Energy Efficient Solutions for EAF

Ecoplants-Technologies by SMS Group

Dr. Christian Fröhling
General Manager Energy & Environmental Technologies / Gas Cleaning
SMS Siemag AG, Germany
The family owned SMS group is internationally active in plant construction and mechanical engineering relating to the processing of steel and nonferrous metals.

<table>
<thead>
<tr>
<th>SMS Siemag</th>
<th>SMS Meer</th>
<th>Paul Wurth</th>
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</thead>
<tbody>
<tr>
<td>1.8 m Euro turnover</td>
<td>1.2 m Euro turnover</td>
<td>ca. 1,500 employees</td>
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<tr>
<td>ca. 7,500 employees</td>
<td>ca. 3,500 employees</td>
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</table>

- Metallurgical plant | Continuous casting | Hot rolling mills | Cold rolling mills | Aluminum rolling mills | Strip processing lines | Furnace technology | Electrics and Automation | Service | Energy & Environmental Technologies

- Steelmaking plants / Continuous casting | Tube plants | Long product rolling mills | Forging technology | Nonferrous metal plants | Induction technology | Electrics and Automation | Service

- Ironmaking | Cokemaking | Steelmaking | Environmental solutions | Recycling technologies | Non Ferrous | Civil & Environmental Engineering
Environment protection and economical success – a conflict?

Green is the colour of nature…

…and the color of money!
Ecoplants – resource-efficient technologies

Upstream/downstream: different technical developments

Focus on process improvement

Focus on yield improvement

Raw materials → Iron and steel making → Reheating → Hot rolling → Products
Selection of references

**CMT™ Minimill**
-72,000 t CO₂ p.a.
-410 t SO₂ p.a.
-225 t NOₓ p.a.

€ -11 € / t steel

**Laminar cooling system**
-1 m. m³ water
-2,500 MWh p.a.

€ - 3-4 € / t steel

**ARCCESS® steady EAF**
-120 kWh t / steel
-8 € t / steel
+30% productivity

**EFA™ – Process**
Sulphur content:
< 50 mg/m³ STP
Dust: < 5 mg/m³

€ up to 1€/t pig iron

**Evaporator for electrolytic tinning lines**
-3,200 t CO₂ p.a.
-42,000 m³ water

€ - 4 m. € p.a.

**Energy Recovery at melting and casting**
- max. 60,000 t CO₂ emissions

€ - 3-4 € / t of steel

**X-Pact® Energy Advisor**
-8 % energy consumption

€ - 5 m. € p.a.

**Gas Cleaning Assistant**
-21 % energy consumption

€ - 185,000 € p.a.
Our product portfolio of environmental technologies

- Energy Recovery Systems (EAF, BOF, SAF, Sinter cooling, CDQ, RHF)
- Gas Recovery (BOF, SAF)
- Process Gas Boiler / Power Plants
- Energy from hot slabs
- Innovative melting
  - Primary Energy Melter
  - S/EAF®
- Complete gas cleaning plants for all metallurgical equipment
- Primary gas cooling / dedusting
- Secondary dedusting systems
- Gas Recovery (BOF, SAF)
- Dedioxination (by lignite coke)
- Desulphurization
- EFA™ process
- Classic waste water treatment
- Make-up water Technologies
- Open & closed cooling cycles
- Thermal processes
- Membrane processes
- Chemical supply
- Waste material SAF & briquettes
- Dry Slag Granulation
- Combined EAF shredder Process
- Maintenance & Optimization
- Revisions & Studies
- Revamp/Modification & Spare parts
- Energy Management & Energy Monitoring Systems
- Water treatment
- By-products & recycling

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Recovery of energy from waste heat at EAF
Recovery of energy from waste heat at melting units

- Hot off-gas (600 – 2,100 °C) has to be cooled down
- Use of chemical and sensible heat for steam generation
- Applications at:
  - EAF
  - BOF / AOD
  - CONARC
  - SAF

→ Recovery of energy
Recovery of energy from waste heat at melting units

1,200 °C → 700 °C → 250 °C → <130 °C

Conventional
Water cooling

Innovative
Steam generation

Steam Utilization

Wasted energy → Energy recovery
Typical set up of an EAF plant with a two step Energy Recovery System

Step 1: Evaporative cooled post-combustion chamber + duct

Step 2: Additional Waste Heat Boiler

1,200 °C

700 °C

250 °C

< 130 °C

Bag house filter
Further development: Compact Boiler for EAF – future design

Advantages of a compact set up:

- Option for energy recovery
- Small layout „footprint“
- Natural circulation
  - No energy consumption by pumps
- Lower maintenance costs
  - No corrosion due to high wall temperature
  - Decreased abrasion due to low off gas velocity

