Energy End-Use: Industry

Share of Industrial Final Energy Use

- Chemical and Petrochemical: 29%
- Iron and Steel: 20%
- Others: 16%
- Wood and wood products: 1%
- Transport equipment: 1%
- Construction: 1%
- Mining and quarrying: 2%
- Textile and leather: 2%
- Machinery: 4%
- Non-ferrous metals: 3%
- Food and tobacco: 5%
- Paper, pulp and print: 6%
- Non-metallic minerals: 10%
Energy End-Use: Industry

Apparent Steel Consumption as a Function of Income

Per capita steel consumption in kg

Per capita GDP in int. 1995 $
Apparent Cement Consumption as a Function of Income
Chapter 8, #6

Structural Change Impact for the EU

- Change in energy intensity 2000 - 2007
- Intensity at constant structure 2000 - 2007
- Impact of structural change on 2007 energy intensity

Countries shown: Slovak Republic, Slovenia, Cyprus, Bulgaria, Poland, Hungary, Croatia, Czech Republic, Latvia, Lithuania, United Kingdom, Netherlands, Belgium, Greece, Norway, Sweden, EU-27, Germany, EU-15, Ireland, Luxembourg, Romania, Portugal, Italy, Spain, Denmark, Finland, Austria, France.
Fisher Ideal Indices for Structural Shift and Real Intensity in Russia
Change in Coke Demand due to Efficiency Improvements in the Blast Furnace Process

Energy efficiency improvements:
- 1760-1800: -1.9% a year
- 1800-1820: -0.2% a year
- 1820-1910: -1.1% a year
- 1910-1920: +0.2% a year
- 1920-1940: -1.4% a year
- 1950-1990: -3.4% a year
- 1760-1990: -1.4% a year
Time-series trend of specific electricity consumption values for the EAF process

- Best Practice
- Oxygen Lancing
- Secondary metallurgy
- Water-cooled walls
- High-Power
- Computer control
- Foaming Slag
- Oxy-fuel burner/water-cooled roof
- Bottom-taphole
- Ladle (low-T tapping)
- Eccentric Bottom Tapping
- Scrap Preheating
- DC-arc technology
- Pneumatic steering

India

US (450 kWh/tls)

Contiarc (2001)

Practical Minimum (high efficiency, high power furnace with scrap preheating and maximum oxyfuel use)

Theoretical Minimum (thermodynamic minimum for steel melting and refining)
India Cement Blend Ratio – Cement Clinker Ratio Comparison with Global Best

- India's Average: 21% Fly Ash, 44% Slag, 85% Clinker cement ratio
- India's Best: 29% Fly Ash, 52% Slag, 50% Clinker cement ratio
- Global Best: 35% Fly Ash, 65% Slag, 50% Clinker cement ratio
Conservation Supply Curve for Electricity Savings in the Indian Cement Industry
Specific Electricity Consumption of the Aluminum Industry

Energy End-Use: Industry

![Graph showing electricity consumption trends for Brazil and the world from 1997 to 2006.](graph_image)
Energy End-Use: Industry

Specific Electricity Consumption of the Aluminum Industry by Region and for the World

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Energy End-Use: Industry

Specific Electricity Consumption vs. Production for World Regions

Cumulative production (kt)

Electricity (kWh/t)

Africa

Oceania

Asia

Latin America

North America

Europe
Estimated Total Final Energy Use of Selected SMEs and Small-scale Clusters Worldwide

Total global final industrial energy use (2007): 127 EJ/yr
Selected SMEs and small-scale clusters: 18 – 32 EJ/yr
(14 – 25% of total global final industrial energy use)

