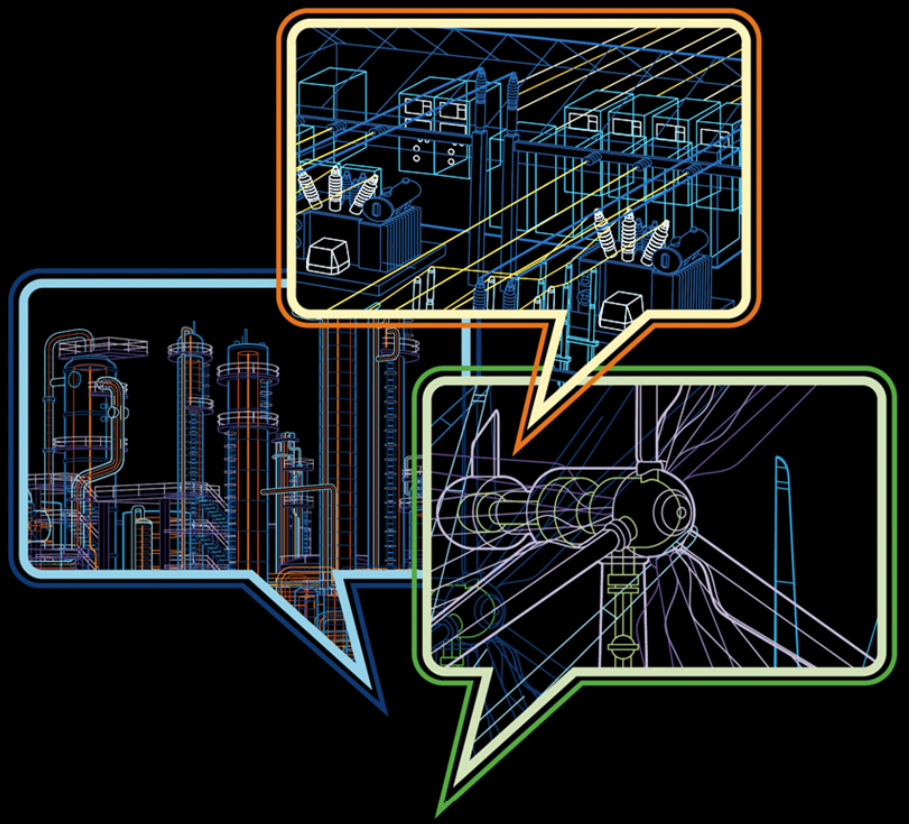


ABB Power Generation Energy Efficiency: February 2012

Richard Vesel

PGEE for IEC

Benefits of a Comprehensive Energy Efficiency Assessment

PGEE: Benefits of a Comprehensive Energy Efficiency Assessment

- Speaker name: **Richard Vesel**
- Speaker title: **Global Product Manager**
  EBoP for Energy Efficiency
- Company name: **ABB Inc.**
- Location: **Wickliffe, Ohio – USA**

- **Email** richard.w.vesel@us.abb.com
- **Phone** **+1-440-585-6596 (office)**
  +1-330-819-5054 (cell)

Plant Losses:
Thermal Process Losses + Auxiliary Plant Loads

- Conventional fossil-fired boiler power plants

  60-70% Thermal loss plus 7 - 15% Auxiliary loss

- CCGT: Combined cycle gas turbine power plants

  45-50% Thermal loss plus 3 - 4% Auxiliary loss

==========

Inefficiency loses money via higher heat rates* and reduced net capacity

==========

- Reduced power sales revenue / Excess fuel cost expenditures

- For North American Coal-fired plants:

Best HR: 9300 Btu/KWh (Eff = 37%)

Worst HR: 14000 Btu/KWh (Eff = 24%)

Plant Efficiency Improvements:
Utilitity Industry Drivers

- **Operating Costs Increasing**
  - Plant net & gross efficiencies gradually deteriorate while fuel costs rise (thermal → electric conversion efficiency declines with age)
  - **Environmental requirements for BACT: Best Available Control Technology, to be applied to plants for energy efficiency improvement and MACT for emissions control (Mercury, Arsenic, NOx, SOx, PM2.5) – USA: December, 2011**

- **Moratorium on new coal plant construction – Public & Financial foes**
  - Cost of ≥ $2M / MW for new plant construction v. Gas of ≤ $1M / MW
  - Least efficient older thermal plants are being retired or moth-balled now!
  - Need to Increase efficiency, output and lifetime of existing viable sites
  - What plants will "make the cut"? Answer: Cleanest & Lowest $/MWhr

- **Negative drivers – Slow economy has temporarily reduced power demands**
  - How long will that last? A lot less than new plant construction cycles!

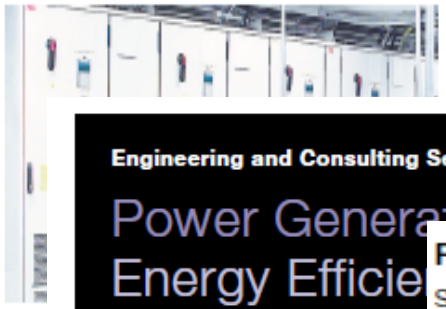
Some example numbers for crunching…

- **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 $\geq$ 25MW
  - Leaks, cycle isolation and operability issues identified, addressed & corrected
  - New motors and VFD's applied to largest pumps & fans
  - Advanced Controls applied to O2, spray flows & controllability issues
  - 25MW of house load reduced to $\leq$ 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

Opportunities in a CCGT plant

- **Fuel quality monitoring**
- **Turbine Instrumentation & Efficiency Monitoring**
- **Burner balancing & tuning**
- **VFD's for fuel compressor**
- **VFD for electrically driven BFP**
  - **Note: Single outlet BFP only**
- **VFD's on cooling system fans and/or pumps**

Power Generation Energy Efficiency
Plant Energy Efficiency Assessments

Technology	Energy Efficiency	Power Generation Energy Efficiency Benefits
	**ABB Variable Frequency Drives**	
	We are the number one industry supplier of	Evaluation of the opportunities for variable speed drives,

Engineering and Consulting Services

Power Generation
Energy Efficie

ABB's Power Gener
Efficiency Assessme
methodology, leadir
and deep knowledg
identify, capture anc
energy savings.

