Energy Neutrality in the Water Industry

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Helge Vandel Jensen, Senior Business Development Manager, Power & Energy, Danfoss Drives

helge@danfoss.com
Key facts

26,645
Employees

2017 Sales
5.8 bn EUR

WORLDWIDE SALES
in more than 100 countries

PRIVATELY HELD
Ownership

72 FACTORIES
in more than 20 countries

NORDBORG,
DENMARK
Headquarters
Business segments

**DANFOSS POWER SOLUTIONS**

- **#2 Market position**
- 32% of Group net sales
- 6,815 employees
- 22 factories in 11 countries
- 1.9bn EUR

**DANFOSS COOLING**

- **#1 Market position**
- 27% of Group net sales
- 6,396 employees
- 13 factories in 10 countries
- 1.6bn EUR

**DANFOSS DRIVES**

- **#2 Market position**
- 24% of Group net sales
- 4,652 employees
- 11 factories in 7 countries
- 1.4bn EUR

**DANFOSS HEATING**

- **#1 Market position**
- 17% of Group net sales
- 5,339 employees
- 26 factories in 12 countries
- 1.0bn EUR
The Water – Food – Energy - Nexus

As population grows, pressures mount

And the relationships between food, water, and energy supplies become critical

Because of growth in global population and the consumption patterns of an expanding middle class, in less than two decades three key demands will sharply increase...

- Energy intensive desalinization efforts use energy to produce drinkable water
- Demand for food +35%
- Demand for energy +45%
- Demand for fresh water +40%

- Food production requires energy to plant and harvest
- Food production requires water
- Crops are being converted into biofuels in some countries
- Increased Urbanization
- Population Increase

www.cna.org/reports/accelerating-risks
Agriculture withdrawal ~ 70% of water globally

Figure 2: Regional variation in water withdrawal per capita and its use by sector.
The Water – Food – Energy - Nexus

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- Energy intensive desalinization efforts use energy to produce drinkable water
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- Population Increase
- Demand for fresh water +40%
- Demand for food +35%
- Demand for energy +45%
- Demands of Larger Middle Class
- Increased Urbanization

*www.cna.org/reports/accelerating-risks*
A few statements from the IEA World Energy Outlook 2016

Chapter 9: Water - Energy nexus:

- Water counts for 4 % of global electricity ~ Russia (+ gasoline)
- Electricity consumption expected to double next 25 years
- The energy saving in “450 Scenario” is ~ 70 large coal fired power plants
- Leakage reduction to 6 % as Denmark ~ 130 TWh saved ~ Poland’s entire electricity need
- Water provision and wastewater treatment ~ 30 – 50 % of municipal electricity bills
- The Aarhus Marselisborg WWTP facility in Denmark produces ~ 100 % more energy than is consumed
- Variable speed drives mentioned multiple places as a key component for obtaining these benefits
A case - Ontario Municipal Energy split

Table 1.1. Ontario Municipal Energy Use by Facility Type (2011)

<table>
<thead>
<tr>
<th>Municipal Energy Use</th>
<th>eGWh</th>
<th>% of Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water &amp; wastewater treatment &amp; pumping</td>
<td>2,235</td>
<td>38%</td>
</tr>
<tr>
<td>Administrative offices</td>
<td>765</td>
<td>13%</td>
</tr>
<tr>
<td>Ice arenas</td>
<td>599</td>
<td>10%</td>
</tr>
<tr>
<td>Indoor recreation facilities</td>
<td>579</td>
<td>10%</td>
</tr>
<tr>
<td>Gymnasiums &amp; recreation centres</td>
<td>462</td>
<td>8%</td>
</tr>
<tr>
<td>Fire stations</td>
<td>193</td>
<td>3%</td>
</tr>
<tr>
<td>Swimming pools</td>
<td>155</td>
<td>3%</td>
</tr>
<tr>
<td>Cultural facilities</td>
<td>92</td>
<td>2%</td>
</tr>
<tr>
<td>Ambulances</td>
<td>64</td>
<td>1%</td>
</tr>
</tbody>
</table>

Note: Energy use reported in equivalent gigawatt-hours (eGWh), combining multiple energy sources.