- Bio-based products: 0.2 – 0.4 EJ
- Meat industry: 0.2 – 0.3 EJ
- Dairy industry: 0.2 – 0.3 EJ
- Glass industry: 0.9 – 1.7 EJ
- Textiles and leather: 0.9 – 1.8 EJ
- Ferrous and non-ferrous metals: 1 – 1.8 EJ
- Sugar industry: 0.6 – 1.3 EJ
- Other food industry: 1.2 – 2.5 EJ
- Lime: 0.9 – 1.5 EJ
- Small-scale energy-intensive sectors in DCs: 2.4 – 5 EJ
- Wood processing: 1.2 – 2 EJ
- Energy transformation processes: 0.9 – 1.8 EJ
- Building and construction: 1.5 – 2.5 EJ
- Ceramics: 5.6 – 9.3 EJ
Benchmarking Curves

- Cement
- Ammonia
- Aluminium
- Ethylene
Typical Efficiency Distribution for an Iron SME Cluster in India
Energy End-Use: Industry

Share of Manufacturing Energy Use by System Type

% Manufacturing Energy Use by Type of System

- Steam, 35%
- Process Heating, 38%
- Motor Systems, 12%
- Facilities, 8%
- Other, 4%
- Electro-chemical, 2%
- Process Cooling, 1%

Energy Efficiency Improvement Opportunities

- 20% or more typical for motor systems
- 10% or more for steam & process heating systems
- Most plants do not manage these systems for energy efficiency
Reconfiguration of Pumping System to Improve Efficiency

**ENERGY-EFFICIENT PUMPING SYSTEM**

- Variable Speed Drive Efficiency = 96%
- Energy Efficient Motor Efficiency = 95%
- More Efficient Pump Efficiency = 88%
- Coupling Efficiency = 99%
- Low Friction Pipe Efficiency = 90%

* OUTPUT POWER 31

**CONVENTIONAL PUMPING SYSTEM**

- Standard Motor Efficiency = 90%
- Pump Efficiency = 77%
- Coupling Efficiency = 98%
- Pipe Efficiency = 69%

* OUTPUT POWER 31

INPUT POWER 43

INPUT POWER 100

60% OF OUTPUT RATED FLOW
Energy End-Use: Industry

EU Compressed Air System Efficiency Supply Curve

**Legend**

1. Fix leaks, adjust compressor controls, establish ongoing plan
2. Install sequencer
3. Initiate predictive maintenance program
4. Improve end use efficiency
5. Eliminate inappropriate compressed air uses
6. Address restrictive end use drops and connections
7. Eliminate artificial demand with pressure optimization/control/storage
8. Correct compressor intake problems
9. Replace existing condensate drains with zero loss type
10. Correct excessive pressure drops in main line distribution piping
11. Reconfigure branch header piping to reduce critical pressure loss
12. Install dedicated storage with metered recovery
13. Correct excessive supply side pressure drop
14. Match air treatment to demand side needs
15. Improve trim compressor part load efficiency
16. Size replacement compressor to meet demand.

**Average unit price of electricity for EU industry in 2007:** 107.3 US$/MWh*

**Cost effective electricity saving potential:** 18,519 GWh/yr

**Technical electricity saving potential:** 24,857 GWh/yr

**Annual electricity saving potential in industry (GWh/yr)**

**Cost of conserved electricity (US$/MWh-saved)**
EU Fan System Efficiency Supply Curve

**Legend**

1. Fix leaks and damaged seals
2. Correct damper problems
3. Isolate flow paths to non-essential equipment
4. Correct poor airflow conditions at fan inlets and outlets
5. Remove sediment buildup from fan and system surfaces
6. Initiate predictive maintenance program
7. Repair or replace inefficient belt drives
8. Install variable speed drive
9. Replace oversized fans with more efficient type.
10. Replace motor with more energy efficient type.

