



OPTIMIZING OFF- AND ON-GRID ENERGY COST WITH NEW TECHNOLOGY



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Polar Power is pioneering technologies that can radically change the production, consumption, and environmental impact of power generation

- Why pursue energy and maintenance cost reductions?

Because there are opportunities to achieve a substantial competitive edge over competition, either as an MNO, tower operator, or service/maintenance provider.

- There are advanced and proven technologies in energy production and storage that will provide considerable cost savings, but presently are not widely adopted in telecom. New technologies will also significantly streamline and simplify the maintenance processes thereby increasing reliability.
- When considering the cost of a system, or how much time should be spent in engineering the system, it is imperative to consider lost revenues when the system fails.
- Polar provides mobile and stationary energy solutions to the U.S. military since 1984, and many of these technologies are available for cost-effective telecom use.

CHALLENGES

- Energy and Maintenance costs are increasing at a significant rate as broadband services grow. More energy at higher costs.
- Telecommunications and data services reportedly consume 4% of grid power and in the coming years, this number is expected to rise to 20%.
- Demand on the electric grid is growing with electric vehicles, air-conditioning, all electric homes and businesses, and increasing population.
- For over 60 years major metropolitan cities suffer rolling brownouts in the summer due only to air-conditioning demand on the grid, and now there are also electric vehicles. We can expect more frequent outages and of longer duration.
- We can also expect increased oversight on grid usage.
- Cost of Diesel is increasing along with theft rates.
- Restriction on the use of diesel generators is increasing, especially near schools, hospitals, and nursing homes.
- Diesel fuel tanks are increasing in size to meet the desired reserve time of 48 to 72 hours. Permitting processes become more time consuming and expensive, and many landlords object to the increasing amount of fuel on site.
- Finding and maintaining qualified technicians is becoming more difficult and costly.

CHALLENGES

- The 5G rollout increases the power requirements of the site and this is driving the purchase of larger generators. To allow for future growth generators are oversized and this is causing engine problems with wet stacking and condensing water in the crankcase.
- These problems affect the generator's reliability on backup and off-grid sites.
- Also greatly increase the maintenance costs.
- A site going down adversely affects revenues and customer satisfaction.
- There are solutions, and they are simple and cost effective.

Battery selection:

- The type of batteries that have been popular for standby applications (lead-acid) are being installed in off-grid sites that require cycling 1 to 2 times a day. *This is a huge mistake.* The standby batteries typically last 1 to 3 years at prime power sites, making this a very expensive choice.
- In place of selecting the correct battery chemistry, engineers reduce the number of charge cycles by increasing the battery bank size (providing more amp hours of storage) in the attempt of extending the battery life. *This is not a cost-effective solution.*
- Best solution: use a high cycle battery (e.g. Lithium) and keep the battery bank small and let it cycle 2 to 4 times a day.

This [reduces CAPEX and OPEX costs](#) and reduces space.

Generator selection:

- Using a typical AC generator engineered for backup requires frequent replacement when used in prime power and solar applications. To solve this problem managers have reduced AC generator run-time by increasing size of both the battery storage and generator. But this *increases the OPEX and CAPEX cost* while lowering the site reliability.
- Best solution: install a smaller prime power DC generator with a smaller battery bank. This will increase the number of charge cycles, and the generator will run for a slightly longer period. This will significantly reduce fuel consumption, battery and generator purchase and replacement costs.

The key concept here is [Optimization](#).



ENERGY STORAGE: OFF-GRID AND ON-GRID

Battery Storage

- Due to the industry's self-imposed limitations on the maximum equipment operating voltage (i.e., 54-56 Vdc), batteries of all chemistries are not charged completely.
- The 54 to 56 Vdc are adequate as float voltages in standby applications, but the battery storage capacity will diminish over time. And for cycling applications batteries can be rendered useless in 1 to 3 years.
- Battery equalization in the 56 to 60 Vdc is required for most battery chemistries. If these higher voltages are not practical for the equipment, then reduce the number of cells in the battery bank.
 - Example: Lithium/Iron/Phosphate use 15 (vs. 16) cells and lead-acid use 22 cells (vs. 24).
- For those programs that must use the Lead-Acid chemistries we recommend using similar Battery Management Systems as used with Lithium chemistries.
 - Cell to Cell equalization
 - Cell to Cell voltage monitoring
- We recommend against having independent and multiple batteries packs disbursed between the various cabinets. A more efficient solution is a centralized battery bank with temperature regulation and monitoring. If a large amount of energy storage is required, then the batteries should be divided into banks, allowing the cells gone bad to be isolated without having to shut down the entire bank.

