

Diesel generator

From Wikipedia, the free encyclopedia

A **diesel generator** is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas.

Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-opping, grid support and export to the power grid.

Sizing of diesel generators is critical to avoid low-load or a shortage of power and is complicated by modern electronics, specifically non-linear loads. In size ranges around 50 MW and above, an open cycle gas turbine is more efficient at full load than an array of diesel engines, and far more compact, with comparable capital costs; but for regular part-loading, even at these power levels, diesel arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies.

Contents

- 1 Diesel generator set
- 2 Generator size
- 3 Power plants – electrical "island" mode
- 4 Supporting main utility grids
 - 4.1 Grid support
- 5 Cost of generating electricity



A Cummins diesel generator of 150kVA temporarily parked in a tourist resort in Egypt.



A 200 kW Caterpillar diesel generator set in a sound attenuated enclosure used as emergency backup at a sewage treatment substation in Atlanta, United States.

- 5.1 Typical operating costs
- 6 Generator sizing and rating
 - 6.1 Rating
 - 6.2 Sizing
- 7 Installation
- 8 Engine damage
- 9 Fuels
- 10 See also
- 11 References

Diesel generator set

The packaged combination of a diesel engine, a generator and various ancillary devices (such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and starting system) is referred to as a "generating set" or a "genset" for short.

Set sizes range from 8 to 30 kW (also 8 to 30 kVA single phase) for homes, small shops and offices with the larger industrial generators from 8 kW (11 kVA) up to 2,000 kW (2,500 kVA three phase) used for large office complexes, factories. A 2,000 kW set can be housed in a 40 ft (12 m) ISO container with fuel tank, controls, power distribution equipment and all other equipment needed to operate as a standalone power station or as a standby backup to grid power. These units, referred to as power modules are gensets on large triple axle trailers weighing 85,000 pounds (38,555 kg) or more. A combination of these modules are used for small power stations and these may use from one to 20 units per power section and these sections can be combined to involve hundreds of power modules. In these larger sizes the power module (engine and generator) are brought to site on trailers separately and are connected together with large cables and a control cable to form a complete synchronized power plant. A number of options also exist to tailor specific needs, including control panels for autostart and mains paralleling, acoustic canopies for fixed or mobile applications, ventilation equipment, fuel supply systems, exhaust systems, etc.^[1] Diesel generators,



Diesel generator on an oil tanker.

sometimes as small as 200 kW (250 kVA) are widely used not only for emergency power, but also many have a secondary function of feeding power to utility grids either during peak periods, or periods when there is a shortage of large power generators.

Ships often also employ diesel generators, sometimes not only to provide auxiliary power for lights, fans, winches etc., but also indirectly for main propulsion. With electric propulsion the generators can be placed in a convenient position, to allow more cargo to be carried. Electric drives for ships were developed prior to World War I. Electric drives were specified in many warships built during World War II because manufacturing capacity for large reduction gears was in short supply, compared to capacity for manufacture of electrical equipment.^[2] Such a diesel-electric arrangement is also used in some very large land vehicles such as railroad locomotives.

Generator size

Generating sets are selected based on the electrical load they are intended to supply, the electrical load's characteristics such as kW, kVA, var, harmonic content, surge currents (e.g., motor starting current) and non-linear loads. The expected duty (such as emergency, prime or continuous power) as well as environmental conditions (such as altitude, temperature and exhaust emissions regulations) must also be considered.

Most of the larger generator set manufacturers offer software that will perform the complicated sizing calculations by simply inputting site conditions and connected electrical load characteristics.

Power plants – electrical "island" mode

One or more diesel generators operating without a connection to an electrical grid are referred to as operating in island mode. Operating generators in parallel provides the advantage of redundancy, and can provide better efficiency at partial loads. The plant brings generator sets online and takes them off line depending on the demands of the system at a given time. An islanded power plant intended for primary power

source of an isolated community will often have at least three diesel generators, any two of which are rated to carry the required load. Groups of up to 20 are not uncommon.

