ABB Energy Efficiency in 2012

Industrial & Power Generation Energy
Efficiency Plant Assessments & Solutions
EE: Plant Assessments & Solutions

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- Speaker title: Business Development
  ICE Services & Energy Efficiency
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- Phone: 770-361-5650 (cell)
<table>
<thead>
<tr>
<th>You Give Me</th>
<th>I Give Back to You</th>
</tr>
</thead>
<tbody>
<tr>
<td>$25</td>
<td>$25 at year end</td>
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<tr>
<td>$25</td>
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<tr>
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<td>$250,000</td>
<td>$500,000 at year end</td>
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<tr>
<td>$250,000</td>
<td>$500,000 at the end of every year</td>
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**Energy Efficiency!**
Agenda

- Why Energy Efficiency?
- A look at Specific Industries
  - Utilities & Power Generation
  - Water & Wastewater
  - Pulp & Paper
  - Oil & Gas and Chemical
- Equipment Related Energy Efficiency Solutions
- Industrial Energy Efficiency Assessment Process
Why Energy Efficiency?

- Government regulations continue to intensify to drive industrials and utilities to be more energy efficient

- Power demand for utilities has decreased
  - Plant closures

- Industrial plants
  - Product prices continue to receive overseas pressure

- Using energy more efficiently brings benefits on several fronts:
  - it makes the energy go further
  - curbs emissions
  - saves money
Why Energy Efficiency?

Besides direct advantages such as these, efforts to improve the energy efficiency of industrial production processes are often associated with further benefits:

- lower plant downtime
- longer maintenance cycle
- improved productivity
- better product quality
- compliance with building and environmental codes
- employee health and safety;

These so-called “co-benefits” typically see non-energy savings benefits being three to five times the value of energy savings.
Why Energy Efficiency?

- Industrial companies and power utilities are among the biggest users of energy and are therefore among the most sensitive to the need to be more efficient.
- The scope for savings using existing technologies is large.
- The major reason for the gap between awareness of gains from efficiency and actual investment in efficiency is poor information. This includes:
  - lack of information on latest technologies and alternative ways to improve efficiency;
  - lack of efficiency benchmarks;
  - insufficient information on the payback of specific projects.
Utilities and Power Generation Facilities

Power Plant Efficiencies

<table>
<thead>
<tr>
<th>Existing plants</th>
<th>New plants</th>
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<tbody>
<tr>
<td>Thermal plants</td>
<td>Gas CCGT (modern)</td>
</tr>
<tr>
<td>30%</td>
<td>59%</td>
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<tr>
<td>Coal plants</td>
<td>Nuclear plant</td>
</tr>
<tr>
<td>38%</td>
<td>35%</td>
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<tr>
<td>USC Coal plant (modern)</td>
<td></td>
</tr>
<tr>
<td>46%</td>
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</table>

- New plants: Gas CCGT (modern) = 59%, Nuclear plant = 35%
Utilities and Power Generation Facilities

- **Opportunities in a “typical” 400MW fossil-fired boiler unit circa 1970’s**
  - Improve upon Net Heat Rate of 10,800 Btu/kWh
  - Reduce existing house load of > 25MW

- Leaks, cycle isolation and operability issues identified, addressed & corrected

- High efficiency motors and VFD’s applied to largest pumps & fans
- Advanced Controls applied to O2, spray flows & controllability issues
- 25MW of house load reduced to ≤ 20MW
- Net heat rate improvement of 3%+ on average
- Capacity improvement of 6-12MW+ at full output

- Analyze against unit load, cost & sale profiles using above improvements
  - Each Megawatt of utilized additional capacity is worth $500k/yr or more

- Conservative spectrum of project paybacks from less than 6 months, up to 5 years
Water & Wastewater Plants

