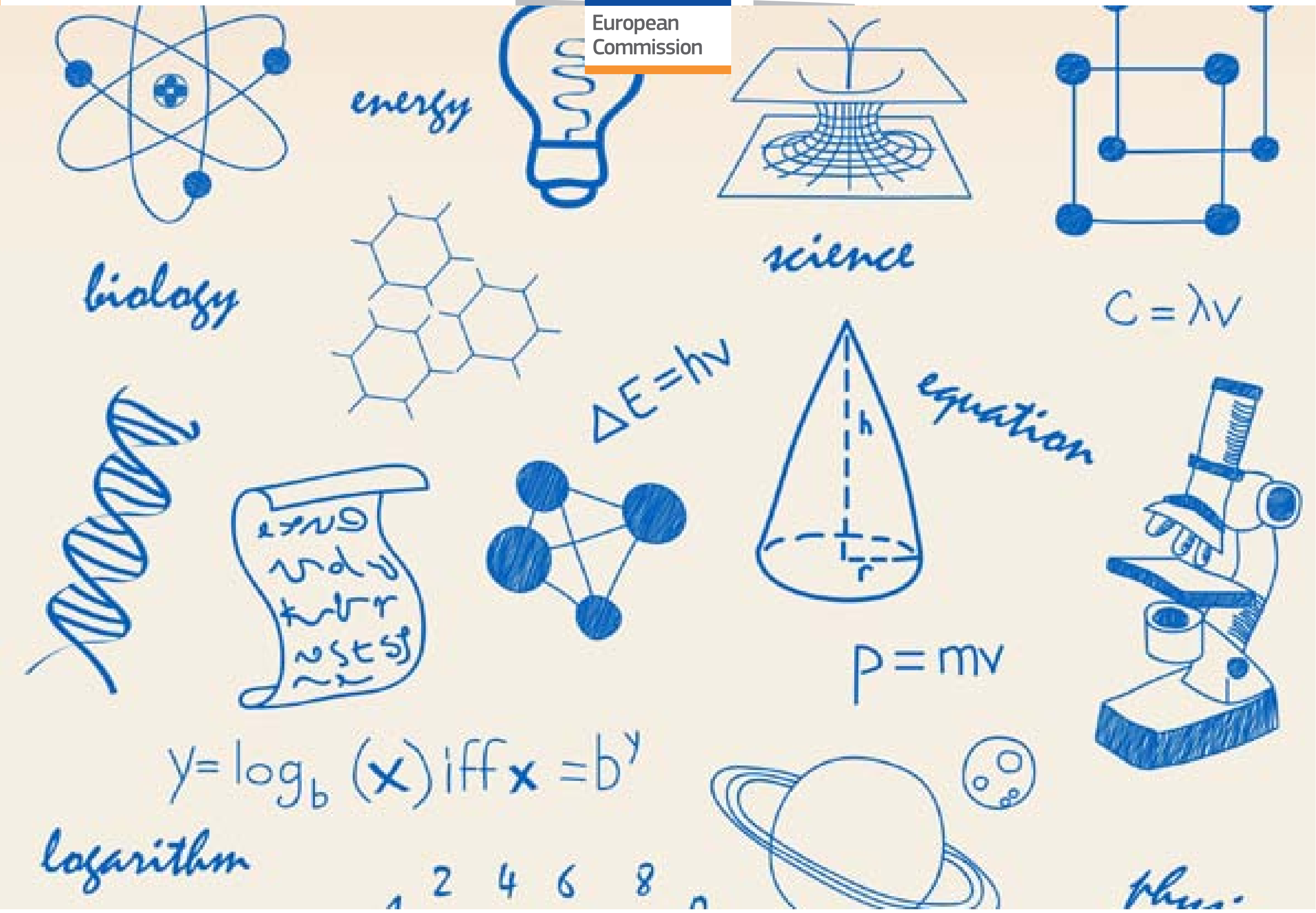

Opinion No 27

An ethical framework for assessing research, production and use of energy

Brussels, 16 January 2013

European Group
on Ethics in Science
and New Technologies
to the European Commission

An ethical framework for assessing research, production and use of energy

Brussels, 16 January 2013

Maurizio SALVI
Chief Editor
Head of the EGE Secretariat

27
Opinion No

European Commission

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AN ETHICAL FRAMEWORK FOR ASSESSING RESEARCH, PRODUCTION AND USE OF ENERGY

The European Group on Ethics in Science and New Technologies No **27** 16/01/2013

Reference: *Request from President Barroso*
Rapporteurs: *Emmanuel Agius, Paula Martinho da Silva, Pere Puigdomènech-Rosell*

THE EUROPEAN GROUP ON ETHICS IN SCIENCE AND NEW TECHNOLOGIES (EGE),

Having regard to the Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December 2007 (The Lisbon Treaty) ([1]),

Having regard to Council Regulation (EU, Euratom) No 617/2010 of 24 June 2010 concerning the notification to the Commission of investment projects in energy infrastructure within the European Union and repealing Regulation (EC) No 736/96 ([2]),

Having regard to Directive 94/22/EC of the European Parliament and of the Council of 30 May 1994 on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons ([3]),

Having regard to Regulation (EC) No 663/2009 of the European Parliament and of the Council of 13 July 2009 establishing a programme to aid economic recovery by granting Community financial assistance to projects in the field of energy ([4]),

Having regard to Regulation (EU) No 1233/2010 of the European Parliament and of the Council of 15 December 2010 amending Regulation (EC) No 663/2009 establishing a programme to aid economic recovery by granting Community financial assistance to projects in the field of energy ([5]),

Having regard to Council Regulation (EC) No 2964/95 of 20 December 1995 introducing registration for crude oil imports and deliveries in the Community ([6]),

Having regard to Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC ([7]),

Having regard to Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005 ([8]),

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([1]) http://eur-lex.europa.eu/JOHtml.do?uri=OJ:C:2007:306:SOM:EN:HTML
([2]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32010R0617:EN:NOT
([3]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31994L0022:EN:HTML
([4]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:200:0031:0031:EN:PDF
([5]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:346:0005:0010:EN:PDF
([6]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995R2964:EN:HTML
([7]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0094:0136:en:PDF
([8]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0036:0054:en:PDF

Having regard to Commission Decision 2010/685/EU of 10 November 2010 amending Chapter 3 of Annex I to Regulation (EC) No 715/2009 of the European Parliament and of the Council on conditions for access to the natural gas transmission networks ([9]),

Having regard to Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2011 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC ([10]),

Having regard to Directive 2008/92/EC of the European Parliament and of the Council of 22 October 2008 concerning a Community procedure to improve the transparency of gas and electricity prices charged to industrial end-users ([11]),

Having regard to Commission Decision 2003/796/EC of 11 November 2003 on establishing the European Regulators Group for Electricity and Gas (repealed by Commission Decision 2011/280/EU on repealing Decision 2003/796/EC on establishing the European Regulators Group for Electricity and Gas) ([12]),

Having regard to Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators ([13]),

Having regard to Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC ([14]),

Having regard to Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003 ([15]),

Having regard to Commission Decision 2006/770/EC of 9 November 2006 amending the Annex to Regulation (EC) No 1228/2003 on conditions for access to the network for cross-border exchanges in electricity ([16]),

Having regard to Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment ([17]),

Having regard to Directive 2008/92/EC of the European Parliament and of the Council of 22 October 2008 concerning a Community procedure to improve the transparency of gas and electricity prices charged to industrial end-users ([18]),

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([9]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:293:0067:0071:EN:PDF
([10]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:295:0001:0022:EN:PDF
([11]) http://eurlex.europa.eu/Notice.do?val=482330:cs&lang=fr&list=482330:cs,&pos=1&page=1&nbl=1&pgs=10&hwords=Directive%202008/92~&checktexte=checkbox&visu=
([12]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:129:0014:01:EN:HTML
([13]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0001:0014:EN:PDF
([14]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32009L0072:en:NOT
([15]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0015:0035:EN:PDF
([16]) http://www.energy-community.org/pls/portal/docs/576181.PDF
([17]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:033:0022:01:EN:HTML
([18]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:298:0009:0019:EN:PDF

Having regard to Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators ([19]),

Having regard to Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC ([20]),

Having regard to Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport ([21]),

Having regard to Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market ([22]),

Having regard to Regulation (EC) No 106/2008 of the European Parliament and of the Council of 15 January 2008 on a Community energy-efficiency labelling programme for office equipment (Energy Star) ([23]),

Having regard to Commission Decision 2003/168/EC of 11 March 2003 establishing the European Community Energy Star Board ([24]),

Having regard to Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005, as amended by Directive 2008/28/EC of the European Parliament and of the Council ([25]) establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council (Ecodesign Directive) ([26]), replaced by Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products ([27]),

Having regard to Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC (The Energy Services Directive) ([28]),

Having regard to Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings and its amendments repealed by its recast directive: Directive 2010/31/EU of the European Parliament and of the Council of on the energy performance of buildings and its amendments (the recast Directive entered into force in July 2010, but the repeal of the current Directive took effect on 1 February 2012) ([29]),

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([19]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0001:0014:EN:PDF
([20]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF
([21]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:123:0042:0042:EN:PDF
([22]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:283:0033:0033:EN:PDF
([23]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:039:0001:0007:EN:PDF
([24]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:067:0022:0024:EN:PDF
([25]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:081:0048:0050:en:PDF
([26]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32005L0032:en:NOT
([27]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF
([28]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf
([29]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:01:EN:HTML

Having regard to the Commission Decision 2007/74/EC of 21 December 2006 establishing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2004/8/EC of the European Parliament and of the Council ([30]),

Having regard to the Commission Decision 2008/952/EC of 19 November 2008 establishing detailed guidelines for the implementation and application of Annex II to Directive 2004/8/EC of the European Parliament and of the Council ([31]),

Having regard to Regulation (EC) No 67/2010 of the European Parliament and of the Council of 30 November 2009 laying down general rules for the granting of Community financial aid in the field of trans-European networks ([32]),

Having regard to Regulation (EC) No 680/2007 of the European Parliament and of the Council of 20 June 2007 laying down general rules for the granting of Community financial aid in the field of the trans-European transport and energy networks (TEN Financial Regulation) ([33]),

Having regard to Decision No 1364/2006/EC of the European Parliament and of the Council of 6 September 2006 laying down guidelines for trans-European energy networks and repealing Decision 96/391/EC and Decision No 1229/2003/EC ([34]),

Having regard to Council Regulation (Euratom) No 2587/1999 of 2 December 1999 defining the investment projects to be communicated to the Commission in accordance with Article 41 of the Treaty establishing the European Atomic Energy Community ([35]),

Having regard to Commission Regulation (EC) No 1209/2000 of 8 June 2000 determining procedures for effecting the communications prescribed under Article 41 of the Treaty establishing the European Atomic Energy Community ([36]),

Having regard to Commission Regulation (Euratom) No 1352/2003 of 23 July 2003 amending Regulation (EC) 1209/2000 determining procedures for effecting the communications prescribed under Article 41 of the Treaty establishing the European Atomic Energy Community ([37]),

Having regard to Council Decision 2008/114/EC, Euratom of 12 February 2008 establishing Statutes for the Euratom Supply Agency ([38]),

Having regard to the EAEC Commission Decision fixing the date on which the Euratom Supply Agency shall take up its duties and approving the Agency Rules of 5 May 1960 determining the manner in which demand is to be balanced against the supply of ores, source materials and special fissile materials ([39]),

Having regard to the EAEC Supply Agency: Rules of the Supply Agency of the European Atomic Energy Community of 5 May 1960 determining the manner in which demand is to be balanced against the supply of ores, source materials and special fissile materials, as amended by the

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([30]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:032:0183:0188:EN:PDF
([31]) http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2008:338:SOM:en:HTML
([32]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:027:0020:0032:EN:PDF
([33]) http://tentea.ec.europa.eu/download/legal_framework/8__regulation_6802007.pdf
([34]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:262:0001:0001:EN:PDF
([35]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999R2587:EN:HTML
([36]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000R1209:EN:HTML
([37]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32003R1352:EN:HTML
([38]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:041:0015:0020:EN:PDF
([39]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31960D0511:EN:HTML

Regulation of the Supply Agency of the European Atomic Energy Community amending the rules of the Supply Agency of 5 May 1960 determining the manner in which demand is to be balanced against the supply of ores, source materials and special fissile materials ([40]),

Having regard to the Convention on Nuclear Safety — Declaration by the European Atomic Energy Community according to the provisions of Article 30(4)(iii) of the Nuclear Safety Convention adherence by Decision of the Council of 7 December 1998 on the approval concerning the accession to the 1994 Convention on Nuclear Safety by the European Atomic Energy Community (Euratom) (not published), as amended by the Decision of the Council of 15 December 2003 modifying the Decision of the Council of 7 December 1998 on the approval concerning the accession to the 1994 Convention on Nuclear Safety by the European Atomic Energy Community (Euratom) with regard to the Declaration attached thereto (not published),

Having regard to Commission Decision 1999/819/Euratom of 16 November 1999 concerning the accession to the 1994 Convention on Nuclear Safety by the European Atomic Energy Community (Euratom), as amended by Commission Decision 2004/491/Euratom of 29 April 2004 amending Commission Decision 1999/819/Euratom of 16 November 1999 concerning the accession to the 1994 Convention on Nuclear Safety by the European Atomic Energy Community (Euratom) with regard to the Declaration attached thereto ([41]),

Having regard to Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations ([42]),

Having regard to Communication 2006/C/155/02 from the Commission on Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States ([43]),

Having regard to Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole ([44]),

Having regard to Commission Recommendation 2010/635/Euratom of 11 October 2010 on the application of Article 37 of the Euratom Treaty ([45]),

Having regard to Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation (and the corrigendum to it), repealing and replacing Council Directive 80/836/Euratom of 15 July 1980 and Council Directive 84/467/Euratom of 3 September 1984 ([46]),

Having regard to Communication 98/C 133/03 from the Commission concerning the implementation of Council Directive 96/29/Euratom laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation ([47]),

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([40]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:P:1960:032:0777:0:EN:HTML
([41]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:172:0007:0008:EN:PDF
([42]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:172:0018:0022:EN:PDF
([43]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2006:155:0002:01:EN:HTML
([44]) http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/00473_en.pdf
([45]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:279:0036:0067:EN:PDF
([46]) http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/9629_en.pdf
([47]) http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/98c13303_en.pdf

Having regard to Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionising radiation during their activities in controlled areas [48],

Having regard to Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionising radiation in relation to medical exposure, and repealing Directive 84/466/Euratom [49],

Having regard to the Communication from the Commission to the European Parliament and the Council on medical applications of ionising radiation and security of supply of radioisotopes for nuclear medicine, COM(2010) 423 final of 6 August 2010 [50],

Having regard to Commission communication 91/C 103/03 on the implementation of Council Directive 89/618/Euratom of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency [51],

Having regard to Commission Decision 2005/844/Euratom of 25 November 2005 concerning the accession of the European Atomic Energy Community to the Convention on Early Notification of a Nuclear Accident [52],

Having regard to Commission Decision 2005/845/Euratom of 25 November 2005 concerning the accession of the European Atomic Energy Community to the Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency [53],

Having regard to the Communication from the Commission to the Council and the European Parliament of 19 April 1996 on illicit trafficking in nuclear materials and radioactive substances (COM(96) 171 final) [54],

Having regard to Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel between Member States and into and out of the Community, repealing Council Directive 92/3/Euratom [55],

Having regard to Commission Decision 2008/312/Euratom of 5 March 2008 establishing the standard document for the supervision and control of shipments of radioactive waste and spent fuel referred to in Council Directive 2006/117/Euratom [56],

Having regard to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [57], to which the European Atomic Energy Community acceded by virtue of Council Decision 2005/84/Euratom of 24 January 2005 approving the accession of the European Atomic Energy Community to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [58], and Commission

(48) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0641:EN:HTML
(49) http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/9743_en.pdf
(50) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0423:FIN:EN:PDF
(51) http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/91c10303_en.pdf
(52) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32005D0844:EN:HTML
(53) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:314:0027:0027:EN:PDF
(54) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:1996:0171:FIN:EN:PDF
(55) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:337:0021:0032:EN:PDF
(56) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:107:0032:01:EN:HTML
(57) http://www.iaea.org/Publications/Documents/Conventions/jointconv.html
(58) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:030:0010:01:EN:HTML

Decision 2005/510/Euratom of 14 June 2005 concerning the accession of the European Atomic Energy Community to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management ([59]),

Having regard to Commission Decision 90/413/Euratom of 1 August 1990 relating to a procedure in application of Article 83 of the Euratom Treaty (XVII-001-ANF Lingen) ([60]),

Having regard to Commission Decision 92/194/Euratom of 4 March 1992 relating to a procedure in application of Article 83 of the Euratom Treaty (XVII-002-UKAEA Dounreay) ([61]),

Having regard to Commission Decision 2006/626/Euratom of 15 February 2006 pursuant to Article 83 of the Treaty establishing the European Atomic Energy Community ([62]),

Having regard to Commission Recommendation 2009/120/Euratom of 11 February 2009 on the implementation of a nuclear material accountancy and control system by operators of nuclear installations ([63]),

Having regard to Commission Regulation (Euratom) No 302/2005 of 8 February 2005 on the application of Euratom safeguards ([64]),

Having regard to the Commission Recommendation 2006/40/Euratom of 15 December on guidelines for the application of Regulation (Euratom) No 302/2005 on the application of Euratom safeguards ([65]),

Having regard to Council Decision 80/565/Euratom of 9 June 1980 approving the conclusion by the Commission of the International Convention on the physical protection of nuclear material ([66]),

Having regard to Council Decision 77/270/Euratom of 29 March 1977 empowering the Commission to issue Euratom loans for the purpose of contributing to the financing of nuclear power stations ([67]),

Having regard to Regulation (EURATOM) No 3 implementing Article 24 of the Treaty establishing the European Atomic Energy Community (on security gradings and the security measures to be applied to information acquired by the Community or communicated by Member States which is covered by Articles 24 and 25 of the Treaty establishing the European Atomic Community) ([68]),

Having regard to the Communication from the Commission *EU 2020 — A European strategy for smart, sustainable and inclusive growth* ([69]),

Having regard to the Commission communication *Global Europe 2050* ([70]),

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([59]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:185:0033:01:EN:HTML
([60]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990D0413:EN:HTML
([61]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992D0194:EN:HTML
([62]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:255:0005:01:EN:HTML
([63]) http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2009:041:SOM:en:HTML
([64]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:054:0001:0070:EN:PDF
([65]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:028:0001:01:EN:HTML
([66]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31980D0565:EN:HTML
([67]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2003:045E:0194:0194:EN:PDF
([68]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31958R0003(01):EN:HTML
([69]) http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%20 2020%20-%20EN%20version.pdf
([70]) http://ec.europa.eu/research/social-sciences/pdf/global-europe-2050-report_en.pdf

Having regard to the UNESCO report *The Ethics of Energy: A Framework for Action* (71),

Having regard to the International Atomic Energy Agency report *Establishing a Code of Ethics for Nuclear Operating Organisations* (72),

Having regard to the Council of Europe Steering Committee on Bioethics (CDBI) document *Legislative developments of nuclear transfer* (73),

Having regard to the round table organised by the EGE on 18 September 2012 in Brussels,

Having regard to the contributions from the EGE open consultations on ethics and energy,

Having heard the EGE Rapporteurs, Emmanuel Agius, Paula Martinho da Silva and Pere Puigdomènech-Rosell,

HEREBY ADOPTS THE FOLLOWING OPINION:

(71) http://unesdoc.unesco.org/images/0012/001235/123511eo.pdf
(72) http://www-pub.iaea.org/MTCD/publications/PDF/P_1311_web.pdf
(73) https://wcd.coe.int/ViewDoc.jsp?id=1885295&Site=CM&BackColorInternet=C3C3C3&BackColorIntranet=EDB021&BackColorLogged=F5D383

CONTENTS

European Group
on Ethics in Science
and New Technologies
to the European Commission

OPINION OF THE EUROPEAN GROUP ON ETHICS IN SCIENCE AND NEW TECHNOLOGIES TO THE EUROPEAN COMMISSION

An ethical framework for assessing research, production and use of energy

Reference: Request from President Barroso

Rapporteurs: Emmanuel Agius, Paula Martinho da Silva, Pere Puigdomènech-Rosell

Maurizio SALVI
Chief Editor
Head of the EGE Secretariat

27
Opinion No

Scope of the Opinion

On 28 June 2011 the Council reached a political agreement on a Commission proposal for a nuclear research and training programme for 2012–13. Although the Council's discussion has been successfully concluded, some Member States felt that a broad discourse on ethical issues and sustainable energy mix in Europe should take place and indicated the need of having an Opinion of the European Group on Ethics in Science and New Technologies (EGE) on this topic. On 19 December 2011, the President of the European Commission requested the EGE to 'contribute to the debate on a sustainable energy mix in Europe by studying the ethical impact of research on different energy sources on human well-being.'

The EGE has accepted this request and decided to focus on the ethical aspects of the use of different energy sources in Europe, as foreseen in the EGE remit ([74]). The group recognises the need to consider issues such as security of supply, storage of energy where necessary due to the nature of electricity generation particularly where intermittent sources are utilised, competition for water and food in the case of biofuels, waste treatment and/or storage and pollution. The Group decided:

- to address the ethical issues arising from energy use within the EU energy agenda, mix of energy, consequences for the future, energy policy and regulation (including environmental considerations), precautionary principle, and intergenerational justice;
- to identify the ethical criteria on the manner in which decisions concerning research on sources of energy (in view of the Council's decision) are to be taken on an informed basis and the implications arising from the use of energy in different areas;
- to propose an integrated ethics framework for the purpose of addressing the ethical issues related to the production, use, storage and distribution of energy;
- to identify the ethically relevant areas of energy research.

([74]) The role of the EGE is to provide the Commission with high-quality and independent advice on ethical aspects of science and new technologies in connection with the preparation and implementation of Union legislation or policies.

1. Scientific aspects

1.1 Introduction

Before the discovery of the ability to control external sources of energy, humans simply used the energy that they could develop through their own bodies. The control of fire (enshrined in myth in the story of Prometheus) has always been considered as a turning point for human societies. Fire was procured by burning plant material such as wood or grasses and was used by prehistoric people, maybe even by ancestral hominids thousands of years ago, for many purposes such as cooking food, protection from other animals, keeping warm, seeing in the dark and producing new materials such as pottery, which, in turn, lead to the smelting of metals.

In historical times, human societies learned to use the energy of animals such as horses or camels for farm work and transport. To these sources, humans added the use of wind energy from windmills or water energy produced in river mills. All these systems use solar energy converted into chemical and mechanical energy by plants and animals or through rain and wind. Many cultures were able to use heat from thermal sources that produce water heated by the internal energy of the planet, the only initial energy source not directly originating from solar energy.

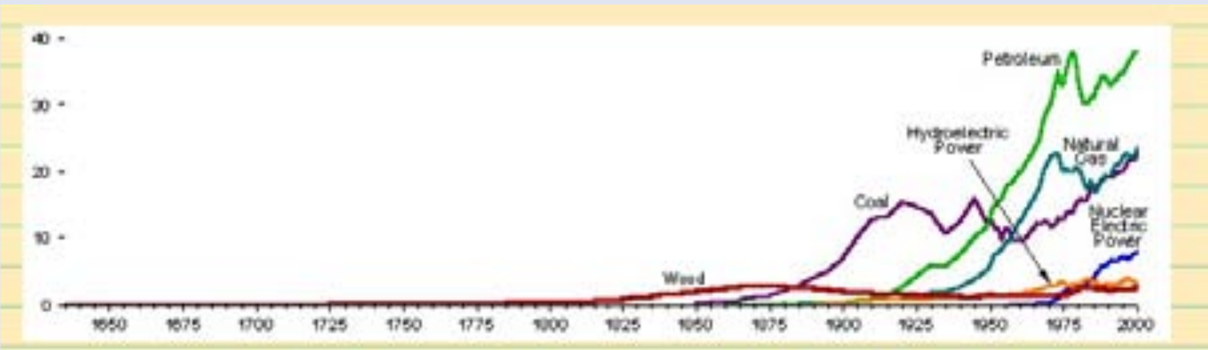
Energy needs have increased enormously and, due to the rapid growth in populations, to industrialisation and urbanisation, they have changed the way we interact with our environment. The massive extension in our use of electronics in our daily lives increases the need for energy in a manner not foreseen in the 20th century! In addition, energy use per person in the developing world is increasing towards that used by those in developed countries.

The most important change in our use of energy took place in the 18th century (Figure 1) when the steam engine was developed to allow energy production that depended only on the availability of a fuel that rapidly became mined coal. The steam engine changed the world; as a result of industrialisation, people interacted differently with their environment and there was a greater need for fuel and food, which had to be transported to where people now lived.

The availability of affordable and transportable energy sustained the Industrial Revolution. Human beings have always needed two forms of energy: that used in a static system, in our homes for heating, cooking, lighting and (today) cooling, and that used for transport, initially animals, then steam engines, and, now, public and private transport based on the internal combustion engine, including aircrafts. The manner in which these are provided to individual homes and businesses differ: hence, the needs have to be addressed somewhat differently. Coal, for example, is heavy, not suitable for most forms of **private** transport. Electricity can be used in transport if power cables can be provided (in public transport, for example, for trains and trams) or if mechanisms for storage are available, for example batteries, flywheels and/or fuel cells.

Coal is fossilised wood accumulated in soil in large quantities. Coal rapidly became a strategic product. Coal mines were the basis of the industrial revolution that developed through the 19th century in Europe and North America and its availability provided the impetus to develop new types of engines for use in transport. Ships and trains powered by coal transformed world trade. Coal mines had an important social impact in the European regions where mines were located. A new culture of miner societies appeared during

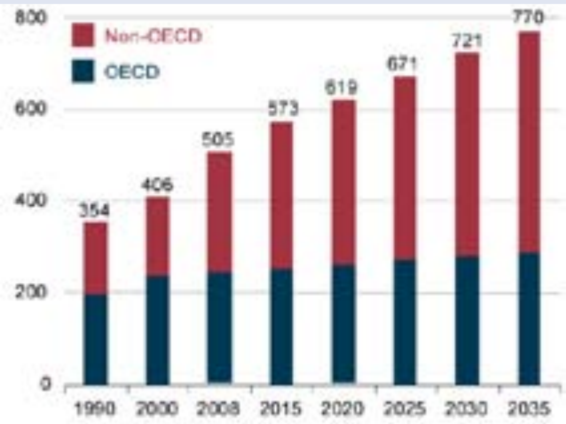
Figure 1.1.1: US Energy consumption by energy resource 1635–2000



Source: http://www.eia.doe.gov/emeu/aer/eh/intro.html the 19th century that had implications on European trade union culture, because of the need to support one another in a dangerous environment. During the 20th century, the decreasing use of coal of European origin and the consequent closure of mines has created social disruptions that are still reverberating in European regions with coal mining traditions.

Coal was initially used for heating and distributed to homes using traditional transport. The gas produced from coal through a distillation process was the first easily transportable energy system that could be distributed for lighting in cities and to houses for heating, and even stored for use in transport. The first grids for distributing energy were those put in place to distribute coal gas. Electric current, discovered in the first half of the 19th century, became the primary source of energy that could be distributed for use everywhere. The first power plants were built in Europe and in the United States in 1882 and were powered by steam engines burning coal, and, even today, coal is the major fuel powering generators for electricity. At the end of the 19th century, the use of petrol became the dominant source of energy. Petrol has been known since antiquity but the possibility to drill underground wells deep enough to obtain large quantities of oil, and to refine it to obtain petrol and other products, produced a new type of industry that has dominated the 20th century. Natural gas first appeared as a by-product of oil production and it soon became a new source of energy in itself.

Figure 1.1.2: World energy consumption 1990–2035



Source: US Energy Information Administration, *International Energy Outlook* (2011).

Energy use is increasing at an accelerating rate and reached 550 exajoules in 2010. One important effect of the increasing use of energy is the development of new industries that are involved in the processes related to the production and distribution of energy. Companies that prospect and extract coal, oil and gas, refine fuels and prepare petrochemicals and transport and distribute fluid fuels have become the largest world companies. There are also companies that produce and distribute electricity as well as those that manage the large electricity grids; to these can be added the companies that build power plants to produce electricity from different fuel sources, including nuclear. Many of these companies are, or were, State-controlled. The energy sector in Europe is one of the most powerful industrial sectors, accounting for 9 % of total European industry and 3 % of the total industrial workforce.

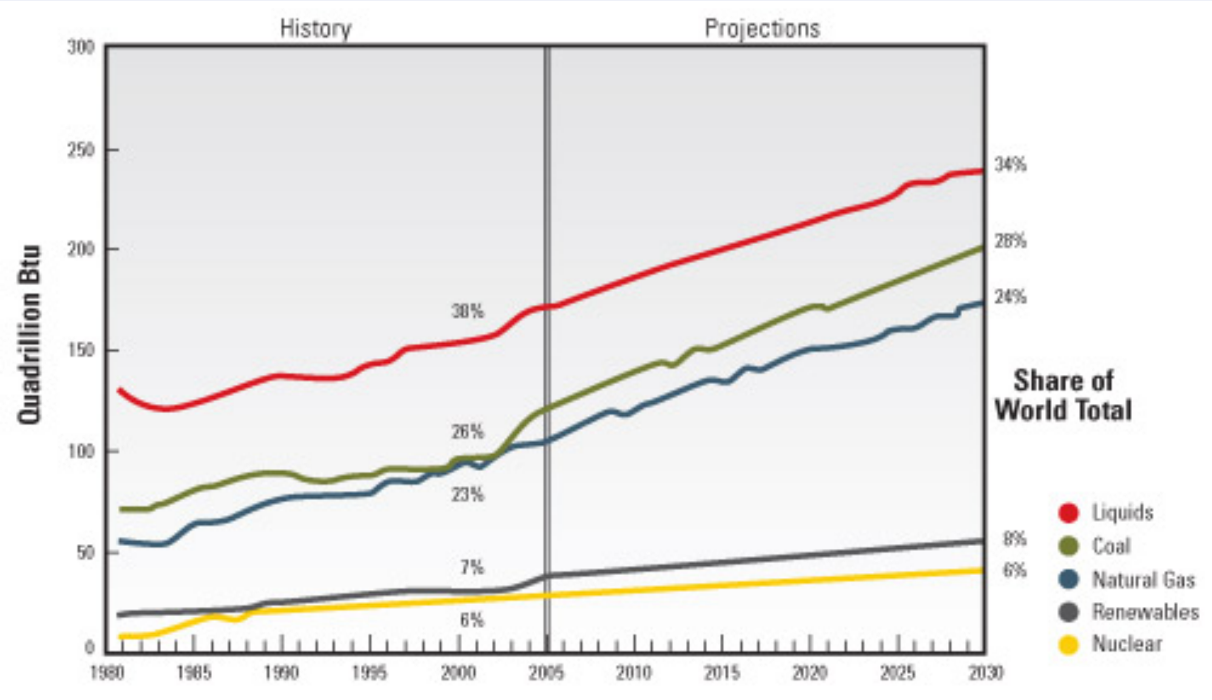
The European project that has produced the European Union started as a community of states that intended to share their sources of energy, and the knowledge to produce it. The founding treaties included the European Coal and Steel Community (1951) and Euratom (1957).

At the beginning of the 21st century, humankind is using an average of 25 times the energy that humans use as food energy to survive. Our society and the well-being of citizens in the developed world depend, essentially, on the availability of energy.

Energy is used for a large number of purposes: heating, transportation, industry, and all services that depend on the availability of electricity. Countries have a specific distribution of uses that varies depending on their needs (e.g. heating needs in cold countries are different from those in warmer countries) and on their economic structure (e.g. highly industrialised countries use more energy for manufacturing). Modern agriculture depends on energy, which means that sustaining the rapidly increasing population of the world is heavily dependent on affordable energy. New electronic systems, such as the Internet and cloud computing, are voracious users of energy. It has been suggested that simply reducing energy provision to about 1 600 kilowatts per individual per year ([75]) would reduce life expectancy by half to about 36.5 years!

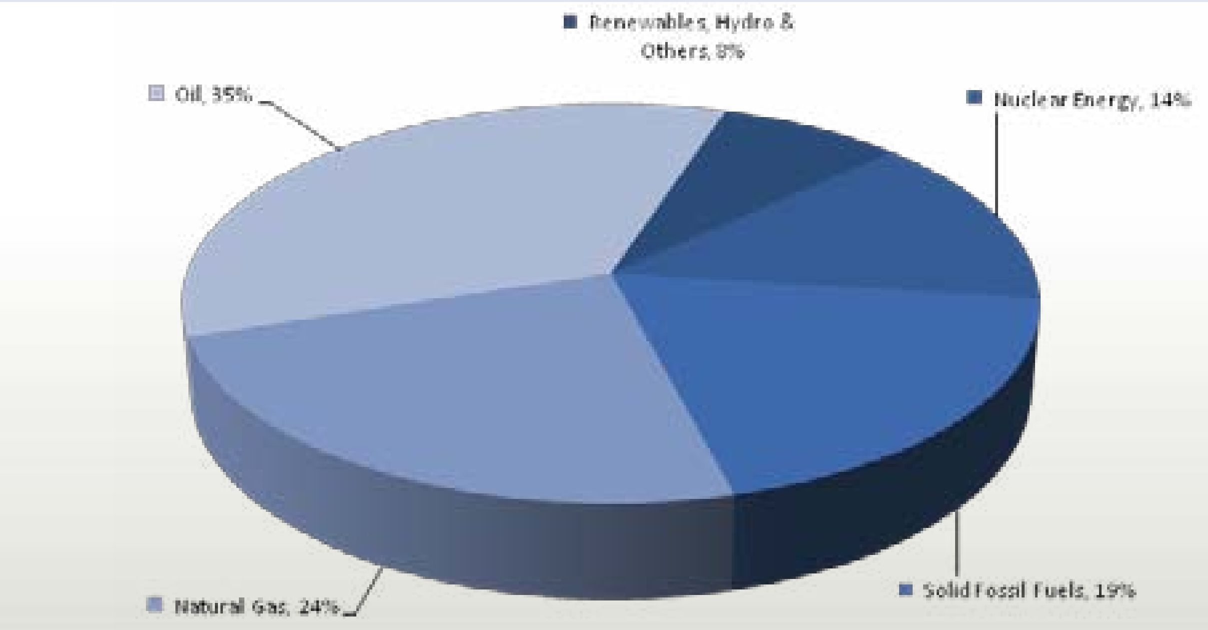
([75]) Madhi Ragheb (2012), *Energy storage and transport systems — Bridging the supply–demand gap* (https://netfiles.uiuc.edu/mragheb/www/NPRE%20498ES%20Energy%20Storage%20Systems/Title-Preface.pdf).

Figure 1.1.3: World marketed energy use: OECD and non-OECD



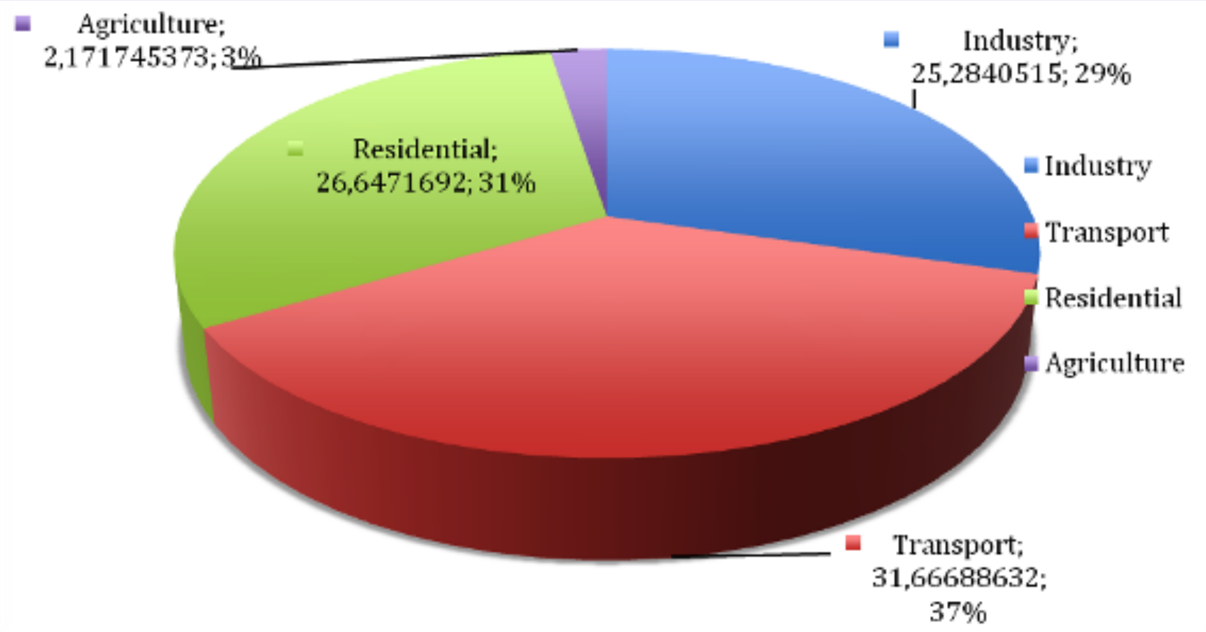
Source: US Energy Information Administration, *International Energy Outlook* (2011).

Figure 1.1.4: Sources of EU primary energy supply



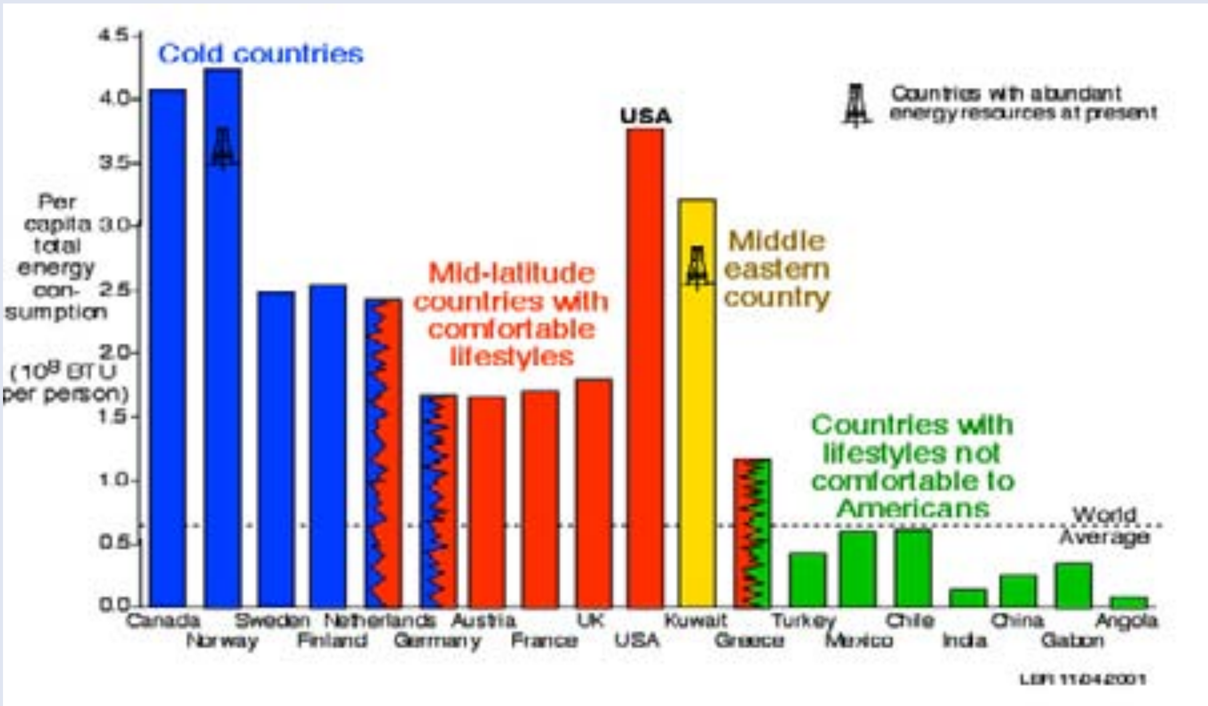
Source: http://ec.europa.eu/bepa/european-group-ethics/docs/pdf/ege_march_2012_dechamps.pdf

Figure 1.1.5: Uses of energy (Kcal and %)



Source: Syllabus, Earth's History of Global Change, University of Georgia (2012).

Figure 1.1.6: Energy consumption per capita



Source: Syllabus, Earth's History of Global Change, University of Georgia (2012).

1.2 Current sources of energy

The available sources of energy can be summarised as follows.

Sources of solar origin

The main source of energy that we use directly or indirectly is the radiation that earth receives from the sun. However, a large part of this energy is radiated back into space or absorbed by the atmosphere, and our systems to transform the energy once it arrives on earth's surface have low conversion rates into other forms of energy. Plants, for example, are able to convert around 1 % of the solar energy they receive into chemical energy in the form of sugars through the process of photosynthesis. It is possible to use solar radiation **directly** either by converting radiation into heat or electricity:

- thermosolar: solar radiation is used to heat a material which has a high thermal conductivity, normally water, and the warm fluid is used either for heating or to produce electricity;
- photovoltaic: solar radiation is captured using the photovoltaic effect to produce electricity directly.

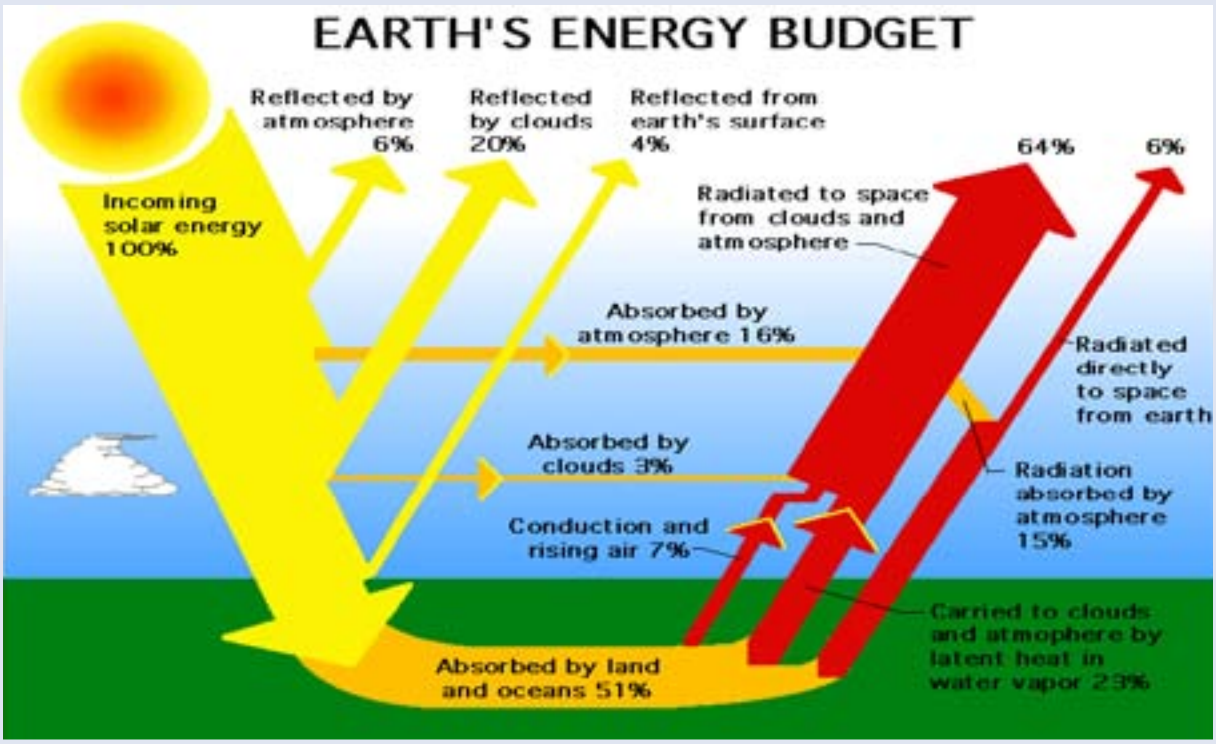
In both cases, the production of electricity depends on the availability of solar energy that varies during the day, from one day to another, and in different parts of the world.

Solar radiation is the **indirect** origin of many different types of energy through the heating of air and evaporation of water that results in rainfall. These sources are used to produce electricity.

Waterfalls and water currents: Hydroelectric power is used to produce electricity in much of the world. It generally requires storing water in reservoirs: the water is then released through turbines that generate electricity. Water currents in rivers or in the sea could also be used for the production of energy but these are essentially at the research stage.

Windmills: The power of the wind produces movement of rotors that in turn are used to produce electricity. The energy contained in the movement of air on windy days has been captured for centuries. The most common form of capture has been sails on ships, but windmills have been used for mechanical power for milling or for pumping water (or oil). Wind turbines may be used to produce electricity and improvements in the technology during the last few years mean that

Figure 1.2.1: Earth's energy budget

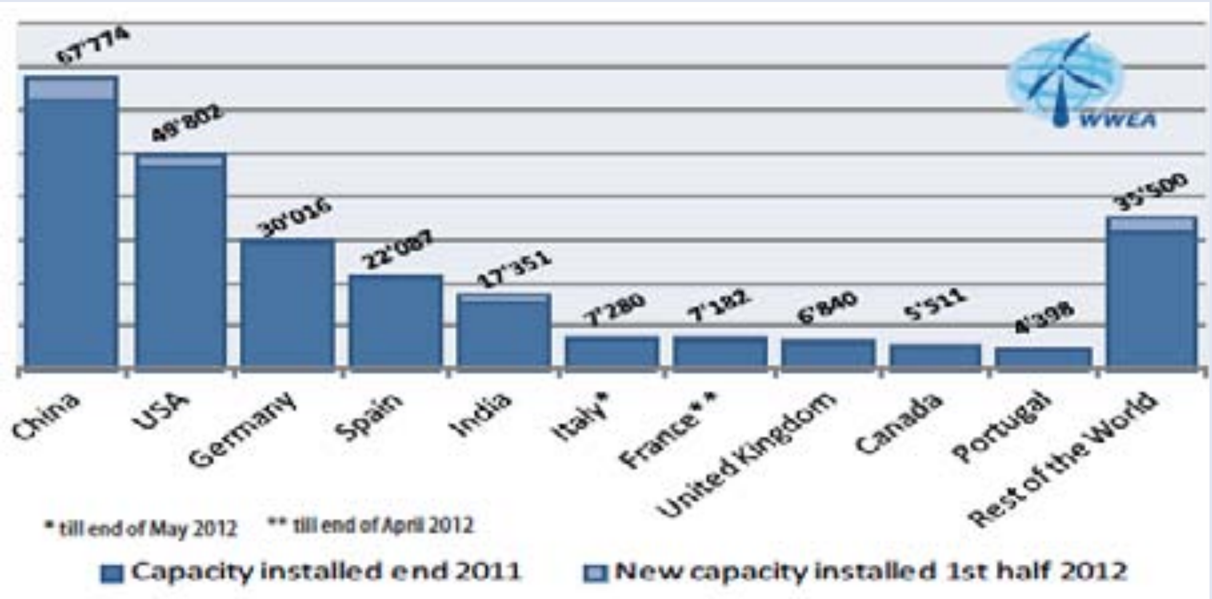


Source: National Aeronautics and Space Administration (2012).

the worldwide wind capacity reached 254 000 MW by the end of June 2012, out of which 16 546 MW were added in the first 6 months of 2012 ([76]).

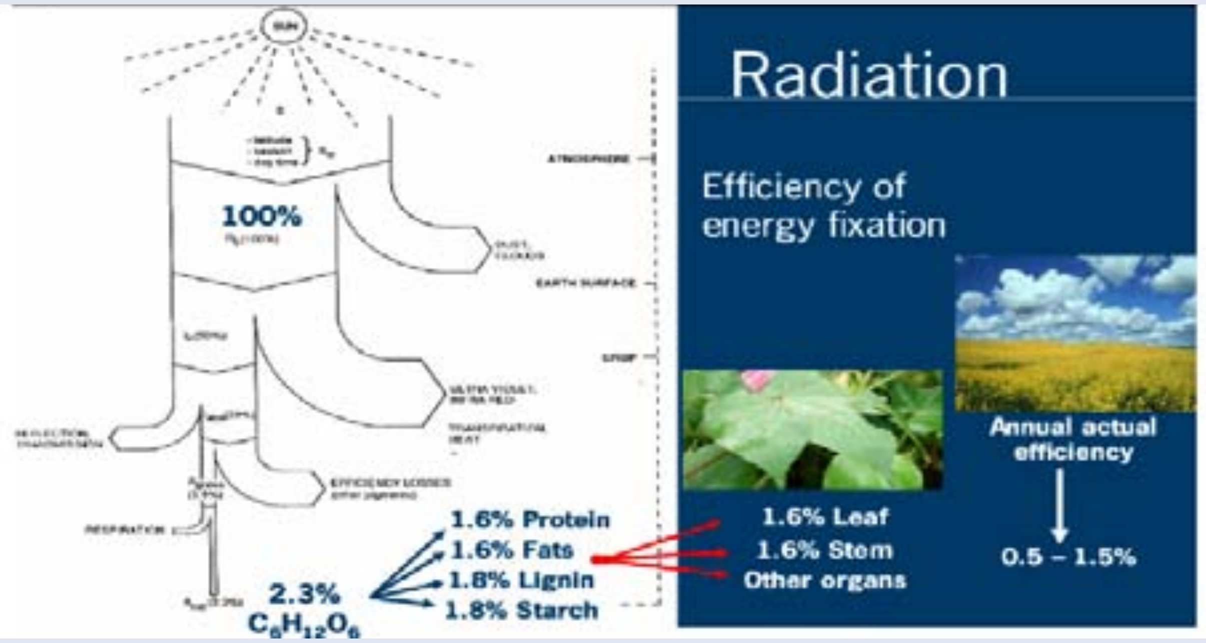
Biofuels and biomass: Plant material from cultivated crops or from plant residues not used for food or feed can be burned to produce electricity or used to produce liquid fuels through fermentation. Algal culture may also be used for biofuel production.

Figure 1.2.2: Total installed capacity 2011–12



Source: World Wind Energy Association, Half-Year Report (2012).

Figure 1.2.3: Biofuel supply



Source: Adapted from Jongschaap, R. E. E., 'A to Z of Jatrofa curcus Workshop — Introduction to the role of Jatrofa curcas in biofuel supply', Plant Research International, Wageningen, Netherlands.

