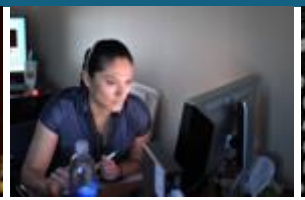
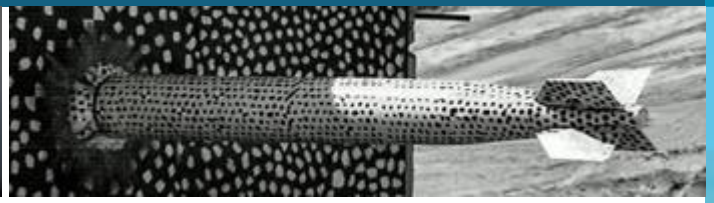
Diesel Generator


Sandia National Laboratories *May 27, 2020*

Benjamin Schenkman

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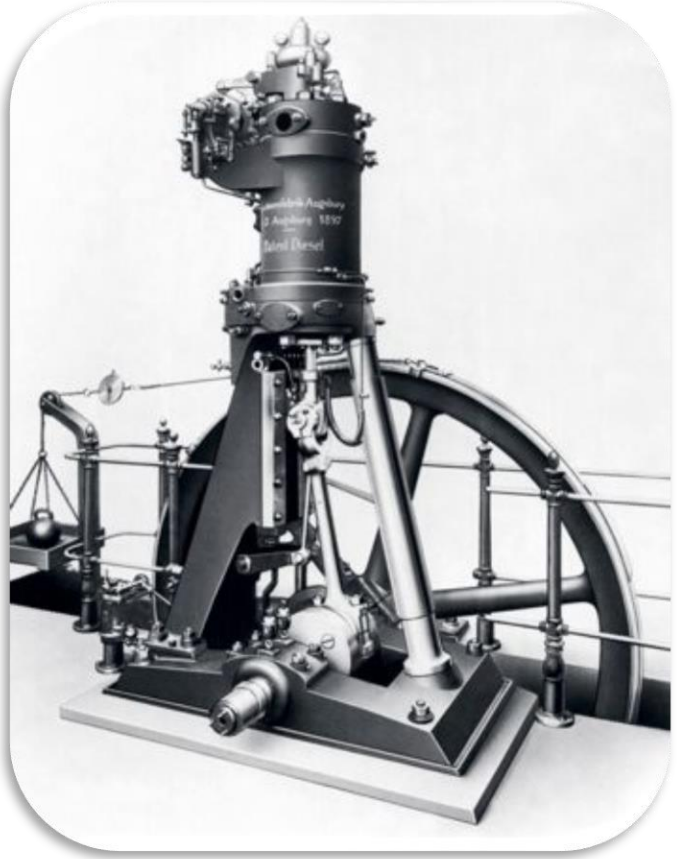
Overview

1. What is a diesel generator
2. Diesel vs gasoline
3. Diesel generators and the grid
4. Diesel generator Maintenance
5. Enhancements in diesel generators
6. Hybrid diesel generator