Heat exchanger bundles
Evaporative cooled walls
Postcombustion zone
1,200 °C
Dropping of coarse dust & slag
230°C
Four different cases for EAF

**120 t EAF**
- 100% Scrap
- Offgas temp.: 250°C
- Energy recovery: 30 t/h steam

**190 t EAF**
- 49% Scrap, 51% DRI
- Offgas temp.: 250°C
- Energy recovery: 45 t/h steam

**120 t EAF**
- 60% scrap, 40% hot metal
- Offgas temp.: 250°C
- Energy recovery: 45 t/h steam

**190 t EAF**
- 90% HDRI, 10% CDRI
- Offgas temp.: 270°C
- Energy recovery: 91 t/h steam
Electricity tariffs worldwide

Electricity prices Thailand: 2 - 4 Thai Baht/kWh

Sources: Eurostat, EIA
Options for steam utilisation

- Power generation
- Air separation
- Fan or pump drive turbine
- Steam injector pumps for VD / RH process
- Cooling by absorption chilling
- Steam accumulator vessels
- Steam net
- ORC process
- Water treatment (e.g. desalination)

Wide influence on ROI!
Examples for steam utilisation

**Drive vacuum pumps at VD/RH plant with steam**
- Usage of steam to degas steel
  
  **Steam need:** 1 t steam / 10-20 t steel

  **Steam conditions:** 10-15 bar / 185-208° C

**Cooling by absorption chilling**
- Delivery of steam to steam-fired absorption chillers

  **Cold production for cooling control rooms**

  **Steam need:** 1 t steam / 0.45 MWh

  **Steam conditions:** 1.1 bar / 125 °C
Steam network

Delivery of steam to different producers

**DRI-Plant**
- 1 t Steam / 2 t DRI
- 145 – 190 °C / 3 – 15 bar

**Heating Pickling Line**
- Heating of pickling fluid
  - 1 t steam / 40-50 t sheets

**Fan or pump drive turbine**
- Delivery of steam to fan drive
  - 1t steam / 90 - 170 KWh

**Evaporation of liquid wastes**
- e.g. Preparation of oil-in-water emulsions by using steam
  - 1 t steam / 6.5m³
**Key Data**

**Customer**
- FuXin

**Order**
- 2010

**Commissioning**
- 2014

**Technology**
- Aggregates: EAF, AOD, LF, Gas Cleaning
- Energy Recovery at: AOD and EAF

**Sizes**
- Melting Aggregates:
  - 1x 160-t EAF
  - 1x 180-t AOD
  - 1x 180-t LF
- Steam Generation: 50 t/h (peak)
Example EAF: steam generation at one charge (FuXin, China)

Generated steam amount EAF
Heat 27.04.2014 06:05 to 07:30

Generated Steam: 34.7 t/charge
Steam Flow behind Drum: 24.5 t/hour
Degasser Steam Amount: 4.7 t/hour
Example EAF: Human-Maschine-Interface (FuXin, China)
Client: Tisco
Order intake: 2012
Commissioning: 2014

Technology:
Furnace: X-Melt® CONARC®
Planning & supply for new long product mill

Technical Data:
Steam generation: two boiler units, up to 60 t/h
CO₂ reduction: 25,000 tons per year

Energy Recovery System:
Stage 1: cools down to 600 °C
Stage 2: cools down to 200 °C
ARCESS® steady EAF (S/EAF®)
Efficient
Flat bath operation
Steady DRI charging
S/EAF® - core components

Ecoplants criteria

Ecological benefit:
Energy recovered: approx. 120 kWh per ton of steel
Emissions saved: Approx. 80 kg CO₂ per ton of steel
Economical benefit: Increase in productivity: 30%

DRI handling system
Energy recovery system
Material handling system
Electrode slipping system
Transformer
Oxygen Injection
Movable slag door
Hot metal launder
A new electric arc furnace S/EAF® for continuous operation

Revolutionary
Electrodes are clamped and slipped continuously

- Oxygen injection
- Patented moving slag door
- Hot Metal Launder
- Patented Tapping Device
Energy Recovery at S/EAF®

Scenario
120 t S/EAF® with
85% HDRI + 15% CDRI

- Steam generation: 88 t/h
  (398°C, 38 bar = superheated)
- 18 MW\textsubscript{el}
- Steam production: 747,000 t/a
- Electricity production 157,700 MWh p.a.
S/EAF®: Electric Arc Furnace without non-productive downtime

EAF operation

steady EAF operation

- 30%
Comparison of S/EAF® and EAF Process – Scenario Calculation

Increased Productivity at same Heat Size or smaller Equipment for same annual Steel Production