Phase 1: Opportunity Identification –This phase identifies specific opportunities to deliver improvements, by understanding how and where energy is used, identifying areas of unnecessary losses, and comparing current performance with established best practice.

Phase 2: Energy Management Master Plan – Identified opportunities are developed into a detailed implementation plan to deliver savings. This plan takes the form of a suite of individual improvement projects, each with well defined benefits and benefit verification methods, costs, implementation method, technology options, and potential vendors for non-ABB-supplied items.

Phase 3: Implement, Commission, Sustain – Here the projects are brought to reality, with the further support of ABB Power Generation Products and Integrated Services. After installation and commissioning, Services remains engaged throughout the life-cycle of the equipment, insuring that it meets it expectations.

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Power generation energy efficiency
Full-plant energy efficiency assessment

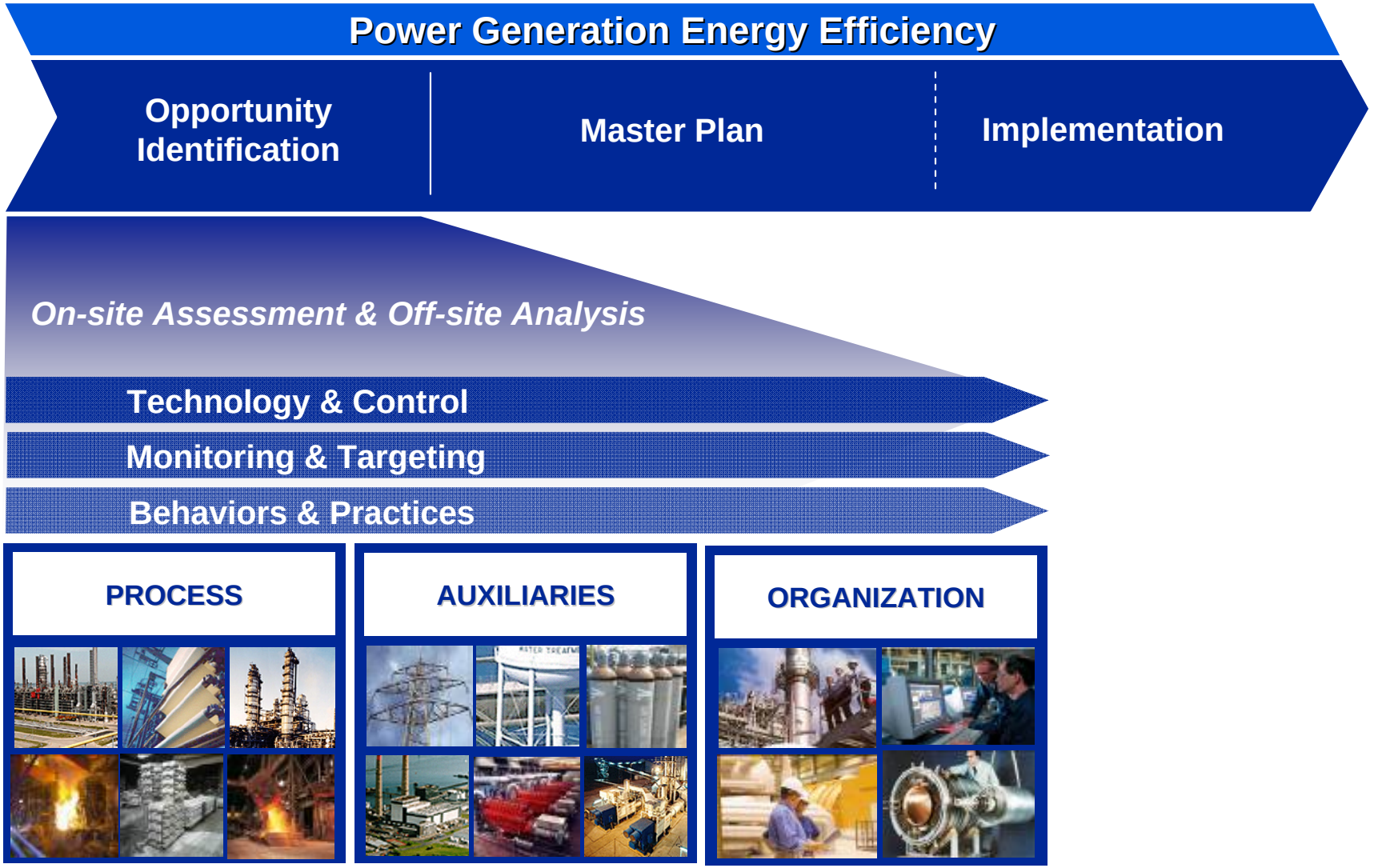
Power Generation Energy Efficiency

Opportunity Identification

Master Plan

Implementation

Case Study



PGEE Assessment Program:
Review of Monitoring & Targeting

Recording	Measuring and recording energy consumption
Analyzing	Correlating energy consumption to a measured output, e.g. production quantity
Comparing	Comparing energy consumption to an appropriate standard or benchmark
Targeting	Setting targets to reduce or control energy consumption
Monitoring	Comparing energy consumption to the set target on a regular basis
Reporting	Reporting results including any variances from the targets which have been set
Controlling	Implementing management measures to correct any variances.

