Energy Monitoring, Targeting and Reporting (MT&R) Techniques for Energy Management

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Our Firm

Energy management consulting services to address technical, behavioural and organizational aspects

We design and implement cost effective approaches to address comfort, efficiency and reliability.

650 energy audits in over 1000 buildings, which is equal to 73 million square feet of building area audited and 9,000 energy accounts analyzed.

Identified $22 million dollars in annual energy savings equivalent to taking 18,000 cars off the road every year.
A Holistic Approach to Energy Management

Organizational  Technical

Behavioural

Continuous Improvement
What Does MT&R Mean?

**Monitoring**
- The regular collection of energy & driver data
- Analysis of data
- The investigation of deviations from expected performance using some performance model

**Targeting**
- the identification of the level of energy consumption which is desirable

**Reporting**
- putting information in a form that drives action to control energy use and achieve targets
MT&R is…

A method to detect abnormal changes in energy performance.
  – To trigger corrective action

Necessary conditions:
  – Consumption is related to measurable driving factors or influences
  – Abnormal use is signaled by a deviation of actual from expected consumption.

“I want a means of knowing when energy use has really increased, and is not open to debate or being rationalized away by anecdotal analysis”
MT&R: Essential Process

Measure

Result

Data

Analyze

Take Action

Information
Where Can We Do MT&R?

- Simply an area of energy use
  - A good starting point!
- Equipment or process
- Department
- Cost centre
  - Energy account centre
- Plant wide
- Site wide
Getting Started in MT&R

- Ensure commitment and resources
- Select energy use area
  - Collect energy & driver data.
- Investigative analysis
  - Learn what drives energy
  - Develop performance models
  - Develop targets
- Develop reporting
- Monitor against targets, report and drive action
- Review results, refine, expand to other areas
Central to MT&R is an Energy Performance Model

- **Historical consumption**
  - Static, not dynamic with drivers
- **Key Performance Indicator (KPI)**
  - Be careful!
- **Statistical model** \( E = F \) (drivers)
  - simple linear regression
  - multivariate non-linear regression
- **Simulation models**
  - may already exist for process
  - complex
Analysis Tool Kit

“tools that help to identify, understand, quantify and display the relationship between energy and what drives it”

**Basic**
- Excel works well!
- Visualization
- Time series
- Scatter plots
- Variability
- Regression
- CUSUM
- Control charts

**Advanced**
- Data mining & neural nets
Data and Information

- Data is the “raw material”
- Information is the “refined product”
- Action decisions need information

<table>
<thead>
<tr>
<th>Data</th>
<th>kWh &amp; Tonnes Produced for a melt furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>Regression and CUSUM</td>
</tr>
<tr>
<td>Information</td>
<td>kWh/Tonne increased last week. Why?</td>
</tr>
<tr>
<td>Action</td>
<td>Corrections to electrode positioning in furnace</td>
</tr>
</tbody>
</table>
Data Already Exists!

Consumption data

Consumption Drivers
  – production
    • Volume
    • On-line time
  – weather for buildings
  – ore grade / hardness
  – etc…

Sources:
  – Monthly invoices
  – Production records
  – Manual data forms periodically
  – Portable data loggers
  – Fully automated measurement
  – Process information systems
Let’s Do Some Analysis
…and Answer Some Questions

- How many energy saving measures have been introduced?
- When did each take effect?
- How much energy has each measure saved?
- Are all the energy saving measures still working?
- Have any breakdowns been restored?
- What further savings can be achieved?
A KPI … May Not Be A Good Performance Model!

“Performance Model”
\[ \text{kWh} = 76 \times \text{Tonnes} + 59669 \]

- KPI = 168 kWh/Tonne
- Better performance?

- KPI = 138 kWh/Tonne
- Worse performance?

“Standard”
KPI = 146 kWh/Tonne
Activity: Find a CUSUM

• Assemble historical data
• Visualize data (scatter plot)
• Develop overall relationship
• Plot changes in performance
  – end to end CUSUM
• Determine best performance/practice
• Develop target relationship
• Estimate historical opportunity
  – CUSUM versus best performance
• Develop control report
Energy Improvement Targets

- Best fit data
- Best historical performance
- Based on plan of action
- Percentage improvement
- Best in the group
- Meet national or international indicators
MT&R Reporting – Closing the Loop

Summary Information

Exception Reports & Budget

Control Information

Management

Supervisors

Operators & Maintenance

Data Collection & Analysis

“People in the (feedback) loop”

Energy Consuming System
Reporting for Action

• Match report to action
  – Design report around actions
  – Procedures to guide/ensure action
• Ensure people understand
  – Often requires training
• Minimal “extra” information
• Frequency of feedback
  – tune the control loop for stability
Daily Control Report

... for Operating Engineers

### Natural Gas

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<th>Consumption</th>
<th>Value</th>
<th>Mean</th>
<th>LCL</th>
<th>UCL</th>
<th>In Control?</th>
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<td>Temp (°C)</td>
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<tr>
<td>Pkg Wt. (kg)</td>
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</table>

Index:

- Value: 1.10
- Mean: 1.00
- LCL: 0.95
- UCL: 1.05
- In Control?: NO

(Index = Actual Gas/Predicted Gas = Gas(m³)/9855.151*Mean Temp+0.0455/Pkg Wt.)