For On-Grid sites we strongly recommend using Super Capacitors and removing all batteries



ENERGY STORAGE: OFF-GRID AND ON-GRID

Battery and Generator sizing:

- Batteries must be sized based on having their discharge rate higher than the power demand of the load (amps), then factoring in the desired reserve time.
- For Prime power, the DC generators should not be sized based on just the kW rating, instead determine the kW hours needed per day divided by your desired daily run time and this will give you the optimum kW size. Make sure the kW rating does not exceed the sum of the load and max charge rating of the battery.
- For on-grid DC generator size based on the load demand in amps and not from the kW rating AC generator. During the power outage the DC generator can regulate the current charge into the battery and the load allow the grid to recharge the battery when power is restored.
- Over or under sizing generators and batteries can cost considerable expense in capital expenditure and maintenance.

Advantage of Lithium Battery in Off-Grid installations

- The Lithium chemistry is about $\frac{1}{4}$ the volume and weight of the lead-acid for the same amount of usable energy.
- The lithium battery has a much shorter recharging cycle time than lead-acid, reducing the generator run time.
- The Lithium chemistry is 15% to 20% more efficient than lead-acid technologies saving a significant amount of fuel and solar charging.
- A non standby type lead-acid batteries typically last 3 to 5 years and the lithium is 4 to 8 years.
- As the lead-acid batteries age, they lose efficiency in the charge/ discharge cycle to the extent that the battery can consume a similar amount of energy as the load itself.

Super Capacitor to Replace Starting Battery:

- The starting battery is the number one failure point on generator starting
- We see three problems with starting batteries:
 1. They are popular targets for theft
 2. Upon replacement, many operators choose an unreliable (but convenient) battery
 3. Reliability is compromised at low and high temperatures
- The super capacitor is charged from the load battery using a DC-DC converter.

Main Features:

- Voltage: 16V, Capacitance: 500F
- Environmentally safe, No toxic chemicals
- Virtually maintenance free
- Service life 15 – 20 years or 500,000 start cycles
- Operating range -40°C to +65°C
- High cranking amps
- Resists shock and vibration
- Lightweight





15KW DIESEL WITH SUPER CAPACITOR STORAGE

No battery storage required on Site for low CAPEX and OPEX

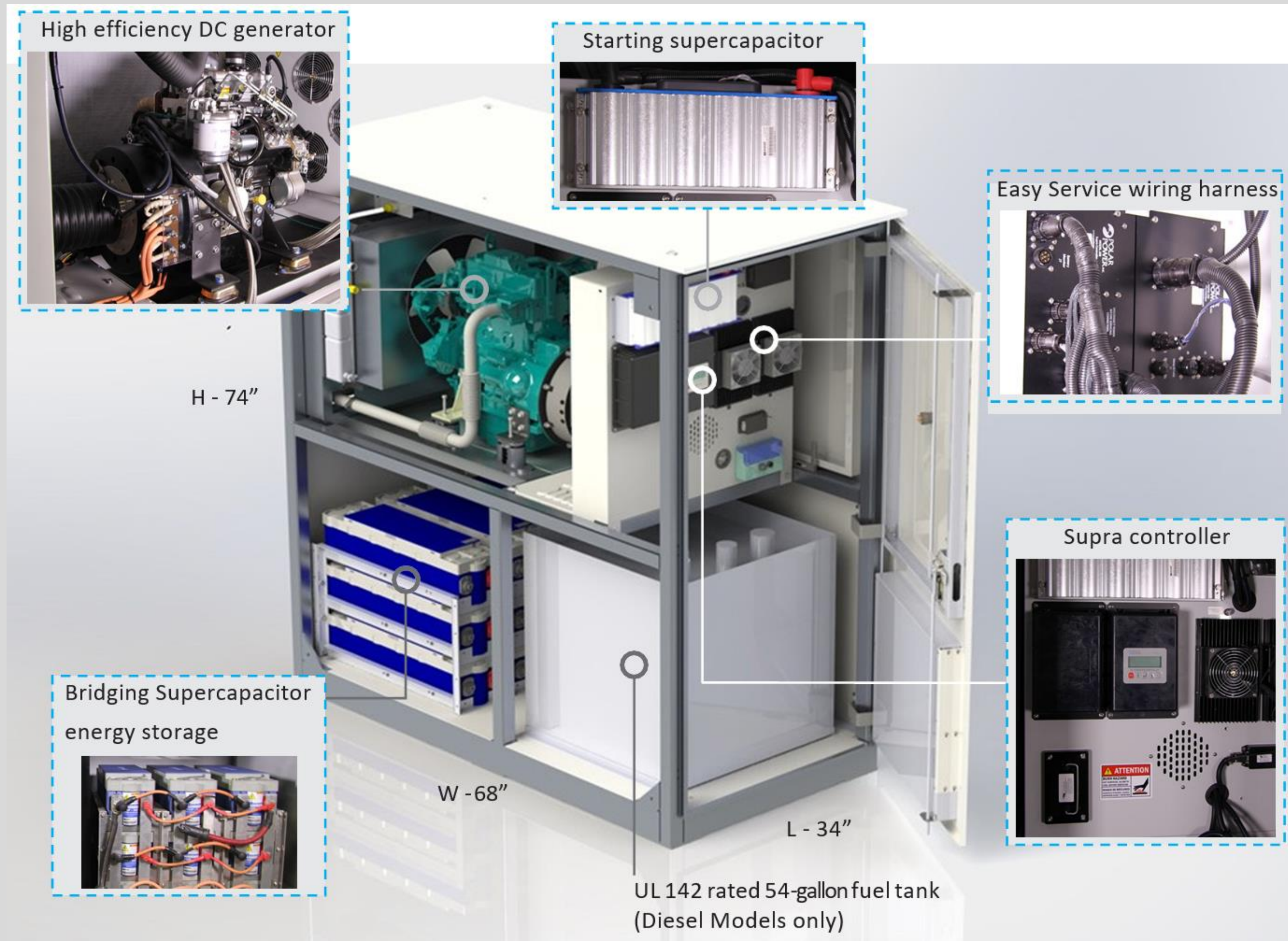
- DC Generator (Yanmar 3TNV88 Engine)
- Up to 15 years no site battery replacement
- 280 amps DC current (500 amp models available)
- Powder coated Aluminium enclosure
- Small footprint (68" X 34" x 72")
- 54 gal UL142 rated double walled diesel tank
- Fuel level sensor
- Integrated Polar Supra digital controller
- Ethernet connection



