Danvest Hybrid Wind Diesel – System Introduction

January 2013

The Danvest Wind Diesel (WD) systems with high wind penetration for "Off Grid" operations are based on standard diesel-generator sets fitted with Danvest WD equipment. The modified diesel-generator sets automatically and continuously backup wind turbine energy supply from 0 to 100%:

- When the wind energy is sufficient to supply all power demand - the engine is clutched out and stopped, while the alternator remains connected to the busbar:
  - for control of reactive power, voltage and frequency (dumpload controlling), and
  - to function as a flywheel in the rotatory system.

- When wind is decreasing or demand for power is increasing - the engine is started and clutched in automatically in 1-3 sec.

- Dumpload controlling enables fast dynamic load balancing between the fluctuating wind energy and the varying consumer power demand resulting in a stable voltage and frequency of 50/60 Hz +/- 0.1 to 0.3 Hz. The wind/power demand fluctuations are effectively smoothed to a negligible level.

- Fitted with the Danvest WD equipment (which pre-pressurizes and pre-heats the diesel generator up to 30% engine load) for low load operation, enables the engines to operate for longer periods at low load and accelerate up to a high load within a few seconds, thus maintaining normal service intervals. At low load operation the diesel generator functions as a very soft dumpload.

With the Danvest WD system an annual fuel-saving of up to 50-85% can be obtained. The additional cost of the wind turbines and the WD equipment is far less than the cost saving achieved through the reduced fuel consumption.

The cooling system retains all waste and surplus wind energy for water desalination/purification or district heating and in this way, the highest plant efficiency is obtained. Raw water feeding systems are integrated into the total cooling system and both Reverse Osmosis (RO) and distillation processes, and district heating can be combined to obtain a high plant efficiency, of up to 0.95%.

The Danvest WD system, which is especially designed for remote areas, is containerised and simple to install and operate.

The Danvest WD system offers a complete infrastructure solution with electrical power, pure water and/or district heating in one compact turn-key system.

Existing diesel power installations can be converted to WD systems via the Danvest WD technology to obtain higher wind penetration, typically annual wind penetration from 20-85%.
Danvest Energy - Desalination Systems: Danvest Energy is specialized in wind/diesel/desalination system combinations.

Danvest’s desalination systems are designed as containerised modules, wherein the cooling system and raw water system are integrated with production capacities from 100 to 3,000 m³/day/unit. The modules can supply fresh water for: irrigation, municipal water supply, industrial process water and high quality drinking water.

The desalination modules are based on "State of the Art" RO processes, ultra filtration, distillation and disinfection technologies.

Danvest Energy - District Heating System: All waste energy and surplus wind energy is retained in the main cooling system and can be utilised for district heating in the local area. With booster tanks, the energy can be accumulated to cover fluctuations in the consumer demand and thereby operate with high efficiency.

Turnkey Solutions: Danvest will perform all design and engineering works for the total system and in cooperation with - acknowledged manufacturers of wind turbines, desalination equipment, district heating systems, finance houses and local contractors - Danvest will supply complete turn-key solutions.

Capacity:

<table>
<thead>
<tr>
<th></th>
<th>Electric Power</th>
<th>100-10,000 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard module</td>
<td>100-1,500 kW</td>
<td></td>
</tr>
<tr>
<td>Fresh water</td>
<td>100-20,000 m³/day</td>
<td></td>
</tr>
<tr>
<td>Standard module</td>
<td>100-3,000 m³/day</td>
<td></td>
</tr>
</tbody>
</table>

In Summary: The preconditions for introducing wind energy conversion systems in isolated grids gives a financial motivation to search for alternative technology solutions which can reduce energy production based on expensive fuel. The Danvest WD system provides the solution.

Danvest has extensive know-how based on experience with design, engineering (diesel engine know-how), production, installation, operation and implementation of WD systems, and we have been at the forefront of innovative developments and the designs of WD concepts to viable and commercial extents.

The following key features of the Danvest WD system:

- The diesel generator sets operate independently from but in parallel with the WD system, this means that if a breakdown occurs in the WD equipment, it is cut out and the diesel based generator sets continue operating.
- The WD system must be simple and robust - making it possible for existing staff to operate and maintain after a brief induction and training session.
- The WD system including wind turbines is based on worldwide known and proven technology securing high reliability of operation and maintenance.
- The WD system operates automatically and continuously - often replacing manual and periodic operation in existing systems.
- The WD system takes over the full responsibility for continuously supplying power of high quality.
- The service system ensures optimal operating conditions through a remote worldwide communication system in parallel with similar systems for the wind turbines.
Danvest Dynamic Dumpload Controlling: Ensures a governing of the total rotatory system, where heavy masses from the wind turbines and diesel generator comprise a dynamic frequency system with the following effects:

- Minimize inertia gust
- Minimize wear on bearings, couplings and gear wheels
- Minimize transients in the electric system
- Stabilize fluctuations from wind and consumer power demand.

Optimal Design: With unique experience in the field of Wind Diesel installation for given locations, a calculation program is developed which Danvest uses to provide an optimal system design and to set up the most optimal component combination of wind and engine power capacities for the local installation to obtain the lowest kWh price. For feasibility studies the annual wind penetration and fuel saving is calculated and the amount of waste heat and surplus wind energy are calculated for utilisation.

High Wind Penetration: With our optimal design and engineering the lowest annual kWh cost is obtained, wherein the wind turbines capacity will often be 120-150% of the maximum consumer load during the day. Surplus wind energy will only take place at high wind which only occurs significantly fewer hours over the year compared to the many hours with average wind which covers the main part of the average power consumption over the year.

Performance Guarantees: The guarantees are split:

<table>
<thead>
<tr>
<th>Component</th>
<th>Is covered and flowed down to the component manufacturer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Is covered by Danvest:</td>
</tr>
<tr>
<td></td>
<td>Continuous power supply.</td>
</tr>
<tr>
<td></td>
<td>Wind energy converted into power at 95% +/- 2.5%.</td>
</tr>
<tr>
<td></td>
<td>Annual auxiliary power under 5% of consumer power.</td>
</tr>
<tr>
<td>Function</td>
<td>Danvest will continually ensure power balance between power consumption and production in obtaining high Plant efficiency as 95% +/- 2.5%.</td>
</tr>
<tr>
<td>Power Quality</td>
<td>At any operational mode within predefined limits:</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60Hz +/- 0.1-0.3Hz</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.8-0.98</td>
</tr>
<tr>
<td>Harmonic vibrations</td>
<td>under limited demand</td>
</tr>
<tr>
<td>Quality</td>
<td>according to EU standard.</td>
</tr>
</tbody>
</table>

PC Based Remote Monitoring and Adjustment System: For remote controlling via the Internet in parallel with wind turbine control systems. In this way the WD plant - engine conditions - can be controlled and adjusted from a central service centre by skilled engineers or an authorised local engine agency.

Life Time: Life time is up to 20 years for the main components including the diesel engine because of the high wind penetration with reduced diesel engine operation.

Contact: to discuss the advantages and cost savings that a Danvest WD system can bring to your specific power or water operation, or to order a Danvest WD turn-key solution please contact:

Danvest Energy A/S, Tuborg Boulevard 12, 2900 Hellerup, Denmark
Website: [www.danvest.com](http://www.danvest.com)