Issue and direction of Energy Network Optimization in Petrochemical Industry

Infotrol Technology, Co., Ltd. since 2004
## Revision History

<table>
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<th>Date</th>
<th>Version</th>
<th>Author</th>
<th>Comment</th>
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<td>2015. 10. 15</td>
<td>1.0</td>
<td>KTW</td>
<td>Presentation Content Scheme</td>
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<td>2015. 10. 16</td>
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<td>2015. 10. 19</td>
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**Energy Network in Process Industry**

- **Definition:** Network of energy production, distribution and consumption
- **Network composition:** Furnace, Boiler, gas turbine, HRSG, turbine, heat exchanger, electrical/steam motor, let down equipment, heat pump, header line and users, etc.
- **Application area:** Process industry such as petrochemicals, refinery and chemical companies etc
# Energy Network Management Issues & Solutions

Typical energy management issues and solutions with economic effect in process industries such as petrochemical, refinery, etc.

<table>
<thead>
<tr>
<th>Issues</th>
<th>Solutions</th>
<th>Estimated Effect</th>
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<tbody>
<tr>
<td>Steam production and consumption is not matched (energy imbalance)</td>
<td>Data reconciliation based steam balance</td>
<td>Increased steam data accuracy</td>
</tr>
<tr>
<td>Not concern on measurement error</td>
<td>Data reconciliation based steam balance</td>
<td>Erroneous measurement detection and management</td>
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<tr>
<td>Unknown energy loss</td>
<td>Systematic unknown loss identification through energy balance</td>
<td>Unknown loss identification and reduce energy loss</td>
</tr>
<tr>
<td>Building steam balance for an event takes a long time</td>
<td>Real time on-line steam balance system</td>
<td>Reduced engineer work load and improve energy system analysis</td>
</tr>
<tr>
<td>Energy intensity increase from the operational mistake</td>
<td>On-line operational surveillance and measure system</td>
<td>Improve energy intensity by reducing the operational mistake</td>
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<tr>
<td>Difficulty in setting new steam balance for operational and/or process changes</td>
<td>Build what-if utility simulator</td>
<td>Complex-wide economic analysis for process and/or operational changes</td>
</tr>
<tr>
<td>Do not know whether the current steam operation is optimal</td>
<td>Need to build the optimal steam system</td>
<td>Reduce energy intensity while supplying the required energy</td>
</tr>
<tr>
<td>Do not fully utilize the steam potential energy (exergy)</td>
<td>Build the steam utilizing maximization system</td>
<td>Maximizing the steam energy utilization</td>
</tr>
<tr>
<td>Lack of efficient response for the electric price change</td>
<td>Build the optimal system considering the electric price</td>
<td>Economic benefit from optimal operation of electric production and import</td>
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## Required energy management system to minimize the energy intensity