Generators can be electrically connected together through the process of synchronization. Synchronization involves matching voltage, frequency and phase before connecting the generator to the system. Failure to synchronize before connection could cause a high short circuit current or wear and tear on the generator or its switchgear. The synchronization process can be done automatically by an auto-synchronizer module, or manually by the instructed operator. The auto-synchronizer will read the voltage, frequency and phase parameters from the generator and busbar voltages, while regulating the speed through the engine governor or ECM (Engine Control Module).

Load can be shared among parallel running generators through load sharing. Load sharing can be achieved by using droop speed control controlled by the frequency at the generator, while it constantly adjusts the engine fuel control to shift load to and from the remaining power sources. A diesel generator will take more load when the fuel supply to its combustion system is increased, while load is released if fuel supply is decreased.

Supporting main utility grids

In addition to their well known role as power supplies during power failures, diesel generator sets also routinely support main power grids worldwide in two distinct ways:

Grid support

Emergency standby diesel generators, for example such as those used in hospitals, water plant, are, as a secondary function, widely used in the US and, in the recent past, in Great Britain to support the respective national grids at times for a variety of reasons. In the UK the tenders known as the Short Term Operating Reserve have exhibited quite variable prices, and from 2012 the volume of demand-side participation, which mainly entails the use of on-site diesels, has dropped as the tendered prices fell. Some 0.5 GWe of diesels have at times been used to support the National Grid, whose peak load is about 60 GW. These are sets in the size range

200 kW to 2 MW. This usually occurs during, for example, the sudden loss of a large conventional 660 MW plant, or a sudden unexpected rise in power demand eroding the normal spinning reserve available.^[3]

This is beneficial for both parties - the diesels have already been purchased for other reasons; but to be reliable need to be fully load tested. Grid paralleling is a convenient way of doing this. This method of operation is normally undertaken by a third party aggregator who manages the operation of the generators and the interaction with the system operator.

These diesels can in some cases be up and running in parallel as quickly as two minutes, with no impact on the site (the office or factory need not shut down). This is far quicker than a base load power station which can take 12 hours from cold, and faster than a gas turbine, which can take several minutes. Whilst diesels are very expensive in fuel terms, they are only used a few hundred hours per year in this duty, and their availability can prevent the need for base load station running inefficiently at part load continuously. The diesel fuel used is fuel that would have been used in testing anyway.^{[4][5]}

In Great Britain, National Grid can generally rely upon about 2 GW of customer demand reduction via back-up diesels being self-despatched for about 10 to 40 hours a year at times of expected peak national demand. National Grid does not control these diesels - they are run by the customer to avoid "triad" transmission network use of system (TNUoS) charges which are levied only on consumption of each site, at the three half-hours of peak national demand. It is not known in advance when the three half-hours of peak national demand (the "triad" periods) will be, so the customer must run his diesels for a good deal more half-hours a year than just three.

The total capacity of reliably operable standby generation in Britain is estimated to be around 20 GW, nearly all of which is driven by diesel engines. This is equivalent to nearly 29% of the British system peak, although only a very small fraction will ever be generating at the same time. Most plant is for large offices blocks, hospitals, supermarkets, and various installations where continuous power is important such as airports. Therefore, most is in urban areas, particularly city and commercial centres. It is estimated that around 10% of plant exceeds 1 MW, about 50% is in the 200 kW-1 MW range, and the remaining 40% is sub-200 kW. Although it is growing, only a very small proportion is believed to be used regularly for peak

opping, the vast majority just being only for standby generation. The information in this paragraph is sourced from section 6.9 of the government report : "Overcoming Barriers To Scheduling Embedded Generation To Support Distribution Networks"^[6]

A similar system to Great Britain's Short Term Operating Reserve operates in France. It is known as EJP; at times of grid stress, special tariffs can mobilize at least 5 GW of diesel generating sets to become available. In this case, the diesels prime function is to feed power into the grid.^[7]

During normal operation in synchronization with the electricity net, powerplants are governed with a five percent droop speed control. This means the full load speed is 100% and the no load speed is 105%. This is required for the stable operation of the net without hunting and dropouts of power plants. Normally the changes in speed are minor. Adjustments in power output are made by slowly raising the droop curve by increasing the spring pressure on a centrifugal governor. Generally this is a basic system requirement for all powerplants because the older and newer plants have to be compatible in response to the instantaneous changes in frequency without depending on outside communication.^[8]