- Energy costs are the largest operating costs in almost all water applications (from 20% in Thermal desalination up to 60% in pumping stations)
- Tighter water quality standards and water scarcity are drivers for energy intensive technologies
- Environmental responsibility (sustainability)
- Direct or indirect government incentives for reduction of energy consumption
- Rapid payback for the investments ranging from few months to 5 years based on the application
Water and Wastewater Plants
Typical Energy component in OPEX

Wastewater Treatment
- Energy: 50%
- Maint: 11%
- Chem: 13%
- Oper: 21%
- Others: 5%

Desalination
- Energy: 33%
- Thermal: 17%
- Membrane: 25%
- Steam: 35%
- Others: 5%

Water Treatment
- Energy: 45%
- Maint: 15%
- Oper: 20%
- Chem: 10%
- Others: 10%

Pumping Stations
- Energy: 60%
- Oper: 22%
- Others: 3%
- Maint: 12%
Water and Wastewater Plants

Energy consumption split in water applications

**Water Treatment**
- Misc: 5%
- solids handling: 20%
- Clar & Filtration: 10%
- Aeration: 45%
- Chem Feed: 10%
- Raw/Inplant Pumping: 10%

**Desalination**
- Misc: 11%
- chemicals: 5%
- Outfall pump: 10%
- Desalination pumps: 50%
- Pretreatment: 12%
- Seawater pumping: 12%

**Water Treatment**
- finish water pumping: 50%
- inplant pumping: 10%
- filtration: 10%
- Misc: 2%
- rapid mix: 5%
- chem feed: 8%
- Raw water pumping: 15%

**Water Pumping**
- Misc: 5%
- Chem: 5%
- Building: 10%
- Pumping: 80%
Water and Wastewater Plants
Control optimization
Success Stories

Scenario
- Butterworth WWTP receives and treats wastewater from the Townships of Morris and Randolph.
- The plant routinely treats an average of 2.2 MGD per day, but can accommodate up to 10 MGD during storm surges.
- Over aeration was identified as one of the key areas for energy improvement.

Project goals
- Reduce electricity / pumping cost.
- Reduce sludge removal.
- Reduce chemicals.
- Overcome effects of ambient temperature.

Results
- Energy consumption reduced by 50% on aeration.
- Indirect benefits of 10% on pumping, chemicals.
- Efficient process control for steady discharge.

ABB OFFERINGS:
- Instrumentation
- Drives and motors
- Automation systems

[Diagram of water and wastewater treatment process with ABB offerings highlighted.]
Pulp & Paper Plants
Areas of Assessment

Power Plant
- Boiler air-to-fuel ratios & economizers
- Optimum driver loading & energy export

Paper Machine
- Avoidance of downtime
- Optimum machine scheduling
- Advanced process control

Pulping Plant
- Heat recovery & integration
- Optimum pulping residency times

Compressed Air
- Air leakage reduction
- Compressor load-demand optimization

Biomass Cogeneration
- Opportunities to use biomass fuels.

Electrical Systems & Distribution
- Power systems, power quality
- Monitoring & targeting – electrical and thermal
- Motor and drive applications.
- Instrumentation and control systems
Further examples of Pulp & Paper energy efficiency opportunities, by plant area:

**Power Station**
- Optimum boiler air-to-fuel ratios
- Optimum analysis of turbine performance with extraction rates versus MW generation
- Blowdown optimisation and recovery
- Energy Management Optimisation – supply, purchasing and forecasting
- Opportunities for cogeneration/CHP

**Utilities Distribution**
- Steam trap maintenance & monitoring
- Increased condensate recovery efficiency
- Compressed air/steam leakage & insulation
- Pinch analysis for optimum site composites
- Optimisation of cooling water systems
- Optimal selection of steam distribution pressures & temperatures

**Paper Processes**
- Reduced air requirements (e.g. ventilation)
- Waste heat recovery from process
- Energy efficient motor technologies
- Quantification of the optimum pumping/fan requirements and VSD applications
- Vacuum Systems