Municipal water and wastewater systems are typically the largest energy uses reported by Ontario municipal governments.
The energy neutrality concept is a lot more than optimizing the wastewater facility

<table>
<thead>
<tr>
<th>Water Production</th>
<th>Water Distribution</th>
<th>Wastewater Pumping</th>
<th>Wastewater Treatment</th>
<th>Energy Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-optimizing raw water pumping</td>
<td>Optimized pressure management/zones</td>
<td>De-ragging, prevent clogging, save energy</td>
<td>Real on-line computer control</td>
<td>High-efficiency CHP (Combined Heat &amp; Power) facility</td>
</tr>
<tr>
<td>Pumps which fit demand</td>
<td>Reduce leakage, also active leakage</td>
<td>Optimal pump and pump station design</td>
<td>High Speed Turbo blowers</td>
<td>Carbon harvest</td>
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<td>Reservoir filling at night</td>
<td>Adjust pressure to service level</td>
<td>Sludge age control</td>
<td>Energy-optimal “bottom” aeration</td>
<td>Insulation of digester</td>
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<tr>
<td>Avoid energy burners</td>
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<td>Avoid burning carbon</td>
<td>Electricity production when prices are high (sector coupling)</td>
<td></td>
</tr>
</tbody>
</table>

Highly efficient components and VSD’s in all process steps are preconditions
The energy neutrality concept is a lot more than optimizing the wastewater facility

Water Production

Energy reduction: 20-45%
Energy-optimizing raw water pumping
Pumps which fit demand
Reservoir filling at night
Avoid energy burners

Water Distribution

Energy reduction: 20-40%
Leakage reduction: 30-40%
Optimized pressure management/zones
Reduce leakage, also active leakage
Adjust pressure to service level
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Wastewater Pumping

Energy reduction: 5-25 (50)%
De-ragging, prevent clogging, save energy
Optimal pump and pump station design

Wastewater Treatment

Energy reduction: 25-60%
Real on-line computer control
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Energy Production

Energy production increase: 20-60%
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The effect of pressure management
Gold Coast Water, Australia

30% pressure reduction

Before pressure management

After pressure management

Reduction in service breaks 73%
Reduction in mains breaks 56%

Ref.: Guidelines for water loss reduction giz
Pressure management experience

Experience from:
- 112 systems
- In 10 different countries

Average result:
- 38% reduction in pressure
- New breaks reduced by 53%

Other benefits:
- Typically 38% water leakage reduction
- Energy consumption reduced by 20 – 40%
- Extended asset lifetime
- Fewer network related complains

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Energy surplus producing wastewater facility
Marselisborg WWTP Aarhus Denmark

- Size: 200,000 PE ~ 26,000 m³/day
- No external carbon sources
- 142% electricity in 2014
- Excess heat ~2.1 GWh/year in 2014
- Total energy produced ~ 192%

Advanced real-time online sensor based process control
Mindset change to e.g.: carbon harvesting, efficiency KPI’s, etc
Upgrade to highly efficient components based on ROI
SCADA fallback process control strategy
VSD’s on all rotating equipment
The World Wide first energy-neutral water catchment area – Marselisborg, Aarhus Water, Denmark

Fact box
• Energy neutrality for the whole water cycle (water supply + wastewater)
• Catchment area for 200,000 people. No wind, solar or heatpump energy is produced
• Based on energy savings & household wastewater energy production (no external carbon)

<table>
<thead>
<tr>
<th>Marselisborg catchment area</th>
<th>Status 2014</th>
<th>Status 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water treatment, distribution [kWh] (avg. 0.51 kW/m³, high)</td>
<td>3,1 mill</td>
<td>3,2 mill</td>
</tr>
<tr>
<td>Wastewater transport [kWh]</td>
<td>0,7 mill</td>
<td>0,8 mill</td>
</tr>
<tr>
<td>Marselisborg WWTP [kWh] (BOD₅ = 2,4/TN= 6,0/TP = 0.2)</td>
<td>3,4 mill</td>
<td>3,2 mill</td>
</tr>
<tr>
<td><strong>Total energy consumption [kWh]</strong></td>
<td><strong>7,2 mill</strong></td>
<td><strong>7,2 mill</strong></td>
</tr>
<tr>
<td>Energy production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity production [kWh]</td>
<td>4,4 mill</td>
<td>4,8 mill</td>
</tr>
<tr>
<td>Heat production [kWh]</td>
<td>2,1 mill</td>
<td>2,6 mill</td>
</tr>
<tr>
<td><strong>Total energy production [kWh]</strong></td>
<td><strong>6,5 mill</strong></td>
<td><strong>7,4 mill</strong></td>
</tr>
<tr>
<td>Own energy supply degree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wastewater treatment process, electricity and heat [%]</td>
<td>192 %</td>
<td>234 %</td>
</tr>
<tr>
<td>Wastewater treatment process, electricity [%]</td>
<td>142 %</td>
<td>150 %</td>
</tr>
<tr>
<td><strong>Total Marselisborg catchment area [%]</strong></td>
<td><strong>94 %</strong></td>
<td><strong>103 %</strong></td>
</tr>
</tbody>
</table>

290 VFD’s installed in catchment area
Energy Neutrality and Reduced water loss in the water cycle

Also referred to as:
Industry 4.0, Water 4.0, Digitalization of the water industry
http://www.danfoss.com/energy-and-water/#/