Cutting Energy in a Commercial Office Building

A Case Study

Abstract

This article describes the achievement in energy savings through advanced optimal control of a medium sized commercial office building with a poor energy star rating. The building started with a conventional HVAC system without a centralised DDC control system. Implementing advanced optimal control with an Enertrol energy management control system improved the NABERS energy rating of the building from 0 to 3.5 stars. This reduced the energy consumption by 68% and greenhouse gas emissions by 55% on average. The potential of actual energy savings or improvement of the energy star rating for commercial buildings in general greatly varies with the current energy efficiency of the building; obviously, less savings are expected for a well preforming HVAC system with a higher energy star rating.

Enertrol is an advanced optimal control system that reduces energy and demand of commercial buildings and for industrial applications. With the growing concern of energy, and with the intention to improve the energy ratings of commercial buildings, Enman developed the 5th generation Enertrol package to maximise energy saving.

To test this evolutionary development Enman applied for government assistance through the Green Building Fund for 440 Elizabeth Street, Melbourne, a commercial building owned by Select Growth Properties Ltd and managed by Kliger Wood. Aus Industry provided a substantial grant through the Green Building Fund to implement this evolutionary Enertrol system.

HVAC System

Heating Ventilation and Air Conditioning (HVAC) is the primary energy user of most commercial buildings; 440 Elizabeth Street is no different. In this particular building each floor has its own Air Handling Unit (AHU) with a centralised cooling and heating system for chilled water and hot water throughout the building. Chilled water is provided through two old reciprocating water cooled chillers with two cooling towers. Hot water is provided from a central gas fired boiler. The hot and cold water are circulated through the building via pumps associated with the system. The chiller plant room is shown in Figure 1.

The office space temperature is controlled through a mixture of VAV and CAV systems. The entire system was controlled by a stand alone discreet control system without any centralized BMS (Building Management System). The control system had temperature based conventional economy cycle control. The chiller flow rate was controlled by partially closed valves in order to control the flow through the building with no variable speed control of the pumps.
New Control System

The overall building control system has been replaced by the Enertrol system. This used a complete new centralised BMS integrated with the Enertrol controller as shown in Figure 2.

The BMS provides the front end control that interfaces to the building facility managers through graphical representations of the entire system. The BMS also monitors and controls all of the field devices; from the sensors to the VAV/CAV and AHU controllers which control the entire HVAC system.

Enertrol provides all of the intelligence to perform the calculations for optimisation of the system. Enertrol has mathematical models which are continuously monitoring and optimising the plant and services in real time to minimise overall energy usage whilst maintaining the comfort level of the building. The mathematical models are tunable through a series of configuration displays contained in graphical representations within the BMS to adapt to the specific building control requirements.

Enertrol interfaces to the BMS gathering all the information needed for the decision making process including weather conditions, status of all of the field equipment as well as the incoming electricity and gas information. After Enertrol collects all the information and performs the calculations and reaches the decisions it then commands the BMS to control the entire HVAC system for optimal control scenarios. Enertrol also provides a comprehensive energy and performance reporting system through the BMS operator interface.
Enertrol Control Functions

A unique control system which provides energy savings are:

- **Chiller optimal control**
  - Variable optimal chilled water temperature control depending on cooling demand.
  - Optimal chiller loading provides required cooling at minimum energy input by chiller.
  - Chiller inhibit operation based on weather conditions minimises simultaneous or cycling of heating and cooling.

- **Boiler optimal control**
  - Variable hot water temperature mainly high and low hot water temperature depending upon heating load.
  - Boiler inhibit operation based on weather conditions minimises simultaneous or cycling of heating and cooling.
  - Boiler loading and selection for multiple boiler operation.

- **Cooling tower control**
  - This utilises water circulation for all the cooling towers all the time when any of the chillers are running.
  - Variable cooling water temperature to minimise the fan and chiller combined energy use. This uses a two speed fan on the cooling tower fans.

