INTERNATIONAL ENERGY AGENCY

ENERGY TECHNOLOGY PERSPECTIVES 2006

In support of the G8 Plan of Action

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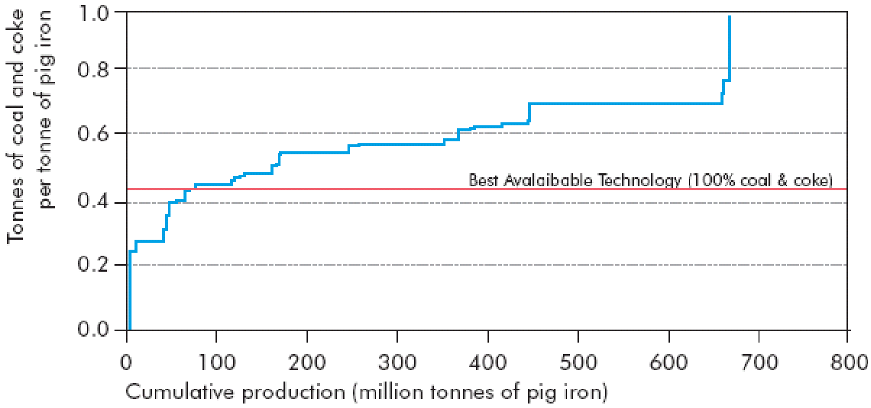
Presentation Overview

- Industry
- Transport
- Buildings and Appliances
- Power plants
- Annex 1: assumptions
- Annex 2: ETP methodology

Industry, iron and steel (1/3)

Figure 7.7 ▶ Coal and coke use in blast furnaces, 2003[5]

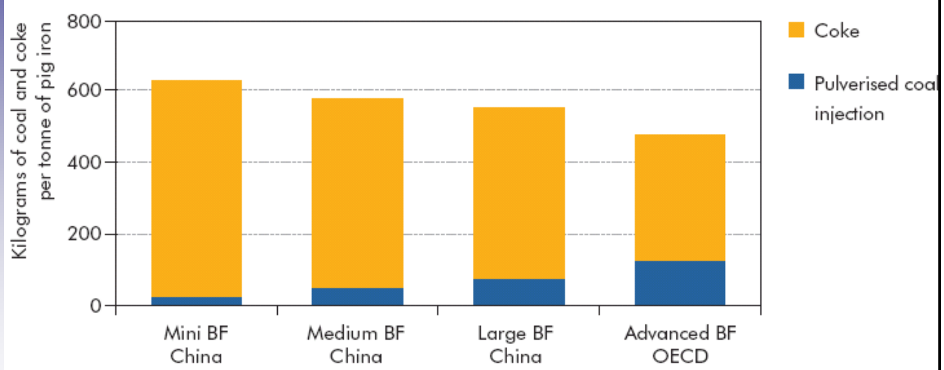


Key point

Coal and coke use in blast furnaces varies widely among countries.

Industry, iron and steel (2/3)

Figure 7.8 ▶ Fuel rates of Chinese blast furnaces compared with advanced furnaces[6]



Key point

Coal and coke use in blast furnaces depends on the furnace size and the pulverised coal injection rate.

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Industry, iron and steel (3/3)

Table 7.3 Global technology prospects for coal injection

Injection of coal	2003-2015	2015-2030	2030-2050
Technology stage	Commercial	Commercial	Commercial
Investment costs (USD/t)	50-55	50	50
Energy reduction (%)	5%	7%	10%
CO_2 reduction (Gt/yr)	0 – 0.05	0.05 – 0.1	0.1 – 0.2

Coal injection is already a widely applied technology. It is financially attractive because it obviates the coke-making process. Moreover, it results in substantial energy savings, as one energy unit of coke is replaced by one energy unit of coal. Trials have shown that coal injection can replace up to half the coke now used in blast furnaces. Assuming that coal and coke have the same energy content, that half of all coke is replaced by injected coal, and that the energy used in coke production is 8 GJ per tonne coke, the potential for coal savings would amount to 1 EJ per year and reduce CO2 emissions by 100 Mt.