<table>
<thead>
<tr>
<th>Area</th>
<th>Required Function</th>
<th>Estimated Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant-wide energy network</strong></td>
<td>• Provide plant-wide energy network overview</td>
<td>• Capturing plant-wide energy flow</td>
</tr>
<tr>
<td><strong>steam/energy balance and Energy</strong></td>
<td>• Data Reconciliation based energy mass balance</td>
<td>• Enhanced accuracy of energy balance</td>
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<tr>
<td><strong>management system</strong></td>
<td>• Real time on-line management of energy production and consumption</td>
<td>• Real time on-line energy management</td>
</tr>
<tr>
<td></td>
<td>• Energy loss identification</td>
<td>• Reduce energy loss</td>
</tr>
<tr>
<td></td>
<td>• Easily maintenance and update of the system</td>
<td>• Fast respond for process and/or operational change</td>
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<tr>
<td><strong>Energy system what-if simulation</strong></td>
<td>• Simulate for the process and/or operational change</td>
<td>• Establish new steam balance for changed process and/or operation</td>
</tr>
<tr>
<td></td>
<td>• Evaluate complex-wide benefit from the subprocess energy reduction</td>
<td>• Economic analysis of each subprocess energy reduction</td>
</tr>
<tr>
<td></td>
<td>• Define new energy projects</td>
<td>• Prioritize energy projects with estimated economic benefit</td>
</tr>
<tr>
<td><strong>Optimization</strong></td>
<td>• Real time on-line optimal operational guide while keeping the energy requirement</td>
<td>• Keeping real time optimal operation</td>
</tr>
<tr>
<td></td>
<td>• Provide breakdown effect of optimal operation</td>
<td>• Identify the operational change resulting in optimization</td>
</tr>
<tr>
<td></td>
<td>• Closed-loop optimization if necessary</td>
<td>• Automatic optimal operation</td>
</tr>
<tr>
<td><strong>Abnormal detection and root cause</strong></td>
<td>• Abnormal detection and root cause analysis of Energy intensity by providing logical detection of abnormality</td>
<td>• Fast detection and measure for increasing energy intensity</td>
</tr>
<tr>
<td><strong>analysis of energy intensity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Support ISO50001 and greenhouse gas</strong></td>
<td>• Support ISO50001</td>
<td>• Support standardized energy management procedure</td>
</tr>
<tr>
<td><strong>emission trading scheme</strong></td>
<td>• Support emission trading scheme</td>
<td>• Provide energy accounting data, more accurate and credible</td>
</tr>
<tr>
<td></td>
<td>• Support energy accounting system</td>
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</table>
Project Objective

Construct Energy Management system to optimize complex-wide energy network and minimize plant energy intensity.

- **Energy Network Optimization System**
  - Complex-wide Energy Balance
  - Complex-wide Energy Network Optimization
  - Main Energy Equipment Efficiency Management
  - What-if simulation of energy network

- **Complex-wide Energy Management System**
  - Energy intensity management by plant or process
  - Energy Network optimization and management system
  - Energy balance and optimization report
  - Energy Usage Management by quantity and price base

Note: Induce energy innovation by sharing company-wide information sharing using Web technology.
Proposed Solution

- **ENetOPT**
  - **Energy balance**
    - Steam production and consumption balance
    - Analyze erroneous measurement
    - Analyze the energy & mass loss identification (steam, trap, tracing)
  - **Simulation**
    - Simulate Effect of New energy equipment installation
      - Boiler, HSRG, Turbine investment effect
    - Simulate Effect of Plant Operation Condition
      - MP, LP usage change (change due to product output or process revamp)
  - **Energy equipment efficiency**
    - Boiler, Turbine, Pump, Heat exchanger efficiency calculation and analysis
  - **Optimization**
    - Load balance considering boiler efficiency
    - Optimize Turbine exhaust, condensing and electricity

- **EMS**
  - **Energy Network Monitoring**
    - Complex wide summary and detailed plant energy network
    - Steam/Condensate measured, balance and optimization
  - **Inter-company utility trading history**
    - Histories utility trading and reports via various diagram
    - Calculates optimum trade amount
  - **Greenhouse emission management**
    - Histories and report green house gas emission
  - **Energy Intensity**
    - Analyze the cause of plant energy intensity increase
  - **Optimization**
    - Display and Report energy optimization condition and result
  - **Equipment Efficiency**
    - Equipment Efficiency calculation and monitoring
    - Analyze abnormal operation cause
**ENetOPT: Functional Configuration**

**On-line Energy Balance**
- Energy balance for each equipment, unit, plant and complex-wide
- Data reconciliation with standard deviation of each measurement

**Visual Modeling**
- Drag & Drop based visual modeling of energy network
- Equation-based system

**Optimization**
- Minimize energy cost
- Maximize the utilization of high value energy
- Mixed Integer Linear Programming

**Efficiency and Energy Intensity**
- Equipment efficiency calculation
- Unit and plant energy intensity definition and calculation
- Abnormal and inefficiency operation detection

