

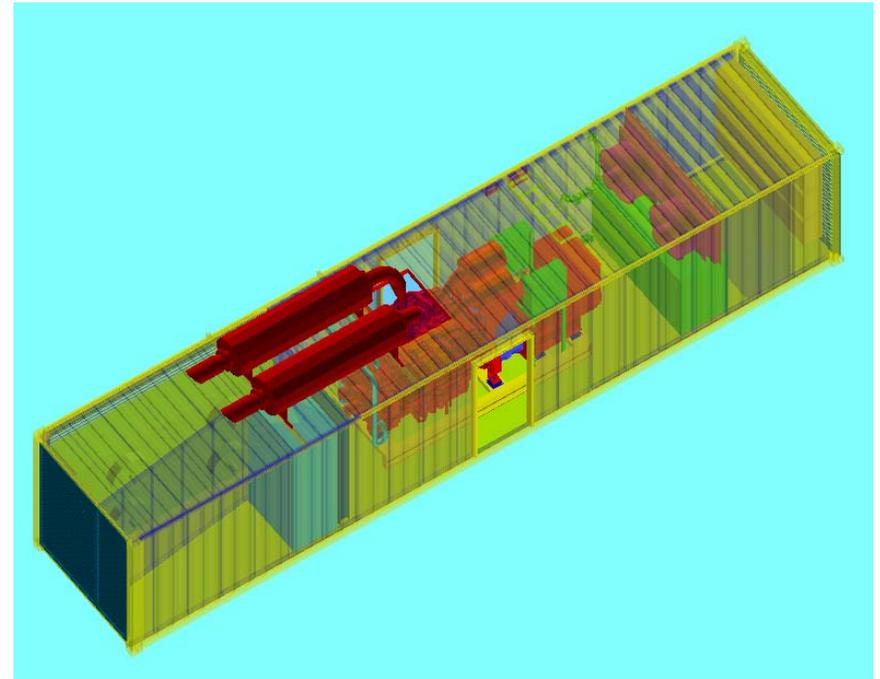
Hybrid Power System

Vestas Wind Systems A/S



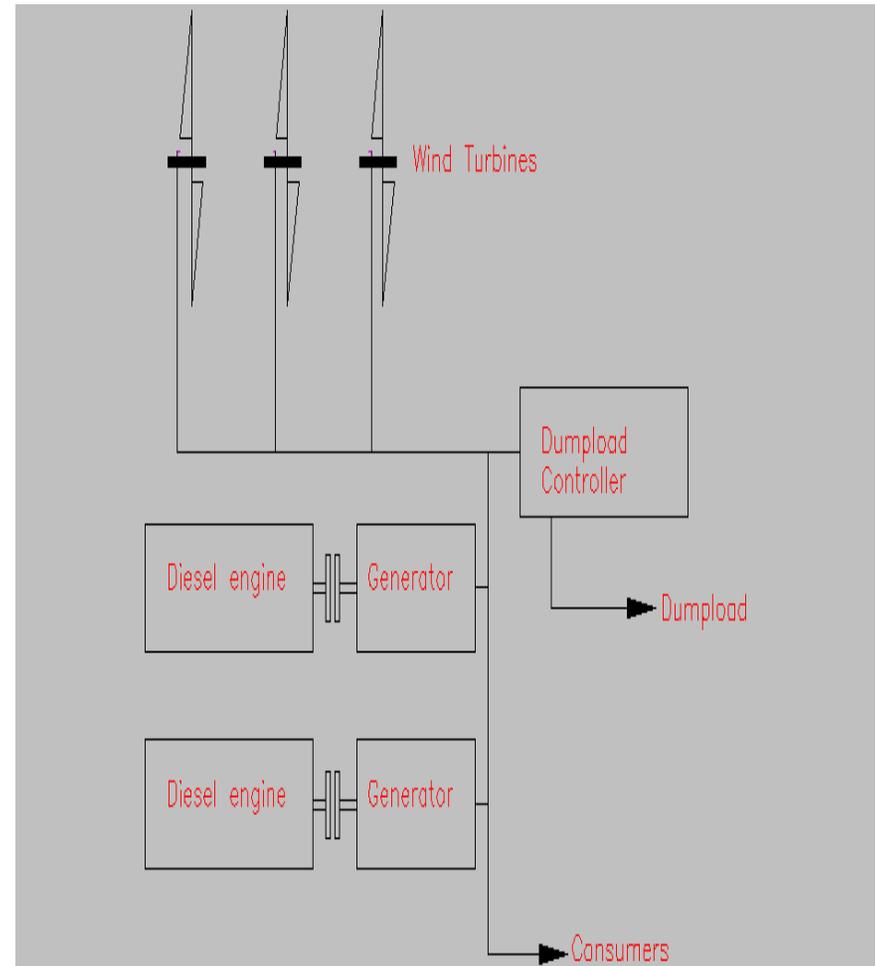
Hybrid Power System

- A Hybrid Power System (HPS) is a complete stand alone power supply system, with a combination of 2 different prime movers.
- The system is suitable for installation in isolated and remote areas with no (or week) grid connection.