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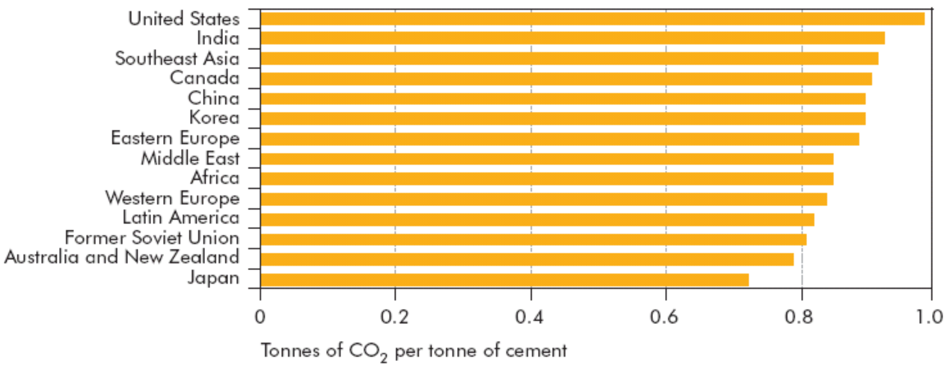
Industry, cement (1/3)

Figure 7.10 Average CO_2 emissions per tonne of cement by country and region



Source: World Business Council for Sustainable Development (WBCSD), 2002.

Key point

The range of average CO_2 emissions per tonne of cement is very limited.

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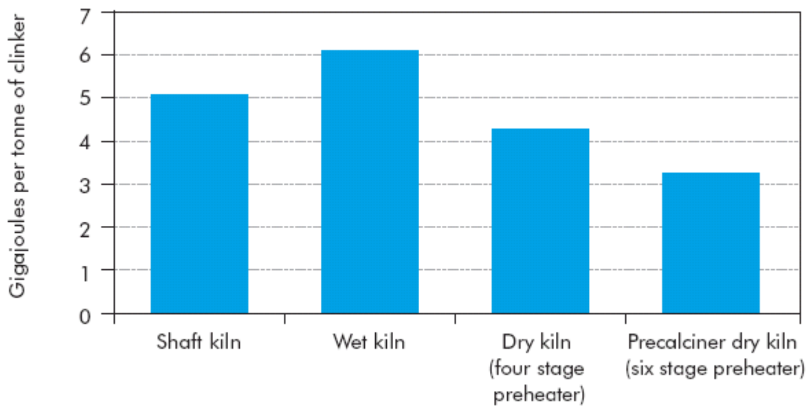
Industry, cement (2/3)

Figure 7.11 ▶ Energy efficiency of various cement-clinker production technologies



Key point

Best cement-clinker technologies are 30 to 40% more efficient than others.

Industry, cement (3/3)

Table 7.8 ▶ Cement technologies and fuel mix by region

	Process type				Fuel share			
	Dry (%)	Semi-dry (%)	Wet (%)	Vertical (%)	Coal (%)	Oil (%)	Gas (%)	Other (%)
United States	65	2	33	0	58	2	13	26
Canada	71	6	23	0	52	6	22	15
Western Europe	58	23	13	6	48	4	2	42
Japan	100	0	0	0	94	1	0	3
Australia and New Zealand	24	3	72	0	58	<1	38	4
China	43	0	2	55	94	6	<1	0
Southeast Asia	80	9	10	1	82	9	8	1
South Korea	93	0	7	0	87	11	0	2
India	50	9	25	16	96	1	1	2
Former Soviet Union	12	3	78	7	7	1	68	<1
Eastern Europe	54	7	39	0	52	34	14	<1
Latin America	67	9	23	1	20	36	24	12
Africa	66	9	24	0	29	36	29	5
Middle East	82	3	16	0	0	52	30	4

Source: WBCSD, 2002, IEA estimates.

