Energy Saving System in Industry

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Energy Saving System in Industry

- Economical need of Energy Saving
- Concept of Cleaner Production
- Energy Saving Technology
- Heat pump as the Energy Saving Technology
- History of Heat Pump in Brewery
- Virtual Factory as the Energy Saving Tool
- Sample of Virtual Factory
- Reference of Energy Audit with Virtual Factory
- Reference of Energy Saving CDM
World wide increase of the Energy Cost
Push up the Break Even Point.

1. Economical need of Energy Saving

Back ground
> industrialization,
> exhaustion of resources
> population increase,

Break-even point shifts to higher sales amount and less profit.
Global Warming Effect is one of the huge External Diseconomy. The effect of Climate Change may be physical, ecological, social or economic. External Diseconomy should be change into Internal Diseconomy.

Outside Diseconomy: medical cost, waste treatment cost etc.

Inside Diseconomy:
- Residence
- River pollution
- Sea pollution

Factors:
- Waste
- Effluent
- Exhaust gas & CO2

1. Social need of Energy Saving
**Definition of Cleaner Production (CP)**

- **Cleaner production** is a preventive, company-specific environmental protection initiative. It is intended to minimize waste and emissions and maximize product output. By analyzing the flow of materials and energy in a company, one tries to identify options to minimize waste and emissions out of industrial processes through source reduction strategies. Improvements of organization and technology help to reduce or suggest better choices in use of materials and energy, and to avoid waste, waste water generation, and gaseous emissions, and also waste heat and noise.
Terms Related to Cleaner Production

- Waste minimization
- Pollution prevention
- Eco-profitability
- Low/non-waste technologies
- Zero waste emission
- Green productivity
- Lean manufacturing
Material Balance Model

Raw materials → 90 → Finished products → 80

Product waste/ negative economic value → Waste (material, water) → 10
Improved Specific Energy Consumption

Specific Energy input: 100/90
- Energy saving

Specific Energy output:
- 100/90 >>
- Waste heat Reduction

Raw materials: 100
- Product waste/ negative economic value
- Waste (material, water)

Finished products: 90
- 80
- 10
Material & Energy Stream of Factory

Efficiency

Production efficiency (yield) =

Specific energy (utility) consumption =

Energy, Utility

Raw material

Product

Process 1

Process 2

Process 3

Waste heat

Waste water, waste

Product

Energy, Utility

Product
Production efficiency improvement and Energy efficiency improvement will contribute to factory management and environment conservation.

Concept of Cleaner Production

The Natural relationship in CP

- Increase in yield
- Increase in profit
- Decrease in waste
- Decrease in waste treatment cost
- Environment-friendly
- Increase in energy efficiency / production
- CO2 emission reduction
- Energy efficiency improvement
Benefits of Cleaner Production

- Increased productivity
- Reduced operating costs
- Public health and environmental benefits
- Improved worker health and safety
- Reduced risk of liability
- Improved corporate image
- Improved global competitiveness
Benefits:

- Organized workflow
- Reduced water spillages
- Increased productivity

**Before CP**: unorganized workflow and production area

**After CP**: layout modification
Benefits:

• Reduced water consumption and wastewater generation by about 160 m³/month (75% reduction)

• Dry area

• Reduces workers’ risk

Uses continuous flow of water
Water overflows from the tub

Uses cooling tower that recycles water for the cooling tank

Savings: 1,920 m³ water/year
3 Approaches which contributes to Energy Saving in Factory

- Production Technology > Process Engineering
- Manufacturing Technique > Manufacturing Engineering
- Energy Saving Technology > Thermodynamic Engineering

- Cooperation of these 3 kind of Engineer should realize an effective Energy Saving System.
Production Technology

- Production Technology can save the Energy by....
  a. Modification of production process.
  b. Developing new process.
  c. Developing new method.
Manufacturing Technique can save the Energy by....

a. Increasing productivity

b. Modification of Layout

c. Better operation Technique
Thermodynamic Technology

- Thermodynamic Technology can save the Energy by....
  a. Efficient Use of Energy; Cascade use of Heat
  b. Heat recovery and Recycle; Heat Pump
  c. New Energy generation from Waste; Biogas utilization Technology from Waste water & Biomass Energy generation from Waste.
  d. Energy Efficient improvement of Equipment
Improvement of Thermal efficiency of Cooking Sweat Bun (for understanding)

Simple Steamer
- 50% steam is exhausted from top
- Thermal efficiency should be 35% with gas burner
- Energy: 100%

Effective Use of Steam
- 1st step
- 52% energy
- Only 5% steam is exhausted
- Thermal efficiency should be 35% with gas burner