What is a diesel generator

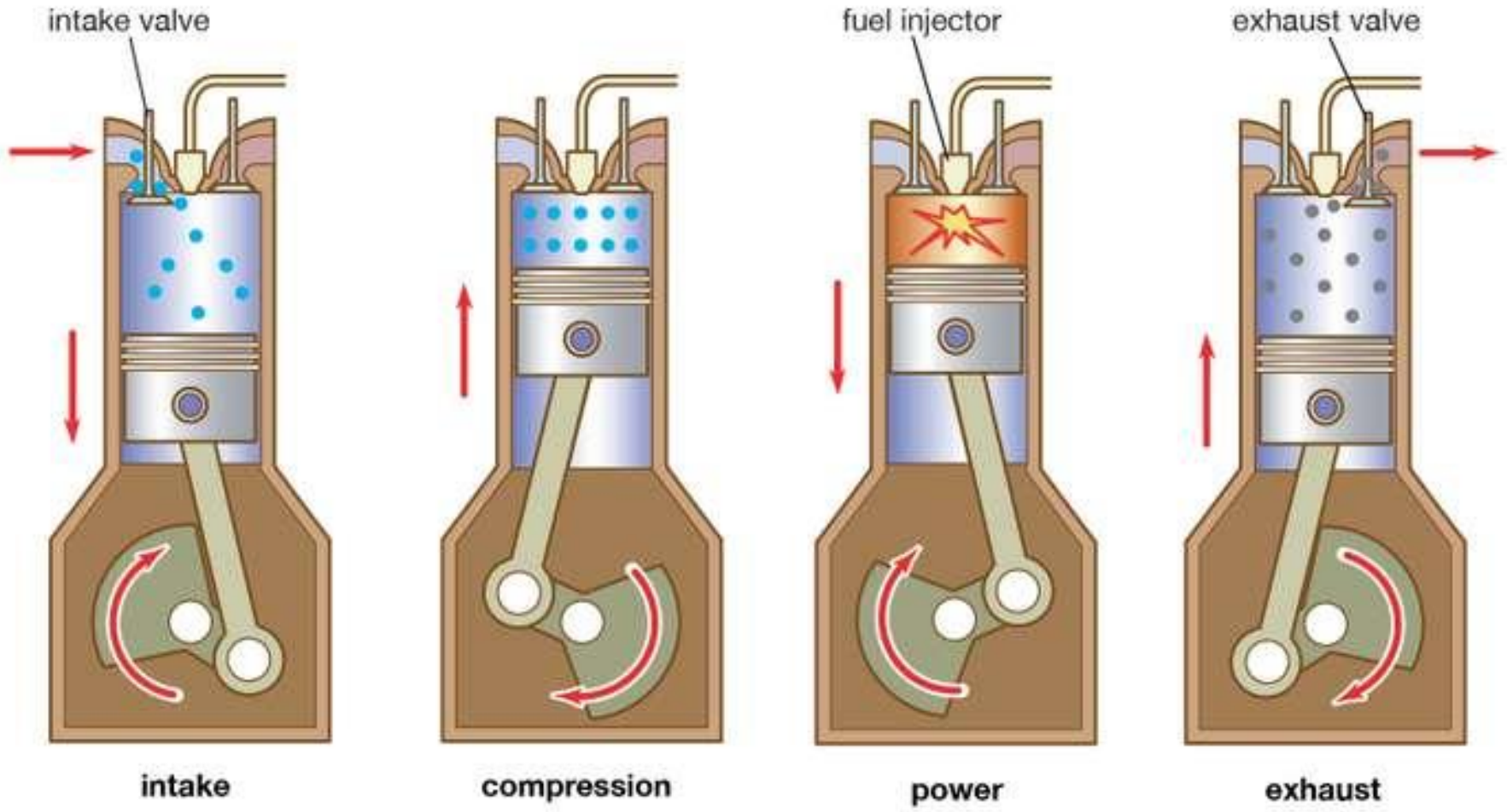
Diesel generator history

- The first electromagnetic power dynamo was built by Michael Faraday in 1831 which produced a small DC voltage. “Faraday Disk”
- In 1882, a British electrician, J. E. H Gordon built a large two-phase alternating current generator
- Diesel engine was developed by Rudolf Diesel in the 1890’s
- February 17, 1897 was the first successful test at 26.2% efficiency (steam engine was 6% and gasoline was 12%)
- 70,000 working diesel engines by the end of 1912