Industry, ammonia

Table 7.16 ▶ Energy consumption in ammonia production, 2003

Region	Production (Mt ammonia/yr)	Energy intensity (GJ/t ammonia)	Energy intensity index	Gas use (PJ/yr)	Oil use (PJ/yr)	Coal use (PJ/yr)
Western Europe	11.8	36	100	426	–	–
North America	14.9	37.9	105	565	–	–
Former Soviet Union	18.7	39.9	111	746	–	–
Other Europe	5.4	43.6	121	235	–	–
Asia	61.4	40	111	636	500	1 320
Latin America	7.9	36	100	285	–	–
Africa	1.4	36	100	49	–	–
Middle East	9.8	36	100	351	–	–
Oceania	1.1	36	100	40	–	–
World	*132.4*	*39.4*	*109*	*3 333*	*500*	*1 320*

Source: European Fertilizer Manufacturers Association (2003) and IEA data.

Technology strategies: industry

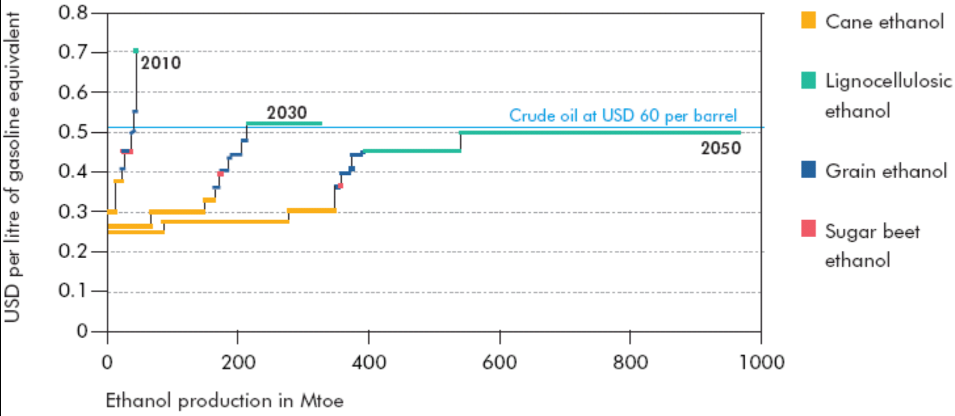
CO_2 emission reductions in the Map scenario below the Baseline due to industrial technologies

Technologies	2015	2030	2050	Gt CO_2/year
Co-generation technologies	★	★★	★★	0.3
Motor systems	★★	★★★	★★★★	1.5
Steam systems	★	★★	★★	0.3
Energy efficiency in existing basic materials production processes	★★	★★	★★★	0.4
Process innovation in basic materials production processes		★	★★	0.2
Fuel substitution in basic materials production processes		★★	★★★	0.5
Materials/product efficiency		★	★★	0.3
Feedstock substitution		★★	★★★	0.4
CO_2 capture and storage		★★	★★★★	1.5

Note: The reductions are illustrated by a category ★ (< 0.1Gt CO_2/yr of the total reduction), ★★ (between 0.1 – 0.3 Gt), ★★★ (between 0.3 – 1 Gt), ★★★★ (>1Gt).

Transport, biofuels (1/2)

Figure 5.6 ▶ Ethanol supply curves

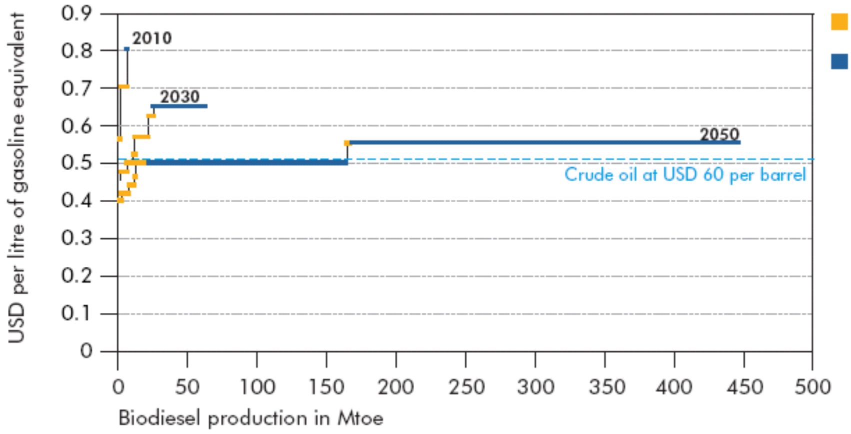


Key point

Rapid development of ethanol can displace a significant portion of transport oil demand by 2050.