<table>
<thead>
<tr>
<th></th>
<th>EAF&lt;sub&gt;160&lt;/sub&gt;</th>
<th>S/EAF®&lt;sub&gt;160&lt;/sub&gt;</th>
<th>S/EAF®&lt;sub&gt;120&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tapping weight</td>
<td>160 t</td>
<td>160 t</td>
<td>120 t</td>
</tr>
<tr>
<td>Production capacity</td>
<td>1.6 m. tpy</td>
<td>2.1 m. tpy</td>
<td>1.6 m. tpy</td>
</tr>
<tr>
<td>Productivity</td>
<td>210 t/h</td>
<td>280 t/h</td>
<td>210 t/h</td>
</tr>
<tr>
<td>Specific energy consumption</td>
<td>420 kWh/t</td>
<td>400 kWh/t</td>
<td>390 kWh/t</td>
</tr>
<tr>
<td>incl. Energy Recovery</td>
<td>375 kWh/t</td>
<td>310 kWh/t</td>
<td>305 kWh/t</td>
</tr>
<tr>
<td>Tap-to-tap time</td>
<td>46 min</td>
<td>34,5 min</td>
<td>34,5 min</td>
</tr>
<tr>
<td>Transformer capacity</td>
<td>160 MVA</td>
<td>160 MVA</td>
<td>130 MVA</td>
</tr>
<tr>
<td>Energy Recovery</td>
<td>9,5 MW&lt;sub&gt;el&lt;/sub&gt;</td>
<td>25 MW&lt;sub&gt;el&lt;/sub&gt;</td>
<td>18 MW&lt;sub&gt;el&lt;/sub&gt;</td>
</tr>
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</table>
PEM Primary Energy Melter
PEM – Primary Energy Melting

Optimization of energy input for scrap-based steelmaking

- **Overheating**: 10% of the energy input
- **Melting**: 19% of the energy input
- **Heating**: 71% of the energy input

**Energy vs. Temperature**

- **Energy, kWh/t**
  - 0 - 400
  - 400 - 800
  - 800 - 1200
  - 1200 - 1600

- **Temperature, °C**
  - 0 - 1,600

- **Primary energy preferable**
- **Electrical energy**
- **Melting point Fe**
- **Melting with gas** (instead of electric energy)
  - 200 MJ / t
  - 1,400 MJ / t

**PEM**

**LF**

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01.10.2014
Primary Energy and CO₂ reductions using PEM technology

Concept

- Scrap melting with primary energy
- Direct conversion of primary energy into heat
- No energy losses through electric power generation and transmission

<table>
<thead>
<tr>
<th>CO₂ emissions (kg/t, total)</th>
<th>CO₂</th>
<th>EAF*</th>
<th>PEM</th>
<th>- 35 %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>330</td>
<td>215</td>
<td></td>
<td></td>
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</tbody>
</table>

| Primary energy | 1.485 | 1.010 | - 32 % |

Pilot plant facts

- Installation: in existing melt shop
- Target: increase hot metal offer for BOF
- PEM melting capacity: 30 t/h
- Shaft diameter: 2 m
- Start hot commissioning: 05/2014

* Average according to a study by World Steel Association
Energy recovery from hot slabs
Energy recovery from hot slabs

- **Segments**
- **Crane**
- **Slab yard**
- **furnaces**
- **enclosure**
- **Hot rolling**
- **laminar cooling**
- **coil yard**

**Average temperature**

- 1550°C
- 1050°C
- 850°C
- 400°C
Rise of energy efficiency: Transportable isolation box

- Simple steel design with isolation, includes couple device for crane
- Multifunctional applicable

A: Slow cool down at crack vulnerable steel grades (high carbon contents)

B: Isolation = Low temperature losses → for hot charging
Energy recovery from hot slabs

Focus

Segments  Crane  Slab yard

furnaces  enclosure  Hot rolling  laminar cooling  coil yard

average temperature
°C

1550
1050
850
400

Slab remains on special heat exchanger module until next slab arrives

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Energy recovery

- 50 - 70 kW_{therm} / m²
  at casting outlet

- 15 m roller table (1,500 mm wide slabs) enables the generation of about 7,000 to 10,000 tons of steam p.a.

- No influence on production process!
- Simple and maintenance free design
- Modular and easy expandable
- Qualified for hot charging
Design of heat exchanger module

Cross section drawing of the heat recovery system

Roller Table  Heat Exchanger  Steam Drum  Connection to steam grid
Reference: Salzgitter Flachstahl, Germany

Pilot installation in GER

- 1 module (15m)
- 1-2 t steam per hour (8 barg, 170°C)
- First Heat: Feb 2015
Environmental Services
# Environmental Services

## Overview

### Maintenance
- Maintenance
- Inspection
- Repair work
- Revisions
- Service-contracts
- Replacement 1:1
- Spare parts

### Modification
- Plant upgrades/ Retrofit
- Performance improvement
- Emission reduction
- Efficiency improvement
- Firing system upgrades
- Life time calculation
- Plant behavior

