

*Introduction*

*Manufacturing Industry Energy Use and CO<sub>2</sub> Emissions*

*General Industry Indicators Issues*

*Chemical and Petrochemical Industry*

**Table**  
*of*

*Iron and Steel Industry*

*Non-Metallic Minerals*

*Pulp, Paper and Printing Industry*

*Non-Ferrous Metals*

*Systems Optimisation*

*Life Cycle Improvements Options*

*Annexes*

	Foreword .....	3
	Acknowledgements .....	5
	Table of Contents .....	7
	List of Figures .....	13
	List of Tables .....	15
	Executive Summary .....	19
<b>Chapter 1</b>	<b>▶ INTRODUCTION</b> .....	<b>31</b>
	Scope of Indicator Analysis .....	31
	Energy and CO <sub>2</sub> Saving Potentials .....	33
	Next Steps .....	36
<b>Chapter 2</b>	<b>▶ MANUFACTURING INDUSTRY ENERGY USE AND CO<sub>2</sub> EMISSIONS</b> .....	<b>39</b>
<b>Chapter 3</b>	<b>▶ GENERAL INDUSTRY INDICATORS ISSUES</b> .....	<b>45</b>
	Energy Indicators Based on Economic and Physical Ratios .....	45
	Methodological Issues .....	46
	Definition of Best Available Technique and Best Practice .....	48
	Data Issues .....	49
	<b>Practical Application of Energy and CO<sub>2</sub> Emission Indicators</b> .....	<b>51</b>
	Pulp, Paper and Printing .....	51
	Iron and Steel .....	52
	Cement .....	52
	Chemicals and Petrochemicals .....	53
	Other Sectors / Technologies .....	53
	<b>International Initiatives: Sectoral Approaches to Developing Indicators</b> .....	<b>54</b>
	Intergovernmental Panel on Climate Change Reference Approach .....	54
	Pulp and Paper Initiatives .....	55
	Cement Sustainability Initiative .....	55
	Asia-Pacific Partnership on Clean Development and Climate .....	56
	Benchmarking in the Petrochemical Industry .....	56
<b>Chapter 4</b>	<b>▶ CHEMICAL AND PETROCHEMICAL INDUSTRY</b> .....	<b>59</b>
	Introduction .....	60
	Global Importance and Energy Use .....	61
	<b>Petrochemicals Production</b> .....	<b>64</b>
	Steam Cracking: Olefins and Aromatics Production .....	66

Propylene Recovery in Refineries and Olefins Conversion	71
Aromatics Extraction	71
Methanol	72
Olefins and Aromatics Processing	74
<b>Inorganic Chemicals Production</b> .....	<b>75</b>
Chlorine and Sodium Hydroxide	76
Carbon Black	77
Soda Ash	78
Industrial Gases	80
<b>Ammonia Production</b> .....	<b>82</b>
<b>Combined Heat and Power</b> .....	<b>85</b>
<b>Plastics Recovery Options</b> .....	<b>86</b>
<b>Energy and CO<sub>2</sub> Emission Indicators for the Chemical and Petrochemical Industry</b> .....	<b>87</b>
Energy Efficiency Index Methodology	88
CO <sub>2</sub> Emissions Index	91
Life Cycle Index	93
<b>Energy Efficiency Potential</b> .....	<b>94</b>

## **Chapter 5 ► IRON AND STEEL INDUSTRY** \_\_\_\_\_ **95**

<b>Introduction</b> .....	<b>96</b>
<b>Global Importance and Energy Use</b> .....	<b>96</b>
<b>Indicator Issues</b> .....	<b>99</b>
System Boundaries	99
Product and Process Differentiation	99
Allocation Issues	99
Feedstock Quality Issues	101
<b>Energy Indicators</b> .....	<b>102</b>
Energy Intensity Indicators and Benchmarks	102
Energy Intensity Analysis	103
Efficiency Improvements	106
<b>Coke Ovens</b> .....	<b>108</b>
Coke Oven Gas Use	111
Coke Dry Quenching	111
<b>Iron Ore Agglomeration</b> .....	<b>113</b>
Ore Quality	115
<b>Blast Furnaces</b> .....	<b>116</b>
Coal and Coke Quality	119
Coal Injection	120