Transport, biofuels (2/2)

Figure 5.7 ▶ Biodiesel supply curves



Key point

Advanced biomass-to-liquid technologies are needed for large production of biodiesel.

FAME=Fatty-Acid Methyl Esters; BTL=Biomass To Liquid synthesis

Technology strategies: transport

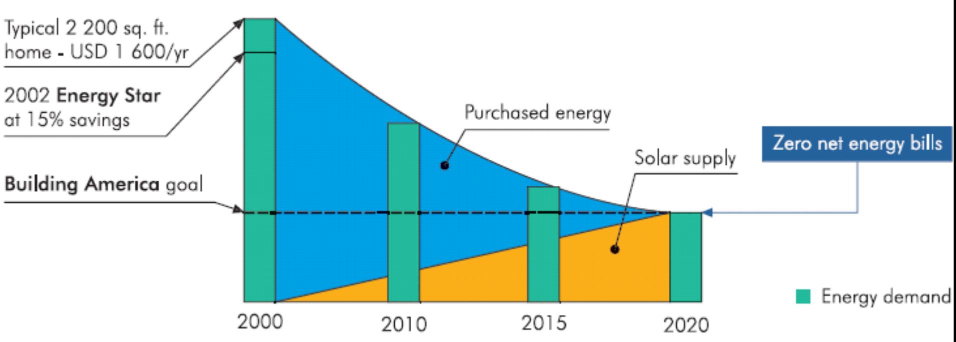
CO_2 emission reductions in the Map and TECH Plus scenarios below the Baseline due to transport technologies

	Technologies	2015	2030	2050	Gt CO_2/year
Transport – vehicles	Vehicle fuel economy improvements (all existing modes and vehicle types)	★★	★★★★	★★★★	2.2
	Hybrid vehicles	★★	★★★	★★★★	1.4
	Ethanol flex fuel vehicles				0 (enabling)
	Hydrogen fuel cell vehicles		★	★★★	0.8
	Non-engine technologies	★★	★★★	★★★★	1.8
Transport - fuels	Biodiesel (from vegetable oil)	★	★★	★★	0.2
	Biodiesel (biomass to liquids)		★	★★★	0.6
	Ethanol (grain/starch)	★	★★	★★	0.2
	Ethanol (sugar)	★★	★★★	★★★	0.7
	Ethanol (lignocellulosic)		★★	★★★	0.7
	Hydrogen		★	★★★	0.7

Note: The reductions are illustrated by a category ★ (< 0.1Gt CO_2/yr of the total reduction), ★★ (between 0.1 – 0.3 Gt), ★★★ (between 0.3 – 1 Gt), ★★★★ (>1Gt).The CO_2 emission reduction in the last column refers to the Map scenario, expect for lignocellusic ethanol, hydrogen and fuel cells, which are based on the TECH Plus scenario.

Buildings

Figure 6.5 ▶ Zero energy buildings



Source: LaFrance, 2004.

Key point

Zero energy buildings can be achieved over the next 20 years.

