National Grid's use of Emergency Diesel Standby Generator's in Dealing with Grid Intermittency and Variability
Potential Contribution in Assisting Renewables

David Andrews, Senior Technical Consultant, Biwater Energy.

(A talk originally given by as the Energy Manager at Wessex Water at an Open University Conference on Intermittency, 24th Jan 2006)

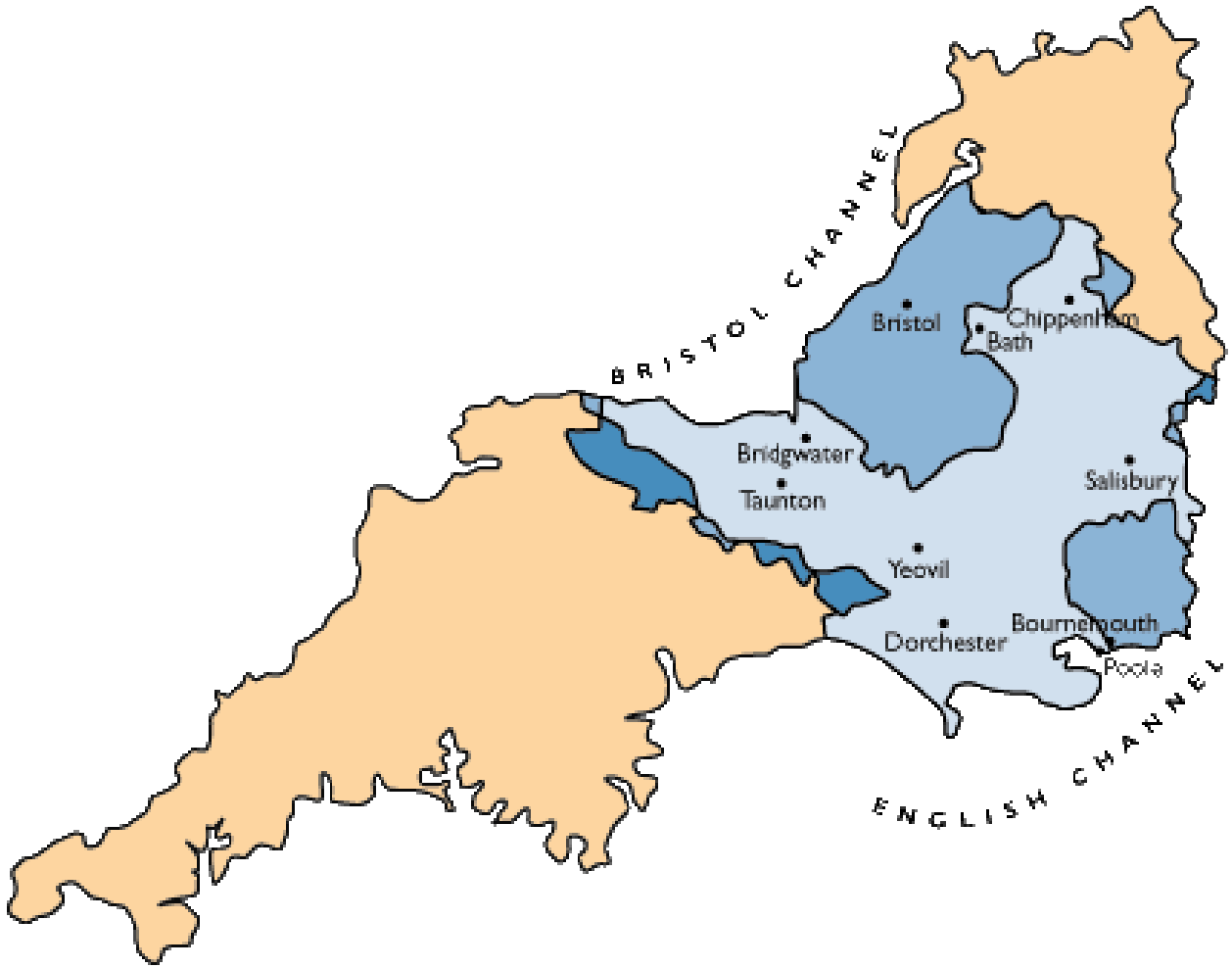
Wessex Water – Overview

- One of ten water and sewerage companies in England and Wales
- Over 10,000 square km's area
- Overall performance recognised independently as one of the best

LOCATION & CUSTOMER BASE

2.5m sewerage individuals

- 1.35m sewerage only
- 1.1m water and sewerage
- 0.13m water only



Wessex Water – Overview

Water Supply

- **123 treatment plant, 366 pumping stations**
- **11,000 km’s water main**

Wastewater

- **392 treatment plant, 1,314 pumping stations**
- **15,000 km’s sewers**

Wessex Water – Energy costs

- Energy is one of the largest operational costs

  - average electrical use is about 27 MW

  = one 747 jet engine output

  = 0.06% of UK average demand of 39 GWe

  - Clean Water treatment and supply ~ £4 - 8m

  - Wastewater collection and treatment ~ £6 - 10m

- about 4.5 MW continuous biogas CHP generation
- About 32 standby diesel engines, totaling 18 MW used routinely to support National Grid, 4 minute start up and paralleling.

How Are Diesels Presently Used to Assist With Intermittency?