**Steam Boxes**
- Pulping residency times, high speed and optimum temperature evaluation
- Improved process control and monitoring & targeting programmes
- Optimum machine scheduling – avoidance of energy consumption during downtime
- Steam Boxes
Water Treatment Focus Areas

Raw water abstraction
- Analysis of raw water
- Raw water pre treatment
  - Flocculation
  - Coagulant
  - Chlorination
  - Instrumentation

Steam raising boilers
- Feed water train
- De-aerator / hotwell
- Boilers
  - Chemical treatment program
  - Control of treatment / analysis
- Condensate treatment
- Instrumentation
- Maintenance regiment

Purification of raw water
- Storage
- Organic removal
- Ion exchange train
- Regeneration
- Instrumentation

Cooling Towers
- Treatment program
- Operating practices
  - Dosing equipment
  - Control of treatment / analysis
- Maintenance regiment
Industrial Energy Efficiency
Case Study – Pulp & Paper

- Industrial Energy Efficiency program
  - Efficiency of generation, distribution and use of energy
  - Energy management practices
  - Optimization of energy purchase
  - Specific equipment studies (vacuum pumps, power quality, heat recovery, grinding pumps)

- 45 Individual energy saving opportunities identified:
  - Estimated energy savings up to €4 Million per year (€1.7 Million low or no capital)
  - Wide range of opportunities from simple control system updates to capital projects
  - Opportunities in boiler system, behaviour and practices, compressed air, power factor correction, variable speed drives, heat recovery and water use
Industrial Energy Efficiency
Case Study – Pulp & Paper

- Industrial Energy Efficiency program
  - Guangzhou Paper is the largest pulp and paper manufacturer in southern China
  - Joint team carried out an Opportunity Identification study, following data analysis and site evaluation
- Opportunity Identification phase revealed current operating conditions and the potential for improvement in:
  - Technology & Controls;
  - Behaviors & Practices;
  - Monitoring & Targeting.
- 18 major energy-saving opportunities identified:
  - Estimated energy savings of US $1.3 to US$ 2.7 Million per year
  - Prioritization of major energy saving opportunities from a large number of potential improvement projects
## Recent ABB Studies in Pulp & Paper Consulting Activity

<table>
<thead>
<tr>
<th>Client</th>
<th>Location</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>April Paper</td>
<td>Indonesia</td>
<td>IEE Opportunity Identification Study</td>
</tr>
<tr>
<td>FutureMark</td>
<td>USA</td>
<td>IEE Opportunity Identification Study</td>
</tr>
<tr>
<td>MeadWestvavo</td>
<td>USA</td>
<td>IEE Opportunity Identification Study</td>
</tr>
<tr>
<td>Mylykoski Paper</td>
<td>Finland</td>
<td>IEE Opportunity Identification Study</td>
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<td>Guangzhou Paper</td>
<td>China</td>
<td>Industrial Energy Efficiency Opportunity Identification Study</td>
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<td>UPM Kymmene</td>
<td>Europe &amp; Scandinavia</td>
<td>Corporate wide Energy Monitoring &amp; Targeting system</td>
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<tr>
<td>St Regis Paper</td>
<td>UK</td>
<td>Powerhouse control system upgrade study</td>
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<tr>
<td>Arjo Wiggins</td>
<td>UK</td>
<td>Mill performance baseline and improvement programme</td>
</tr>
<tr>
<td>Stora Enso</td>
<td>Spain</td>
<td>IEE Opportunity Identification Study</td>
</tr>
<tr>
<td>Rigid Paper</td>
<td>UK</td>
<td>Compliance with Making Paper Safely</td>
</tr>
<tr>
<td>Aylesford Newsprint</td>
<td>UK</td>
<td>Compliance with IEC61508, functional safety systems</td>
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<tr>
<td>M:Real</td>
<td>Finland</td>
<td>Maintenance performance assessment</td>
</tr>
<tr>
<td>Curtis Fine Paper</td>
<td>UK</td>
<td>Mill performance improvement</td>
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<tr>
<td>Iggesund Paperboard</td>
<td>UK</td>
<td>Mill performance improvement</td>
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<tr>
<td>Kimberley Clarke</td>
<td>UK</td>
<td>Risk Based Inspection, pressure systems</td>
</tr>
<tr>
<td>JSC Kotlas</td>
<td>Russia</td>
<td>Maintenance performance assessment</td>
</tr>
<tr>
<td>Carter Holt Harvey</td>
<td>New Zealand</td>
<td>Risk Based Inspection, black liquor boiler</td>
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Energy Efficiency Impacts all Industries
Energy Reduction Strategies