([76]) http://www.wwindea.org

Biogas: Methane may be produced from fermentation of organic (plant and animal) residues, to produce electricity or used as a gas for transportable fuels.

Solar energy concentrated by microorganisms and plants in geological periods

Coal: Coal is the product of fossilised plants that have accumulated during hundreds of millions of years and have been transformed through geological processes. Coal is burned either to produce electricity or for heating.

Gas: Natural gas is essentially methane produced from massive quantities of photosynthetic microorganisms that have been transformed through geological processes. Natural gas is used to produce electricity, or directly for heating and transport.

Petroleum: Petroleum is the product of large masses of photosynthetic microorganisms that have sedimented during millions of years and have been transformed through geological processes. It is used to produce fuel for transportation, heating and electricity. It is also an important source for many chemical products such as plastics, fibres and pharmaceuticals. It can be found in large quantities in defined locations on the planet.

These sources are the main sources of energy supply in the world; they have a high energy content and a number of complex and efficient systems have been developed to make use of them. As these sources are the consequence of the fixation of energy by organisms in the past millions of years, they are, by definition, limited in quantity and their use depletes the resource. The estimations of existing reserves of petrol, gas and coal vary considerably: these reserves are **non-renewable** resources produced over millions of years, and current production is not significant.

Sources of energy remaining from the origin of the planet

Geothermal: Geothermal energy is normally collected from water at high temperature from natural sources. The internal heat of the planet can also be used to heat a fluid. This type of energy is used for heating and for the production of electricity.

Nuclear energy: Nuclear energy is currently produced from the fission of heavy isotopes such as uranium or thorium and used to produce electricity. Nuclear **fission** energy depends on the availability of fissile elements that have to be extracted in mines and, hence, they, too, are limited in quantity and can be considered **non-renewable**. Nuclear **fusion** energy, the origin of solar energy, would make use of much more abundant materials but it is not presently a controlled energy source. In theory, a vast amount of energy could be produced from the fusion of light nuclei but this technology remains at a research stage.

Other sources

Tidal energy: The movement of water in tidal systems or in rivers is captured using turbines to produce electricity. It is used to produce electricity in coastal regions where tides are sufficient to make these systems economically viable. The same principle can be applied to the movement of water in rivers.

Renewable and non-renewable energy sources

Some types of energy have their origin (directly or indirectly) in the energy of the sun that arrives continuously at the surface of our planet or in the internal heat of the planet. We do not expect these sources of energy to decrease in the foreseeable future. For this reason, the energy obtained in this way is continuously renewed. That is the reason why we consider energy from direct (i.e. thermosolar, photovoltaic) or indirect (i.e. wind, sea currents, hydraulic or biofuels) solar origin and from the internal energy of the planet (geothermal) as **renewable**. Energy from those sources that were accumulated in previous periods of the planet's history and that are present in fixed quantities will be exhausted at some time in the future: for this reason, coal, petrol and gas are categorised as **non-renewable**. This is also the case for nuclear energy obtained from fission because reserves of uranium (in particular) are also limited.

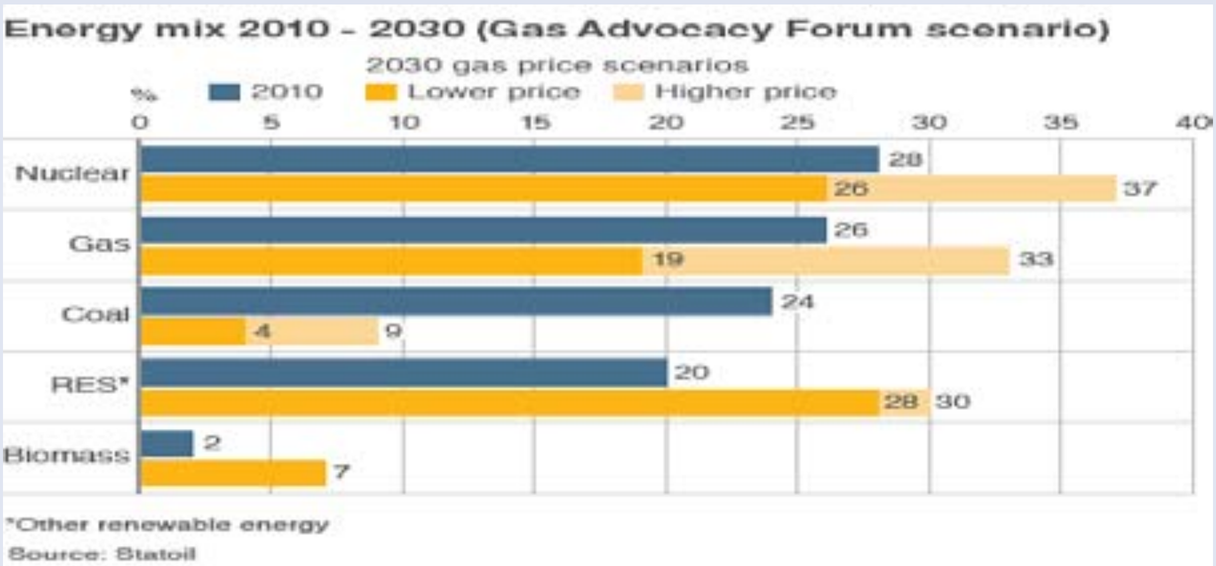
The key issue as regards non-renewable sources of energy is that reserves will be depleted at some point and our society has to prepare itself to rely on sources of energy that will not be exhausted. Estimates of the reserves of fossil fuels, and even of uranium needed to drive nuclear power plants, vary widely, depending on new reserves being identified or the politics of those making the estimates. Although it has been proposed that the maximum of some fossil energies (peak oil point) may be reached in this century, technology has been developed to obtain petroleum and gas from wells at great depths under the sea, in polar regions and in places where they are distributed in large volumes (shale oil and shale gas) which are becoming accessible through changes in mining technologies. These technologies increase the reserves of fossil fuels that may be available, although at high economic and/or environmental costs. It is, therefore, necessary to decrease the use of non-renewable fuels through the adoption of renewable sources as soon as possible in order to slow down the depletion of these resources. At the same time, a number of developments can be used as **bridge technologies** to allow access to adequate levels of energy from the existing present situation until renewable sources account for the majority of the energy used in our societies.

Fracking

Exploitable reserves of fossil fuels have been increased dramatically due to the possibility of using the so-called unconventional sources that include shale gas and shale oil but also tar sands, extra heavy oil or gas hydrates. Shale gas is a natural gas (predominantly methane) distributed in some types of rocks and that, in some cases, is extracted by the process of hydraulic fracturing or 'fracking'. It involves drilling a deep hole in the dense shale rocks that contain natural gas and then pumping vast quantities of water mixed with sand and chemicals into it at very high pressure. This opens up tiny fissures in the rock, through which the trapped gas can then escape. It bubbles out and is captured in wells that bring it to the surface, where it can be piped off. The effects of its extraction on water pollution and on the emission of methane to the atmosphere have been shown and they have been a matter of concern.

Nevertheless, fracking provides a huge, relatively untapped until recently, source of hydrocarbon fuels that alleviate the scarcity of gas and petroleum products. The use of fracking and other unconventional sources of fossil fuels has meant that the United States is once again exporting these fuels, having been a net importer until fairly recently. The use of shale gas has been discussed in many European countries and a number of reports have been published on this subject; for example, the recent report by the Royal Society and the Royal Academy of Engineering in the United Kingdom where a number of recommendations on their use are proposed ([77]).

Figure 1.2.4: Energy mix 2010–30 (Gas Advocacy Forum scenario)



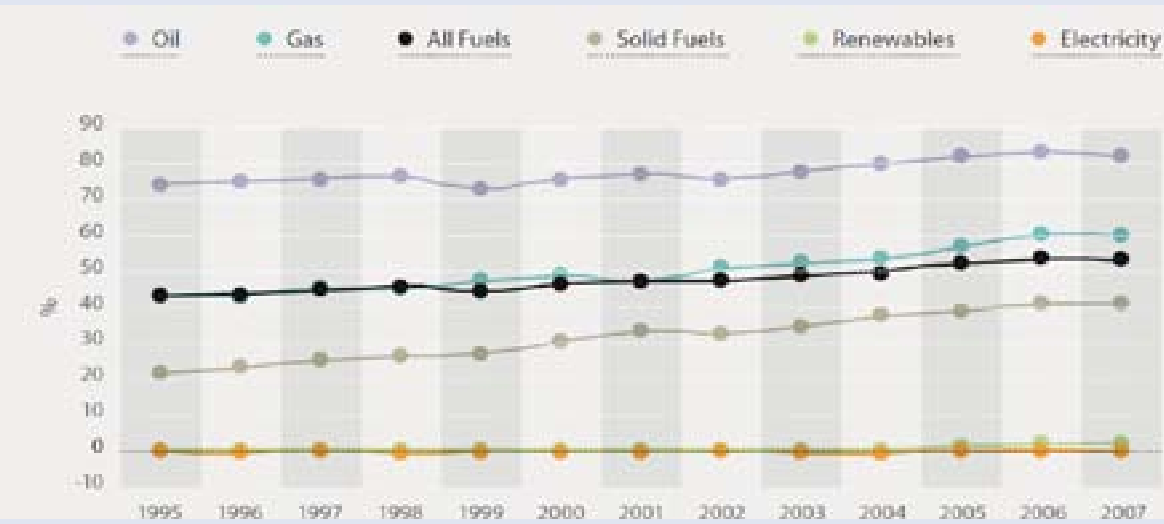
Source: Statoil.

([77]) http://royalsociety.org/policy/projects/shale-gas-extraction/report/

Figure 1.2.5: Imports of energy products

Source: Imports of energy products in different European countries, Eurostat (2008).

Figure 1.2.6: Import dependency



Source: EU-27 — *Import Dependency*, Eurostat (2007).

The energy mix used varies in space and in time. It is not the same in different European countries and it changes with time.

Most European countries import the major part of the energy they use. This creates a significant an important imbalance in the economy of these countries, transfers large amounts of money to energy-rich countries and creates a dependence on countries that may be in politically unstable regions of the world.

1.3 Different sources of energy undergo complex cycles

The energy that we presently use in industry, at home or for transportation has to be transformed from the different sources available, transported to where it is needed and used for many different purposes. In particular, some types of energy may be for **static** uses such as domestic and industrial use or **dynamic** uses such as transportation. The requirements in both cases may be very different, in particular regarding the place where the energy is produced and the manner in which it is distributed. During all these processes, the energy cycle from production to use may need specific investment, may create social problems, risks to populations, and may produce residues that have to be disposed of. All these aspects have to be considered for each type of energy in order to be aware of the effects of using energy from different sources.

Energy production

Hydraulic energy can only be produced where there are strong water currents or a sufficient drop in water level and may need the construction of a dam to control the energy production process. That means that some territory may have to be flooded, resulting in environmental or social effects. Reservoirs usually allow the continuous production of electricity except in periods of serious droughts. They are normally some distance from urban and industrial areas and risks of accidents for populations downstream exist. Some territories may be subject to floods, resulting in environmental or social effects. On the other hand, dams may also prevent flooding.

Windmills are preferentially constructed in places where strong winds exist. They may have environmental or social effects (e.g. visual impact) and are noisy, may interfere with bird migration, and their construction needs specific metal products (which require energy to produce). They are normally some distance from urban or industrial areas and production of electricity depends on the strength of the wind.

Thermosolar and **photovoltaic** panels are preferentially constructed in places with solar irradiation that is, by definition, irregular through the day and night, and seasonally. They may be integrated into buildings or be concentrated in specific places. Photovoltaic panel construction uses scarce metal products.

Biofuels and **biomass** are produced from cultivated plants or algae that have made use of photosynthesis to transform solar energy into chemical energy. This was probably the first source of energy — burning wood. Processing is needed to produce efficient fuels (ethanol or a diesel oil equivalent). Present (first-generation) sources are crops such as maize, sugar cane, rapeseed and soybean that are diverted from food production. Biomass from forest, domestic or industrial waste can also be used. Present biofuel production may compete with food uses and the energy balance may not be clear. These are often called first-generation biofuels. Second-generation biofuels would make use of the transformation of the lignocellulose present in plants into its component sugars and then to ethanol or other liquid fuels. Fuels from **microalgae**, also often called third-generation biofuels, would mimic the original process of petrol production but, at present, the costs and energy balances are still not well established.

Geothermal and **tidal** systems are only possible at very specific places in the world. They may have environmental impacts and they are usually distant from urban or industrial users.

Coal, **petrol** and **gas** have to be obtained from places where they exist in mines or by underground or underwater drilling. Recently, gas and petrol have been obtained in distributed materials such as oil sands and shale gas formations. The extraction procedures may have a strong environmental impact and they have the risk of accidents. All these materials are found in specific regions of the world. Europe has coal reserves, but few reserves of petrol and gas, thus being dependent on imports.

Transport

Many sources of energy are distant from industrial or domestic users and, therefore, the energy has to be transported. Methods of transporting energy include physical transport such as coal, petrol or gas by means of ships or trucks or, in the case of fluid sources, by the use of gas ducts or oleo ducts. Gas can be transported directly to houses or industries. All these systems may have important geopolitical implications and they are prone to accidents.

Electricity is transported making use of metal cables. Electricity networks are presently a key element in the distribution of energy. They have an important visual impact and they may produce accidents in some areas. Distribution of electricity, but also of gas and petrol, gives rise to systems of transport (**energy grids**) that are increasingly important to compensate energy production and demand in different locations.

The grid

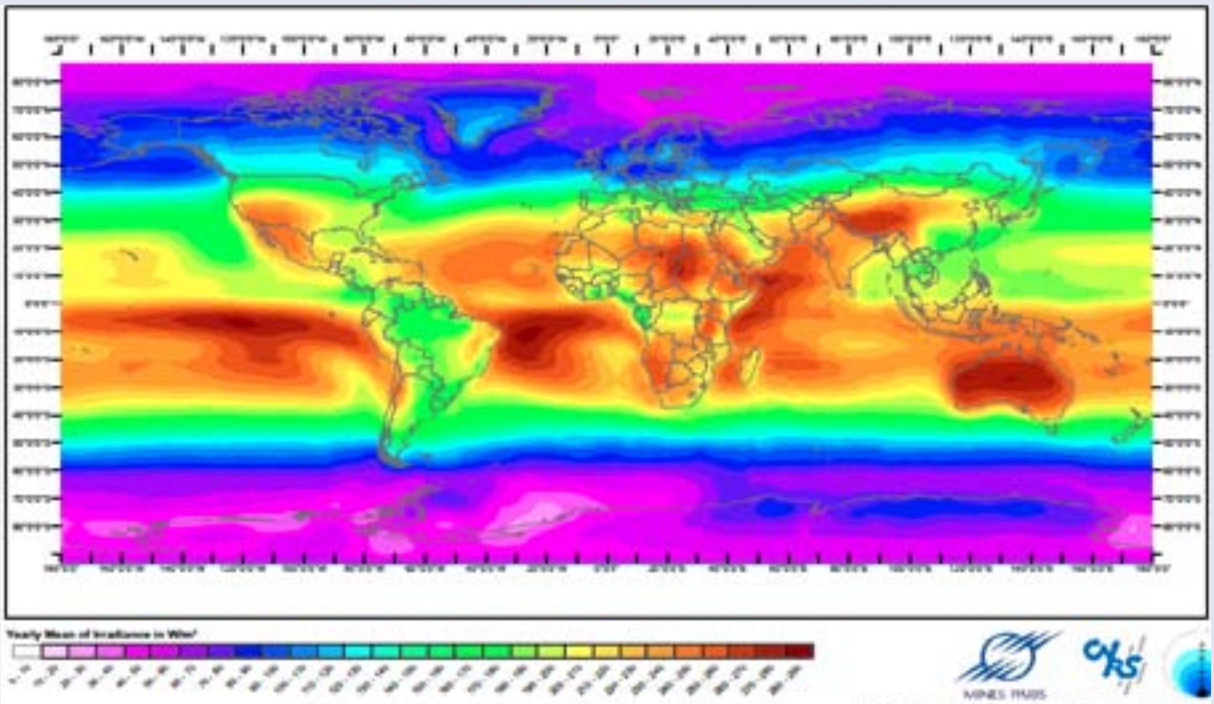
Where once energy was distributed within small communities, as urbanisation has increased, the need to provide energy within large conurbations has become a necessity. Gas and electricity are distributed to commerce, industry and consumers, and national and international grids are being developed to provide both gas and electricity where needed and to even out fluctuations in use. At the moment, electricity is generated by a small number of power stations placed as near as possible to the 'mines' where the fuel is produced (if coal powered). Where, only recently, coal mines were being closed as gas- and oil-powered energy generation were deemed financially and environmentally more effective, coal is once again becoming important. Production of shale gas in the United States means that coal prices are falling, and coal has climbed from about 25 % to 30 % of the global share of primary energy production) ([78]).

The generated electricity is then transported at high voltages to end-users via a distribution network — a grid. The electricity is transformed to lower voltages and distributed to individual businesses and homes via a secondary grid. Gas is distributed via a vast network of pipelines. For example, gas is distributed through nearly 300 000 km of pipes in the United Kingdom. In addition, gas is transported across continents through pipelines that enable its use thousands of kilometres from the drilling sites. There is likely to be a greater reliance on 'smart grids' and 'distributed grids' that cross international boundaries in the future; these grids provide stability to the systems, if designed in an effective manner. The dilemma of an increased demand for energy not being balanced by energy-generation resources requires new ways of addressing energy needs.

Domestic and commercial users are becoming aware of both the cost of energy and the need to save energy effectively. Users could become 'smart clients' producing energy to add to the grid or consuming energy when their own generation capability is less than their needs. In addition, the grids need to cope with an increasing trend towards decentralised generation systems that are volatile producers (e.g. dependent on sunlight or wind) that feed into the energy grids: there is a need to store energy at times of overproduction for use when demand exceeds generation capacity.

A smart grid is an energy distribution system or network that is designed to monitor use and adjust to changing conditions automatically. These new smart grids deliver power by automatically re-routing where necessary, shift-ing loads and managing generation so as to deliver power where and when it is needed. The smart grids enable the development of energy generation systems near to where they are required, and microgeneration is becoming a manageable asset — where consumers generate their own electricity and add it to the grid.

Figure 1.3.1: Averaged solar radiation 1994–2004

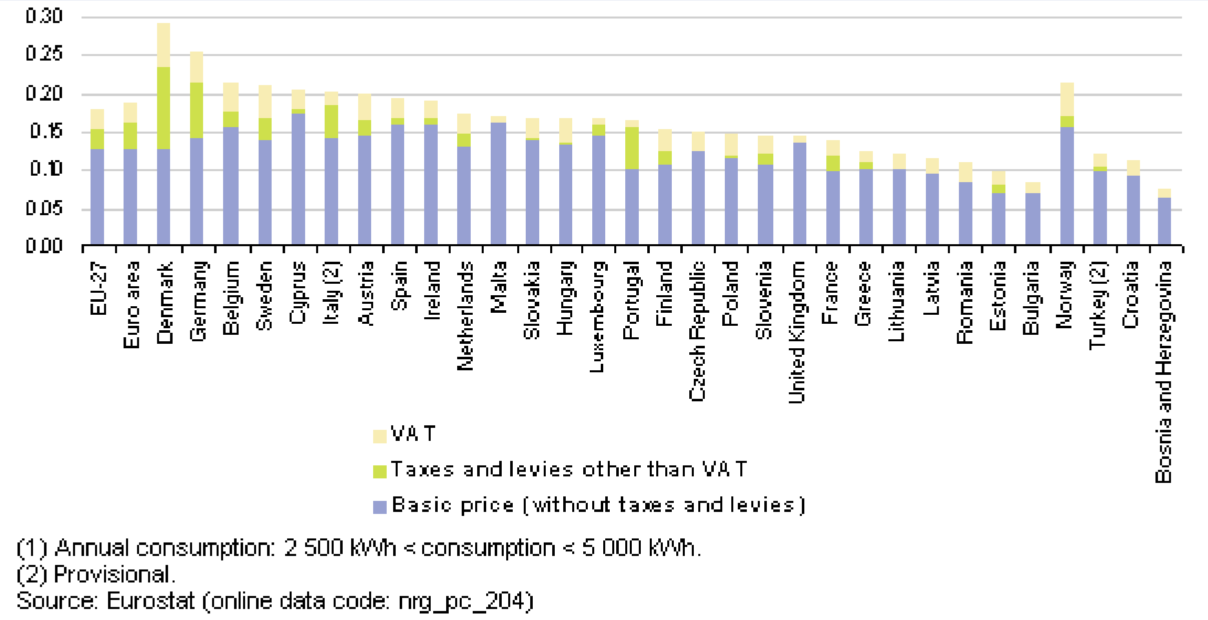


Source: Centre for Energy and Processes, École des Mines de Paris.

([78]) *The Guardian*, 29 October 2012 (http://www.guardian.co.uk/environment/2012/oct/29/coal-threatens-climate-change-targets).

([79]) Eurostat (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Electricity_prices_for_household_consumers,_first_half_2011_(1)_(EUR_per_kWh).png&filetimestamp=20111124164000) (accessed 29 October 2012).

Figure 1.3.2: Electricity prices for household consumers, first half of 2011 (EUR/kWh) ([79])



Source: Eurostat (online data code: nrg_pc_204).

A major problem with electricity generation is that demand fluctuates with time and place. Storing electricity when an excess is generated presents a problem; hence, the usual solution is to attempt to balance demand and generation in real time. New renewable sources, however, make the balancing act impossible and storage becomes essential.

In the case of gas, storage is much easier, although storage capacity and, hence, security of supply create problems.

Electricity production

Electricity production can be **concentrated** in power plants where coal, fuel from petrol or gas, and biomass are burned to produce heat that is then used to produce electricity. The present level of efficiency and safety of electricity production depends on the type of power plants and the fuel used.

Electricity can also be produced in nuclear plants. They constantly produce electricity except when accidents occur or revisions are needed and production is stopped. Specific risks from the escape of radioactivity in accidents have been demonstrated. Accidents in nuclear power plants, in particular those of Chernobyl and Fukushima, have had important impacts on the European perception of the safety of these systems. Thus, the perceived risk of nuclear accidents is a factor that has a major impact in taking decisions on the use of this energy source.

Thermosolar and photovoltaic panels and windmills may be placed in or on buildings or near areas where energy is needed, but have the disadvantage that the energy needs to be stored in some way. Engines and heating from coal, gas or petrol are distributed through specific systems or grids. Biogas can also be used or converted in the proximity of users. All these systems constitute a **distributed** system of energy production that may contribute to the production of energy as a whole if adequate grids are available. In this case, the design of buildings that incorporate not only systems that reduce the use of energy but that also produce energy may be an interesting factor in reducing the transport of energy for urban use.

Residues

An important concern in energy generation is the residues that are produced. They can be separated into various types. Particles and gases are produced by and during fuel combustion. The burning of coal, biomass and some fuels derived from petrol produce **particles** that may have important health effects. It has been shown that this is especially important in primitive types of ovens but also in the case of coal, petrol and diesel engines. Burning coal or petroleum products is a major source of pollution, producing environmental effects such as photochemical smog. In 1306, concerns over air pollution were sufficient for the English King Edward I to (briefly) ban coal fires in London! Efforts during the 20th century efficiently reduced such effects in cities such as London.

The production of energy using traditional fuels results in the emission to the atmosphere of gases such as carbon dioxide, nitrogen oxides and methane, which are the important factors producing *greenhouse* effects and, therefore, actors in **climate change**. Any type of combustion of carbon-containing fuel such as coal, gas, petrol derivatives or biofuels produces carbon dioxide. The correlation of this continued production with the increase in the global temperature has been shown to drive climate change that has unequivocally been shown to have global effects that have become a major environmental concern. For this reason, reduction in carbon dioxide and methane emissions has become a priority. This may be achieved through the use of the so-called **low-carbon** technologies that use low proportions of fossil fuels (including some form of carbon capture). Methods to attempt a reduction of these effects through **carbon dioxide sequestration** are actively being investigated but no system has been shown to be efficient in the reduction of greenhouse gases in the atmosphere.

The main reason for concern at the use of fission for energy production is the long life of the residues and waste materials and, hence, the danger to humans and the environment over an immensely long timescale. The timescale for environmental and human (health) damage from coal or oil is not as obvious, although climate change provides similar problems in terms of length. The production of electricity in nuclear power plants gives rise to **radioactive waste** (i.e. material with high radioactivity) and, importantly, this waste may have a lifetime of thousands of years — and no system exists to recycle it. It must, therefore, be disposed of in controlled sites that have to be maintained 'safe' for a very long time. Even the combustion of coal releases significant amounts of radioactivity into the atmosphere annually.

Efficiency

Energy is defined as the ability to perform work and classical physics has affirmed the **principle of conservation of energy** that states that energy is not created nor destroyed but only transformed. This means that all the processes described here are only processes of transformation of energy from one form to another. The question is: How efficient are these processes of transformation? Some forms of energy are useful to perform the kind of work desired while other ones may be considered wasteful. Electricity production from the chemical energy contained in coal or fuel in power plants has greatly increased in efficiency, measured as the proportion of chemical energy that is finally converted into electrical energy, a part of which will be lost during transport. An example of waste is the heat lost during this process or that which is finally dispersed into the environment.

1.4 EU research

The technologies used for the production, transport, storage and treatment of residues are rapidly evolving and Europe has always been at the forefront of research in these technologies. For this reason, the European Union has always had an important chapter on energy in the funds for R & D ([80]). A summary of these funds follows where the funds attributed to research in fusion energy, atomic energy, and renewable energy are presented. Funds for research in nuclear fusion are especially important because of the ITER programme (originally, International Thermonuclear Experimental Reactor). The ITER programme is the largest world investment that could lead to the construction of a power plant producing electricity from fusion. According to the information provided by the European Commission, the main energy sectors being addressed by the EU in its research programmes are the following.

1.4.1 Research in nuclear fusion

Inside the sun, fusion reactions take place at very high temperatures (around 15 million °C) and under enormous gravitational pressures. At such high

([80]) Data is available online (http://ec.europa.eu/research/energy/eu/research/index_en.htm).

temperatures, gas becomes plasma. Plasma is the fourth state of matter (solid, liquid and gas being the other three) and is best described as an electrically charged gas. In plasma, the negatively charged electrons in the gas atoms are completely split off from the positively charged atomic nuclei (or ions). The sun is a massive fusion power station. It produces around 300 billion billion watts (3×10^{26}) of power, consuming 600 million tonnes of hydrogen fuel every second. The sun burns hydrogen gas — the simplest atomic nucleus consisting of a single proton (a positively charged atomic particle).

Scientists and engineers are working to reproduce fusion on a small scale. However, this is a significant scientific and technical challenge. The earth does not have the gravitational pressure of the sun so plasma must be confined and heated to temperatures 10 times higher than those in the sun in order to get a sufficient number of fusion reactions. Making fusion work on earth requires two heavier types (or isotopes) of hydrogen: deuterium — with a nucleus of one proton and one neutron (an atomic particle with similar mass to the proton but no electrical charge) — and tritium (with one proton and two neutrons). When these two nuclei fuse together, they produce a new helium nucleus (also known as an alpha particle) and a high-energy neutron. In a future fusion power plant, the energy of that neutron will be captured and used to heat steam to generate electricity as in a normal power station, while the electrically charged alpha particle will transfer its energy to the plasma, keeping it hot and maintaining the reaction. The raw fuels for fusion are water and lithium ([81]). The fusion fuels are not radioactive ([82]) and have a low environmental impact ([83]). The neutrons generated by fusion will interact with the materials close to the reactor, but careful choice of these materials should ensure that no long-term legacy of radioactive waste is produced by fusion power.

International Thermonuclear Experimental Reactor

ITER is an international nuclear fusion research and engineering project, which is currently building the world's largest and most advanced experimental tokamak nuclear fusion reactor at the Cadarache facility in the south of France. The ITER fusion reactor itself has been designed to produce 500 MW of output power for 50 MW of input power — 10 times the amount of energy put in. The machine is expected to demonstrate the principle of producing more energy from the fusion process than is used to initiate it, something that has not yet been achieved with previous fusion reactors. Nuclear fusion has many potential attractions. Firstly, its hydrogen isotope fuels are relatively abundant — one of the necessary isotopes, deuterium, can be extracted from seawater, while the other fuel, tritium, could possibly be created using neutrons produced in the fusion reaction itself. Furthermore, a fusion reactor would produce virtually no carbon dioxide or other atmospheric pollutants, and its other waste products would be very short-lived compared to those produced by conventional nuclear reactors.

The ITER reactor is a large-scale scientific experiment that aims to demonstrate that it is possible to produce commercial energy from fusion. The ITER reactor itself is designed to produce approximately 500 MW of fusion power sustained for up to 1 000 seconds (compared to JET's peak of 16 MW for less than a second) by the fusion of about 0.5 g of deuterium/tritium mixture in its approximately 840 m^3 reactor chamber. Although the reactor is expected to produce 10 times more energy (in the form of heat) than the amount consumed to heat the plasma to fusion temperatures, the generated heat will not be used to generate any electricity. During its operational lifetime, the reactor will test key technologies necessary for the next step: the demonstration

([81]) There is around 0.033 g of deuterium in every litre of water. Tritium is not found on earth but can be easily made from lithium — an abundant metal found in the batteries that power mobile phones and laptops. Tritium can be made *in situ* in a fusion reactor by using the neutron released by the fusion reaction. If the neutron is absorbed by a surrounding 'blanket' of lithium, tritium is produced.

([82]) The volume of gas in a fusion reactor will always be low, at around 1 g of fuel in 1 000 m^3. Any problem will always cool the plasma and stop reactions — so a runaway situation is impossible. Furthermore, the raw fuels for the reactor (deuterium and lithium) are not radioactive. Tritium is mildly radioactive but will be produced and used within the reactor. Consequently, no transport of radioactive fuels will be needed for a fusion power plant — and even the worst possible accidents would not require the evacuation of neighbouring populations.

([83]) Fusion power will not create greenhouse gases, produce other harmful pollutants or result in long-lasting radioactive waste. Its fuel consumption will be extremely low. A 1 000 MW electric fusion power station would consume 100 kg of deuterium and 3 tonnes of lithium a year to generate 7 billion kWh of power. To do the same, a coal-fired power station would need 1.5 million tonnes of coal.

fusion power plant that will prove that it is possible to capture fusion energy for commercial use.

1.4.2 Research in nuclear fission

Global energy demand is on the rise and the European Union (EU) is increasingly relying on imports to meet its energy needs [84]. The 151 nuclear reactors operating within the EU [85] provide over 30 % of our electricity needs and avoid the emission of 700 million tonnes of carbon dioxide per year. Having been in use for over 50 years, nuclear energy already forms part of the energy mix in those EU Member States that have decided to use it.

Fission research

For about two decades, civil nuclear power stations in a number of European countries have been responsible for producing approximately one third of all the EU's electricity. Nuclear science and technology has other applications apart from energy production. For example, radiation is used extensively in medical diagnostic and therapeutic practices, such as imaging (e.g. X-rays), cancer radiotherapy or radioactive tracers. All uses of radioactive materials require appropriate safety measures to protect workers and the public [86].

Current Euratom research efforts focus on the safe, long-term management of hazardous radioactive waste, investigating advanced concepts for nuclear reactor technology, optimising the use of uranium resources, and ensuring that all uses of nuclear technology meet high safety and performance standards. The Directorate-General for Research and Innovation's budget for nuclear fission and radiation protection research is EUR 287 million for 2007–11.

1.4.3 Research in non-nuclear energy production

Photovoltaic

Converting the sun's radiation directly into electricity is achieved by solar cells. These cells are made of semiconducting materials similar to those used in computer chips. Solar cells are used in consumer products (such as calculators or watches), mounted on roofs of houses or assembled into large power stations. Today, the majority of photovoltaic modules are used for grid-connected power generation, but a smaller market for off-grid power is growing for remote areas and developing countries.

Fuel Cell and Hydrogen (FCH) energy technologies

Fuel cells, as a conversion technology, and hydrogen, as a clean energy carrier, have great potential to contribute to addressing the energy challenges facing Europe. The use of hydrogen as an energy carrier requires developing the entire supply chain, from carbon-lean hydrogen production to efficient conversion of the hydrogen with fuel cells to power end-use applications. Hydrogen can be produced in many different ways, using a wide range of technologies. Currently, hydrogen is a widely used industrial gas. However, its use in energy applications is still in its early stages. Today, hydrogen production is mostly on a large scale. Hydrogen can be burned either to provide heat, or to drive turbines, or in internal combustion engines for motive and electrical power [87]. Whilst the production

(84) In 2007, dependence on imported energy in the EU amounted to 53 %; if the current trend continues, by 2030, energy dependence will have grown to 67 %. By the same year, carbon dioxide emissions are forecast to exceed the 1990 limits set by the Kyoto Protocol by 5.4 %.

(85) At the EU level, a wide range of nuclear-related activities such as health protection, safeguarding against proliferation of nuclear weapons, supply of nuclear fuel and nuclear research fall under the scope of the Treaty Establishing the European Atomic Energy Community (Euratom), one of the original Treaties of Rome in 1957 and signed by all EU Member States. Nuclear research is funded by the European Commission through multiannual Euratom framework programmes, run in parallel with the much larger framework programmes under the EC Treaty.

(86) Key thematic areas of interest include safe long-term management of radioactive waste (including disposal as well as technologies to reduce and recycle hazardous material), nuclear installation safety, the design of more efficient and sustainable nuclear reactors, and the risks of low and protracted exposure to ionising radiation. Key cross-cutting areas include research infrastructures and education and training. Most funding is shared cost, with partners in supported projects providing matching financing.

(87) A number of hydrogen-fuelled passenger cars and buses are already in circulation, but increasing their number to a commercial scale requires lowering the price through technological development and mass-market production processes. Commercialisation also depends largely on the development of infrastructure for the production, storage, and distribution of hydrogen and special refuelling stations. Currently, only a small number of hydrogen refuelling stations exist worldwide, and refuelling station costs need to be reduced to make them commercially viable.

of hydrogen requires energy, it is a transportable fuel if the fire risk can be minimised.

Fuel cells offer a significant advantage over traditional combustion-based thermal energy conversion in that they provide efficiencies of electrical power supply in the range of 35 % to 55 %, whilst causing very low levels of pollutant emission. They offer advantages of weight compared with batteries, and instantaneous refuelling, similar to combustion engines ([88]).

Concentrated solar power

Concentrated Solar Power (CSP) is a technology which produces electricity by concentrating solar energy on a single focal point. This concentrated energy is then used to heat up a fluid, produce steam and activate turbines that produce electricity. The focusing of solar power can be achieved through a variety of techniques such as parabolic troughs, parabolic dishes or power tower systems. CSP can also provide combined heat and power, particularly in desalinisation plants. The exploitation of solar energy differs substantially depending on sunlight conditions. Increasing the deployment of CSP technologies will require the removal of technical barriers. Improvements are needed in order to increase the grid flexibility and enhance the storage technologies. Moreover, the fact that sunshine is intermittent poses a challenge in terms of efficient storage of surplus of energy. Thermal storage and hybrid operation (using biomass or fossil fuel as an alternative heat source) need to be further explored and improved. In the same way, further research into new applications, including water desalination and hydrogen production, needs to be continued and strengthened. Additional aspects to be addressed are land use, and landscape transformation, materials consumption and conversion efficiency.

Wind energy

Wind energy is one of the fastest-growing energy sources. Since 2000, around one third of all installed electricity generating capacity in the EU has been wind power ([89]). Onshore, wind energy is a near-mature technology. The main technological development in recent years has been a trend towards ever-larger wind turbines. Since the first commercial wind turbines of the 1980s, their size has evolved from 0.022 MW to about 6 MW today. By 2030, average turbine sizes of 2 MW (onshore) and 10 MW (offshore) are expected, with gigawatt-size wind farms likely for offshore. For the time being, wind energy from offshore contributes only a very small share to Europe's total wind energy generation. This is expected to change in the coming decades since wind conditions are more preferable offshore and many well-placed onshore sites will be already in use. However, there are still important problems to be solved before offshore wind can be massively deployed ([90]). The actual contribution of wind energy to total electricity generation in 2007 was roughly 119 TWh (including 4 TWh offshore) which corresponds to around 3.7 % of total EU electricity demand (as wind is an intermittent energy source, only part of its capacity can actually be used). More than two thirds of total EU wind capacity is currently installed in the three pioneering countries — Denmark, Germany and Spain. Denmark satisfies more than 20 % and Spain more than 10 % of its electricity demand by wind energy.

Increasing wind deployment needs to be accompanied by increased grid flexibility and developments in storage technologies. Increasing shares of wind energy will require a new grid philosophy and flexible, robust transmission and distribution grid infrastructures. Given that wind is an unpredictable and fluctuating energy source, the further development of energy storage mechanisms is another key prerequisite for large-scale wind deployment. In addition, wind technology needs

([88]) Electrochemical energy conversion involves complex developments of materials: due to the close link between electricity flow and corrosion processes, morphological changes, building of resistive layers and exhaustion of catalytically active components, material development for enhanced lifetimes becomes the major challenge in fuel cell basic research and development.

([89]) The share of wind power in total electricity production in Europe was 3.7 % in 2007, but with huge differences among the Member States: Germany and Spain together account for more than half of the total installed capacity in Europe. In Denmark, wind energy contributes more than 20 % of the total electricity production of the country. The wind power industry has the ambition to continue the fast growth of recent years. The sector's objective is to provide 20 % of final EU electricity consumption by 2020.

([90]) The most challenging areas are turbine design, load management, the grid integration and better storage capacities. Wind power capacity witnessed a tremendous growth in recent years and reached a capacity of 56 GW (of which 1.08 GW are offshore) in 2007 which corresponds to 7.3 % of total capacity in the EU (data from the European Wind Energy Association (EWEA)). More than 40 % of new electricity-generating capacity added in 2007 was wind energy!

to be tested at an appropriate (large) scale and under relevant climatic conditions.

Bioenergy and biofuels

Bioenergy is the conversion of biomass resources such as agricultural and forest residues, organic municipal waste and energy crops into useful energy carriers including heat, electricity and transport fuels. For thousands of years, firewood was the traditional source of heat for domestic purposes — local heating and food preparation — and this is still the case in many parts of the world. Today, the availability of biomass-derived solid fuels in clean and convenient forms (e.g. chips, pellets and briquettes) and modern combustion equipment have created renewed interest in the use of solid biofuels for domestic heating. For the commercial and industrial sectors, currently available equipment allows the efficient production of heat from biofuels on a larger scale.

Biofuels have been discussed because, in some cases, the balance of energy production (the energy obtained compared to the input of energy needed for the production) is negative in some cases and because the use of plants that are also used for food may introduce a competing use that has an effect on food prices. First-generation biofuels make use of starch and lipids to produce ethanol and biodiesel. Second-generation biofuels will make use of lignocellulose, which is more abundant and can be obtained from different types of crops. A third generation of biofuels may be obtained from microalgae.

Biomass, in addition to being convertible into energy carriers, can also be converted into biomaterials and biochemicals. The simultaneous production of bioenergy, biomaterials and biochemicals takes place in bio-refineries. In a bio-refinery, analogous to a petroleum refinery, biomass feedstocks are converted into energy, fuels or other products using a range of thermochemical and biochemical processes. Some of these techniques are already at a stage of commercial development while others require further research and technological development ([91]).

([91]) The total annual demand for biomass has increased steadily over recent years and currently accounts for over 10 % of global primary energy consumption. Approximately two thirds of this biomass is consumed in developing countries as traditional, non-commercial biomass for domestic cooking and heating.

Geothermal energy

For close to 100 years, geothermal energy has also been used for electricity generation. Today, so-called Enhanced Geothermal Systems (EGS, also known as Hot Dry Rock) enable the exploitation of the earth's heat to produce electricity without having natural water resources. To extract energy from hot impermeable rock, water is injected from the surface into boreholes in order to widen them and create fractures in the hot rock. Flowing through these holes, the water heats up and, when it returns to the surface, is used to generate electricity. Clean, renewable, constant and available worldwide, geothermal energy is already being used in a large number of thermal and electric power plants.

Ocean energy

Oceans are an enormous source of energy. It is estimated that 0.1 % of the energy in ocean waves could be capable of supplying the entire world's energy requirements five times over. Currently, a number of technologies aimed at harnessing this potential have been investigated and are at various stages of development including tidal and marine energy, wave energy, differences in temperature and salinity energy. Conversion of tidal energy into electricity has been widely investigated and can be compared to the technology used in hydroelectric power plants. Electricity could be generated by water flowing in to and out of gates and turbines installed along a dam or barrage built across a tidal bay or estuary. Technologies for exploiting wave and currents energy have been, or are being, developed and tested on a small scale and, for a limited number of cases, on a large scale. Technologies related to differences in temperature or salinity are at an early stage of development. With Ocean Thermal Energy Conversion (OTEC), the difference in temperature between cold, deep-sea waters and warm, shallow waters creates a thermodynamic cycle, which can be used to produce electricity. In the case of salinity gradients, the difference in salinity between seawater and fresh water creates a pressure difference that can be exploited to extract energy. Today, ocean energy provides around 0.02 % of the EU's energy needs and is primarily used for electricity production.

Hydropower

Hydropower is an extremely flexible technology for power generation. Hydro reservoirs provide built-in energy storage, and the fast response time of hydropower enables it to be used to optimise electricity production across grids, meeting sudden fluctuations in demands. Despite being a mature technology in comparison with other renewable energy sources, hydropower still has a significant potential [92].

In 2006, hydropower accounted for approximately 80 % of electricity generated from renewable sources in Europe, and 10 % of total electricity consumption in Europe. Electricity generation from small hydropower systems made up about 3 % of the total electricity generation in Europe. Like other energy technologies, hydropower technologies need to improve efficiencies, reduce costs and environmental impacts and improve dependability. In general, large hydroelectric plants have little difficulty in competing with conventional generation, but small hydro, especially the very small and the low-head plants, can normally only compete where allowances are made for the external costs associated with fossil fuels and nuclear power.

Clean coal technologies and carbon capture and storage

Technological progress in recent years has created a remarkable new opportunity for coal. A new generation of coal-fired power plants is emerging with higher efficiencies and, thus, lower emissions. In parallel, a suite of technologies is being developed for the safe capture and storage of carbon dioxide (CCS) from fossil fuel conversion processes [93].

The main fossil fuel-based electricity generation technology in the EU is pulverised coal. A typical state-of-the-art supercritical pulverised coal plant operates at 45 % efficiency, while few, more advanced, coal power plants demonstrate efficiencies up to 48 %. Other technologies, such as Integrated Gasification in Combined Cycle (IGCC) and circulating fluidised bed combustion could be commercialised during the same period, with efficiencies reaching 45–55 %. Zero emission fossil fuel power plants (ZEP plants) make the assumption that they will capture at least 85 % of the carbon dioxide formed during the power generation process [94]. The first generation of commercialised pulverised coal, combined cycle gas turbine and IGCC plants with carbon dioxide capture are expected to have efficiencies of 33 %, 48 % and 35 % respectively.

Currently, fossil fuel power plants are the backbone of the European electricity generation system, providing 56 % of the total electricity demand, followed by nuclear energy (31 %) and renewables (13 %). In the EU, coal plants have a 29 % share in electricity generation and natural gas combined cycle plants, 19 %.

Smart grids

The upgrade and development of energy networks across the EU is one of the key challenges to securing a sustainable and competitive energy future in the EU. Today's energy networks are primarily based on large central power stations with one-way power flow from the network to the passive consumer. In the future, energy networks need to become 'smarter'. Smart energy networks will be more resilient and able to avoid blackouts. They will allow significant savings in energy with better interconnections, and enable an active role for consumers. In addition, smart energy networks will increase the use of renewable energy resources by better integrating them. The re-engineering process from current networks to smart energy networks encompasses a complex range of issues covering market design, organisational, regulatory and technical issues.

Materials and future and emerging technologies

Materials research is probably a necessary element in the development of the technologies needed to provide a clean, reliable supply of efficient energy. The aim is to push the limits of the future emerging

(92) New plants can be developed and old ones upgraded, especially in terms of increasing efficiency and electricity production as well as environmental performance. In particular, the development of low-head or very low-head small hydro plants holds much promise.

(93) The challenge is to bring these technologies together into a new concept for future coal-based near-zero emission power production. Carbon Capture and Storage (CCS) is a technology which would allow capturing and storing the carbon dioxide emitted by the large fossil fuel power plants, which are mostly fired with coal, lignite or natural gas. CCS could play an important role in a transition phase towards a decarbonised economy, and as such offers a unique opportunity in the medium term.

(94) The carbon dioxide that will be captured is to be transported to suitable underground locations where it will be stored permanently and safely. Currently, all elements of the technology of ZEP plants have been developed and utilised by other industrial sectors; however, on much smaller scales than those needed for electricity generation. Capture technology (pre- and post-combustion and oxyfuel) is at an advanced stage. From the technology point of view, ZEP plants can be commercialised as of 2020, with first-of-a-kind plants coming into operation by 2015.

technologies, at the same time encouraging the materials community to work together and share their findings.

Energy storage

Much of the energy produced through renewable technologies depends on the vagaries of weather and climatic conditions — for example, wind power depends on strength of wind, solar at least partially on the absence of clouds, and wave power on the tides. In addition, electrical energy for transport needs to be stored in some form. The demand for energy varies as well, depending on external temperatures, and even on the timing of commercial breaks in television programmes. Storage is useful in 'load-levelling', where electricity is stored during periods of low demand and released when there is high demand. During the passage of the Storage Act (2011) in the United States, the chair of the Senate Committee stated:[95]

> *Deployment of storage technologies will make our nation's electricity grid more reliable while also enabling more efficient use of existing energy sources as well as new ones, such as wind and solar ... These technologies have the potential to cut electricity bills, reduce peak power demand and lower greenhouse gas emissions ([95]).*

An important report into storage issues was published in March 2012 by the Congressional Research Services in the United States: *Energy Storage for Power Grids and Electric Transportation: A Technology Assessment* ([96]).

([95]) Office of Senator Ron Wyden, 'Wyden, Collins, Bingaman Legislation Will Increase Investments in the Storage of Renewable Energy', press release, 10 November 2011.

([96]) http://www.fas.org/sgp/crs/misc/R42455.pdf

2. Regulatory and policy frameworks for energy and environment

The topics of energy and environment have become so important that an extensive and diversified number of rules of different nature and comprehensiveness (hard or soft law, binding regulations, strategy plans, roadmaps, etc.) have been developed. At the same time, the development of 'law' addresses a range of areas of EU jurisdiction — environment, common market, movement of capital, services and persons, competition, foreign policy, etc. It is neither possible, nor necessary, to address them all in detail. We, therefore, address the regulations deemed most relevant, having regard to the most recent energy policy options adopted in the EU as well as the fundamental legislation (the Lisbon Treaty).

2.1 The European Coal and Steel Community and the Treaty Establishing the European Atomic Energy Community

The establishment of the **European Coal and Steel Community** (ECSC), which came into being in July 1952, was the first great achievement of the supranational Europe following the Second World War. For the first time, the six Member States of this organisation surrendered part of their national sovereignty, albeit in a limited field. While it might have been feared that the effort undertaken by the ECSC would not bear fruit, the Messina Conference of June 1955 attempted to relaunch the European process. The Conference was followed by a series of other meetings of ministers and experts. A preparatory committee was set up at the beginning of 1956 with the task of preparing a report on the creation of a European Common Market. In April 1956, the committee proposed a set of two projects that corresponded to the two options chosen by the States:

1. the creation of a generalised common market;

2. the creation of an atomic energy community.

These 'Treaties of Rome' were signed in Rome in March 1957. The first treaty established a European Economic Community (EEC) and the second established a European Atomic Energy Community, better known as Euratom. Following unproblematic ratification in the various countries, the two treaties entered into force on 1 January 1958.

The main objective of the Euratom Treaty was to tackle the general shortage of 'conventional' energy in the 1950s: the six founding States (Belgium, Germany, France, Italy, Luxembourg and the Netherlands) looked to nuclear energy as a means of achieving energy independence. Since the costs of investing in nuclear energy could not be met by individual States, the founding States joined together to form Euratom. The general objective of the Treaty is, therefore, to contribute to the formation and development of Europe's nuclear industries, so that all the Member States can benefit from the development of atomic energy, and to ensure security of supply. At the same time, the Treaty guarantees high safety standards for the public and prevents nuclear materials intended principally for civilian use from being diverted to military use. It is important to note that Euratom's powers are limited to peaceful civil uses of nuclear energy.

Although the Euratom Treaty does not give the Community strict, exclusive powers in certain fields, it retains real added value for its members: on the basis of this Treaty, the Commission has adopted recommendations and decisions which, although not binding, set European standards. In addition, other Community policies, for example the environment and research policies, have also had a marked impact on the nuclear industry.

Over the years, other nuclear energy issues have grown in importance ([97]), notably operational safety of nuclear facilities, storage of radioactive waste, and nuclear non-proliferation (nuclear safeguards). Although the Member States retain most powers in these fields, a degree of uniformity has been achieved at international level with the aid of a series of treaties, conventions and initiatives which, one by one, have pieced together an

([97]) The value added by Euratom and the EU can be seen particularly clearly in the context of enlargement. As a result of Euratom, the EU pursues a harmonised Community approach to nuclear energy with which candidate countries must comply. The enlargements of the EU to the east put the spotlight on the nuclear sector, and particularly nuclear safety issues. Nuclear power is an important energy source for many eastern European countries (candidates or new members of the EU). However, the safety standards in their nuclear power plants and the level of protection of the public and workers are not always sufficient. In this context, the Commission has provided them with support to improve the situation via the PHARE programme. Since the collapse of the Soviet Union, many of the newly independent States (NIS) are facing the same problems and they too receive aid from the Commission.

international regulatory framework governing activities in the nuclear sector (the Convention on Nuclear Safety). The Treaty amending the EU and EC Treaties, which was signed in December 2007, changed certain provisions of the Euratom Treaty via its Protocol No 12 amending the Treaty establishing the European Atomic Energy Community. These changes are limited to adaptations taking account of the new rules established by the amending Treaty, particularly in the institutional and financial fields ([98]). In March 2007, the Commission reviewed and assessed the outlook for the Euratom Treaty ([99]).