- The master prime mover is a wind turbine generator (WTG), the slave is a diesel engine generator (DG).
- The main economical benefit of installing a HPS is fuel saving.



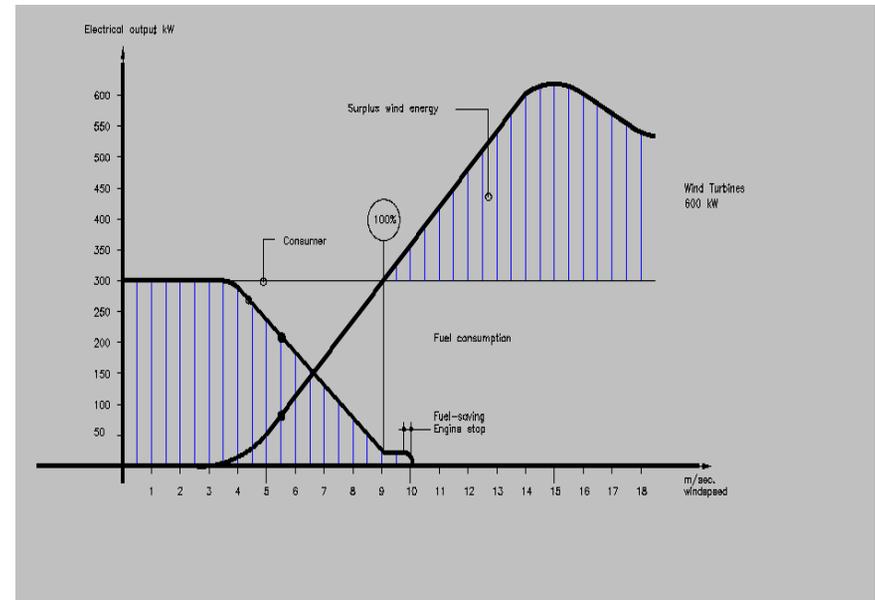
Hybrid Power System

- The HPS plant will be delivered as a complete containerized system, with a minimum of interface on site.
- The system comprises following main components:
 - Wind turbine generator(s)
 - Diesel generator(s)
 - Dumploads
 - Control system



