Industrial Process And Energy Optimization
Industry Workshop

Energy Savings Assessment Methodology –
Cost Effective Ways of Establishing the Action Plan

By

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**Energy Savings Assessment Methodology Cost Effective Ways of Establishing the Action Plan**

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Approved for public release, distribution unlimited

Driving Forces (in random order)

* Need for modernization (old junk with poor function needs to be replaced)
* Saving (energy) money
* Reduced maintenance costs
* Better - quality of products
  - productivity
  - indoor climate => health and well-being
* Environmentally sound to reduce energy related emissions
“The critical Eye” and “The questioning Mind”

These are important tools to detect the defects.

*Why do you have all these technical systems?
*What is the purpose of having this ventilation system?
*Why heat, ventilate and illuminate 100´ sqft 24 hrs per day when you only use 20 % of the space, between 7 a.m. and 5 p.m?
*How does one system affect other systems?
Six Sigma as base for Systematic Energy Systems Analysis

Define the Defect

Measure Costs of Defect

Analyse and Suggest Solution

Implement suggested Measures

Control that you Achieve the resulting change
How do you define the DEFECT?

The Defect is:

**Unnecessary Energy Use**, i.e.

Energy that you use without you being aware of it or you just don’t give a damn about it.

At least, it does not contribute to your output.
System defects occur

In the **swamp** between Technical Systems, Organisation, Responsibility and Motivation

Age of equipment
Lack of routines
Lack of maintenance
Lack of responsibility

It cannot be lack of knowledge or skills !?
System Defects, examples

Simultaneous cooling and heating / moisturising and dehumidification

Lighting at day-time with maximum cooling loads

Cooling loads without external sun protection (external blindfolds or sun protection film on windows)

Separate and independent cooling units for every machine (electronics). Causing massive cooling loads for central cooling system

Aerotempers heating air inside open doors / air locks
Examples of Defects, discovered by “The critical Eye” and “The questioning Mind”

1. The timer that seemed to be wrong by 12 hours. That was the case but it also only had the possibility to turn equipment on, never off. This meant 8760 hrs/year.

2. The ground heating system that tried to heat the Swedish ground to +20 °C. The staff thought that the thermostat setting was for an aerotemper.

3. The compressed air duct that went under the concrete floor in a factory and ended with an open end. It was discovered when the durability of the floor was checked. 5 m³/min for 10 years cost a lot of money. One year earlier the company bought a new compressor since they were short of capacity…. 

Methodology for Success in Industrial Plants

- Standardized Questionnaire
- Preparation before inventory
- Inventory of plant and facilities
- 20 Points Check List
- Measurements of loads of interest
- Analysis and Tools to Establish Status Report and Suggested Measures
- Profitability and Financing. **Point of Decision**
- Implementation under Supervision
- Recurrent Staff Training to Achieve Long-Lasting Top Performance
- Follow-Up and Operational Phase
- Changing Conditions – Continuous Improvements
Methodology

Target: Reduce energy use/ costs/ environmental emissions by at least xx %

Tools for analysis and calculations:
- Ventilation calculation program
- TeknoSim
- Energy Balance
- Environment/ Energy/ Cost follow-up spread-sheet
- Life-Cycle Cost analysis tools
- MILP tool

Tools for continuity:
- Check lists
- Follow-up, key figures
- Action plan at deviation from target

Continuous improvements !!
## Areas of Improvement, examples

<table>
<thead>
<tr>
<th>Energy Contracts</th>
<th>Production / Processes</th>
<th>Building and Supply systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Electricity</td>
<td>• Machines/equipment</td>
<td>• Building envelope</td>
</tr>
<tr>
<td>• Fuels or heat</td>
<td>• Coolant systems</td>
<td>• Heating system</td>
</tr>
<tr>
<td>• Compressed air</td>
<td>• Washing processes</td>
<td>• Cooling system</td>
</tr>
<tr>
<td>• PFC contracts</td>
<td>• Process ventilation</td>
<td>• Ventilation</td>
</tr>
<tr>
<td></td>
<td>• Use of compressed air</td>
<td>• Lighting</td>
</tr>
<tr>
<td></td>
<td>• Combustion of solvents</td>
<td>• Compressed air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tap water system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• HVAC control and regulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Moisturising / dehumidification</td>
</tr>
</tbody>
</table>

Organization, Routines, Responsibility, Motivation
20 Points Check List
For Industrial Plants and Comm. bldgs

To be used on-site, at Inventory phase

Gives you 80 % of profitable possible savings

Singularities stand for the remaining 20 %. These are new ones at every single plant

For commercial buildings the ratio is 90 / 10

Covers all areas of production, organization, technical systems performance and efficiency
20 Points Check List, Examples (11 Points)

Production hours, divided on departments
Operating hours, ventilation, lighting....
Temperature set values, heating system, ventilation, cooling system
Temperatures in premises, different parts
Doors, gates, air locks, heaters in air locks
Cooling machines (process and general), COP, status, temperatures
Max Peak Demand, time of day, year. Annual energy use
Compressed air: 5 step action program
Process interaction with each other and with supply systems
Night Time Walkabout
Benchmarking, key figures.
Night Time Walkabouts

