"INOGATE Technical Secretariat & Integrated Programme in support of the Baku Initiative and the Eastern Partnership energy objectives"

BUILDING PARTNERSHIPS FOR ENERGY SECURITY
INOGATE
New Technical Secretariat

Energy Audit in CHP and HOB

March 5, 2015
Chisinau, Moldova

Henrik Steffensen
A. DEVELOPMENT OF THE AUDIT MODEL
   I. Historical Aspects
   II. Motiva Analysis Model

B. IMPLEMENTING THE MODEL IN DIFFERENT POWER PLANTS
   I. Scheduling and Project Phases
   II. Savings Calculations
   III. Auxiliary Means

C. RESULTS AND EXPERIENCES

D. CASE STUDIES
   I. CHP power plant
   II. Municipal power plant
DEVELOPMENT OF THE AUDIT MODEL – HISTORICAL ASPECTS

ENERGY EFFICIENCY ASSESSMENT WORK HAS ALWAYS PLAYED AN IMPORTANT ROLE IN POWER INDUSTRY

- Feasibility studies, energy balance calculations, condition monitoring, etc.

ENERGY EFFICIENCY ASSESSMENT WORK HAD TRADITIONALLY MAINLY FOCUSED ON DEMAND SIDE

POTENTIAL FOR POWER PLANT PERFORMANCE IMPROVEMENT AND PROCESS INTEGRATION CAN BE IMPLEMENTED

ENERGY VOLUMES AT A POWER PLANT ARE CONSIDERABLE AND MUST THEREFORE BE EVALUATED AND COMPARED TO OTHER PLANTS
DEVELOPMENT OF THE AUDIT MODEL – ANALYSIS MODEL

- Power Plant Energy Audit Model includes
  - brief work instructions
  - reporting model (with remarks)
  - an example report of power plant energy audit

- Scope plants: Municipal power plants
  - CHP power plants
    - Conventional boiler plants (Peat, Coal, Oil, Natural Gas etc.)
    - Combined cycle power plants with gas turbine
  - Condensing power plants
  - Nuclear, wind and hydroelectric power plants are excluded

- Analysing concentrated on power plant processes
- Audit includes a plan and a schedule for implementing the proposed saving measures
Figure 1: Efficiency comparison between cogeneration and separate production of electricity and heat. (Numbers below arrows represent units of energy in typical values.)
<table>
<thead>
<tr>
<th>CHP plant type</th>
<th>Total efficiency (LHV) Fuel utilization rate</th>
<th>Power to heat ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas-fired boiler with extraction turbine</td>
<td>88 - 90%</td>
<td>0.20 - 0.35</td>
</tr>
<tr>
<td>Biomass boiler and extraction turbine</td>
<td>88 - 90%</td>
<td>0.20 - 0.35</td>
</tr>
<tr>
<td>Combined cycle gas turbine with steam turbine</td>
<td>85 - 92%</td>
<td>0.40 - 1.1</td>
</tr>
</tbody>
</table>
Environment
Composition of the natural gas consumed in Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>GCV kWh/m³</th>
<th>Methane</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>North sea</td>
<td>11.6</td>
<td>96</td>
<td>4</td>
</tr>
<tr>
<td>Algeria</td>
<td>11.3</td>
<td>84</td>
<td>17</td>
</tr>
<tr>
<td>Russia</td>
<td>10.8</td>
<td>98</td>
<td>2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>9.2</td>
<td>81</td>
<td>19</td>
</tr>
</tbody>
</table>
ANALYSIS REPORT MODEL

1. Summary
   - text
   - tables 1,2
   - economical profitability

2. Basic info

3. Energy Production and use

4. Plant processes, economy and impacts

5. Saving measures, economy and impacts

TABLE 1

<table>
<thead>
<tr>
<th>Fuels (GWh/a)</th>
<th>Heat prod.</th>
<th>Electr prod.</th>
<th>Efficiency (%)</th>
<th>Investments (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

TABLE 2

<table>
<thead>
<tr>
<th>Savings</th>
<th>Invest.</th>
<th>Pay back period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saving measur. 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saving measur. 2</td>
<td></td>
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ENERGY ANALYSES REPORT
Company Ltd
Helsinki 5.9.1999
Company Oy

Kauppa ja teollisuusministeriön energiakatselmushanke
DNro: 333/954/93
Päätöksen pvm: 30.12.1993