- **NGT Frequency Service Participants**
- **NGT Reserve Service Participants**

NGT Frequency Service

- **NGT Frequency Service** participants - these are large users such as steel works, cold stores, who are happy to be paid to shut off instantaneously whenever grid frequency starts to fall using frequency sensitive relays
- Contracted to stay off for 20 minutes

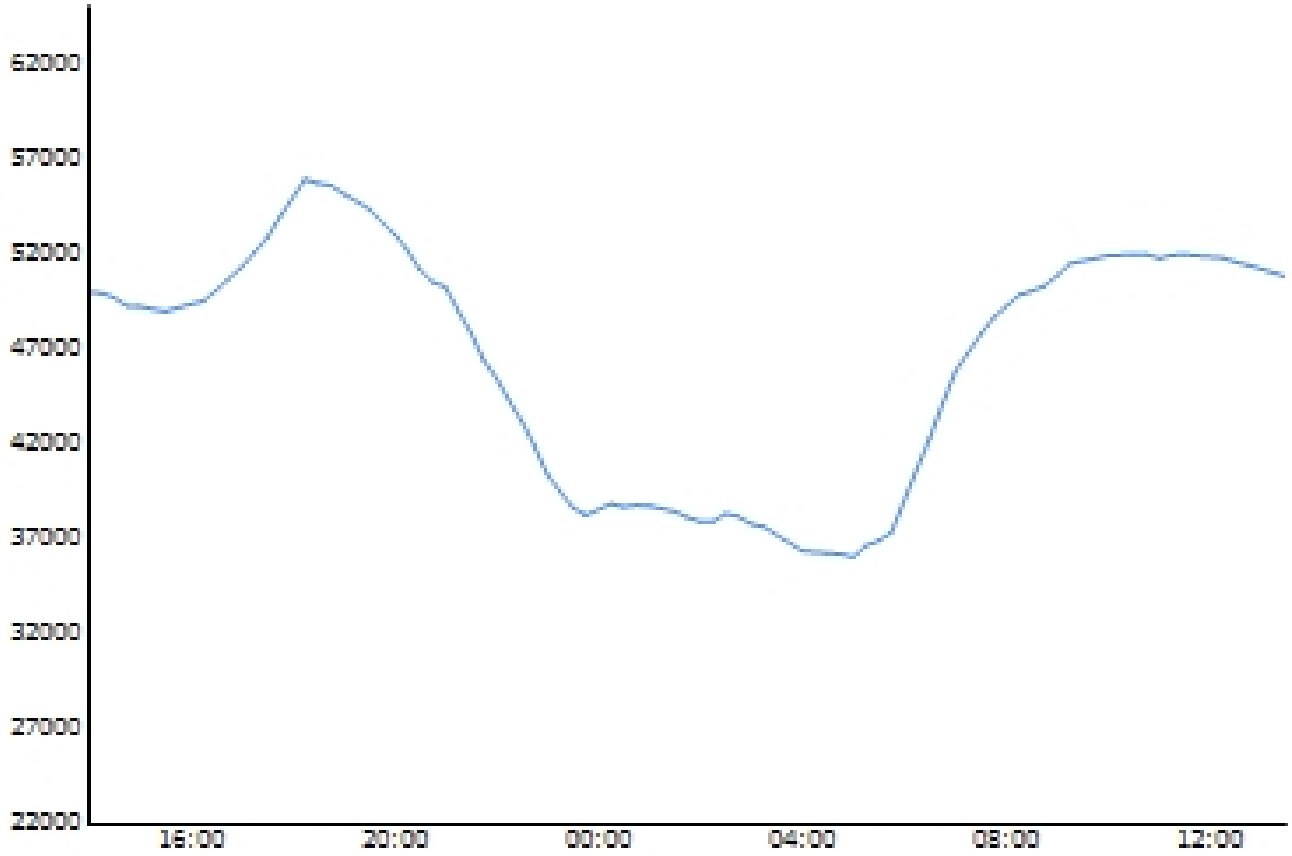
NGT Reserve Service

- **NGT Reserve Service** participants are small diesel (such as us) and gas turbine generators, etc who are paid to start up and connect to the grid within 20 minutes whenever **Frequency Service** customers are called.
- Must be reliable and able to stay on and run for an hour or so.