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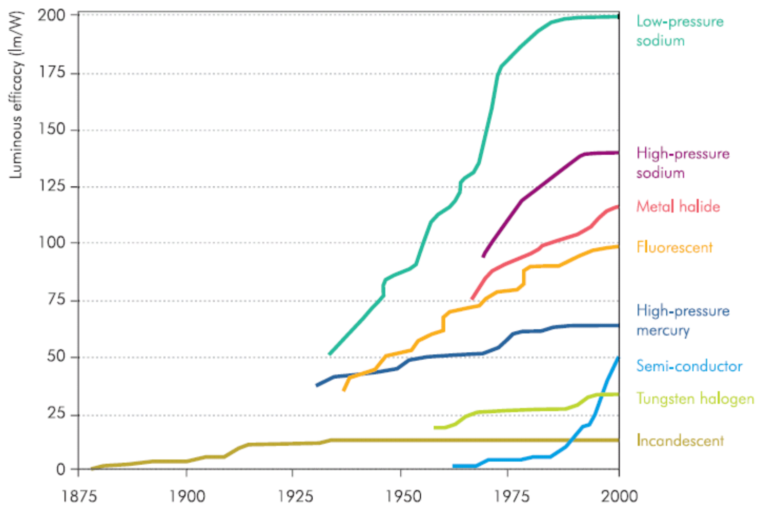
Appliances

Figure 6.12 ▶ Evolution of luminous efficacy of major light sources used for general lighting



Source: IEA 2006; reproduced with permission from www.lamptech.co.uk

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Technology strategies: building and appliances

CO_2 emission reductions in the Map scenario below the Baseline due to building and appliance technologies

Technologies	2015	2030	2050	Gt CO_2/year
Heating and cooling technologies	★★	★★★	★★★★	1.1
District heating and cooling systems	★	★★	★★★	0.5
Building energy management systems	★	★★	★★	0.2
Lighting systems	★★	★★★	★★★★	1.0
Electric appliances	★★★	★★★	★★★★	2.1
Reduce stand-by losses	★★	★★	★★	0.3
Building envelope measures	★★	★★★	★★★★	1.6
Solar heating and cooling	★★	★★	★★★	0.6

Note: The reductions are illustrated by a category ★ (< 0.1Gt CO_2/yr of the total reduction), ★★ (between 0.1 – 0.3 Gt), ★★★ (between 0.3 – 1 Gt), ★★★★ (>1Gt).

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Technology strategies: fossil power plants

CO_2 emission reductions in ACT scenarios below the Baseline due to fossil power generation technologies

Technologies	2015	2030	2050	Gt CO_2/year
Combined cycle (natural gas)	★★	★★★	★★★★	1.6
Advanced steam cycles (coal)	★	★★	★★	0.2
Integrated Gasification Combined-Cycle (coal)		★	★★	0.2
Fuel Cells		★	★★	0.2
CCS Advanced steam cycle with flue-gas separation (coal)		★★	★★★★	1.3
CCS Advanced steam cycle with oxyfueling (coal)		★★	★★★★	1.3
CCS Integrated Gasification Combined-Cycle (coal)		★★	★★★★	1.3
CCS Chemical absorption flue-gas separation (natural gas)				0.1

Note: The reductions are illustrated by a category ★ (< 0.1Gt CO2/yr of the total reduction), ★★ (between 0.1 – 0.3 Gt), ★★★ (between 0.3 – 1 Gt), ★★★★ (>1Gt). The CO_2 emission reduction in the last column refers to the Map scenario.

Technology strategies: renewable power plants

CO_2 emission reductions in the ACT scenarios below the Baseline due to renewable power generation technologies

Technologies	2015	2030	2050	Gt CO_2/year
Hydro (small & large)	★	★★★	★★★	0.5
Biomass	★★	★★	★★★	0.5
Geothermal		★★	★★	0.3
Wind (onshore & offshore)	★★	★★★	★★★★	1.3
Solar photovoltaics		★	★★	0.3
Concentrating solar power		★	★★	0.2
Ocean energy			★★	0.1

Note: The reductions are illustrated by a category ★ (< 0.1Gt CO2/yr of the total reduction), ★★ (between 0.1 – 0.3 Gt), ★★★ (between 0.3 – 1 Gt), ★★★★ (>1Gt). The CO_2 emission reduction in the last column refers to the Map scenario.