**Report**
- Steam/condensate balance
- Energy Network optimization
- Database of the all the input and result
- Connect to the database for the customized report

**Simulation**
- Energy Production and distribution simulation for the changed operational change
- Simulation for the new or changed facilities
- Extend to operator training

**Field data Interface**
- OPC (DA3.0, UA)
- RTDB (PHD, CIM I/O, INSQL, PI)
- RDB (Oracle, SQL)
- XML
ENetOPT: Visual Modeling

- Easily build the Energy Network by drag & drop energy equipment stencil
  - Easily build and modify the energy network without any hard coding program
  - ENetOPT creates automatically equation based code

Mathematical modeled energy equipment stencil
- Multi-layer configuration
- Steam and Coolant equipment modeled template
- Can provide the custom specific energy equipment
- Can fully utilize MS VISIO functions such as hyperlink to user documents
ENetOPT: Plant-wide Energy Balance

- Data Reconciled material balance and energy calculation based on the status of the flow
- Balance report created
- Automatic periodic running at the frequency given by user
- Use to analyze the energy loss identification, erroneous measurement, etc.
ENetOPT: What-if Simulation

Simulation for the change of operational conditions and/or energy equipment arrangement

Analyze the effect of load change, new energy consumption and production facility, etc.

Analysis report created
ENetOPT: Equipment Efficiency Management

- Calculation and management of each equipment and unit section’s performance efficiency
- Early detection of inefficient equipment or unit section
- Analyze the performance trend of each equipment daily, monthly and yearly
- With logical flow chart program such as Infotrol's IPOES to detect the source of efficiency deterioration and to suggest the improvement
ENetOPT: Optimization

- Maximization of high value energy utilization
- MILP engine
- Drag-and-drop modeling build internally cost function and all necessary constraints
- Optimal steam/ electric motor selection
EMS: Web-based EMS (Energy Management System)

- HTML5 based Energy Management System configuration

  - Energy Production and Consumption Monitor
    - Plant Energy Usage and Energy Intensity
    - Complex-wide and detailed plant energy network
    - Inter-Company Energy Utility Trade Management
    - Steam Production Price Calculation
    - Utility Unit Price
    - Green house gas emission management

  - Energy Intensity Monitor and Analysis
    - Energy Utility (Steam, Fuel, Electricity) Usage Analysis
    - Real Time Abnormal Operation Detection and Alarm

  - Energy Network Optimization
    - Optimal Operating Condition
    - Current Energy Intensity and Energy Equipment Optimization Effect

  - Equipment Efficiency Monitor and Analysis
    - Turbine, Heat Exchanger, Boiler Efficiency
    - Analysis of Equipment Efficiency Degradation
EMS: Energy Produce and Consumption Monitoring

- Plant Energy Usage and Energy Intensity
- Complex-wide and detailed plant energy network
- Utility Cost Calculation
- Energy information including inter-company utility trading and green house gas management
EMS: Plant Energy Network Monitoring

- Report current fuel, steam, electricity usage, and trend
- Monitors the cost of energy utility and Greenhouse gas emission
- Induce energy usage reduction

### NCC planta 사용/대차 원산 현황 (단위: 건강) [2015-05-26]

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### NCC 연탄의 원산 현황 (단위: 건강) [2015-06-26]

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<th>접속(A)</th>
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### NCC 연탄의 수량 [2015-06-26]
EMS : Energy Network Monitoring

- Complex wide overview energy network summary
- Detailed plant energy network
- Steam/condensate measured, balance and optimization result
EMS: Steam Cost Calculation and Management

- Real time and Monthly utility price calculation
- Water, Steam, Electricity, and Steam price calculation and management
- Systemize the utility product price calculation

Summary of Price Determination

- Raw Water Cost
- Raw Water Price
- Water Processing
- Water Price
- Steam Processing
- Steam Price
- Electricity Produce
- Cost: Price * Quantity

Determination of Price by LS (Linear least squares)
EMS: Inter-company energy utility history