- **Optimal building and pre and post cooling**
  The start of the air conditioning plant is variable. Depending upon the weather conditions and building space temperature it calculates the start time of the HVAC system for a pre defined occupancy time. It also stops the chiller and boiler ahead of HVAC stopping time to utilise latent energy which reduces thermal waste at the end of the building operation.

- **Night purge**
  - Enertrol provides a control algorithm to pre cool the building at night when the ambient temperature can cool the building.

- **Enthalpy based economy cycle**
  Enertrol provides an intelligent optimal economy cycle control algorithm replacing the conventional temperature based economy cycle.
Demand Management and Control
Enertrol monitors both incoming electricity and gas meters. It monitors the electricity demand and controls the demand to a set target in order to maintain a contract demand and hence reduce electricity cost.

Energy Reporting System
Enertrol provides a comprehensive energy reporting function in order to create reports highlighting the energy performance of the building with regard to energy usage and greenhouse gas emissions.

Energy Saving
The system has been operational for only two months. Table 1 and Figure 3 show the energy savings for the month of September 2009 vs 2010. The month of September shows the energy savings after the Enertrol system was fully implemented.

Table 1: Energy & Greenhouse Reduction

<table>
<thead>
<tr>
<th></th>
<th>ENERGY</th>
<th>GHG CO₂-e Tonnes</th>
<th>DEMAND KW</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>On Peak kWh</td>
<td>Off Peak kWh</td>
<td>Total kWh</td>
</tr>
<tr>
<td>Sep-09</td>
<td>94,991.88</td>
<td>46,305.48</td>
<td>141,297.36</td>
</tr>
<tr>
<td>Sep-10</td>
<td>43,619.64</td>
<td>17,606.16</td>
<td>61,225.8</td>
</tr>
<tr>
<td>Saving</td>
<td>51,372.24</td>
<td>28,699.32</td>
<td>80,071.56</td>
</tr>
<tr>
<td></td>
<td>54.08%</td>
<td>61.98%</td>
<td>56.67%</td>
</tr>
</tbody>
</table>

Figure 3: Energy Use Profile Before and After Enertrol Implementation
The energy savings estimated by Enman prior to the project implementation were exceeded due to the success of the Enertrol system. The pre project estimated and post project actual savings are given below:

- Estimated energy (electricity) saving before project implementation: 39%
- Achieved energy (electricity) saving: 45%

Prior to the Enertrol implementation the building NABERS rating was very poor. The implementation of this system is expected to improve the energy rating by 2 to 2.5 stars.

**Lessons Learnt**

Building energy efficiency can be significantly improved and is economically viable through control system upgrades introducing VSD technology without undergoing major equipment changes such as chillers etc. However this efficiency depends upon the optimisation schemes utilized within the control system upgrade.

Figure 4 shows the electricity demand for the month of September 2009 vs. 2010.

![Figure 4: Demand Profile Before and After Enertrol Installation](image)

Energy saving achieved in the month of September is 56% while the system was still being fine tuned. It is expected that the overall energy (electricity) reduction round the year will be around 40% – 50% which is a major achievement in energy saving through the Enertrol advanced and optimal control algorithms utilized.

The savings from several functions as part of the Enertrol system are listed below. These savings apply to the affected equipment.

- AHU fan optimal speed control - 54%
- Pump optimal speed control - 37%
- Chiller and boiler optimal control - 25%
- Economy cycle advanced control - 30%
- Optimal pre and post cooling – 5%
- Night purge – 2-3%

The equipment operation hours have been drastically reduced and hence reduced the maintenance cost and increased the life of equipment. The chiller run hours were reduced by over 40% together with reduction of start/stop operation.
Conclusion

Building energy efficiency can be improved in many ways as has been outlined above; from energy efficient HVAC configuration, to replacing the chiller with new energy efficient models, to lighting upgrades, to lift control upgrades etc.; however energy efficiency improvement through advanced optimal control provides the maximum benefit per unit of capital investment. To achieve the maximum benefit it is imperative that the control system be commissioned and tuned properly to match the building applications.

For further details contact

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