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Technology strategies: nuclear power plants

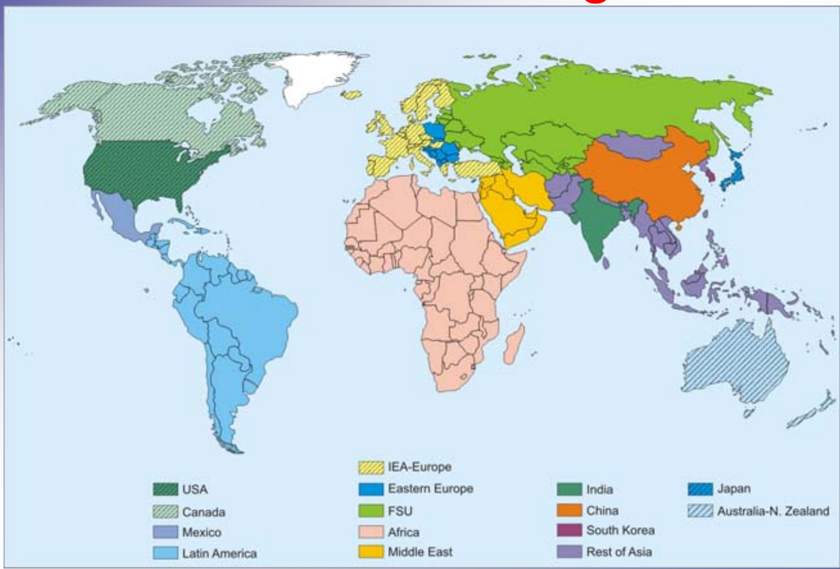
CO_2 emission reductions in the ACT and TECH Plus scenarios below the Baseline due to nuclear power generation technologies

Technologies	2015	2030	2050	Gt CO_2/year
Nuclear power generation II and III	★★	★★★	★★★★	1.8
Nuclear power generation IV		★★	★★★★	1.9

Note: The reductions are illustrated by a category ★ (< 0.1Gt CO_2/yr of the total reduction), ★★ (between 0.1 – 0.3 Gt), ★★★ (between 0.3 – 1 Gt), ★★★★ (>1Gt). The CO_2 emission reduction in the last column refers to the Map scenario for generation II and III and the TECH Plus scenario for Generation IV.

Annex 1: ETP assumptions

15 ETP model regions



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Population (1/2)

Global population expanded on average by 1.6% per year from 1971 to 2003. It is set to grow by an average of 0.9% per year to 2050, from an estimated 6.4 billion in 2003 to almost 9.1 billion in 2050. Population growth will slow over the projection period, from 1% per year in 2003 to 2030 to 0.7% per year in 2030 to 2050.

The population of the developing regions will continue to grow most rapidly, by 1.1% per year from 2003 to 2050. This is lower than the average rate of 2% in the last three decades. Population in the transition economies is expected to decline. The OECDs population is expected to grow by an average of 0.1% per year out to 2050, with North America contributing much of the increase. The share of the world population living in developing regions, as they are classified today, will increase from 76% now, to 80% in 2030 and to 83% in 2050.

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Population (2/2)

Table B.2 ▶ Population growth assumptions
(% average annual growth rates)

	1971-2003	2003-2030	2030-2050	2003-2050
OECD	**0.8**	**0.4**	**-0.2**	**0.1**
OECD North America	1.3	0.9	0.5	0.7
OECD Europe	0.5	0.1	-0.9	-0.3
OECD Pacific	0.8	0.0	-0.2	-0.1
Transition economies	**0.5**	**-0.3**	**-0.1**	**-0.2**
Developing countries	**2.0**	**1.2**	**0.9**	**1.1**
China	1.4	0.4	0.1	0.3
India	2.0	1.1	0.5	0.9
Other Asia	2.1	1.3	0.9	1.1
Middle East	3.1	1.9	2.0	1.9
Latin America	1.9	1.0	0.7	0.9
Africa	2.7	1.9	1.8	1.9
World	**1.6**	**1.0**	**0.7**	**0.9**

GDP Assumptions (1/2)

Global GDP growth is expected to slow gradually in all regions to 2050, with the annual average growth rate slowing from 3.2% in the period 2003 to 2030 to 2.6% in 2030 to 2050. This compares to an average rate of 0.3% per year between 1971 and 2003. China, India and other Asian countries are expected to grow faster than others. Growth will pick up in Africa and the transition economies. The combined GDP of developing countries will double over the period to 2050.

