# Denham wind/diesel system

case study

## ...increased wind energy input with enhanced system reliability

### Location

Denham is an isolated town in the Shark Bay World Heritage Area of Western Australia. The population is approximately 900 permanent residents and the town is a popular tourist destination.

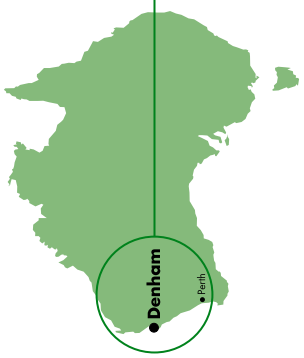
*The wind farm at Denham during construction.*

### Site History

Denham has an excellent wind resource. A 30kW wind turbine was operated for water desalination in the 1990s. In mid-1998 Australia's first large variable speed wind turbine, a 230kW Enercon E-30, was installed and connected to the local diesel fuelled electricity grid.

### Showcase for New Technology

In March 1999, the Australian Greenhouse Office awarded a $1 million Renewable Energy Showcase grant to install a high penetration wind energy solution based on two additional wind turbines, associated control systems, and energy storage technology. The original flywheel energy storage system was replaced with an alternative solution utilising a Low Load Diesel generator (LLD™) with a Dynamic Grid Interface (DGI™).




### Current system

The Denham power system comprises: three wind turbines (690kW total capacity); four conventional diesel generators (1,720 kW total capacity); a 250kW Low Load Diesel generator (LLD™) with a Dynamic Grid Interface (DGI™); and a Master Controller with Generator and Feeder Controllers.

### Wind Penetration

The first Enercon wind turbine installed supplied approximately 20% of the town's electricity requirements annually, displacing about 150,000 litres of diesel fuel. The 3 turbines now supply approximately 40% of Denham's annual electrical energy consumption. Maximum instantaneous wind energy penetration of over 70% now occurs. Around 25% more energy from the wind farm can be utilised with the LLD™ technology included in the system.

### Unique

The Low Load Diesel generator (LLD™) is an advanced diesel engine with electronic direct fuel injection that is highly fuel efficient, and can be operated below 10% of its nameplate rating for extended periods of time. The DGI™ is an inverter controlled dynamic load that allows the LLD™ to operate at low loads, while ensuring system integrity during abnormal grid conditions. The DGI™ ensures that following a sudden loss of load (e.g. a feeder trip), the LLD™ does not operate in reverse power. D&WS's unique high wind penetration system maximises the wind energy input into the system while enhancing grid reliability and power quality and reducing diesel fuel consumption.

*The Low Load Diesel in the Denham power station.*

D&WS DIESEL AND WIND SYSTEMS

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## Wind Turbine Specifications

| | | | |
|---|---|---|---|
| General | Installed | 1998 | 1999 |
| | Number of turbines (total) | 1 | 3 |
| | Capacity (total) | 230 kW | 690 kW |
| | Turbine brand | Enercon E-30 230 kW | |
| | Turbine type | Variable Speed, pitch controlled, inverter connected | |
| | Generator | Multi-pole synchronous | |
| | Mechanical | Direct drive (no gearbox) | |
| | Manufactured | Germany/India/Australia | |
| Rotor | Swept area | 707m$^2$ | |
| | Rotor diameter | 30 metres | |
| | Number of blades | 3 | |
| | Rotational speed | 18 to 50 RPM | |
| | Method of control | Blade pitch (feather) | |
| | Main method of stopping rotor | Blade pitching (separate electric motors control pitch of each blade) | |
| Tower | Tower height | 50 metres | |
| | Tower material | Painted steel | |
| | Tower access | Internal ladder to top, exterior ladder to nacelle | |
| | Manufactured | India (stage 1) RCR Tomlinson, Perth (stage 2) | |
| Operational data | Cut-in wind speed | 2.5 m/s (9 km/hr) | |
| | Rated wind speed | 13 m/s (47 km/hr) | |
| | Cut-out wind speed | 25 m/s (90 km/hr) | |
| | Survivable wind speed | 63 m/s (227 km/hr) | |

## Diesel Plant

| Genset | Minimum loading permitted | Step Load Capability for 10% transient speed reduction |
|---|---|---|
| Diesel 1 280 kW | 40% | approx. 40% |
| Diesel 2 580 kW | 40% | approx. 44% |
| Diesel 3 580 kW | 40% | approx. 44% |
| Diesel 4 280 kW | 40% | approx. 40% |
| 250 kW Detroit Low Load Diesel | Less than 10% | 75% |

## Dynamic Grid Interface (DGI™)

| | |
|---|---|
| Maximum power sinking capacity | 100 kW |
| Minimum operating voltage | 75% of nominal |
| Maximum operating voltage | 115% of nominal |
| Restart delay when voltage is within tolerance | 0 to 300 sec |