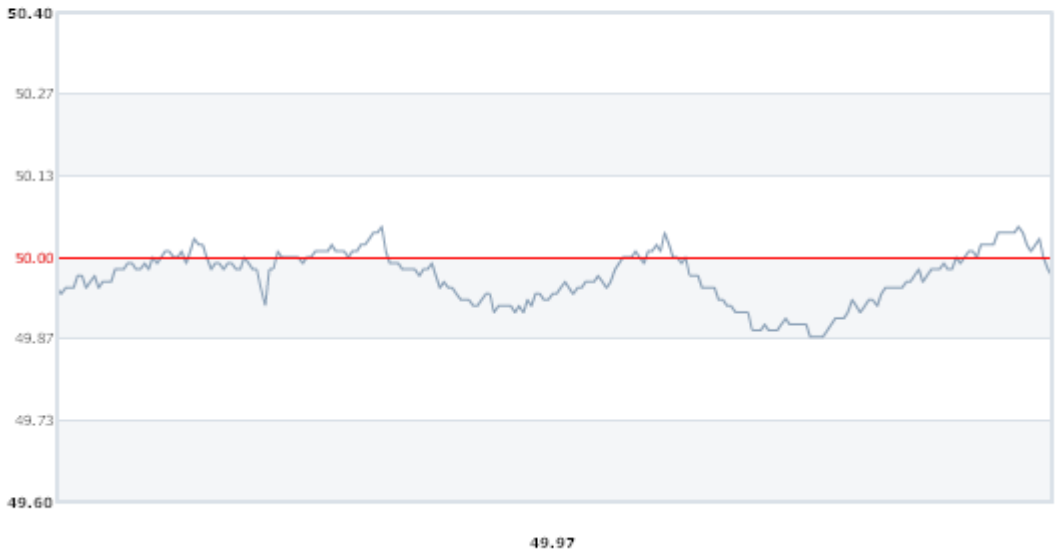
Energy & Services

Electricity demand - Last 24 Hours

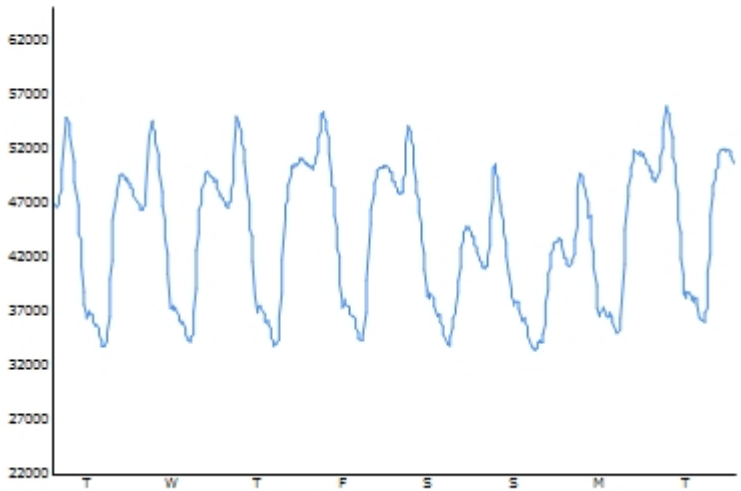
19th Feb 2008



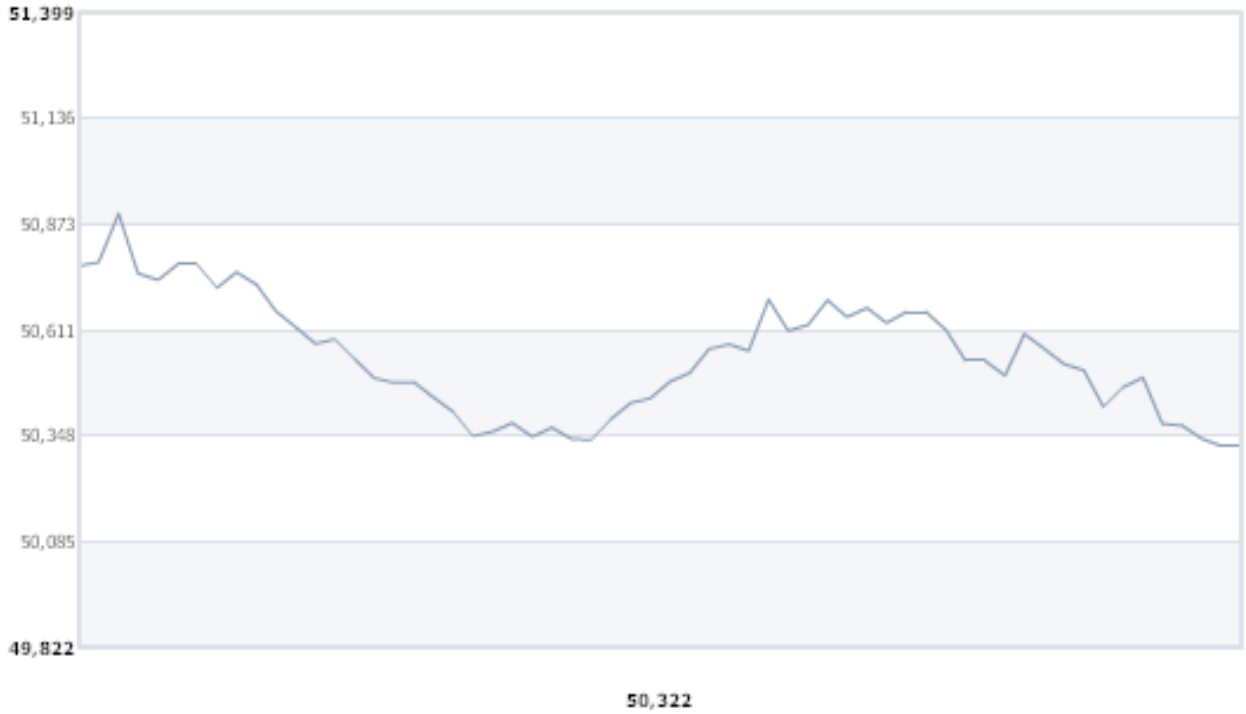
Real Time Frequency Data - Last 60 Minutes 19th Feb 2008 - 1800



Electricity demand - Last 8 Days



Real Time Demand Data - Last 60 Minutes



The graph above shows MW demand over the last hour. Please note that the graph refreshes itself every 15 seconds, but may need manually refreshing if left open for a prolonged period.

Context -Types of Capacity on the System

- 57GW in use at peak winter demand
- 1.5 GW of spinning reserve – can come on in 20 – 30 seconds.
- NGT likes to have 8.5 GW additional spare but not running, some of it warming (Down to 4.5GW recently)
- 2.25 GW of Frequency Service loads
- 2.25 GW of Reserve Service diesels etc
- 2 GW? Fast response plant
- Dinorwig and Ffestiniog 2 GW in 15 secs