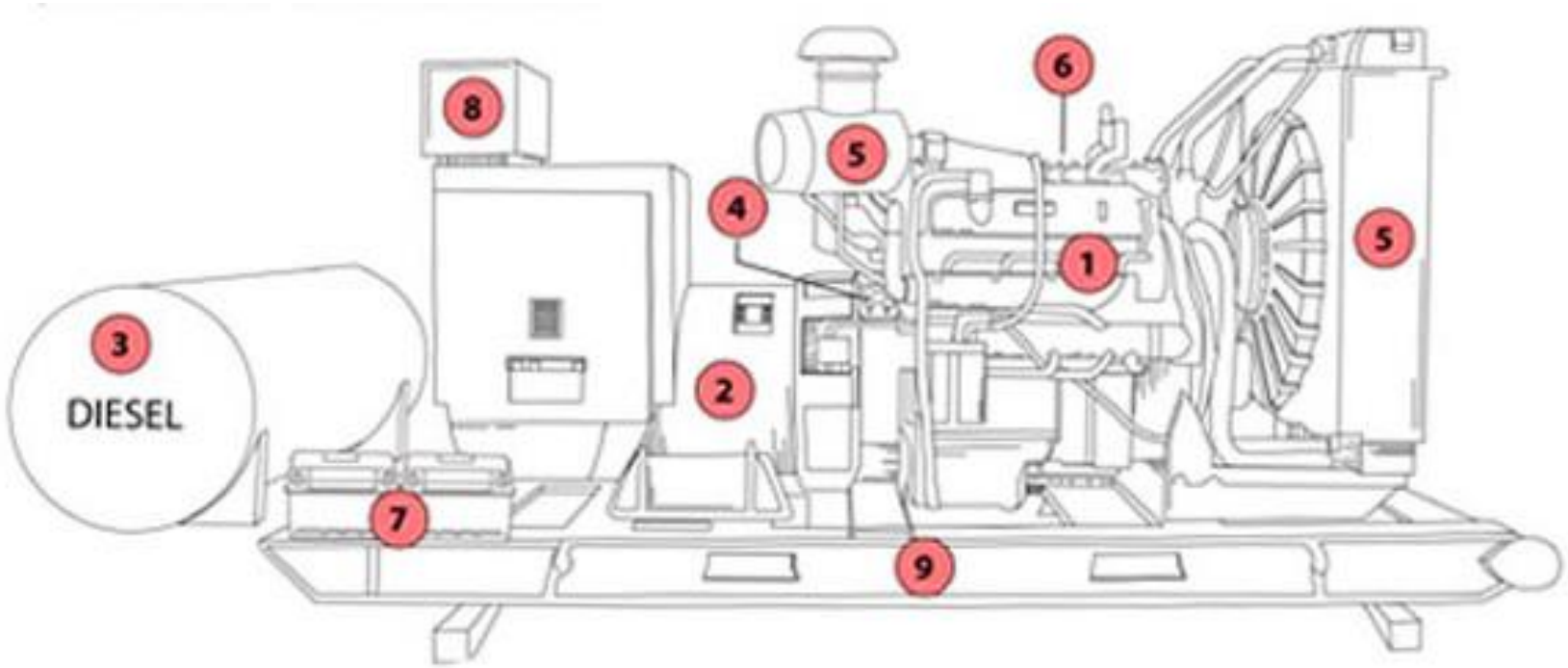
1 cylinder, four-stroke, water-cooled, air injection of fuel
Output: 14.7 kW (20 hp)
Fuel consumption: 317 g/kWh (238 g/hp-hr)
Efficiency: 26.2%
Number of revolutions: 172 min-1
Displacement volume: 19.6 L
Bore: 250 mm
Stroke: 400 mm

Basics of diesel engine operation



https://www.britannica.com/technology/diesel-engine

Diesel genset parts



1. Engine
2. Alternator
3. Fuel System
4. Voltage Regulator
5. Cooling & Exhaust Systems
6. Lubrication System
7. Battery Charger
8. Control Panel
9. Main Assembley Frame

https://dieselgeneratordirect.uk/how-does-a-diesel-generator-work.html

Diesel vs gasoline

Diesel vs. gas engine

ADVANTAGE of Diesel

- Evaporates slower than gasoline -- its boiling point is actually higher than the boiling point of water.
- Less refining to create diesel fuel, which is why it use to be cheaper than gasoline
- Higher energy density than gasoline. (30% more)
- Less frequency in maintenance
- Less hazardous to start a fire

ADVANTAGE of Gasoline

- Lighter and more compact
- Fuel does not “gel” in cold temperatures as diesel does
- Lower maintenance cost
- Faster response to load changes

Diesel vs natural gas generator

Diesel vs. natural gas generator

ADVANTAGE of Diesel

- Lower installed cost ($856/kW vs $920/kW)[1]
- Longer lifespan
- Less hazardous to start a fire
- No spark plugs or wires reducing frequency of maintenance and operating cost
- On-site fuel supply since natural gas is typically piped in

ADVANTAGE of Natural Gas

- Fuel does not "gel" in cold temperatures
- Quieter when in operation
- Combined Cooling, Heating and Power is typically paired with natural gas generators
- Cost of fuel is typically cheaper when available
- Emissions of sulfur, nitrogen and carbon dioxide are considerably low

[1] https://www.eia.gov/electricity/generatorcosts/

Diesel vs propane generator

Diesel vs. propane generator

ADVANTAGE of Diesel

- Longer lifespan
- Less hazardous to start a fire
- No spark plugs or wires reducing frequency of maintenance and operating cost (up to 3x)
- Fuel is typically cheaper
- Lower capital costs in generators 30kW or greater