2.2 The Treaty of Lisbon and the Treaty on the Functioning of the European Union

The Treaty of Lisbon entered into force on 1 December 2009 and amends the EU main treaties, the Treaty on European Union (TEU) and the Treaty establishing the European Community (TEC), now called the Treaty of Functioning of the European Union (TFEU). Among other things, for the first time, the Treaty defines the different categories of the EU's competences as being exclusive, shared and supporting ([93]). Articles 2 to 6 TFEU list the respective areas for each type. In relation to the policies where the Community already had competences, the Treaty only provides codification. For example, it codifies the EU environmental competence, which remains a shared responsibility ([100]).

2.2.1 Energy policy and the Treaty

The Treaty introduces a chapter on energy (Chapter XXI, Article 194) in the TFEU setting up the policy framework of the EU energy policy establishing four objectives guiding its development. This new Article 194 reveals the importance of energy as one of the main priorities of the EU stating that:

> *In the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy shall aim, in a spirit of* ***solidarity*** *between Member States, to: (a) ensure the functioning of the energy market; (b) ensure* ***security*** *of energy supply in the Union; (c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and (d) promote the interconnection of energy networks.*

Solidarity

Solidarity is the base for the implementation of the established policies. This spirit of solidarity is found in the measures that the Council, on a proposal from the Commission may take when 'appropriate to the economic situation, in particular if severe difficulties arise in the supply of certain products, notably in the area of energy', as established in Article 122(1) TFEU ([101]). And, although the 'solidarity clause' among the Union and the Member States is also present in Article 222 TFEU in the event of natural or man-made disasters, it is not, however, defined for energy policies purposes what the spirit of solidarity will imply.

Shared competence and autonomy of the Member States

Energy is a sphere of shared competence with the Member States and the Commission. In fact, the autonomy of Member States in certain matters of decisions on energy issues is now underlined in the specific provision on energy of Article 194(2) ([102]). Decisions on

([98]) Unlike the EC Treaty, no major changes have ever been made to the Euratom Treaty, which remains in force. The European Atomic Energy Community has not merged with the European Union and, therefore, retains a separate legal personality, while sharing the same institutions.

([99]) http://europa.eu/legislation_summaries/institutional_affairs/treaties/treaties_euratom_en.htm

([100]) http://www.clientearth.org/reports/clientearth-briefing-lisbon-treaty-impact-on-climate-and-energy-policy.pdf

([101]) Article 122(1) TFEU states: Without prejudice to any other procedures provided for in the Treaties, the Council, on a proposal from the Commission, may decide, in a spirit of solidarity between Member States, upon the measures appropriate to the economic situation, in particular if severe difficulties arise in the supply of certain products, notably in the area of energy.

([102]) Article 194(2): Without prejudice to the application of other provisions of the Treaties, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the measures necessary to achieve the objectives in paragraph 1. Such measures shall be adopted after consultation of the Economic and Social Committee and the Committee of the Regions. Such measures shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply, without prejudice to Article 192(2)(c) (http://www.lisbon-treaty.org/wcm/the-lisbon-treaty/treaty-on-the-functioning-of-the-european-union-and-comments/part-3-union-policies-and-internal-actions/title-xxi-energy/485-article-194.html).

energy should be taken within the normal procedures of the legislative procedure in order to 'establish the measures necessary to achieve the objectives in paragraph 1' (ensure the functioning of the energy market; ensure security of energy supply in the Union; promote energy efficiency and energy saving and the development of new and renewable forms of energy; and promote the interconnection of energy networks). Member States are competent to determine their national energy policies in regard to the right to determine the conditions for exploiting the national energy resources, their choice between different energy sources and the general structure of their energy supply ([103]). EU measures based on the energy provisions of the TFEU will not be possible if they affect a Member State's right to determine the conditions for exploiting its energy resources. However, the EU measure could be based on Article 192(1) of the environmental policy title and, therefore, could be adopted by ordinary legislative procedure (ex codecision) even if it affects Member States' rights to determine the conditions for exploiting their own energy resources.

Member States' competence could, in some circumstances, also be limited by unanimous decisions of the Council after consultation with the European Parliament and the Economic and Social Committee of the Regions on measures significantly affecting a Member State's choice between different energy sources and the general structure of its energy supply (Article 192(2)(c) TFEU) ([104]).

This new legal basis introduced in the Treaty allowing the EU to establish measures related to energy policy and the responsibility of the Member States for national energy sources is a balance to be achieved revealing the complex environment of the application of energy policies. Moreover, those decisions remain a responsibility of the Member States, which means that decisions may vary from country to country, sometimes affecting many other countries apart from the one where those national decisions have been taken.

([103]) The above rules may change when energy policy options refer to environmental provision (under environmental legal bases, most measures dealing with energy issues from an environmental/climate change perspective can be adopted, either by codecision under Article 192(1) TFEU or by special legislative procedure (unanimity of the Council) under Article 192(2) TFEU). Therefore, measures at EU level affecting Member States' choice between energy sources or the structure of the energy supply could not be adopted if its legal basis is the energy provision of the TFEU but could be adopted by the ordinary legislative procedure (ex codecision) under Article 192(1) of the environmental policy provisions. The same applies to EU measures significantly affecting Member States' choice between energy sources or the structure of their energy supply which could be adopted (by unanimity) at EU level if based on the Article 192(2) TFEU under the environment title (http://www.clientearth.org/reports/clientearth-briefing-lisbon-treaty-impact-on-climate-and-energy-policy.pdf).

([104]) Article 192 TFEU states:
1. The European Parliament and the Council, acting in accordance with the ordinary legislative procedure and after consulting the Economic and Social Committee and the Committee of the Regions, shall decide what action is to be taken by the Union in order to achieve the objectives referred to in Article 191.
2. By way of derogation from the decision-making procedure provided for in paragraph 1 and without prejudice to Article 114, the Council acting unanimously in accordance with a special legislative procedure and after consulting the European Parliament, the Economic and Social Committee and the Committee of the Regions, shall adopt: (a) provisions primarily of a fiscal nature; (b) measures affecting: — town and country planning, — quantitative management of water resources or affecting, directly or indirectly, the availability of those resources, — land use, with the exception of waste management; (c) measures significantly affecting a Member State's choice between different energy sources and the general structure of its energy supply. The Council, acting unanimously on a proposal from the Commission and after consulting the European Parliament, the Economic and Social Committee and the Committee of the Regions, may make the ordinary legislative procedure applicable to the matters referred to in the first subparagraph.
3. General action programmes setting out priority objectives to be attained shall be adopted by the European Parliament and the Council, acting in accordance with the ordinary legislative procedure and after consulting the Economic and Social Committee and the Committee of the Regions. The measures necessary for the implementation of these programmes shall be adopted under the terms of paragraph 1 or 2, as the case may be.
4. Without prejudice to certain measures adopted by the Union, the Member States shall finance and implement the environment policy.
5. Without prejudice to the principle that the polluter should pay, if a measure based on the provisions of paragraph 1 involves costs deemed disproportionate for the public authorities of a Member State, such measure shall lay down appropriate provisions in the form of: — temporary derogations, and/or — financial support from the Cohesion Fund set up pursuant to Article 177.

The Member States have the right to conduct their bilateral energy relations with non-EU countries but they are also subject to general obligations of cooperation and competition within the EU. This is also important in view of the trans-European networks in the areas of energy structures and the special consideration due to the aim of promoting the interconnection and interoperability of national networks as well as the access to such networks and, in particular, of the need to link island, landlocked and peripheral regions with the central regions of the Union, as stated in Article 170 TFEU ([105]).

In the same line regarding the competences of each Member State, it is underlined that the principle of neutrality in the system of property ownership in the Member States ([106]) established in Article 345 TFEU, which, in the context of energy, assumes a particular importance.

Although the Treaty has not previously established an EU competence on energy, the EU has been developing energy policies through its competences with regard to the environment, competition and internal market policies which have contributed in shaping the energy sector. With the establishment of the legal basis in Article 194, the connection with those policies and legislations continues to be essential. Those provisions contribute to understanding the complexity of the legal structure and the need of interpretation in view of the competences established and the policies to implement ([107]).

([105]) Article 170 TFEU states:
1. To help achieve the objectives referred to in Articles 26 and 174 and to enable citizens of the Union, economic operators and regional and local communities to derive full benefit from the setting-up of an area without internal frontiers, the Union shall contribute to the establishment and development of trans-European networks in the areas of transport, telecommunications and energy infrastructures.
2. Within the framework of a system of open and competitive markets, action by the Union shall aim at promoting the interconnection and interoperability of national networks as well as access to such networks. It shall take account in particular of the need to link island, landlocked and peripheral regions with the central regions of the Union.

([106]) Article 345 TFEU: The Treaties shall in no way prejudice the rules in Member States governing the system of property ownership.

([107]) The question of how to determine the legal basis for specific legislation is based on the European Court of Justice jurisprudence which states that the choice of legal basis must be informed by the stated objectives and the content of the measure. Where a measure has more than one objective and they are of similar importance, it must be based on the various provisions unless there is a clear incompatibility in the decision-making procedures (e.g. Case C-300/89, *Commission* v *Council* (1991) ECR I-287, para.10; Case C-300/89 *Commission* v *Council* (1991) ECR I-2867, paras 17–21; and Case C-388/01 *Commission* v *Council* (2004) ECR I-4829, para. 58).

The following table provides some examples of EU common standards in the energy fields.

Energy package	Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the **internal market in electricity** Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the **internal market in natural gas** and repealing Directive 2003/55/EC
European Energy Label	Council Directive 92/75/EEC of 22 September 1992 on the indication by **labelling** and standard product information of the consumption of energy and other resources of household appliances Commission Directive 98/11/EC of 27 January implementing Council Directive 92/75/EEC with regard to **energy labelling** of household lamps Regulation (EC) No 106/2008 of the European Parliament and of the Council of 15 January 2008 on a Community **energy-efficiency labelling** programme for office equipment Commission Directive 2003/66/EC of 3 July 2003 amending Directive 94/2/EC implementing Council Directive 92/75/EEC with regard to energy labelling of household **electric refrigerators, freezers and their combinations** Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by **labelling and standard product information** of the consumption of energy and other resources by energy-related products
Energy networks	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *Energy Infrastructure priorities for 2020 and beyond — A Blueprint for an integrated European energy network*, COM(2010) 677 final of 17 November 2010 Regulation (EC) No 1775/2005 of the European Parliament and of the Council of 28 September 2005 on conditions for access to the **natural gas transmission networks**
Energy efficiency/ renewables	Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of **electricity supply and infrastructure investment** Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *Energy 2020 — A strategy for competitive, sustainable and secure energy*, COM(2010) 639 final of 10 November 2010 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC Commission Decision of 30 June 2009 establishing a template for **National Renewable Energy Action Plans** under Directive 2009/28/EC, C(2009)5174-1 Green Paper *A European Strategy for Sustainable, Competitive and Secure Energy*, COM(2006) 105 final of 8 March 2006 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *20 20 by 2020 — Europe's climate change opportunity*, COM(2008) 30 final of 23 January 2008 Commission Decision 2007/74/EC of 21 December 2006 establishing harmonised **efficiency reference values** for separate production of electricity and heat in application of Directive 2004/8/EC of the European Parliament and of the Council Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of **cogeneration** based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of **ecodesign** requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 95/57/EC and 2000/55/EC of the European Parliament and of the Council Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on the **energy end-use efficiency** and energy services and repealing Council Directive 93/76/EEC
Energy efficiency in buildings	Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of **buildings** Directive 2010/13/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of **buildings**
Fossil fuels	Council Directive 2006/67/EC of 24 July 2006 imposing an obligation on Member States to maintain **minimum stocks** of crude oil and/or petroleum products Directive 2003/55/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in **natural gas** and repealing Directive 98/30/EC Council Directive 2004/67/EC of 26 April 2004 concerning measures to safeguard security of **natural gas supply** Council Regulation (EC) No 405/2003 of 27 February 2003 concerning Community monitoring of imports of **hard coal** originating in third countries
Competition	Regulation (EC) No 1228/2003 of the European Parliament and of the Council of 26 June 2003 on conditions for access to the network for cross-border exchanges in **electricity** Report from the Commission to the Council and the European Parliament Progress in creating the internal **gas and electricity market**, COM(2008) 192 final of 15 April 2008

2.2.2 Energy and environmental policy in the Treaty

Article 191 TFEU ([108]) refers to the objectives of the EU environmental policy, the principles to be taken into account in the definition and application of such policies, implementing what is stated on the Charter of Fundamental Rights of the European Union (Article 37 on environmental protection) ([109]).

Those principles, together with the requirement in Article 194(1) (Energy Chapter), regarding the 'need to preserve and improve the environment' and those of Article 11 TFEU ([110]), can lead to the conclusion that the principles mentioned in the chapter on the environment should be taken in consideration in the energy legislation. In fact, the **integration principle**, stated in Article 11 applied to the environment protection has, as its consequence, the integration of environmental protection requirements into the definition and implementation of Union policies and activities, in particular with a view to promoting sustainable development. Consequently, principles applicable primarily to the environment, such as the sustainable development principle or the precautionary principle, may be envisaged as also being applicable to energy policies.

Member Sates' autonomy is one of the most relevant characteristics of energy policies. Shared competence may be one of the most challenging tasks in EU policies in the present and coming years. The fragmentation of law is also verified not only at different levels but for different sectors: energy, environment, climate, competition, etc., and has, for sure, transnational dimensions. A decision taken in one country or in several countries may have consequences in a global dimension.

2.3 EU energy policy

In order to develop and monitor the legal framework established in the Treaty, the EU has developed an energy policy and plans including strategies, action plans, roadmaps, papers and reports whose policies must be implemented through legal documents either binding or indicative, such as directives or national plans, reporting obligations, etc. Key objectives and milestones are provided in the following main policy documents:

- ERA framework
- SET-Plan
- Energy 20-20-20 strategy
- Energy Roadmap 2050

2.3.1 European Research Area framework

The Treaty states that research policy is a shared competence between Member States and the Union. Article 179 TFEU lays down the right of the Union to create the necessary conditions for realising the European Research Area. Article 182(5) TFEU provides for the use of the legislative procedure to establish the necessary measures for the implementation of the European Research Area (ERA). The completion of the ERA does not call into question the sovereignty of the Member

([108]) Article 191 TFEU states:
1. Union policy on the environment shall contribute to pursuit of the following objectives: — preserving, protecting and improving the quality of the environment,— protecting human health, — prudent and rational utilisation of natural resources, — promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change.
2. Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay. In this context, harmonisation measures answering environmental protection requirements shall include, where appropriate, a safeguard clause allowing Member States to take provisional measures, for non-economic environmental reasons, subject to a procedure of inspection by the Union.
3. In preparing its policy on the environment, the Union shall take account of: — available scientific and technical data, — environmental conditions in the various regions of the Union, — the potential benefits and costs of action or lack of action, — the economic and social development of the Union as a whole and the balanced development of its regions.
4. Within their respective spheres of competence, the Union and the Member States shall cooperate with third countries and with the competent international organisations. The arrangements for Union cooperation may be the subject of agreements between the Union and the third parties concerned. The previous subparagraph shall be without prejudice to Member States' competence to negotiate in international bodies and to conclude international agreements.

([109]) Article 37 of the Charter of Fundamental Rights of the European Union states: A high level of environmental protection and the improvement of the quality of the environment must be integrated into the policies of the Union and ensured in accordance with the principle of sustainable development.

([110]) Article 11 TFEU: Environmental protection requirements must be integrated into the definition and implementation of the Union policies and activities, in particular with a view to promoting sustainable development.

States. In the ERA, national research systems do not disappear but work together in an open way. The policy options selected respect the subsidiarity principle to the extent that the Union is best placed to identify areas of action for Member States, given the persistent barriers and the limited progress observed 12 years after the launch of the ERA at the Lisbon European Council in 2000.

The ERA is a unified research area open to the world based on the internal market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States shall strengthen their scientific and technological bases as well as their competitiveness and their capacity to collectively address grand challenges.

Launched in March 2000, the ERA has become one of the key objectives of the Union since the entry into force of the Lisbon Treaty. An ERA framework and supporting measures were announced in the 2010 Innovation Union (IU) flagship initiative of the Europe 2020 strategy. On two occasions (February 2011 and March 2012), the European Council has called for the ERA to be completed by 2014.

The overarching policy goal of the ERA is to increase the performance, excellence and impact of Europe's R & D system. This will help the EU get back on to the path of economic growth by fostering scientific excellence and research, underpinning innovation and increasing the attractiveness of the EU as a research location. Notably, it will help speed up the quest for solutions to societal challenges such as ageing of the population and energy security. The combination of the ERA and Horizon 2020 (the Commission's proposal for research and innovation) is expected to generate an extra 1.17 % of growth and almost 1.1 million more jobs annually by 2030. The five key priorities are: increasing the effectiveness of national research systems; improving transnational competition and cooperation, including on key research infrastructures; a more open labour market for researchers; gender equality and mainstreaming in organisations carrying out and selecting research projects; and optimal circulation and transfer of scientific information. The Horizon 2020 programme, currently being discussed in the European Parliament and by the Council, will be the financial pillar of the Union's actions to create the IU. The actions in the ERA communication will be the non-financial pillar. Both are closely interlinked: funding measures are crucial to the realisation of ERA, notably through their effect on coordination, common agenda setting and pooling of resources, and to continue shaping the landscape of European research institutions. Horizon 2020 will support the ERA policy priorities. As far as energy policy and research is concerned, the ERA concept is put into practice by the Strategic Energy Technology Plan (SET-Plan).

2.3.2 SET-Plan

The SET-Plan (the European Strategic Energy Technology Plan) defines a new EU approach to accelerate the development of cost-effective low-carbon technologies that are crucial to achieve the transformation of the entire EU energy system (20-20-20 goals). The SET-Plan establishes a number of innovative mechanisms ensuring its effective implementation. Member States' governments are engaged in the steering group that defines the overall strategy. At a sectoral level, six European industrial indicatives bring together industry active in each of these areas to define ambitious objectives and work together towards achieving them. Research centres pool part of their resources in the European Energy Research Alliance and try to establish common research agendas. The SET-Plan includes: the European Industrial Bioenergy Initiative (EIBI); the European CO_2 Capture, Transport and Storage Initiative; the European Electricity Grid Initiative (EEGI); the Duel Cells and Hydrogen Joint Technology Initiative; the Sustainable Nuclear Initiative; Energy Efficiency — the Smart Cities Initiative; the Solar Europe Initiative; the SET-Plan Steering Group; the European Energy Research Alliance; and the SET-Plan Information System.

The SET-Plan faces up to the challenges of this sector:

- in the short term, by increasing research to reduce costs and improve performance of existing technologies, and by encouraging the commercial implementation of these technologies ([111]);
- in the longer term, by supporting development of a new generation of low-carbon technologies ([112]).

([111]) Activities at this level should, in particular, involve second-generation biofuels, capture, transport and storage of carbon, integration of renewable energy sources into the electricity network and energy efficiency in construction, transport and industry.

([112]) The activities to be carried out should focus, among other things, on the competitiveness of new technologies relating to renewable energies, energy storage, and sustainability of fission energy, fusion energy, and the development of trans-European energy networks.

Implementation of the SET-Plan will involve collective efforts and activities in the private sector, the Member States and the EU, as well as internationally. The SET-Plan, first of all, proposes a new governance method for energy technologies, based on joint strategic planning.

The SET-Plan also improves the effectiveness of the implementation of the jointly decided actions, so as to take full advantage of the possibilities offered by the ERA and the internal market. The Commission will, therefore, gradually launch new European industrial initiatives, in wind energy, solar energy, bio-energy, capture, transport and storage of CO_2, the electricity network and nuclear fission, which will take the form of public–private partnerships or joint programmes between Member States. An increase in resources, both financial and human, is another major element of the SET-Plan. Finally, the SET-Plan makes provision for intensified international cooperation, in order to promote the development, marketing, deployment and accessibility of low-carbon technologies worldwide.

2.3.3 Energy 20-20-20 strategy

In January 2008, the European Commission proposed binding legislation to implement the 20-20-20 targets. This 'climate and energy package' (a 20 % reduction in EU greenhouse gas emissions from 1990 levels; an increase in the proportion of EU energy produced from renewable resources to 20 %; a 20 % improvement in the EU's energy efficiency) was agreed by the European Parliament and the Council in December 2008 and became law in June 2009.

The core of the package comprises four pieces of complementary legislation.

- A revision and strengthening of the Emissions Trading System (ETS), the EU's key tool for cutting emissions cost-effectively. A single EU-wide cap on emission allowances will apply from 2013 and will be cut annually, reducing the number of allowances available to businesses to 21 % below the 2005 level in 2020. The free allocation of allowances will be gradually replaced by auctioning, and the coverage sectors and gases covered by the system will be somewhat expanded.

- An 'effort-sharing decision' governing emissions from sectors not covered by the EU ETS, such as transport, housing, agriculture and waste: the targets range from an emissions reduction of 20 % by the richest Member States to an increase in emissions of 20 % by the poorest. These national targets will cut the EU's overall emissions from the non-ETS sectors by 10 % by 2020 compared with 2005 levels.

- Binding national targets for renewable energy which, collectively, will lift the average renewable share across the EU to 20 % by 2020 (more than double the 2006 level of 9.2 %). The targets will contribute to decreasing the EU's dependence on imported energy and to reducing greenhouse gas emissions.

- A legal framework to promote the development and safe use of carbon capture and storage (CCS) [113].

The climate and energy package creates pressure to improve energy efficiency but does not address it directly: that is being done through the EU's energy efficiency action plan.

2.3.4 Energy Roadmap 2050

The aim of the Energy Roadmap 2050 is to achieve the low-carbon 2050 objectives while improving Europe's competitiveness and security of supply [114]. The Roadmap will be followed by further policy initiatives on specific energy policy areas in the coming years, starting with proposals on the internal market, renewable energy and nuclear safety next year.

To achieve the goal of cutting emissions by over 80 % by 2050, Europe's energy production will have to be almost carbon-free. How to achieve this without disrupting energy supplies and competitiveness is the

(113) CCS is a promising family of technologies that capture the carbon dioxide emitted by industrial processes and store it in underground geological formations where it cannot contribute to global warming. Although the different components of CCS are already deployed at commercial scale, the technical and economic viability of its use as an integrated system has yet to be shown. The EU, therefore, plans to set up a network of CCS demonstration plants by 2015 to test its viability, with the aim of commercial update of CCS by around 2020. Revised EU Guidelines on State aid for environmental protection, issued at the same time as the legislative package was proposed, enable governments to provide financial support for CCS pilot plants.

(114) In March 2011, the EC published the overall decarbonisation roadmap covering the whole economy. All sectors — power generation, transport, residential, industry and agriculture — were analysed. The Commission has also been preparing sectoral roadmaps, inter alia, the Energy Roadmap 2050, the last, and focusing on the whole energy sector.

question answered in the Roadmap: the Roadmap identifies a number of elements that have positive impacts in all circumstances and, thus, define some key outcomes, such as the following.

- **Decarbonisation of the energy system is technically and economically feasible**: all decarbonisation scenarios foresee the achievement of the reduction in emissions target and can be less costly than current policies in the long term.
- **Energy efficiency and renewable energy are critical**: irrespective of the particular energy mix chosen, higher energy efficiency and important rising shares of renewables are necessary to meet the carbon dioxide targets in 2050 ([115]).
- **Early investments cost less**: investment decisions for the necessary infrastructure up to 2030 must be taken now, as infrastructure built 30–40 years ago needs to be replaced. Acting immediately can avoid more costly changes in 20 years ([116]).
- **Contain the increase of prices**: investments made now will pave the way for the best prices in the future. Electricity prices are bound to rise until 2030, but can fall thereafter as a result of lower costs of supply, saving policies and improved technologies. The costs will be outweighed by the high level of sustainable investment brought into the European economy, the related local jobs, and the decreased import dependency.
- **Economies of scale are needed**: a European approach will result in lower costs **and secure supply** compared to national parallel schemes. This includes a common energy market which should be completed by 2014.

The Roadmap 'will allow Member States to make the required energy choices and create a stable business climate for private investment, especially until 2030' ([117]), since the goal to cut greenhouse gas emissions by 80–95 % by 2050 has serious implications for our energy system as well as the objective that two thirds of our energy should come from renewable sources.

2.4 *Access to energy services as a human right in the EU*

The major source of international human rights law is multilateral treaties between States such as the two 1966 Covenants on Civil and Political Rights and Economic, Social and Cultural Rights ([118]). To date, there are no international treaties that specifically and explicitly refer to access to energy services as a right. However, it can be argued that the right of access to modern energy services is already implicit in a range of existing human rights. It is increasingly apparent that the socioeconomic goals contained in the latter Covenant (hereafter CESCR) cannot be achieved without access to energy services. Article 11 CESCR sets out a number of rights essential for the realisation of the right to an adequate standard of living, including access to 'adequate food, clothing and housing, and to the continuous improvement in living conditions'. Access to energy services is fundamental to cooking, lightning, heating and cooling, and sewerage. Article 12 CESCR confers the right to the highest attainable standard of physical and mental health. The acquisition of such a standard is impossible without access to sustainable energy services. Not only is energy a prerequisite to the supply of hospital services and equipment but also the maintenance of health is compromised by the use of traditional fuels for cooking. Articles 6 and 7 CESCR establish the right to work. The majority of employment possibilities require access to sustainable energy. While very basic farming, manual work and craftwork may be an exception, access to lighting, heating and cooling, clean water, modern machinery, telephones and computers are basic requirements nowadays in order to truly meet the right to full and productive employment promoted by these articles. In particular, the right to safe and health working conditions, as set out in Article 7, is not possible without access to energy. Finally, Article 13 CESCR establishes the right to educa-

([115]) The scenarios also show that electricity will play a greater role than now. Gas, oil, coal and nuclear also figure in all scenarios in different proportions, allowing Member States to keep flexible options in their energy mix provided a well-connected internal market is achieved quickly.

([116]) The EU's energy evolution requires, in any case, modernisation and much more flexible infrastructure such as cross-border interconnections, 'intelligent' electricity grids and modern low-carbon technologies to produce, transmit and store energy.

([117]) Foreword by Günther H. Oettinger, European Commissioner for Energy, Energy Roadmap 2050.

([118]) Based on Bradbrook, A. J., 'Placing Access to Energy Services within a Human Rights Framework', *Human Rights Quarterly*, 2006, 389–415.

tion. While it may be possible to educate children to a certain level without access to energy, the effective implementation of this right requires access to modern energy services. This interrelationship between energy services with other socioeconomic rights of fundamental importance is evident in other international and regional instruments.

With reference to the EU our analysis starts ([119]) with Article 6 TEU which states that: 'The Union recognises the rights, freedoms and principles set out in the Charter of Fundamental Rights of the European Union of 7 December 2000, as adapted at Strasbourg, on 12 December 2007, which shall have the same value as the Treaties'. Article 36 of the Charter provides that:

> *The Union recognises and respects access to services of general economic interest as provided for in national laws and practices, in accordance with the Treaty establishing the European Community, in order to promote the social and territorial cohesion of the Union.*

The TEU and the TFEU do not define the term 'services of general economic interest' (hereafter SGEI). The European Commission and the European Court of Justice have been left with the difficult task of providing the legal meaning of this term. The Commission, in its *Green Paper on Services of General Interest* referred to such services as 'services of an economic nature which the Member States or the Community subject to specific public service obligations by virtue of a general interest criterion. The concept of services of general economic interest thus covers in particular certain services provided by the big network industries such as transport, postal services, energy and communications' ([120]). With regard to the provision of electric energy service, the Commission has taken the position that vertically integrated electric public utilities provide 'services of general economic interest' ([121]). The European Court of Justice has taken the same position ([122]).

Article 14 TFEU stresses the importance and special status of SGEI:

> *Without prejudice to Article 4 of the Treaty on European Union or to Articles 93, 106 and 107 of this Treaty, and given the place occupied by services of general economic interest in the shared values of the Union as well as their role in promoting social and territorial cohesion, the Union and the Member States, each within their respective powers and within the scope of application of the Treaties, shall take care that such services operate on the basis of principles and conditions, particularly economic and financial conditions, which enable them to fulfil their missions. The European Parliament and the Council, acting by means of regulations in accordance with the ordinary legislative procedure, shall establish these principles and set these conditions without prejudice to the competence of Member States, in compliance with the Treaties, to provide, to commission and to fund such services.*

The concept of SGEI thus establishes the right of every citizen to access certain services considered as essential and imposes obligations on industry to provide a defined service at specified conditions, including complete territorial coverage ([123]).

Do the obligations imposed by European law on its institutions and Member States in relation to the SGEI undertakings create rights for the recipients of such services? For advocates of access to energy services as a human right, Article 36 of the Charter does not establish this right. The phrase 'recognises and respects' implies that access to SGEI such as gas and energy is a principle of law insofar that such access is provided for in the national laws and practices of Member States. If Member States legislate the right to access to SGEI, then the EU Treaties recognise that right to access as a general principle of EU law. The EU principle of access to SGEI only means that the EU cannot take any legislative steps to curtail the access for EU citizens to SGEI providers entrusted by Member States with public service obligations.

Even though it is the Member States that are competent to impose public service obligations on SGEI providers, the EU is attempting to provide some uniformity to these. Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning

([119]) Mainly based Avales, L. (2011), 'Electric Energy Access in European Law: A Human Right?', available online (http://ssrn.com/abstract=2008887).

([120]) Commission *Green Paper on Services of General Interest*, COM(2003) 270 final of 21 May 2003, paragraph 17.

([121]) Commission Decision 91/50/EEC of 16 January 1991 relating to a proceeding under Article 85 of the EC Treaty.

([122]) Case C-392/92, *Almelo* v *IJselmij* [1994] ECR I-1277.

([123]) Commission *Green Paper on Services of General Interest*, COM(2003) 270 final of 21 May 2003, paragraph 50.

common rules for the internal market in electricity (Electricity Directive) is a major step in that direction. If properly implemented by the Member States, it will provide a series of rights of European citizens that, as a group, may define the elements of a European-wide right to energy access. Article 3 of the Electricity Directive, Public service obligations and customer protection, directs Member States to enact a series of rights. This leads authors, such as Luis Aviles, to the following conclusion and proposal: 'Europe is close to recognising that access to affordable energy should be a fundamental right of EU citizens and it should do so in the next revision of the Charter' ([124]).

Finally, the human right to access to energy services from the point of view of the Council of Europe should be noted. Although the European Convention of Human Rights does not mention a right to energy services, it could be argued that a Member State that allows its citizens to live without a modicum of electrical energy in their homes violates human dignity and possibly rights under Article 8(1) of the Convention:

Everyone has the right to respect for his private and family life, his home and his correspondence ([90]).

At least one national court has tackled this issue under the Convention: in 1988, the Court of Appeal in Brussels held that the enjoyment of electricity and gas services are indispensable to human dignity. The Court went on to say that public authorities have the positive duty to provide gas and electric service within the framework of social services ([126]).

([124]) Avales, L. (2011), 'Electric Energy Access in European Law: A Human Right' available online (http://ssrn.com/abstract=2008887).

([125]) Article 7 of the European Charter of Fundamental Rights contains a comparable provision: 'Everyone has the right to respect for his or her private and family life, home and communications'.

([126]) Decision of 25 February 1988, J.L.M.B. 1989, 1132.

3. Ethics

The European Community has taken the shape of a political community as a result of common beliefs, ideals and values. From the beginning, there was a consensus that peace (the overarching goal of the unification in post-war Europe) was to be achieved only on the basis of democracy. Furthermore, there was a shared belief that economic prosperity was bound to a free market and 'movement without borders' within the community — the latter being especially important with respect to the labour market. The European Community, which, since its inception, has given primacy to the respect of human dignity and to the protection of every individual human being, has endorsed these important ethical principles in the Charter of Fundamental Rights of the European Union. The Charter indicates, inter alia, a set of values, such as human dignity, freedom, democracy, the respect for pluralism, non-discrimination, tolerance, justice, solidarity and subsidiarity, as the milestones of the European Union and its policy design, which need to be incorporated in the EU policies. Energy is a policy sector, which cannot be exempted from this process. The relevance of an integrated ethics approach regarding the complex multilayer decision-making process of the energy policy is central and methodologically innovative.

While an 'energy policy' and 'energy strategy' have been established for the next few decades, it is far from clear what exactly the framework for 'energy ethics' may look like. In the 1970s, Hans Jonas introduced his principle of responsibility for the era of science, technology and knowledge societies, directing our attention towards a concept of responsibility that is not only concerned with implications of present or past actions, but rather with the implications of today's action on future generations. Jonas' approach is echoed in part in the implementation of the 'precautionary principle' in the legal EU framework, which reverses the burden of proof — the argument for the greater overall benefit of an action — in cases of expected harms or risk of envisioned technologies. More striking, however, is Jonas' attention to long-term effects for which present generations must shoulder their responsibility. This newly awakened consciousness and conscientiousness towards future generations is striking because it is only since the industrialisation in the 19th and 20th centuries that the impact of human action is such that it may destroy the very conditions of the well-being of future generations simply by continuing to live as we currently do. At the beginning of the 21st century, it has become clear that climate change, environmental damage, and radical changes in social conditions for billions of people today, and in the near future, demand that, with the development of industry and technology, the scope of our responsibility has also been broadened: the way we live and use natural resources, the way we promote the development of any society and the choices we make today have an impact both in space (regional and global) and in time (present and in the future). The principle of sustainability emerged as a term that tries to embrace this new responsibility, particularly with respect to the impact of present actions on future generations.

The EU has responded to the challenge of the global and intergenerational responsibility by integrating ethics into its political and legal framework. The EGE supports the European Commission in spelling out the ethical dimension since new developments in science and new technologies demand new answers. This is clearly true in the area of energy. Yet, the task of spelling out the integrated ethics approach of the EU energy policy differs from previous tasks because energy is a 'horizontal' issue (i.e. it is a necessary element of multiple policy fields, connecting, for example, the development of agriculture with urban development and architecture, transport systems with the stock market, international environmental politics and national security concerns, and the EU energy research agenda with the UN). Energy policy is also related to the need to provide clean and sufficient food and water to the population. The Millennium Development Goals aim to fight poverty and promote economic, social, and political development on a global scale — since 'energy' is the condition for the very state of modern societies — a responsible policy approach is called for in order to enable the EU to take into account the impact of the energy options in almost every sphere of modern society and transform today's societies in such a way that neither one part of today's world nor future generations' well-being is sacrificed for the advantage of the other. Today, the EU should respond to this challenge not only because it has committed itself to do so, but also because: (a) its own history of industrialisation calls for it; (b) its dependence and vulnerability to imports demands prudent policy strategies; and (c) its research agenda is one of the strongest worldwide so that it seems to be feasible that the EU may play a crucial role in the development of sustainable energy technologies and energy saving technologies.

The EU's ambitious energy policy, aimed at a smart energy economy and 'low-carbon society' covering the full range of energy sources from fossil fuels (oil, gas and coal) to nuclear energy and renewables (solar, wind, biomass, geothermal, hydroelectric and tidal) by 2050, entailing an 80 % reduction in greenhouse gas emissions, major improvements in energy efficiency and savings, and the goal that non-renewable energies are slowly replaced by renewable energies needs to be considered and analysed in relation to the Lisbon Treaty and the moral values enshrined in the Charter. The Lisbon Treaty provides a compromise between the promotion and facilitation of a common European energy policy and respect for subsidiarity and national sovereignty. An ethics framework is required in order to set the priorities which will provide the means for well-being, independent of where or when one happens to be born. Respect for fundamental human rights and European values, solidarity among the Member States of the European Union, and a prudent equilibrium between a common policy, competition between different energy plans, and national diversification regarding energy sources are all necessary elements of such a framework. Any EU policy, the Lisbon Treaty states, is to be realised in a spirit of solidarity between the Member States. In this spirit, the EU strives to secure the rights and enhance the well-being of all citizens.

A set of shared values exists in the EU that can serve as the guide to respect for national sovereignty and the necessity of a cooperative and common EU approach. Ethical goals for responsible decision-making (access to energy and security of supply, safety and precaution, sustainability and responsibility, as well as social and intergenerational justice) can be extrapolated as common values from the Charter ([127]). The following fundamental values play a key role in the debate on energy.

1. Respect for human dignity and human rights — among them, the right to healthcare and a safe environment, the right to access to energy as an important condition for basic human flourishing, the right to active democratic participation in the decision-making processes regarding energy policies and the right to transparency and information;
2. Justice including distributive, social, political, and intergenerational justice.
3. Solidarity identifies the shared responsibility and concern for EU and global welfare, which calls for cooperation in order to achieve the goal of securing the well-being of present and future generations.

These overarching rights and values guide the development of an ethics framework oriented at a responsible design of the EU energy policy. Ethical criteria for responsible decision-making (access to energy, security of supply, sustainability and safety), can be extrapolated from the Charter ([128]). However, their implementation is accompanied by several difficulties which need to be identified and spelled out explicitly.

3.1 Ethical concerns

Security of supply of energy was clearly an important economic factor for the establishment of the European Union, promoting interconnection and cooperation among states at a time when European citizens yearned for peace. For many decades, energy was taken for granted, assuming that it would always be available, affordable and easily accessible. A number of events have made it clear that this is no longer the case, in particular, the realisation that fossil-based energy is non-renewable and will eventually be depleted. Even though huge resources of gas and oil have recently been discovered or made accessible through new extraction techniques, the fossil reserves will eventually be depleted. Various documents on the international, European and national level have been written to emphasise the need to establish secure, safe, and sustainable energy policies and strategies. While the problems of security, diversification of energy supply and sufficient investment needed for secure energy delivery have been addressed, mainly from an economic perspective, not enough attention has been paid to the ethical issues related to the production, processing, storage and distribution of energy.

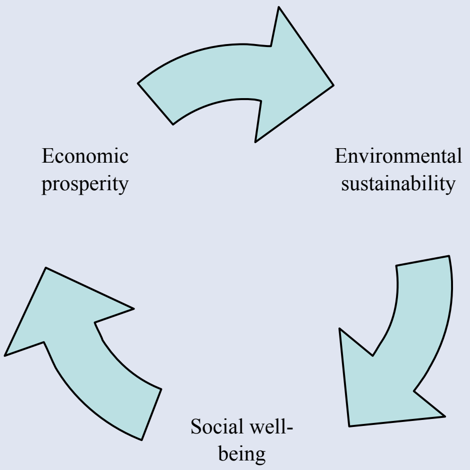
Besides the obligation to secure energy, safety and sustainability have become additional criteria which need to be considered in any energy policy. As stated in the previous chapter of this Opinion the Lisbon Treaty, in Article 191, commits to the contribution and pursuit of environmental objectives (to preserve, protect and improve environment quality; to protect human health; to utilise natural resources prudently and rationally). It

([127]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2007:303:0001:0016:EN:PDF

([128]) See footnote 123.

also includes the precautionary principle and preventive measures as means to protect the environment ([129]).

Environmental policies will therefore strive to direct the economic competition towards ensuring energy security, while preventing present and future environmental damage of the sort that accompanied the industrialisation of the 19th and 20th centuries. An equilibrium between economy prosperity, environmental sustainability, and social welfare or the well-being of individuals needs to be reached in all EU policies, and in energy policies in particular.



Europe's energy policy becomes one of the greatest tests that Europe has to face in the coming decades. It is important to address the EU energy policy in the light of the Lisbon Treaty's Energy Policy objectives: (a) ensuring the functioning of the energy market; (b) ensuring energy security; (c) promoting energy efficiency and energy saving, and the development of new and renewable forms of energy; and (d) promoting the interconnection of energy networks ([130]).

These four main objectives of EU energy policy need to be implemented in such a way that they can respond to the following challenges facing us today:

- security of supply;
- affordable access to all users;
- increasing dependence on imports,
- climate change and the necessity to enable the transition to renewable energy;
- strain on energy resources;
- the issue of diversity of energy mix;
- the need of a coherent external energy policy;
- the equilibrium between the principle of subsidiarity and autonomy of Member States;
- solidarity among Member States; and
- funding of research that encourages innovation in all areas of energy technology, and that ensures the competitiveness of the European economy.

In this chapter, the EGE identifies some ethical concerns related to the debate on research required to achieve a sustainable energy mix. The group spells out the four ethical criteria or 'pillars' of ethical analysis, which need to be integrated in energy policy strategies: the right to access to energy, energy security, energy sustainability and energy safety.

3.1.1 Justice as a horizontal principle

The EGE emphasises that these four criteria (access to energy, security of supply, sustainability, and safety)

([129]) Article 191:
1. Union policy on the environment shall contribute to pursuit of the following objectives: —preserving, protecting and improving the quality of the environment, — protecting human health, — prudent and rational utilisation of natural resources, — promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change.
2. Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay.

([130]) Article 194:
1. In the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy shall aim, in a spirit of solidarity between Member States, to: (a) ensure the functioning of the energy market; (b) ensure security of energy supply in the Union; (c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and (d) promote the interconnection of energy networks.

are complemented by a horizontal principle (justice), which is the foundation for the realisation of human dignity and human rights. Justice is 'horizontal' or crossing across the four ethical criteria referred to in the previous paragraph because the concept of justice embraces a number of elements:

- 'justice as equity' which is the basis of justice as the guarantee of *equal* human right to well-being and, hence, the right to access of energy as the condition of human flourishing;
- 'commutative justice' which refers to the economic cooperation and, among others, the rules of fairness in international trade;
- 'distributive justice' which guarantees the fair distribution of energy and accompanies the difficult issue of access to energy;
- 'social justice' which guarantees that the interests of those most vulnerable and disadvantaged in the present generation and the well-being of future generations are equally safeguarded through security of reliable and affordable supply of energy and safety issues;
- 'participatory justice' which accompanies the requirement for democratic, participatory decision-processes (e.g. regarding the energy sources and energy mix of a given country and/or the EU, regarding the priority-setting of the criteria to which we will return later, or regarding the question of safety and risk acceptance);
- 'intergenerational justice' which underpins sustainability and advocates that the rights and interests of future generations are to be taken seriously into account in any decision-making process of the present generation;
- 'environmental justice' which safeguards the ecological balance of nature, protects and promotes ecological diversity, and requires the development of a sustainable economy in order to preserve the 'common heritage' of mankind'.

While the relation between justice and human rights is very tight, the EGE does not wish to apply or promote an *exclusively* 'anthropocentric' approach to the energy debate. Rather, the group acknowledges that the natural resources which past and present generations have utilised, and are utilising for the purpose of their well-being, are the very basis of human life and flourishing. Without the transcendence of our moral responsibilities beyond myopic human needs and desires, the basis of human flourishing would be endangered and would not serve future generations in the same way as ours. The negative ramifications of climate change are but one reminder of the simple truth that our one and only planet Earth is the environment for all living beings and must not be tampered with.

Hence, the EU's energy policy should embrace those strategies of responsibility which create the best possible equilibrium of environmental protection, promotion of well-being, and economic prosperity. Without solidarity among the European Member States and the international community, this equilibrium will not be achieved. Social justice demands also a sense of solidarity with the whole family of 'humankind'. The current generation has a moral obligation to regulate its current consumption in order to share its resources with the poor and with future generations. The one solid factor for asserting that it is the obligation of present generations to care about possible and probable future generations or, alternatively, that future generations have claims on us, which can only be advocated for by the present generation, is the unity and solidarity of mankind. There is no social justice without sharing and participation. The intergenerational community of humankind becomes just when present generations learn to share the resources of the earth with all current and future members of the human species. Global and intergenerational sharing moves us beyond the old model of development to a radical rethinking leading to fundamental structural change.

Participation is at the very core of social and political justice. All members of the human species have the same fundamental dignity and right. Since the resources of the earth are the 'common heritage of humankind', all members of the human species have the right not only to share in the common goods of the earth, but also to participate in their management.

3.2 Societal impact

Public policies on energy production, storage and distribution may have an immense impact on the well-being and the quality of life of citizens. Security of energy supply is essential to guarantee basic human needs. Safety is a necessary condition for the protection of health and the environment. If the EU energy policy (both the 2020 strategy and the Energy Roadmap 2050) is successful, it will, in part, improve the health and overall well-being of EU citizens who will less and less be exposed to hazardous wastes and emissions associated with fossil fuels, or to the emissions and risks of atomic energy production and waste storage.

In addition, decisions on energy technologies raise questions about political decision-making including the participatory public debate on the choices of energy sources, the distribution of costs and risks, storage of waste, and transparency about the side effects of any energy technologies. EU energy policy must not only find an equilibrium between economy, ecology, and social issues, but also — as part of the processes of democratic deliberations — between a decentralised and centralised implementation of energy technologies, on the one hand, and bottom-up and top-down policy decision-making processes on the other hand: local energy decisions may have an impact on the national energy policy and may jeopardise the EU goals of a secure, safe, and sustainable energy strategy.

The precautionary principle requires an assessment of risk and, when necessary, its minimisation. No energy source is without some form of impact on the fabric of society. Due to the varying economic and environmental impacts of renewable energy systems, the transition to sustainable energy may also have significant social consequences. For example, the development of renewable energy systems may change the structures of employment in certain regions, depending on their industrial base and on their reliance on non-renewable energy sources. A decentralised energy strategy could increase consumer choice regarding households' energy suppliers with respect to the EU dependency on energy import; furthermore, changes in the supply chains may have an impact on international relations, changing political relations internationally as certain nations end their reliance on others for energy.

It is equally important to stress that changes in communal and individual attitudes and practices are an integral aspect of every public policy on energy: best practice on how to use energy more efficiently, save costs and reduce waste is one of the pillars of the Lisbon Treaty — and that cannot only mean the development of more efficient technologies. Public authorities can lead by example and apply energy efficiency criteria in all public procurement of works, services or products. One could think of social competitions regarding creative ideas to save energy, or providing incentives for individuals, communities, or even regions, to transform their individual, social, and economic habits (e.g. in architecture, urban development, the use of common ground within cities, transportation of goods or public transportation). The consequences of particular uses of energy (local, national, supranational and global) should be faced in order to raise awareness of individual and collective responsibility for energy security. Since energy touches the core of human multi-relationships, the engagement of public participation in the decision-making process concerning energy policies is crucial in a democratic society. Transparency is, therefore, needed to enable citizens and democratic bodies to make informed choices on supranational, national, regional or local energy needs and systems.

3.3 Economic impact

Humanity's ability to extract and exploit fossil fuels has been the catalyst for technological and industrial development that has led to unprecedented socio-economic prosperity in many regions of the world. Until recently, security of supply was the main concern from an economic perspective: as shown in Chapter 1 of this Opinion, economic development in the 19th and 20th centuries emerged with the assumption that the natural resources, which were necessary for industrial progress, could be exploited without major costs to either individuals or societies, or the environment. Energy, therefore, became an object of economic deliberation because of the economic power of those countries that could dictate (and continue to do so) the price and supply of energy on the global market. For the EU, the high dependency on imports makes it especially vulnerable to the volatility of the market, and it raises many questions concerning the security of supply. Energy saving and energy efficiency has become part of an inherent economic strategy to reduce (or at least to stabilise) energy costs. In this situation, reliance on one source is certainly not a prudent strategy and, therefore, the EU has long encouraged the use of an energy mix. For a long time, it was believed that market competition would itself result in a move towards efficient solutions, but the international, European, and national energy structures have not succeeded in transforming the energy market into a 'healthy' energy mix addressing social, environmental, sustainability and safety concerns. Proponents of non-renewable energy systems argue that fossil fuels continue to be much more economically feasible than renewable energy sources, while proponents of renewable energy, too, argue for the positive economic balance of these systems. The Energy Roadmap 2050 ([131])

([131]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52011DC0885:EN:NOT demonstrates that a mix of non-renewable and renewable energy is the only realistic option in the short and medium term to respond to energy needs and, at the same time, maintain energy prices which are economically feasible. The main issue is that demand for energy is increasing exponentially worldwide (in particular in emerging economies) and that the global energy demand requires urgent action.

Since any EU energy policy has to establish an equilibrium between the economic, environmental and social dimensions, it must ensure that there is not only fair competition but also transparency of energy costs, emissions, risks, social and environmental impact of the utilisation of natural resources and the general rationale concerning energy efficiency and energy saving as well as the interconnection and cooperation. The overall costs of every energy source, including all hidden and external costs (such as those involved in the entire life cycle of the source, from development, production, transport, distribution, storage, maintenance, waste storage, environmental and human impact to the insurance and indirect costs of safety measures) must be objective and available. The external costs — planning, construction, operation, networking and costly emergency planning systems, on the national, regional and international level — should be taken into account. The costs of these contributions, such as the costs of environmental damage and the costs of dismantling a technological structure of current energy sources may or may not be included in the costs calculated. What is needed is an economic policy of 'true process' (i.e. with all external costs included, rather than a policy of 'cheap' energy).

3.4 Environmental impact

Any energy source has an environmental impact if the whole cycle from retrieval to distribution to waste storage is considered. As elaborated in the first part of the Opinion, the group of non-renewable energy sources is as diverse with respect to the different sources as is the group of renewables, which, per se, have a better environmental balance.

Future generations are likely to be disadvantaged by the environmental impact caused by irresponsible decisions and use of energy sources. Since both spatial and temporal dimensions of the consequences of human activity play a crucial role in the ethics of energy, the present generation faces the ethical challenge to broaden its moral perspective by taking seriously into account the long-term effects of its decisions and actions on posterity. This challenge is based on the demands of social justice that appeal to the principle that a community has the moral duty to give particular help to those who are disadvantaged out of human solidarity.

The ethical challenge to protect future generations stems from the fact they are in a disadvantaged position with respect to the present generation which has the power to affect their quality of life. They are disadvantaged for three reasons: firstly, they are 'downstream' in time from us and thus subject to the long-term consequences of our actions; secondly, the scope of their choices is restricted by decisions taken by their predecessors; thirdly, future generations are inherently disadvantaged since they are 'mute', having no representatives among the present generation, and so their interests are often neglected in present socio-economic and political planning.

3.5 Comparative approach

In order to address the ethical issues that arise from changes to an energy mix and the research that is needed to ensure effective delivery of energy to citizens, it is crucial to provide comparative data on all energy production systems throughout their 'life cycle' to enable comparison. The need is complicated by requirements to examine the full cycle of energy production in both scientific and social terms. Taking coal as an example, the mining of the coal is a hazardous occupation both for the miners and for those living in close proximity to the coal mines due to accidents in the mines and environmental impacts — especially in modern opencast mines — and health impacts due to dust and pollution. Coal mining communities are traditionally close-knit communities, where any changes have major social impacts. This is followed by the need to transport the material to the plants processing the coal or using it for generation of electricity. Without treatment and some form of carbon capture associated with the coal-fired plants, pollution due to partially combusted particular matter can impact on health and the environment in the proximity of the plant, and nuclear radiation, inherent in the coal, may also be a problem. The combustion of coal produces carbon, nitrogen and sulphur compounds that significantly contribute to the environmental damage unless properly addressed in the treatment of the effluent. Whilst the reserves of coal are great, they are not infinite, and they are not renewable.