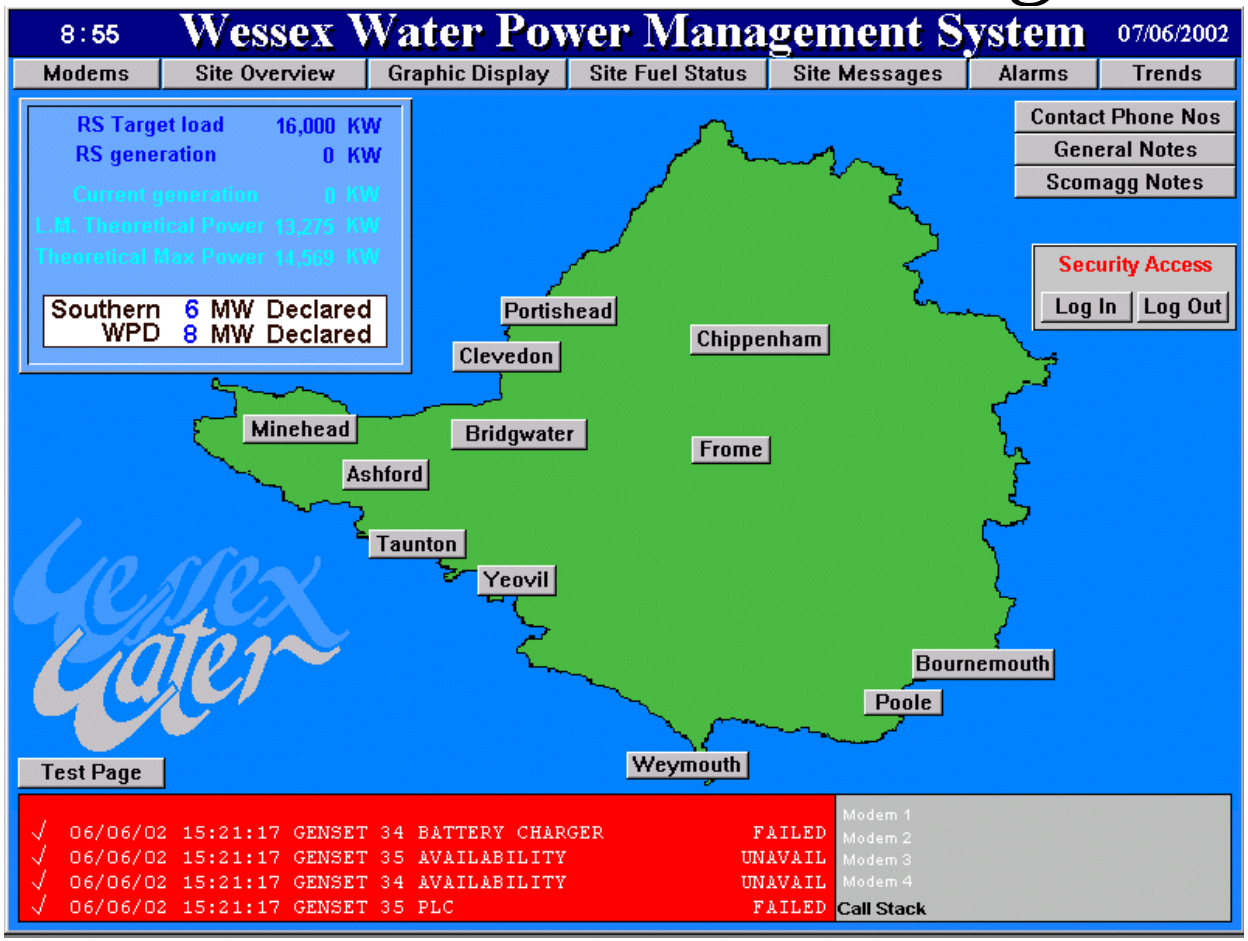
How Do NGT Reserve Service and Frequency Service cope with Intermittency/Variability?

- Say a 660 MW turbine trips – grid frequency starts to drop
- Under frequency relays on Frequency Service customers trip up to 660 MW of load for up to 20 minutes as frequency falls
- NGT issue Reserve Service start up signal for 660 MW which becomes available within 20 minutes
- When Reserve Service becomes available, Frequency Service loads are re-connected
- Frequency Service relays are then re-armed
- An hour or so later, Frequency Service diesels are replaced with new levels of large power stations and can be stood down

Biggest Source of Intermittency

- Whenever Sizewell B is operating, it is capable of stopping at any time, without warning 1.3GW.
- This is the largest source of intermittency, since it is the largest power generating unit which can be lost, yet NGT readily copes with it using methods outlined over leaf

Wessex Water Diesel Engines



Operator interface page: General Map showing some of the LM sites.

Wessex Water Diesels

32 Sets spread across 24 Sites totalling 18 MW

Site	kW Output
Ashford	470
Blackwell Hams	480
Chilton Trinity	650
Clevedon	270
Durleigh	470
Empool	500
Frome	340
Fulwood	610
Holdenhurst 1	600
Holdenhurst 3	385
Minehead 1	260
Minehead 2	390
Poole Inlet	390
Poole RSPS	800
Poole BAF	750
Portishead	380
Swanage STW	800

Site	kW Output
Portbury Wharf	245
Radipole 1	675
Radipole 2	675
Sutton Bingham	690
West Huntspill	550
Weston super Mare 1	700
Weston super Mare 2	700
Weston super Mare 3	650
Black Rock 1	640
Black Rock 2	640
Corfe Mullen WTW	450
Kingston Seymour 1	640
Kingston Seymour 2	750
Weymouth 1	750
Weymouth 2	750

Small set maybe 150kW

Poole inlet pumping station – 390kW + fuel tank

1MW containerised set, fuel in background

Wessex Water Diesel Generator Control System (1)

- This gives one central point of control via a master PLC (small computer) and a PLC retro fitted to each of the generators
- It gives to day visibility of status and permits control and scheduling of each set and reporting of availability to NGT.
- Permits instantaneous start by NGT and constant reporting of output when so doing
- Permits scheduled runs instructed 1-3 hours ahead from **A Large Power Supply Company**