Cost of generating electricity

Typical operating costs

Fuel consumption is the major portion of diesel plant owning and operating cost for power applications, whereas capital cost is the primary concern for backup generators. Specific consumption varies, but a modern diesel plant will at its near-optimal 65-70% loading, generate 3 kWh per litre.^{[9][10]}

Generator sizing and rating

Rating

Generators must provide the anticipated power required reliably and without damage and this is achieved by the manufacturer giving one or more ratings to a specific generator set model. A specific model of a generator operated as a standby generator may only need to operate for a few hours per year, but the same model

operated as a prime power generator must operate continuously. When running, the standby generator may be operated with a specified - e.g. 10% overload that can be tolerated for the expected short running time. The same model generator will carry a higher rating for standby service than it will for continuous duty. Manufacturers give each set a *rating* based on internationally agreed definitions.

These standard rating definitions are designed to allow correct machine selection and valid comparisons between manufacturers to prevent them from misstating the performance of their machines, and to guide designers.

Generator Rating Definitions

Standby Rating based on Applicable for supplying emergency power for the duration of normal power interruption. No sustained overload capability is available for this rating. (Equivalent to Fuel Stop Power in accordance with ISO3046, AS2789, DIN6271 and BS5514). Nominally rated.

Typical application - emergency power plant in hospitals, offices, factories etc. Not connected to grid.

Prime (Unlimited Running Time) Rating: Should not be used for Construction Power applications. Output available with varying load for an unlimited time. Typical peak demand 100% of prime-rated kW with 10% of overload capability for emergency use for a maximum of 1 hour in 12. A 10% overload capability is available for limited time. (Equivalent to Prime Power in accordance with ISO8528 and Overload Power in accordance with ISO3046, AS2789, DIN6271, and BS5514). This rating is not applicable to all generator set models.

Typical application - where the generator is the sole source of power for say a remote mining or construction site, fairground, festival etc.

Base Load (Continuous) Rating based on: Applicable for supplying power continuously to a constant load up to the full output rating for unlimited hours. No sustained overload capability is available for this rating. Consult authorized distributor for rating. (Equivalent to Continuous Power in accordance with ISO8528, ISO3046, AS2789, DIN6271, and BS5514). This rating is not applicable to all generator set models

Typical application - a generator running a continuous unvarying load, or paralleled with the mains and continuously feeding power at the maximum permissible level 8,760 hours per year. This also applies to sets used for peak shaving /grid support even though this may only occur for say 200 hours per year.

As an example if in a particular set the Standby Rating were 1000 kW, then a Prime Power rating might be 850 kW, and the Continuous Rating 800 kW. However these ratings vary according to manufacturer and should be taken from the manufacturer's data sheet.

Often a set might be given all three ratings stamped on the data plate, but sometimes it may have only a standby rating, or only a prime rating.

Sizing

Typically however it is the size of the maximum load that has to be connected and the acceptable maximum voltage drop which determines the set size, not the ratings themselves. If the set is required to start motors, then the set will have to be at least three times the largest motor, which is normally started first. This means it will be unlikely to operate at anywhere near the ratings of the chosen set.

Many gen-set manufacturers have software programs that enable the correct choice of set for any given load combination. Sizing is based on site conditions and the type of appliances, equipment, and devices that will be powered by the generator set.^{[11][12]}

Installation

Manufacturers provide detailed installation guidelines to ensure correct functioning, reliability and low maintenance costs. There are a range of different styles of generators for camping, RV's standby power, and portable commercial applications. When purchasing a generator online you must ensure that the product comes with installation guidelines and that ts stipulated within the product description.^{[13][14]} Guidelines cover such things as:

- Sizing and selection - typical loads of electrical devices, expected load for the application

- Electrical factors - Peak loads versus steady and allowing for certain appliances
- Cooling - Engine cooling during the power generation process
- Ventilation - Allowing air flow during the cooling process (design)
- Fuel storage - How long will the generator run for at a specific usage rate
- Noise - dB levels to be expected for specific models
- Exhaust - ppm(parts per million) levels of certain element, consider the environment and those around the generator
- Starting systems - key start, pull start, button start - lots of options.