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POWERCAP COMPONENTS





ALL WEATHER HORIZONTAL ENCLOSURE

Main Features:

- All Aluminum construction with a heavy layer of powder coating and stainless hardware. Designed for weather extremes, especially hurricanes
- Compact design, small footprint and light weight. Use elevator for rooftop installations, helicopter transport, or small pickup truck for installation.
- Long operational life and very low maintenance
- High efficiency with low fuel consumption
- Automatic start/stop with remote control and battery charging algorithms included.
- All aluminum cabinet, 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



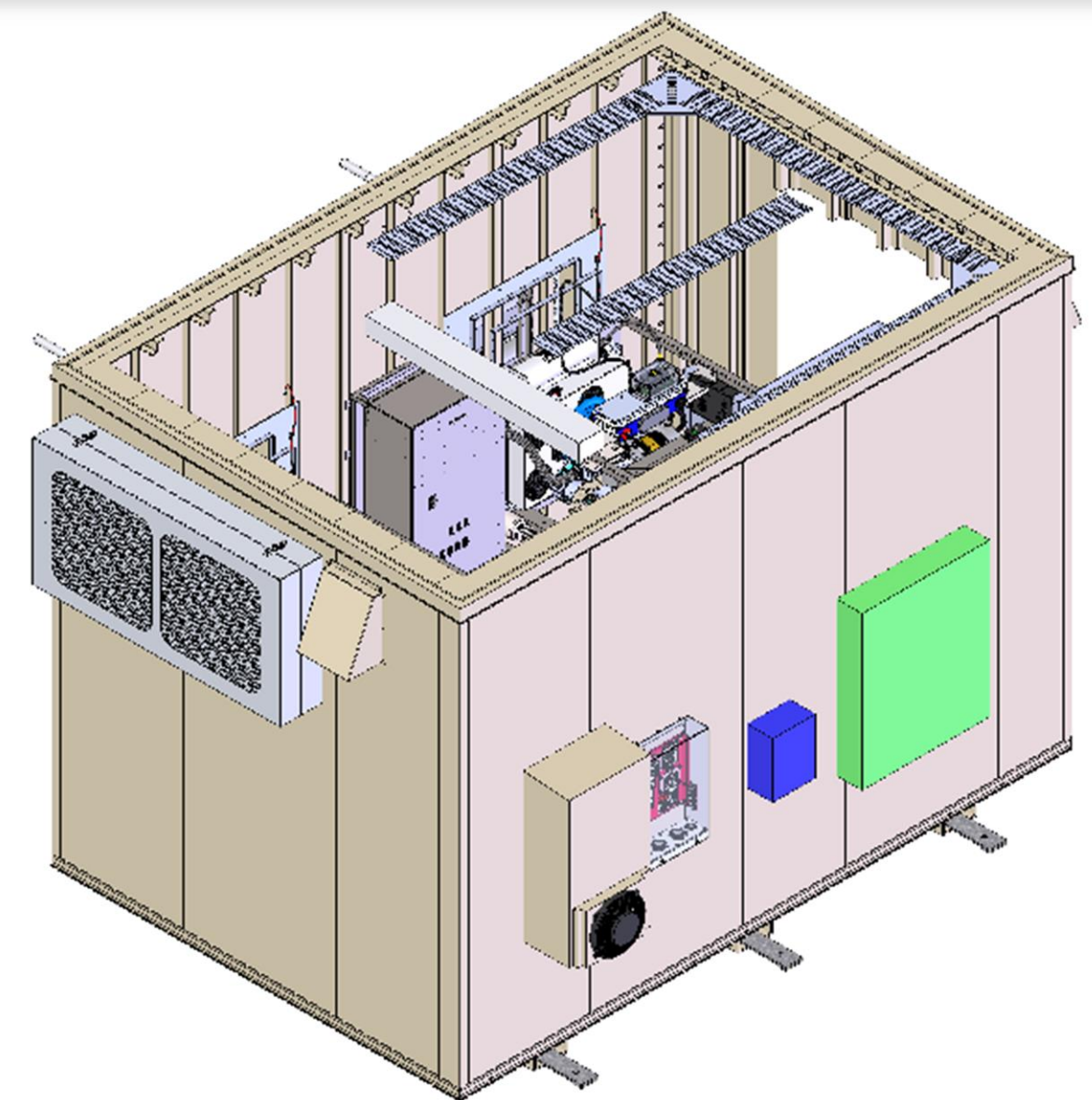
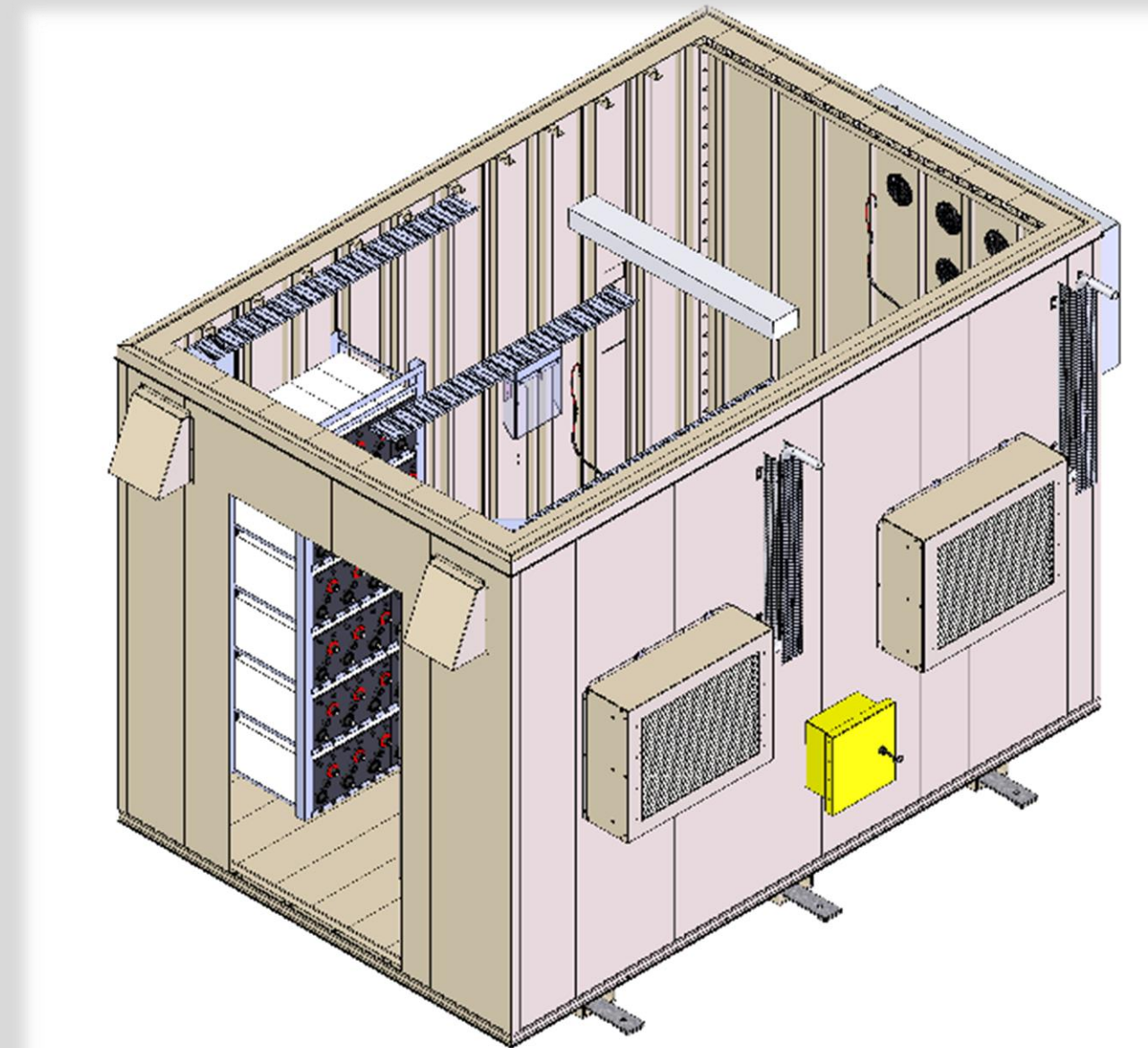
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WALK-IN INTERGATED SHELTER

For weather extremes a walk shelter is best for the maintenance crew.