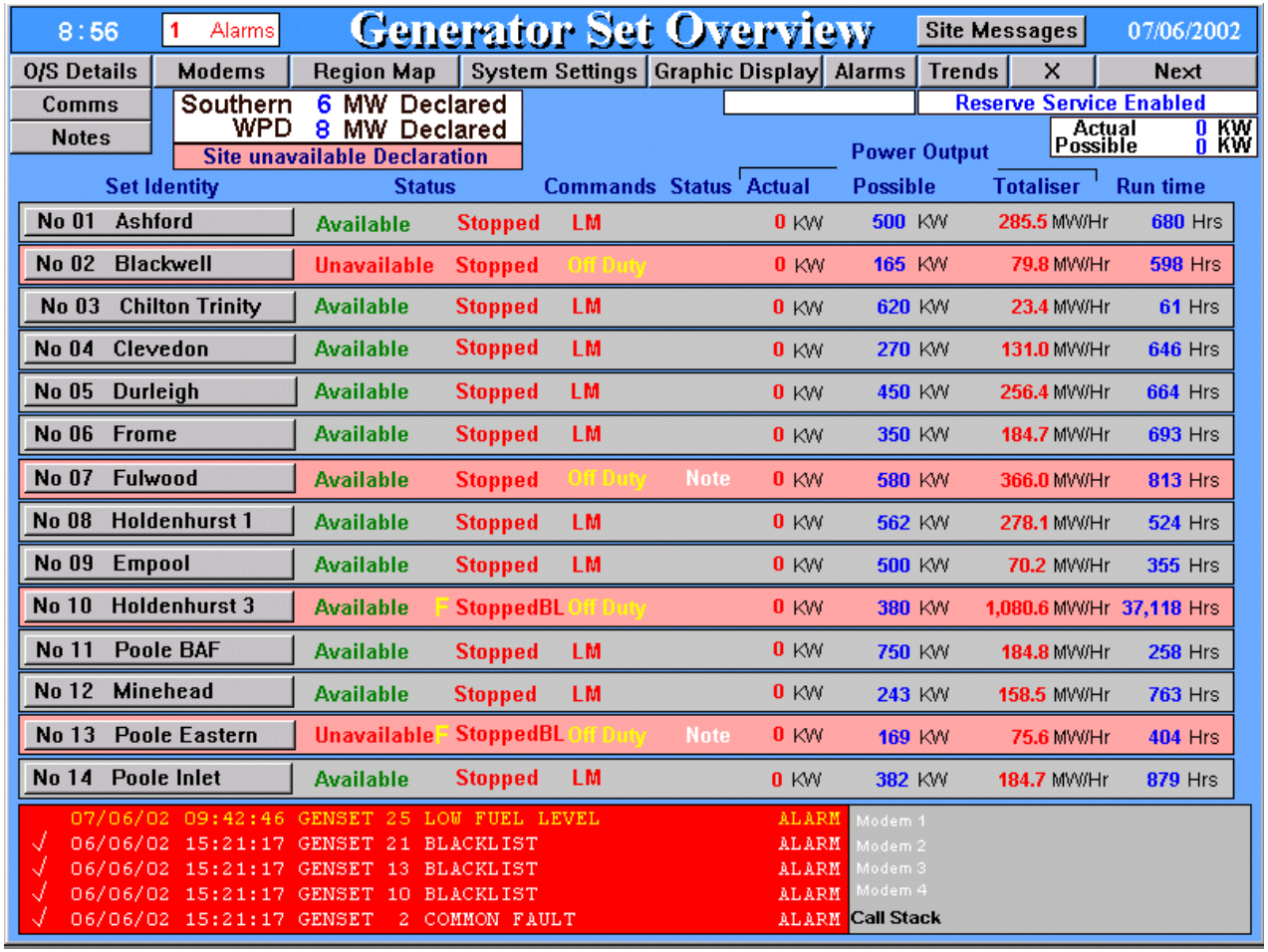
Wessex Water Diesel Generator Control System (2)

- Allows Triad avoidance runs to be instructed 7 hours ahead when Triad warnings are received
- Whenever the system has a run scheduled, the local operators are automatically sent an SMS message telling them that a run is about to start.
- This enables them to monitor it and reminds them to keep their eye on the fuel levels.