In the case of nuclear power, there is a risk of a devastating hazard — the meltdown of the fission material and containment facilities causing both the equivalent of a nuclear bomb, in the worst of cases, to the uncontrolled release of radioactive material with resultant impacts on human health and the environment. The long half-life of some nuclear materials means that where such a problem happens, its effects may last for thousands of years. Once the fuel used in nuclear plants is exhausted, the remaining radioactive material has to be stored safely in a manner that minimises the risk to human health and the environment, possibly for thousands of years. In many cases, this storage of nuclear waste has proven to be the greatest challenge in the use of nuclear energy, which adds to the risk of hazards [132]. Nuclear fuels are also non-renewables that are mined.

In transitioning to renewable energies, the EU needs to assess the relative environmental impact of the different 'green technologies in order to find the best possible solutions. For example, the green, renewable energy systems may also have a negative environmental impact because of the need for storage systems and distribution technologies. However, renewable energy systems that utilise water, solar or wind to produce power create no carbon dioxide emissions once they are constructed and, therefore, do not contribute to the negative effects of climate change during this phase of their use. Still, hydropower projects, such as dams, can negatively affect fish and wildlife by obstructing natural water flows, and the massive water reservoirs they create may irreversibly change the surrounding ecosystem. They may also disrupt communities and change the way in which they interact with their environment. Other concerns about environmental impacts refer to arable land sustainability and food security (the amount of agricultural land that may be required to generate significant levels of biomass energy and biofuels), the amount of air pollution that stems from inappropriate use in comparison to other renewable systems, etc.

Even windmills provide environmental headaches — they are noisy, and may impact on bird and insect ecosystems. The production of the electronics and generation systems may also have environmental and health consequences, and the storage of electricity when an excess is produced is a problem. Each technology has its pros and cons, and a comparative analysis of the merits and demerits of using a particular source of energy is necessary.

3.6 The four ethical criteria for an ethical assessment

Various documents on the international, European and national level have been written to emphasise the need to establish secure and sustainable energy policies and strategies. The problems of security, diversification of energy supply and sufficient investment needed for secure energy delivery have been addressed mainly from an economic perspective; however, not enough attention has been paid to the ethical issues related to the production, processing, storage and distribution of energy.

The energy challenge is one of the greatest tests that Europe has to face. It is therefore essential for the European Union to address, within an ethical approach (environmentally, economically and socially compatible), its main criteria of energy policy:

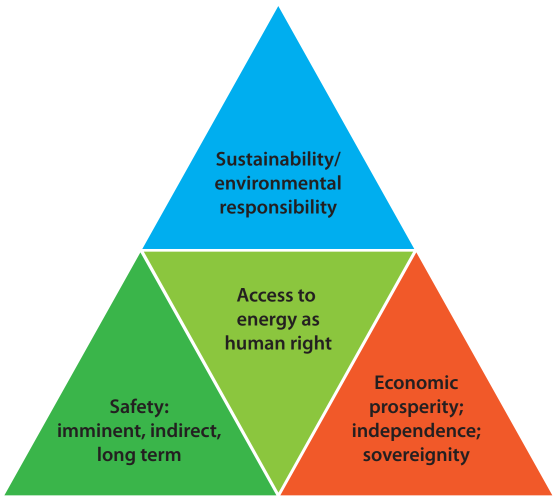
1. Access to energy
2. Security of EU energy supply
3. Sustainability
4. Safety.

3.6.1 Access to energy

Energy is a fundamental factor in the provision of many vital services which improve the quality of life and enable economic and social development: transportation, comfortable indoor temperatures, agriculture, food production, preservation and cooking, health services, lighting, communication and information, commercial and industrial processes. 'Energy poverty' reduces or even threatens people's well-being (e.g. by reducing their chances to flourish and participate in social and economic life). The history of energy consumption shows how important energy is to the quality of human life. Accordingly, the disruption of energy supply and a lack of adequate, reliable, diverse and affordable access to energy sources affects human rights. This is why 'energy security' has risen to the top of the political agenda in the 21st century. Inequalities in access to affordable energy have given rise to inequalities in social security and standards of living. Energy should be available to individuals at a level that allows them to achieve their personal security and aspirations while

(132) http://ec.europa.eu/energy/nuclear/safety/stress_tests_en.htm

Figure 3.6.1: Illustration of access to energy as a first priority (Example A)



Consequences in case of conflicting goals:

Global approach, linked to overall struggle to fight poverty:

- People before environment
- Produce and supply as much energy as possible
- Minimal safety standards: acceptable risks
- Climate change as long-term goal, but rights of present generation comes first
- Economic prosperity to be considered as global goal (Development goals: energy as tool/means to development), global justice 'regime' necessary to meet the goal

EXAMPLE A: FIRST PRIORITY — ACCESS TO ENERGY

If global energy security — based on every human being's **right of access to energy** as a condition of their well-being — is the first priority of policies, the EU's concerns for its own energy security, safety standards, environmental concerns and, potentially, also national sovereignty are secondary to the achievement of this goal. Energy production and utilisation will include any available source on earth, and a regional approach will complement the global approach. When it comes to striking a balance between social, economic and environmental concerns, access rights will 'trump' the other two areas of concern: a longer-term view can be taken of environmental concerns, research can be directed towards the short-term use of energy sources (e.g. fracking) and safety criteria may be relaxed in the interests of economic prosperity. Global development economics are linked to more energy use and, in the short term at least, demand can be met only by the increased exploitation of natural resources. A new wave of oil drilling, fracking and nuclear energy in many parts of the world underlines that economic prosperity really is the number one priority for global energy policy.

not compromising the environment and the rights of others. The promotion of national or international welfare must therefore consider access to energy as a key goal for all actors involved in energy policy.

3.6.2 Security of EU energy supply

Key terms for the ethical evaluation of future energy supply are sustainability and security of supply. The goal of security of supply entails not only reducing import dependency but also increasing supply diversity and the stability of the electricity and gas grids. The EU's experiences of gas supply interruptions in early 2006, 2008, 2009 and 2010, its strong dependence on imports of petroleum products, and the geopolitical uncertainty in many producer regions, led to the adoption of the regulation concerning measures to safeguard security of gas supply ([133]).

Risks associated with the security of supply are those related to a high dependence on foreign sources of energy imported from a limited number of suppliers (the EU-27 currently imports 83.5 % of its oil and 64.2 % of its gas consumption; overall, import dependency is around 54 % and is projected to slightly increase by 2050 ([134])), including supplies from politically unstable regions; gradual depletion of fossil fuel resources and rising global competition for energy resources; increas-

([133]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:295:0001:0022:EN:PDF

([134]) http://www.european-council.europa.eu/media/171257/ec04.02.2011-factsheet-energy-pol_finaldg.en.pdf ing electrification from more variable sources (e.g. solar PV and wind) which poses new challenges to the grid to ensure uninterrupted delivery of electricity; low resilience to natural or man-made disasters and adverse effects of climate change.

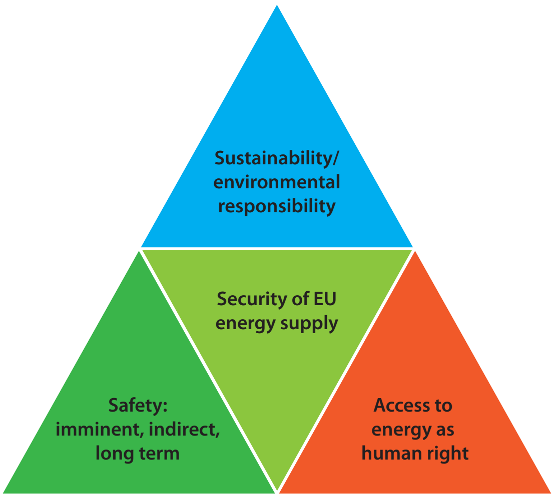
Given that the EU has set energy targets and that, at the same time, Member States are free (in accordance with the principle of subsidiarity) to decide their energy mix, a paradigm shift is needed in the ethical assessment of security of supply, which should be based on an integrated approach taking into account:

- solidarity in energy policies (no country can resolve the energy production issues on its own);
- dependency and vulnerability: the energy mix should not depend on one source alone (ethical basis of dependency);
- the need for energy to be produced safely, in an environmentally and socially compatible manner and at competitive prices (covering all costs); mechanisms for sourcing energy should not adversely impact on food or water security; and the need for an adequate infrastructure to deliver energy.

3.6.3 Sustainability

The key term for the ethical evaluation of future energy supply is sustainability. With the guiding criterion of sustainability, the objective of environmental compatibility stands alongside social equilibrium and economic efficiency for collectively achieving a future-oriented structure for society. The challenge is to build a responsible energy future through sustainable development which means helping to meet the world's growing energy needs in economically, environmentally, and socially responsible ways. Contributing to sustainable development means consciously balancing short and

Figure 3.6.2: Illustration of security of EU energy supply as first priority (Example B)



Consequences in case of conflicting goals:

- Regional/EU approach has priority to global approach
- Members States/national sovereignty
- Produce as much as possible
- Cooperation, driven by competitiveness
- Present well-being and prosperity has priority to future generations
- Minimal safety standards
- Minimal environmental standards

EXAMPLE B: FIRST PRIORITY — SECURITY OF ENERGY SUPPLY

If **energy security of supply** within the EU is the first policy priority, then safety standards, environmental concerns and national decisions concerning the energy mix are secondary to the achievement of this goal. Energy production will come from any available sources conducive to the aim of the EU to acquire self-sustainability in the energy sector. The EU's dependency on imported energy will be considered as a threat to overall prosperity and any steps to greater independence will be welcomed. It is clear, however, that economic considerations will 'trump' other areas of concern: a longer term view can be taken of environmental concerns while research is directed towards the short term use of energy sources (e.g. fracking), the global struggle against energy poverty may well be delayed for short term EU benefits, and even safety criteria may be relaxed in the interests of economic prosperity linked to security of energy supply. The question then is whether this priority-setting is compatible with the EU ethical framework, which clearly seeks to promote an ethically sound energy policy that safeguards the balance between social, environmental and economic concerns.

long-term interests and integrating economic, environmental and social considerations into energy decisions.

Sustainable development criteria have been pushed to the front line of energy policy. In the light of concerns about climate change due to human enhancement of the greenhouse effect, there is growing concern about how energy needs are addressed on a sustainable basis. Until about 20 years ago, energy sustainability was thought of simply in terms of availability relative to the rate of use. Today, in the context of the ethical framework of sustainable development, including, particularly, concerns about global warming, other aspects are also very important. These include environmental effects and the question of wastes, even if they have no immediate environmental effect.

The principle of sustainable development, as defined in the Report of the Brundtland Commission ([135]), *Our Common Future*, implies that the present consumption of energy be examined in light of the foreseeable needs of future generations. The Brundtland Commission's definition includes not only sustainability's environmental dimensions, but its economic and social aspects as well. It underlines the need to maintain economic growth and reduce poverty by providing more energy. Changes in people's lifestyles also help to save energy if they respect nature and are sustained as a basis for supply.

Responsibility for future generations therefore also extends in particular to the provision of energy and a fair distribution of risks and burdens in the long term. A sound ethical policy on the responsible and sustainable use of energy technologies should involve both a wide human environmental context and a long-term horizon. As George Bernard Shaw so succinctly put it: 'We are made wise not by the recollection of our past, but by the responsibility for our future.' Now, as never before, we understand clearly the possible impact of the decisions we take today on the lives of those who will follow us. At the same time, we possess the right information and the proper tools to act to ensure that economic growth and an improved quality of life do not necessarily result in increased resource use and pollution. We, thus, have the opportunity to exercise our responsibility and to assess the need to redefine human development in terms that go beyond the strictly economic, so as to establish a genuine vision of sustainability that is viable for decision-makers.

([135]) http://www.un-documents.net/wced-ocf.htm

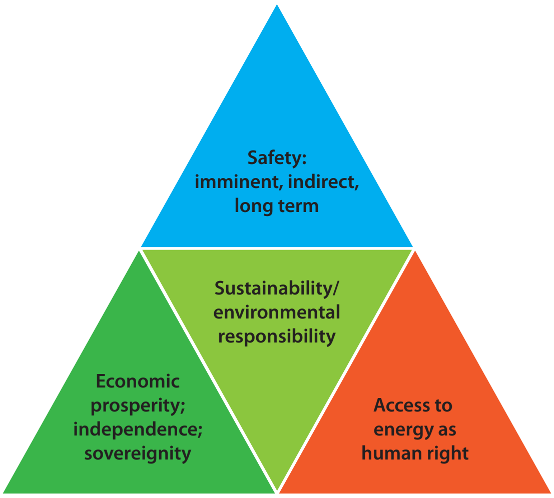
Since the production and use of energy can be a threat to the environment, energy sources should be renewable in order to be sustainable. Hence, urgent action needs to be taken to safeguard the environment for present and future generations. This involves reductions in the negative environmental consequences of energy exploration, production, and storage and distribution. Moreover, renewable sources of energy must be developed and combinations of renewable energy strategies must be found to facilitate the transition from non-sustainable to sustainable energy supply. We have specific duties towards future generations: the resources must be exploited in as economical and rational a manner as possible, above all when we know full well that a large part of the non-renewable energy resources may be depleted within one or two centuries. There is, therefore, a duty at every level to limit energy consumption and wastage. The exploitation of a resource whose disappearance could threaten the existence of entire industries requires that governments view energy control policies as a major aspect of their development programmes. Environmentally friendly technologies and consumption structures have to be developed, distributed, maintained and expanded in all parts of the world.

Reductions in energy consumption can be brought about by changing people's attitudes and educating consumers to adopt new lifestyles. We highly recommend the promotion of sustainability in schools. Citizens' participation in energy transition policies empowers them to control consumption. Incentives for energy-efficient urban renovation are to be encouraged.

The central criterion for the evaluation of an energy technology must be: Does the technology support or hinder sustainable development or is it neutral? To comply with the requirements of sustainability, an energy technology must be:

- socially, environmentally and (macro-)economically sound and socially acceptable;
- within human grasp (e.g. all potential technical, social and environmental consequences can be comprehensibly assessed);
- flexible (e.g. requires follow-up measures through centuries and is tied to large units, difficult to steer due to intrinsic dynamics);
- tolerant to errors, failures and misuse.

Figure 3.6.3: Illustration of sustainability/environmental responsibility as first priority (Example C)



Consequences in case of conflicting goals:

- International/global policies
- Produce as sustainable as possible
- Liability with producers
- Future well-being is equal to well-being of present generations
- Sustainability has priority to safety standards or prosperity and energy security

EXAMPLE C: FIRST PRIORITY — SUSTAINABILITY

If **sustainability** is the first priority of the energy policy, it certainly challenges the current energy economics: the promotion of nuclear energy, fracking, or even new forms of coal and oil mining will need to be reinterpreted in light of the priority of sustainability. The goal of transforming EU industry, households, transport systems, etc., will all be assessed in light of their contribution to either the ongoing pollution of the environment or the use of natural resources. The transition to renewable energies will need to be promoted more consistently, and research will need to be redirected if it does not pass the test of this criterion. Whether the priority of sustainability can be harmonised with the social and economic issues stated above without threatening either prosperity or social rights remains to be seen.

3.6.4 Safety

The notion of risk postulates a negative consequence and the likelihood of it happening, which depends on the degree of hazard and exposure. The definition of negative effects is context-dependent — sociocultural factors play a central role in defining the 'negative' consequence (e.g. death, illness, natural degradation, economic vulnerability, choice and social control) and impact the entire risk assessment process. Risk also includes the broad range of cultural, social and psychological consequences that give rise to different types of public perceptions. A comprehensive concept of risk and safety includes the dimensions of security of supply and economic stability as well as environmental protection. Environmental, economic, social and technical risks are closely interlinked. All the risks involved in all sources of energy must be adequately evaluated, assessed, and communicated to society.

The starting point for risk assessment is the reasoning that there can never be zero risk and that the risks when using mineral oil, gas, coal, biomass, hydropower, wind, solar power and nuclear energy are different but can be critically compared. As none of the energy options is risk-free, the judgement for acceptability rests on a comparative assessment of the anticipated consequences of all available options on the basis of the above mentioned multilayer assessment criteria. This requires all of the risks and opportunities to be evaluated as well as is scientifically possible, whereby direct and indirect consequences over the whole life cycle must be included. Alongside the scale of the consequences, the probability of their occurrence should also be taken into account. In connection with the impact evaluation, the risks and opportunities must be weighed up against each other. Ethical considerations assist in making the most rational and fairest assessment possible.

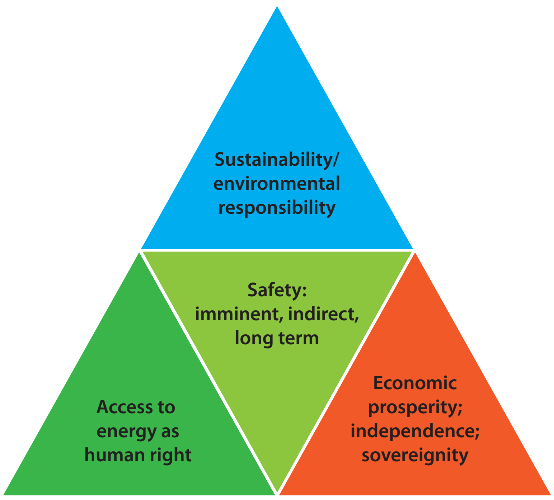
The previous consideration applies on a case-by-case basis to whatever technology is scrutinised in its entire life cycle. Reducing the risks down to purely technical aspects would not fulfil the requirement for an integrated approach and comprehensive assessment. Consequences in terms of the environment and health should receive the same amount of attention as the cultural, social, economic, individual and institutional implications. A safety culture embraced by governments and operating organisations is necessary in the production, storage and distribution of energy in maintaining a low level of risk. A rational choice of energy sources should involve a comparison of the risks presented by the various energy chains available.

Equally important is the relationship between the probabilistic considerations and the magnitude of the consequences of the risk associated to the use of a given technology. A critical assessment is especially important, in particular when the consequences of energy technologies assume the character of 'eternal burdens'.

3.7 Conclusions

The EU's aim of a smart energy economy, in which energy is more secure, competitive and sustainable, cannot be adequately delivered without the underpinning of a proper set of ethical criteria that promotes and facilitates the implementation of a common (harmonised) European energy policy, based on solidarity between Member States, which also serves as a reliable guide to the EU's priority-setting in energy research and use. Every decision that a country takes on energy sources is ultimately based on society's value judgements, over and above technical and economic considerations. It is, therefore, important that European institutions foster a value system that promotes harmonisation and consistency in research, development and capacity-building in the field of energy. Since the manner in which energy is provided has become highly critical, the EU is facing the challenge of promoting a strategic view in the areas of research and development activity based on a sound common ethical perspective and not

Figure 3.6.4: Illustration of safety as first priority (Example D)



Consequences in case of conflicting goals:

- International/global policies
- Produce as safe as possible
- Liability with producers
- Precautionary Principle/Proportionality
- Present well-being is equal to well-being of future generations
- Safety has priority to sustainability standards or prosperity and energy security

EXAMPLE D: FIRST PRIORITY — SAFETY

If **safety** is considered the first priority of any energy policy, comparative risk assessment studies will put the whole life cycle of any energy source (i.e. production, storage, distribution, transport and waste) under scrutiny. Safety is directly connected to people's health, and this priority may easily conflict with the goal of energy security. As in the first scenario (Access to energy), but unlike the second scenario (Security of energy supply), safety standards must be implemented internationally if considered from an ethical perspective. But, EU research could provide the means to study the ramifications and risks of non-renewable and renewable energy sources alike. This priority belongs to the area of 'social' concerns, and is easily linked to environmental concerns too — insofar as environmental hazards easily translate into social risks or health issues. However, if safety 'trumps' any demand for energy security, it will become crucial to examine the criteria for risks. The precautionary principle is helpful in this respect, but it seems to be based on alternatives which might not be available in the sector of energy.

just a tactical approach based on cost reduction and the prospect of abundant short-term resources. The EU needs a moral vision that throws light on the structural and technological changes in order to move forward towards smart energy technology by 2050. This revolution or paradigm shift in energy systems needs to be accompanied by ethical criteria that guide public policy decisions.

In order to meet the energy challenge — how to provide everyone with sufficient energy to sustain their human dignity and health and to achieve their individual potential without damaging the carrying-capacity of the environment to sustain humans and other living species — all possible sources of energy must be objectively examined. It must be accepted that different solutions will be appropriate in different places and that they may change over time. It is a known fact that Europe's objective is to ultimately move to renewable, non-polluting energy sources and that, for this reason, the transition to such sources must be accelerated. The extraordinary complexity of the issue of energy emphasises the need to consider the full range of social, cultural, economic, technical, political and environmental barriers for making genuine and morally acceptable progress.

What seems to be needed is robust monitoring and continuous evaluation of each energy source. This requires the guidance of an appropriately designed ethical matrix or measurement tool in the context of both research prioritisation and technological development that ultimately reflects the ethical principles enshrined in the Charter. Responsible and reasonable balancing of options in the domain of research and use of our energy mix, particularly in critical and conflicting situations, calls for the ethical guidance of a sound and consistent roadmap that guarantees the right to access, security of supply, competitiveness, safety and sustainability. These objectives are not easily reconcilable.

The four ethical criteria which the EGE has identified in this chapter as requirements for any analysis of energy sources and utilisation, translate differently into the three main areas of social, economic, environmental concern. These assessment criteria are needed to evaluate and compare the complexity of different energy-related technologies and, at the same time, throw light on their future development. The main objective of these ethical criteria is to:

- assist political decision-making to provide more certainty to relevant stakeholders as regards possible future policy orientations at the EU level by their main social, economic, and environmental goals;
- show trade-offs among different policy objectives;
- help policymakers set milestones.

The well-being of present and future generations ultimately depends not only on the identification but also on the prioritisation of sound ethical criteria that enlighten and empower all stakeholders involved in the field of energy policies to reach an equilibrium of the social, economic and environmental concerns. The EU's ambitious energy policy cannot be reached without a collective effort, in a spirit of solidarity and justice, to analyse continuously in a critical way the different energy-related technologies, on a case-by-case basis, in the light of the ethical matrix discussed in the previous sections which mirror the ethical principles enshrined in the Charter of Fundamental Rights of the European Union. This is the only way forward in the field of energy for the benefit of both present and future generations!

4. Recommendations

Fossil fuels were the energy source that shaped 19th and 20th century life. Global energy consumption is set to triple by the end of this century, yet supplies of fossil fuels are rapidly being depleted. In addition, the consequences of their exploitation without adequate measures to reduce the production of gases that impact on the environment are serious. In this context, a question looms over humanity today: How will we meet increasing energy demands while ensuring we do not add to atmospheric greenhouse gases?

New and improved low-carbon technologies, in particular renewables, are vital if Europe is to meet the energy objectives set for 2020 and 2050 in relation to combating climate change, security of energy supply and competitiveness.

Ethical considerations are integral to the formation of energy policy. This ethical analysis requires that the production systems being considered are comparable: the analysis cannot only consider economic issues, but must consider the impact, positive or negative, that may occur during the entire *life cycle* of the system and this should encompass the impact on the environment and the implications of the use (or, indeed, cessation of use) of a particular energy source.

The following recommendations are based on the ethical framework proposed in this Opinion, by which actions and policies should be analysed with the express intention of delivering a sustainable future for Europe. The EGE has adopted an integrated ethics approach based on the cross-cutting principle of justice and the balance of subsidiarity and solidarity. Furthermore, the rationale for the following recommendations is to achieve the best possible *equilibrium* between the four criteria of analysis (access right, security, safety, and sustainability), in light of social, environmental and economic concerns.

4.1 Access to energy

Access to energy is an essential condition for human flourishing. A basic level of energy supply is, therefore, morally imperative. Article 36 of the Charter of Fundamental Rights of the European Union [136] advocates that EU citizens have a right to access to 'services of general economic interest' although energy is not explicitly specified as one of these services. The Charter also requires that everyone has the opportunity to contribute to shaping European Society, which, of course, includes use of energy services. The protection of the principle of equality in this respect is relevant in several domains of an individual's life, such as home, health, work and education.

The EGE welcomes actions taken by the European Commission in the energy sector and invites the EU to actively participate and promote access to energy services in European societies. The EGE recommends that:

- the EU secures and promotes the right of access to sufficient energy services to European citizens and this right to be included in the next revision of the Treaty or the Charter;
- in accordance with the Millennium Development Goals, the EU should collaborate to ensure access to energy within a global perspective.

The EGE acknowledges that energy poverty still exists in Europe, particularly at a time of rising fuel prices and decreasing household spending power.

The EGE recommends that:

- both quantitative and qualitative data on energy poverty should be collated and analysed across Member States by the Commission; on the basis of these data, the Commission should then prepare, adopt and implement an action plan to tackle energy poverty in the interests of solidarity and the health and well-being of European citizens.

4.2 Safety and impact assessment

Energy mix implies the production and use of different types of energy sources that all have inherent risks and limitations which must be considered during their entire life cycle. Safety considerations are, therefore, central elements for a responsible use, and policy

(136) Article 36: The Union recognises and respects access to services of general economic interest as provided for in national laws and practices, in accordance with the Treaty establishing the European Community, in order to promote the social and territorial cohesion of the Union.

design, of energy. Proper impact assessment methodologies to compare the security and safety of the energy mix instruments are necessary. Risk and impact assessments and stress tests of energy sources should use the best available data, be analysed by independent experts, be based on transparency, and cover the entire cycle of the energy scrutinised (production, transport, storage, residues, dismantling and permanent disposal of waste material, etc.) as well as collateral effects such as competition for land with food production.

Integrative approaches, seeking a balance of social, environmental and economic concerns, need to be established to properly reflect the multilayer complexity of the energy mix in the European Union. The EGE recommends the following.

- Data regarding any kind of elements that affect risk in the production and transport of energy, health and environmental consequences of its use, and the total costs of any kind of energy production, should be available in a well-informed and transparent way so that society informs itself in order to take decisions. The above should include (as examples): the energy balances (including energy spent in construction, transport, dismantling and permanent disposal of waste material); social, environmental and the economic impacts of the different energy sources such as biofuels (competition with food production and water availability), windmills (environmental impact), hydroelectric (flooding of soils and villages), photovoltaic (costs during the whole cycle, including the use of rare metals), nuclear (safety and long-term residues), fracking (gas emissions, water pollution, geological disruption), coal (air and water pollution, impact on communities if mining is abandoned), etc., including the contribution to climatic changes.

- Impact assessments of any energy source throughout its whole life cycle should be carried out on a comparative basis including the question of accountability.

- A comparative integrated impact assessment should be required for all energy sources, particularly new technologies. Such an assessment should also involve the participation of local communities at the earliest possible opportunity and assess impact and risks across the entire *life cycle* of the energy production, storage and use, in line with the Lisbon Treaty and the precautionary principle.

The group is aware that shale gas and shale oil are considered in the political debate to be a promising energy source for EU energy security and autonomy, and that decisions on whether to use this technology are complex and linked to multiple factors, including environmental protection, macroeconomic and geopolitical considerations. The Group, however, states that the European Union should commission studies to: (i) obtain additional data on the environmental and social impact of fracking; (ii) show the impact of shale gas on the transition to renewables; (iii) provide possibilities as to how to implement appropriate institutional oversight. The Group, therefore, agrees that, from an ethical viewpoint, if safety and environment issues remain following these studies, fracking should not be pursued within the EU unless these conditions are met.

4.3 Security of energy supply

Security of supply of energy is one of the main targets of domestic and European Union policies. Since the European Union is highly dependent on energy imports, energy supply is vulnerable. The energy mix, which is a national competence in the EU, is a very complex issue since national decisions affect European Union Member States and the European Union as a whole. It has been argued that these decisions are uncoordinated and may contradict EU energy targets. The EGE therefore recommends that the European Union:

- decreases its vulnerability to imported energy sources in a sustainable and environmentally sound manner;

- ensures a coordinated policy in the field of energy supply as well as energy mix in order to achieve European Union security of supply targets at national and European level;

- develops a European energy smart grid to secure and optimise energy supply by consolidating cooperation among European Union Member States in the spirit of solidarity and by developing decentralised systems to support the energy supply; furthermore, decentralised systems such as microgeneration of energy should be sustained when possible.

4.4 Sustainability

The current sources of energy rely mainly on energy stored in fossil reserves, such as oil, petrol and gas, which are, by definition, limited. Other energy sources, such as nuclear fission, are also dependent on limited raw materials. Energy systems based on the above materials are becoming less sustainable and alternative renewable energy tools have acquired a central role in the European and global debate on energy. Economy of energy is a central guiding principle in energy production and distribution and, for this reason, any action that improves efficiency and reduces energy waste should be implemented.

The conversion of energy stored in fossil fuels has determined significant climate consequences and induced the EU to adopt decarbonised energy policies for the future.

Current and future access to energy that is problematic due either to reduction of reserves or because of present environmental impact, which is a key factor in climate change, are issues that oblige decision-makers to confront the issues pertaining to intergenerational justice and responsibility.

The EU has already made choices in its energy and environmental policies to transition from non-renewable energy sources to renewables. However, this goal can only be achieved if the energy mix that is currently supported is regularly assessed in light of this overall goal. Given the current data on climate changes, the EGE recommends that the EU closely coordinates its policies with international environmental and economic expertise regarding the question of how quick the transition is possible and at what point the non-renewable and renewable energy mix becomes counterproductive. In the assessment, the comparative method proposed by the EGE should be elaborated and applied in a transparent way. The EGE recommends **that the European Union implements policies to**:

1. reduce emissions of carbon dioxide and other gases producing greenhouse effects in the production of energy, as stated in the Energy Roadmap 2050;

2. favour the development and use of low-carbon technologies with special attention to renewables, for example by fiscal and other relevant measures;

3. make every effort to improve energy efficiency and to reduce energy waste; particular attention should be paid to the following implementing measures to achieve this goal:

    (a) the establishment of smart grids;

    (b) encouraging incentives and establishing normative requirements to reduce and distribute energy production and uses in the field of transport, construction, heating, etc. (non-essential energy uses, incentives to build energy-efficient urban renovation);

    (c) promoting actions to promote availability of renewable technologies to vulnerable groups of society;

4. enhance the awareness of citizens (starting from an early age) regarding the need to adopt new attitudes and lifestyles for the responsible use of energy by promoting and financing educational projects and awareness-raising initiatives (e.g. promoting sustainability in schools);

5. evaluate the different Member States' strategies on a regular basis, particularly in light of the policies to use 'conventional', low-carbon and 'renewable' energy sources.

4.5 Research

Research on energy is crucial if the European Union goals and targets stated in the Energy Roadmap 2050 are to be achieved. Research priorities need to be consistent with these goals and targets and should include the integrated ethics approach that the EGE has adopted in this Opinion. The EGE stresses the need for Europe to invest in research on low-carbon technologies, in particular renewable energy. For these reasons, the EGE recommends that priorities for research should be identified and should include:

- research on technologies that would contribute to the development of European smart grid infrastructure that is configured so as to have sufficient capability to harness the potential benefits of low-carbon and renewable technologies, in particular when decentralised energy production is developed;

- research on new technologies for the storage of energy where and when an excess is produced in order to facilitate the use of energies that are intermittent;

- interdisciplinary research on the storage and transport of materials and the residues related to energy production and use;

- analyses of the residues from different energy sources, their reduction or elimination and possible reuse — research to determine the most suitable technologies, regulations and infrastructures for future carbon capture, storage and sequestration;

- research on energy efficiency in all areas, but particularly in urban design and architecture, transport, utilities and industrial facilities;
- research funding being allocated to ongoing work in the area of psychosocial modelling of individual and community behavioural interventions in the area of energy conservation in order to support energy-efficiency initiatives in setting new standards beyond current best practice.

A balance between research on different sources of energy has to be decided and the reasons for that need to be spelled out (and made public):

- comparative studies on the implementation of the Energy Roadmap 2050 in European Union Member States (quantitative and qualitative data), with specific emphasis on sociocultural and geographical factors that have justified the adoption of specific energy mix systems at local level;
- comparative impact assessments of all energy sources, using the integrated methodology of technological, social, and political scenarios — this should include scenarios of worst case (social, environmental), short and long-term prognoses, geopolitical contexts and safety risks for workers;
- social sciences (individual responsibilities), psychology, social anthropology, sociology, ethics and law.

The EGE is of the view that, as argued in previous Opinions, the development of science and technology requires critical and independent ethical analysis which can be facilitated by supporting a community of experts. In order to help this process, the Group therefore recommends that interdisciplinary research on the ethical, legal and social implication (thematic programme) of energy to be financed under Horizon 2020.

4.6 Democratic deliberation, participatory instruments and responsibility for future generations

Democratic deliberation is essential in making choices on how citizens respond to the challenges of energy production and uses. Several instruments have been explored in the last decades to strengthen participatory mechanisms.

The EGE recommends that the European Union should set incentives to implement participatory approaches, for example in the following areas:

- civil society 'hearings';
- local and regional energy cooperatives;
- local initiatives to save energy;
- local and regional initiatives for low-carbon urban development and community design.

Both spatial and temporal dimensions of the consequences of human activity play a crucial role in the ethics of energy. Consequently, the present generation faces the ethical challenge to broaden its moral perspective by taking seriously into account the long-term effects of its decisions and actions on posterity. This challenge is based on the demands of social justice that appeal to the principle that a community has the moral duty to give particular help to those who are disadvantaged out of human solidarity.

Therefore, the EGE recommends that:

- the European Union and its institutions should set up an 'ombudsperson' structure to protect the interests of future generations; the function of this office would not be to decide, but to promote enlightened decisions by bringing into discussions the long-term effects of all political, socioeconomic and technological decisions.

The European Group on Ethics in Science and New Technologies

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4. Recommandations

Les combustibles fossiles ont été la source d'énergie qui a façonné la vie des XIX[e] et XX[e] siècle. Alors que la consommation mondiale d'énergie devrait tripler d'ici à la fin du siècle, les réserves de combustibles fossiles diminuent rapidement. En outre, les conséquences de leur exploitation sont considérables sans les nécessaires mesures adéquates destinées à réduire la production de gaz nocifs pour l'environnement. Dans ce contexte, deux questions planent aujourd'hui au-dessus de l'humanité: comment répondre à l'augmentation de la demande d'énergie sans augmenter nos rejets de gaz à effet de serre dans l'atmosphère?

Les technologies à faible intensité de carbone, qu'il s'agisse de nouvelles technologies ou de technologies améliorées, notamment les énergies renouvelables, sont essentielles pour que l'Europe puisse atteindre les objectifs énergétiques qu'elle s'est fixés pour 2020 et 2050 en ce qui concerne la lutte contre le changement climatique, la sécurité d'approvisionnement en énergie et la compétitivité.

Les considérations éthiques font partie intégrante de la définition de la politique dans ce domaine. Cette analyse éthique requiert que les systèmes de production examinés soient comparables. L'analyse ne peut porter uniquement sur les questions économiques, mais doit tenir compte des incidences, positives ou négatives, qui peuvent se produire sur l'ensemble du *cycle de vie* du système, dont l'incidence sur l'environnement et les implications de l'utilisation (voire de l'abandon de l'utilisation) d'une source d'énergie donnée.

Les recommandations qui suivent se fondent sur le cadre éthique proposé dans le présent avis, à l'aune duquel les actions et politiques devraient être analysées dans le but exprès de garantir un avenir durable pour l'Europe. Le GEE a adopté une approche éthique intégrée, fondée sur le principe transversal de justice et sur l'équilibre entre subsidiarité et solidarité. En outre, la raison d'être des recommandations suivantes est de trouver le meilleur équilibre possible entre les quatre critères d'analyse (droit d'accès, sécurité, sûreté et durabilité), à la lumière des préoccupations sociales, environnementales et économiques.

4.1 Accès à l'énergie

L'accès à l'énergie est une condition essentielle de la prospérité humaine. Un niveau minimal d'approvisionnement en énergie est donc moralement impératif. L'article 36 de la charte des droits fondamentaux de l'Union européenne ([74]) défend un droit d'accès pour les citoyens de l'Union européenne aux «services d'intérêt économique général». L'énergie n'est pas explicitement mentionnée parmi ces services. Néanmoins, la charte exige également que chacun ait la possibilité de contribuer à façonner la société européenne, ce qui comprend évidemment l'utilisation de services énergétiques. À cet égard, la protection du principe d'égalité de traitement est utile dans plusieurs domaines de la vie d'une personne, tels que la vie domestique, la santé, le travail et l'éducation.

Le Groupe européen d'éthique des sciences et des nouvelles technologies (GEE) se félicite de l'action de la Commission européenne dans le secteur de l'énergie et invite l'Union à participer activement à la promotion de l'accès aux services énergétiques dans les sociétés européennes. Le GEE recommande:

- que l'Union garantisse et promeuve le droit d'accès des citoyens européens à des services énergétiques suffisants et que ce droit soit inclus dans la prochaine révision du traité ou de la charte des droits fondamentaux;
- que, conformément aux objectifs du millénaire pour le développement, l'Union collabore avec ses partenaires en vue d'assurer l'accès à l'énergie dans une perspective mondiale.

Le GEE reconnaît que la pauvreté énergétique existe toujours en Europe, en particulier en cette période de hausse des prix du pétrole et de baisse du pouvoir d'achat des ménages.

Le GEE recommande:

- que des données tant quantitatives que qualitatives sur la pauvreté énergétique soient rassemblées et analysées dans les États membres par la Commission. Sur la base de ces données, la Commission devrait alors élaborer, adopter et mettre en œuvre un plan d'action pour lutter contre la pauvreté énergétique dans un souci de solidarité et au bénéfice de la santé et du bien-être des citoyens européens.

([74]) «L'Union reconnaît et respecte l'accès aux services d'intérêt économique général tel qu'il est prévu par les législations et pratiques nationales, conformément au traité instituant la Communauté européenne, afin de promouvoir la cohésion sociale et territoriale de l'Union.»

4.2 Sécurité et analyse d'impact

Le bouquet énergétique implique la production et l'utilisation de différents types de sources d'énergie qui présentent toutes des risques et contraintes intrinsèques dont il convient de tenir compte sur l'ensemble du cycle de vie. Les considérations liées à la sécurité sont donc des éléments déterminants pour une utilisation responsable de l'énergie et la définition des politiques en la matière. Des méthodes appropriées d'analyse d'impact permettant de comparer la sécurité et la sûreté des instruments du bouquet énergétique sont nécessaires. L'évaluation des risques et des incidences ainsi que les tests de résistance portant sur les sources d'énergie doivent reposer sur les meilleures données disponibles, analysées par des experts indépendants et conformes au principe de transparence, et couvrir l'ensemble du cycle de vie de la source d'énergie considérée (production, transport, stockage, résidus, démantèlement et évacuation définitive des déchets, etc.) ainsi que les effets collatéraux tels que la concurrence avec les terres destinées à la production alimentaire.

Des approches intégratives, visant un équilibre entre les considérations sociales, environnementales et économiques, doivent être établies afin d'appréhender au mieux la complexité multifactorielle associée au bouquet énergétique de l'Union européenne. Le GEE recommande:

- que des données concernant tout type d'élément ayant une incidence sur les risques dans la production et le transport de l'énergie, les conséquences de son utilisation en matière de santé et d'environnement ainsi que les coûts totaux de tout type de production d'énergie soient disponibles sous une forme probante et transparente, de sorte que la société soit informée en vue de prendre des décisions. Ce qui précède inclut, à titre d'exemple: les bilans énergétiques (y compris l'énergie dépensée dans la construction, le transport, le démantèlement et l'évacuation définitive des déchets), les incidences sociales, environnementales et économiques des différentes sources d'énergie telles que les biocarburants (concurrence avec la production de denrées alimentaires et disponibilité de l'eau), les éoliennes (incidences sur l'environnement), l'hydroélectricité (inondations des sols et des villages), l'énergie photovoltaïque (coûts sur toute la durée du cycle de vie, y compris l'utilisation de métaux rares), le nucléaire (sûreté et déchets à long terme), la fracturation (émissions de gaz, pollution de l'eau, rupture de la structure géologique), le charbon (pollution de l'air et de l'eau, impact sur les collectivités lorsque l'extraction minière est abandonnée), etc. La contribution au changement climatique doit également être prise en compte;
- qu'une analyse d'impact de l'ensemble des sources d'énergie tout au long de leur cycle de vie soit effectuée sur une base comparative et tienne compte de la question de la responsabilité;
- qu'une analyse d'impact intégrée comparative soit requise pour toutes les sources d'énergie, en particulier pour les nouvelles technologies. Cette analyse devrait également prévoir la participation des collectivités locales au stade le plus précoce possible et évaluer les incidences et les risques sur l'ensemble du *cycle de vie* de la production, du stockage et de l'utilisation de l'énergie, en accord avec le traité de Lisbonne et le principe de précaution.

Le Groupe est conscient que le gaz de schiste et le schiste bitumineux sont considérés, dans le débat politique, comme une source d'énergie prometteuse pour la sécurité et l'autonomie énergétiques de l'Union et que les décisions sur l'opportunité d'utiliser cette technologie sont complexes et liées à de multiples facteurs, dont la protection de l'environnement et des considérations macroéconomiques et géopolitiques. Le Groupe déclare toutefois que l'Union européenne devrait faire réaliser des études pour 1) obtenir des données complémentaires sur les effets environnementaux et sociaux de la fracturation, 2) montrer l'incidence du gaz de schiste sur la transition vers les énergies renouvelables et 3) fournir des possibilités quant à la manière de mettre en œuvre un contrôle institutionnel approprié. Le Groupe s'accorde donc à reconnaître, d'un point de vue éthique, que si les problèmes liés à la sécurité et à l'environnement persistent à la suite de ces études, la fracturation ne devrait pas se poursuivre au sein de l'Union, à moins que ces conditions ne soient remplies.

4.3 Sécurité d'approvisionnement en énergie

La sécurité d'approvisionnement en énergie est l'un des principaux objectifs des politiques nationales et de l'Union européenne. Dans la mesure où l'Union est fortement tributaire des importations d'énergie, son approvisionnement énergétique est vulnérable.

Le bouquet énergétique, qui relève de la compétence nationale dans l'Union européenne, est une question très complexe étant donné que les décisions nationales affectent les États membres de l'Union européenne et l'Union dans son ensemble. D'aucuns font valoir que ces décisions ne sont pas coordonnées et qu'elles peuvent être en contradiction avec les objectifs de l'Union en matière d'énergie. Le GEE recommande dès lors que l'Union européenne:

- réduise de manière durable et écologiquement rationnelle sa vulnérabilité à l'égard des sources d'énergie importées;

- assure une politique coordonnée en matière d'approvisionnement énergétique et de bouquet énergétique afin d'atteindre les objectifs de l'Union européenne relatifs à la sécurité d'approvisionnement aux niveaux national et européen;

- développe des réseaux énergétiques intelligents pour sécuriser et optimiser l'approvisionnement énergétique, en renforçant la coopération entre les États membres de l'Union européenne dans un esprit de solidarité et en mettant en place des systèmes décentralisés à l'appui de l'approvisionnement énergétique. Plus encore, les systèmes décentralisés, tels que la microproduction d'énergie, devraient être soutenus lorsque cela est possible.

4.4 Durabilité

Les sources actuelles d'énergie reposent principalement sur l'énergie stockée dans les réserves fossiles, comme le pétrole, l'essence et le gaz, qui sont, par définition, limitées. D'autres sources d'énergie, telles que la fission nucléaire, dépendent également de matières premières limitées. Les systèmes énergétiques tributaires des matières premières précitées deviennent moins durables et d'autres sources d'énergie renouvelables ont acquis une place centrale dans le débat qui se tient à l'échelle mondiale et européenne dans le domaine de l'énergie. Les économies d'énergie constituent un principe directeur clé dans la production et la distribution d'énergie, raison pour laquelle toute mesure qui permet d'améliorer l'efficacité énergétique et de réduire le gaspillage d'énergie devrait être mise en œuvre.

La conversion de l'énergie stockée dans les combustibles fossiles a eu des conséquences considérables sur le climat, ce qui a amené l'Union européenne à adopter des politiques visant à instaurer un système énergétique sans carbone.

L'accès présent et futur à l'énergie, qui est problématique en raison soit d'une réduction des réserves soit des répercussions actuelles sur l'environnement, qui sont un facteur clé du changement climatique, est une question qui contraint les décideurs à se pencher sur les questions de justice et de responsabilité intergénérationnelles.

Dans ses politiques énergétique et environnementale, l'Union a déjà posé certains choix en faveur d'une transition des sources d'énergie non renouvelables vers les sources d'énergie renouvelables. Toutefois, cet objectif ne peut être atteint que si le bouquet énergétique qui est actuellement défendu est régulièrement évalué à la lumière de cet objectif général. Compte tenu des données actuelles sur le changement climatique, le GEE recommande que l'Union coordonne étroitement ses politiques avec la réflexion internationale en matière économique et environnementale en ce qui concerne la question de savoir à quelle vitesse cette transition peut s'opérer et à partir de quand la combinaison des sources d'énergie renouvelables et non renouvelables devient contre-productive. Lors de cette évaluation, la méthode comparative proposée par le GEE devrait être précisée et appliquée d'une manière transparente. Le GEE recommande **que l'Union européenne mette en œuvre des politiques visant à:**

1) réduire les émissions de dioxyde de carbone et d'autres gaz à effet de serre lors de la production d'énergie, comme indiqué dans la feuille de route européenne pour l'énergie à l'horizon 2050;

2) favoriser la mise au point et l'utilisation de technologies à faible intensité de carbone, en accordant une attention particulière aux sources d'énergie renouvelables, par exemple au moyen de mesures fiscales et d'autres mesures appropriées;

3) assurer par tous les moyens l'amélioration de l'efficacité énergétique et la réduction du gaspillage d'énergie. Pour atteindre cet objectif, une attention particulière devrait être accordée aux mesures suivantes:

    a) mise en place de réseaux intelligents,

    b) mesures d'incitation et exigences normatives afin de réduire et de répartir la production et l'utilisation d'énergie dans les domaines des transports, de la construction, du chauffage, etc. (utilisations énergétiques non essentielles, incitations à intégrer l'efficacité énergétique dans la rénovation urbaine),

c) actions visant à promouvoir la disponibilité des technologies renouvelables pour les groupes vulnérables de la société;

4) sensibiliser les citoyens (dès le plus jeune âge) à l'adoption de nouveaux comportements et modes de vie propices à une utilisation responsable de l'énergie, par la promotion et le financement de projets pédagogiques et d'actions de sensibilisation (par exemple la promotion de la durabilité dans les écoles);

5) évaluer régulièrement les différentes stratégies des États membres, notamment au regard des politiques concernant l'utilisation des sources d'énergie «conventionnelles», «à faible intensité de carbone» et «renouvelables».

4.5 Recherche

La recherche dans le domaine de l'énergie est essentielle si l'on veut atteindre les objectifs et cibles de l'Union européenne fixés dans la feuille de route pour 2050. Les priorités de recherche doivent être cohérentes avec ces derniers et devraient inclure l'approche intégrée en matière d'éthique que le GEE a adoptée dans le présent avis. Le GEE souligne la nécessité pour l'Europe d'investir dans la recherche sur les technologies à faible intensité de carbone, en particulier les énergies renouvelables. Pour ces raisons, le GEE recommande que des priorités de recherche soient définies et qu'elles englobent les éléments suivants:

- les technologies susceptibles de contribuer au développement d'une infrastructure européenne de réseaux intelligents configurée de manière à offrir suffisamment de capacité pour exploiter les avantages potentiels des technologies à faible intensité de carbone et des technologies liées aux sources renouvelables, en particulier lorsque la production décentralisée d'énergie se développera;

- les nouvelles technologies de stockage de l'énergie lorsque la production est excédentaire, afin de faciliter l'utilisation des énergies intermittentes;

- les travaux de recherche interdisciplinaires sur le stockage et le transport des matières et résidus liés à l'utilisation et à la production d'énergie;

- l'analyse de la production de résidus liée aux différentes sources d'énergie, la réduction ou l'élimination de ces résidus et leur éventuelle réutilisation; la recherche en vue de déterminer les technologies, réglementations et infrastructures futures les plus appropriées pour le piégeage et le stockage du carbone;

- l'efficacité énergétique dans tous les domaines, mais particulièrement l'urbanisme et l'architecture, les transports, les services d'utilité publique et les installations industrielles;

- le financement qui devrait être consacré aux travaux de recherche en cours dans le domaine de la modélisation psychosociale des actions visant à modifier les comportements individuels et collectifs influençant la conservation de l'énergie, afin de soutenir des initiatives en matière d'efficacité énergétique de nature à relever les normes au-delà des meilleures pratiques actuelles.

Un équilibre entre la recherche sur les différentes sources d'énergie doit être trouvé et les décisions correspondantes doivent être motivées (et rendues publiques):

- des études comparatives concernant la mise en œuvre de la feuille de route européenne sur l'énergie à l'horizon 2050 dans les États membres de l'Union (données quantitatives et qualitatives), avec une attention particulière pour les facteurs socioculturels et géographiques qui ont justifié l'adoption de bouquets énergétiques spécifiques au niveau local;

- une analyse d'impact comparative de toutes les sources d'énergie, sur la base de la méthode intégrée des scénarios technologiques, sociaux et politiques. Il s'agit notamment d'envisager le scénario du cas le plus défavorable (social et environnemental), les prévisions à court terme et à long terme, les contextes géopolitiques et les risques de sécurité pour les travailleurs;

- les sciences sociales (responsabilités individuelles), la psychologie, l'anthropologie sociale, la sociologie, l'éthique et le droit.

Le GEE estime, comme il l'a fait valoir dans des avis précédents, que le développement des sciences et de la technologie requiert une analyse éthique critique et indépendante, qui peut requérir le soutien d'un groupe d'experts. Afin de faciliter ce processus, le Groupe recommande par conséquent que la recherche interdisciplinaire sur les implications éthiques, juridiques et sociales (programme thématique) de l'énergie soit financée dans le cadre du programme «Horizon 2020».

4.6 Délibération démocratique, procédures de participation et responsabilité envers les générations futures

La délibération démocratique est indispensable si l'on veut effectuer des choix sur la manière dont les citoyens répondent aux défis de la production et de l'utilisation de l'énergie. Plusieurs outils ont été explorés au cours des dernières décennies pour renforcer les mécanismes participatifs.