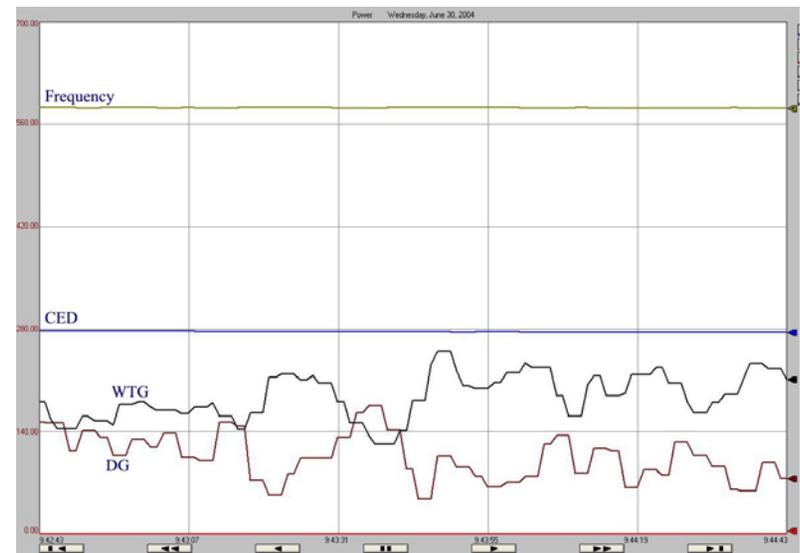
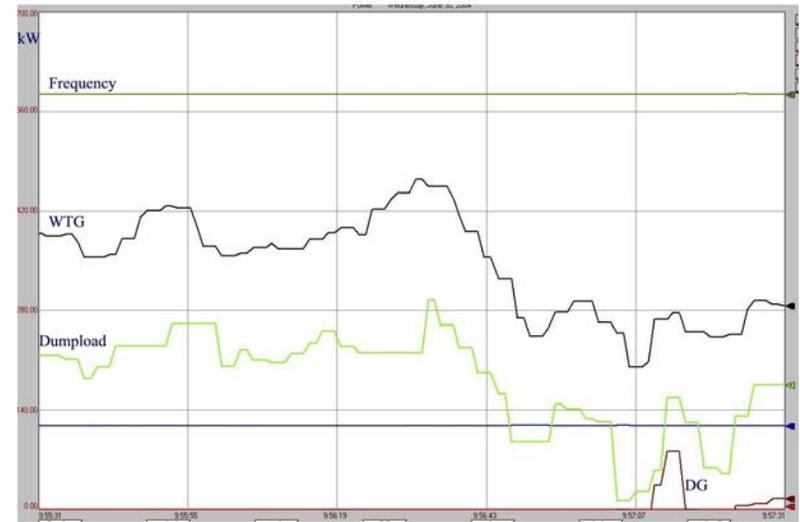
Hybrid Power System

- Working principles:
- The main philosophy is, that whenever there is sufficient wind, the WTG will supply the energy.
- When the output from the WTG is less than the CED, the DG will supply the needed topping up energy.
- When there is no wind, the DG will supply all the energy needed.



Hybrid Power System

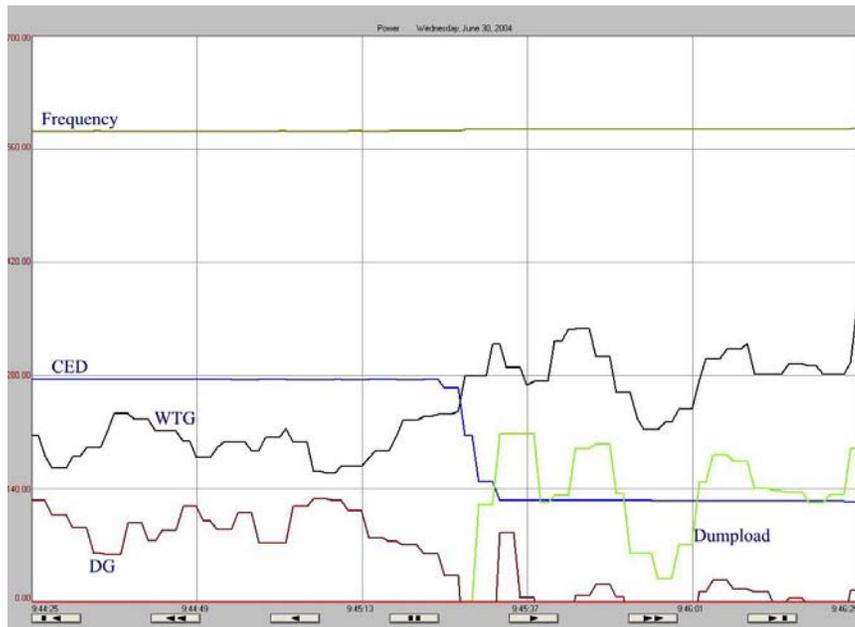
- The diesel is stopped when there is sufficient power supplied by the WTG
- Surplus energy from the WTG will be used in electrical dump loads.
- As an option, this surplus energy can be used in FW production (seawater desalination) or other heating / electrical purposes



Hybrid Power System

- More WTG, Diesel generator, dump load, consumer loads, frequency curves....