Wessex Water Diesel Management System

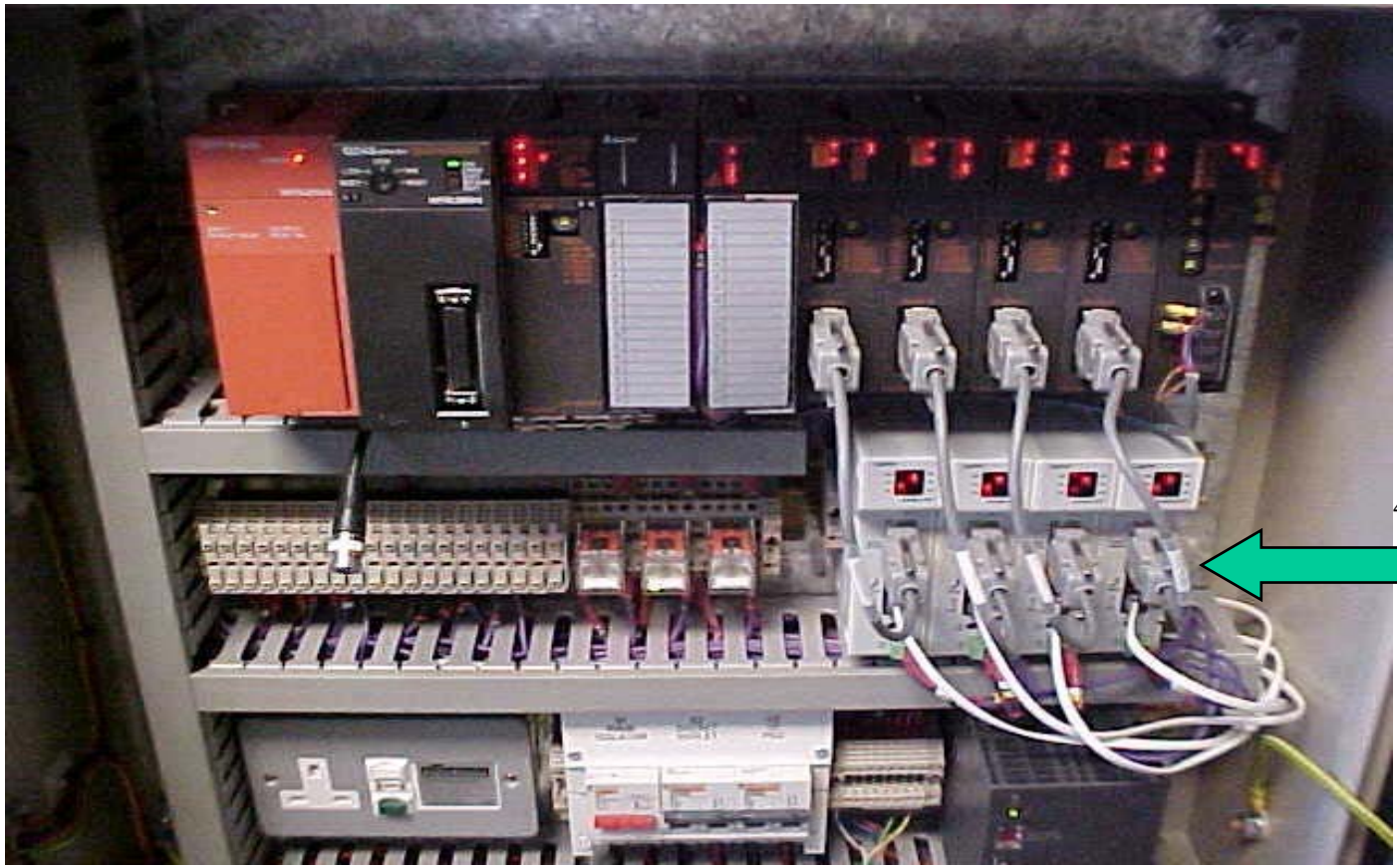
NGT Computer on the left, operator interface on the right Can dial in remotely via lap top.

Wessex Water Diesel Management System



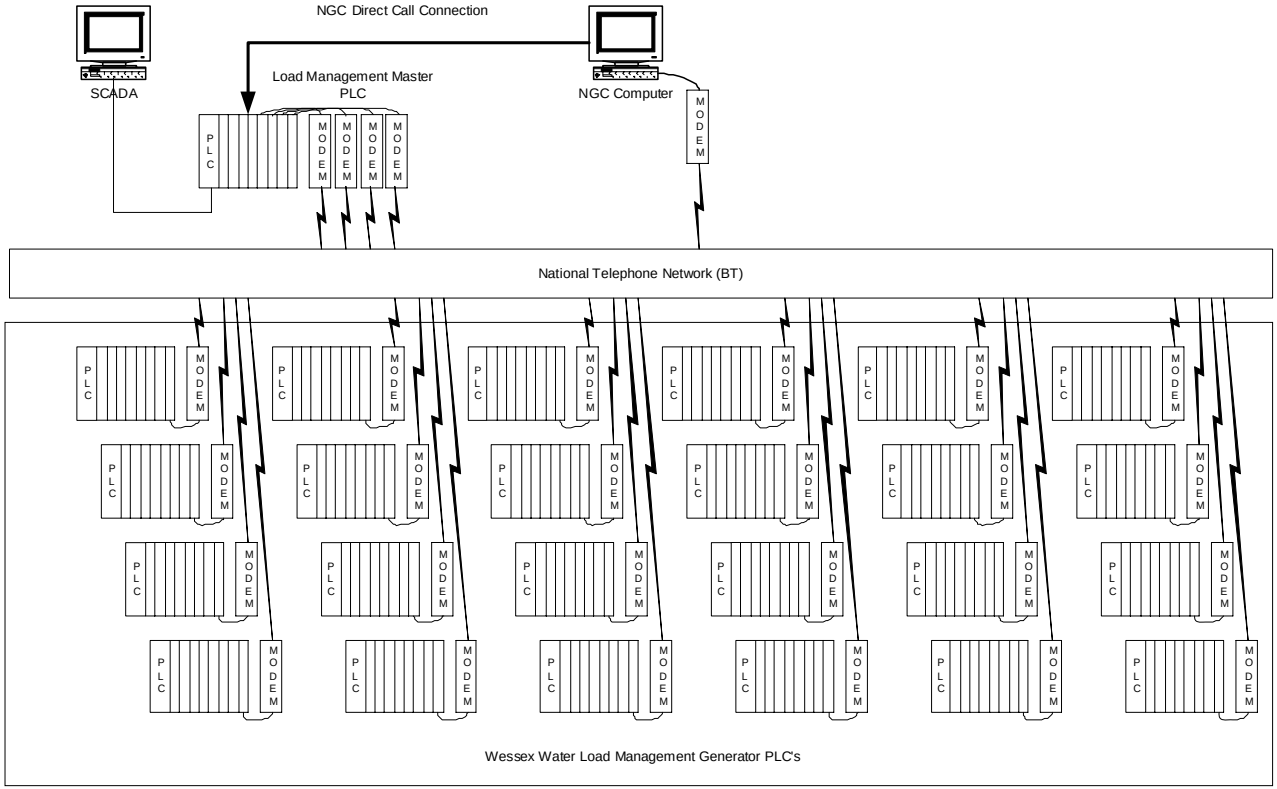
Operator interface page: Overview Page showing first 14 sets with various status's simulated.