ADVANTAGE of Propane

- Long fuel shelf life
- Quieter when in operation
- No “wet stacking” issues
- Emissions of sulfur, nitrogen and carbon dioxide are considerably low
- Better suited for small generators such as homes and small loads

Diesel generators and the grid

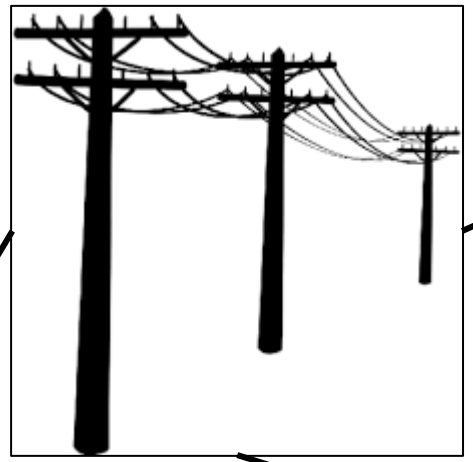
Generator ratings

- Prime Power
  - Application: Isolated grid which diesel generator is used to provide power to variable loads
  - Maximum power accessible at the variable load for an unlimited number of hours per year
  - Recommended that variable load does not exceed 70% average of the prime power rating during any operational period of 250 hours
  - If running at 100% prime power, yearly hours should not exceed 500
  - 10% overload capability for a 1 hour period within a 12 hour cycle of operation
- Continuous Power
  - Application: Constant loads not attached to a utility (i.e. mining, agriculture, military, etc.)
  - Provides power at 100% constant load for unlimited number of hours each year
- Standby/back-up Power
  - Application: Loads that require standby or backup power such as hospitals
  - Most commonly rated generator sets
  - Supply back-up or emergency power for a limited duration during a power outage
  - No overload capability built into the units
  - Typically do not run in conjunction with a public utility source
  - Sized for a maximum of 80% average load factor and roughly 200 hours per year

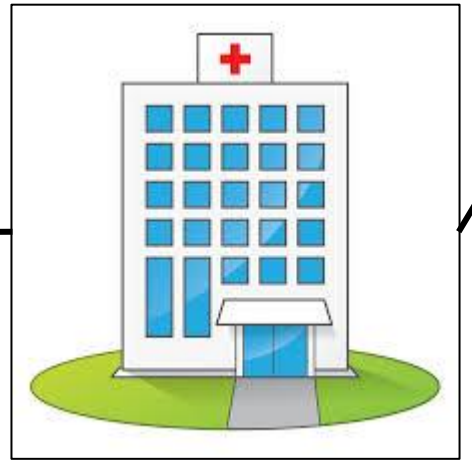
Diesel generator grid locations

Off Grid Military Base

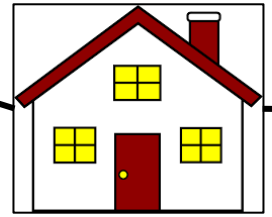
Diesel Power Plant (Main Source or Microgrid)



Industrial Diesel Back-up



Home Diesel Back-up



Diesel generator maintenance

Maintenance schedule

- Maintenance schedule varies by manufacturer on a daily, weekly, monthly and annually basis
- Typical Maintenance ($0.02/kWh)
  - Lubrication
    - Oil and filter change
  - Cooling
    - Cooling fluid level
  - Fuel System
    - Fuel filter change and fuel polishing
  - Testing Battery
    - Voltage, terminal cleaning, specific gravity, electrolyte level
  - Routine Engine Exercise
    - Test under load (>33%) every 30 days or monthly
  - Cleaning
    - Visual cleaning
  - Exhaust System
    - Inspect gasket and seals for leaks