Efficiency Improve with Boiler Steam
- 2nd step
- 24% energy
- Multi use of steam and productivity increase with multi steam box
- Thermal efficiency should be 97% with steam

Efficiency Improve with Microwave Steamer
- 3rd step
- 54% energy
- Use of boiler or Microwave oven to reduce running cost
- Thermal efficiency should be 85% with microwave

<table>
<thead>
<tr>
<th>1st Step</th>
<th>2nd Step</th>
<th>3rd Step</th>
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<tbody>
<tr>
<td><strong>Production Technology</strong></td>
<td>Making Recipe. Cooking with high density steam to avoid dryness.</td>
<td>Analyze the gelatinization</td>
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<td><strong>Manufacturing Technique</strong></td>
<td>Supply much steam to keep steam density.</td>
<td>Multi use of steam and productivity increase with multi steam box</td>
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<td><strong>Thermo Dynamics</strong></td>
<td>Observation of Steam behavior</td>
<td>Analysis of Heat demand</td>
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Thermal efficiency should be 35% with gas burner:
- 1st step: 100%
- 2nd step: 52%
- 3rd step: 24%

Boiler Efficiency: 80%
Power Generation Efficiency: 40%
Thermal Efficiency according Heat Source of Cooking

Microwave Oven

Thermal Efficiency
80~90%(35%)

Continuous Steamer

Key: Fill the equipment with high density steam
To reduce the intrusion of air as much as possible.
Too much air increase drying. > quality problem
> Increase the heat requirement.
Blower control is very important.
It should be control to minimize the air leak from open space (inlet and outlet of product) and minimize the exhaust from blower.

Heat recovery from the exhaust vapor as hot water with water scrubber.
It is important to minimize the air intrusion to increase the temperature of recovered heat.
If we can realize the 0 intrusion of air, recovered hot water temperature will be 100°C.
Vapor recovery and recycle System

Vapor Recovery and Recycle system with Steam Ejector. It can minimize the steam consumption by recycling the vapor. Minimum heat consumption is the heat to increase the temperature of sweat bun from inlet temperature to 100°C. Steam to heat up this temp. drive the ejector to pressurize the flash vapor.
Heat Pump as the Energy Saving Technology

**Pump & Heat Pump**

**Power requirement**

\[ P_r = f(G, H) \]

\[ P_r = 0.163 \times G \times H \]

\[ G; \text{ m}^3/\text{min} \]

\[ H; \text{ m} \]

**High temperature**

\[ T_c \]

**Low temperature**

\[ T_e \]

**Power requirement**

\[ P_r; f(Q_h, dT) \]

\[ P_r = \frac{Q_h}{COP} \]

**COP; Coefficient of Performance**

\[ COP_c = \frac{(273.16 + T_c)}{(T_c - T_e)} \]

\[ Q_h; \text{ kW/h} \]

\[ Q_c; \text{ kW/h} \]

**Low temperature**

\[ T_e \]
COP of Heat Pump

- **COP**: Coefficient of Performance
  - COP = output energy / input energy
- **Theoretical COP**: Carnot COP = \( \frac{273.16 + T_c}{T_c - T_e} \)
  - \( T_c \): Condensing Temperature
  - \( T_e \): Evaporative temperature
- **COPec**: Economical Marginal COP
  - COPec: Electricity cost (yen/kWh) / Fuel Cost (yen/kWh)
- **COPem**: Environmental Marginal COP
  - environmental impact of electricity per kWh / environmental impact of fuel per kWh
  - Environmental impact: global warming, pollution, etc
Heat Pump as the Energy Saving Technology

Heat Pump for Air-conditioning

Winter

Room

Atmosphere

Summer

Atmosphere

Room
Heat Recovery by Heat Pump (Industrial Use)

Waste Heat → Heat Pump → Usable Heat
Carnot Cycle and Reverse Carnot cycle > current situation

- Carnot Cycle: Turbine
- Turbine efficiency has reached 55% of Carnot equitation.
- Reverse Carnot Cycle* Heat Pump, Refrigeration
- Current Heat Pump COP is only 20% of Carnot COP
  - Big Temperature difference of Condenser (Air cooled)
  - Big Temperature of Air Cooler
- Improvement possibility
  - Water cool or Evaporative condenser can increase COP
  - Water scrubbing Cooler can increase COP
  - It is possible to reduce 3% of Total Energy Consumption of Japan.
- Barrier
  - Hassle of handling of water
  - Big Inertia of current market Technology

Carnot Equatation
Output Work: (High Temp-Low Temp)/(273.16+High Temp.)