Wessex Water Diesel Management System



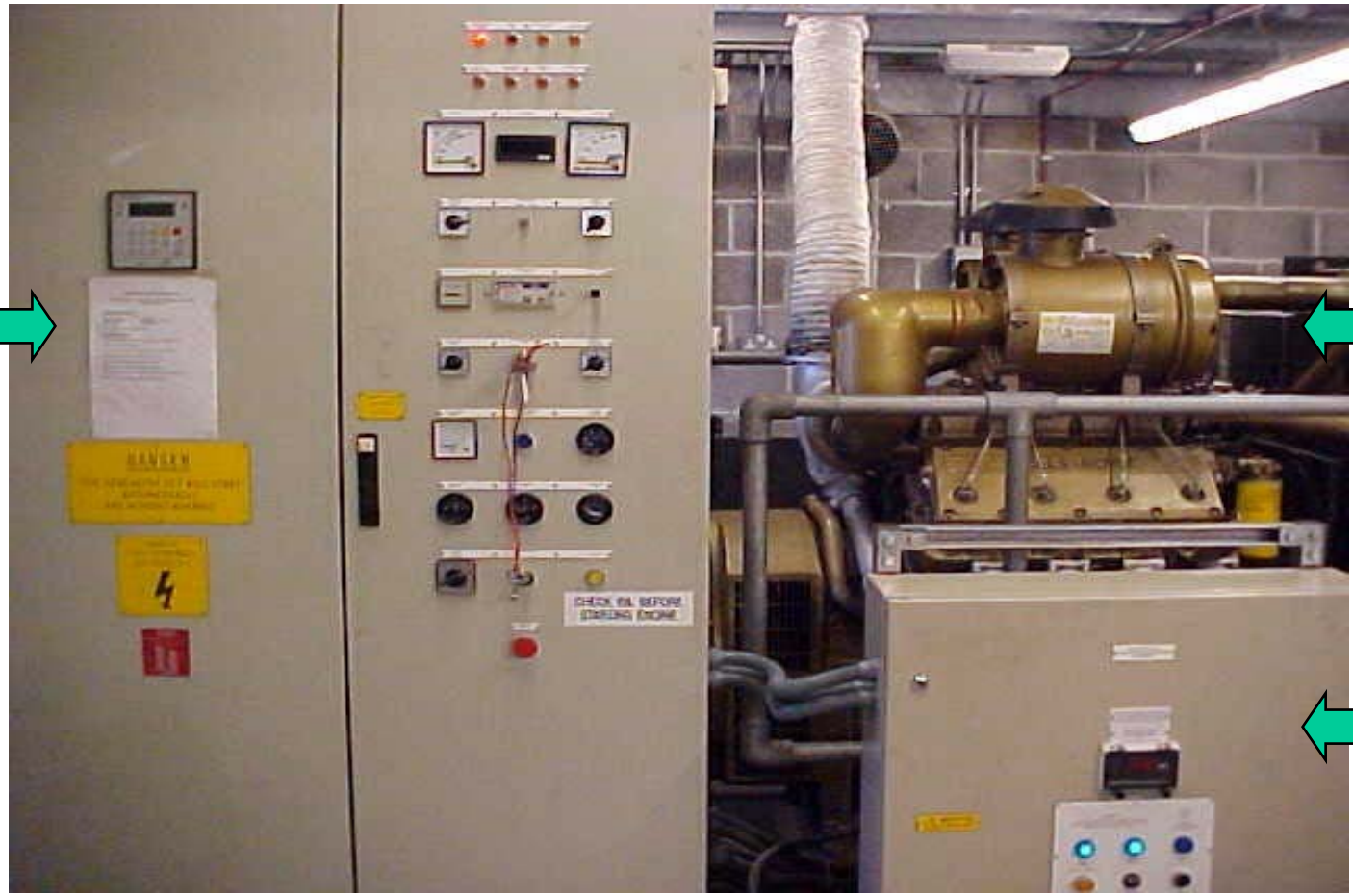
Master Control PLC, with its 4 modems.

Wessex Water Diesel Management System



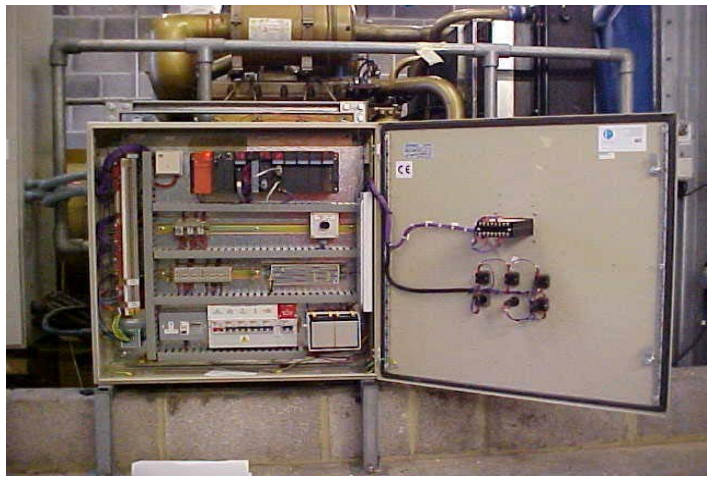
A direct call can be initiated from the NCG SRD dispatch computer.