Power Generation Energy Efficiency
Areas of investigation & evaluation

Technology & Control

Identification of improvements through process control, equipment modification or alternative energy efficient technologies, typically covering the following energy systems:

- Gas Turbines
- Steam Boilers, Turbines & Systems
- Electric Generator & Related Equipment
- Major Pump, Fan & Motor Systems
- Electrical Systems – High Voltage & Site MV/LV Systems
- Compressed Air & Industrial Gases
- Heating, Ventilation & Air Conditioning (HVAC)
- Refrigeration & Chilling Systems

Behaviors & Practices

Assessment of behaviors and practices relating to energy efficiency across site processes and utility operations through a comprehensive review versus best practice, including:

- Energy Strategy & Policy
- Energy Management Methods
- Capital Investment
- Information Technology
- Operational Management
- Operational Planning & Performance
- Training & Development
- Maintenance Practices & Strategies
- Staff Motivations & Incentives

Power Generation Energy Efficiency
Example of site assessment schedule

- Concentrated site assessment with 2 on-site teams:

	Day 1 (07th June 2010)	Day 2 (08th June 2010)	Day 3 (09th June 2010)	Day 4 (10th June 2010)	Day 5 (11th June 2010)
ABB Team A	Kick-Off Boiler Island	Turbine Island KPI Systems	Electrical Infrastructure	Consolidation & Contingency	Close-out meeting
ABB Team B	Kick-Off Materials Handling	Water Systems Comp Air	Maintenance /Flue Gas Treatment	Consolidation & Contingency	

Power Generation Energy Efficiency
A few site assessment examples

Equipment Inspected, Plant Data Extracted & Analyzed

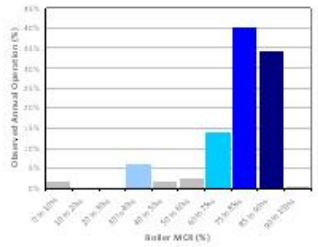


Fig 2 – Unit load profile

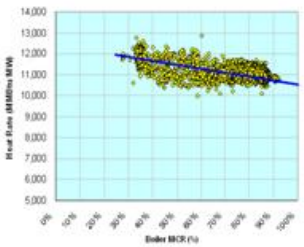


Fig 3 – Heat Rate v. Load

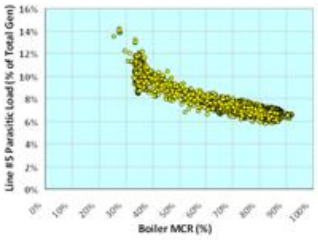


Fig 4 – Aux Load v. Load

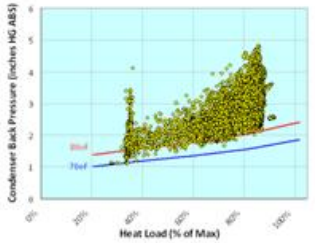


Fig 5 – Condenser BP v. Load

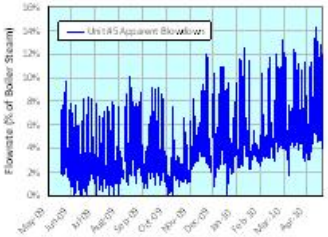


Fig 6 – Blowdown Rate

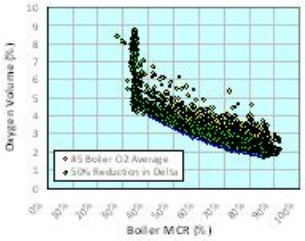
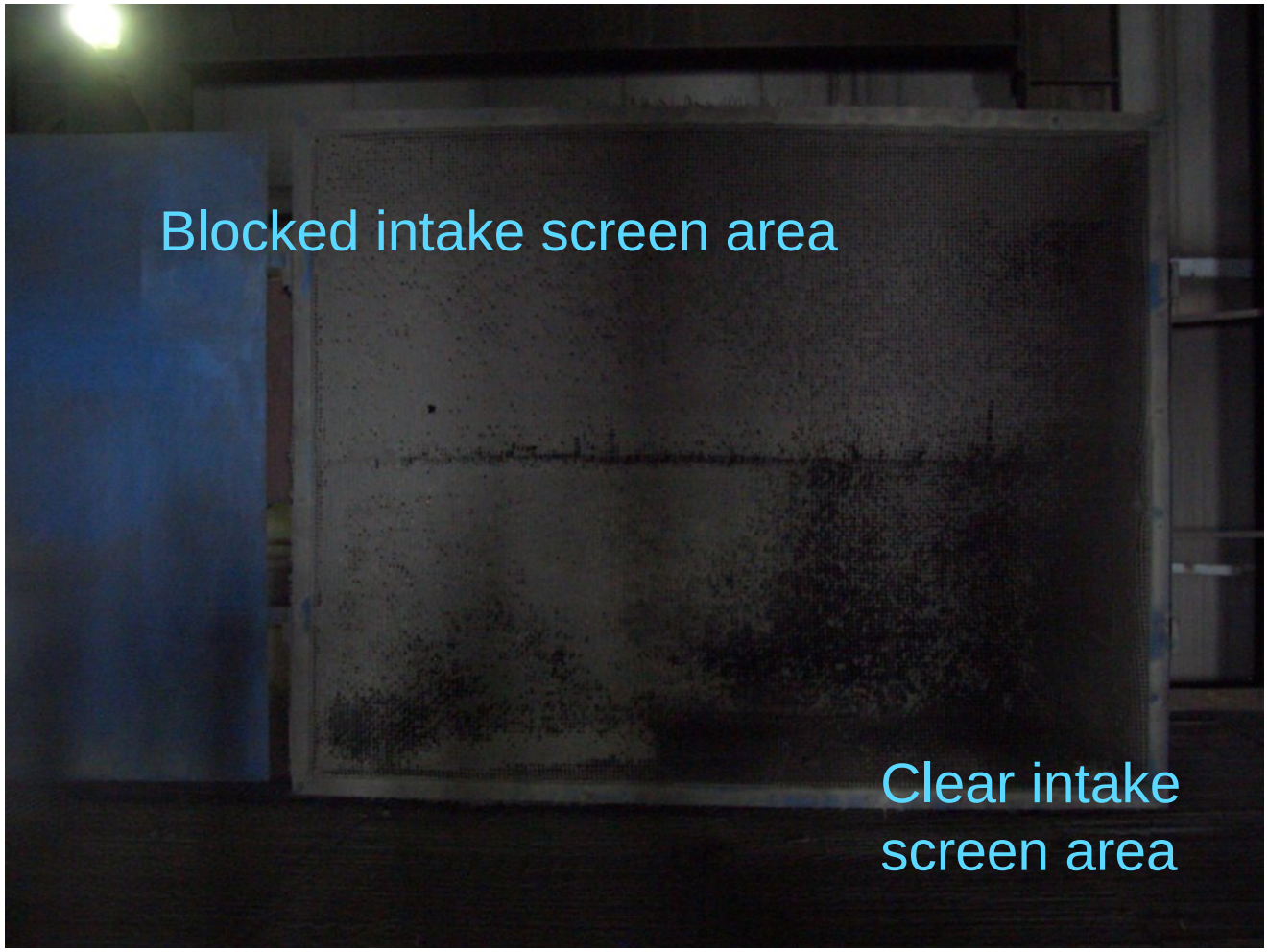