Le GEE recommande que l'Union européenne adopte des mesures d'incitation visant à mettre en œuvre des approches participatives, par exemple dans les domaines suivants:

- «auditions» de la société civile;
- coopératives locales et régionales dans le domaine de l'énergie;
- initiatives locales visant à économiser l'énergie;
- initiatives locales et régionales concernant un développement urbain et des aménagements collectifs à faible intensité de carbone.

La dimension spatiale comme la dimension temporelle des effets de l'activité humaine jouent un rôle crucial dans l'éthique de l'énergie. Par conséquent, la génération actuelle est confrontée au défi éthique d'élargir sa perspective morale en prenant sérieusement en compte les effets à long terme de ses décisions et actions sur la postérité. Ce défi découle des exigences de justice sociale, selon le principe qu'une communauté a le devoir moral d'accorder une aide particulière à ceux qui sont défavorisés, par solidarité humaine.

Le GEE recommande par conséquent:

- que l'Union européenne et ses institutions mettent en place une structure de médiation («ombudsperson»), pour protéger les intérêts des générations futures. Sa fonction ne serait pas de prendre des décisions, mais de promouvoir des décisions éclairées en intégrant dans les discussions les effets à long terme de toutes les décisions politiques, socio-économiques et technologiques.

4. Empfehlungen

Fossile Brennstoffe waren die Energiequelle, die das Leben im 19. und im 20. Jahrhundert geprägt hat. Der weltweite Energieverbrauch soll sich bis Ende dieses Jahrhunderts verdreifachen; die Vorräte an fossilen Brennstoffen werden aber schon bald erschöpft sein. Hinzu kommt, dass deren Ausbeutung ohne angemessene Maßnahmen zur Reduzierung des Ausstoßes umweltschädigender Gase gravierende Konsequenzen hat. Vor diesem Hintergrund stellen sich heute zwei große Fragen für die Menschheit: Wie können wir die steigende Energienachfrage decken und gleichzeitig sicherstellen, dass wir nicht noch mehr Treibhausgase produzieren?

Neue und verbesserte Technologien mit geringem CO_2-Ausstoß, insbesondere erneuerbare Energien, sind von fundamentaler Bedeutung, wenn Europa die für 2020 und 2050 mit Blick auf Klimaschutz, Energieversorgungssicherheit und Wettbewerbsfähigkeit anvisierten energiepolitischen Ziele erreichen will.

Ethische Erwägungen sind integraler Bestandteil bei der Formulierung energiepolitischer Konzepte. Eine Analyse unter ethischen Gesichtspunkten setzt voraus, dass die betrachteten Produktionssysteme vergleichbar sind. Die Analyse darf sich nicht auf wirtschaftliche Aspekte beschränken, sondern muss die – positiven und negativen – Auswirkungen berücksichtigen, zu denen es während der gesamten Lebensdauer eines Systems kommen kann; dazu zählen sowohl die Umweltauswirkungen als auch die Konsequenzen der Nutzung (oder des Ausstiegs aus der Nutzung) bestimmter Energiequellen.

Die nachstehenden Empfehlungen basieren auf dem in dieser Stellungnahme vorgeschlagenen ethischen Rahmen, dem zufolge Maßnahmen und politische Strategien mit der ausdrücklichen Absicht analysiert werden sollten, eine tragfähige Zukunft für Europa zu sichern. Die EGE hat sich für einen integrativen ethischen Ansatz entschieden, der auf dem Querschnittsprinzip der Gerechtigkeit und einem ausgewogenen Verhältnis zwischen Subsidiarität und Solidarität basiert. Darüber hinaus zielen die nachstehenden Empfehlungen darauf ab, unter Berücksichtigung sozialer, ökologischer und wirtschaftlicher Anliegen ein bestmögliches Gleichgewicht zwischen den vier zugrunde gelegten Analysekriterien (Recht auf Zugang, Versorgungssicherheit, Sicherheit und Nachhaltigkeit) zu gewährleisten.

4.1 Zugang zu Energie

Der Zugang zu Energie ist eine wesentliche Voraussetzung für das Wohlergehen der Menschheit. Eine Energiegrundversorgung ist somit ein Gebot der Moral. In Artikel 36 der Charta der Grundrechte der Europäischen Union ([74]) ist das Recht der EU-Bürgerinnen und -Bürger auf Zugang zu „Dienstleistungen von allgemeinem wirtschaftlichen Interesse" verankert. Energiedienstleistungen werden dabei nicht explizit aufgeführt. Die Europäische Grundrechtecharta verlangt zudem, dass jeder Mensch die Möglichkeit hat, an der Gestaltung der europäischen Gesellschaft mitzuwirken, was selbstverständlich auch die Inanspruchnahme von Energiedienstleistungen einschließt. Hier ist die Wahrung des Gleichheitsgrundsatzes in verschiedenen Lebensbereichen des Einzelnen von Bedeutung – ob es um Wohnung, Gesundheit, Arbeit oder Bildung geht.

Die EGE begrüßt die von der Europäischen Kommission im Energiesektor getroffenen Maßnahmen und fordert die EU auf, einen aktiven Beitrag zu leisten, um den Zugang zu Energie in den europäischen Gesellschaften zu verbessern. Die EGE empfiehlt,

- dass die EU das Recht der europäischen Bürgerinnen und Bürger auf Zugang zu ausreichenden Energiedienstleistungen gewährleistet und fördert und dass dieses Recht bei der nächsten Überarbeitung des Vertrags dortselbst oder in die Grundrechtecharta Eingang findet;

- dass die EU – im Einklang mit den Millenniumszielen – daran mitwirkt, den Zugang zu Energie in einer globalen Perspektive sicherzustellen.

Die EGE stellt fest, dass es in Europa nach wie vor Energiearmut gibt, gerade in Zeiten steigender Kraftstoffpreise und einer abnehmenden Kaufkraft der privaten Haushalte.

Die EGE empfiehlt,

- dass die Kommission für alle Mitgliedstaaten quantitative und qualitative Daten über Energiearmut zusammenträgt und analysiert und anschließend

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([74]) Artikel 36: „Die Union anerkennt und achtet den Zugang zu Dienstleistungen von allgemeinem wirtschaftlichen Interesse, wie er durch die einzelstaatlichen Rechtsvorschriften und Gepflogenheiten im Einklang mit den Verträgen geregelt ist, um den sozialen und territorialen Zusammenhalt der Union zu fördern."

auf der Grundlage dieser Daten einen Aktionsplan zur Bekämpfung von Energiearmut – im Interesse der Solidarität und von Gesundheit und Wohlergehen der europäischen Bürgerinnen und Bürger – ausarbeitet, beschließt und umsetzt.

4.2 Sicherheitsbewertung und Folgenabschätzung

Energiemix bedeutet, dass unterschiedliche Arten von Energie aus unterschiedlichen Quellen erzeugt und genutzt werden. Ihnen allen sind Risiken und Grenzen immanent, welche über ihre gesamte Lebensdauer hinweg zu berücksichtigen sind. Mit Blick auf eine verantwortungsvolle Energienutzung und eine verantwortungsvolle Energiepolitik sind Sicherheitsüberlegungen somit unterlässlich. Erforderlich sind angemessene Folgenabschätzungsmethoden, die einen Vergleich der Energiemixinstrumente unter den Aspekten Sicherheit und Gefahrenabwehr ermöglichen. Risikobewertungen, Folgenabschätzungen und Stresstests für Energieträger sollten sich auf die besten verfügbaren – von unabhängigen Experten analysierten und transparent erhobenen – Daten stützen und den gesamten Zyklus (Erzeugung, Transport, Lagerung, Rückstände, Unschädlichmachung und Entsorgung von Abfällen usw.) einschließlich etwaiger Nebeneffekte berücksichtigen, wie etwa die Konkurrenz mit der Nahrungsmittelproduktion um Agrarflächen.

Es müssen Gesamtkonzepte entwickelt werden, die auf ein ausgewogenes Verhältnis zwischen sozialen, ökologischen und wirtschaftlichen Aspekten abstellen und der Vielschichtigkeit und Komplexität des Energiemixes in der Europäischen Union angemessen Rechnung tragen. Die EGE empfiehlt,

- dass Daten zu Faktoren, die die Risiken bei Erzeugung und Transport von Energie beeinflussen, zu den Folgen von deren Nutzung für Gesundheit und Umwelt und zu den Gesamtkosten jeder Art der Energieerzeugung verfügbar gemacht werden, so dass eine ausreichende Information und Transparenz gewährleistet ist und die Gesellschaft sich im Hinblick auf anstehende Entscheidungen selbst kundig machen kann; die einschlägigen Daten sollten (beispielsweise) Folgendes abdecken: die Energiebilanz (einschließlich des Energieeinsatzes bei Bauarbeiten, Transport, Unschädlichmachung und Entsorgung von Abfällen) sowie die sozialen, ökologischen und wirtschaftlichen Auswirkungen der verschiedenen Energieträger wie Biokraftstoffe (Konkurrenz mit Nahrungsmittelerzeugung und Wasserverfügbarkeit), Windräder (Umweltauswirkungen), Wasserkraft (Flutungen von Böden und Dörfern), Fotovoltaik (Kosten während der gesamten Lebensdauer, einschließlich Verwendung seltener Metalle), Kernenergie (Sicherheit und Endlagerung), Fracking (Gasemissionen, Wasserverschmutzung, geologische Störungen), Kohle (Luft- und Wasserverschmutzung, Folgen einer Einstellung von Bergbautätigkeiten für die betreffenden Kommunen) usw., und zwar unter Berücksichtigung des jeweiligen Anteils am Klimawandel;

- dass für alle Energiequellen über ihre gesamte Lebensdauer hinweg vergleichende Folgenabschätzungen durchgeführt werden, wobei auch der Aspekt der Haftung zu berücksichtigen ist;

- dass eine vergleichende, integrative Folgenabschätzung für alle Energiequellen, insbesondere für neue Technologien, verlangt wird; im Rahmen einer solchen Bewertung sollten zum frühestmöglichen Zeitpunkt auch die Kommunen eingebunden und die Auswirkungen und Risiken bei Erzeugung, Lagerung und Nutzung von Energie über den gesamten Lebenszyklus hinweg – im Einklang mit dem Vertrag von Lissabon und dem Vorsorgeprinzip – beurteilt werden.

Die Gruppe ist sich dessen bewusst, dass Schiefergas und Schieferöl in der politischen Debatte mit Blick auf die Energieversorgungssicherheit und die Autonomie der EU als vielversprechende Energiequellen gesehen werden und dass Entscheidungen über die Nutzung dieser Technologie komplex sind und einer Vielzahl von Faktoren Rechnung tragen müssen, unter anderem ökologischen, makroökonomischen und geopolitischen Erwägungen. Die Gruppe weist jedoch darauf hin, dass die Europäische Union Studien in Auftrag geben sollte, um 1. zusätzliche Daten über die ökologischen und sozialen Auswirkungen des Fracking verfügbar zu machen, 2. die Auswirkungen der Schiefergasförderung auf den Übergang zu erneuerbaren Energien zu untersuchen und 3. Möglichkeiten aufzuzeigen, wie eine geeignete institutionelle Kontrolle gewährleistet werden kann. Deshalb gelangt die Gruppe übereinstimmend zu der Auffassung, dass, wenn diesen Studien zufolge weiterhin Sicherheits- und Umweltbelange ungeklärt bleiben, aus ethischen Gründen von der Fracking-Technologie in der EU Abstand genommen werden sollte, solange nicht die erforderlichen Voraussetzungen gegeben sind.

4.3 Energieversorgungssicherheit

Energieversorgungssicherheit ist eines der Hauptziele der nationalen Politik wie auch der Politik der

Europäischen Union. Da die Europäische Union in hohem Maße von Energieimporten abhängig ist, ist die Energieversorgung anfällig. Die Festlegung des Energiemixes, die in der EU in die nationale Zuständigkeit fällt, ist äußerst komplex, da nationale Entscheidungen auch die Mitgliedstaaten der Europäischen Union und die Europäische Union als Ganzes betreffen. Es werden Befürchtungen geäußert, dass solche Entscheidungen ohne jegliche Abstimmung getroffen werden und den energiepolitischen Zielen der EU zuwiderlaufen können. Daher empfiehlt die EGE, dass die Europäische Union

- ihre aus der Abhängigkeit von importierten Energieträgern resultierende Verwundbarkeit auf nachhaltige und umweltverträgliche Weise mindert;

- eine Koordinierung in Bezug auf Energieversorgungspolitik und Energiemix sicherstellt, um die Ziele der Europäischen Union im Bereich der Energieversorgungssicherheit sowohl auf nationaler als auch auf europäischer Ebene zu erreichen;

- zur Sicherung und Optimierung der Energieversorgung durch eine Konsolidierung der Zusammenarbeit zwischen den Mitgliedstaaten der Europäischen Union im Geiste der Solidarität intelligente europäische Energienetze aufbaut und dezentrale Systeme zur Unterstützung der Energieversorgung entwickelt; darüber hinaus sollten – soweit möglich – dezentrale Systeme wie die Mikroerzeugung von Energie gefördert werden.

4.4 Nachhaltigkeit

Die derzeitigen Energieträger nutzen in erster Linie Energie, die in – per definitionem begrenzten – fossilen Ressourcen wie Öl, Brennstoffen und Gas gespeichert ist. Auch andere Energiequellen wie etwa die Kernspaltung hängen von Rohstoffen ab, die nur begrenzt verfügbar sind. Energiesysteme, die auf den oben genannten Stoffen basieren, sind immer weniger tragbar, und alternative, erneuerbare Energieträger spielen inzwischen in der europäischen und der weltweiten Energiedebatte eine wichtige Rolle. Energieeinsparung ist ein zentrales Leitprinzip bei der Energieerzeugung und -verteilung. Deshalb sollten alle Maßnahmen ergriffen werden, die zu einer höheren Effizienz und einer Reduzierung des Energieverbrauchs beitragen können.

Die Umwandlung der in fossilen Brennstoffen gespeicherten Energie hat erhebliche Konsequenzen für das Klima, was die EU dazu bewogen hat, eine Dekarbonisierungspolitik für die Zukunft auf den Weg zu bringen.

Der gegenwärtige und künftige Zugang zu Energie, der sowohl aufgrund des Schwindens der Reserven als auch angesichts der Umweltauswirkungen – eines entscheidenden Faktors für den Klimawandel – Probleme aufwirft, zwingt die Entscheidungsträger, sich mit Fragen der Generationengerechtigkeit und -verantwortung auseinanderzusetzen.

Die EU hat mit ihrer Energie- und Umweltpolitik bereits Entscheidungen zugunsten eines Übergangs von nichterneuerbaren zu erneuerbaren Energiequellen getroffen. Dieses Ziel kann jedoch nur dann erreicht werden, wenn der Energiemix, auf den derzeit gesetzt wird, regelmäßig im Lichte dieses übergeordneten Ziels bewertet wird. Angesichts der aktuellen Daten zum Klimawandel empfiehlt die EGE, dass die EU ihre Politik eng an internationalen ökologischen und ökonomischen Expertisen ausrichtet, wenn es um die Fragen geht, wie rasch der Übergang vollzogen werden kann und ab wann der Energiemix aus nichterneuerbaren und erneuerbaren Energien kontraproduktiv wird. Im Zuge der Bewertungsarbeiten sollte eine vergleichende Methodik – wie von der EGE vorgeschlagen – ausgearbeitet und auf transparente Weise angewandt werden. Die EGE empfiehlt, dass die Europäische Union Maßnahmen trifft, um

1. die Emissionen von Kohlendioxid und anderen Treibhausgasen bei der Energieerzeugung zu reduzieren, wie im Energiefahrplan 2050 ins Auge gefasst;

2. durch fiskalische oder andere zweckdienliche Maßnahmen die Entwicklung und Nutzung von Technologien mit geringem CO_2-Ausstoß unter besonderer Berücksichtigung erneuerbarer Energien zu fördern;

3. sicherzustellen, dass alle möglichen Anstrengungen zur Verbesserung der Energieeffizienz und zur Reduzierung des Energieverbrauchs unternommen werden, wobei – mit Blick auf die Realisierung dieses Ziels – folgenden Umsetzungsmaßnahmen besonderes Augenmerk gelten sollte:

   a) Aufbau intelligenter Netze,

   b) Förderung von Anreizen und Festlegung normativer Anforderungen mit dem Ziel, Energieerzeugung und -nutzung in den Bereichen

Verkehr, Baugewerbe, Heizen usw. (Energienutzungen von nachrangiger Bedeutung, Anreize für energieeffiziente Stadtsanierung) zu reduzieren und zu verteilen;

c) Förderung von Maßnahmen, die darauf abstellen, auf erneuerbaren Energiequellen basierende Technologien für benachteiligte gesellschaftliche Gruppen verfügbar zu machen;

4. das Bewusstsein von Bürgerinnen und Bürgern (bereits im jungen Alter) für neue Verhaltens- und Lebensweisen im Interesse einer verantwortungsvollen Energienutzung durch Förderung und Finanzierung entsprechender Bildungsprojekte und Sensibilisierungsmaßnahmen (z. B. von Nachhaltigkeitsprojekten in Schulen) zu schärfen;

5. regelmäßig die unterschiedlichen Strategien der Mitgliedstaaten zu bewerten, insbesondere hinsichtlich der Nutzung „konventioneller“, „CO_2-armer“ und „erneuerbarer“ Energiequellen.

4.5 Forschung

Energieforschung ist von zentraler Bedeutung für die Verwirklichung der im Energiefahrplan 2050 erklärten Ziele der Europäischen Union. Die Forschungsprioritäten müssen mit diesen Zielen in Einklang stehen und sollten sich an dem von der EGE in der vorliegenden Stellungnahme dargelegten integrativen Ethikkonzept ausrichten. Die EGE unterstreicht, wie wichtig es für Europa ist, in die Forschung von Technologien mit geringem CO_2-Ausstoß zu investieren, insbesondere in erneuerbare Energien. Daher empfiehlt die EGE, Forschungsprioritäten festzulegen, die Forschungsarbeiten zu folgenden Bereichen umfassen sollten:

- Technologien, die zum Aufbau einer intelligenten Netzinfrastruktur in Europa beitragen, die so konfiguriert ist, dass ausreichend Kapazitäten vorhanden sind, um die potenziellen Vorteile von Technologien mit geringem CO_2-Ausstoß und Technologien für erneuerbare Energien auszuschöpfen, vor allem bei der Entwicklung einer dezentralen Energieerzeugung;

- neue Energiespeichertechnologien, die bei Erzeugung von Überschüssen die Nutzung intermittierender Energien erleichtern;

- interdisziplinäre Forschung auf dem Gebiet der Lagerung und der Beförderung von im Zusammenhang mit der Energieerzeugung und -nutzung benötigtem Material und anfallenden Rückständen;

- Analysen zu den bei verschiedenen Energiequellen anfallenden Rückständen, ihrer Reduzierung oder Beseitigung oder etwaigen Wiederverwendung; Forschungsarbeiten zur Ermittlung der am besten geeigneten Technologien, Vorschriften und Infrastrukturen für die CO_2-Abscheidung und Speicherung;

- Energieeffizienz in allen Bereichen, vor allem aber in Städteplanung und Architektur, Verkehr, öffentlichen Versorgungseinrichtungen und Industrieanlagen;

- Forschungsfinanzierung für laufende Arbeiten auf dem Gebiet der psychosozialen Modellierung von Verhaltensinterventionen bei Einzelpersonen und Gemeinschaften im Bereich der Energieeinsparung mit dem Ziel, Energieeffizienzinitiativen und die Festlegung neuer Standards – über die derzeit bestehende „Best Practice“ hinaus – zu befördern.

Es gilt, ein ausgewogenes Verhältnis zwischen Forschungsarbeiten zu den verschiedenen Energiequellen herzustellen und die Gründe hierfür darzulegen (und öffentlich bekannt zu machen):

- vergleichende Studien zur Umsetzung des Energiefahrplans 2050 in den Mitgliedstaaten der Europäischen Union (quantitative und qualitative Daten) mit einem besonderen Schwerpunkt auf soziokulturellen und geografischen Faktoren, die ausschlaggebend für die Festlegung spezifischer Energiemixsysteme auf lokaler Ebene sind;

- vergleichende Folgenabschätzungen für alle Energiequellen unter Zugrundelegung der integrativen Methode technischer, sozialer und politischer Szenarien; dabei sollten (soziale, ökologische) Worst-Case-Szenarien, kurzfristige und langfristige Prognosen, geopolitische Kontexte und auch Sicherheitsrisiken für die Arbeitnehmer berücksichtigt werden;

- Sozialwissenschaften (individuelle Verantwortung), Psychologie, Sozialanthropologie, Soziologie, Ethik und Recht.

Die EGE ist – wie auch in den vorangegangenen Stellungnahmen dargelegt – der Auffassung, dass die

Entwicklung von Wissenschaft und Technologie eine kritische und unabhängige ethische Analyse erfordert, die durch eine Unterstützung der ethischen Fachdisziplin erleichtert werden kann. Um diesen Prozess voranzubringen, empfiehlt die Gruppe daher interdisziplinäre Forschungsarbeiten zu den ethischen, rechtlichen und sozialen Implikationen der Energienutzung (thematisches Programm); entsprechende Vorhaben sollten im Rahmen von Horizont 2020 finanziert werden.

4.6 Demokratische Diskurse, Partizipationsinstrumente und Verantwortung für künftige Generationen

Der demokratische Diskurs ist von wesentlicher Bedeutung für die Entscheidungen, die Bürgerinnen und Bürger als Antwort auf die Herausforderungen im Bereich der Energieerzeugung und -nutzung treffen. In den vergangenen Jahrzehnten wurden verschiedene Instrumente zur Stärkung von Partizipationsmechanismen erforscht.

Die EGE empfiehlt, dass die Europäische Union Anreize für die Implementierung partizipatorischer Ansätze setzt, z. B. in folgenden Bereichen:

- „Anhörungen“ der Zivilgesellschaft;
- kommunale und regionale Energiegenossenschaften;
- kommunale Energieeinsparungsinitiativen;
- kommunale und regionale Initiativen zur Förderung einer auf einen reduzierten CO_2-Ausstoß abzielenden Stadtentwicklung und Kommunalplanung.

Sowohl die räumliche als auch die zeitliche Dimension der Folgen menschlichen Handelns spielen eine wichtige Rolle in der Energieethik. Die heutige Generation steht vor der ethischen Herausforderung, ihre moralische Perspektive zu erweitern und sich ernsthaft mit den Langzeitwirkungen zu befassen, die ihre Entscheidungen und ihr Handeln für die Nachwelt haben. Diese Herausforderung erwächst aus den Erfordernissen sozialer Gerechtigkeit; dabei geht es um den Grundsatz, dass eine Gemeinschaft aus menschlicher Solidarität heraus moralisch verpflichtet ist, denen Hilfe zu leisten, die benachteiligt sind.

Daher empfiehlt die EGE,

- dass die Europäische Union und ihre Organe eine Einrichtung unter der Bezeichnung „Ombudsperson“ schaffen, deren Aufgabe es sein soll, die Interessen künftiger Generationen zu vertreten, deren Funktion nicht darin bestehen würde, Entscheidungen zu treffen, sondern vielmehr darin, dafür zu sorgen, dass Entscheidungen in Kenntnis der Sachlage getroffen werden, indem sie die Langzeitwirkungen sämtlicher politischer, sozioökonomischer und technologischer Entscheidungen in die Debatte einbringt.

ANNEX I: Expenditure of the European Union in Energy Research

Research in nuclear fission energy is mainly related to safety and waste management issues; it has to be taken into account that the following Figures A1 and A2 include only funds from the European Union and not investments by Member States.

Figure A1: Research funds for different types of energy in the European Union

	1984–87 (FP1) million ECU	1987–91 (FP2) million ECU	1990–94 (FP3) million ECU	1994–98 (FP4) million ECU	1998–02 (FP5) million EUR	2002–06 (FP6) million EUR	2007–13 (FP7) million EUR	TOTAL million ECU = million EUR
Fusion	**480**	**611**	**568**	**965**	**788**	**824**	**4 156**	**8 392**
of which ITER	0	0	0	0	0	46	3 273	3 319
Total Fission	**460**	**440**	**228**	**476**	**472**	**528**	**1 155**	**3 759**
of which JRC Fission			19	292	281	319	750	1 661
Non-nuclear energy	**830**	**122**	**217**	**1 076**	**1 042**	**900**	**2 350**	**6 537**
of which RES	310	44	93	397	550	437	1 050	2 881
TOTAL	**1 770**	**1 173**	**1 013**	**2 517**	**2 302**	**2 252**	**7 661**	**18 688**

Comments:
Only funding through the FPs has been taken into account
Main figures from Council Decisions, except:
Calculations EURATOM FP 3 Amendment 1 (extrapolated)
Calculations EURATOM FP 4 Amendment 2 (extrapolated)
FP 3 includes JRC (as stated in Council Decision): implications fission
ECU = EUR all at constant prices

Figure A2: Public expenditure for research on energy technologies in Europe

	1984–87 (FP1) %	1987–91 (FP2) %	1990–94 (FP3) %	1994–98 (FP4) %	1998–02 (FP5) %	2002–06 (FP6) %	2007–13 (FP7) %	TOTAL %
Fusion	**27**	**52**	**56**	**38**	**34**	**37**	**54**	**45**
of which ITER	0	0	0	0	0	2	43	18
Total Fission	**26**	**38**	**23**	**19**	**21**	**23**	**15**	**20**
of which JRC Fission	0	0	2	12	12	14	10	9
Non-nuclear energy	**47**	**10**	**21**	**43**	**45**	**40**	**31**	**35**
of which RES	18	4	9	16	24	19	14	15
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Figure A3: Annual budget for EU energy research 2002–13

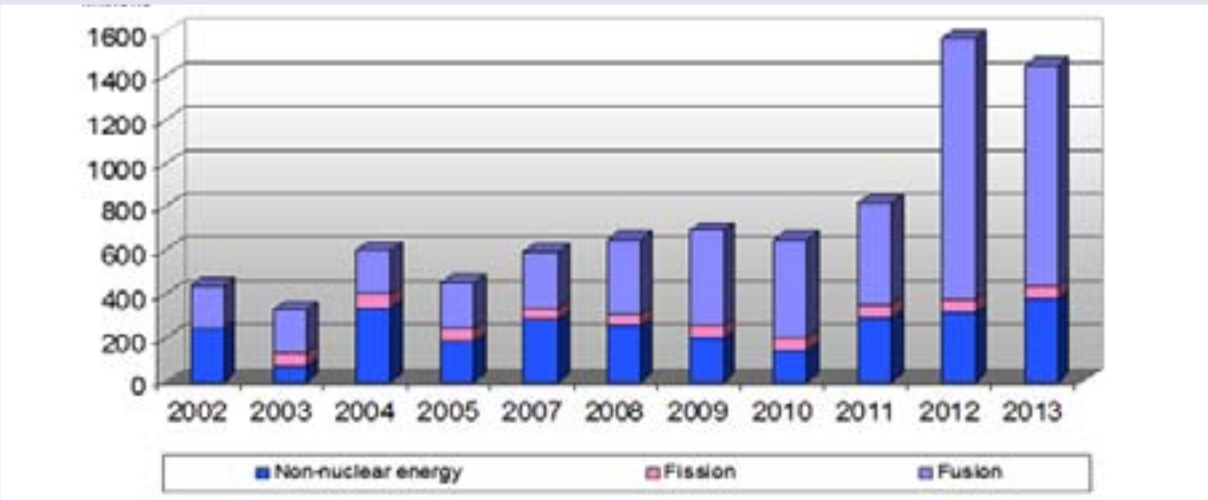
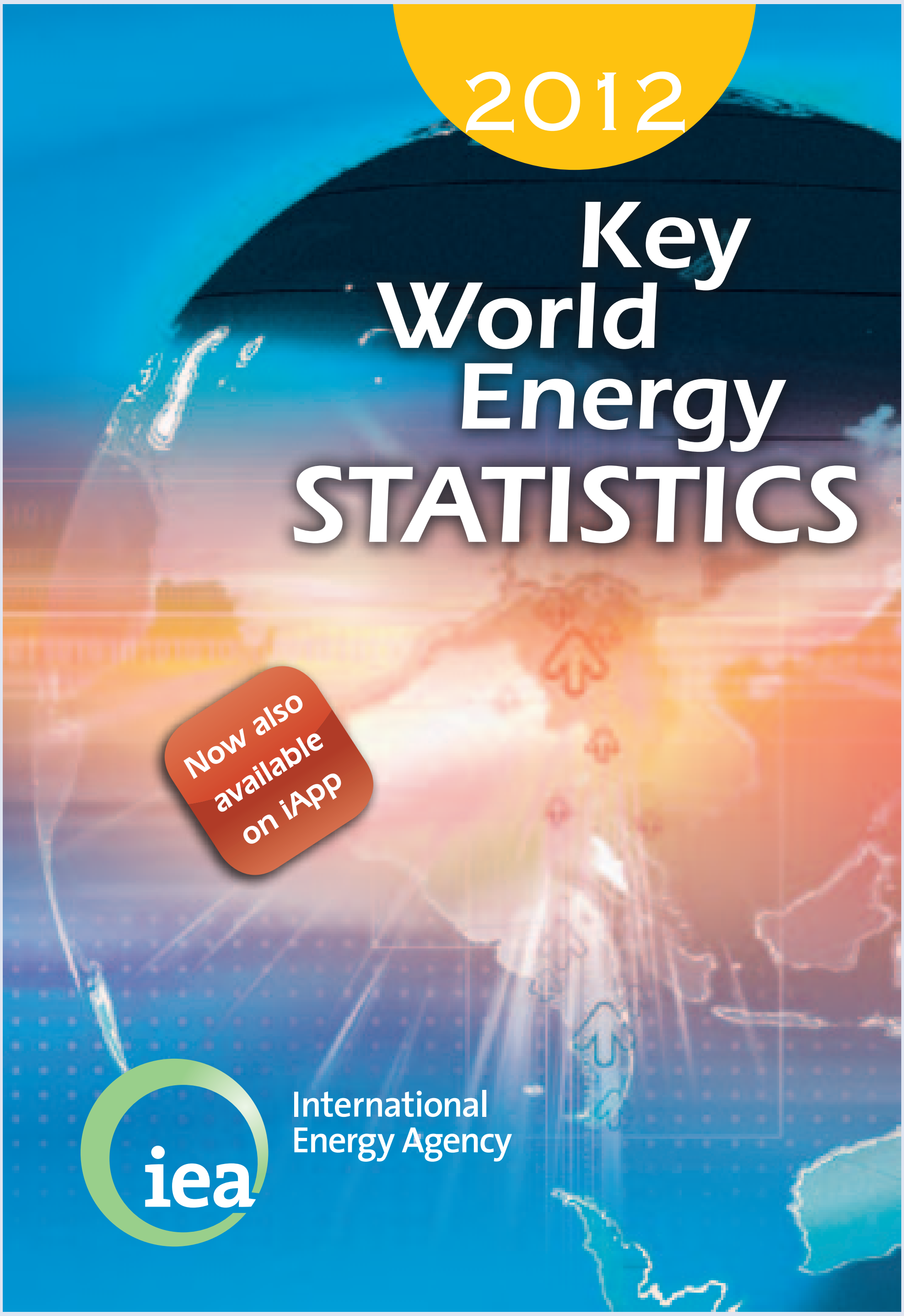


Figure A3 shows the annual budgets of the EU framework programmes for fission, fusion and non-nuclear energy research. The largest part of the budget, especially in recent years, is dedicated to fusion research, in particular to the construction of the ITER reactor.

ANNEX II: IEA Key World Energy Statistics 2012

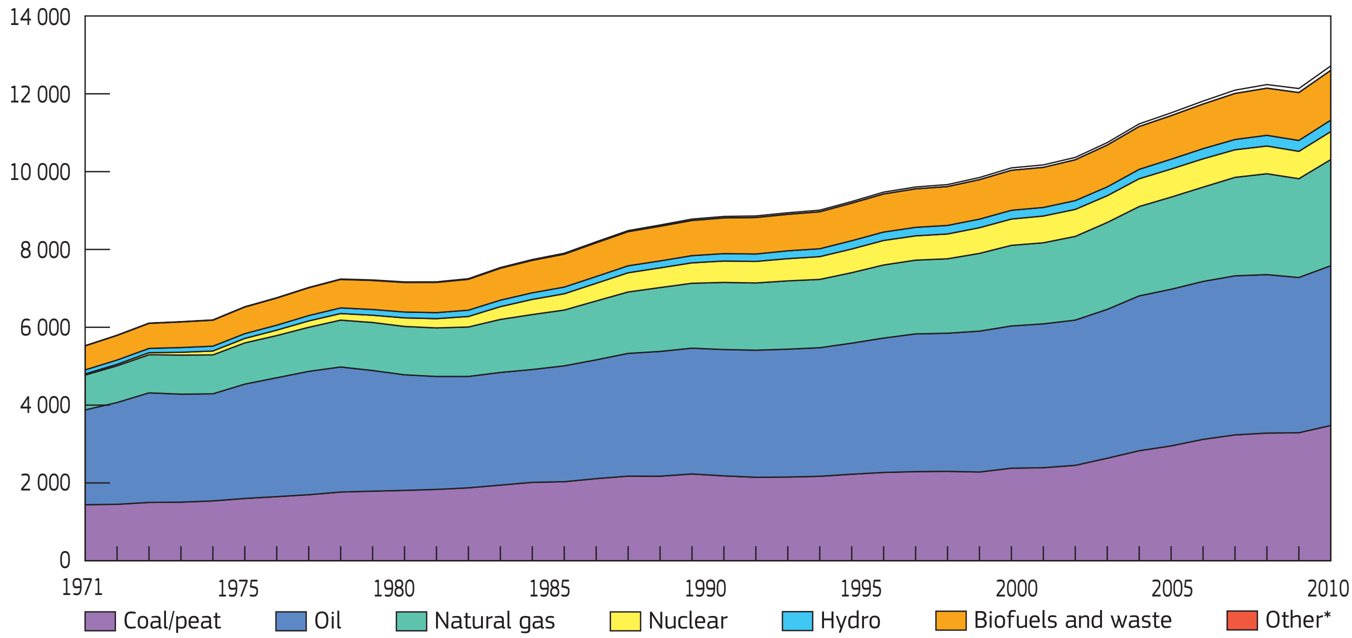


Key World Energy Statistics 2012 © OECD/IEA 2012

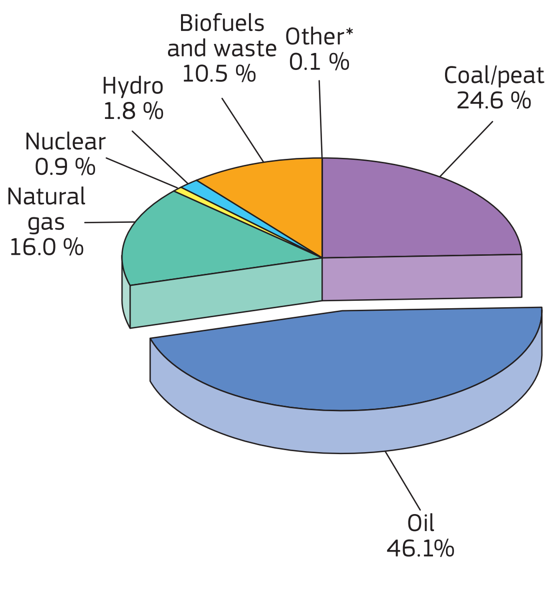
TOTAL PRIMARY ENERGY SUPPLY BY FUEL

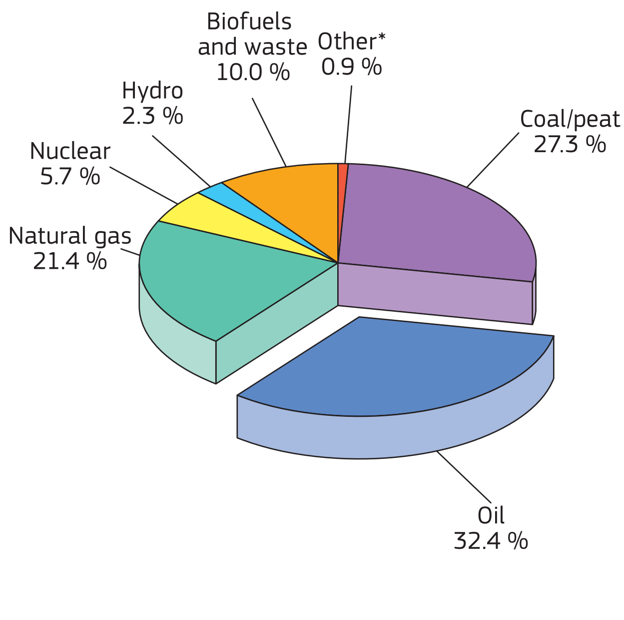
World

World total primary energy supply from 1971 to 2010 by fuel (Mtoe)



1973 and 2010 fuel shares of TPES



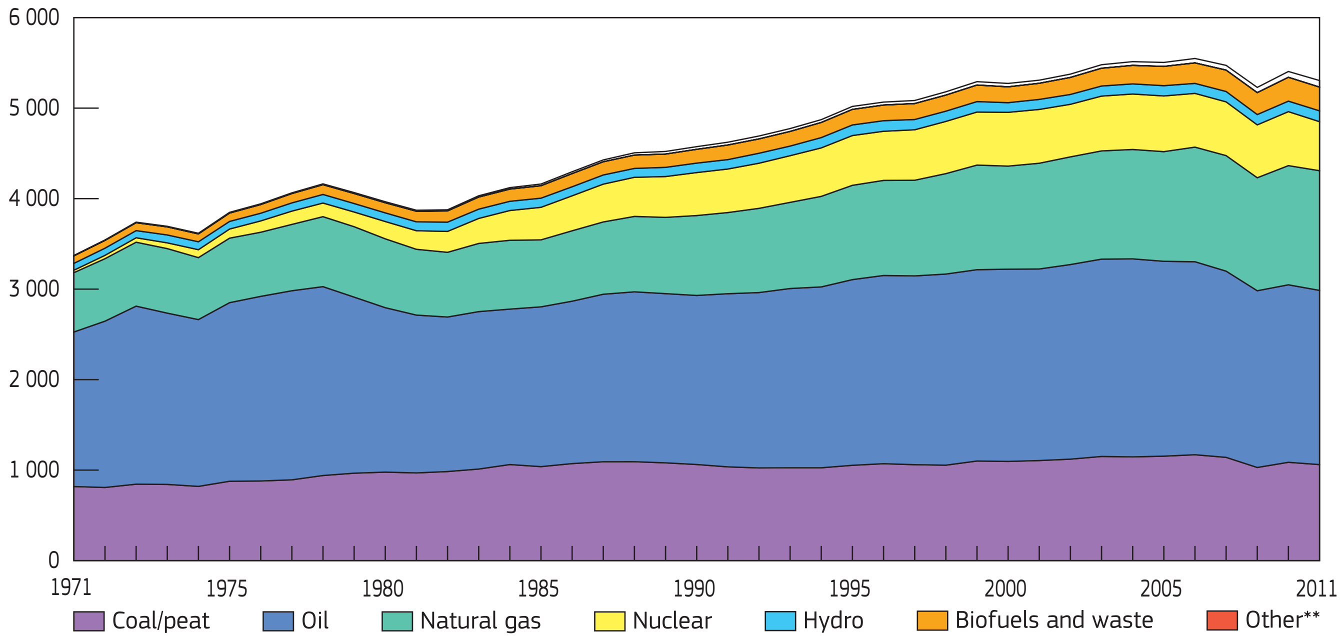


*Other includes geothermal, solar, wind, heat, etc.

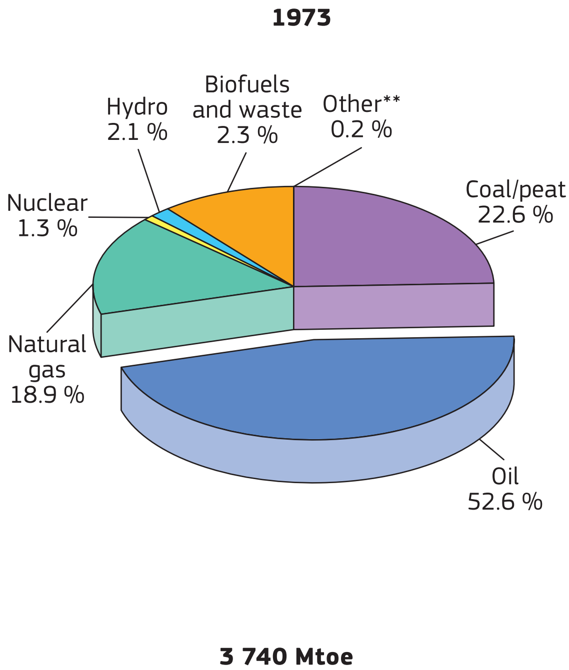
TOTAL PRIMARY ENERGY SUPPLY
BY FUEL

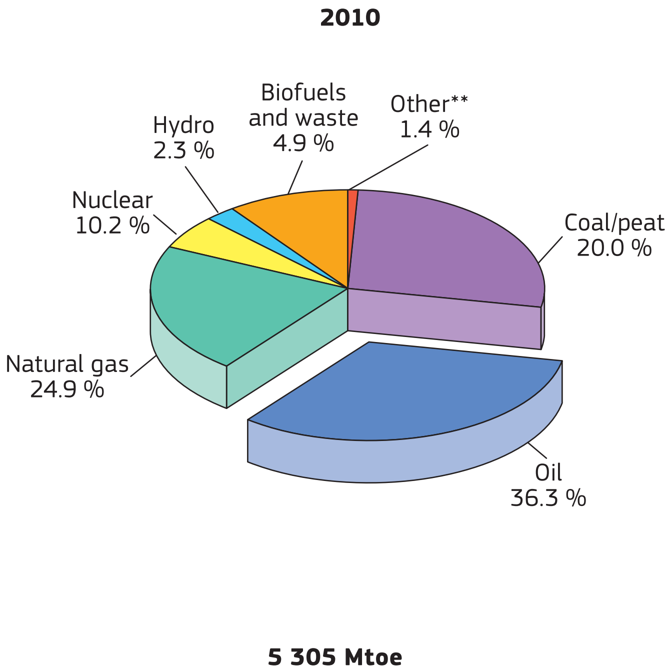
OECD

OECD total primary energy supply* from 1971 to 2011 by fuel (Mtoe)



1973 and 2011 fuel shares of TPES*





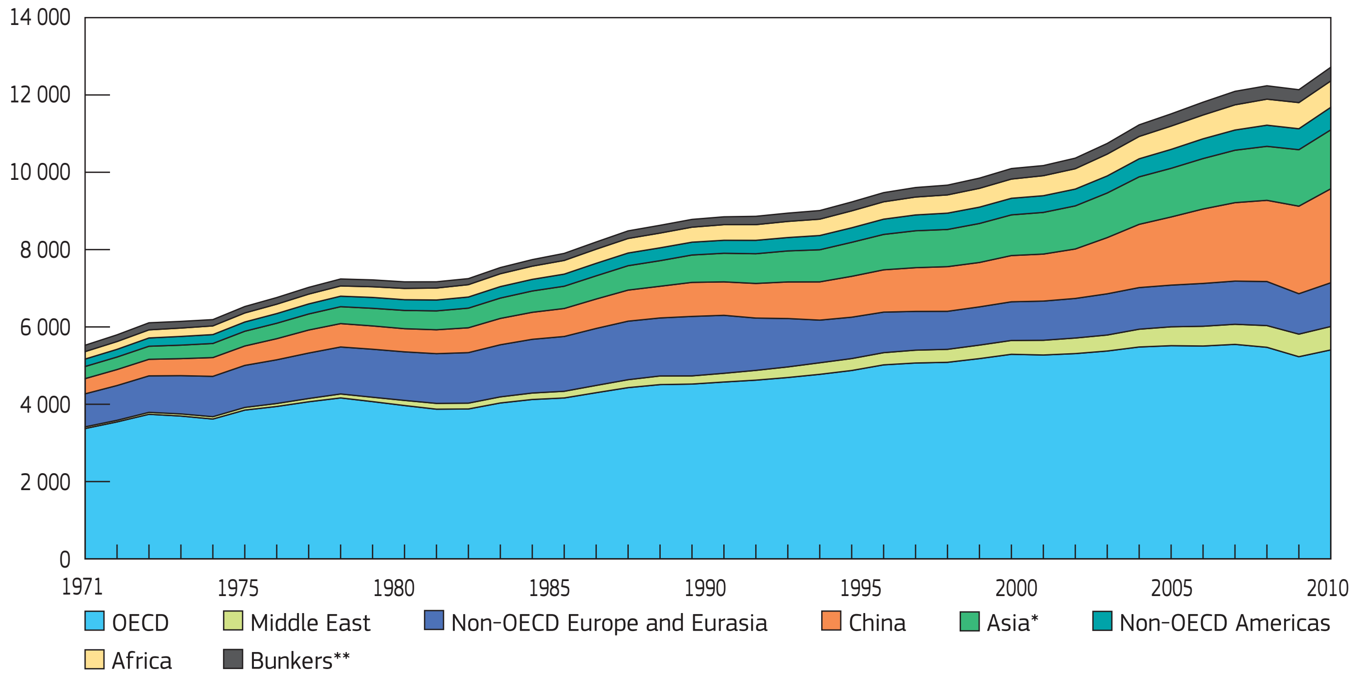
*Excludes electricity trade.

**Other includes geothermal, solar, wind, heat, etc.

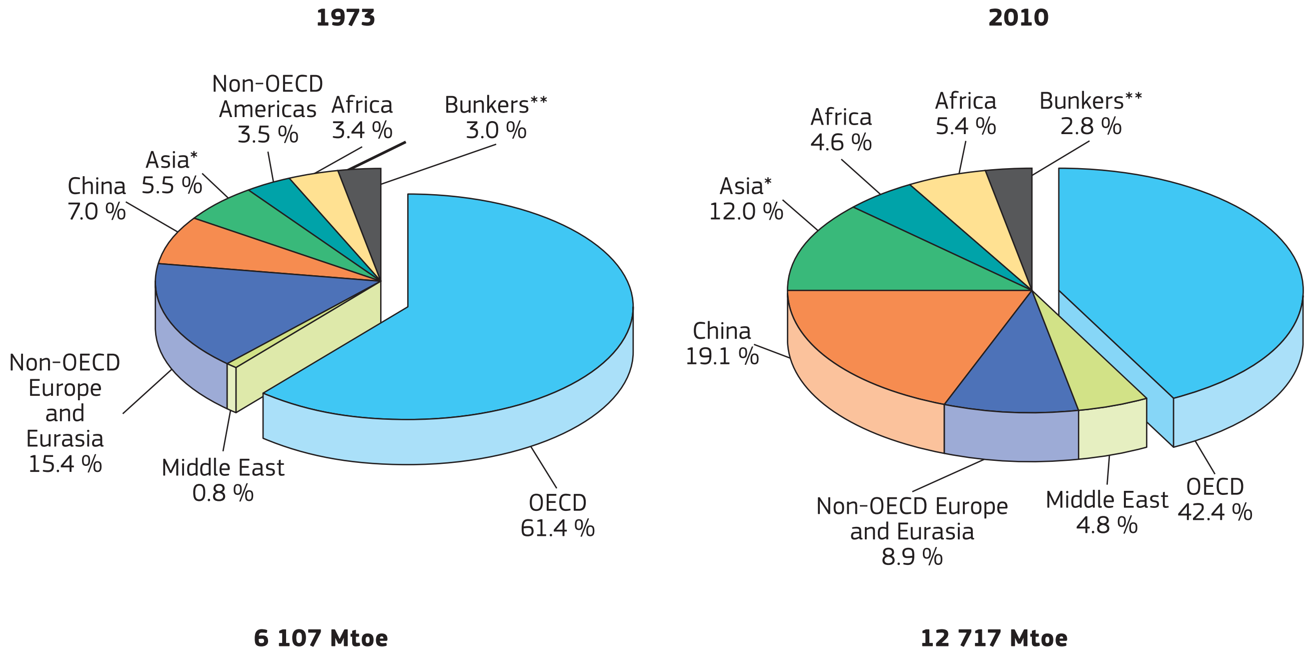
TOTAL PRIMARY ENERGY SUPPLY BY REGION

World

World total primary energy supply from 1971 to 2010 by region (Mtoe)



1973 and 2010 regional shares of TPES



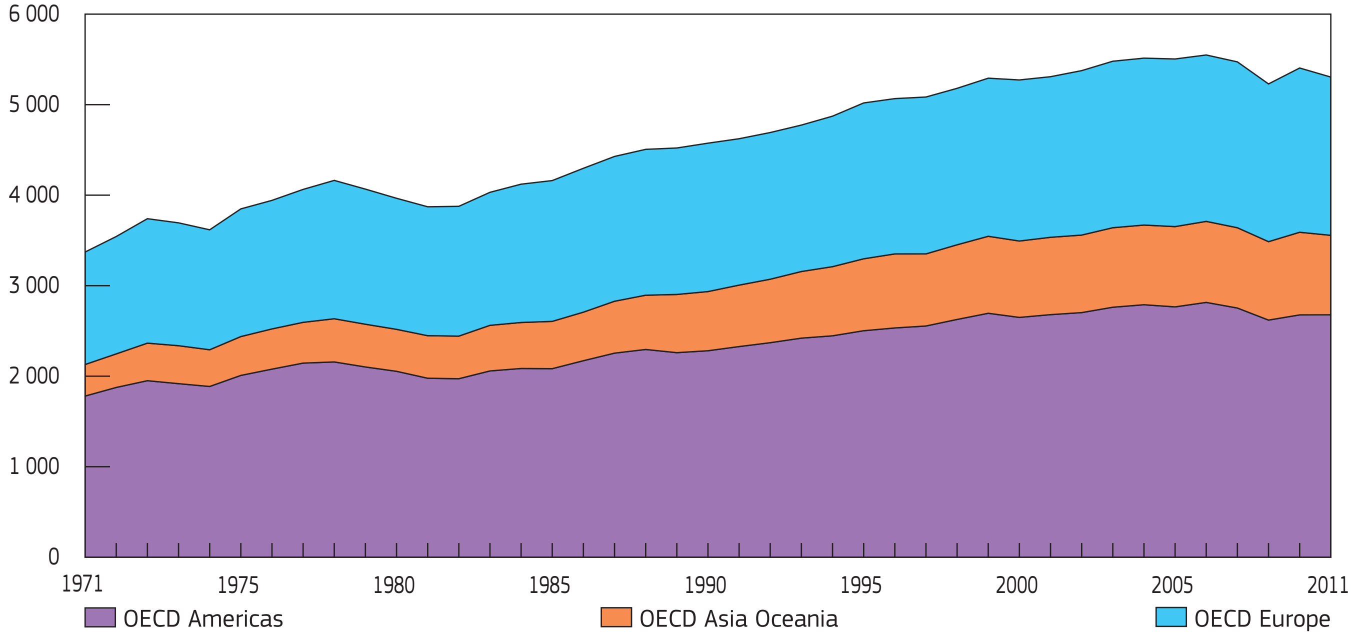
*Asia excludes China.