Current COP
Theoretical Output = 72%
Current Out Put 35-40%

Carnot Equatation
COP: (273.16+High Temp.)/(High Temp-Low Temp)

Theoretical Output = 19
Current COP 5
VRC; Vapor Re-Compression System
>Primitive and Efficient Heat Pump

History of Heat Pump in Brewery
VRC; First implementation 1982

- Barrier for implementation
  - a. Can not change the operation condition
  - b. Process Engineer afraid of Kettle crash
- Performance
  - a. COP; 7.3
- Specification of VRC
  - a. Recover Vapor; 10ton/h
  - b. Motor 1000kW

10ton Vapor 6267kWh
1000kW (850kWh)
COP; 7.37
3bar 133 degree C
VRC; Following effort

- Brewing Engineer
  - Analysis of Function and Mechanism of Wort Boiling > reduction of evaporation ratio 10% to 6.7%

- Process Engineer
  - Increase Efficiency of Cocker (Heater) > Discharge pressure became lower; 3bar(133dC) to 1.5bar(113dC)

- Heat Pump Engineer
  - More effective utilization of Energy

Figure 2: Wort movement
VRC; Latest VRC System

History of Heat Pump in Brewery

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# VRC; Comparison Table, First vs Latest

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<th></th>
<th>First</th>
<th>Latest</th>
<th>Difference</th>
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<tr>
<td>Capacity of Compressor</td>
<td>10t/h</td>
<td>4.7ton/h</td>
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<tr>
<td>Tc</td>
<td>133 degree C</td>
<td>113 degree C</td>
<td>20 degree C</td>
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<tr>
<td>Motor</td>
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<td>COP</td>
<td>7.34</td>
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</table>

**History of Heat Pump in Brewery**

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“Virtual Factory” as the Energy Saving Tool by Process Analysis

- Understanding the process in detail
- Understanding the energy usage mechanism in the process.
- Making the Virtual Factory in computer is very effective to understand the factory process mechanism.
- Virtual Factory is the communication tool for 3 kind of Engineer; Production, Manufacturing , Thermodynamic Engineer .
- Virtual Factory verifies the theoretical energy consumption to compare with the actual data.
- Virtual Factory accepts any changes easily and estimates the improved energy consumption accordingly.
- Energy-saving equipment and system can be also designed and implemented in the Virtual Factory.
Energy consumption in process units based on the Material & Energy balance analysis

“Example” of Wort boiling in Brewery

Estimated energy consumption

Process description

Material & energy balance
Structure of Virtual Brewery

Beer Brewing Process

Utility Buffer

Utility System

Waste Treatment System

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Energy-saving analysis using Virtual Factory

**Virtual Factory (existing)**

- Compare to Calculated result with actual data.
- Investigate the reason of differences
  - material loss, heat loss?
  - mistake in program?
  - control system?
  - bad efficiency of equipment
- Try to modify or adjust actual factory operation
- Try energy-saving operation referring to Virtual Factory data

**Virtual Factory (Energy saving Plan)**

- Design the energy saving System
- Estimate energy saving amount
- Feasibility study
  - location, available space
  - budget estimation
  - estimation of CER: Carbon Emission Reduction
  - CDM Project or not
- Economical analysis: IRR, PBP
Energy-saving activity

- Search the points of losses and repair or modify them.
- Modify or adjust control system.
- Clean or modify the heat exchanger.
- Add more data in monitoring system.
- Add more and appropriate buffers with control system in order to keep high-efficiency operation for the utility equipment such as boilers and compressors.
- Add heat recovery or biogas recovery system in order to reduce energy consumption.
- Modify the production process itself.
Sample of Virtual Factory - Sugar Mill Summary

Cane Receiving

Cane Milling

Juice Heating

Concentration

Crystallization

Bagass Boiler

Steam Turbine

Ethanol production

Sugar storage

Molasses Tank

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Sample of Virtual Factory - Palm Oil Summary
## Reference of Energy Saving Audit by Virtual Factory - 1

<table>
<thead>
<tr>
<th>Industry or Factory</th>
<th>country</th>
<th>year</th>
<th>Estimated Energy Saving</th>
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<td>Brewery</td>
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<td>Fish processing</td>
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## Reference of Energy Saving Audit by Virtual Factory -2

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### Reference of Energy Saving Audit by Virtual Factory -6

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<td>Hotel</td>
<td>Laos</td>
<td>2015</td>
<td>30%</td>
<td>OECC</td>
</tr>
<tr>
<td>Shoe Maker</td>
<td>Laos</td>
<td>2015</td>
<td>30%</td>
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</tr>
<tr>
<td>Pig Farming</td>
<td>Laos</td>
<td>2015</td>
<td>30%</td>
<td>OECC</td>
</tr>
</tbody>
</table>
Reference of Brewery in Vietnam - Thanh Hoa Beer