- Frequency characteristics from DS/EN 50160 :



2.1 Power frequency

The nominal frequency of the supply voltage shall be 50 Hz. Under normal operating conditions the mean value of the fundamental frequency measured over 10 s shall be within a range of

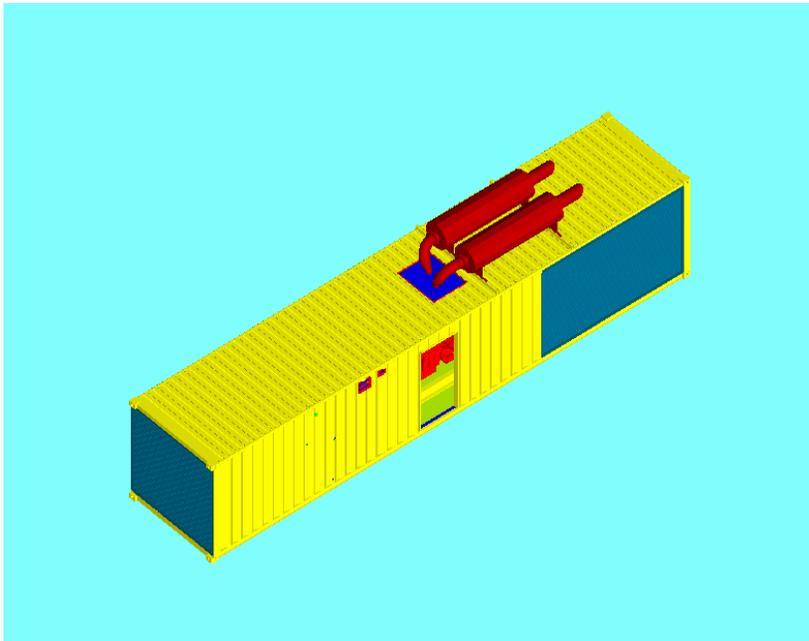
- for systems with synchronous connection to an interconnected system

50 Hz ± 1 %	(i.e. 49,5 ... 50,5 Hz)	during 99,5 % of a year,
50 Hz + 4 %/- 6 %	(i.e. 47 ... 52 Hz)	during 100 % of the time.
- for systems with no synchronous connection to an interconnected system (e.g. supply systems on certain islands)

50 Hz ± 2 %	(i.e. 49 ... 51 Hz)	during 95 % of a week,
50 Hz ± 15 %	(i.e. 42,5 ... 57,5 Hz)	during 100 % of the time.

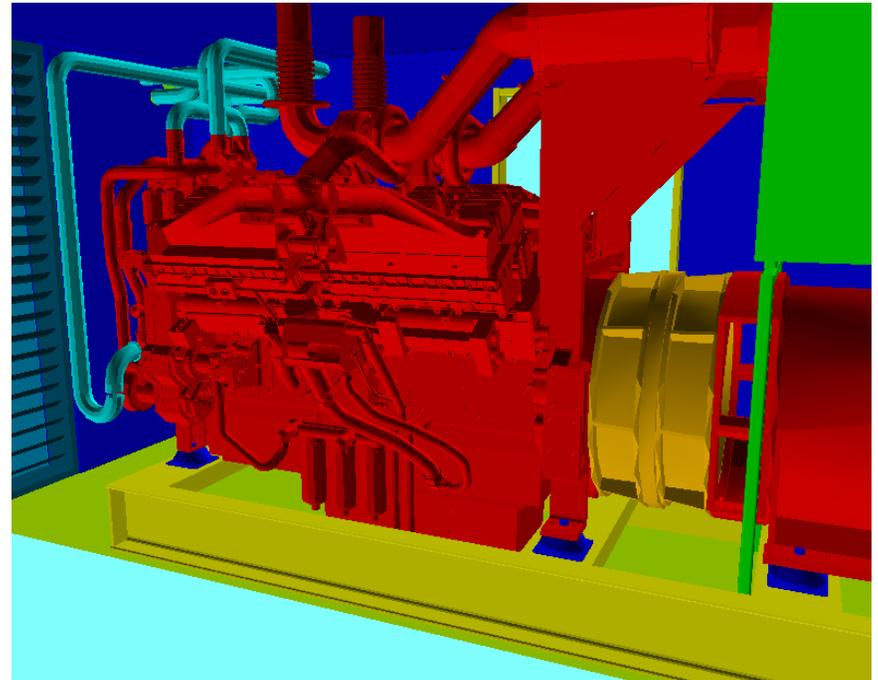
Hybrid Power System

- 1 MW Diesel generator module built in 40" container.
- The quality of the electricity has been checked and certified by RISØ, the Danish National Energy Laboratory.



