	13:20	16.4	19.5	6.3	21.9	40
3-Dec-11		16.3	18.2	8	23.5	
4-Dec-11	9:51	16.4	19.4	5.6	19.5	
5-Dec-11	12:24	16.4	19.5	7.7	20	
Total	**76.26**	**113.6**	**133.2**	**51.4**	**158.7**	**133**
06-Dec-11	4:21	16.5	19.6	5	26.2	30
07-Dec-11	11:09	16.5	19.4	10.8	23.0	
08-Dec-11	7:49	16.5	19.5	8.2	24.1	20
09-Dec-11	13:45	16.6	19.6	11.5	25.8	50
10-Dec-11	13:38	16.6	19.6	11.1	23.4	
11-Dec-11	4:55	16.5	19.4	3.2	24.1	
12-Dec-11	10:20	16.6	19.6	6.1	24.3	20
Total	**65.57**	**115.8**	**136.7**	**55.9**	**170.9**	**120**

6.5 kW DC DG run time/week: 70 hrs
Consumption per hour: 1.8 liters
Fuel consumption per week: 126 liters

15 KVA AC DG run time/week: 84 hrs
Consumption per hour: 2.7 liters
Fuel consumption per week: 227 liters

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