“The Crocodile Dundee method”

Unsurpassed efficiency in detecting defects

Night or Weekend

No advertising
Bring one of the bosses, with economical responsibility and enough power to make changes
Document your findings written report photographs

Use results for improvements, not for accusations
Analysis tools, part of the tool-box

• Energy balance programs, for buildings
• Ventilation system calculations, heat and electricity
• Check lists, energy system reviews
• Measurements
• Cause and effect analysis
• LCC analysis tool kits
• Pinch analysis
• Optimization models, LP or MILP
• PLC recordings in manufacturing processes
• Check list / guidelines for new equipment, new processes, purchasing routines
• Environmental and cost follow-up tools, spread-sheets
• Energy coordination (for new buildings and industrial plants)
• Simulation programs (CFD, Teknosim...)
Energy Systems Simulator/Optimizer

- ... is a software product for cost-optimizing the energy system. The objective is to minimize the system cost, consisting of investment costs, energy costs and raw material costs. The structure of the energy system is represented as a network of nodes and branches. A MILP model of the energy system is generated.

Industrial Energy System

- Equation matrix describing all relationships and limits within the system

Fuel  
Electricity  
Material  
Production Demand

In co-operation with Linköping University, Div. Energy Systems
Energy Systems Simulator/Optimizer

- Forecast the energy need; days, weeks or years ahead
- The effect on energy costs when investing in new process technology or new equipment
- Analyse the cost when converting to other energy carrier
- Analyse the effect on higher electricity costs, taxes on CO₂
- Simulations to study the impact of changed boundary conditions on the total system
- Increased awareness. Perform systematic analyses and avoid suboptimization. Simplifies continuous optimization
- Optimization of production strategy
Six Sigma as base for systematic Energy Systems Analysis

D - Define the Defect
M - Measure Costs of Defect
A - Analyse and Suggest Solution
I - Implement suggested Measures
C - Control that you Achieve the resulting change
Transfer Machine, changed operation

Principal process map over improvement

Before improvement
- OP in waiting position for a new part > 2 min
- OP in waiting position for a new part < 2 min
- In conveyer empty or out conveyer full

After improvement
- OP in waiting position for a new part > 2 min

Focus on:
- spindel engine
- cutting fluid
- ventilation
- hydraulics

kW
Coolant System at Engine Factory

- Coolant flow
- Machine
- Filter and water pump
- Container
Coolant flow and Chip Transport in channel under machines
Logging PLC signals and Energy

Energidata + PLC signaler + Ventilation OP 80 under mätperioden (19/6 - 25/6)

CHTOT kW

Ventilation
Vakumpump 1 (15 kW)
Vakumpump 2 (15 kW)
Kavitationspump (90 kW)
Filterpump (22 kW)
Hydraulikpump (7,5 kW)
Avkylningspump (15 kW)
Blåsfläkt/torkfläkt (1,1 kW)
Varmluftselement (24 kW)
Vattenvärme (72 kW)

1290 detaljer
2003 detaljer
64 detaljer/h
57 detaljer/h
Unnecessary energy use = DEFECT

OP 70

Compressed air

Ventilation

Control Process ventilation via signal coolant "on"

Coolant

New method for position control; benchmarking with other machines in same factory: shut off when done

Shut off when machine not in operation?

Optimize coolant flow

Coolant flow "on" continuously

Exchange 90 kW pumps
Pumps only in use when needed

Meas. station

Install magnetic valve

Optimization of spindle benchmarking Ford

Exchange 90 kW pumps

Fish bone diagram, OP 70. Brainstorming result
Calculated savings, based on measured data

Saving potential, one year for Op 70
GROB Transfer machine

From 2 to 1
From 3 to 2
From 3 to 1
From 3 to 1 and from 2 to 1
Total energy use

<table>
<thead>
<tr>
<th></th>
<th>kWh</th>
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<tbody>
<tr>
<td>From 2 to 1</td>
<td>5027</td>
</tr>
<tr>
<td>From 3 to 2</td>
<td>111,775</td>
</tr>
<tr>
<td>From 3 to 1</td>
<td>121,411</td>
</tr>
<tr>
<td>From 3 to 1 and from 2 to 1</td>
<td>126,439</td>
</tr>
<tr>
<td>Total energy use</td>
<td>516,202 kWh</td>
</tr>
</tbody>
</table>
**Transfer Machine Savings by minimized idling time. Achieved results.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine operation, electricity</td>
<td>99 MWh/year</td>
</tr>
<tr>
<td>Process ventilation, electricity</td>
<td>7 MWh/year</td>
</tr>
<tr>
<td>Process ventilation, heat</td>
<td>40 MWh/year</td>
</tr>
<tr>
<td>Coolant pumping, electricity</td>
<td>20 MWh/year</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>166 MWh/year (-19%)</strong></td>
</tr>
</tbody>
</table>

In addition: Compressed air (not measured)  
Handling of coolant, cleaning, cooling...  
More to be done (pumps, pressure......)

**All of this easily achieved by re-programming PLC**
And finally...........

Some hard examples on complex relations from reality....... 

The old-fashioned way; Could we please start the overhead projector now?