- Lightweight all-Aluminum shelter 12'x8'
- Can be helicoptered to the site assembled
- Trucked to the site then easily assembled
- Withstands very high winds up to 180 mph
- Electric louvers for weather extremes
- Mineral wool insulation for resistance to brush fire
- Battery (various chemistries)– 1000 – 4000 Ah
- Two DC gensets can be installed of highest reliability
- DC HVAC (optional) for battery cooling
- Polar DAC (Direct Ambient Cooling)
- Polar Supra 2020 Master Controller





POLAR ENCLOSURE AND OTHER FEATURES

Polar's Vertical Enclosure

- Available in sizes from 6 to 27 kW
- Can fit in the elevator for rooftop installations
- 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 and built nests creating fire hazards.
- Double louvers to keep the rain out and the noise in
- Simple and convenient access to serviceable parts
- Supplied with stainless braided covered fuel and coolant hoses that protects hose against rodents and insects.
- Electric fuel pump to ensure reliable starting in all climates.
- Enclosed, UL 142, 54 gallon fuel tank.
- Electric Fans on radiator to reduce acoustic noise and improve fuel efficiency.





SOLAR HYBRID SYSTEMS USING PROPANE (LPG)

Offers the lowest operating cost and maintenance

- LPG can be delivered anywhere that diesel can
- On a negotiated delivery contract LPG can cost lower than diesel
- Easier to permit on Federal Land
- These energy efficient sites produce less carbon emission than most electric utilities, providing a strong positive public image.



THE IDEAL LPG GENERATOR

- **Engine Higher Fuel Economy**
 - Closed loop combustion control with fuel injection or electronic carburetor.
 - Increased compression ratio
 - Eliminate the engine's parasitic loads – water pump, engine fan, starting battery alternator, belts and pulleys
- **Engine Lower Maintenance and Increase reliability**
 - Replace belt driven water pump and radiator cooling fan with energy efficient electric fan and water pump
 - Increase oil sump size and add Ultra-fine oil filtration
 - Increase engine maintenance intervals up to 1 year over 2 to 4 weeks for traditional LPG engines
 - Cast iron engine block with crankshaft bearings between each cylinder (connecting rod)
 - Use Stellite valves to meet the higher combustion temperatures of LPG
- **Incorporate Long Life Alternator**
 - No bearings
 - No Brushes, slip rings, exciters
- **Corrosion Resistant Components and Enclosures** for rugged outdoor use



60,000 to 90,000 hour life engine
Engineered for LPG and natural gas



4,000 to 6,000 hour engine



BENEFITS OF LPG

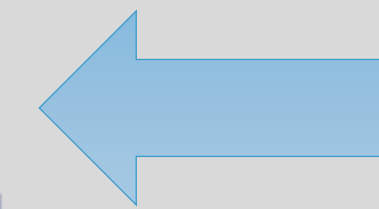
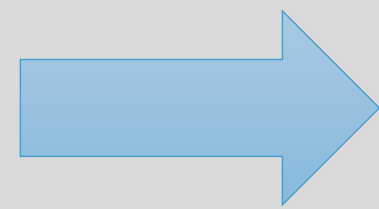
Comparison	Diesel	LPG
ENVIRONMENTAL	• Rapidly changing emission standards reduce engine availability to OEM’s and increases engine cost. • Strict emission controls is increasing Diesel engine complexity thereby reducing reliability and making maintenance more difficult.	✓ Environmentally Clean Fuel, rarely effected by change in environmental regulations. ✓ Clean exhaust ideal for use near population centers.
STORAGE, SHELF LIFE TRANSPORTATON	• Diesel fuel has limited storage life and sometimes requires additives. Transportation of Diesel to the site exposes the fuel to water contamination which can damage the engine. • Diesel engines require clean and moisture free fuel to operate reliably.	✓ LPG has virtually unlimited shelf life which leads to greater engine reliability. ✓ During emergencies LPG may be more Obtainable. ✓ Using Vapor feed contaminants remain in the tank.
ENGINE NOISE	• Due to compression ignition, Diesel engines produce much higher noise (knock) thereby requiring a noise attenuation system. Noise is a concern when systems are installed close to population centers.	✓ Low operating noise of LPG engine allows for deployment of engines in close proximity to population centers and indoor facilities.
FUEL THEFT	• Diesel theft is a key factor increasing operating costs by 10% to 25%. In addition, the practice of diluting diesel fuel as a means of pilferage leads to premature engine failure.	✓ LPG is more difficult to steal; making it the ideal fuel for telecom applications.
LIFE CYCLE COSTING	• Diesel engines are subject to damage (wet stacking) if run with light loads. • Quality Diesel engines will have a service life of 14,000 to 30,000 hours.	✓ The service life of a “quality” LPG engine is 60,000 to 90,000 hours. ✓ Due to environmental benefits, most nations provide subsidies to use of LPG thereby reducing operating costs.