### Electricity

<table>
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<tr>
<th>Consumption</th>
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<th>LCL</th>
<th>UCL</th>
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<td>Temp (°C)</td>
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<td>Pkg Wt. (kg)</td>
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Index:

- Value: 1.01
- Mean: 1.00
- LCL: 0.93
- UCL: 1.07
- In Control?: YES

(Index = Actual Elec/Predicted Elec = Electricity(kWh)/5605.34*200*Mean Temp*1.5+Mean Temp^2*0.107/Pkg Wt.)
What’s the Potential?

• Depends on the situation
  – Complexity of system
  – Level of variability
  – Extent of waste
  – Ability to control
• Use investigative analysis
  – As presented today
• Common practice suggests 6% of usage in new MT&R
Source of Savings in MT&R

Energy Consumption vs. Factor(s) of Influence

- Reduce Variability
- Increase Efficiency
- Reduce Non-Productive Energy (waste)
Do We Need More Meters and Other Infrastructure?

- Typically…NO, not in the beginning.
- Best to start with existing data sources and systems
- Expand system based on success, effectiveness and need
- Little victories!
MTR Applications
Historical Data - Boiler
Visualize Data (Scatter Plot)

Bunker "C"

Steam
Develop Relationship

\[ y = 0.1088x + 1064.1 \]

\[ R^2 = 0.9939 \]
CUSUM Reveals Periods of Best Performance

Need to identify best practice leading to best performance for periods 67-97!
Establish Target: Best Performance Model

\[ y = 0.108x + 496.8 \]

\[ R^2 = 0.997 \]

Period 67-97
CUSUM of Deviation from Best Performance

Past savings opportunity for achieving best performance.
Energy Map Tells the Story

“Energy Map”
- shows the CUSUM trends and flow of electricity (blue) and material (red)
MT&R: Critical Element of BC Hydro Program

Quantify energy management practices & end-use savings potential
- Energy Studies & Audits
- Energy Management Practices Assessment

Step One
Collect information about site operation

Information Gathering

Measure, report, target & provide feedback to meet objectives:
- Monitoring, Targeting & Reporting

Planning

Develop a Sustainable Energy Management Program using the following:
- Energy Manager
- Monitoring, Targeting & Reporting
- Energy Studies & Audits

Management Commitment

Continuous Energy Management Improvement

Execution

Power Smart program options might include:
- Monitoring, Targeting & Reporting
- Employee Awareness
- Energy Studies & Audits
- Motor Management Planning
- Pumps Initiative
- Compressed Air Initiative
- Refrigeration Initiative
- Self-Generation Optimization

Implementation

Monitoring & Feedback

Building the Program

Energy Management Assessment
"After we started using CUSUM, the savings were almost instantaneous. A week or two after we started, we were saving approximately $9,600 per day in natural gas," says John Velden, the Site-wide Energy Manager at Syncrude's Mildred Lake, Alberta, facility.

"CUSUM really makes a trend change jump out. In a lot of cases [without CUSUM], small changes can get lost in the data noise," says Velden. Velden points to the example of a positive shift in energy consumption after an operator cleaned a heat exchanger."
Energy Management Information Systems (EMIS)

An information system that supports the functions of MT&R
MT&R in Action: Site Wide

Xstrata Brunswick Mine uses energy management information system to save millions

“A series of energy efficiency measures have resulted in significant energy savings and emissions reduction at Xstrata Brunswick Mine in Bathurst, New Brunswick, a CIPEC Leader in the Mining Sector. Waste heat recovery projects, for example, have saved around $2 million annually and reduced the steam load by an average of 20 GJ per hour and greenhouse gas (GHG) emissions by 13 kilotonnes a year. The company’s energy management information system (EMIS) led to a reduction in energy intensity of 8 percent from 2006 to 2008, easily exceeding the company’s goal of 1 percent annually.”
Dashboard and Project

Energy Saving Tip: Install Lighting Controls. Installing lighting controls like dimmers, timers, motion sensors, and photocells, is a simple and efficient means of reducing lighting energy.
Performance Index by Site
Base Period Analysis

Project: PUMA Demo (DEMO)
Site: S4 Demo Site 4
Meter: GAS-S4-001 (123456)
Analysis: Heating Analysis - 2002

Weather Location: Vancouver (BC)
Fuel Type: Natural Gas

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<th>Date</th>
<th>Days</th>
<th>Consumption (GJ)</th>
<th>D.B./Day</th>
<th>Inc.</th>
<th>Mult.</th>
<th>Offset</th>
<th>Baseline</th>
<th>% Deviation</th>
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Weather Sensitivity: 0.0702
Regression equation: GJ = [0.1227 x HDDs] + [0.01026 x days]

Base Load: 0.1026 GJ per day

Dail Consumption (GJ / Day) vs. Degree Days / Day
Advanced Savings by Meter (2003)
Advanced Savings by Meter (2010)
Energy Savings Breakdown

Energy Savings Breakdown: Compare Sites (2009)
Project: PUMA Demo (DEMO)
Year: 2009

Legend:
- Blue: Electrical
- Red: Fuel
- Green: Energy Total

Notes:
1. Actual excludes consumption where a baseline does not exist.
2. Estimated excluded from cost where applicable.
3. Cost baselines are based on cost per unit of consumption.
4. “Year” refers to fiscal year ending in December.
MT&R In Summary

- Plant Energy & Production Data
- Best Performance
- Create Actionable Energy Targets
- Best Practice
- Plant Process Knowledge

Lower Your Energy Costs
1. Reduce waste
2. Prioritize efficiency projects
3. Better forecasting

www.energent.com
Thank You for Your Interest!

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