- Established in 1987
- 150km from capital Hanoi (3 hrs by car)
- 51ML annual beer production (in 2004, 7th largest production (1.2 million kL-beer total in Vietnam)
- ISO9000 certified in 2002
- Expanded production line in Apr 2004 (Capacity: 8kL/brew), and renewal of the exiting brewhouse (30kL/brew) in Sep 2004
- Products: Bia Thanh Hoa, Saigon, Hanoi
Reference of Energy Saving with CDM - MYCOM Project

 Implemented Energy-saving Systems

Latest VRC System

Optimal Pasteurizing System

Economical Methane recovery System

Cascade Cooling System

Dynamic Ice Storage/Transportation System

Ai-Ai Energy Associates
VRC System for Wort Kettle

Discharged steam has great energy!

Saving steam by reusing the discharged steam

Conventional heat recovery system

VRC system

COP=15~20

Ai-Ai Energy Associates
Wort Kettle: evaporates about 2 tons of water in 1 batch. The conventional system discharges waste steam into atmosphere.

Scrubber: cleans the waste steam and generates hot water for pre-heating the wort for the following batch.

99°C

85°C

97°C

78°C

Energy Storage Tank
61m³
Heat Pump for pasteurizer

- Temperature of Showering for final cooling zone is kept by Heat Pump Chiller stably.

- Heat Pump supply the condensing heat to the first heating zone to heat up the bottled Beer.

- Irregular operation (starting, finishing and temporary stop and restart), cooling tower supply and recuperate the heat of the pasteurizer depending on the situation.
Biogas Recovery System

Waste Water from Brewhouse

UASB (high temperature)

Bio-gas Boiler

Gas Holder

Gas compressor

Steam Accumulator
Cascade cooling system for ice water chilling

Water cooling from 28°C to 5°C (Large temp. differential).
Based on 1763kW (500TR) Cooling load.

Power consumption reduces to 60%. Compressor capacity reduces to 70%.

Conventional Cooling System

<table>
<thead>
<tr>
<th>Tc</th>
<th>Te</th>
<th>dT</th>
<th>kW</th>
<th>M3/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>0</td>
<td>35</td>
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<tr>
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<td>76</td>
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</table>

II Total: 219 1389

II /I: 60% 70%

II -I: 143 603

Cascade Cooling System

<table>
<thead>
<tr>
<th>Tc</th>
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</table>

II Total: 219 1389

II /I: 60% 70%

II -I: 143 603

Displacement volume of Compressor

COP=4.87

COP=8.06
Cascade Cooling System

Started operation in August 2005

Reference of Energy Saving with CDM-MYCOM Project

Ai-Ai Energy Associates
Dynamic Ice Storage & Transportation System

Dynamic Ice Storage Tank

Jacket cooling

Plate cooling

Air cooler

Dynamic Ice Transporting Loop Piping

Reference of Energy Saving with CDM-MYCOM Project
## Comparison table of Transportation Performance

<table>
<thead>
<tr>
<th>Transport system</th>
<th>Dynamic ice</th>
<th>Chilled water</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td>-2°C/3°C</td>
<td>0°C/3°C</td>
</tr>
<tr>
<td><strong>Specific heat transportation</strong></td>
<td>19.8W/kg</td>
<td>3.5W/kg</td>
</tr>
<tr>
<td><strong>Diameter of Pipe</strong></td>
<td>125mmNB</td>
<td>250mmNB</td>
</tr>
<tr>
<td><strong>Required volume of water</strong></td>
<td>59m³/h</td>
<td>332m³/h</td>
</tr>
<tr>
<td><strong>Required pump power</strong></td>
<td>5.5kW</td>
<td>30.0kW</td>
</tr>
<tr>
<td><strong>Running cost</strong></td>
<td>83yen/h</td>
<td>450yen/h</td>
</tr>
</tbody>
</table>

Cooling load is 1000Mcal/h
Head of pump is 20m
Dynamic Ice System

Heat recovery from NH₃ discharge gas to make hot water

Pd: Td: 110°C

Refrig. Comp. No.1 100kW
Refrig. Comp. No.2 100kW
Refrig. Comp. No.3 100kW
Refrig. Comp. No.4 100kW

Dynamic Ice Maker

Dynamic Ice Storage tank -4°C, 170m³

To use existing refrigeration compressor to make dynamic ice
Total Energy Saving Performance

- Energy-saving: 3,386 Toe
- CO2 emission reduction: 10,376 Ton
Thank you for your attention!