Plastic Waste Use	121
Charcoal Use	121
Top-Pressure Recovery Turbines	123
Blast Furnace Gas Use	123
Blast Furnace Slag Use	124
Hot Stoves	126
<b>Basic Oxygen Furnaces</b> .....	<b>126</b>
Basic Oxygen Furnace Gas Recovery	127
Steel Slag Use	127
<b>Electric Arc Furnaces</b> .....	<b>128</b>
<b>Cast Iron Production</b> .....	<b>131</b>
<b>Direct Reduced Iron Production</b> .....	<b>132</b>
<b>Steel Finishing</b> .....	<b>135</b>
<b>Energy Efficiency and CO<sub>2</sub> Reduction Potentials</b> .....	<b>136</b>
<b>Chapter 6 ► NON-METALLIC MINERALS</b> .....	<b>139</b>
<b>Introduction</b> .....	<b>140</b>
<b>Cement</b> .....	<b>140</b>
Global Importance and Energy Use	140
Cement Production Process	140
Energy and CO <sub>2</sub> Emission Indicators for the Cement Industry	162
<b>Lime</b> .....	<b>163</b>
Overview	163
Lime Production Process	164
Energy Consumption and CO <sub>2</sub> Emissions from Lime Production	166
<b>Glass</b> .....	<b>166</b>
Overview	166
Glass Production Process	167
Energy Consumption and CO <sub>2</sub> Emissions from Glass Production	168
<b>Ceramic Products</b> .....	<b>169</b>
Overview	169
Ceramics Production Process	172
Energy Consumption and CO <sub>2</sub> Emissions from Ceramics Production	173
<b>Indicators for Lime, Glass and Ceramics Industries</b> .....	<b>174</b>
<b>Chapter 7 ► PULP, PAPER AND PRINTING INDUSTRY</b> .....	<b>175</b>
<b>Global Importance and Energy Use</b> .....	<b>176</b>
<b>Methodological and Data Issues</b> .....	<b>176</b>

<b>Pulp and Paper Production and Demand Drivers</b> .....	<b>178</b>
<b>Energy Use in the Pulp and Paper Industry</b> .....	<b>180</b>
Pulp Production .....	182
Paper Production .....	183
Printing .....	185
<b>Energy Indicators</b> .....	<b>187</b>
Energy Intensity Indicators versus Benchmarking .....	187
Energy Efficiency Index Methodology .....	187
Expanding Indicators Analysis in the Pulp and Paper Industry .....	195
<b>Combined Heat and Power in the Pulp and Paper Industry</b> .....	<b>196</b>
<b>Paper Recycling and Recovered Paper Use</b> .....	<b>198</b>
<b>Use of Technology to Increase Energy Efficiency and Reduce CO<sub>2</sub> Emissions</b> .....	<b>200</b>
<b>Differences in Energy Intensity and CO<sub>2</sub> Emissions across Countries</b> .....	<b>201</b>
<b>Energy Efficiency Potentials</b> .....	<b>204</b>

## **Chapter 8 ► NON-FERROUS METALS** .....

Introduction .....	207
Global Importance and Energy Use .....	207
Aluminium Production .....	208
Copper Production .....	213
Energy Efficiency and CO <sub>2</sub> Reduction Potentials .....	216

## **Chapter 9 ► SYSTEMS OPTIMISATION** .....

Introduction .....	217
<b>Industrial Systems</b> .....	<b>218</b>
Industrial System Energy Use and Energy Savings Potential .....	218
Motor Systems .....	220
Steam Systems .....	227
Barriers to Industrial System Energy Efficiency .....	231
Effective Policies and Programmes .....	231
<b>Combined Heat and Power</b> .....	<b>236</b>
Benefits of CHP .....	238
Barriers to CHP Adoption .....	239
CHP Statistics .....	240
Indicators for CHP Energy Efficiency Benefits .....	242

<b>Chapter 10 ► LIFE CYCLE IMPROVEMENT OPTIONS</b>	<b>247</b>
Introduction .....	247
Indicator Issues .....	247
<b>Trends in the Efficiency of Materials and Product Use</b> .....	<b>249</b>
Buildings	252
Packaging	252
Transportation Equipment	254
<b>Recycling and Reuse</b> .....	<b>256</b>
Petrochemical Products	259
Paper	262
Aluminium	264
Steel	265
<b>Energy Recovery</b> .....	<b>268</b>
Petrochemical Products	271
Paper	273
Wood	273
<b>Annexes ► Annex A • Process Integration</b> .....	<b>275</b>
<b>Annex B • Industry Benchmark Initiatives</b> .....	<b>283</b>
<b>Annex C • Definitions, Acronyms and Units</b> .....	<b>287</b>
<b>Annex D • References</b> .....	<b>303</b>