Each component of the process should be evaluated as follows:

- Does the process equipment need to run at all?
- Can it be run for fewer hours (e.g. part time versus full time use)?
- Can the process or equipment achieve the same results at a lower flow capacity to enable reduced energy?
- Are there losses in the system which are contributing to additional energies?
- Can the operation be shifted from on-peak hours to off-peak hours?
- Is all rotating equipment, including their drives, operating at optimum design conditions?
- Is the process efficient at the existing loading conditions or does equipment need to be modified or replaced?
Plant Efficiency Improvement Solutions from ABB

- “Drive Power” equipment – Motors & Drives for large pump & fan systems
- Advanced Variable Frequency Drive (VFD) solutions for auxiliary loads
- Advanced Multi-Variable Controls: Model-Predictive Control Technology
- New Energy-Efficient Transformers
MV & LV Motors – Available New Efficiencies

- Induction motors
  - Older or rewound motor efficiencies ~85% or lower
  - New High Efficiency ~97%
  - Available up to 22 MW
  - Induction motors are usually the first choice for applications up to 10 MW

- Synchronous motors
  - Efficiencies of 98% or more
  - Typically considered for higher power ratings (e.g. above 8 MW to more than 100 MW)

- Permanent Magnet Motors
  - Low RPM applications
  - Can still be used with VFD’s
VFD’s Create Energy Savings and Reduce Emissions

- Pumps and fans typically run at partial loads
- Huge energy savings can be achieved by controlling their speed with variable speed drives
- A pump or fan running at half speed consumes as little as one eighth of the energy compared to one running at full speed
- Energy consumption can be reduced by as much as 60% with variable speed drives
- Variable speed drives help to reduce CO₂ and other emissions
Medium Voltage Drives: New in 2011

ACS 2000

- Targeted specifically for Power Generation Pump, Fan and Compressor Applications
- Direct-to-Line Connection w/ Low Harmonics
- Air-cooled
- Power range: 400 kW – 2 MW (550 – 2800 HP)
- Output voltages: 4.16 kV, 6.9kV
- Active Front End permits VAR Compensation
- Modular Solution for “off the shelf” applications
ABB Transformers: Right-Sized and Efficient

- Aging unit step-up transformers
  - This item “touches” every bit of electrical power exiting the plant - rebuild or replace with new efficient designs
  - Up to 35% efficiency improvement
  - Improved reliability avoids outages!

- Unit Auxiliary Transformer
  - Should be “right sized” with current needs for best efficiency
  - Rebuild or replace aged UAT’s with new efficient design
Advanced Control and Optimization of Power Plants

How APC Improves Performance

- Handling simultaneous constraints and variables
Advanced Control and Optimization of Power Plants

Improving Heat Rate – MS Temperature Maximization

• Reduce variability
• Shift target
• Higher steam temperature improves heat rate
Advanced Control and Optimization of Power Plants

Improving Capacity – Coordinated MS Pressure Control

- Reduce variability
- Shift target
- Higher steam pressure increases capacity
Industrial Energy Efficiency
Site Program Overview

**Industrial Energy Efficiency**

- **Opportunity Identification**
- **Master Plan**
- **Implementation**

**Delivering Energy Savings across Industry Sectors**

- Water / Wastewater
- Primary & Secondary Aluminium
- Iron & Steel Integrated Mills
- Oil & Gas - Processing
- Pharmaceuticals

- Pulp & Paper Mills
- Industrial Chemicals
- Food & Drink Manufacturing
- Oil & Gas – Refineries
- Power Generation
ABB’s proven methodology to help customers reduce energy consumption.