POLAR's PERMANENT MAGNET ALTERNATOR

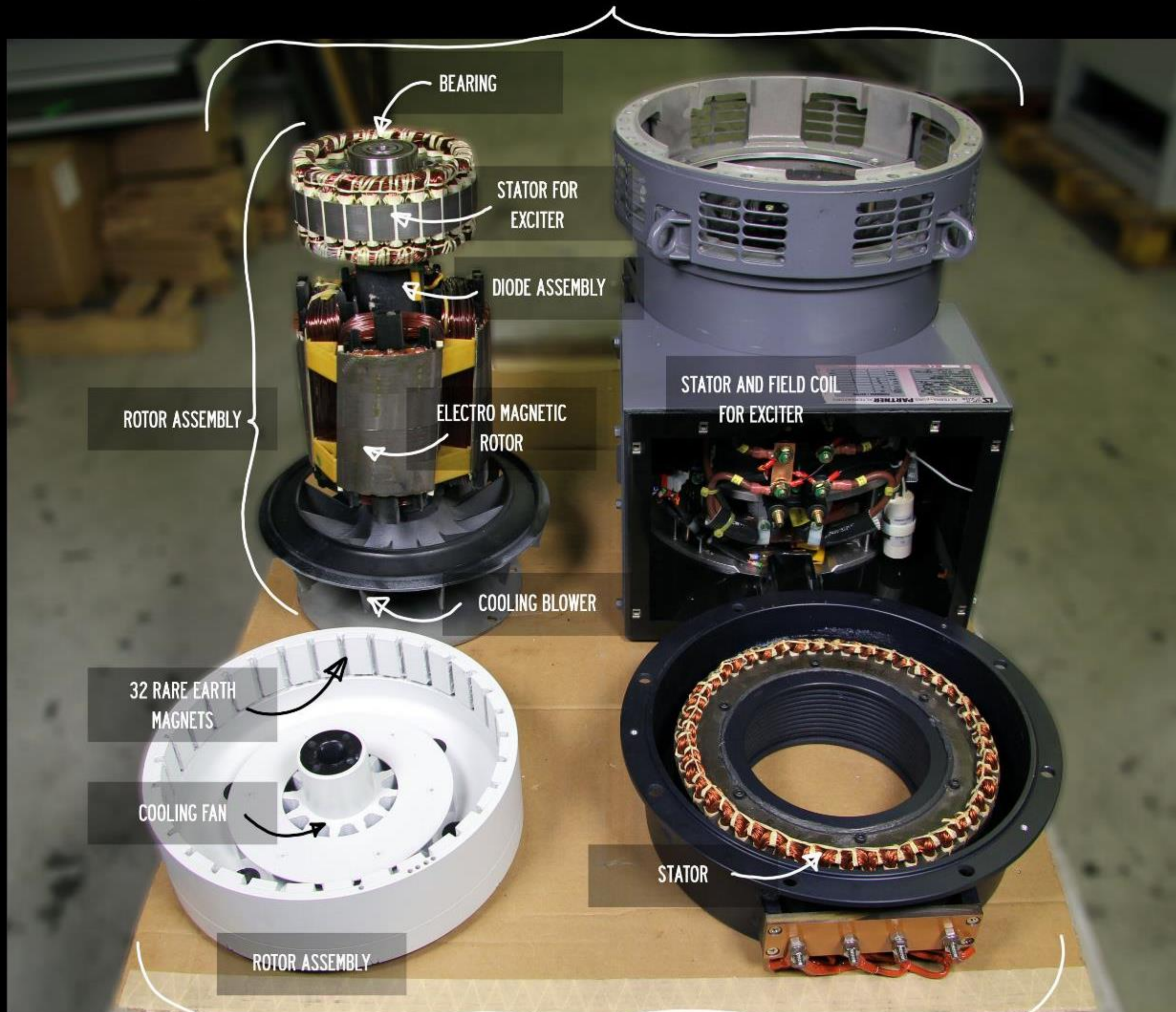
SIMPLICITY = RELIABILITY

Leroy Sommer
AC Model 42.2
20 kVA/16kW
246 LBS
18 IN



Polar's DC
Model 8220
22 kW
49 LBS
5.5 IN

AC 50/60 HZ ALTERNATOR ALSO REWOUND FOR DC APPLICATIONS



POLAR POWER PM ALTERNATOR

POLAR DC ALTERNATOR

NO MAINTENANCE, HIGH RELIABILITY

- NO BEARINGS
- NO EXCITERS
- NO ROTATING DIODES, ELECTRICAL COMPONENTS, WIRE AND LAMINATIONS

LONG LIFE WITH NO PARTS TO WEAR

- 100,000+ HOURS

VERY COMPACT

- REDUCES FOOTPRINT OF GENERATOR

MAGNETS INCREASE EFFICIENTCY

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