North America is expected to have the highest GDP growth among the OECD regions over the 2003 to 2050 period, at 2.1% per year on average, while OECD Pacific is assumed to grow by 1.8% per year and OECD Europe by 1.5% per year. All regions are expected to experience a continuing shift in their economies away from energy-intensive heavy manufacturing towards lighter industries and services.

GDP Assumptions (2/2)

Table B.1 ▶ Economic growth assumptions
(% average annual growth rate)

	1971-2003	2003-2030	2030-2050	2003-2050
OECD	**2.9**	**2.2**	**1.3**	**1.8**
OECD North America	3.1	2.4	1.6	2.1
OECD Europe	2.4	2.1	0.7	1.5
OECD Pacific	3.5	2.0	1.6	1.8
Transition economies	**0.7**	**3.7**	**3.4**	**3.6**
Developing countries	**4.7**	**4.3**	**3.5**	**3.9**
China	8.4	5.0	3.8	4.5
India	4.9	4.7	3.6	4.2
Other Asia	*5.2*	*4.1*	*3.1*	*3.7*
Middle East	2.9	3.0	2.9	3.0
Latin America	2.9	3.2	2.8	3.0
Africa	2.7	3.8	3.6	3.7
World	**3.3**	**3.2**	**2.6**	**2.9**

Annex 2: ETP methodology

ETP concept

- Based on MARKAL code
- Developed by Energy Technology Systems Analysis Programme, one of the IEA Implementing Agreements
- Proven and improved over the past 30 years
- In use in more than 30 countries worldwide
- National/local energy planning

The ETP model

- Global, 15-region MARKAL model
- Long-term (2050) analysis of energy technology policy issues
- Least-cost decision making, perfect foresight
- Economic partial equilibrium model
- Full coverage of energy system (global, supply and demand side)
- 1500 technologies

ETP technology database

- One global technology "library"
- Efficiency for new technologies the same across all regions
- Region-specific constraints and technology availability
- Region-specific cost indices
- Region and sector specific discount rates
- Region-specific standing capital stock