TABLE 5-1. MAINTENANCE SCHEDULE

MAINTENANCE ITEMS	SERVICE TIME						
	See Engine Schdl.	Daily or after 8 Hours	Weekly or after 50 Hours	Monthly or after 100 Hours	6 Months or after 250 Hours	Yearly or after 500 Hours	4000 – 45000 Hours
General Genset Inspection	X[1]	X[2]					
Check Coolant Heater		X					
Check Oil Level		X					
Check Coolant Level		X					
Check Fuel Level		X					
Check Charge Air Piping		X					
Check Air Cleaner (Clean if required)			X[3]				
Check Battery Charging System			X				
Drain Water and Sediment from Fuel Tank			X[5]				
Drain Exhaust Condensate Trap				X			
Check Starting Batteries				X			
Change Air Cleaner Element					X[3]		
Check Radiator Hoses for Wear & Cracks					X		
Test Generator Insulation Resistance						X[7]	
Grease generator bearing (P7)							X
Drain Fuel Filter(s)	X[1]						
Check Anti-freeze and DCA Concentration	X[1]						
Change Crankcase Oil and Filter	X[1, 6]						
Check Drive Belt Tension	X[1]						
Change Coolant Filter	X[1]						
Clean Crankcase Breather	X[1]						
Change Fuel Filters	X[1]						
Clean Cooling System	X[1]						
Test Rupture Basin Leak Detect Switch						X[8]	

https://na.eventscloud.com/file_uploads/404b1c4a2df40a9a2f6a4c51da33d56b_PlannedMaintenanacePres.31311-Copy.pdf

Load Bank Testing

Standby generator load bank test

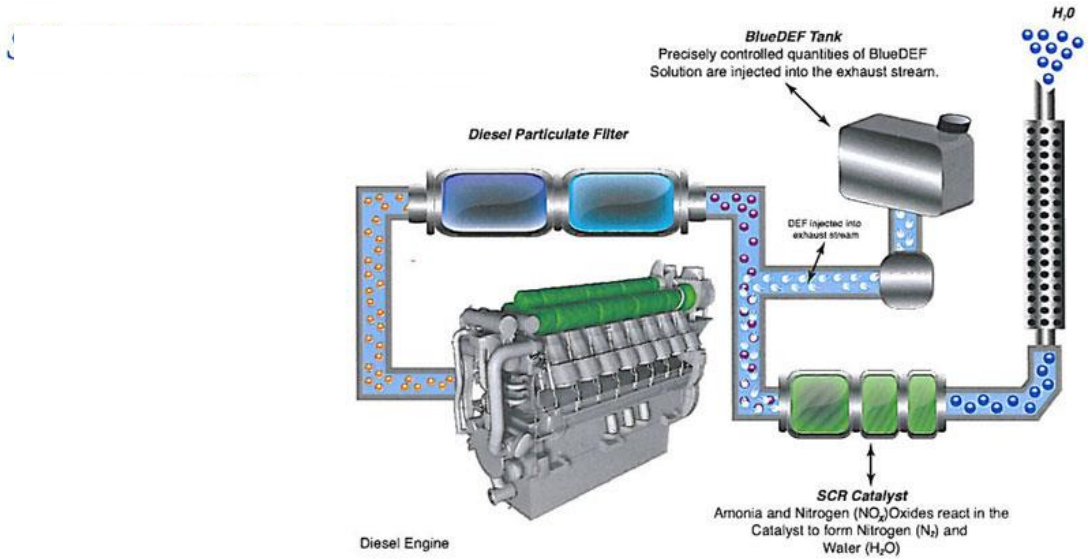
- Detects potential deficiencies in system which may appear in extended operation.
- Insures full rated output capacity.
- Removed potentially damaging deposits commonly referred to as “wet stacking” in the combustion chamber and exhaust system which may have accumulated under lightly loaded operation.
- Re-seat piston rings in the cylinder walls or liners.
- May be required annually by local code or regulations

https://na.eventscloud.com/file_uploads/404b1c4a2df40a9a2f6a4c51da33d56b_PlannedMaintenanacePres.31311-Copy.pdf