Fig 7 – Excess O2 v. Load

Sample Results: FD Fan Intake at boiler top (PL)



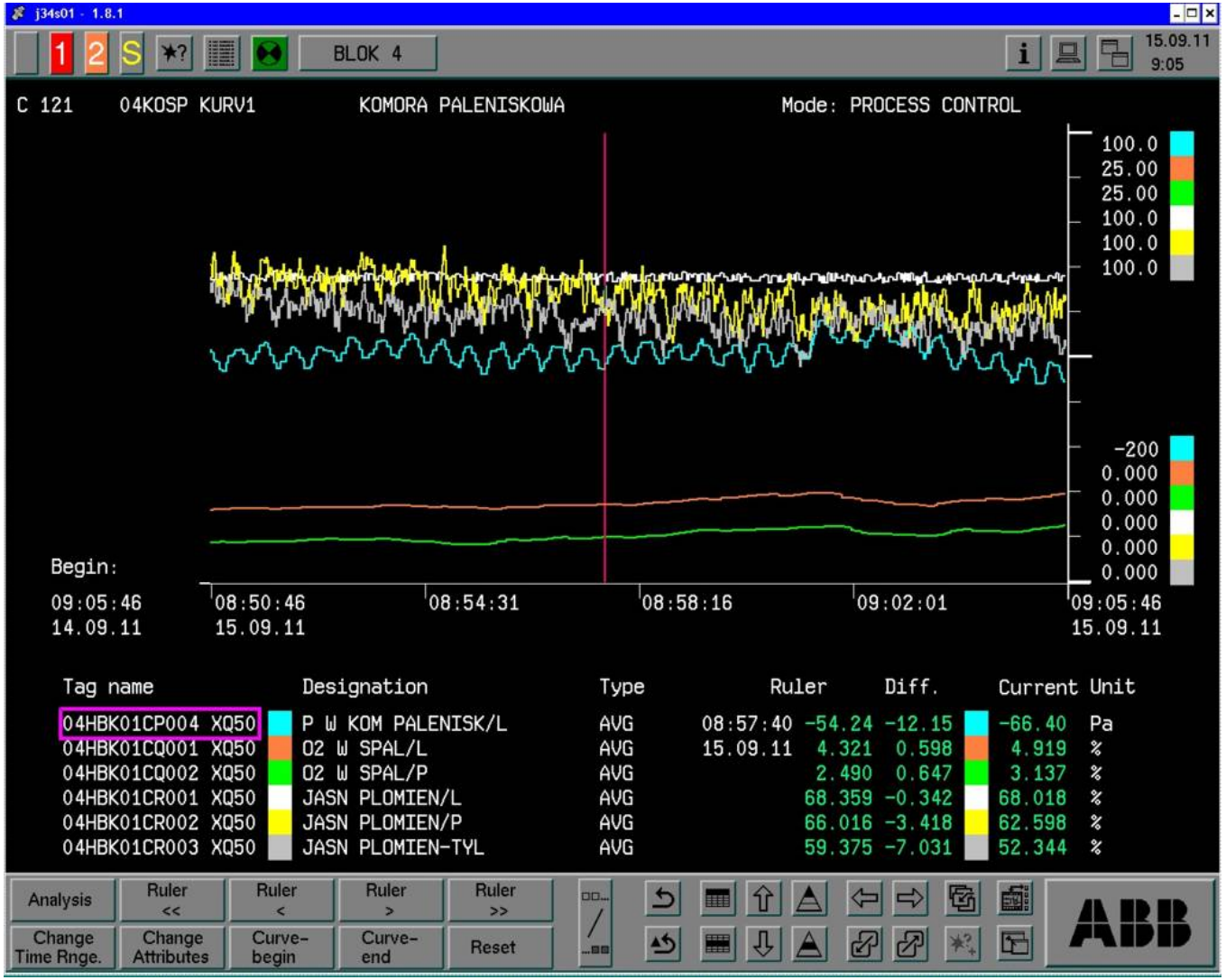
Cleaning the air inlet will allow for more air flow

This will increase intake flow for the primary air, secondary air and the mill fans.