Technical electricity saving potential: 13,015 GWh/yr

Average unit price of electricity for EU industry in 2007: 107.8 US$/MWh*

Cost effective electricity saving potential: 12,590 GWh/yr
EU Pumping System Efficiency Supply Curve

Legend:
1. Isolate flow paths to non-essential or non-operating equipment.
2. Install variable speed drive
3. Trim of change impeller to match output to requirements
4. Use pressure switches to shut down unnecessary pumps
5. Fix leaks, damaged seals, and packing
6. Replace motor with more energy efficient type
7. Replace pump with more energy efficient type
8. Remove sediment/Scale buildup from piping
9. Initiate predictive maintenance program
10. Remove scale from components such as heat exchangers and strainers

Technical electricity saving potential: 38,773 GWh/yr

Average unit price of electricity for EU industry in 2007: 107.8 US$/MWh

Cost effective electricity saving potential: 26,921 GWh/yr

Annual electricity saving potential (GWh/yr)

Cost of conserved electricity (US$/MWh-saved)
Energy End-Use: Industry

Estimated Payback Periods for Steam-Based Systems

2 – 4 years
- Modify steam turbine operation
- Use oxygen for combustion
- Change process steam use

> 4 years
- Install CHP system

< 9 months
- Improve insulation
- Implement steam trap program
- Clean heat transfer surfaces

9 months – 2 years
- Heat feed water with boiler blowdown
- Lower excess oxygen
- Flue gas heat recovery
The systemic vision of an industrial process
Energy End-Use: Industry

Hot and Cold Composite Curves and Possible Heat Recovery in the System

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Primary Energy Savings by the Integration of Heat Pumps and of a Cogeneration Unit and Heat Pumps
Energy Flows for the Global Industrial Sector

- Coal and coal products (21.5) → Product (44.6)
- Crude, NGL, petroleum prod. (13.6) → Loss and waste (43.0)
- Natural gas (18.1)
- Renewables (7.5)
- Electricity (22.3)
- Heat (4.6)

Global industrial sector

Total (87.6)
Exergy Flows for the Global Industrial Sector

- Coal and coal products (21.5)
- Crude, NGL, petroleum prod. (13.6)
- Natural gas (18.1)
- Renewables (7.5)
- Electricity (22.3)
- Heat (1.3)

Global industrial sector

Product (25.1)

Loss and waste (59.2)

Total (84.3)
Energy End-Use: Industry

Supply Curve of Saved Electricity for 2020

More efficient industrial motors

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Energy Use of GDP per Unit in China

Energy End-Use: Industry
Conservation Supply Curves for the Iron and Steel Industry without Productivity Benefits and Including Productivity Benefits

Energy End-Use: Industry

Annual Cost-Effective Primary Energy Savings
Excluding Non-Energy Benefits: 1.9 GJ/tonne
Including Non-Energy Benefits: 3.8 GJ/tonne

difference: 1.9 GJ/tonne, approximately 168 PJ/year

1994 Weighted Average Primary Fuel Price ($2.14/GJ)

Cost Curve Without Productivity Benefits
Cost Curve Including Productivity Benefits

Discount Rate = 30%

Energy Savings (GJ/tonne)

Cost of Conserved Energy ($/GJ)

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Sources of Energy Efficiency Investment in OECD and Developing Countries

- **Developing Countries**
  - Equity: 73%
  - Grants: 23%
  - Debt: 5%

- **OECD**
  - Equity: 97%
  - Grants: 3%
  - Debt: 0%
Use of ODA and Carbon Finance for IEE Projects

Carbon revenue

Attractive low-risk IEE project

High risk, low cost-effective IEE project

ODA financing
Obstacles Influencing the Diffusion of Highly Efficient Electrical Motors

Energy End-Use: Industry
Energy End-Use: Industry

Joint Energy Efficiency Target Path of 17 Companies of the Efficiency Table and Achieved Energy Savings
Energy End-Use: Industry

Existing, Frozen Efficiency and BAU Scenarios and the Savings in 2030

FE Frozen

225 EJ

New

G. Savings in New 53 EJ

Total savings w.r.t. FE scenario G+F

135 EJ

EE

New

F. Savings in Existing 37 EJ

Existing Surviving

55 EJ

Existing

175 EJ

Existing

115 EJ

2005

2030

BAU

2030

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