Hybrid Power System

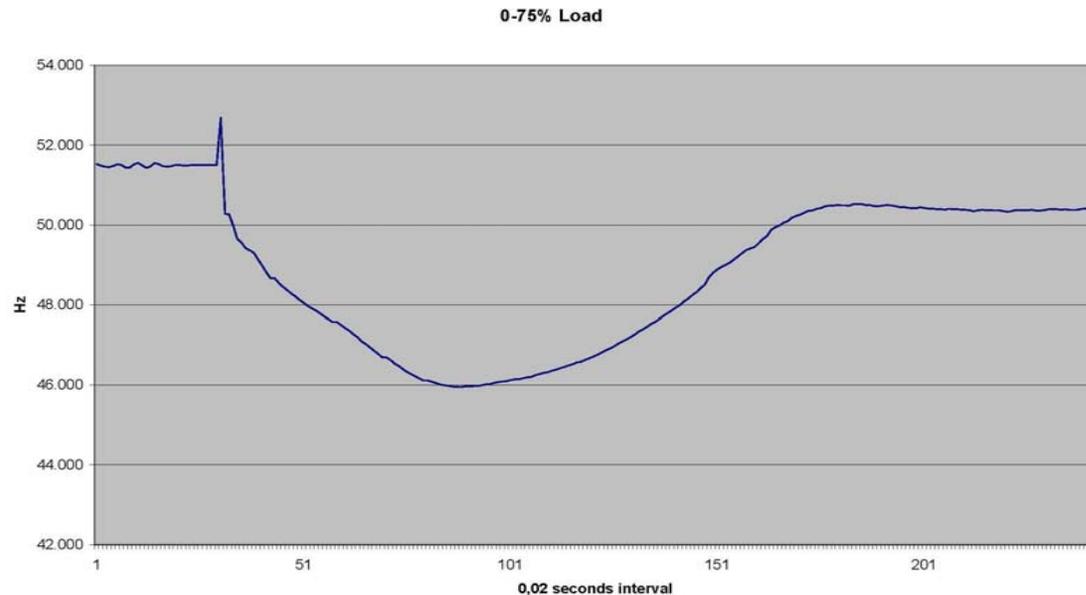
- One of the main features in the hybrid power system is the electromagnetic clutch between diesel engine and generator.
- When the clutch engaged, mechanical power is supplied by the diesel engine, giving electrical output from the generator.
- When the clutch disengaged, the WTG is supplying electrical power to the generator, making it act as an electrical motor. This is important to supply reactive power, needed for the WTG.



Hybrid Power System

Load appliances, DG only.

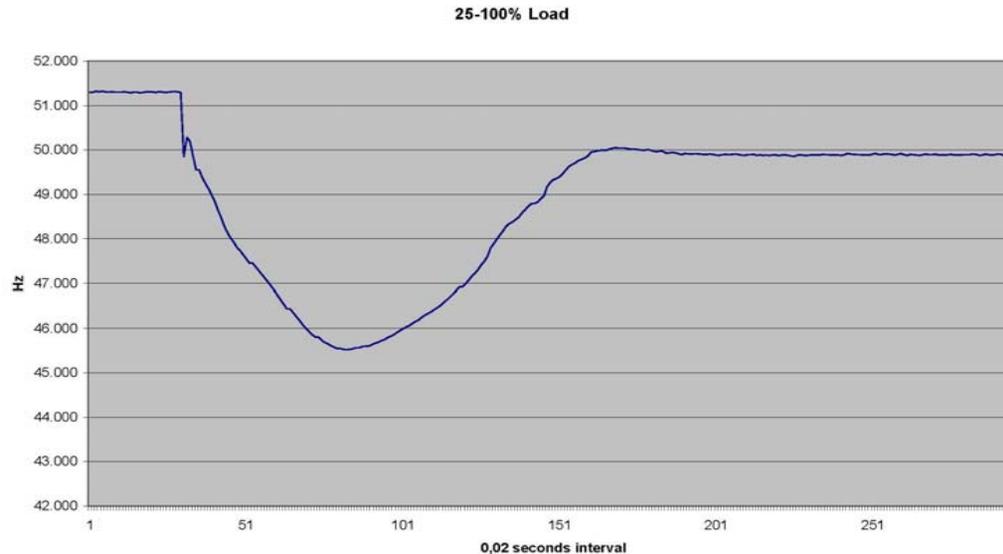
- 0-75% instantaneously.
- 46,0-52,7 HZ.
- Sufficient response from diesel engine
- Recovery time 2,8 sec.
- All values are measured at testbed, before HPS adjustments. Droop and Gain not optimised.