**Includes international aviation and international marine bunkers.

TOTAL PRIMARY ENERGY SUPPLY
BY REGION

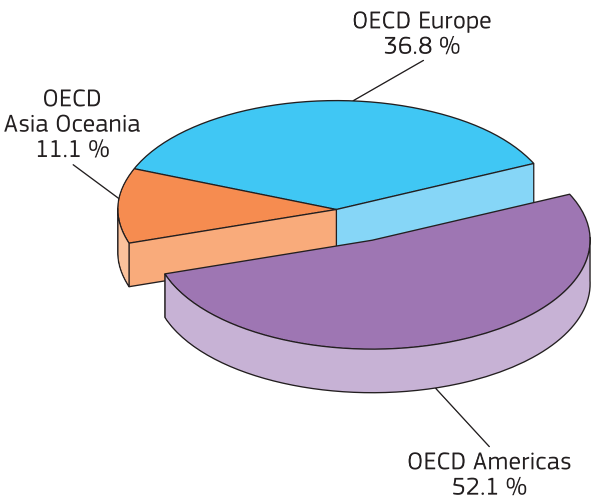
OECD

OECD total primary energy supply* from 1971 to 2011 by region (Mtoe)



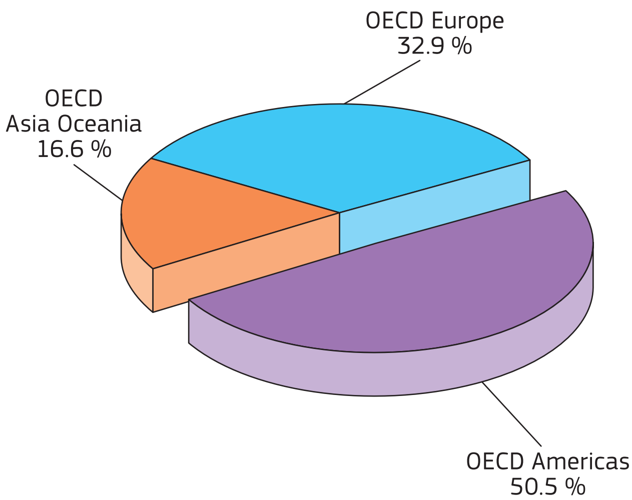
1973 and 2011 regional shares of TPES*

1973



3 740 Mtoe

2011

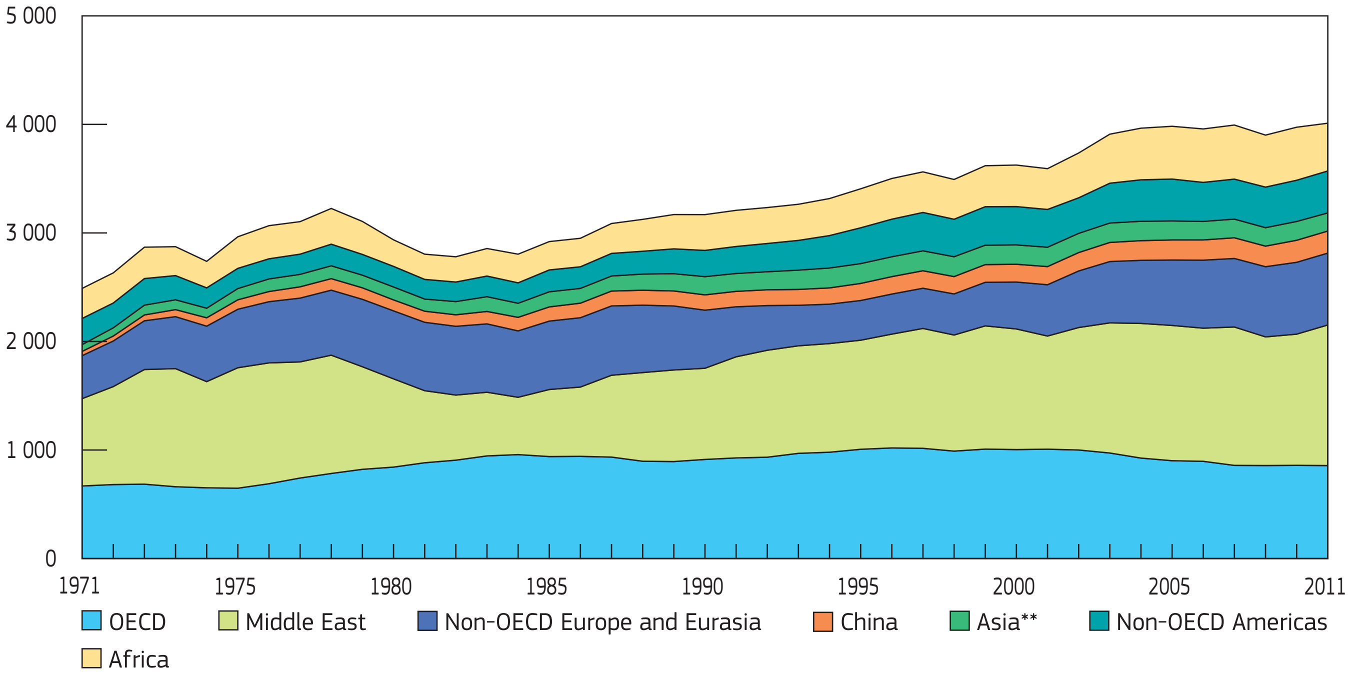


5 305 Mtoe

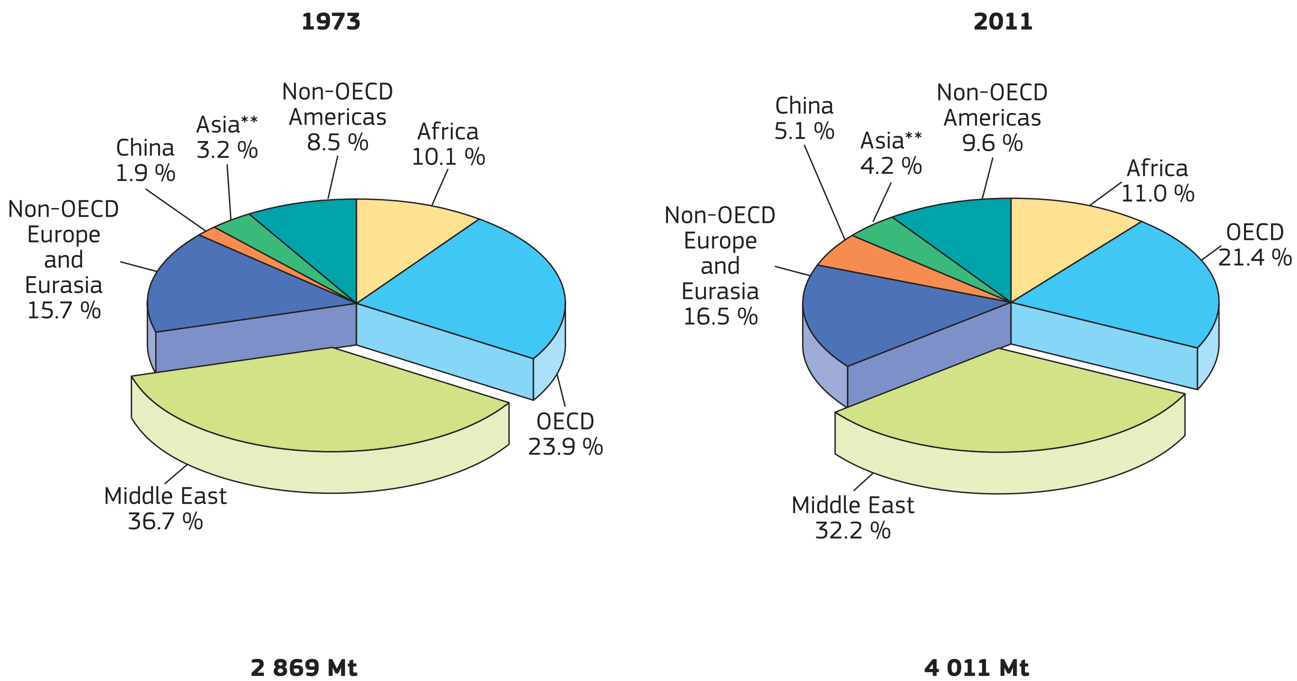
*Excludes electricity trade.

Crude oil production

Crude oil* production from 1971 to 2011 by region (Mt)



1973 and 2011 regional shares of crude oil* production



*Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.

**Asia excludes China.

Producers, net exporters and net importers of crude oil*

Producers	Mt	% of world total
Saudi Arabia	517	12.9
Russia	510	12.7
United States	346	8.6
Iran	215	5.4
China	203	5.1
Canada	169	4.2
United Arab Emirates	149	3.7
Venezuela	148	3.7
Mexico	144	3.6
Nigeria	139	3.5
Rest of the world	1 471	36.6
World	**4 011**	**100.0**

2011 data

Net exporters	Mt
Saudi Arabia	333
Russia	246
Nigeria	129
Iran	126
United Arab Emirates	105
Iraq	94
Venezuela	87
Angola	84
Norway	78
Mexico	71
Others	609
Total	**1 962**

2010 data

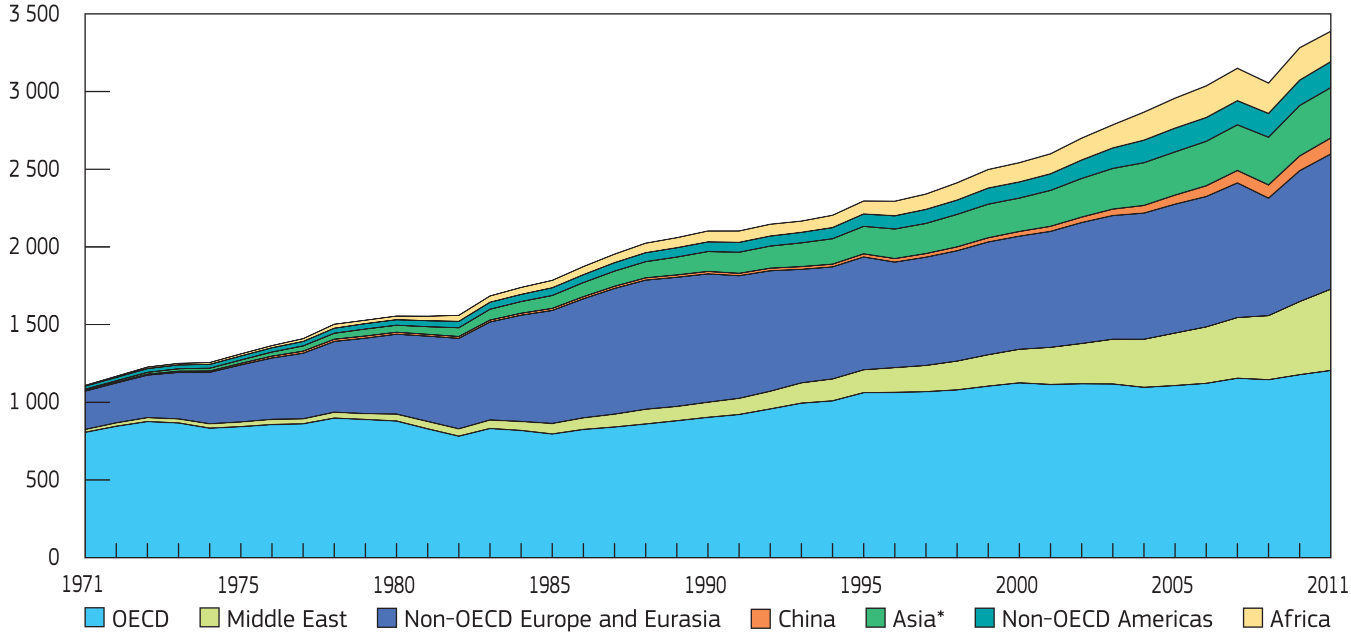
Net importers	Mt
United States	513
China	235
Japan	181
India	164
South Korea	119
Germany	93
Italy	84
France	64
Netherlands	60
Singapore	57
Others	483
Total	**2 053**

2010 data

*Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.

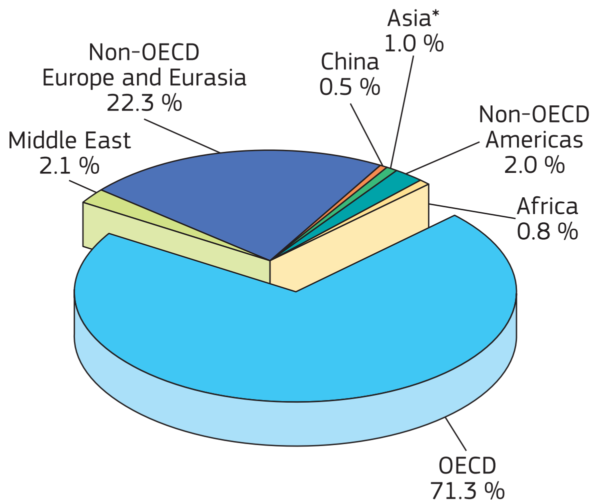
Natural gas production

Natural gas production from 1971 to 2011 by region (billion cubic metres)



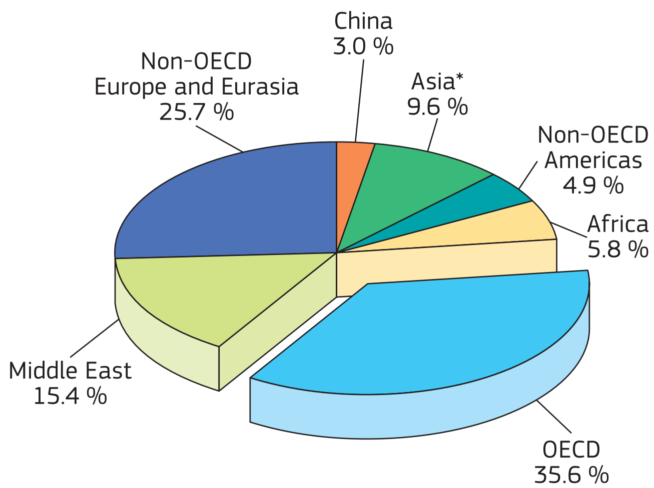
1973 and 2011 regional shares of natural gas production

1973



1 226 bcm

2011



3 388 bcm

*Asia excludes China.

Producers, net exporters and net importers of crude oil*

Producers	bcm	% of world total
Russia	677	20.0
United States	651	19.2
Canada	160	4.7
Qatar	151	4.5
Iran	149	4.4
Norway	106	3.1
China	103	3.0
Saudi Arabia	92	2.7
Indonesia	92	2.7
Netherlands	81	2.4
Rest of the world	1 126	33.3
World	**3 388**	**100.0**

2011 data

Net exporters	bcm
Russia	196
Qatar	119
Norway	99
Canada	63
Algeria	49
Indonesia	46
Netherlands	33
Turkmenistan	29
Nigeria	26
Malaysia	22
Others	152
Total	**834**

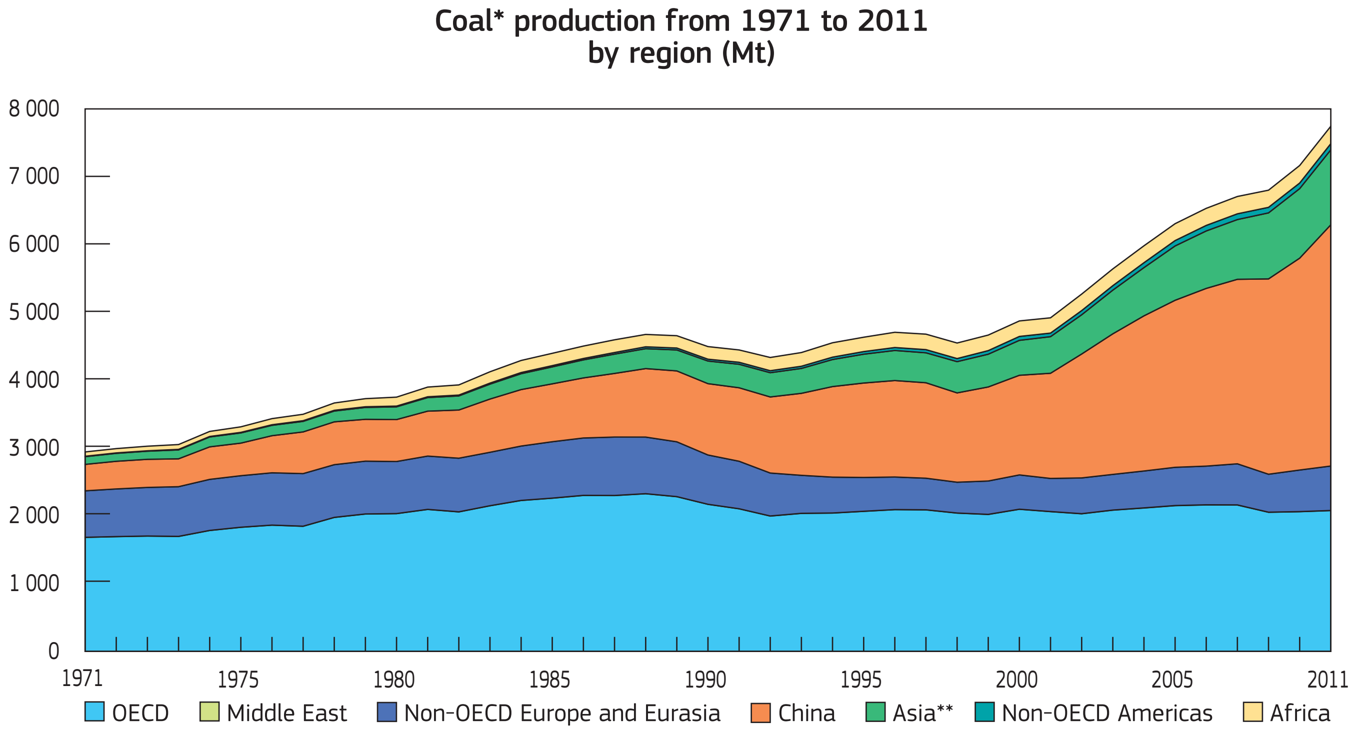
2011 data

Net importers	bcm
Japan	116
Italy	70
Germany	68
United States	55
South Korea	47
Ukraine	44
Turkey	43
France	41
United Kingdom	37
Spain	34
Others	279
Total	**834**

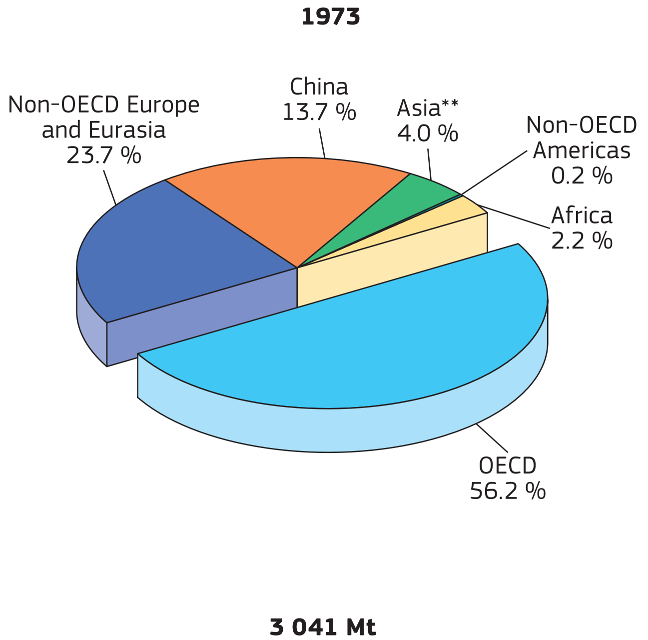
2011 data

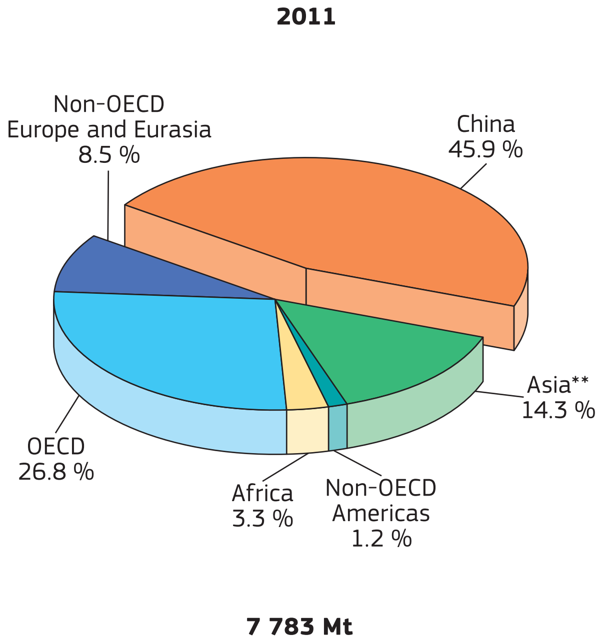
*Net exports and net imports include pipeline gas and LNG.

Coal production



1973 and 2011 regional shares of coal* production





*Includes steam coal, coking coal, lignite and recovered coal.

**Asia excludes China.

Producers, net exporters and net importers of coal*

Producers	Mt	% of world total
China	3 576	45.9
United States	1 004	12.9
India	586	7.5
Australia	414	5.3
Indonesia	376	4.8
Russia	334	4.3
South Africa	253	3.3
Germany	189	2.4
Poland	139	1.8
Kazakhstan	117	1.5
Rest of the world	795	10.3
World	**7 783**	**100.0**

2011 data

Net exporters	bcm
Indonesia	309
Australia	285
Russia	99
United States	85
Colombia	76
South Africa	70
Kazakhstan	34
Canada	24
Vietnam	23
Mongolia	22
Others	14
Total	**1 041**

2011 data

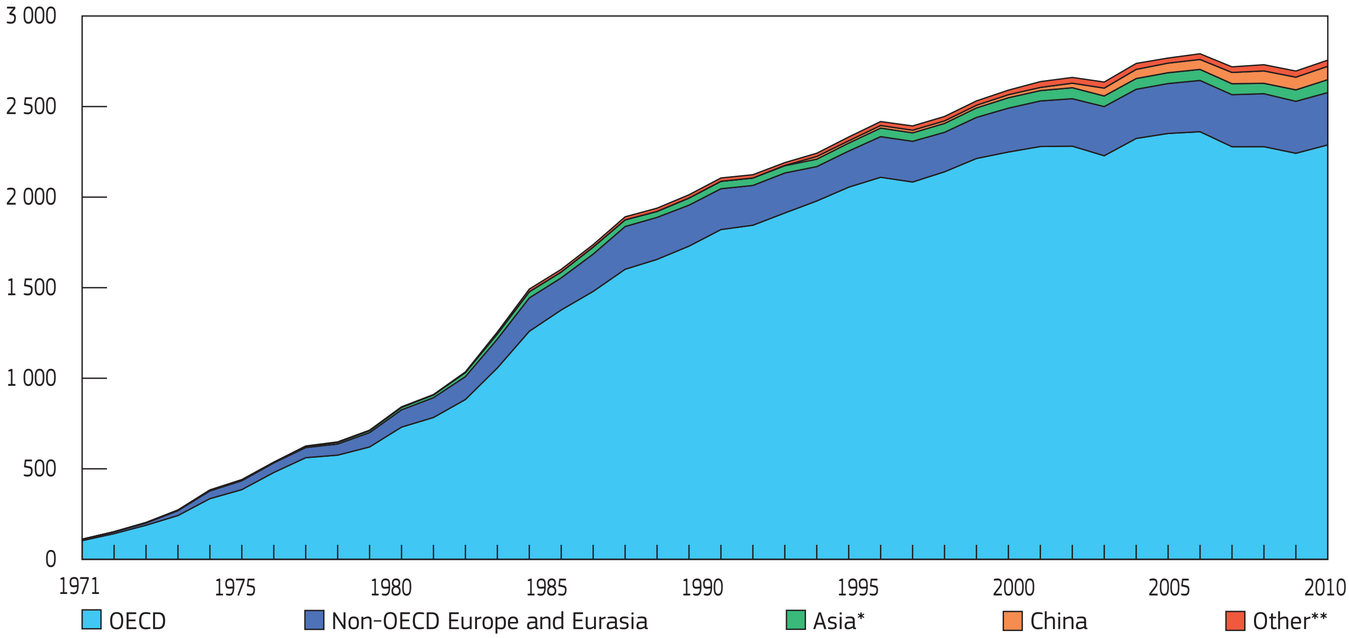
Net importers	bcm
China	177
Japan	175
South Korea	129
India	101
Taiwan	66
Germany	41
United Kingdom	32
Turkey	24
Italy	23
Malaysia	21
Others	213
Total	**1 002**

2011 data

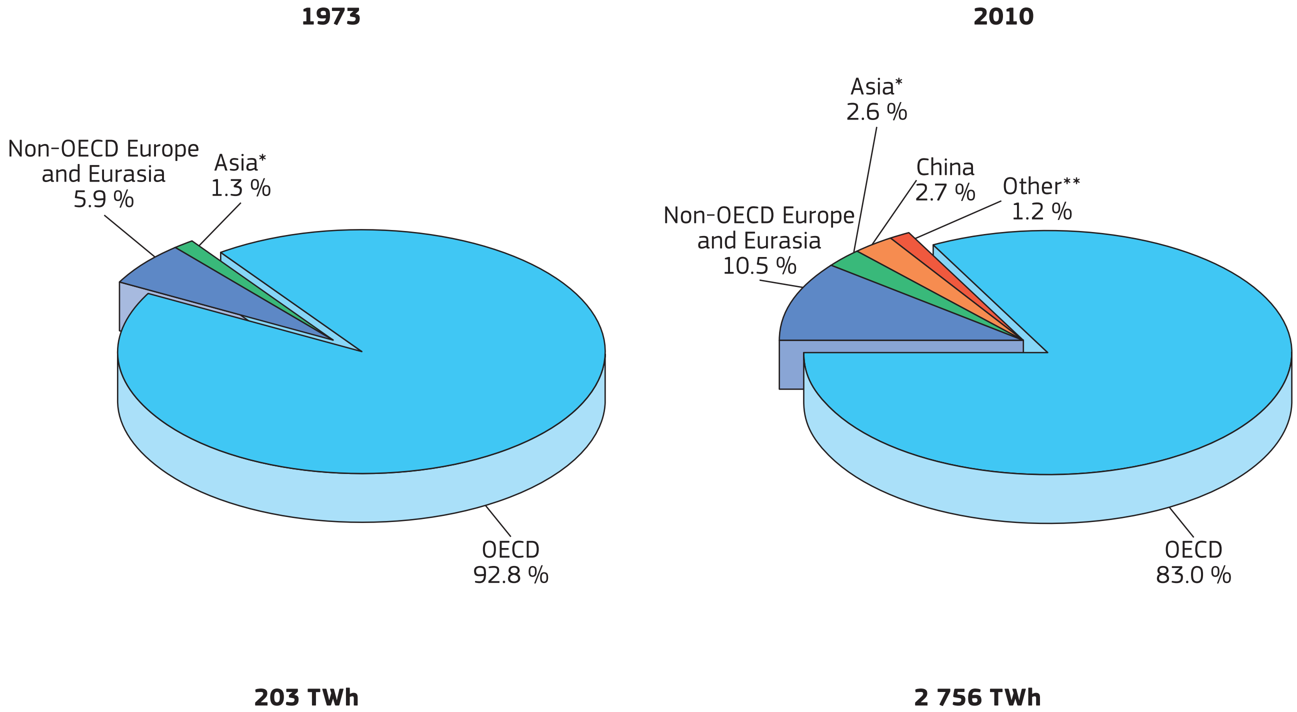
*Includes steam coal, coking coal, lignite and recovered coal.

Nuclear production

Nuclear production from 1971 to 2010 by region (TWh)



1973 and 2010 regional shares of nuclear production



*Asia excludes China.

**Includes steam coal, coking coal, lignite and recovered coal.

Producers of nuclear electricity

Producers	TWh	% of world total
United States	839	30.4
France	429	15.6
Japan	288	10.4
Russia	170	6.2
South Korea	149	5.4
Germany	141	5.1
Canada	91	3.3
Ukraine	89	3.2
China	74	2.7
United Kingdom	62	2.2
Rest of the world	424	15.5
World	**2 756**	**100.0**

2010 data

Installed capacity	GW
United States	101
France	63
Japan	49
Russia	24
Germany	20
South Korea	18
Ukraine	14
Canada	13
United Kingdom	11
Sweden	9
Rest of the world	53
World	**375**

2010 data

Country (top 10 producers)	% of nuclear in total domestic electricity generation
France	75.9
Ukraine	47.3
South Korea	29.9
Japan	26.0
Germany	22.6
United States	19.3
Russia	16.5
United Kingdom	16.4
Canada	14.9
China	1.8
Rest of the world*	12.2
World	12.9

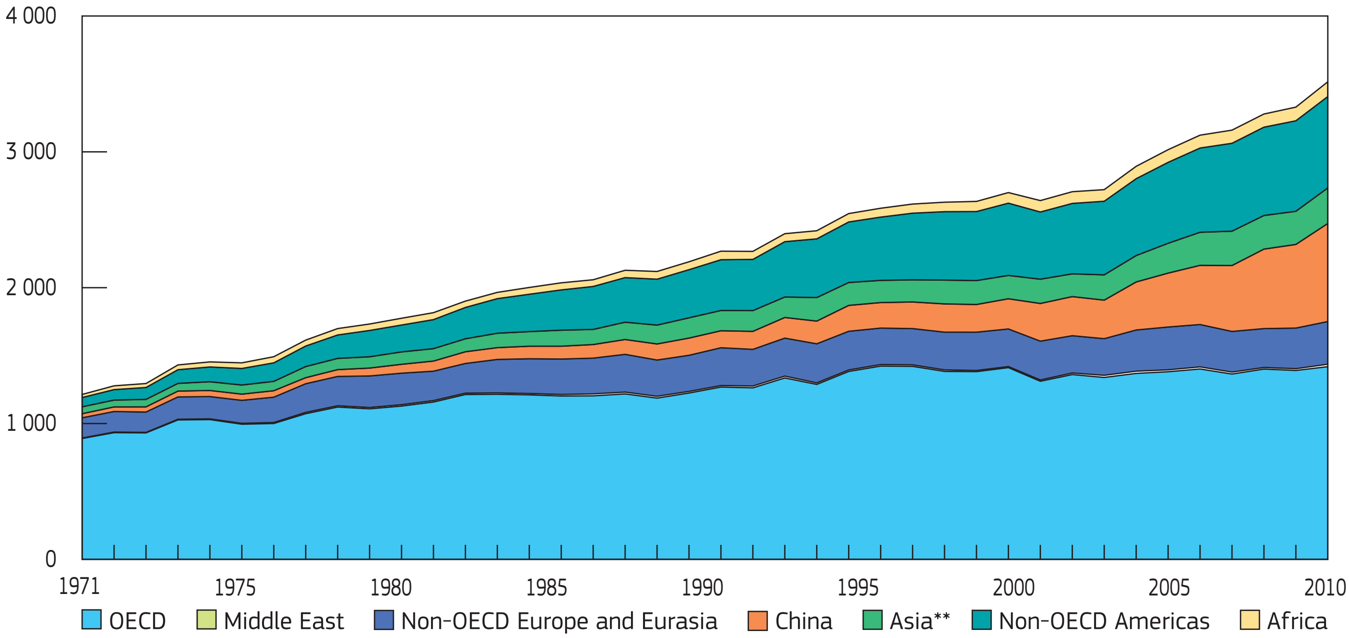
2010 data

*Excludes countries with no nuclear production.

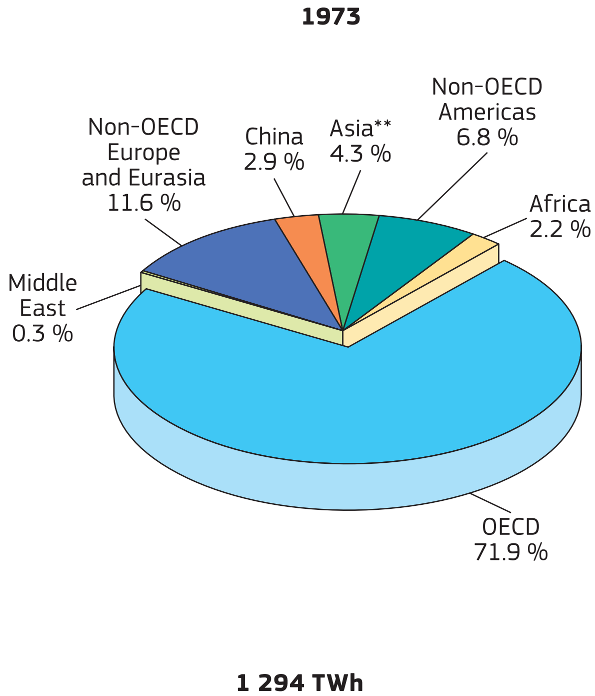
Sources: IEA, Commissariat à l'Énergie Atomique et aux Energies Alternatives (France).

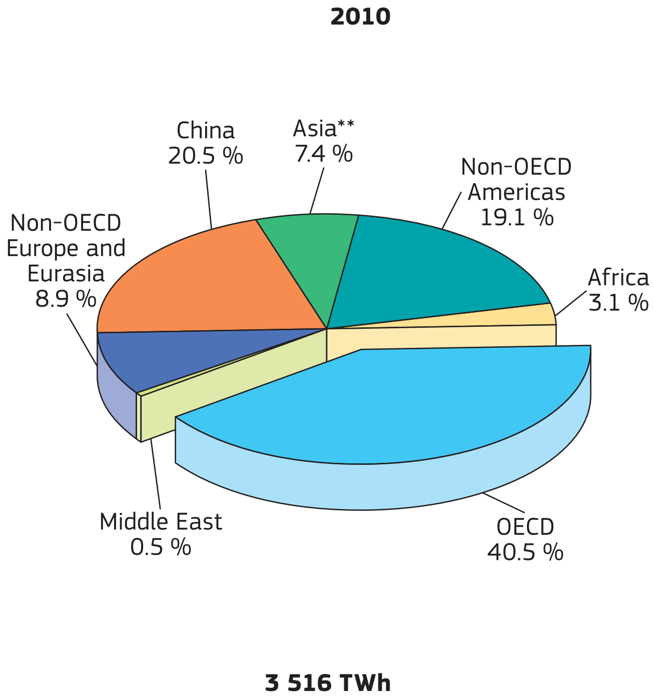
Hydro production

Hydro* production from 1971 to 2010 by region (TWh)



1973 and 2010 regional shares of hydro* production





*Includes pumped storage.

**Asia excludes China.

Producers of hydro* electricity

Producers	TWh	% of world total
China	722	20.5
Brazil	403	11.5
Canada	352	10.0
United States	286	8.1
Russia	168	4.8
Norway	118	3.4
India	114	3.3
Japan	91	2.6
Venezuela	77	2.2
France	67	1.9
Rest of the world	1 118	31.7
World	**3 516**	**100.0**

2010 data

Installed capacity	GW
China	171
United States	100
Brazil	79
Canada	75
Japan	47
Russia	47
India	37
Norway	30
France	25
Italy	21
Rest of the world	331
World	**963**

2009 data

Country (top 10 producers)	% of hydro in total domestic electricity generation
Norway	94.7
Brazil	78.2
Venezuela	64.9
Canada	57.8
China	17.2
Russia	16.2
India	11.9
France	11.7
Japan	8.1
United States	6.5
Rest of the world**	15.4
World	16.3

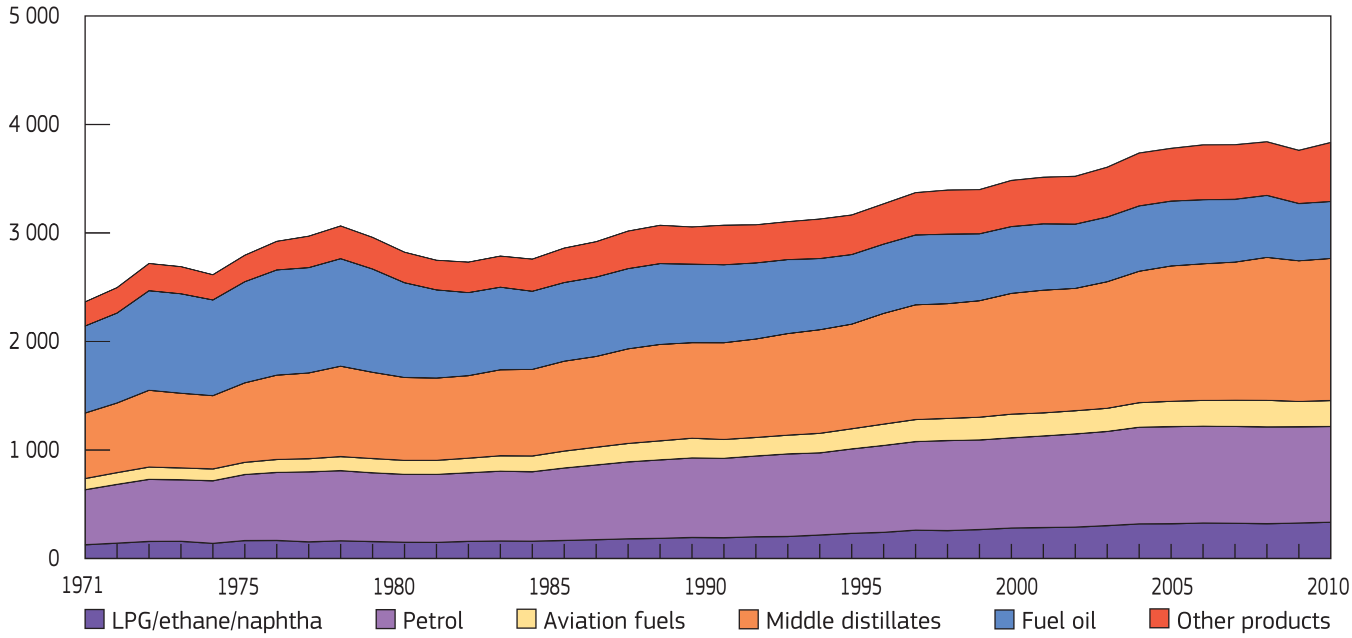
2010 data

*Includes pumped storage.

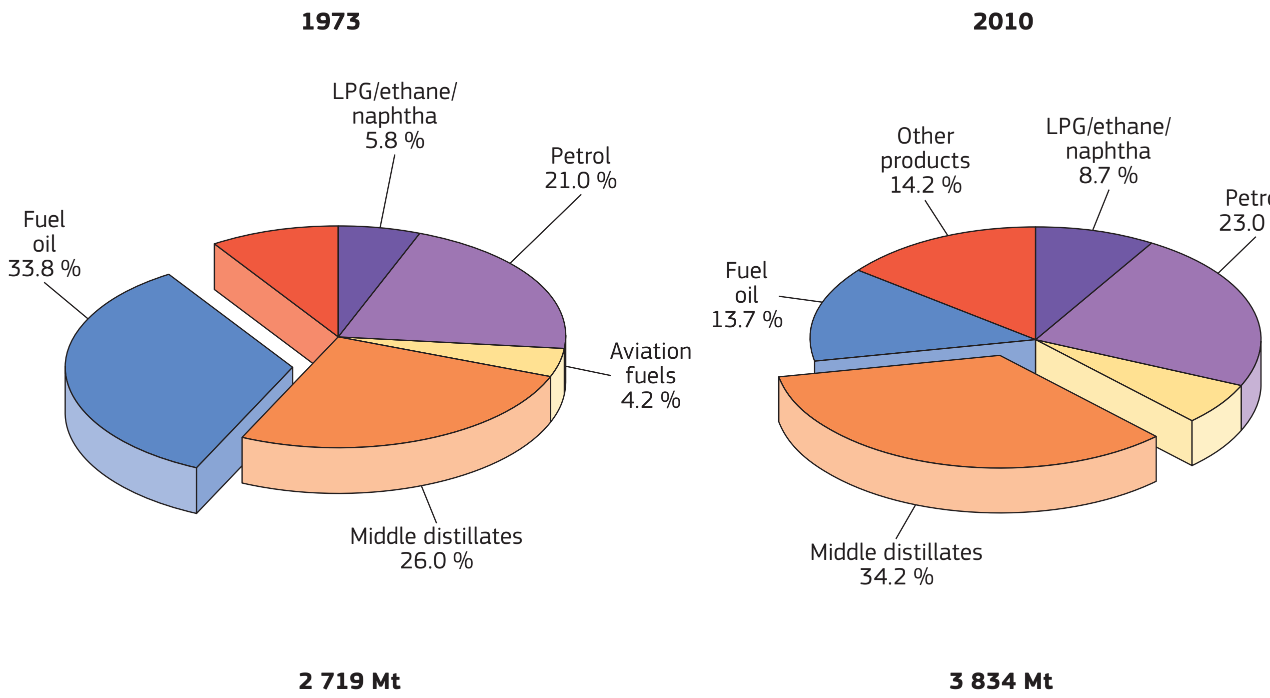
**Excludes countries with no hydro production.
Sources: IEA, United Nations.

Refining by product

World refinery production from 1971 to 2010 by product (Mt)



1973 and 2010 shares of refinery production by product



Producers, net exporters and net importers of oil products

Producers	Mt	% of world total
United States	802	20.9
China	403	10.5
Russia	240	6.3
India	206	5.4
Japan	178	4.6
South Korea	120	3.1
Germany	101	2.6
Canada	100	2.6
Brazil	97	2.5
Saudi Arabia	94	2.5
Rest of the world	1 493	39.0
World	**3 834**	**100.0**

2010 data

Net exporters	Mt
Russia	111
Saudi Arabia	50
India	42
United States	30
Kuwait	29
Venezuela	25
Algeria	19
Italy	16
Netherlands	15
South Korea	13
Others	122
Total*	**472**

2010 data

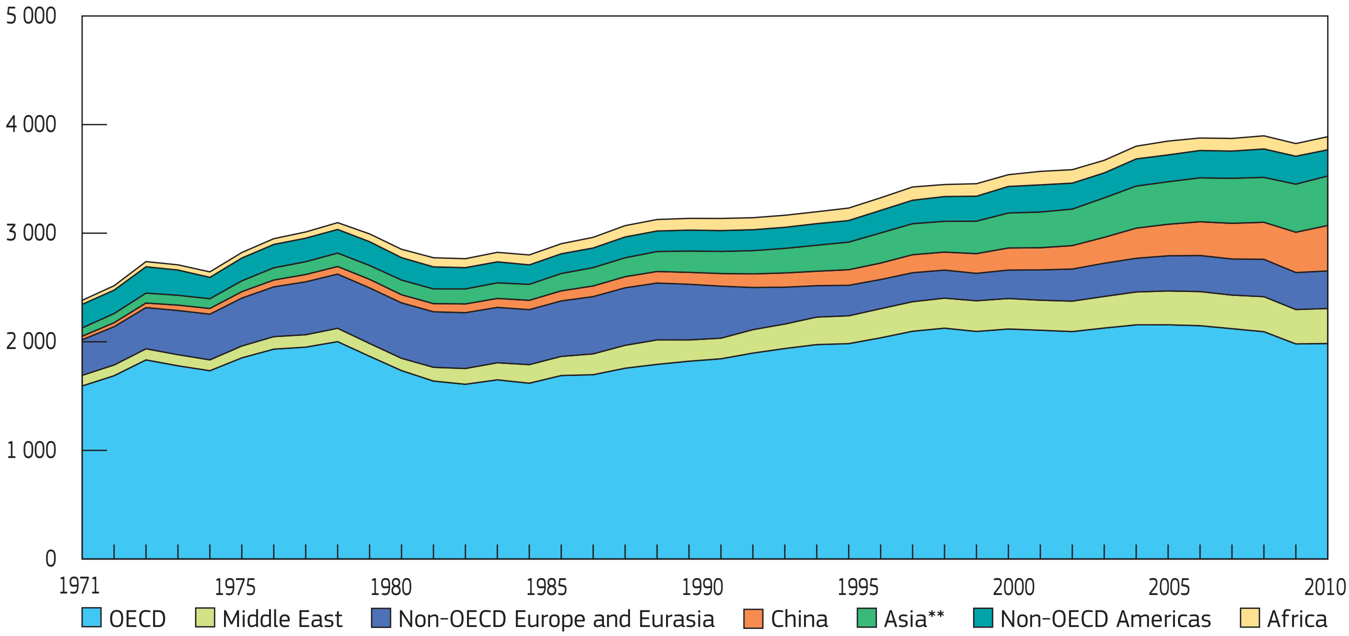
Net importers	Mt
Japan	26
Hong Kong	21
China	20
Mexico	19
France	19
Germany	18
Indonesia	16
Brazil	15
Singapore	15
Australia	13
Others	228
Total*	**410**

2010 data

*The discrepancy between total net exports and total net imports arises from different data sources and possible misallocation of bunkers into exports for some countries.

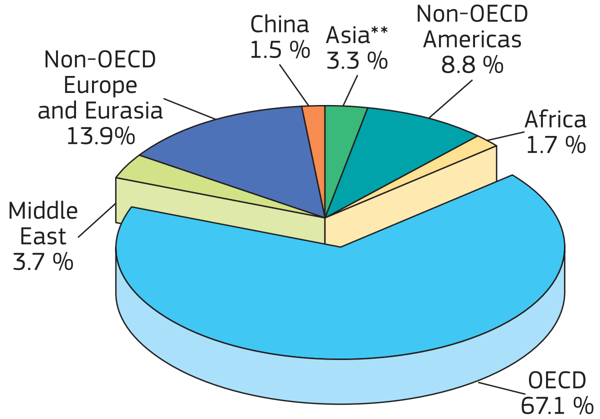
Refining by region

World refinery throughput* from 1971 to 2010 by region (Mt)



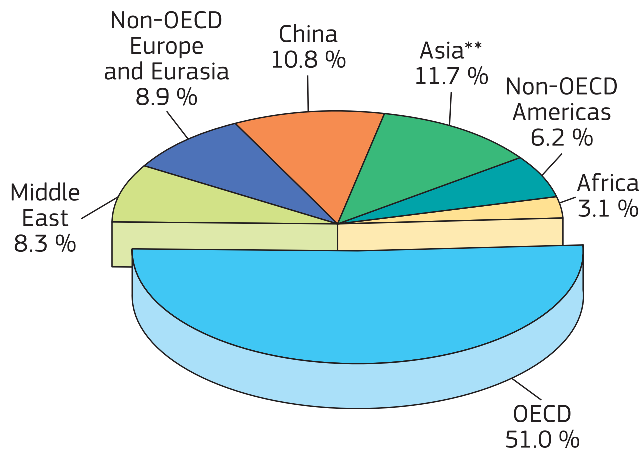
1973 and 2010 regional shares of refinery throughput*

1973



2 738 Mt

2010



3 889 Mt

*Includes crude oil, NGL, refinery feedstocks, additives and other hydrocarbons.

**Asia excludes China.

Producers, net exporters and net importers of oil*

Crude distillation capacity	kb/cd	% of world total
United States	17 565	18.8
China**	10 137	10.9
Russia	5 371	5.8
Japan	4 594	4.9
India	4 163	4.5
South Korea	3 003	3.2
Germany	2 183	2.3
Italy	2 132	2.3
Saudi Arabia	2 116	2.3
Brazil	1 981	2.1
Rest of the world	40 144	42.9
World	**93 389**	**100.0**

2011 data

Net exporters	Mt
Saudi Arabia	382
Russia	357
Iran	134
Nigeria	123
Venezuela	112
United Arab Emirates	101
Kuwait	99
Iraq	86
Norway	86
Angola	81
Others	611
Total	**2 172**

2010 data

Net importers	Mt
United States	483
China	254
Japan	207
India	122
Germany	110
South Korea	106
France	83
Singapore	72
Spain	69
Italy	68
Others	627
Total	**2 201**

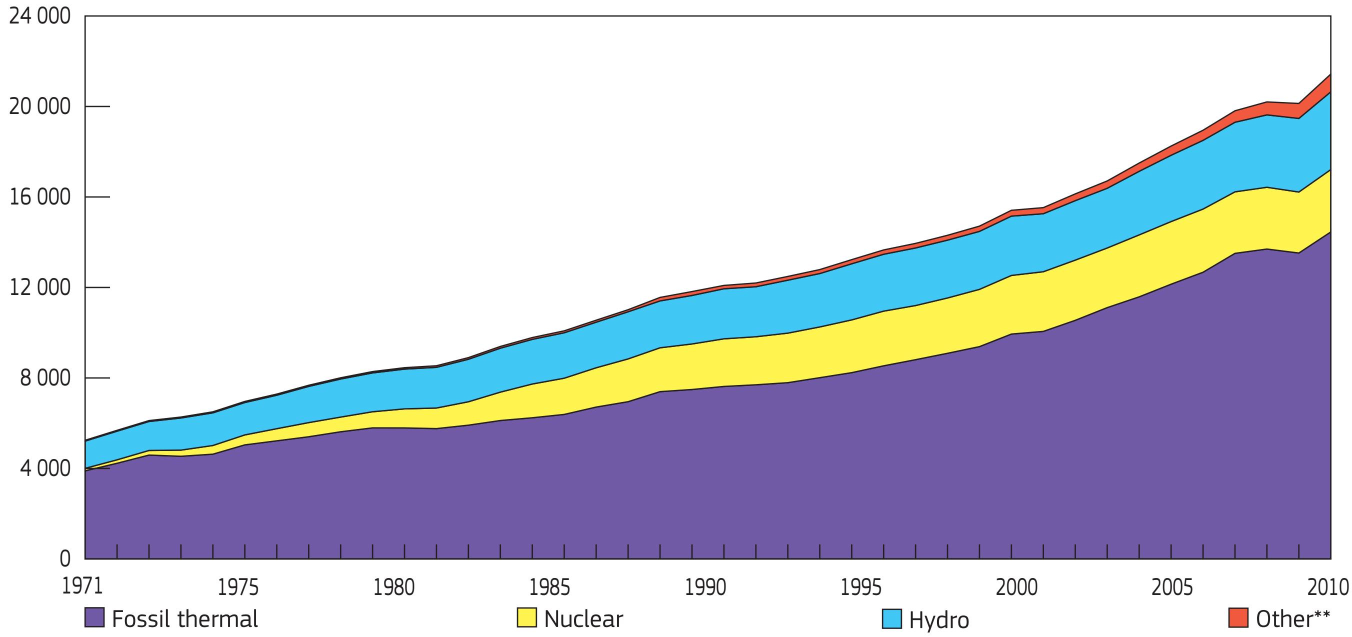
2010 data

*Crude oil and oil products.