Industrial Energy Efficiency is a 3 phase program, designed to deliver sustainable energy savings:

**Industrial Energy Efficiency**

<table>
<thead>
<tr>
<th>Opportunity Identification</th>
<th>Master Plan</th>
<th>Implementation</th>
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<tbody>
<tr>
<td>“Find the Savings”</td>
<td>“Develop the Solution”</td>
<td>“Gain the Benefits”</td>
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<tr>
<td>On-site Assessment</td>
<td>Solution Options</td>
<td>ABB Services</td>
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<tr>
<td>Recommendations</td>
<td>Cost Estimates</td>
<td>ABB Technologies</td>
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<tr>
<td>Technology &amp; Control</td>
<td>Payback &amp; ROI</td>
<td>Solution Implementation</td>
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<tr>
<td>Behaviors &amp; Practices</td>
<td>Project Specification</td>
<td>Measure Success</td>
</tr>
<tr>
<td>Monitoring &amp; Targeting</td>
<td></td>
<td>Quantify Benefits</td>
</tr>
</tbody>
</table>
Industrial Energy Efficiency
Phase 1: Opportunity Identification

Industrial Energy Efficiency

Opportunity Identification | Master Plan | Implementation

On-site Assessment & Off-site Analysis

Technology & Control
Monitoring & Targeting
Behaviors & Practices

PROCESS

UTILITIES

ORGANIZATION
(IEE) Opportunity Identification

Engagement Process

- 1st Phase of IEE
- Typical Process
  - Completed within 6 - 8 weeks
  - Conducted by:
    - Energy Consultant team
    - Specialist Engineers
  - Staged Approach
  - On Site Assessment
  - Remote Analysis

1. Request for Information
2. Initial Data Review
3. Site Assessment
4. Remote Analysis
5. Presentation of Portfolio
(IEE) Opportunity Identification
Deliverables – Opportunity Portfolio & Payback Chart

Opportunity Portfolio
Portfolio of energy saving opportunities by plant area or system with estimates of energy savings and likely investment magnitude

Payback Chart
A 2-dimensional graphical representation of the relative return-on-investment of each identified energy saving opportunity.
(IEE) Master Plan
Alignment Workshop & Prioritization Process

- Alignment Workshop Goals
  - Confirm opportunities
  - Reduce assumptions
  - Identify constraints
  - Agree potential ROI
- Prioritization Process
  - Project ranking process
    - FEASIBLE
    - SIMPLE
    - QUICK
- Agreed set of projects for development (Tier 1)
Phase 2: Creating the Energy Efficiency Master Plan
Alignment workshop – prioritization of projects

Each Energy Efficiency Project is jointly evaluated with the customer:

- Does the project fit with budget constraints?
- Does the project fit ROI requirements?
- Is the project feasible given operating requirements of the plant?
- Is the project feasible given the culture of the plant personnel?

The list of potential energy efficiency opportunities is organized into a comprehensive suite of projects, that can be implemented, tracked and evaluated over the long-term, as they best fit the customer’s operational needs.
Prioritization Chart
A visual representation of simple payback, project value and project ranking as a combination of ‘feasible’, ‘simple’ and ‘quick’ parameter assessment.
## Project Portfolio

Tiered portfolio of energy saving projects, prioritised into projects for immediate development (Tier 1) and projects requiring further information or confirmation prior to development (Tier 2).

### TIER 1

Projects for immediate development.

### TIER 2

Projects requiring further information or confirmation prior to development.