- Reports inter-company energy utility history categorized by product and company
- Calculates Optimum Amount of Trade

<table>
<thead>
<tr>
<th>Item</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company &amp; Product</td>
<td>Histories inter-company energy utility categorized by company and product</td>
</tr>
<tr>
<td>Trade Scheme</td>
<td>Report Trade quantity using various diagram</td>
</tr>
<tr>
<td>Report</td>
<td>Generate Trade quantity report in monthly or in user defined interval</td>
</tr>
</tbody>
</table>
EMS : Green house gas emission management

- Histories basic green house gas emission data
- Report Greenhouse gas emission

Summary

- Emission
  - Manage allowable emission quantity, accumulation in month term
- Emission Report by Sector
  - Manage greenhouse gas emission categorized by plant (Monthly Trend)
- Emission Report by Team
  - Manage team emission categorized by team, and comparison to previous month data (Monthly Report)
- Company wise emission report
  - Report fuel usage and emission categorized by plant and equipment
- Displays the result of energy network operating cost optimization
- Report Optimum Operating Cost
- Optimization can be interfaced to DCS
Typical System Configuration

Web based Energy Monitoring & Management:
- Field Data, Balance and Optimization

Optional: Energy Intensity Analysis

- One license for server
  - Used to plant-wide on-line energy optimization system
- Two license for PC
  - Used normally for design, simulation and off-line optimization
**Issues and direction**

- **Steam mass balance**
  - For mass (steam/condensate) imbalance, it is not so sure whether it is caused by measurement error, or any loss, or tracing and/or tracking, etc.
  - Unmeasured value is estimated, but the balanced value for the estimated value is changed significantly according to the operational condition.
  - Gross error detection is very difficult since in most cases, measurement redundancy is not so sufficient
    - Input data analysis for erroneous measurement
    - Gross error detection with logical analysis, statistical approach, and any neural and artificial approach

- **Optimization**
  - It is necessary to include the planning functionality for On/Off and swing operation and minimum operating and standby times of the equipment
  - It is frequently asked to show the bottleneck constraint
    - Integrate utility planning and optimization
    - Search for active constraints
Issues for the site application

EMS

- **Energy Intensity**
  - Root cause for energy intensity change of the plant is asked from clients
  - It is necessary to compare the utility diagram and Process diagram
    ➔ Statistical approach

- **Equipment performance**
  - User asked what is the main reason for the performance depreciation
    ➔ Logical analysis for possible reason

- **Steam price**
  - It is necessary to calculate the steam price for each unit in real time
    ➔ Real time estimation of steam value
EMS: Energy Intensity Analysis

- Analyze the cause of plant energy intensity increase
- Reduced dimensional analysis by statistics

**Real Time Reduced Dimensional Analysis**

- Score Plot $T(1), T(2)$
- Hotelling T2 95% confidence limit

- HS header
- Step unit
EMS: Energy Equipment Efficiency Monitoring and Analysis

- Main Energy Equipment Efficiency Calculation
- Main Energy Equipment Efficiency Monitoring
- Analyze Abnormal Operation Cause
Conclusion

- **Typical approach of Energy Network optimization and management is well established**
  - Data reconciliation based energy balance
  - Energy Network optimization covering heat, electricity, fuel gas and hydrogen
  - Energy management of monitoring energy production and consumption

- **Further enhancement of energy network optimization**
  - Gross error detection for the balance
  - Energy Network optimization with planning functions

- **Further enhancement of energy management system**
  - Targeting on energy intensity reduction
  - Energy intensity analysis to figure out the root cause of inferior energy performance

- **Eventually extend to energy network of other industries and covering city**
ENetOPT, ENetPlan, ENetDisplay, IPOES & HIECON-I

- Complex-wide Energy Balance
- Equipment Efficiency
- On-line Energy Intensity
- Energy network optimal operation
- Optimal production plan
- What-if Simulation

Infotrol Technology

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