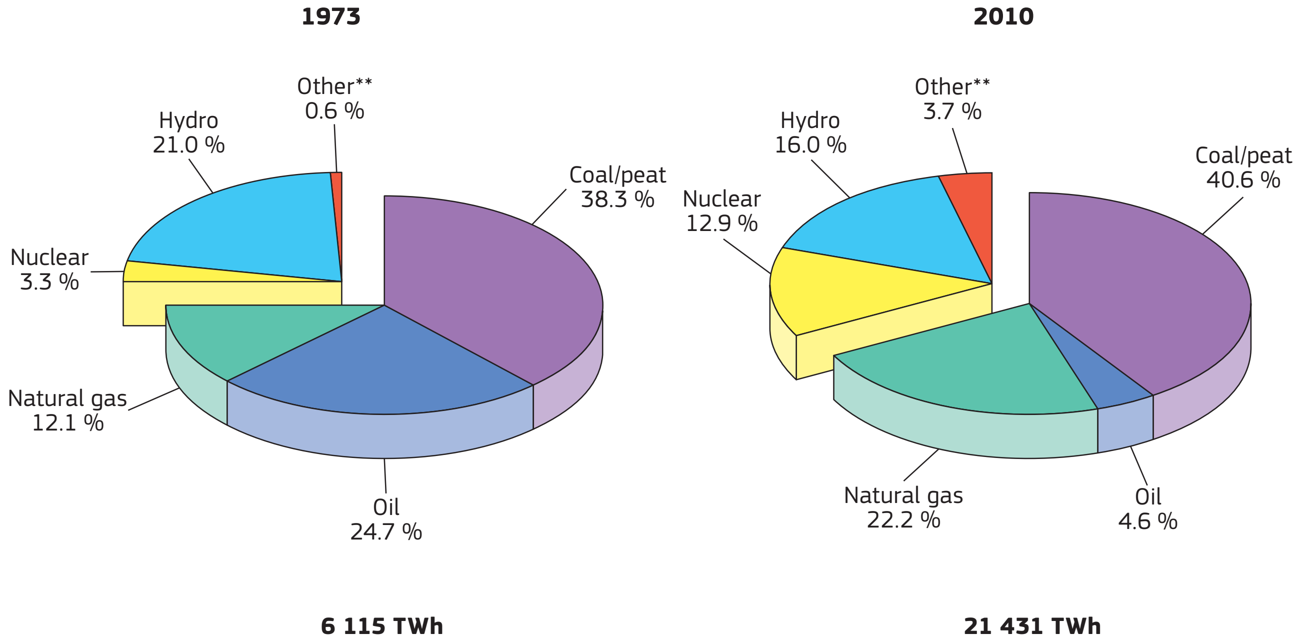
**Includes unlisted small teapot refineries which are estimated at 500 kb/cd (i.e. calendar day).

Electricity generation by fuel

World electricity generation* from 1971 to 2010 by fuel (TWh)



1973 and 2010 fuel shares of electricity generation*



*Excludes pumped storage.

**Other includes geothermal, solar, wind, biofuels and waste, and heat.

Electricity production from fossil fuels

Coal/peat	TWh
China	3 273
United States	1 994
India	653
Japan	304
Germany	274
South Africa	242
South Korea	219
Australia	181
Russia	166
Poland	138
Rest of the world	1 254
World	**8 698**

2010 data

Oil	TWh
Saudi Arabia	129
Japan	97
United States	48
Iran	46
Mexico	44
Kuwait	43
Indonesia	35
Pakistan	33
Egypt	31
India	26
Rest of the world	457
World	**989**

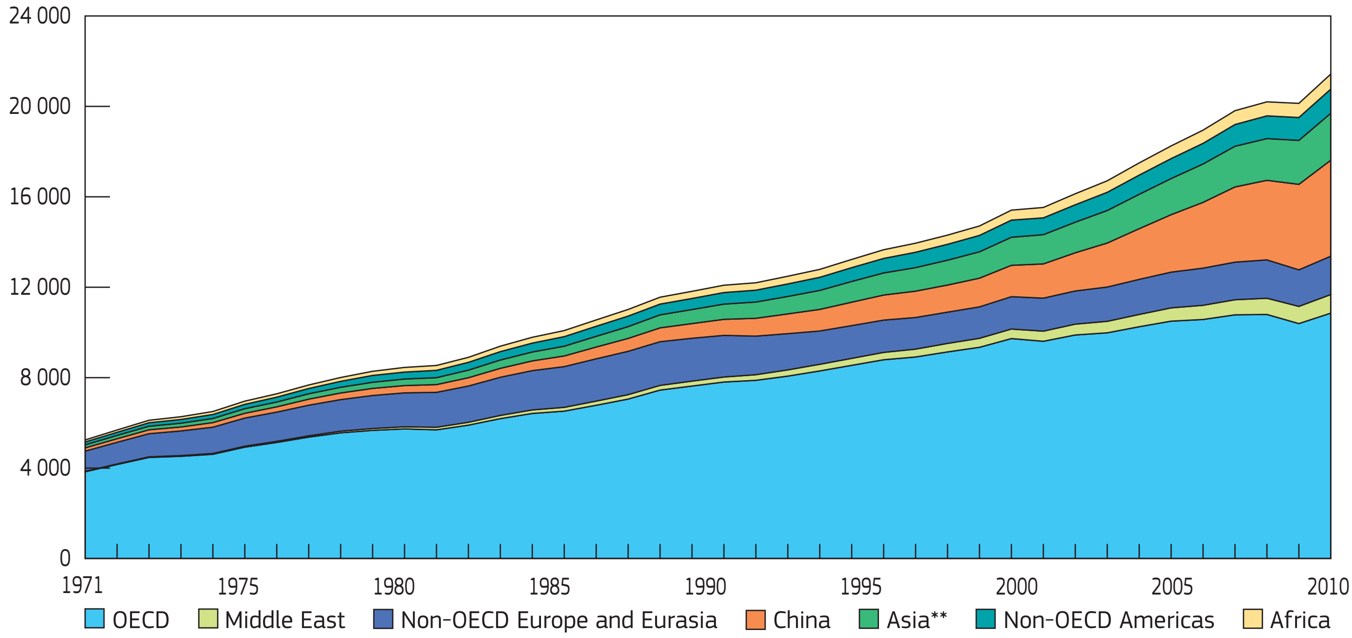
2010 data

Natural gas	TWh
United States	1 018
Russia	521
Japan	305
Iran	177
United Kingdom	175
Italy	153
Mexico	141
Thailand	119
India	118
Saudi Arabia	111
Rest of the world	1 930
World	**4 768**

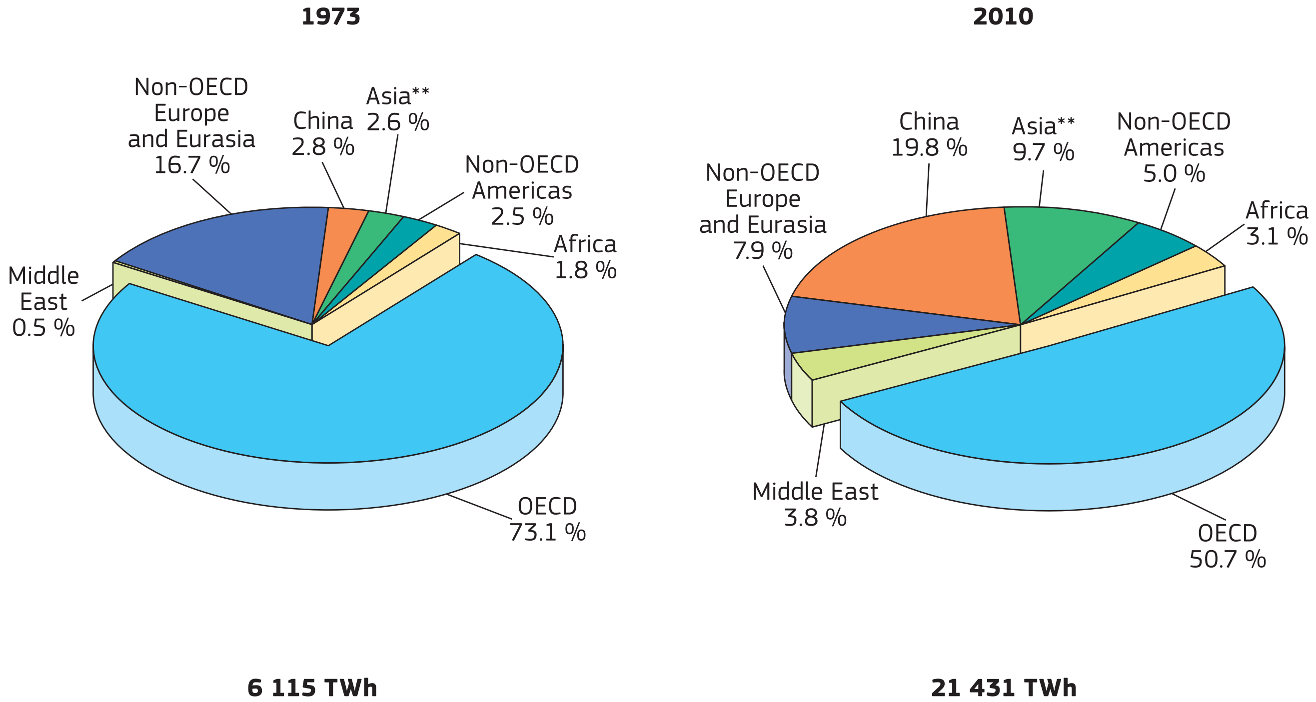
2010 data

Electricity generation by region

World electricity generation* from 1971 to 2010 by region (TWh)



1973 and 2010 regional shares of electricity generation*



*Excludes pumped storage

**Asia excludes China.

Producers, net exporters and net importers of electricity

Producers*	TWh	% of world total
United States	4 354	20.3
China	4 208	19.6
Japan	1 111	5.2
Russia	1 036	4.8
India	960	4.5
Germany	622	2.9
Canada	608	2.8
France	564	2.6
Brazil	516	2.4
South Korea	497	2.3
Rest of the world	6 955	32.6
World	**21 431**	**100.0**

2010 data

Net exporters	TWh
Paraguay	43
France	31
Canada	26
Russia	17
Germany	15
Czech Republic	15
China	14
Bulgaria	8
Spain	8
United Arab Emirates	8
Others	50
Total	**235**

2010 data

Net importers	TWh
Italy	44
Brazil	35
United States	26
Finland	11
Argentina	9
Hong Kong	8
Norway	8
Iraq	6
Lithuania	6
Greece	6
Others	83
Total	**242**

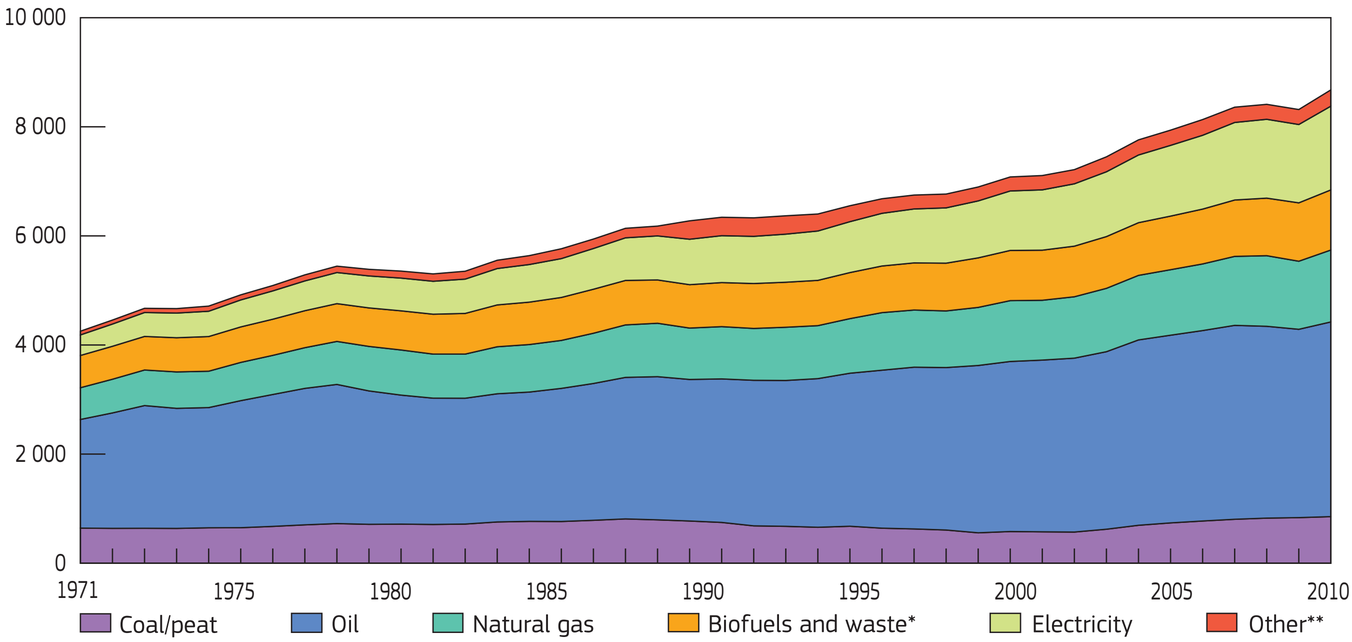
2010 data

*Gross production minus production from pumped storage plants.

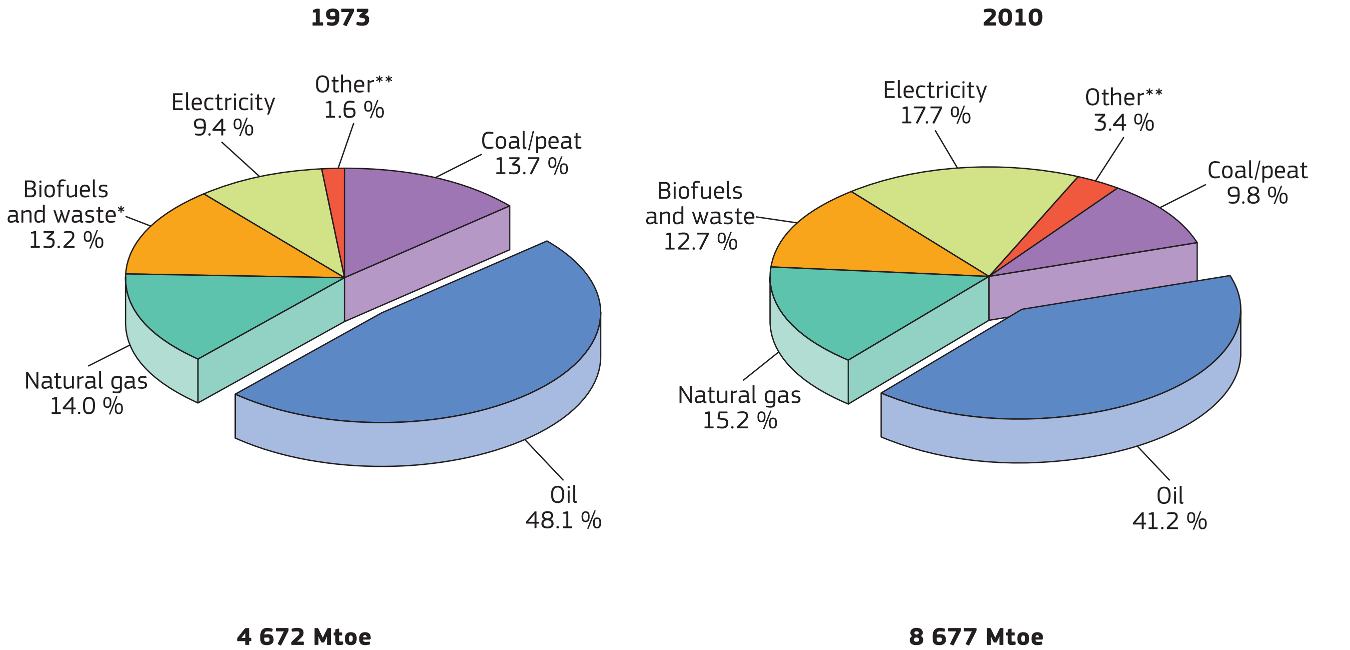
TOTAL FINAL CONSUMPTION
BY FUEL

World

World total final consumption from 1971 to 2010 by fuel (Mtoe)



1973 and 2010 fuel shares of total final consumption



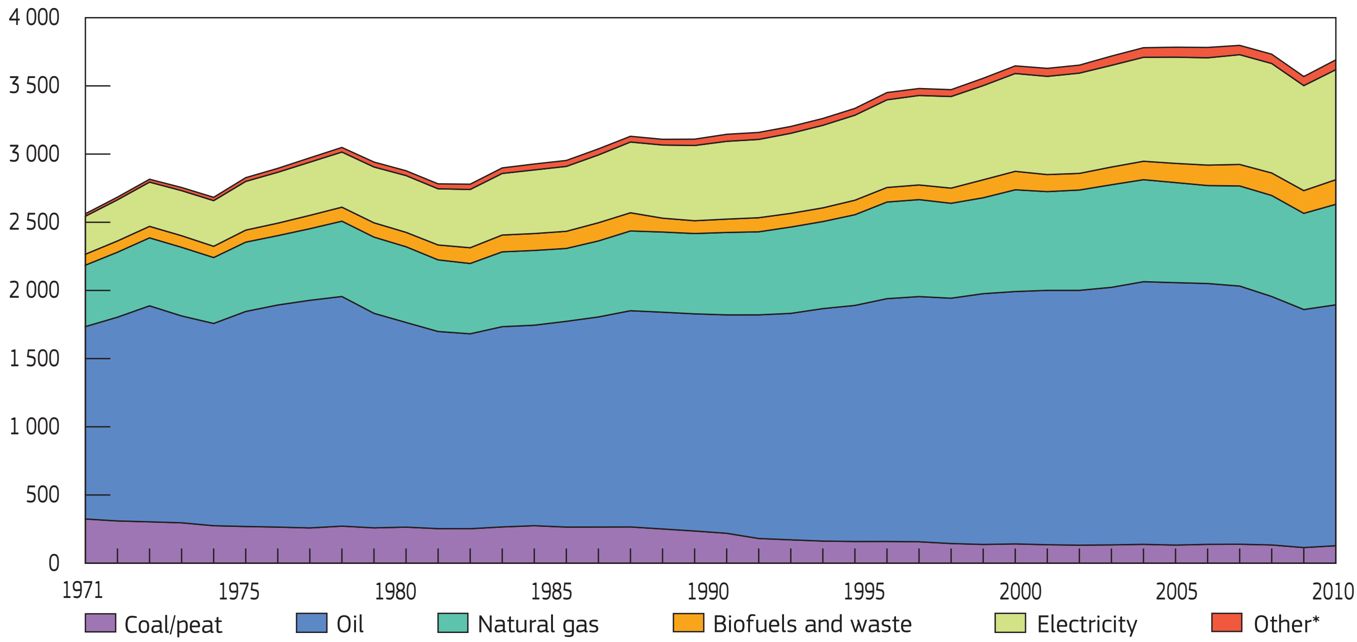
* In data prior to 1994 for biofuels and waste, final consumption has been estimated.

** Other includes geothermal, solar, wind, heat, etc.

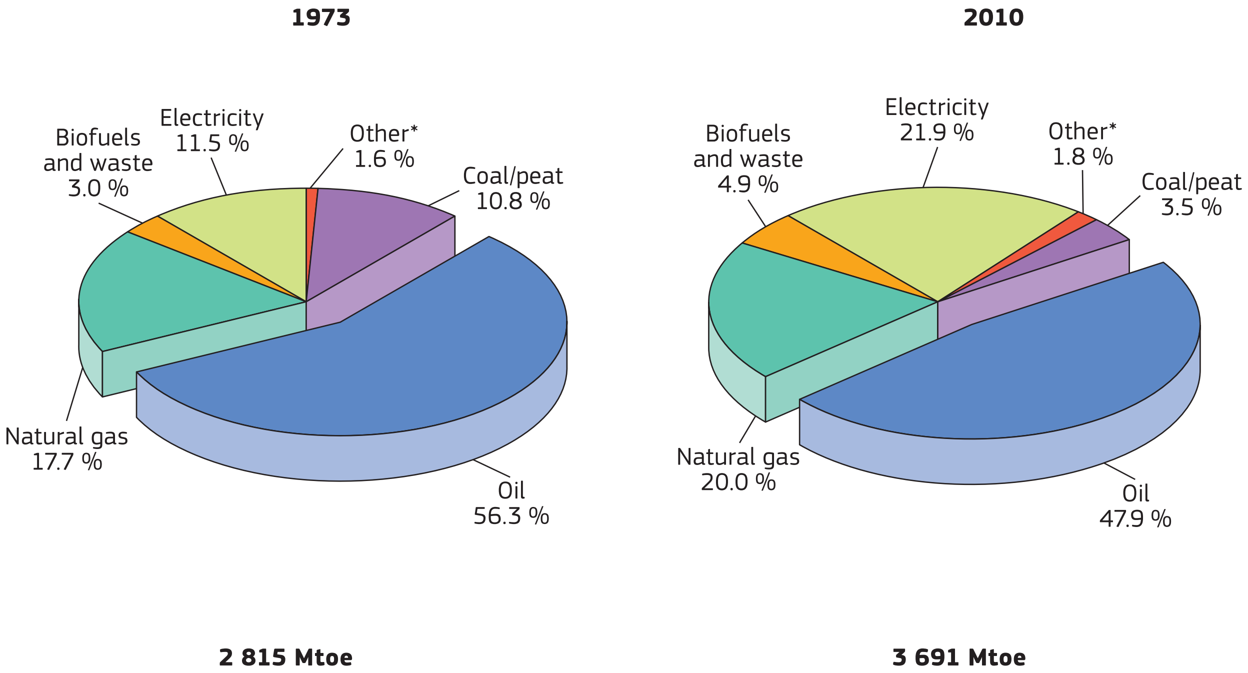
TOTAL FINAL CONSUMPTION BY FUEL

OECD

OECD total final consumption from 1971 to 2010 by fuel (Mtoe)



1973 and 2010 fuel shares of total final consumption

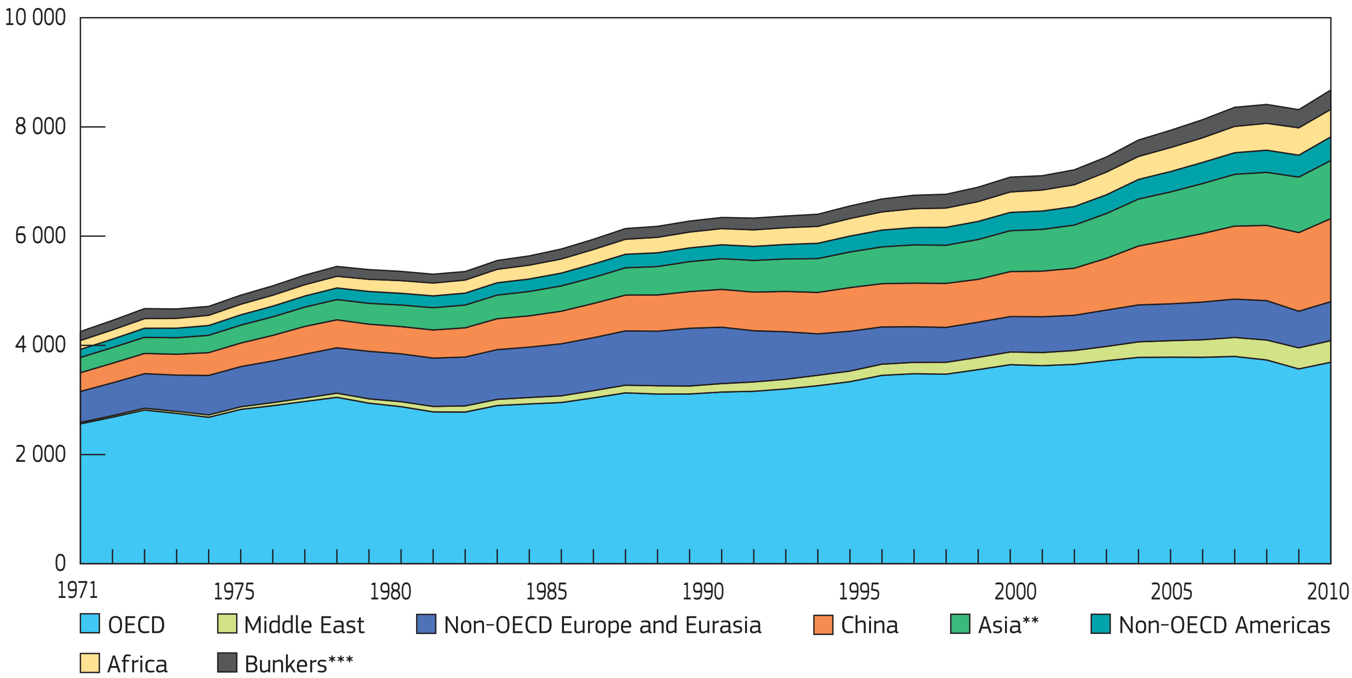


*Other includes geothermal, solar, wind, heat, etc.

TOTAL FINAL CONSUMPTION BY REGION

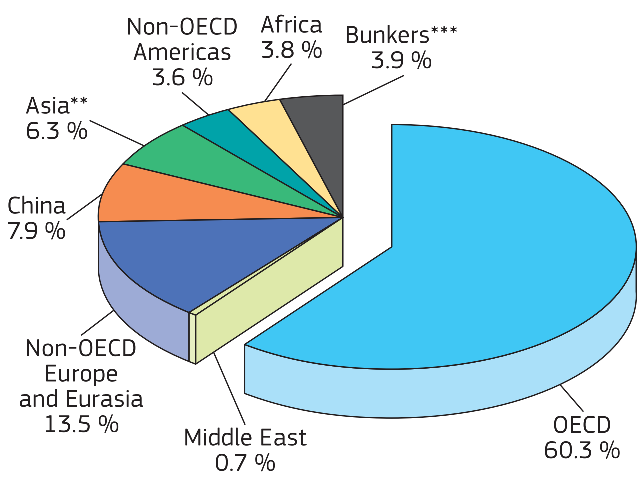
World

World total final consumption* from 1971 to 2010 by region (Mtoe)



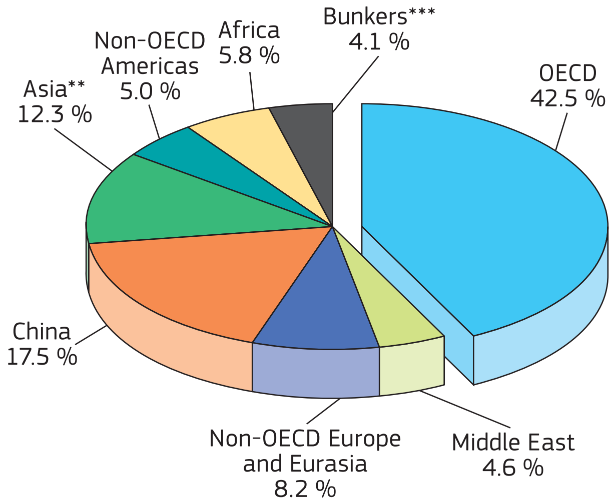
1973 and 2010 regional shares of total final consumption*

1973



4 672 Mtoe

2010



8 677 Mtoe

* In data prior to 1994 for biofuels and waste, final consumption has been estimated.

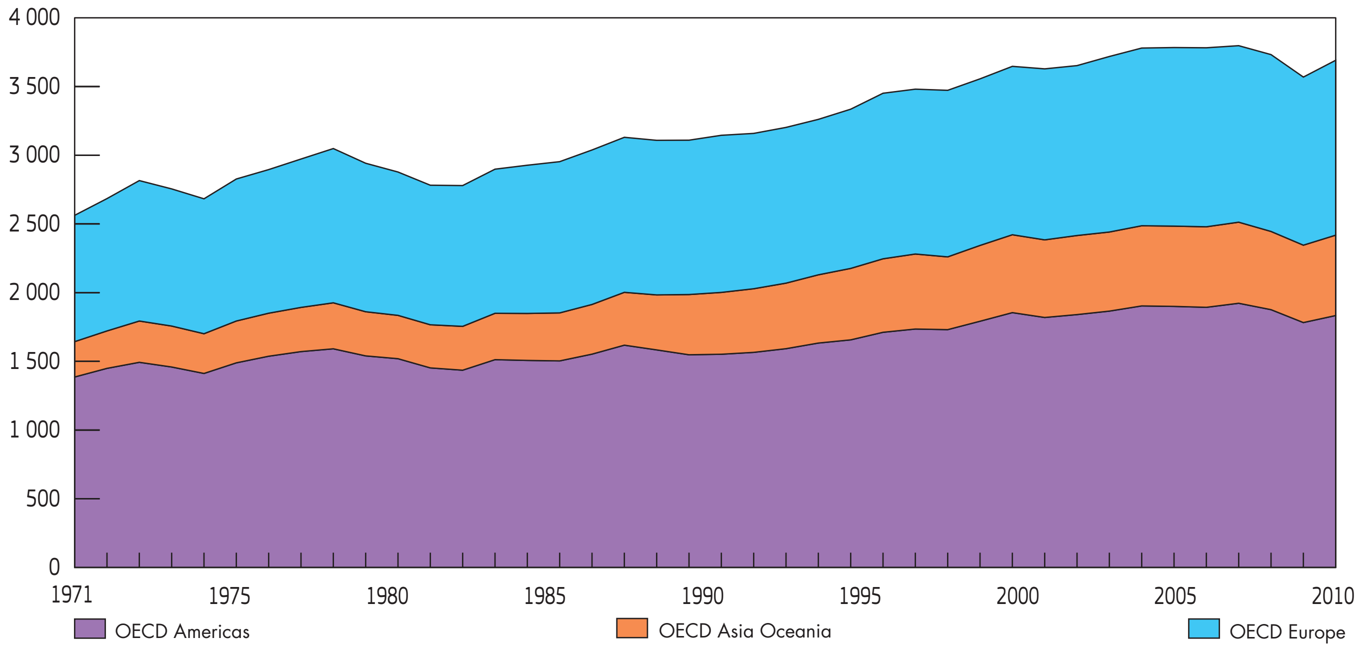
** Asia excludes China.

*** Includes international aviation and international marine bunkers.

TOTAL FINAL CONSUMPTION BY REGION

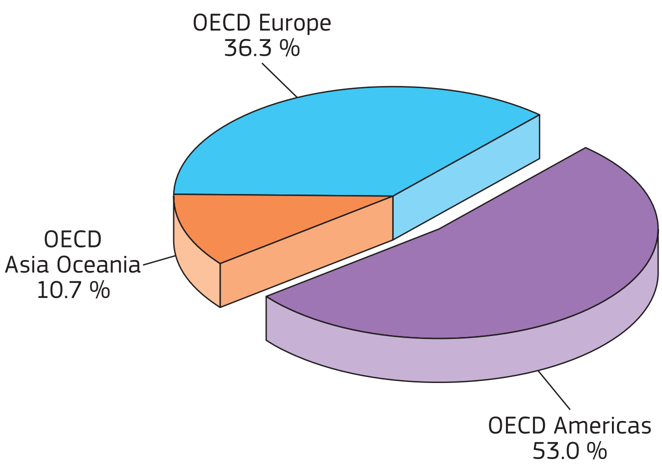
OECD

OECD total final consumption from 1971 to 2010 by region (Mtoe)



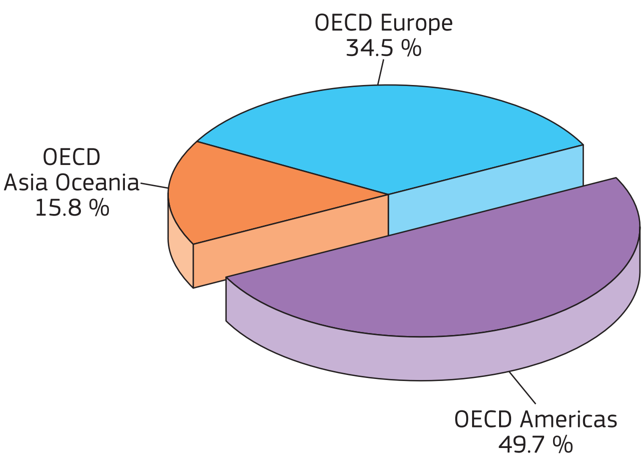
1973 and 2010 regional shares of total final consumption

1973



2 815 Mtoe

2010

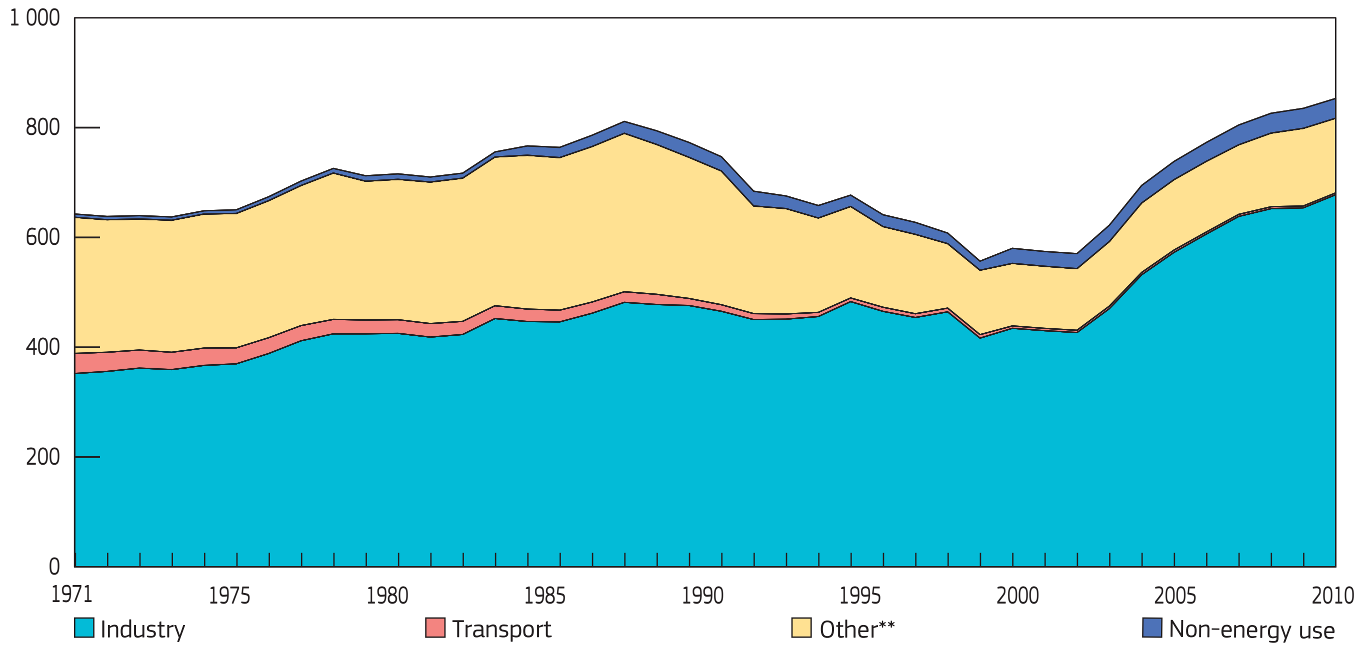


3 691 Mtoe

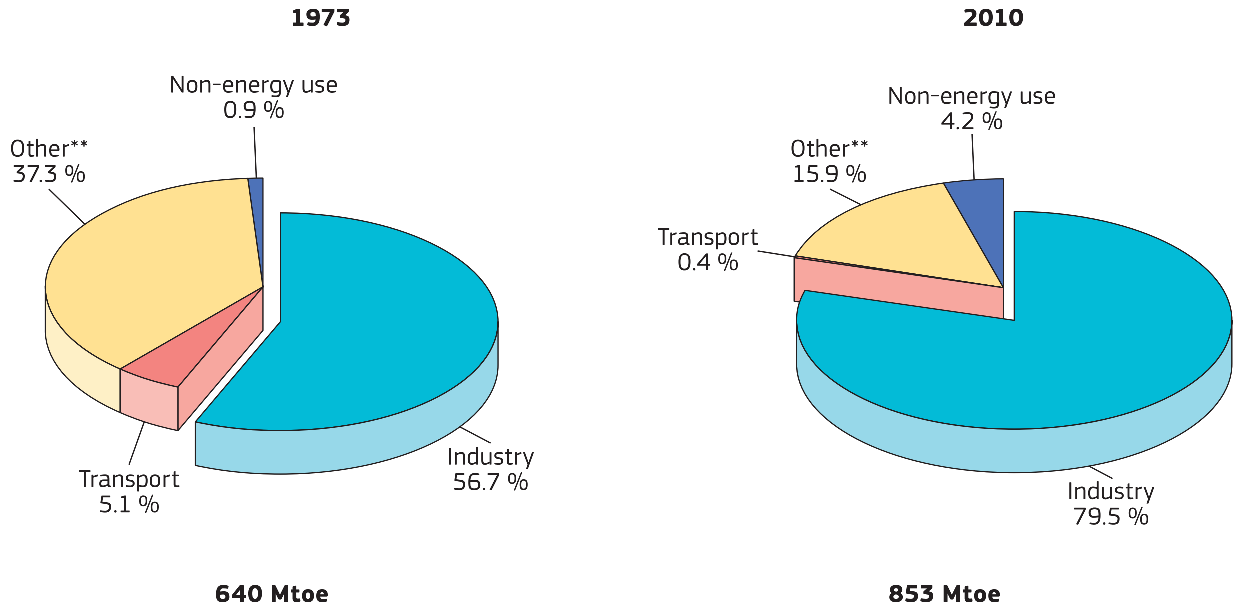
TOTAL FINAL CONSUMPTION BY SECTOR

Coal*

Total final consumption from 1971 to 2010 by sector (Mtoe)



1973 and 2010 shares of world coal* consumption



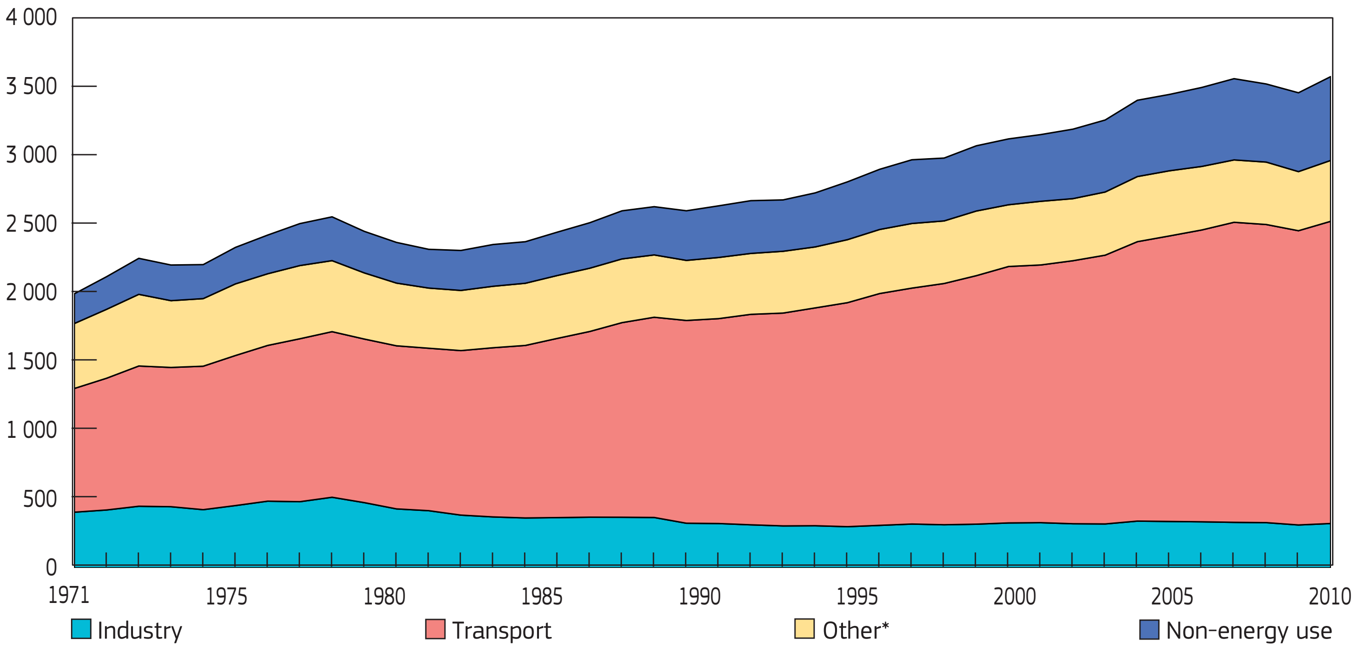
*Coal refers to coal/peat.

**Includes agriculture, commercial and public services, residential, and non-specified other.

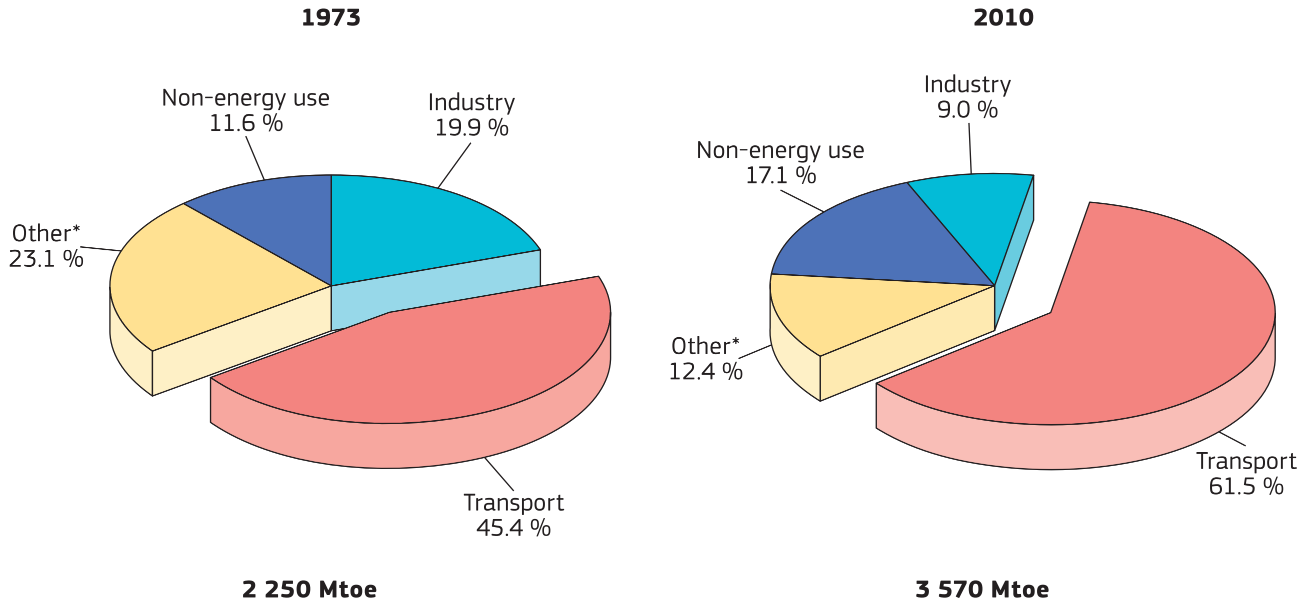
TOTAL FINAL CONSUMPTION BY SECTOR

Oil

Total final consumption from 1971 to 2010 by sector (Mtoe)



1973 and 2010 shares of world oil consumption

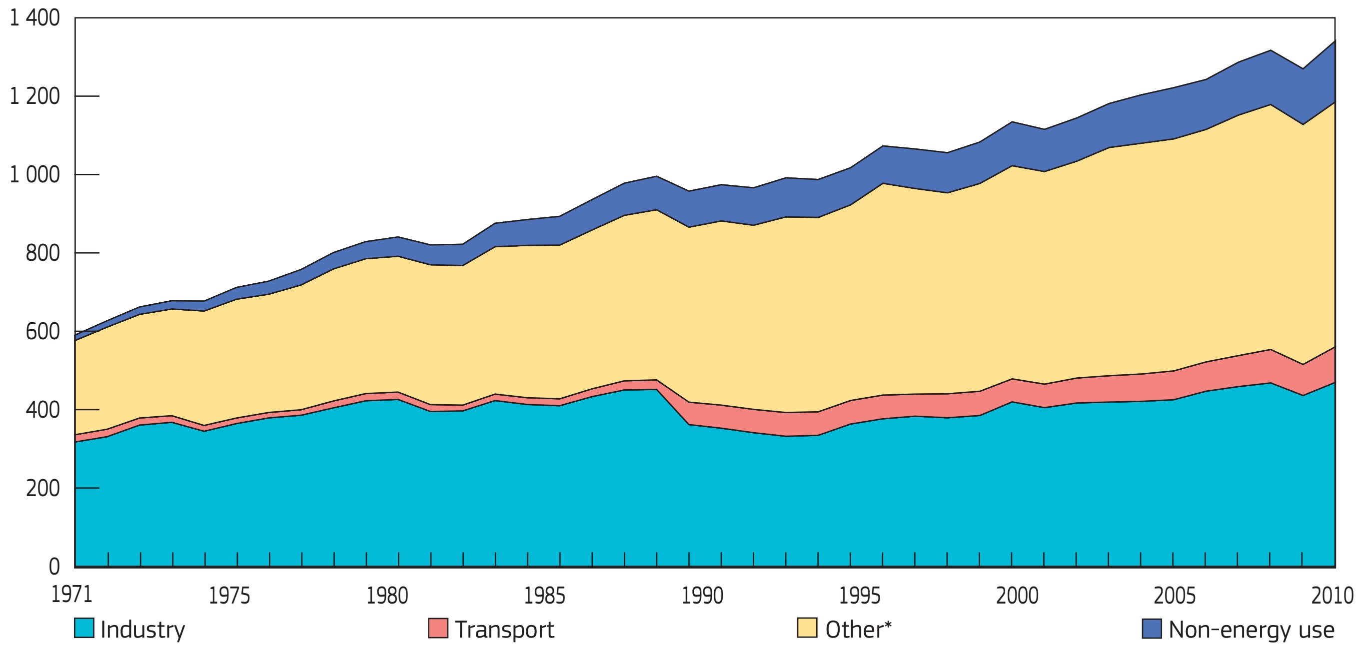


*Includes agriculture, commercial and public services, residential, and non-specified other.

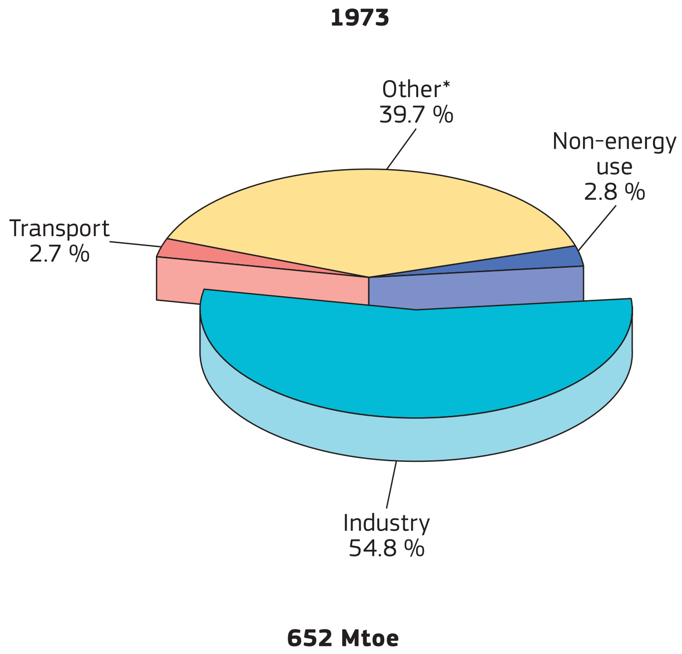
TOTAL FINAL CONSUMPTION
BY SECTOR

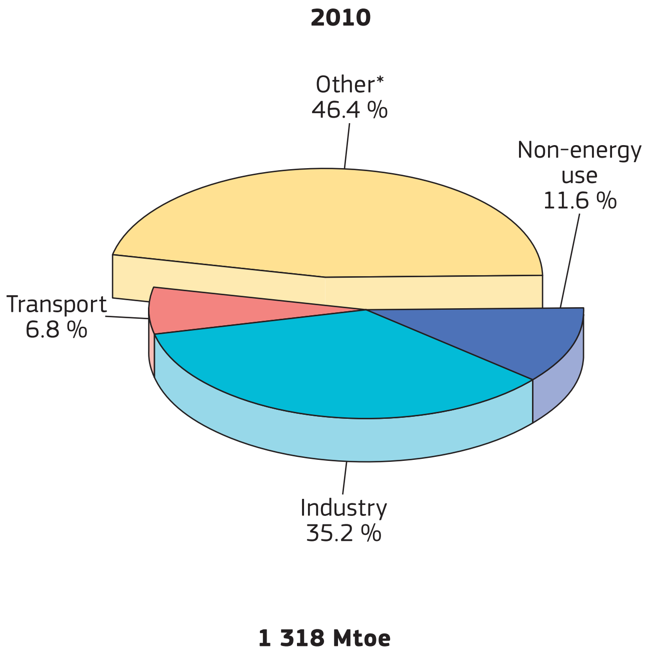
Natural gas

Total final consumption from 1971 to 2010 by sector (Mtoe)



1973 and 2010 shares of world natural gas consumption



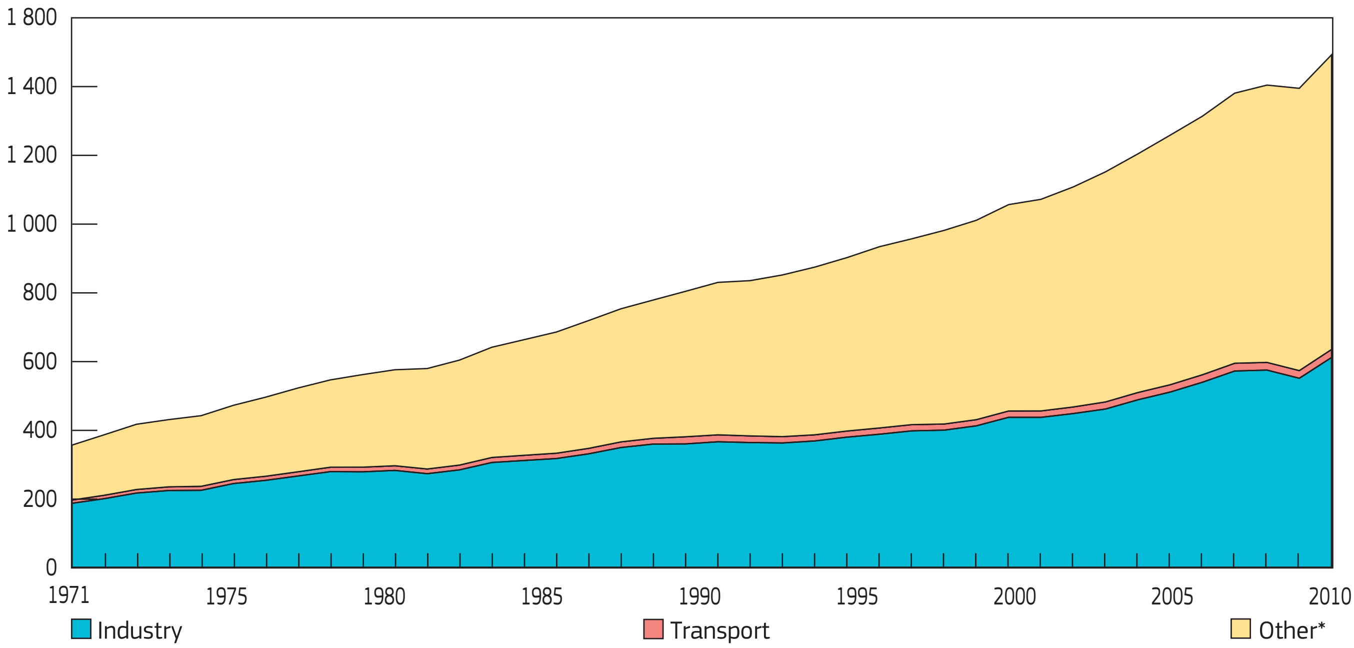


*Includes agriculture, commercial and public services, residential, and non-specified other.