Projects that do not require further development prior to implementation.
Deliverables – Project Specification

- Contains detailed project specific information to enable the implementation of the energy saving opportunity
May be supported with further documentation (e.g. vendor quotations)
Industrial Energy Efficiency
Phase 3: Implementation

Opportunity Identification

Master Plan

Implementation

ABB Program Manager

ABB Energy Team

ABB Engineering

ABB Service

ABB Automation & Technologies

Client Sponsor

Client Energy Team

Client Engineering

Client Contractor

3rd Party/OEM Technologies

MANAGEMENT

EXPERTISE

ENGINEERING

EXECUTION

TECHNOLOGY

ABB Energy Team

ABB Engineering

ABB Service

ABB Automation & Technologies

Client Engineering

Client Sponsor

Client Contractor

3rd Party/OEM Technologies
Industrial Energy Efficiency Assessments: Phases 2 & 3: Planning & Implementation

Most Engineering & Consulting firms stop here:

ABB’s portfolio of products and services allows a long-term partnership with the customer through the entire EE process.
“Rydell” Energy Efficiency Assessment: Recently completed 400MW unit (July 2010)

- 96 page Opportunity Identification Report
- 47 Energy Savings opportunities identified
- $4M - $11M/yr potential savings
- Assessment covered full plant:
  - Boiler Island
  - Turbine & Generator Island
  - Electrical Balance of Plant
  - Control System
  - Performance Monitoring & Usage of information
  - Materials Handling, Water & Air Systems
  - Management processes & internal promotion of Energy Efficiency activities

- One of the major findings: significant blowdown leakage - then repaired during a recent outage
  - Savings $1.2M/yr → Payback for assessment cost: **3 weeks**
Industrial Energy Efficiency identifies zero or low capital investment projects to save energy that can be implemented immediately as “quick wins”.

Following the identification of energy saving projects and development of the Master Plan, projects are implemented according to a prioritised plan.
Energy Efficiency Lite

- Consistent feedback from customers and AMs that $75K for a full plant or unit assessment is difficult to justify

- Energy Efficiency Lite
  - Single Subsystem or piece of equipment
  - Low Cost
  - Flat fee, no detailed proposal process
  - 1 week turnaround on delivery of report
Energy Efficiency Lite

- Example areas:
  - Blowdown/leakage rates
  - Combustion parameters
    - O2 levels
    - Furnace pressure stability
    - SH/RH spray flow levels
    - Heat rate
    - Main steam temp & pressure levels and controls
  - Main Pump and Fan systems, for application of drives, plus actuator performance.
Energy Efficiency Lite

- Benefits
  - On site review of equipment operation and condition
  - On site gathering of historical operation data of equipment
  - Report that the customer will own, outlining:
    - The energy efficiency gains that could be recognized in a specific area
    - The estimated cost of process upgrades or changes to achieve those gains.
    - A clear picture of the return of investment
Energy Efficiency Lite

Annual Operating Hours Rydell Energy: Island Unit 5 at % of 150MW MCR Load

<table>
<thead>
<tr>
<th>% of MCR</th>
<th>Number of Hours</th>
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<tr>
<td>0-10</td>
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<tr>
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<tr>
<td>80-90</td>
<td>450</td>
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<tr>
<td>90-100</td>
<td>500</td>
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</tbody>
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Supply voltage: 480 V
Motor power: 1750 Hp
Motor efficiency: 90.0%

Operating profile:
Annual running time: 7,500 h

Specific fan power: 14.7 kW/(m³/s)
Saving percentage: 62.7%
Annual energy consumption: 4,222,921 kWh
Annual energy saving: 2,712,195 kWh
Annual CO₂ reduction: 1,356,056 lb
CO₂ emission per unit: 0.5 lb/kWh

Currency: $ Energy price: 0.17 $/kWh
Investment cost: 225,000 $ Interest rate: 7.0%
Service life: 10.0 years

Economic results:
Annual money saving: 461,073 $
Payback period: 0.5 years
Net present value: 3,013,385 $

ABB
Power and productivity for a better world™