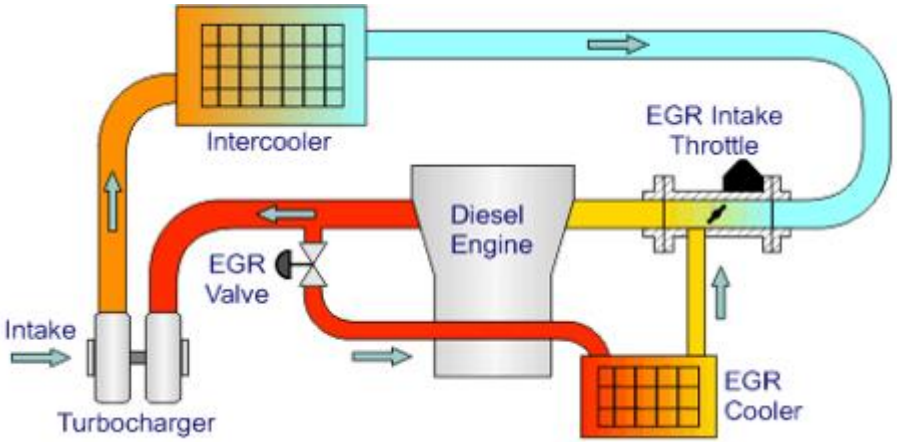
Enhancements in diesel generators

Enhancements

- **GOAL** – Improve Fuel Efficiency and Decrease Emissions
  - Better fuel injection transfer from tank to valves
  - Removing sulfur from the fuel that clog up and reduce performance
  - Analog to digital controls allowing for better optimization and operation of generator operation
  - Exhaust Gas Recirculation (EGR) and Selective Catalytic Reduction (SCR) reducing emissions