Generator H2 cooling water circulation pump leak

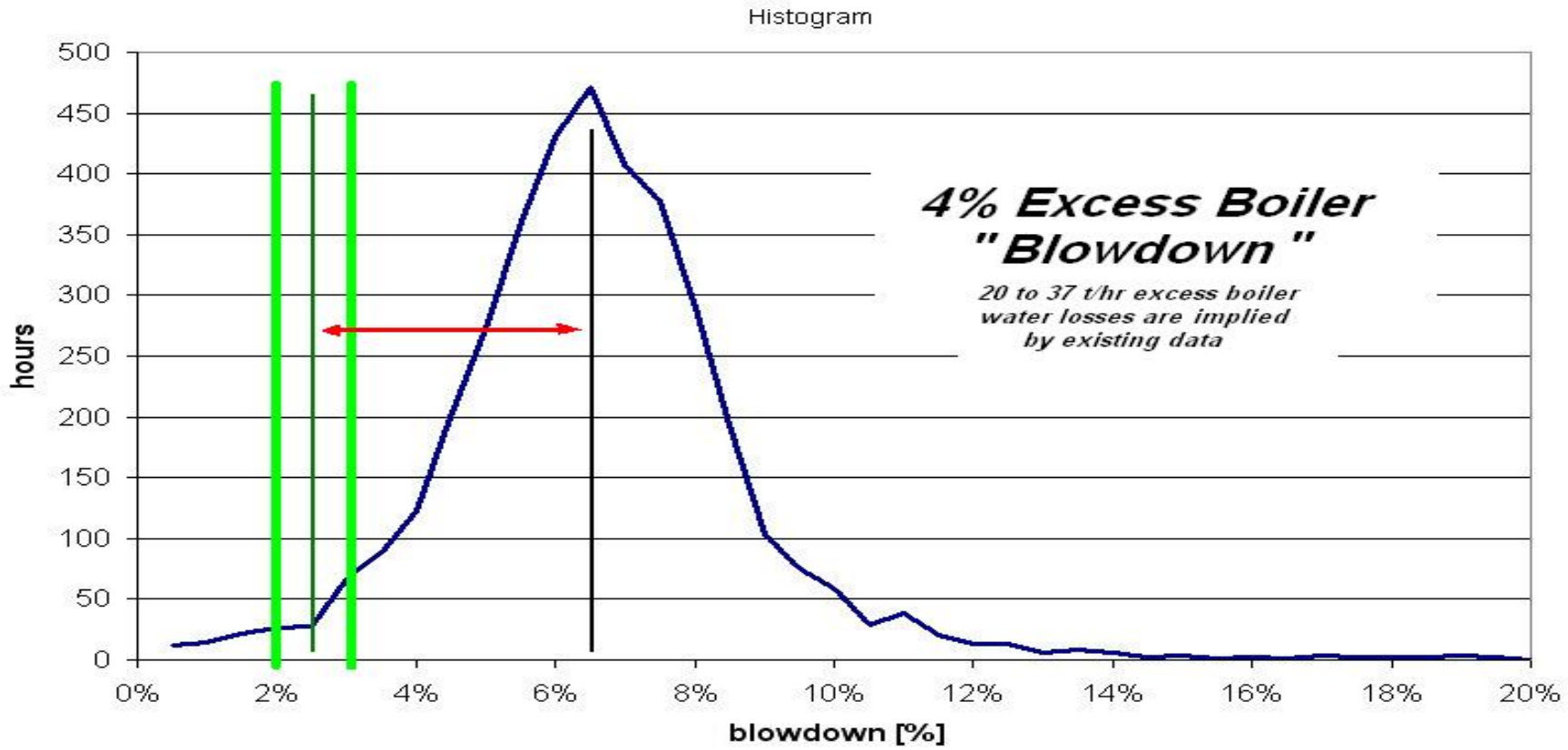
Furnace pressure oscillates with a period of ~30 sec

This may be due to air preheater leakage, so it should be investigated.



Reduction of Blow Down Losses (CN)

- Identify water losses in water-steam cycle
- Find and repair leakages if any
- Install automatic water chemistry monitoring & controls to minimize blow down

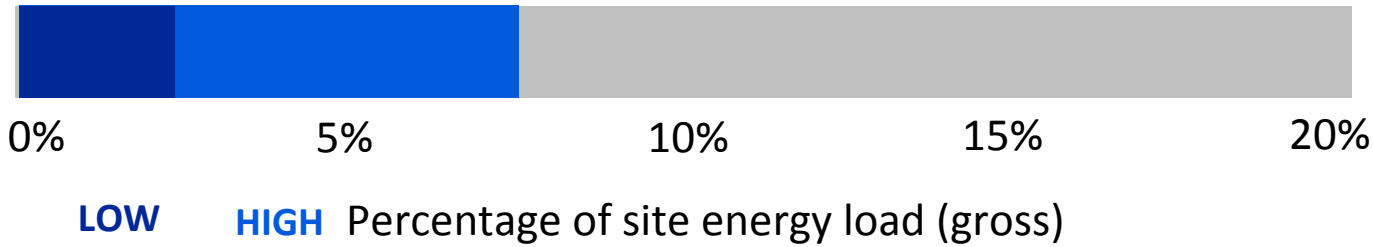


Equiv. Savings 160 – 300 RMB/h

Power Generation Energy Efficiency
400 MW “Rydell” power plant results overview

- Total of 47 energy efficiency opportunities identified across:
  - Technology & Control
  - Behaviors & Practices
  - Monitoring & Targeting
- Total portfolio value range of:

US$ 4 to 11 Million/year



- Analysis stage to confirm and improve resolution of values

“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***

Energy Efficiency Master Plan
Alignment workshop – prioritization of projects

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).