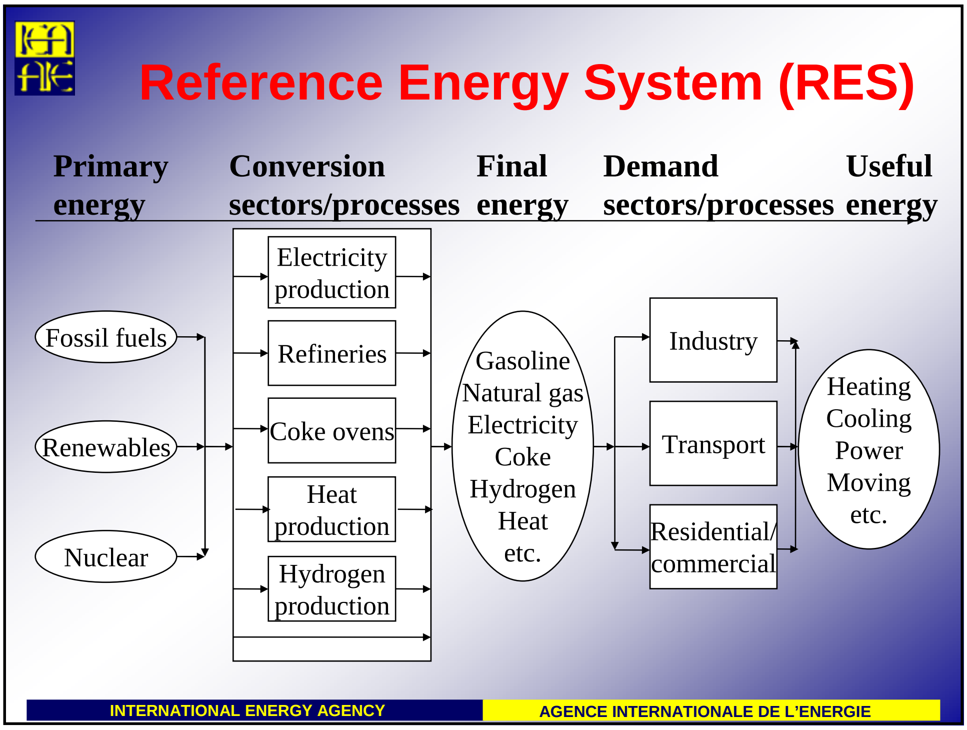
Strong and weak points

Strong points

- Consistency across technologies and regions
- Covers the whole energy system; puts technology-specific information into perspective
- Full fuel chain/systems effects (electricity, hydrogen, biomass etc.)
- Detailed electricity/heat modelling
- Regional differences are accounted for

Weak points

- Ideal market algorithm/rational decision making
- Complex demand side issues are simplified
- Intra-regional details only partially covered
- Seems often a black box for outsiders


Reference Energy System (RES)
Primary energy
Conversion sectors/processes
Final energy
Demand sectors/processes
Useful energy
Fossil fuels
Renewables
Nuclear
Electricity production
Refineries
Coke ovens
Heat production
Hydrogen production
Gasoline
Natural gas
Electricity
Coke
Hydrogen
Heat
etc.
Industry
Transport
Residential/ commercial
Heating
Cooling
Power
Moving
etc.
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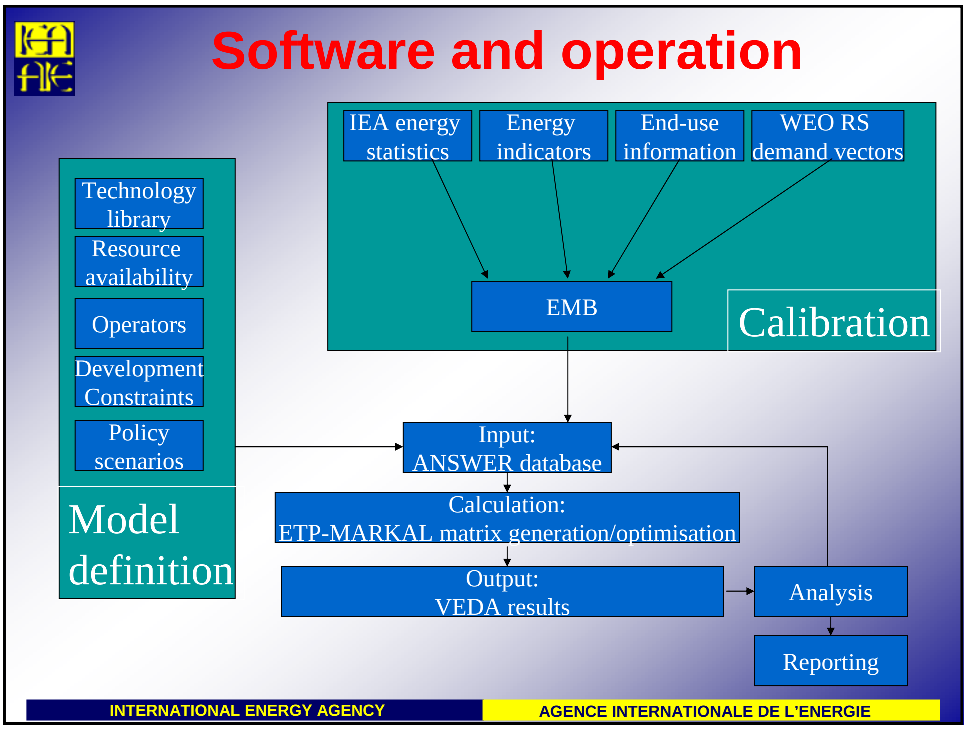
Software and operation
IEA energy statistics
Energy indicators
End-use information
WEO RS demand vectors
EMB
Calibration
Technology library
Resource availability
Operators
Development Constraints
Policy scenarios
Model definition
Input: ANSWER database
Calculation: ETP-MARKAL matrix generation/optimisation
Output: VEDA results
Analysis
Reporting
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