Hybrid Power System

Load appliances, DG only.

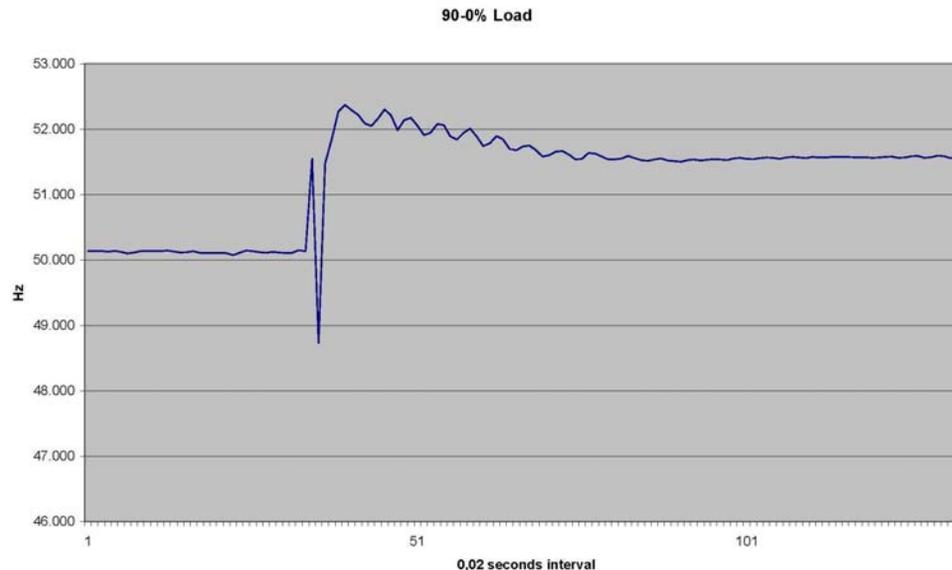
- 25-100% instantaneously.
- 45,6-51,3 HZ.
- Sufficient response from diesel engine
- Recovery time 2,6 sec.
- All values are measured at testbed, before HPS adjustments. Droop and Gain not optimised.



Hybrid Power System

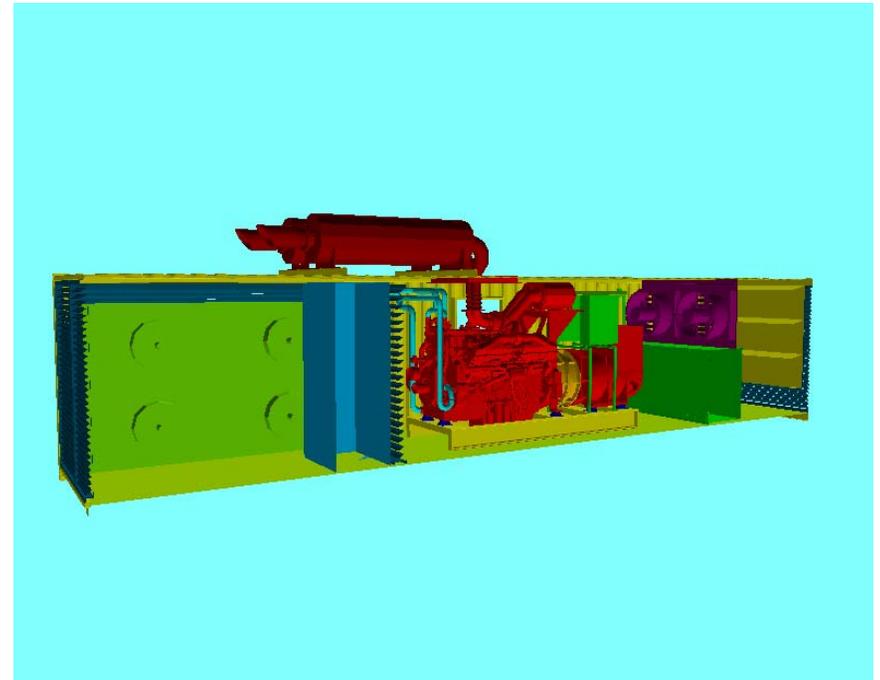
Load appliances, DG only.