Engine damage

Diesel engines can suffer damage as a result of misapplication or misuse - namely internal glazing (occasionally referred to as bore glazing or piling) and carbon build-up. Ideally, diesel engines should be run at least 60% to 75% of their maximum rated load. Short periods of low load running are permissible providing the set is brought up to full load, or close to full load on a regular basis.

Internal glazing and carbon build-up is due to prolonged periods of running at low speeds or low loads. Such conditions may occur when an engine is left idling as a 'standby' generating unit, ready to run up when needed, (misuse); if the engine powering the set is over-powered (misapplication) for the load applied to it, causing the diesel unit to be under-loaded, or as is very often the case, when sets are started and run off load as a test (misuse).

Running an engine under low loads causes low cylinder pressures and consequent poor piston ring sealing since this relies on the gas pressure to force them against the oil film on the bores to form the seal. Low cylinder pressures causes poor combustion and resultant low combustion pressures and temperatures.

This poor combustion leads to soot formation and unburnt fuel residues which clogs and gums piston rings, causing a further drop in sealing efficiency and exacerbates the initial low pressure. Glazing occurs when hot combustion gases blow past the now poorly-sealing piston rings, causing the lubricating oil on the cylinder walls to 'flash burn', creating an enamel-like glaze which smooths the bore and removes the effect of the intricate pattern of honing marks machined into the bore surface which are there to hold oil and return it to the crankcase via the scraper ring.

Hard carbon also forms from poor combustion and this is highly abrasive and scrapes the honing marks on the bores leading to bore polishing, which then leads to increased oil consumption (blue smoking) and yet further loss of pressure, since the oil film trapped in the honing marks is intended to maintain the piston seal and pressures.

Unburnt fuel then leaks past the piston rings and contaminates the lubricating oil. Poor combustion causes the injectors to become clogged with soot, causing further deterioration in combustion and black smoking.

The problem is increased further with the formation of acids in the engine oil caused by condensed water and combustion by-products which would normally boil off at higher temperatures. This acidic build-up in the lubricating oil causes slow but ultimately damaging wear to bearing surfaces.

This cycle of degradation means that the engine soon becomes irreversibly damaged and may not start at all and will no longer be able to reach full power when required.

Under-loaded running inevitably causes not only white smoke from unburnt fuel but over time will be joined by blue smoke of burnt lubricating oil leaking past the damaged piston rings, and black smoke caused by damaged injectors. This pollution is unacceptable to the authorities and neighbors.

Once glazing or carbon build up has occurred, it can only be cured by stripping down the engine and re-boring the cylinder bores, machining new honing marks and stripping, cleaning and de-coking combustion chambers, fuel injector nozzles and valves. If detected in the early stages, running an engine at maximum load to raise the internal pressures and temperatures allows the piston rings to scrape glaze off the bores and allows carbon build-up to be burnt off. However, if glazing has progressed to the stage where the piston rings have seized into their grooves, this will not have any effect.

The situation can be prevented by carefully selecting the generator set in accordance with manufacturers printed guidelines. (the use off additional depth oil and fuel By Pass filtration, down to <3 micron level can prevent buildup of the particulate or carbon build that contributes to the varnishing.)

For emergency only sets, it may be impractical to use the supported load for testing. A temporary or permanent load bank can be used testing. Sometimes the switchgear can be designed to allow the set to feed power into the grid for load testing.^{[15][16][17]}

Fuels

Diesel fuel is named after diesel engines, and not vice versa; diesel engines are simply compression-ignition engines, and can operate on a variety of different fuels, depending on configuration and location. Where a gas grid connection is available, gas is often used, as the gas grid will always remain pressurised even during almost all power cuts; in more rural situations, or for low load factor plant, diesel fuel derived from crude oil is a common fuel; it is less likely to freeze than heavier oils. Endurance will be limited by tank size. Diesel engines can work with the full spectrum of crude oil distillates, from natural gas, alcohols, gasoline, wood gas to the *fuel oils* from diesel oil to cheaper residual fuels that are like lard at room temperature, and must be heated to enable them to flow down a fuel line.^[18] This is implemented by introducing gas with the intake air and using a small amount of diesel fuel for ignition. Conversion to 100% diesel fuel operation can be achieved instantaneously.^[19]

Larger engines (from about 3 MWe to 30 MWe) sometimes use heavy oils, essentially tars, derived from the end of the refining process. The slight added complexity of keeping the fuel oil heated to enable it to flow, whilst mitigating the fire risks that come from over-heating fuel, make these fuels unpopular for smaller, often unmanned, generating stations.