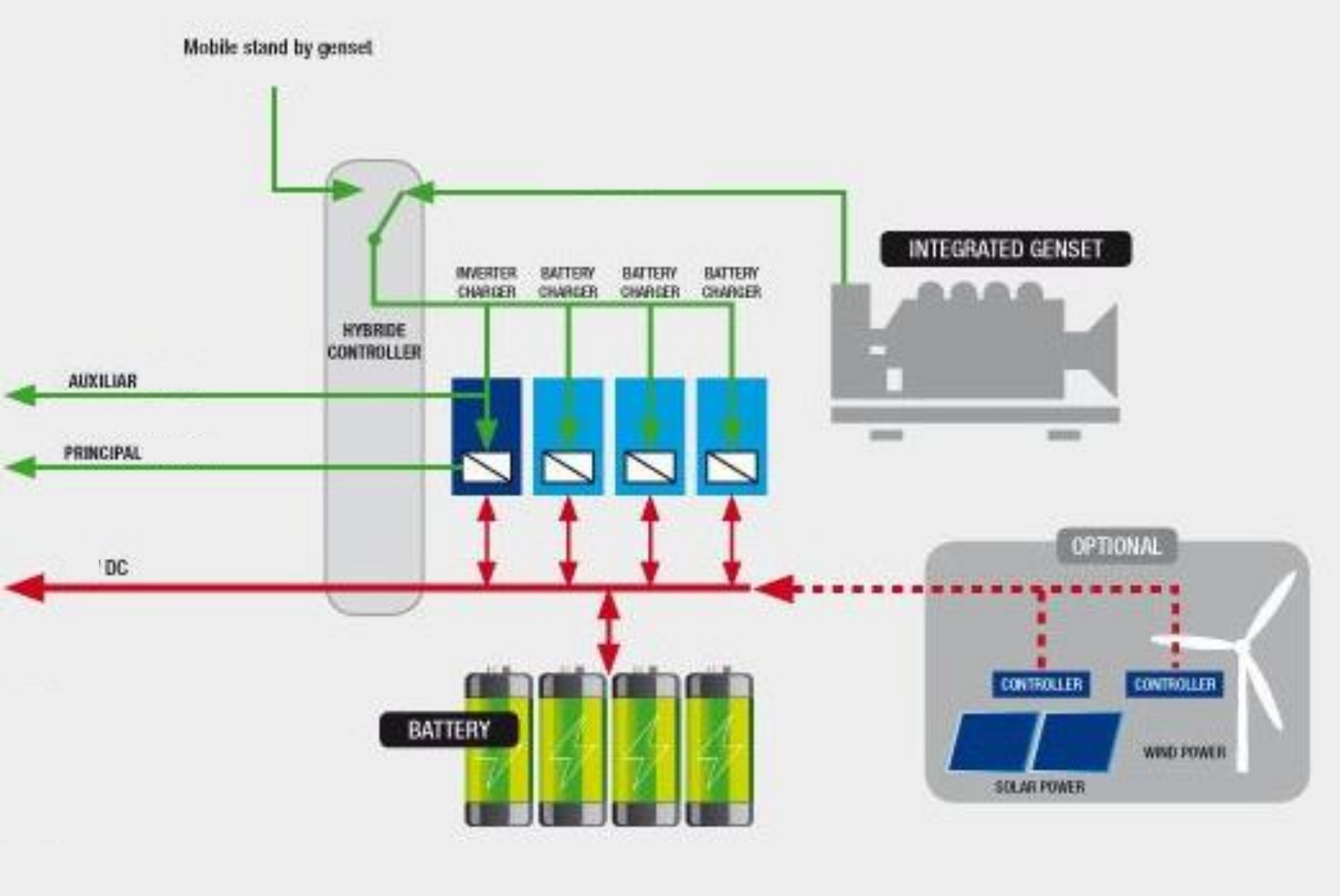
Selective Catalytic Reduction



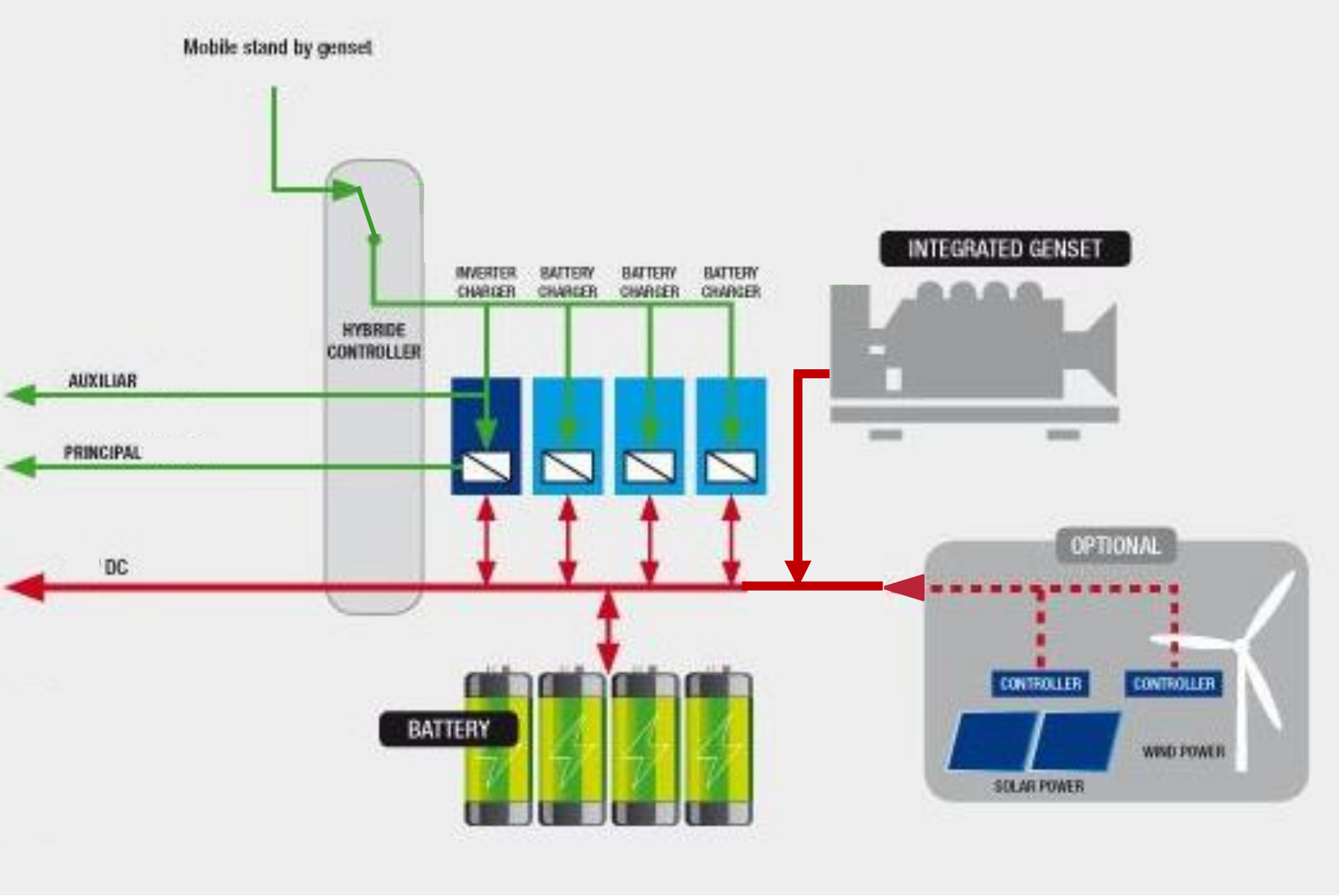
Exhaust Gas Recirculation

Hybrid diesel generator

AC diesel generator and energy storage



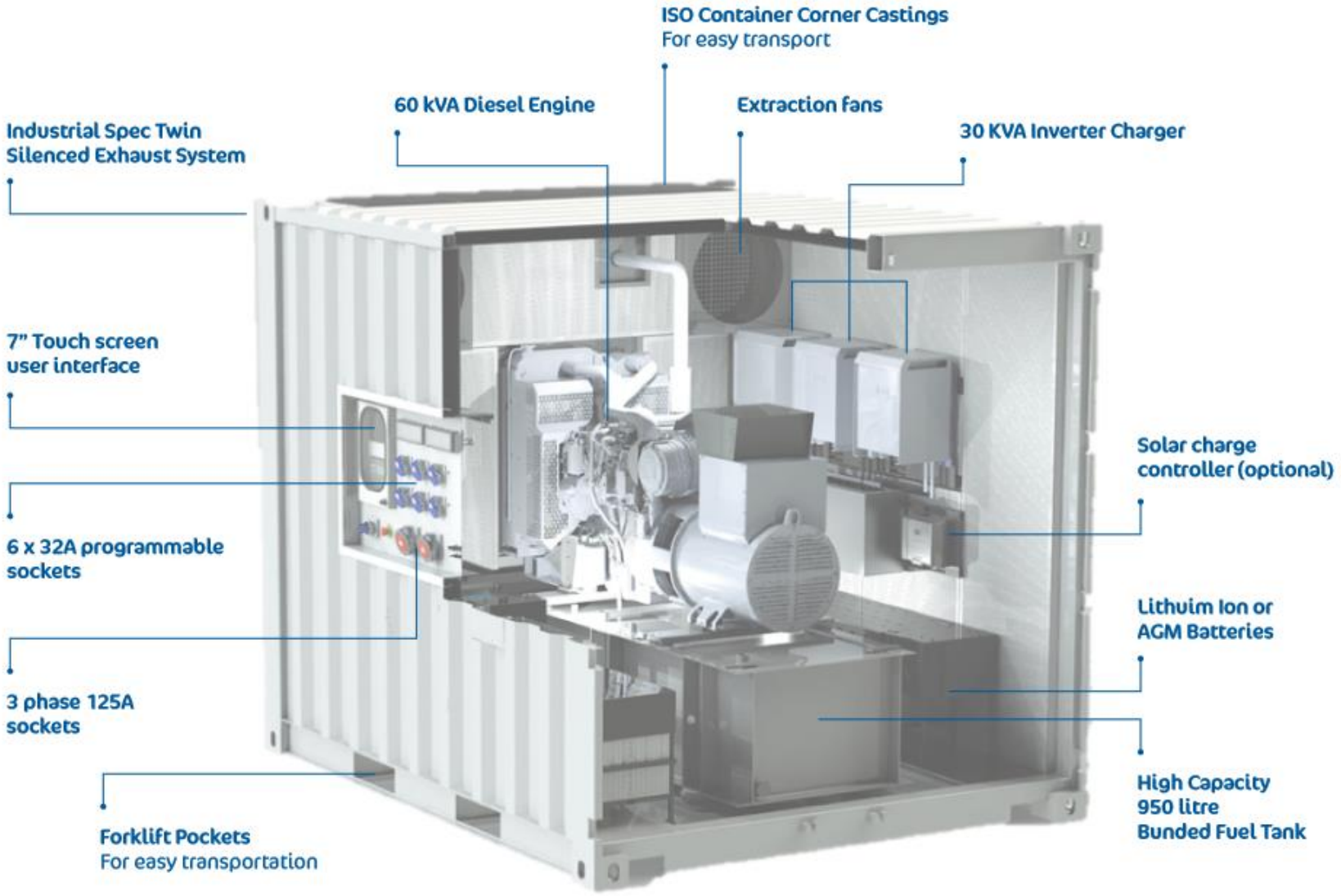
DC diesel generator and energy storage



Benefits

Monthly Savings

- **Runtime** – 60%
- **Diesel Fuel** – 528 gallons
- **CO^2** – 5.5
- **N_2O** – 74kg
- **Noise Pollution**



https://www.fireflyhybridpower.com/wp-content/uploads/2019/07/Firefly-Powerplus-Brochure-Q3-2019.pdf

THANK YOU

Questions

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