J P - TALOTEKNIKKA
PL 37, 00331 HELSINKI

Investments (€)
Internal consumption and losses
Fuel Value: 3,6 mln USD

Energy input
Fuel value:
32.781.967 m3
0,5 USD/m3

100 %

CHP 1
Average for 2011-14

Heat delivered to the network
Fuel Value: 10,2 mln USD

Elecricity delivered to the grid
Fuel Value: 2,6 mln USD

16 %

22 %

62 %
Internal consumption and losses
Fuel Value: 1.3 mln USD

Energy input
Fuel value: 16.4 mln USD
100%

Heat delivered to the network
Fuel value: 12.5 mln USD
76%

CHP 1
Average for 2011-14
16%

Electricity delivered to the grid
Fuel value: 2.6 mln USD
8%
THE TYPICAL BOILER PLANT FOR A HEATING INSTALLATION

To the right is shown the scheme of a typical boiler plant with one boiler, shunt and pump, safety valve and manometer and a pair of valves towards the heating installations.
THE PRE-INSULATED DH PIPES ARE INTRODUCED TO THE BOILER ROOM

The DH pipes are introduced in the boiler room and finished with two main cut-off valves.

Connections for all pressure ranges are done in the same way.
Temporary recirculation as a bypass can be mounted. For pipe leakage detection wires are connected.

The dismantling of the boiler and accessory equipment can begin.
The boiler and accessory equipment have now been removed.

The heat exchanger or the pre-manufactured DH unit can be placed.

A set of cut off valves are often placed for other parallel primary connections such as heat exchangers and domestic hot water tanks with coils etc. These are blocked either with end caps or blind flanges if not used. We will revert to this later.
The heating installation is separated from the higher pressure in the DH system by the heat exchanger.

Due to the risk of overpressure on the secondary side, one or two safety valves have to be installed.

The heat exchanger also serves as a shunt and separation of the fluid in the DH network and the heating installation. Many DH operators will not allow that the DH water circulates in the consumers installations.
To control the temperature on secondary supply, a thermostatic valve can be mounted. This allows constant supply temperature independent of the primary supply temperature.
To avoid dirt and sludge in the heat exchanger, filters are mounted on both primary and secondary side.

To measure the pressure and pressure drops, manometers are mounted.
The pressure drops over the filters can also be done by using one manometer instead of two.

This will avoid possible measuring faults between two manometers.
To make a quick supervision possible during operation, thermometers are installed in four places.

DH-supply and return

Secondary supply and return
The energy supplier will install the energy meter and replace the fitting pipe with the flow part of the energy meter and will install the two sensors in pre-mounted sockets.
If the control valve cannot operate reasonably under the differential pressure in the network, a differential pressure valve can be mounted measuring the $\Delta P$ over the valve.
Emptying and cleaning spigots (taps)

From time to time the heat exchanger needs to be cleaned.

For this is used CIP equipment.
The thermostatic control valve can - with advantage - be replaced by a motor valve connected to an automatic control panel.

The secondary supply temperature is now adjusted according to the outdoor temperature. The secondary return temperature is monitored and can be used for max. DH return temperature limitation.
Often the monitoring on the primary return temperature is used for max. DH return temperature limitation. But that can cause commuting (....) in the DH supply
Extra sockets for additional sensors can be mounted.
NECESSARY EQUIPMENT AND OPERATION
Aftager kan tilpasse anlæg.
Dobbeltbuds og uregulerede anlæg SKAL undgås
Ny regulierbar pumpe anbefales.
Lige ind/udløb (UF 65-S)

<table>
<thead>
<tr>
<th>Måleneurope</th>
<th>Anbefalet min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN15...DN80</td>
<td>q0,6...q40</td>
</tr>
<tr>
<td>DN100...DN250</td>
<td>q60...q1000</td>
</tr>
<tr>
<td></td>
<td>5xDN indløb</td>
</tr>
<tr>
<td></td>
<td>10xDN indløb</td>
</tr>
<tr>
<td></td>
<td>3xDN udloeb</td>
</tr>
</tbody>
</table>

Aftager kan tilpasse anlæg. Dobbelthunts og uregulerede anlæg SKAL undgås.
God areal på beholder
Spiralen manifold udføres som vendt retur.
Manifold og nederste spiraler i større dim. giver lavere hastighed
ved 2 stage spir udføres nederste spiraler i større dimension.