LIGHT WEIGHT

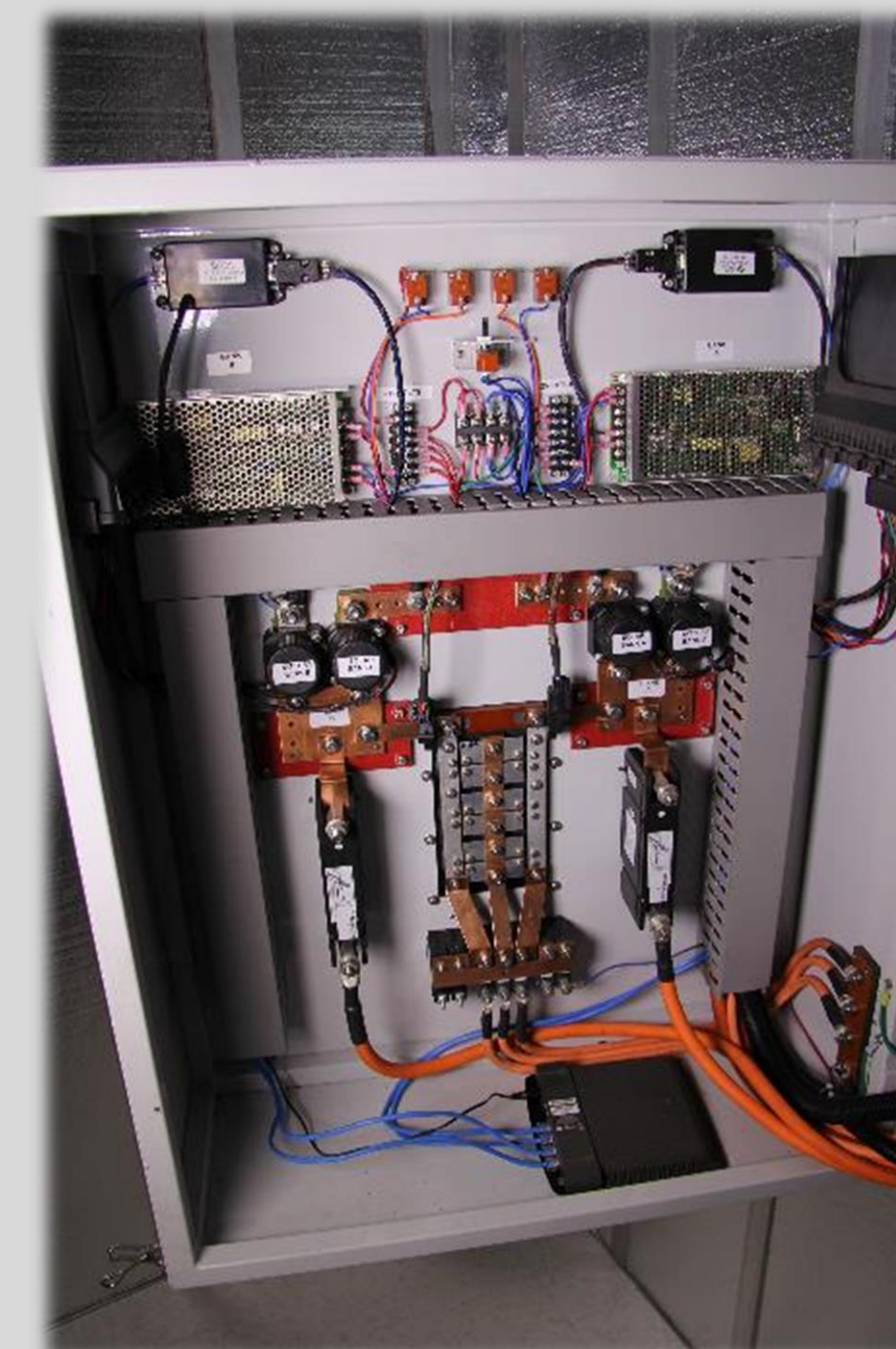
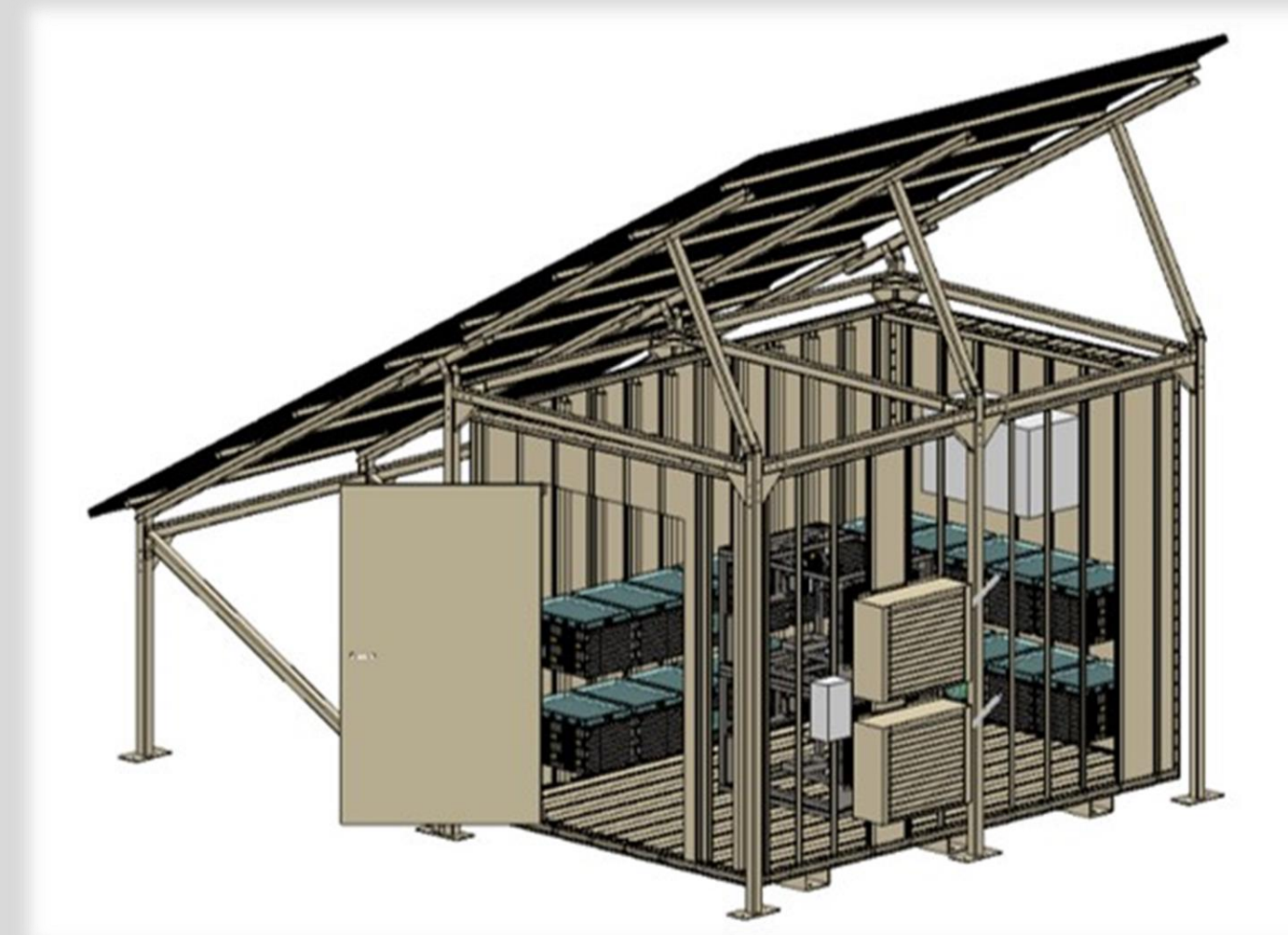
- REDUCES COST TO REPLACE GENERATOR ON SITE
- LESS REINFORCING OF ROOF INSTALLATIONS
- VERY EASY TO SERVICE GENERATOR SET

Polar 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, or generator does not cause the site to go off air: **The other plane assumes the load.**



OIL AND DIESEL REFINING PACK

This is a bypass filter that processes a partial flow of oil to remove particles in the sub-micron level. This filter is also effective in removing moisture that the oil absorbs from the combustion process and marine air. This option can extend the standard oil sump maintenance interval from 200 hours to 400 hours using synthetic lubricants.

Oil Refining:

- Extend the engines service life
- Extends the oil change interval
- Reduces the operational cost of the generator engine

Diesel Fuel refining:

- Significant improvement on generator reliability
- Reduces generator set failure due to water in fuel
- Improves fuel injector service life and reliability





Thank You

Public Corp trading under Nasdaq: POLA

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