ENERGY MANAGEMENT IN A CHILLED WATER PLANT USING THERMAL STORAGE

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GROUPE ÉNERSTAT inc.
Scope

• Overview of the project
  – Storage Approach
  – Operating Schematic
  – Implementation

• Results
  – Monitoring Results
  – Economical Results

• Conclusion
TES Project in IBM Bromont
TES Project in IBM Bromont

- **Chilled Water Production Optimisation using Thermal Energy Storage**
- **Dismantling 2 Old Chillers (1000 tons each)**
  - Over a total of (7000 tons) of installed capacity in the Plant
- **Using Thermal Storage to reduce Peak Load as well as improving plant efficiency**
  - Integrated in a closed loop using water-glycol solution as a thermofluid (250 l/s or 4000 usgpm)
- **Improved control strategy**
  - To secure the chilled water supply to the plant
  - To simplify operation
Novanergy works to maximise efficiencies

Figure 32 - Chiller Performance Vs. Plant Load

Novanergy works to reduce this...
Storage approach

- **The Preferred Storage Approach**
- **Partial storage**
  - In the partial-storage approach, the mechanical equipment runs to meet part of the peak period cooling load, and the remainder is met by drawing from storage. The equipment is sized at a smaller capacity than the design load. Partial storage systems may be run as load-leveling or demand-limiting operations.
  - In a load-leveling system, the equipment is sized to run at its full capacity for 24 hours on the severe days. The strategy is most effective where the peak cooling load is much higher than the average load.
- **Partial-storage load-leveling operating strategy**
  - In a load-leveling system the equipment runs at its full capacity for 24 hours on the design day. When the load is less than the equipment output, the surplus energy is stored. When the load exceeds the capacity, the additional requirement is discharged from storage. A load-leveling approach minimizes the required equipment and storage capacities as well as GHG emissions for a given load.
Energy Efficiency

- The recharge is driving the energy efficiency of the process:
  - **NV1**: High Efficiency Compressor Operation
    - Charge the cold storage tank at low outside temperature
    - Reducing part load improves kW/ton
  - **Free cooling**: night free cooling may be moved to follow day loads
    - **NFC**: by charging the system directly with a cooling tower at night – during mid season –
    - **QFC**: by precooling the cold side to improve overall efficiency [Quasi-Free Cooling approach]
  - **Energy recycling**: exploiting plant energy rejection
    - **DER**: Direct recovery of rejected energy (condenser side)
    - **IER**: Using the differential between the Part load and the nominal operating condition of heating or cooling equipments to recharge at high efficiency eliminating part load operation (reducing energy consumption and equipment wear)
Implementation
2 Storage Tanks

- PCM with 30 F and 40 F melting point
- Useful capacity respectively of
  - 2226 tons-h
  - and 1995 tons-h
Thermodynamic cycle with TES

REFRIGERANT : R134a
COP : 6.324
COP* : 6.364
ηCARNOT : 0.703
Monitoring Results

- **Peak Shaving (kW)**
  - Reduction of Peak loads
    - Up to 1 250 kW
    - Compressor’s efficiency improvement
      - Average kW/tons improvement from 0.9 to 0.5 kW/tons
  - « Free cooling » during mid season

<table>
<thead>
<tr>
<th>Solar Rad.</th>
<th>Temperature (C)</th>
<th>Nbr Hrs</th>
<th>Nbr Hrs</th>
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<tr>
<td></td>
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<td>Wet Bulb</td>
<td>Amplitude</td>
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<td>12,6</td>
<td>1,8</td>
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</tbody>
</table>
Monitoring Results

- **Reduction in energy consumption (kWh)**
  - **Reduction of part loads**
    - Performance increase by more than 15%
  - **Reduction of winter consumption**
    - Improvement of winter free cooling by extending from September to May with a «Quasi Free Cooling» with storage at night: + 3000 hrs
    - Allowing for Higher return temperature from the Free cooling Exchanger
  - **Reduction in condensing temperature**
    - Recharge at night/lower outside temperatures (with average daily amplitude, it represents an improvement of 15% to 21% in kW/tons);
    - Condensing temperature optimization is a net thermodynamic improvement of more than 10% over the year.
Monitoring Results

<table>
<thead>
<tr>
<th>General results</th>
<th>Energy production and storage for the chilled water loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller water Production</td>
<td>18 728 tons-h/day</td>
</tr>
<tr>
<td>Daily Consumption</td>
<td>16 706 kWh/day</td>
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<tr>
<td>Average instantaneous Consumption</td>
<td>696 kW</td>
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<tr>
<td>Average Production (MCP + VFD Chiller)</td>
<td>--</td>
</tr>
<tr>
<td>Average Production (before)</td>
<td>780,3 tons</td>
</tr>
<tr>
<td>Free Cooling</td>
<td>750 tons (for 90% of time)</td>
</tr>
<tr>
<td>Total Chilled Water Production</td>
<td>1455 tons</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0.892 kW/tons</td>
</tr>
<tr>
<td>Efficiency (including Free Cooling)</td>
<td>0.478 kW/tons</td>
</tr>
</tbody>
</table>
Energy Management

- Novanergy - MCP1+MCP2:
  - Improvement in operating conditions for all the chillers in the plant
  - Reduction of 6% in the overall electrical energy consumption of the Plant

- 5 300 MWh per year
- 45% in GHG Emissions for Ch.Water
Economic Analysis

- Comparison with standard design (Common Chillers) show an important improvement in the Return on Investment with the Novanergy system.
  - Interest Rate: 4%; Present Worth Factor: 3%
  - Marginal energy cost: 0.0253 $/kWh
  - No Cost reduction considered (due to the elimination of a 1000 tons chiller)
  - The dollar value of the kWh savings was $134,400.
  - Additional savings from peak load shaving (kW) was $162,400 for a grand total of $296,800.
  - The net present value $\text{NPV} = $3.9 \text{M}$.

- Payback with 400 k$ in grants: **3.7 years**
  - The “Life Cycle Cost Analysis” do not consider the impact of maintenance cost reductions as well as the future price fluctuations of the energy sources which would seriously improve the numbers.
Conclusion

• TES Implementation Results in:
  - Reduction of the Peak Load
  - Reduction of the Energy Consumption
  - Simplification the operation and the maintenance
    • It Follows loads from 100 tons to 2500 tons;
    • It Reduces the Stop and Start to a minimum
    • It Reduces unefficient part loads to the mechanical units and corrects the original « Overdesign »
  - Chilled water supply more stable and safe
    • In case of power shortage or mechanical failure, two pumps are sufficient to operate the chilled water plant
  - Reduction in refrigerant needs (½ of the original design)
  - Reduction in GHG emissions by 45 %
Antarctic icebergs break off from ice shelves - floating ice that’s attached to the continent’s ice sheets. This satellite view shows the Larsen B Ice Shelf after it broke up in March 2002. We see an area about 100 miles across. Larson B is on the Antarctic Peninsula, which is warming. The part of Antarctica where the largest ice shelves are located is not warming.

A peek at the future projected by computer climate models finds that global warming will make its presence felt more dramatically by the end of this century through shifts in the weather and sea-level rise.

Sources: University of Arizona, National Center for Atmospheric Research, Intergovernmental Panel on Climate Change, University of North Carolina; Science Magazine

By Ron Coddington, USA TODAY

Josh Landis, National Science Foundation