Wessex Water Diesel Management System



Typical Site: In the background we see the Generator, in the foreground we see the Generator controller and the Load Management control panel.

Wessex Water Diesel Management System



Load Management control panel, with the door open. Showing the PLC controller etc.

Testing Diesels off Load

- This very quickly ruins an engine – maybe in only 50 hours.
- Under loading means low cylinder pressures and poor ring sealing and low temperatures - leading to poor combustion
- Soot forms, clogging rings, and hard carbon scrapes bores
- Injectors clog with soot, un-burnt fuel contaminates oil
- Diesels must be run at full load once a month to ensure they work.
- In 1987 storms, 50% of Thames Water Generators failed to start or stay running.
- *NGT Reserve Service is the ideal way to prove your diesels without destroying them*

Conversion Costs

- Maybe £3k to fit PLC to set
- Paralleling gear (allows grid connection) maybe £5k
- Tidying up set (noise, fuel) maybe £5k

- So for a 1MW set…£13/kW
- 50 kW…maybe £260/kW
- Running costs - fuel 10p/kWh
  - maintenance -0.5p/kWh

How Many Diesels Are There?

- Wessex has 550 generators of capacity 100MW.
- We only use 32 generators of 18MW capacity
- We could use the others but there are diminishing returns – probably still worth doing though.
- Nationally there are up to 20 GW of emergency diesels (EA Technology)
- Large number could be utilised with right incentives
- Over 20 years this technology will become standard

Back up Power Costs - Spark Spread (Gas) and Dark Spread (Coal)

- It’s the difference between the cost of fuel, and the selling price of that power from that fuel.
- It is the profit needed to pay off the capital and maintenance cost on the power station.
- You can look up spark spreads on various energy trading web sites - Argus, Spectron etc

Value of Spark Spread and Dark Spread

- Spark spreads are reckoned to need to be about £12/MWh for new gas, and £14/MWh for new coal.
- Presently around £9/MWh
- Present load factor is say 43% then as a whole they would be happy to receive £9x0.4 = £3.6/MWh for all units supplied for the whole year = 0.36p/kWh

Other Increased Costs From Renewables

- Tuos - Transmission Use of System charges- currently around 0.2p/kWh
- Assume you had to duplicate the entire grid to accommodate wind - still only adds 0.2p/kWh
- Duos - Distribution Use of system charges - would not change - about 0.2p/kWh.
- Bsuos - Balancing Services Use of System - currently around 0.2p/kWh - hard to see why that would get much larger but assume it doubles.

Total Increased Costs of Back Up, Transmission and Balancing

- Spark spreads - 0.36p/kWh
- Doubled Tuos - 0.4p/kWh
- Distribution - no increase
- Bsuos - assume doubles - 0. 4p/kWh

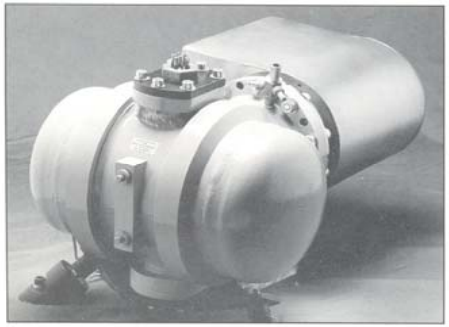
- Say 1.2p/kWh - 12%

Other Similar Technologies

- No reason why Frequency Service could not be applied to a 1 kW deferrable load such a freezers, fridges, storage heater, immersion heater in all 20m homes – 20GW
- an efficient, 1 kW Stirling micro-CHP in every home gives 20 GW - Could be on extended Reserve Service

28.5% , HCV efficient Stirling engine

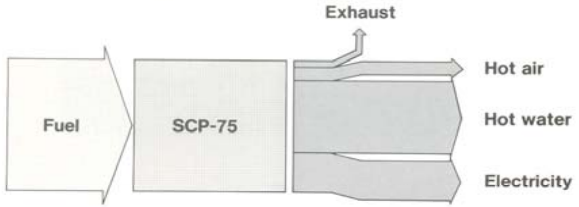
SCP-75 is a carefully designed single-cylinder Stirling cycle engine. The engine is hermetically sealed and has anti-friction bearings which eliminate the need for an oil lubrication system. The Stirling cycle's external combustion and inherently balanced geometry gives the SCP-75 extremely low emission, noise and vibration levels, which will easily meet the stringent environmental demands of the future.



SYSTEM SPECIFICATIONS

Electrical power	3 kW D.C. or A.C.
Heat Power	6 kW as hot water (50–70°C) 1 kW as clean hot air
Fuel consumption	10,5 kW (Higher Calorific Value)
Dimensions	600 mm×400 mm×350 mm

The SCP-75 can be supplied as an integrated CHP unit with pumps, heat exchanger, controllers etc. ready to be installed into a house – effectively a boiler that also produces electricity.



In the CHP (Combined Heat and Power – or co-generation) unit the fuel is converted into electricity, water borne heat and ventilation air which can be used directly for heating.

If you need more information on the SCP-75 unit, please feel free to contact us so that together we can investigate your possibilities to fully exploit the benefits of the SCP-75.

TEM
Malmö Research Center
Nya Agnesfridsvägen 220
S-215 79 MALMÖ
Sweden
Tel. Int. +46 40 343401
Nat. 040 343401
Fax Int. +46 40 948960
Nat. 040 948960

Tryckhuset, Linköping