INDUSTRIAL ENERGY EFFICIENCY - MASTER PLAN PROJECT PORTFOLIO

Date: 08/07/2009 Revision: 2.1

	Site Area	EMMP PRO Idea No.	Idea Title	Energy Savings ($ / year)	Metering F	T	kW	A	EMMP Opportunity Risk Rating: Rating	Frequency	Probability	Severity	Risk	EMMP Project Parameters: Ease	Term	Cost ($K)	Payback	Verification Method
Site Owned	Overall Site	ID-0010A	Energy Saving Opportunity A	XXX	☑	-	-	-	STRA	8	5	2	80	Simple	Long	XXX	XXX	Verification Method 6
Site Owned	Overall Site	ID-0010B	Energy Saving Opportunity B	XXX	-	-	-	-	STRA	8	5	1	40	Simple	Short	XXX	XXX	Verification Method 7
Site Owned	Plant Area 2	ID-0010C	Energy Saving Opportunity C	XXX	-	-	-	-	STRA	8	5	1	40	Moderate	Medium	XXX	XXX	Verification Method 8
EMMP	Plant Area 1	ID-00100	Energy Saving Opportunity 1	XXX	☑	-	-	☑	STRA	8	4	5	160	Moderate	Medium	XXX	XXX	Verification Method 1
EMMP	Plant Area 1	ID-00101	Energy Saving Opportunity 2	XXX	-	☑	-	☑	STRA	8	5	2	80	Complex	Medium	XXX	XXX	Verification Method 2
		ID-00102	Energy Saving Opportunity 3	XXX					STRA	8	5	7	280					
EMMP	Plant Area 1	ID-00103	Energy Saving Opportunity 4	XXX	-	-	☑	-	STRA	6	5	5	150	Simple	Short	XXX	XXX	Verification Method 3
EMMP	Plant Area 2	ID-00104	Energy Saving Opportunity 5	XXX	☑	-	-	-	STRA	8	5	2		Simple	Short	XXX	XXX	Verification Method 4
EMMP	Plant Area 2	ID-00105	Energy Saving Opportunity 6 Energy Saving Opportunity 7 Energy Saving Opportunity 8	XXX	-	-	-	-	STRA	8	5	2	80	Simple	Medium	XXX	XXX	Verification Method 5
EMMP	Overall Site	ID-00106	Energy Saving Opportunity 9 - Tier 1	XXX	☑	-	-	-	STRA	8	5	2	80	Simple	Long	XXX	XXX	Verification Method 6
EMMP	Overall Site	ID-00107	Energy Saving Opportunity 10 - Tier 1	XXX	-	-	-	-	STRA	8	5	1	40	Simple	Short	XXX	XXX	Verification Method 7
EMMP	Plant Area 2	ID-00108	Energy Saving Opportunity 11	XXX	-	-	-	-	STRA	8	5	1	40	Moderate	Medium	XXX	XXX	Verification Method 8
			Phase 2 Total Savings	XXX									*Phase 2 Total Investment*			XXX	XXX	*Averaged Payback*
EMMP Future	Plant Area 2	*AER-0203*	Future EMMP Opportunity 1	XXX	-	-	-	-	STRA	8	5	1	40	Simple	Long	XXX	XXX	Verification Method 1
EMMP Future	Plant Area 3	*AER-0210*	Future EMMP Opportunity 2	XXX	-	-	-	-	STRA	2	2	7	28	Complex	Long	XXX	XXX	Verification Method 2
EMMP Future	Plant Area 1	*AER-0211*	Future EMMP Opportunity 3	XXX	-	☑	-	☑	STRA	8	5	7	280	Complex	Long	XXX	XXX	Verification Method 3
EMMP Future	Overall Site	*AER-0212*	Future EMMP Opportunity 4	XXX	-	-	-	-	STRA	8	4	2		Simple	Medium	XXX	XXX	Verification Method 4
EMMP Future	Overall Site	*AER-0213*	Future EMMP Opportunity 5 Future EMMP Opportunity 6	XXX	-	-	☑	-	STRA	8	4	1		Moderate	Long	XXX	XXX	Verification Method 5
EMMP Future	Plant Area 2	*AER-0214*	Future EMMP Opportunity 7	XXX	☑	-	-	-	STRA	8	5	1	40	Simple	Short	XXX	XXX	Verification Method 6
EMMP Future	Plant Area 2	*AER-0215*	Future EMMP Opportunity 8	XXX	☑	-	-	-	STRA	8	5	1	40	Simple	Short	XXX	XXX	Verification Method 7
EMMP Future	Overall Site	*AER-0216*	Future EMMP Opportunity 9	*XXX*	☑	☑	☑	☑	STRA	8	5	2	80	Moderate	Long	*XXX*	*XXX*	Verification Method 8
EMMP Future	Plant Area 1	*AER-0217*	Future EMMP Opportunity 10	XXX	-	-	-	-	STRA	8	5	2	80	Simple	Medium	XXX	XXX	Verification Method 9
EMMP Future	Overall Site	*AER-0218*	Future EMMP Opportunity 11	XXX	☑	-	-	-	STRA	8	5	2	80	Simple	Long	XXX	XXX	Verification Method 10
EMMP Future	Plant Area 2	*AER-0219*	Future EMMP Opportunity 12	XXX	-	-	-	-	STRA	8	5	2	80	Simple	Short	XXX	XXX	Verification Method 11
EMMP Future	Plant Area 2	*AER-0220*	Future EMMP Opportunity 13	XXX	-	-	☑	-	STRA	8	4	1	32	Moderate	Medium	XXX	XXX	XXX
EMMP Future	Plant Area 4	*AER-0221*	Future EMMP Opportunity 14	XXX	-	-	-	-	STRA	-	-	-	-	Moderate	Medium	XXX	XXX	XXX
EMMP Future	Plant Area 4	*AER-0222*	Future EMMP Opportunity 15	XXX	-	-	-	-	STRA	-	-	-	-	Moderate	Medium	XXX	XXX	XXX
			Further EMMP Total Savings	XXX									*Phase 2 Total Investment*			XXX	XXX	*Averaged Payback*
EMMP N/A	Plant Area 2	*TBC*	Site Owned Opportunity 1	XXX	-	-	-	-	STRA	8	5	1	40	Simple	Short	XXX	XXX	XXX
EMMP N/A	Plant Area 2	*TBC*	Site Owned Opportunity 2	XXX	-	-	-	-	STRA	8	5	2	80	Simple	Medium	XXX	XXX	XXX
EMMP N/A	Overall Site	*TBC*	Site Owned Opportunity 3	XXX	-	-	-	-	STRA	8	5	1	40	Moderate	Long	XXX	XXX	XXX
EMMP N/A	Plant Area 4	*TBC*	Site Owned Opportunity 7	XXX	☑	☑	☑	-	STRA	Ongoing	Ongoing	Ongoing	-	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing Ongoing

KEY

EMMP	Project recommended for immediate EMMP
EMMP Future	Project recommended for future EPC Development
Site Owned	Project recommended for Site Ownership
EMMP N/A	Project considered not applicable for EMMP

F - Flow / IGV% (gas/air) metering *Blue text indicates potential new measurement required*
T - Temperature measurement
kW - Power or Current metering
A - Analytical measurement (e.g. O2)

Projects that do not require further development prior to implementation.

TIER 1

Projects for immediate development.