- 90-0% instantaneously.
- 48,7-52,3 HZ.
- Sufficient response from diesel engine
- Recovery time 0,8 sec.
- All values are measured at testbed, before HPS adjustments. Droop and Gain not optimised.



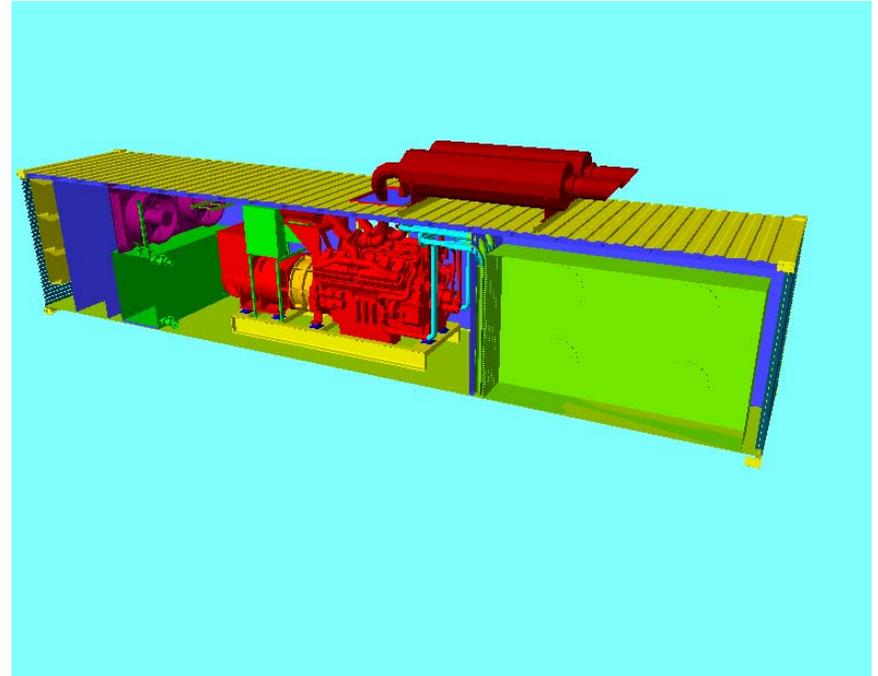
Hybrid Power System

- Fully intelligent electronic diesel engines (Cummins, Caterpillar or MAK)
- 2 Loop cooling water system in order to minimise fuel oil consumption, and in order to meet the coming IMO regulations concerning pollution.
- Preheated cooling water system in order to apply heavy loads instantaneously, without damaging diesel engine (thermal expansions).



Hybrid Power System

- Optimised ventilation and engine combustion air system, in order to help prevent problems during low diesel engine load running.
- Optional remote engine surveillance, with all necessary engine output signals. Can be used to determine the exact condition of the diesel engine, and for planning service intervals.



Hybrid Power System

- Systems range from 1.0 MW to 10 MW for both 50 and 60 HZ applications.
- The capital cost for a Hybrid Power System is higher than a normal diesel generator.
- Through the extensive fuel savings the complete Hybrid Power System is highly competitive to traditional diesel power systems.
- High wind penetration 30%-40%, give a fuel saving in the range of 50-80%.
- Existing diesel power stations can be converted into a Hybrid Power System.
- As a design tool, a calculation programme helps design the optimal system for any given location, using input parameters such as:
 - Consumer loads.
 - Fuel price.
 - Wind data.
 - Financial parameters, i.e. interest rate, payback time, first cost.