### Engineering
- Engineering (case studies, feasibilities)
- Supervision
- Commissioning
- State Examinations
- Measurement + Analysis
- X-pact Energy Advisor (Monitoring-System)
# Concept of Energy Optimization Studies

- One-week on site analysis for the detection of optimization potential
- Priorisation of the potentials with customer
- Development of specific energy efficiency measures

<table>
<thead>
<tr>
<th>Low to no investment</th>
<th>Modernizations</th>
<th>Plant revamp and extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption forecast / individual procurement</td>
<td>Replace inefficient consumers</td>
<td>Waste heat recovery at EAF/BOF</td>
</tr>
<tr>
<td>Peak load shedding</td>
<td>Use more efficient media</td>
<td>Process gas utilisation at BOF</td>
</tr>
<tr>
<td>Optimise production plan from an energetic point of view</td>
<td>Adapt temperature levels</td>
<td>Heat recovery from hot slabs</td>
</tr>
<tr>
<td></td>
<td>Start-stop mechanisms</td>
<td></td>
</tr>
</tbody>
</table>

- Saving energy
- Reducing energy costs
- Recovering energy
Energy efficiency measures and energy costs

Example for saving potential

- **31 m. €/year** Generating electricity from blast furnace gas (2 blast furnaces, 250,000 m³/h gas)

- **5 m. €/year** Electric energy efficiency measures (Savings of 5% by a consumption of 2 TWh electrical energy)

- **2 m. €/year** Usage of converter offgas (3 converters, 1.3 m t liquid steel)

Excerpt from the *Stahl und Eisen* journal 2009

“If an Energy Monitoring Information System has been installed correctly and the respectively appropriate measures have been taken, savings of between 5% and 20% are typical, with 8% being a realistic value. The amortisation period of these systems typically amounts to between one and two years.”

The X-Pact® Energy Advisor is assembled in three levels:

I. Reporting
   - Management ratios
   - Reports
   - Visualization

II. Architecture
   - Bus-Systems
   - Server
   - Databank

III. Performance Measure Concept
   - Dispositive Media
   - Interval measurements
   - Measurement engineering

Target
Energy Consumption
Monitoring → Controlling → Decreasing & Optimization

Energy Consumption

Environmental Services - X-Pact® Energy Advisor

SMS group

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X-Pact® Energy Advisor collects energy data from all plant units
Specific Aspects of our X-Pact® Energy Advisor

- Monitoring
- Reporting-System
- Alarm via E-Mail or SMS

- Description
- Analysis
- Evaluation

- Supervise limiting values
- Aggregate data

- Record data
- Archive data

- Electrical energy
- Media e.g. Gas, fuels, O₂, Water, etc.
- Process data
Benefits of Studies and X-Pact® Energy Advisor by SMS Siemag AG

1. Effective measurement concept
2. Detect energy saving potential
3. Increase efficiency continuously
4. Optimize energy procurement
5. Support energy controlling
6. Profit from Certification ISO 50001

Key points:
- Low Invest
- Reduce Costs
- Increase Consumption
Conventional

Gas Cleaning Assistant

1. Indication of damper position
   - Manual setting
2. Constant pressure in main pipe
   - No network analysis
3. Controlling of ID Fan speed
   - High under-pressure in every process step

- Mathematical model - immediate calculation
- Optimal damper positions
- High accuracy
- Excellent energy efficiency

Gas cleaning process:
1. Exhaust damper
2. Mixer
3. Filter
4. ID Fan
5. P

Network resistances are considered for variable underpressure.
Reference: Kademir, Turkey

Plant Description

**Reference KADEMIR**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Comparison</th>
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<tbody>
<tr>
<td><strong>Annual output:</strong></td>
<td><strong>Conventional</strong></td>
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<tr>
<td>1.3 m. tons of steel</td>
<td>Energy input avg. = 1,600 MWh</td>
</tr>
<tr>
<td><strong>Converters:</strong></td>
<td>Costs = 835,000 € / year</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Heats per year:</strong></td>
<td><strong>GasCleaningAssistant</strong></td>
</tr>
<tr>
<td>14,000 pieces</td>
<td>Energy input avg. = 1,200 MWh</td>
</tr>
<tr>
<td><strong>Energy price:</strong></td>
<td>Costs = 650,000 € / year</td>
</tr>
<tr>
<td>0.06 € / kWh</td>
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</table>

**Savings approximately 185,000 € p.a. ▶ 21%**
Conclusion

Motivation
- Rising energy costs
- Limitation of emissions
- Trend towards Sustainability

Solutions
- Efficient Processes
- Energy Recovery
- Innovative gas cleaning
- Energy Consulting

Global trend towards green energy – we offer the right solutions for you!