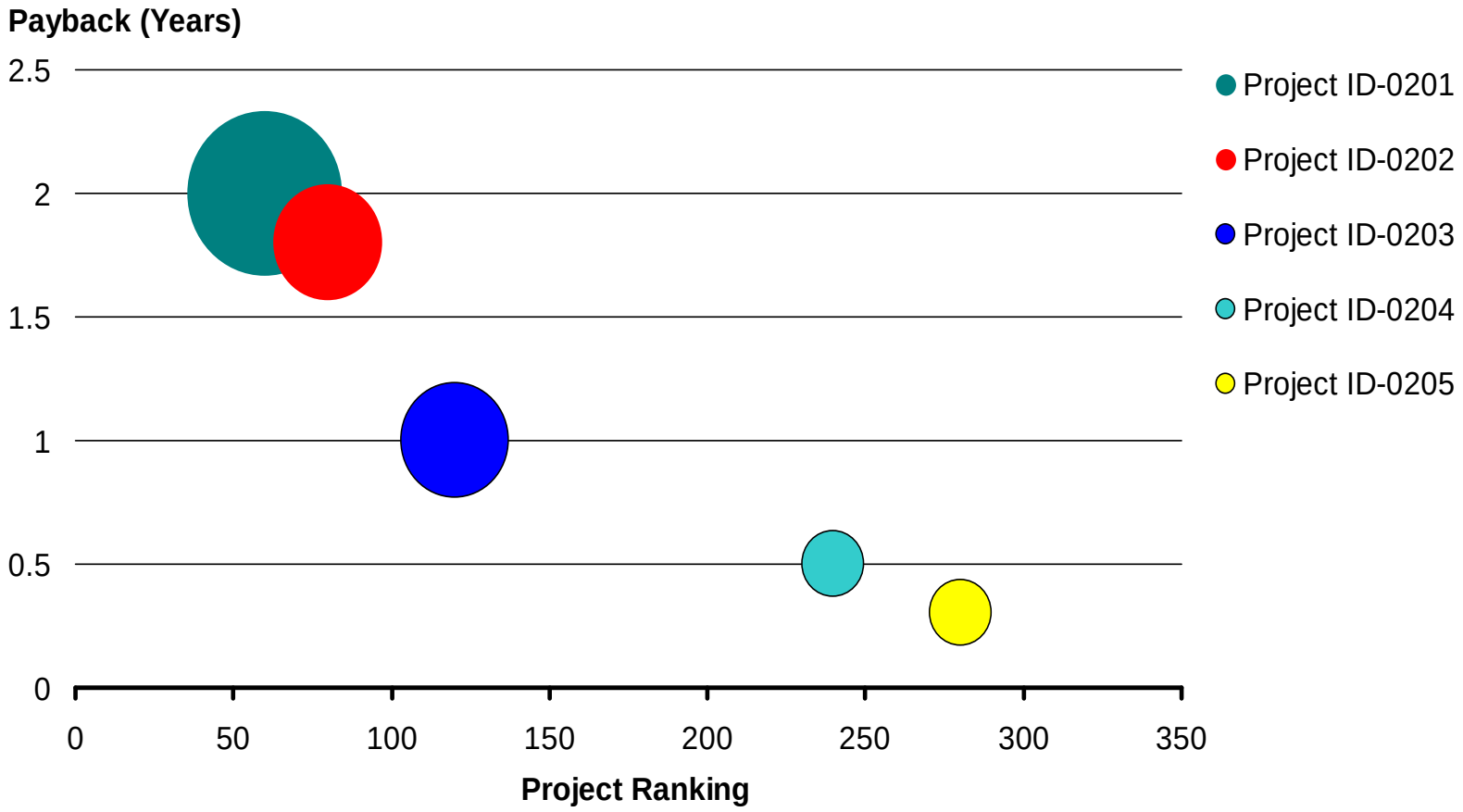
TIER 2

Projects requiring further information or confirmation prior to development.

Projects not considered for development.

Energy Efficiency Master Plan
Alignment workshop – economic prioritization

Prioritization Chart
A visual representation of simple payback, project value and project ranking as a combination of ‘feasible’, ‘simple’ and ‘quick’ parameter assessment.



Power Generation Energy Efficiency

Value creation

ABB ICE Services

What is Power Generation Energy Efficiency?