Other possible fuels include: biodiesel, straight vegetable oil, animal fats and tallows, glycerine, and coal water slurry.

See also

- Calculating the cost of the UK Transmission network: cost per kWh of transmission
- Calculating the cost of back up: See spark spread
- Energy use and conservation in the United Kingdom
- Engine-generator
- Load management
- Motor–generator

- Single-phase generator
- Standby generator
- Three-phase electric power
- Wet stacking

References

1. "Multiple options for diesel gensets exist to tailor specific needs". E. VAN WINGEN.
2. [1] (<http://www2.sea.siemens.com/Industry%20Solutions/Marine>) Archived (<https://web.archive.org/web/20081107052610/http://www2.sea.siemens.com/Industry%20Solutions/Marine>) November 7, 2008, at the Wayback Machine.
3. "Commercial Opportunities for Back-Up Generation and Load Reduction via National Grid, the National Electricity Transmission System Operator (NETSO) for England, Scotland, Wales and Offshore". Claverton-energy.com. 2009-12-22. Retrieved 2012-07-13.
4. <https://web.archive.org/web/20100217164416/http://www.claverton-energy.com/download/131/>. Archived from the original on February 17, 2010. Retrieved February 8, 2016. Missing or empty |title= (help)
5. Andrews, David (June 2007). "Emergency diesel standby generators of Wessex Water potential contribution to dealing with renewable energy sources intermittency & variability". **11** (3). The Institution of Diesel and Gas Turbine Engineers.
6. "Overcoming Barriers To Scheduling Embedded Generation To Support Distribution Networks" (PDF). BERR. Retrieved 2014-07-15.
7. [2] (http://www.claverton-energy.com/?dl_id=131) Archived (https://web.archive.org/web/20100107144324/http://www.claverton-energy.com/?dl_id=131) January 7, 2010, at the Wayback Machine.
8. Speed Droop and Power Generation. Application Note 01302. 2. Woodward. Speed
9. "Cummins Power Generation : Model DGDB" (PDF). Cumminspower.com. Retrieved 2013-10-28.
10. "Approximate Diesel Generator Fuel Consumption Chart". Dieselserviceandsupply.com. Retrieved 2012-07-13.
11. "Diesel Generators - Kubota, Honda, Kohler, Mitsubishi, Daewoo, John Deere, Volvo, Volkswagen, SDMO, VM". Allworlddieselgen.com. Retrieved 2012-07-13.
12. "Caterpillar - Accurate Generator Set Sizing - Online Community". Caterpillar.lithium.com. Retrieved 2012-07-13.
13. [3] (<http://www.generatorreviewsonline.com/>)
14. "Generator Reviews Online - OEM Products and Comparisons". Generatorreviewsonline.com. Retrieved 2014-12-12.
15. "How to Turn Standby Generation Into Profit-Making Assets". Wayne Boakes, generation manager, Wessex Water, Claverton Energy Group Conference, Bath, October 24, 2008
16. "Breaking in a Diesel Engine". Jay Chlebowski, retrieved December 22, 2009
17. "Bore glazing in diesel engines". Cox Engineering, retrieved December 22, 2009

18. "Dual-fuel-electric LNG carrier" (PDF). Thedigitalship.com. Archived from the original (PDF) on 2010-11-18. Retrieved 2013-10-28.
19. "Low Speed Engines". Manbw.com. 2008-11-19. Retrieved 2009-05-11.

Retrieved from "https://en.wikipedia.org/w/index.php?title=Diesel_generator&oldid=754486796"

Categories: [Electrical generators](#) | [Emergency services](#)

- This page was last modified on 12 December 2016, at 22:49.
- Text is available under the Creative Commons Attribution-ShareAlike License; additional terms may apply. By using this site, you agree to the Terms of Use and Privacy Policy. Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a non-profit organization.