Target Market Solutions

End Customers & Buyers

Deliverables & Results

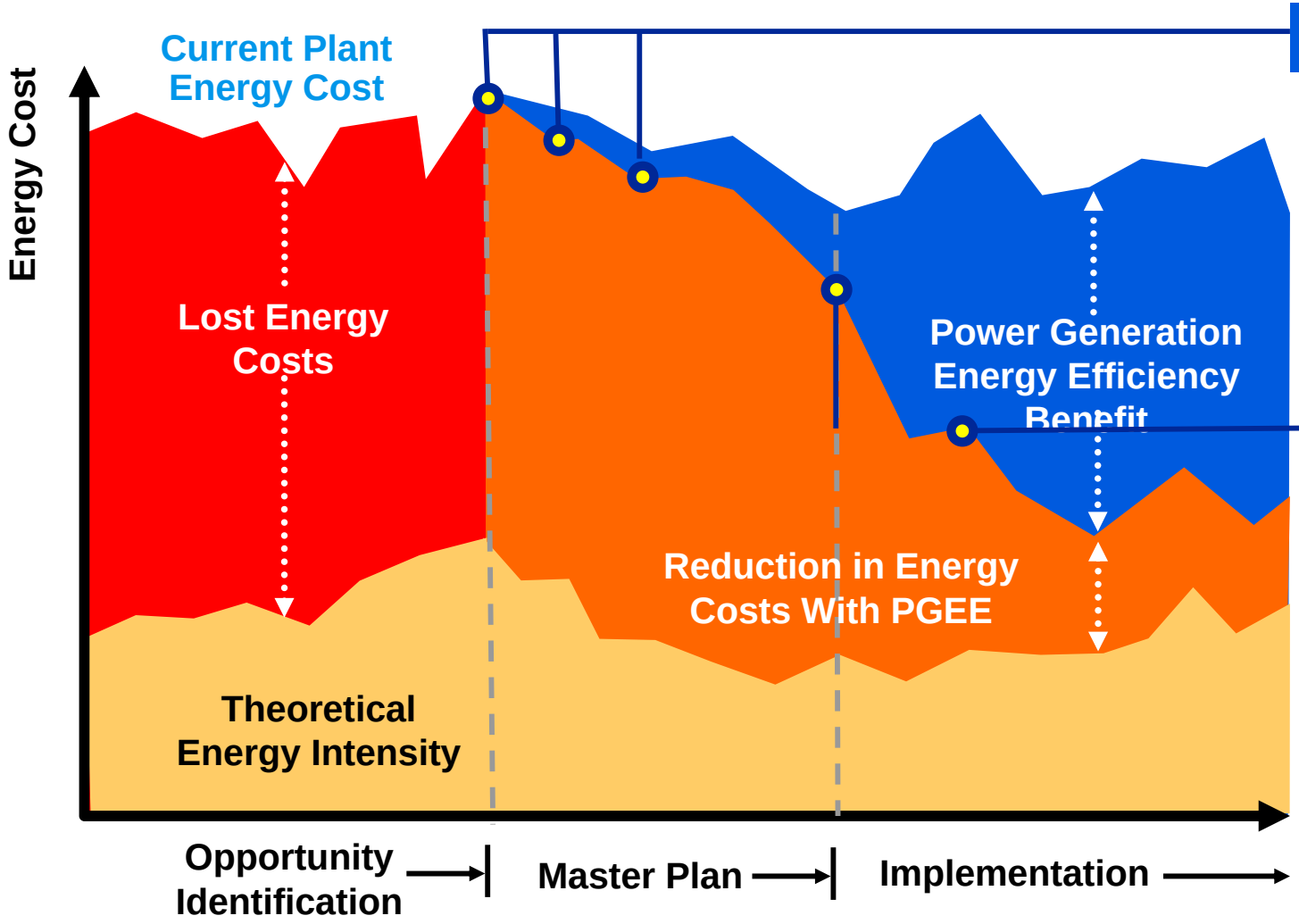
The Sales Process

Resource Requirements & Costs

Customer Involvement

Tools to Support You

Contacts



Quick Wins

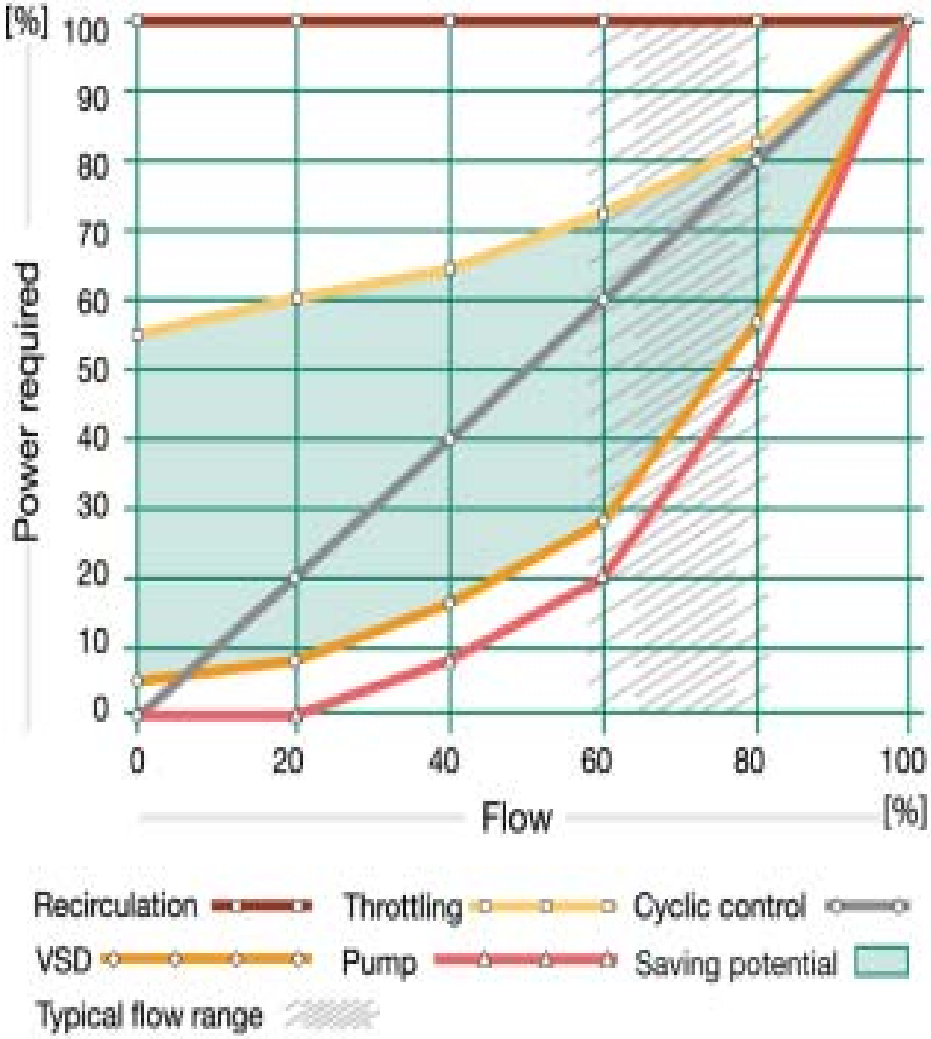
Industrial Energy Efficiency identifies zero or low capital investment projects to save energy that can be implemented immediately as “quick wins”.

Projects

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

Energy Savings and Reduced 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 CO_2 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
- Output voltages: 4.16 kV, 6.9kV
- Active Front End permits VAR Compensation
- Modular Solution for “off the shelf” applications

Advanced Controls
Coal-fired Plant: Lorraine, France

- **Customer needs**
  - Customer wanted to capture added value with faster ramp rate response for secondary frequency control
  - Original controls were installed in 1970's and were operating slowly and poorly
- **ABB's response**
  - Upgraded boiler and turbine controls
  - MODAN Advanced Unit Control
  - Coordinated boiler-turbine control for sliding pressure operation
- **Customer benefits**
  - Improved efficiency and reliability
  - Response capability of ±25MW in 30 sec with 265MW max net output
  - Improved plant revenue due to participation in secondary frequency control program

Drive and Motor Systems
Waste-to-Energy Plant: Florida, USA

- **Customer needs**
  - ID Fans used unreliable old (non-ABB) MV drives
  - Last units made of that type
  - Problematic with many failures
  - No spare parts available
- **ABB's response**
  - ACS1000 - Modern MV-Drive Design
  - High Reliability
  - Fully supported & serviced
  - Six drives installed in 2003
- **Customer benefits**
  - Reduced energy consumption
  - Reduced maintenance – virtually trouble-free and outage-free operation 24/7 for six years
  - Only 1 failure in 1 drive, in six years of operation (cooling fan bearing)

Ask us for more about
Power Generation Energy Efficiency

- **Free** and available to all of our utility customers:
  - Power Plant Energy Efficiency Handbook
  - Rydell Energy Center Assessment Report
  - On-site presentation of our EE approach
  - (Soon – CCGT Assessment report)

- Contact your ABB Service Account Manager, Front End Sales Representative or Strategic Account Manager for an on-site presentation and performing a quick opportunity evaluation.

Power and productivity
for a better world™