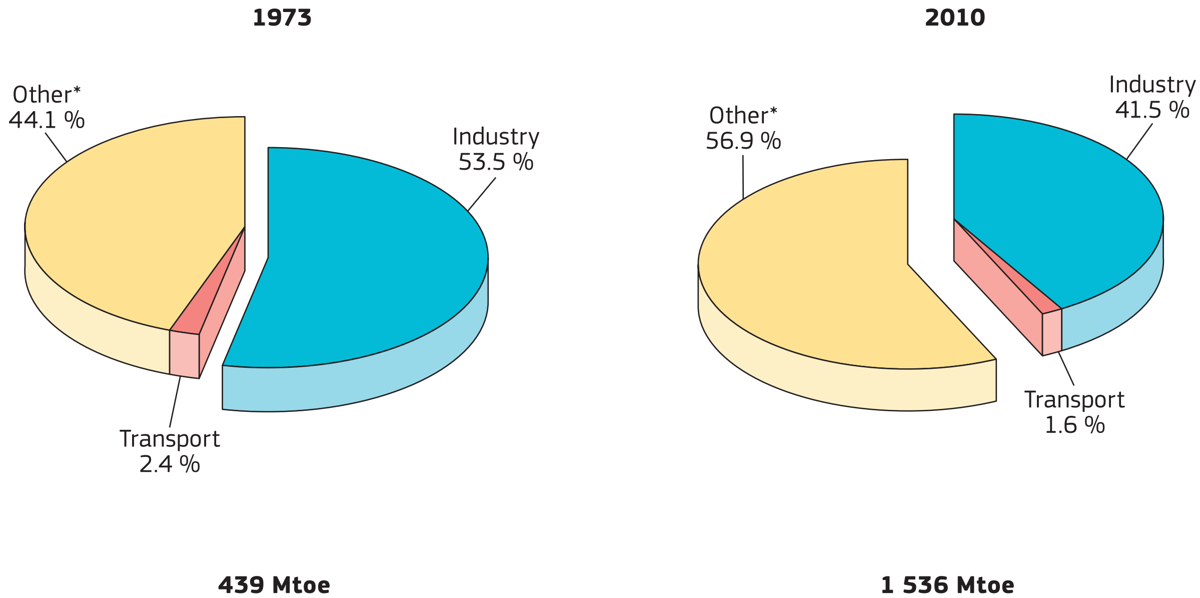
TOTAL FINAL CONSUMPTION
BY SECTOR

Electricity

Total final consumption from 1971 to 2010 by sector (Mtoe)



1973 and 2010 shares of world electricity consumption



*Includes agriculture, commercial and public services, residential, and non-specified other.

SIMPLIFIED ENERGY BALANCE TABLE

World

1973

(Mtoe)

SUPPLY AND CONSUMPTION	Coal/peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste ([a])	Other ([b])	Total
Production	1 477.06	2 938.38	—	993.10	53.05	110.19	643.78	6.13	6 221.69
Imports	140.01	1 561.28	407.65	73.40	—	—	0.12	8.14	2 190.61
Exports	-129.98	-1 612.99	-442.73	-72.56	—	—	-0.19	-8.27	-2 266.72
Stock changes	12.30	-19.68	-16.40	-15.09	—	—	0.06	—	-38.82
TPES	**1 499.40**	**2 866.99**	**-51.49**	**978.85**	**53.05**	**110.19**	**643.76**	**6.00**	**6 106.76**
Transfers	—	-46.76	48.78	—	—	—	—	—	2.02
Statistical difference	8.61	12.00	-6.77	4.78	—	—	-0.17	-0.03	18.43
Electricity plants	-559.66	-22.91	-318.28	-160.52	-52.95	-110.19	-2.61	502.64	-724.47
CHP plants	-86.32	—	-28.26	-50.84	-0.10	—	-0.75	100.70	-65.57
Heat plants	-7.81	—	-0.90	-0.68	—	—	-0.80	7.11	-3.08
Blast furnaces	-81.68	—	-2.72	—	—	—	-0.06	—	-84.45
Gas works	9.87	-0.60	-9.07	-6.21	—	—	—	—	-6.01
Coke ovens ([c])	-98.10	—	-0.68	-0.19	—	—	-0.02	—	-98.99
Oil refineries	—	-2 782.24	2 761.32	—	—	—	—	—	-20.92
Petchem plants	—	5.09	-5.37	—	—	—	—	—	-0.28
Liquefaction plants	-0.73	0.23	—	—	—	—	—	—	-0.50
Other transformation	—	—	-0.12	-0.03	—	—	-23.74	—	-23.89
Energy ind. own use	-35.06	-2.59	-158.81	-106.83	—	—	-0.20	-57.68	-361.16
Losses	-8.86	-7.07	-0.27	-6.03	—	—	-0.25	-43.14	-65.62
TFC	**639.67**	**22.15**	**2 227.36**	**652.29**	**—**	**—**	**615.18**	**515.61**	**4 672.26**
Industry	362.08	16.42	431.56	356.95	—	—	91.51	286.35	1 544.86
Transport ([d])	32.93	—	1 019.05	17.72	—	—	0.24	10.60	1 080.54
Other	238.65	0.00	520.70	259.26	—	—	523.42	218.67	1 760.70
Non-energy use	6.01	5.73	256.05	18.37	—	—	—	—	286.16

([a]) Biofuels and waste final consumption has been estimated.
([b]) Other includes geothermal, solar, wind, electricity and heat, etc.
([c]) Also includes patent fuel and BKB plants.
([d]) Includes international aviation and international marine bunkers.

SIMPLIFIED ENERGY BALANCE TABLE

World

2010

(Mtoe)

SUPPLY AND CONSUMPTION	Coal/peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste	Other ([a])	Total
Production	3 596.04	4 069.38	—	2 719.10	718.96	295.62	1 277.08	113.07	12 789.25
Imports	640.82	2 295.06	1 053.71	817.02	—	—	10.78	51.38	4 868.77
Exports	-681.28	-2 211.55	-1 111.80	-826.35	—	—	-9.29	-50.74	-4 891.01
Stock changes	-79.80	6.49	6.16	17.84	—	—	-0.54	—	-49.86
TPES	**3 475.77**	**4 159.37**	**-51.93**	**2 727.61**	**718.96**	**295.62**	**1 278.03**	**113.71**	**12 717.16**
Transfers	0.00	-156.64	179.33	—	—	—	—	—	22.69
Statistical difference	-49.50	11.30	-27.05	-1.68	—	—	-0.40	0.19	-67.14
Electricity plants	-1 974.84	-34.63	-201.57	-705.47	-715.67	-295.62	-63.40	1 582.73	-2 408.47
CHP plants	-161.19	-0.01	-22.50	-304.76	-3.13	—	-35.21	321.34	-205.45
Heat plants	-103.61	-0.81	-12.92	-90.14	-0.15	—	-10.42	188.67	-29.38
Blast furnaces	-168.50	—	-0.79	-0.11	—	—	—	—	-169.40
Gas works	-8.80	—	-3.53	2.81	—	—	-0.02	—	-9.54
Coke ovens ([b])	-51.08	—	-2.40	-0.00	—	—	-0.01	—	-53.49
Oil refineries	—	-3 964.42	3 921.30	-0.80	—	—	—	—	-43.92
Petchem plants	—	30.51	-31.35	—	—	—	—	—	-0.84
Liquefaction plants	-16.20	7.85	—	-7.10	—	—	—	—	-15.45
Other transformation	0.01	0.13	-0.17	-2.22	—	—	-53.14	-0.39	-55.77
Energy ind. own use	-86.22	-10.10	-210.37	-275.36	—	—	-13.27	-196.78	-792.10
Losses	-2.70	-8.23	-0.58	-24.63	—	—	-0.15	-175.98	-212.27
TFC	**853.14**	**34.34**	**3 535.48**	**1 318.16**	**—**	**—**	**1 102.01**	**1 833.49**	**8 676.63**
Industry	677.86	12.51	310.02	463.87	—	—	195.83	762.85	2 422.94
Transport ([c])	3.36	0.04	2 195.89	89.06	—	—	57.56	23.91	2 369.81
Other	135.96	6.75	435.64	612.83	—	—	848.62	1 046.73	3 086.53
Non-energy use	35.97	15.05	593.93	152.40	—	—	—	—	797.35

([a]) Other includes geothermal, solar, wind, electricity and heat, etc.
([b]) Also includes patent fuel and BKB plants.
([c]) Includes international aviation and international marine bunkers.

SIMPLIFIED ENERGY BALANCE TABLE

OECD

1973

(Mtoe)

SUPPLY AND CONSUMPTION	Coal/peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste	Other ([a])	Total
Production	819.25	710.51	—	706.22	49.22	78.94	87.29	6.13	2 457.55
Imports	121.92	1 277.47	336.20	62.55	—	—	0.03	7.55	1 805.73
Exports	-111.10	-63.58	-172.72	-50.38	—	—	-0.01	-7.01	-404.80
Int'l marine bunkers	—	—	-73.65	—	—	—	—	—	-73.65
Int'l aviation bunkers	—	—	-24.64	—	—	—	—	—	-24.64
Stock changes	14.52	-10.78	-11.36	-12.07	—	—	0.06	—	-19.64
TPES	**844.60**	**1 913.62**	**53.83**	**706.32**	**49.22**	**78.94**	**87.36**	**6.66**	**3 740.55**
Transfers	—	-41.28	42.49	—	—	—	—	—	1.22
Statistical difference	14.82	11.29	2.56	-5.61	—	—	-0.00	0.00	23.06
Electricity plants	-387.69	-20.61	-228.38	-108.33	-49.12	-78.94	-1.43	364.70	-509.81
CHP plants	-52.07	—	-7.89	-11.64	-0.10	—	-0.75	30.94	-41.51
Heat plants	-7.81	—	-0.90	-0.68	—	—	-0.80	7.11	-3.08
Blast furnaces	-65.64	—	-2.72	—	—	—	—	—	-68.36
Gas works	11.02	-0.60	-8.72	-6.37	—	—	—	—	-4.68
Coke ovens ([b])	-25.71	—	-0.68	-0.19	—	—	-0.02	—	-26.60
Oil refineries	—	-1 865.94	1 868.42	—	—	—	—	—	2.48
Petchem plants	—	4.88	-5.16	—	—	—	—	—	-0.28
Liquefaction plants	—	0.02	—	—	—	—	—	—	0.02
Other transformation	—	—	-0.12	-0.03	—	—	—	—	-0.15
Energy ind. own use	-24.53	-0.99	-128.88	-72.36	—	—	-0.07	-33.38	-260.20
Losses	-3.80	—	-0.23	-2.63	—	—	—	-30.54	-37.20
TFC	**303.19**	**0.39**	**1 583.63**	**498.48**	**—**	**—**	**84.30**	**345.49**	**2 815.48**
Industry	182.69	0.39	312.91	250.44	—	—	42.26	169.41	958.08
Transport	7.34	—	665.68	17.00	—	—	0.00	5.30	695.32
Other	110.07	—	393.09	225.47	—	—	42.04	170.78	941.45
Non-energy use	3.10	—	211.95	5.58	—	—	—	—	220.63

([a]) Other includes geothermal, solar, wind, electricity and heat, etc.
([b]) Also includes patent fuel and BKB plants.

SIMPLIFIED ENERGY BALANCE TABLE

OECD

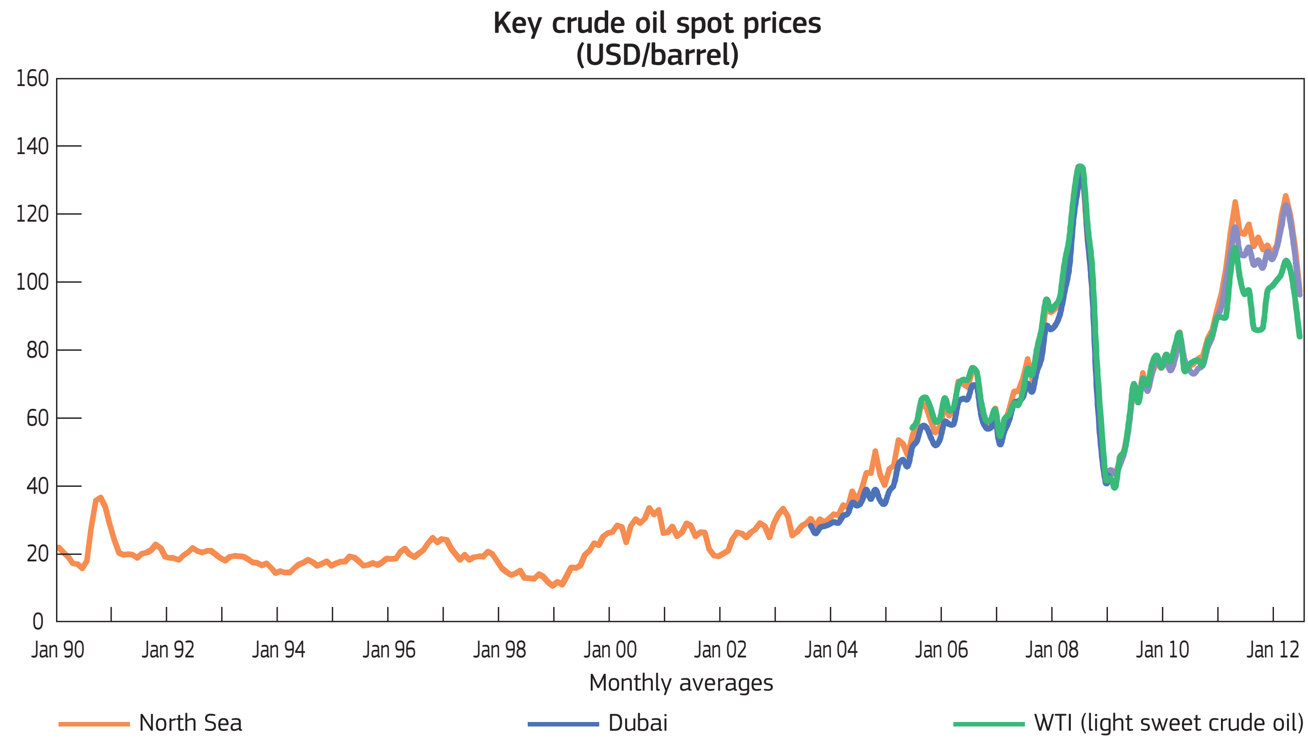
2010

(Mtoe)

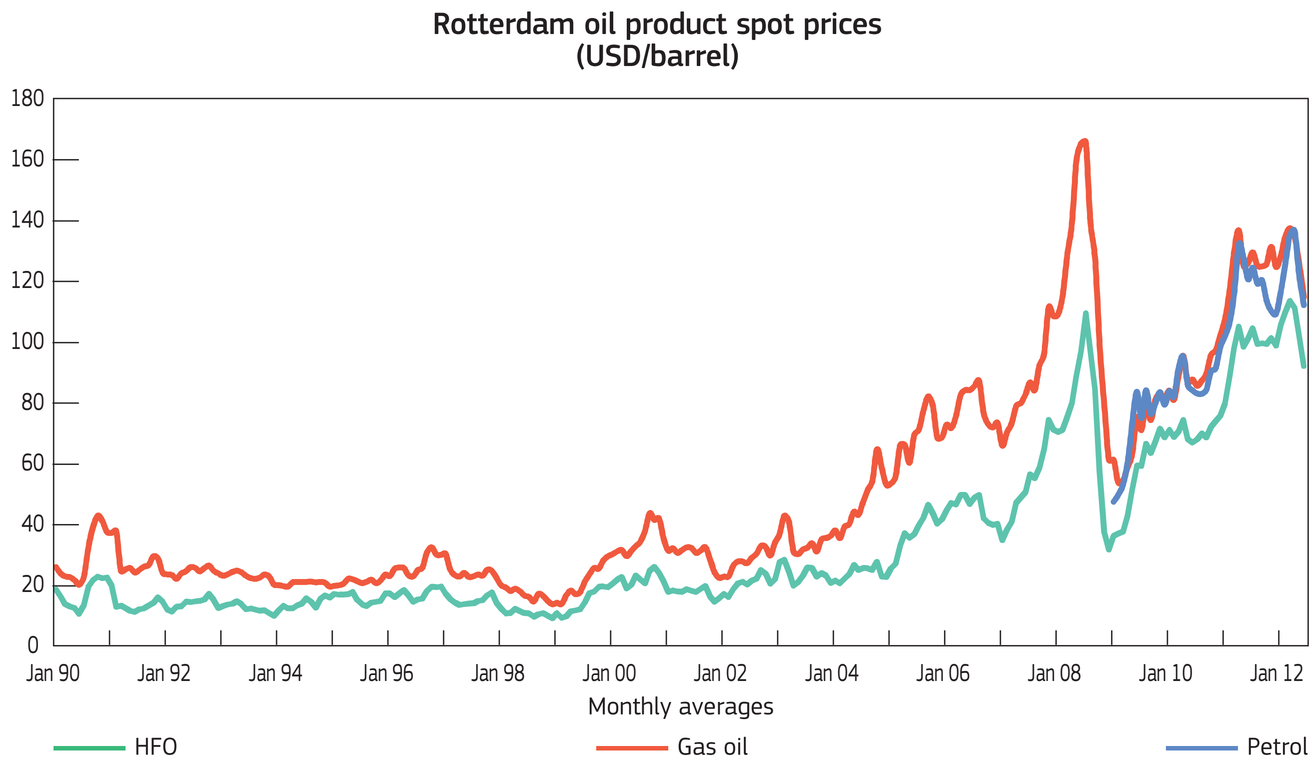
SUPPLY AND CONSUMPTION	Coal/peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste	Other ([a])	Total
Production	984.22	894.85	—	965.11	596.49	116.21	258.50	63.83	3 879.21
Imports	369.05	1 536.81	563.98	636.80	—	—	10.12	33.19	3 149.95
Exports	-285.96	-354.29	-501.46	-299.24	—	—	-5.18	-32.25	-1 478.38
Int'l marine bunkers	—	—	-90.21	—	—	—	—	—	-90.21
Int'l aviation bunkers	—	—	-85.88	—	—	—	—	—	-85.88
Stock changes	19.06	-3.63	1.29	14.30	—	—	0.16	—	31.17
TPES	**1 086.37**	**2 073.74**	**-112.28**	**1 316.96**	**596.49**	**116.21**	**263.60**	**64.77**	**5 405.87**
Transfers	—	-49.66	63.27	—	—	—	—	—	13.61
Statistical difference	-8.20	-5.59	-6.55	1.43	—	—	-0.03	-0.19	-19.14
Electricity plants	-785.14	-4.13	-50.42	-349.41	-593.73	-116.21	-43.97	787.54	-1 155.47
CHP plants	-85.22	—	-15.40	-112.85	-2.76	—	-32.56	152.09	-96.70
Heat plants	-5.14	—	-1.46	-8.35	—	—	-5.79	16.34	-4.40
Blast furnaces	-49.07	—	-0.79	-0.11	—	—	—	—	-49.97
Gas works	-2.04	—	-2.99	3.47	—	—	-0.02	—	-1.59
Coke ovens ([b])	-7.76	—	-1.19	-0.00	—	—	-0.00	—	-8.95
Oil refineries	—	-2 033.89	2 030.82	-0.80	—	—	—	—	-3.87
Petchem plants	—	26.84	-27.33	—	—	—	—	—	-0.49
Liquefaction plants	-0.79	1.30	—	-1.93	—	—	—	—	-1.43
Other transformation	0.02	0.13	-0.08	-0.49	—	—	-0.30	-0.39	-1.12
Energy ind. own use	-14.09	-0.10	-117.47	-107.12	—	—	-0.26	-76.89	-315.93
Losses	-0.94	—	-0.01	-3.84	—	—	-0.03	-64.48	-69.31
TFC	**128.00**	**8.65**	**1 758.12**	**736.95**	**—**	**—**	**180.62**	**878.77**	**3 691.11**
Industry	102.11	2.21	113.47	255.25	—	—	72.09	283.67	828.80
Transport	0.14	0.03	1 107.23	22.67	—	—	40.28	9.33	1 179.69
Other	23.57	0.73	210.10	429.06	—	—	68.25	585.77	1 317.48
Non-energy use	2.19	5.67	327.31	29.97	—	—	—	—	365.14

([a]) Other includes geothermal, solar, wind, electricity and heat, etc.
([b]) Also includes patent fuel and BKB plants.

Crude oil



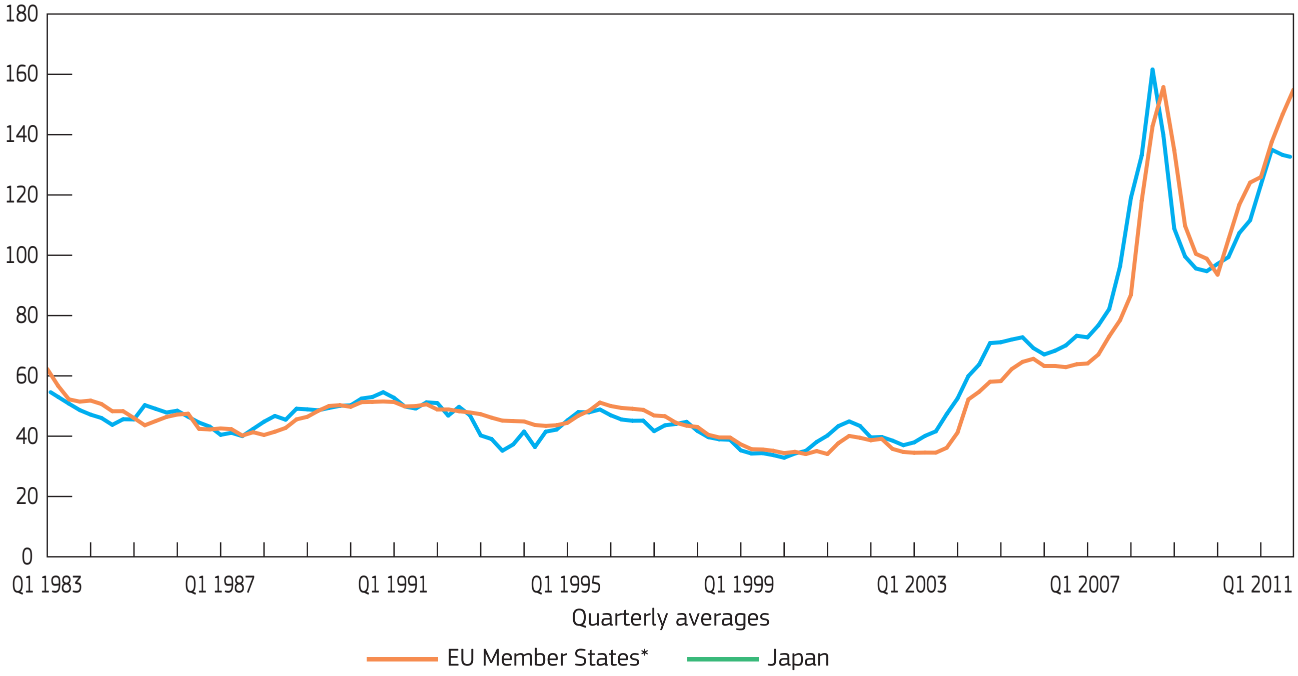
Oil products



Source: All prices based on Argus, Copyright © 2012 Argus Media Ltd, All rights reserved.

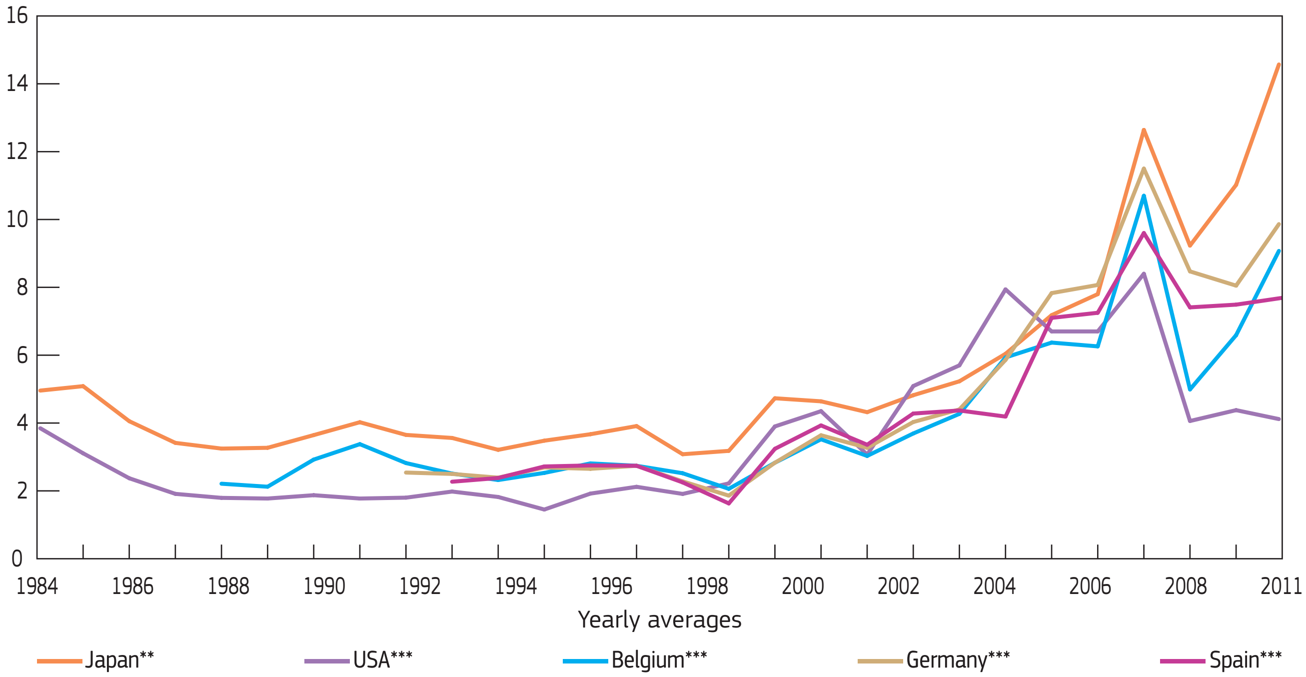
Coal

Steam coal import costs
(USD/tonne)



Natural gas

Natural gas import prices
(USD/MBtu)



*The weighted average for EU member states is based only on imports for which prices are available and may include different components in different time periods.

**LNG

***Pipeline

RETAIL PRICES (a) IN SELECTED OECD COUNTRIES (USD/unit)

	Heavy fuel oil for industry (b) (tonne)	Light fuel oil for households (1 000 litres)	Automotive diesel oil (c) (litre)	Unleaded premium (d) (litre)
Australia	—	—	—	1.666
Austria	863.65	1 326.57	1.079	1.872
Belgium	794.23	1 186.29	1.665	2.226
Canada	848.70	1 176.27	1.295	1.371
Chile	—	1 263.99	—	1.594
Czech Republic	508.43	1 284.86	1.601	1.897
Denmark	972.81	1 961.68	1.573	2.219
Estonia	—	1 370.45	1.527	1.778
Finland	—	1 489.18	1.667	2.125
France	817.85	1 302.60	1.561	2.081
Germany	781.81	1 178.72	1.65	2.144
Greece	895.06	1 319.72	1.639	2.266
Hungary	815.40	x	1.534	1.879
Ireland	1 175.16	1 440.01	1.605	1.987
Israel	c	—	c	—
Italy	875.96	1 914.96	1.839	2.29
Japan	1 057.05	1 158.87	1.328	1.848
Luxembourg	—	1 089.67	1.436	1.82
Mexico	624.96	—	0.679	0.819
Netherlands	760.84	—	1.583	2.268
New Zealand	684.43	—	1.082	1.804
Norway	—	1 795.55	1.869	2.542
Poland	811.71	1 324.77	1.443	1.745
Portugal	1 136.30	1 682.62	1.731	2.136
Slovakia	680.61	—	1.569	1.993
Slovenia	—	1 319.27	1.446	1.865
South Korea	1 056.32	1 232.35	—	1.967
Spain	792.10	1 243.79	1.507	1.847
Sweden	1 493.97	2 044.11	1.763	2.212
Switzerland	—	1 148.66	1.761	1.93
Turkey	1 209.59	1 812.76	2.201	2.48
United Kingdom	c	1 129.09	1.871	2.12
United States	730.10	1 054.47	1.048	0.987

(a) Prices are for 1st quarter 2012 for oil products, and annual 2011 for other products.
(b) Low sulphur fuel oil; high sulphur fuel oil for Canada, Ireland, Mexico, New Zealand, Turkey and the United States.
(c) For commercial purposes.
(d) Unleaded premium gasoline (95 RON); unleaded regular for Japan.

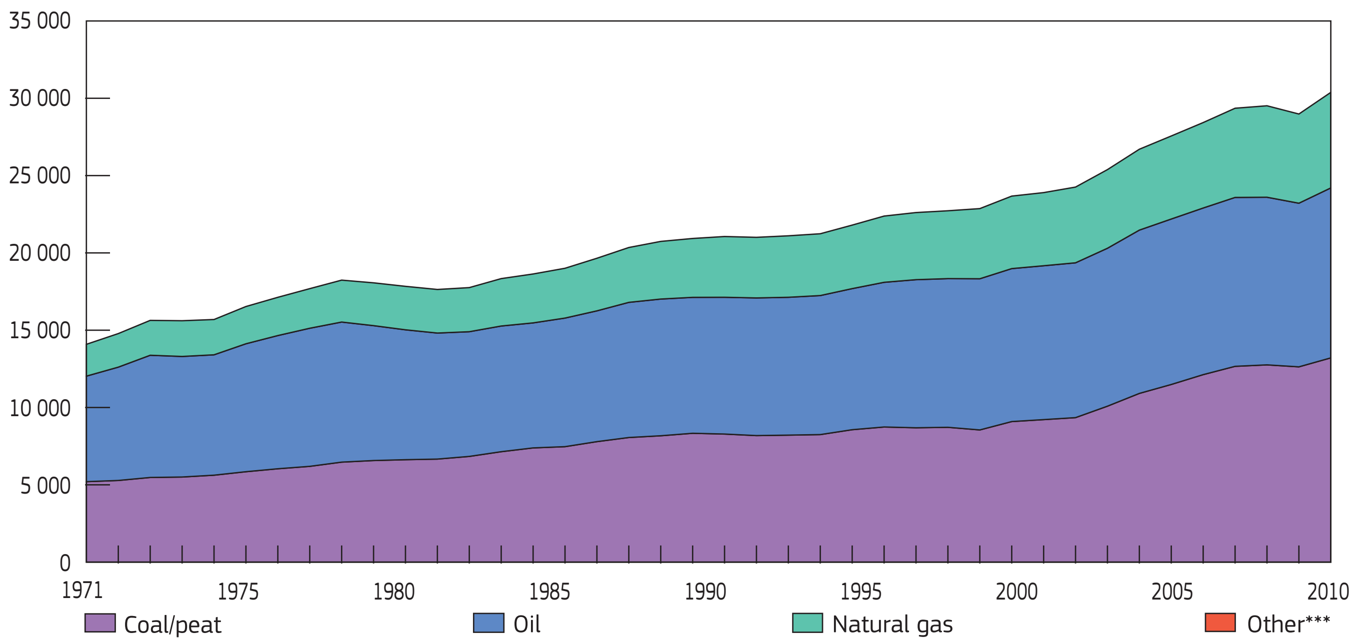
RETAIL PRICES (a) IN SELECTED OECD COUNTRIES (USD/unit)

Nat. gas for industry (MWh GCV) (e)	Nat. gas for households (MWh GCV) (e)	Steam coal for industry (f) (tonne)	Electricity for industry (MWh)	Electricity for households (MWh)	
—	—	—	—	—	Australia
—	93.11	243.11	—	272.85	Austria
36.41	90.58	—	138.51	264.37	Belgium
15.41	37.10	—	—	—	Canada
—	137.84	—	154.31	210.74	Chile
50.82	82.97	c	159.94	210.71	Czech Republic
—	—	—	115.17	409.17	Denmark
—	—	—	—	—	Estonia
45.19	62.18	315.32	113.64	213.61	Finland
51.52	84.65	—	121.54	187.09	France
54.37	92.63	—	157.23	351.95	Germany
56.00	108.06	—	125.57	173.09	Greece
43.63	63.73	—	134.21	233.07	Hungary
43.91	80.65	—	152.39	259.47	Ireland
c	—	x	97.06	148.79	Israel
—	—	140.26	279.31	278.88	Italy
—	—	153.61	179.03	260.93	Japan
50.03	73.53	—	117.30	220.26	Luxembourg
—	36.54	x	117.06	95.20	Mexico
38.53	96.84	—	120.56	237.90	Netherlands
23.76	102.43	c	73.72	212.10	New Zealand
x	x	—	71.17	170.70	Norway
42.57	72.20	109.65	121.77	198.50	Poland
50.19	96.32	234.86	139.14	245.67	Portugal
50.22	68.90	—	178.48	241.72	Slovakia
58.34	98.83	—	126.38	201.85	Slovenia
60.21	64.98	—	—	88.64	South Korea
37.72	89.27	—	148.77	295.31	Spain
69.56	163.93	—	104.20	248.18	Sweden
72.37	107.21	200.25	131.62	222.24	Switzerland
33.83	42.40	86.55	138.64	169.35	Turkey
35.51	64.84	144.27	127.39	204.92	United Kingdom
16.96	35.94	68.71	69.57	117.84	United States

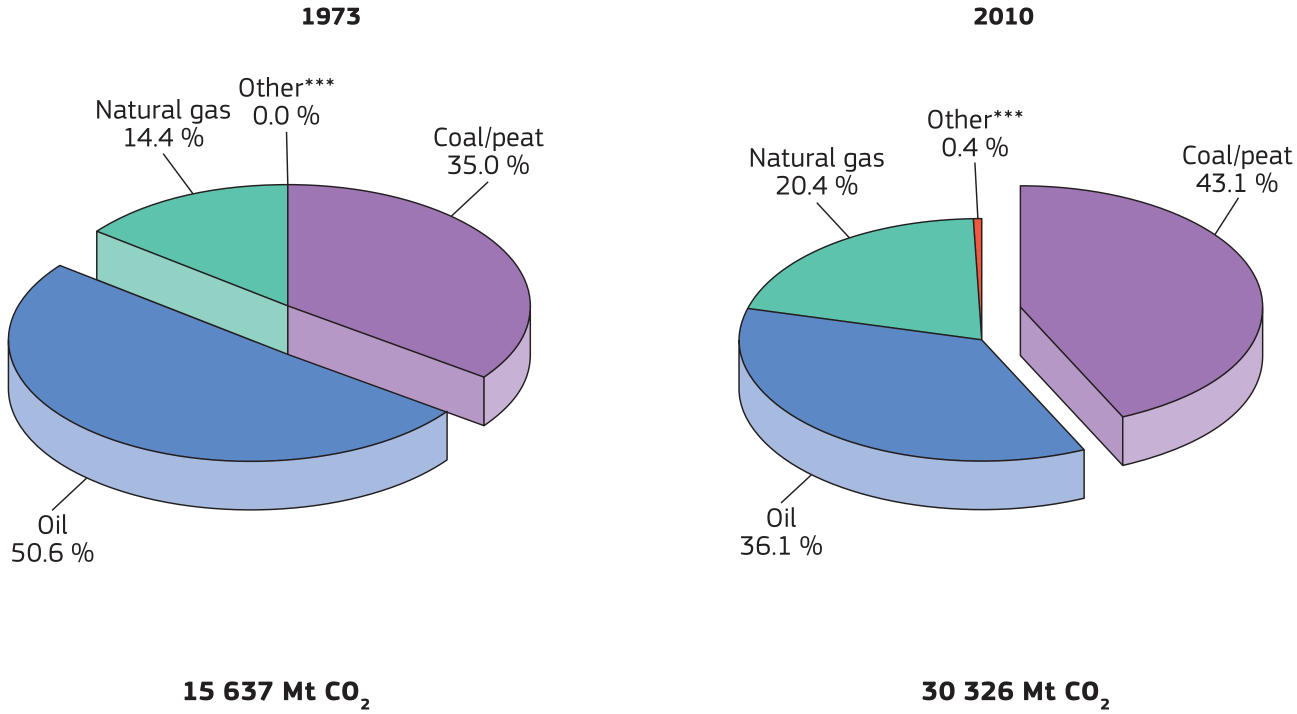
(e) Gross calorific value.
(f) Brown coal for Turkey.
— not available x not applicable c confidential

CO_2 emissions by fuel

World* CO_2 emissions from 1971 to 2010 by fuel (Mt CO_2)**



1973 and 2010 fuel shares of CO_2 emissions**



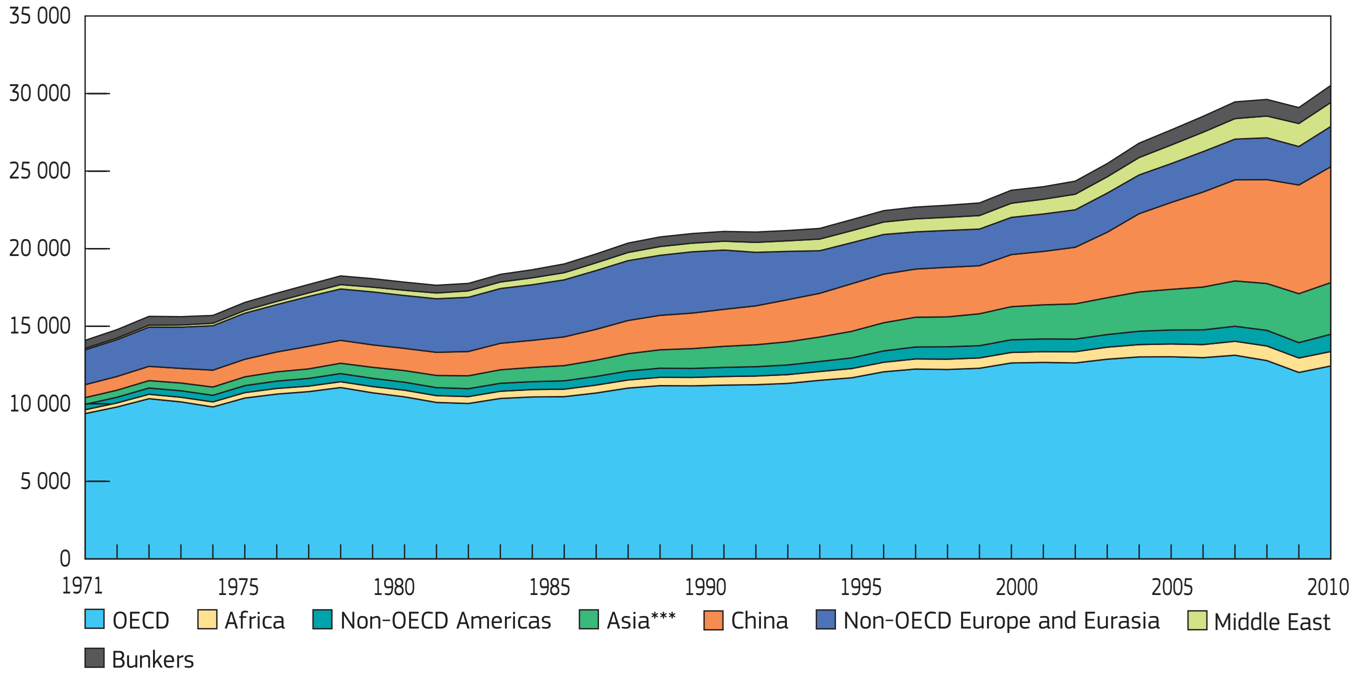
* World includes international aviation and international marine bunkers.

** Calculated using the IEA's energy balances and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (CO2 emissions are from fuel combustion only).

*** Other includes industrial waste and non-renewable municipal waste.

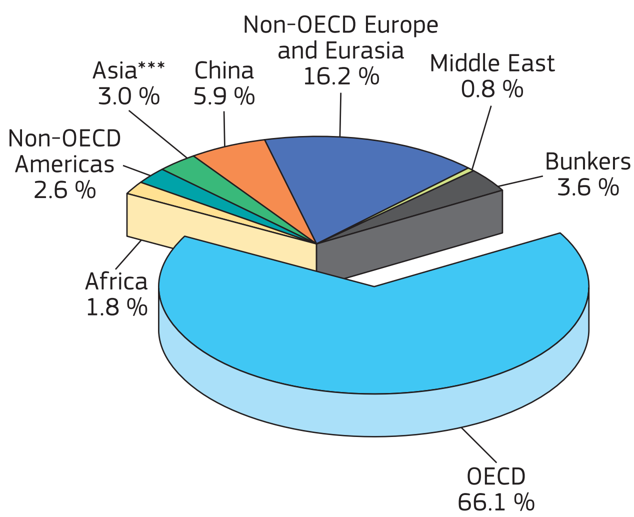
CO_2 emissions by region

World* CO_2 emissions** from 1971 to 2010 by region (Mt of CO_2)



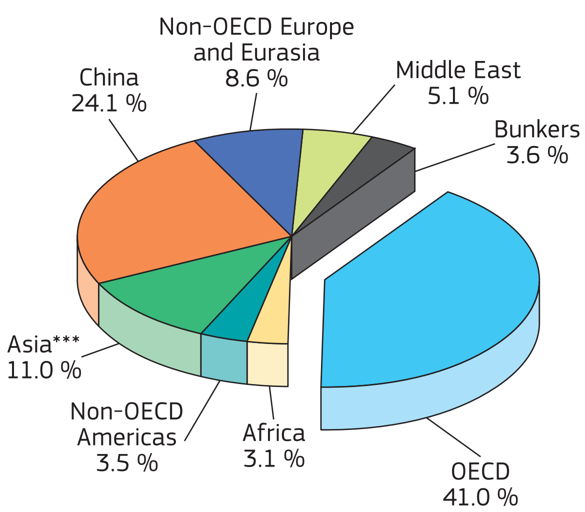
1973 and 2010 regional shares of CO_2 emissions**

1973



15 637 Mt CO_2

2010



30 326 Mt CO_2

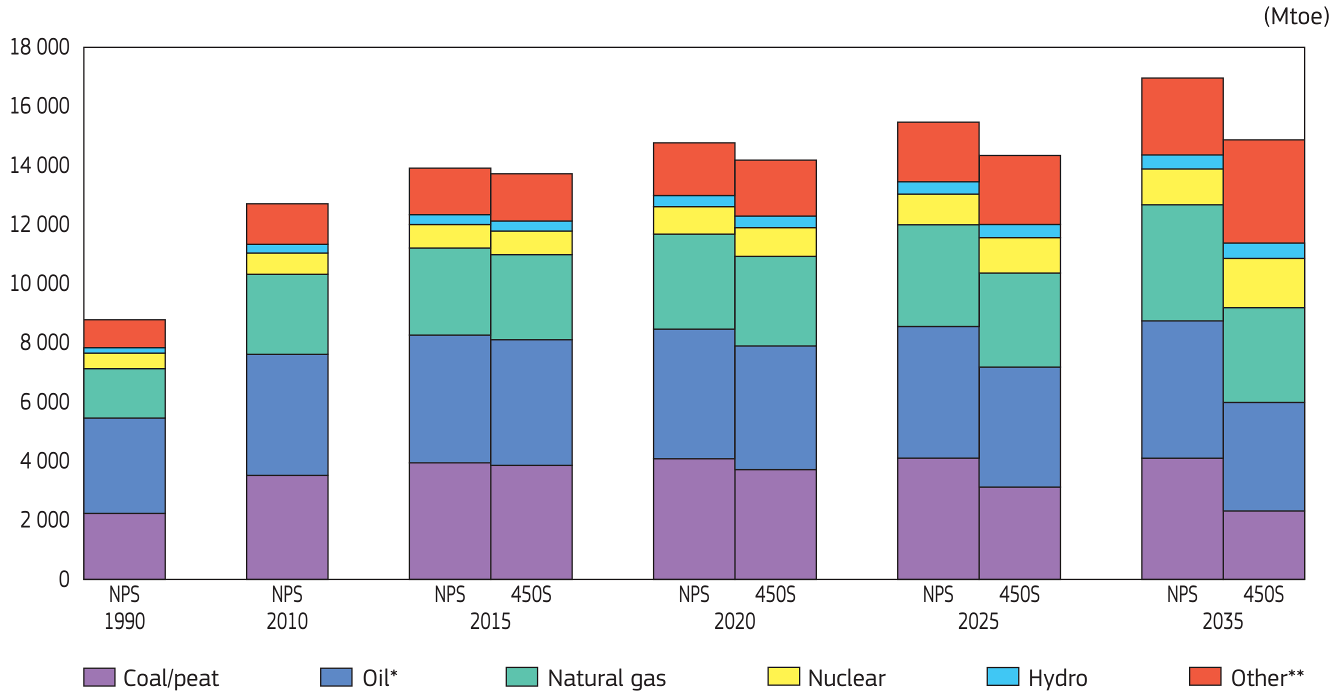
* World includes international aviation and international marine bunkers, which are shown together as bunkers.

** Calculated using the IEA's energy balances and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (CO2 emissions are from fuel combustion only).

*** Asia excludes China.

OUTLOOK FOR WORLD TPES TO 2035

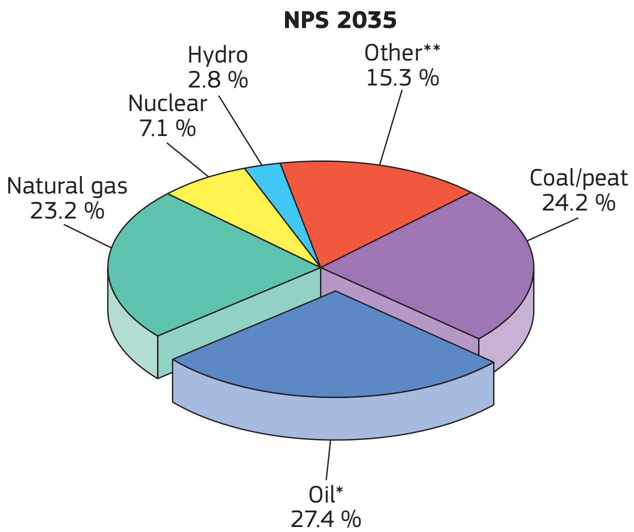
TPES outlook by fuel



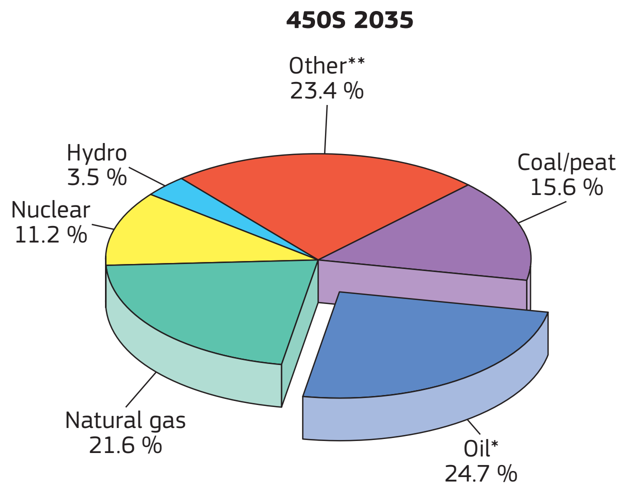
NPS: New Policies Scenario
(based on announced policy commitments and plans)

450S: 450 Scenario***
(based on policies under consideration)

Fuel shares of TPES in 2035 for New Policies Scenario and 450 Scenario



16 961 Mtoe



14 870 Mtoe

* Includes international aviation and international marine bunkers.

** Other includes biofuels and waste, geothermal, solar, wind, tide, etc.

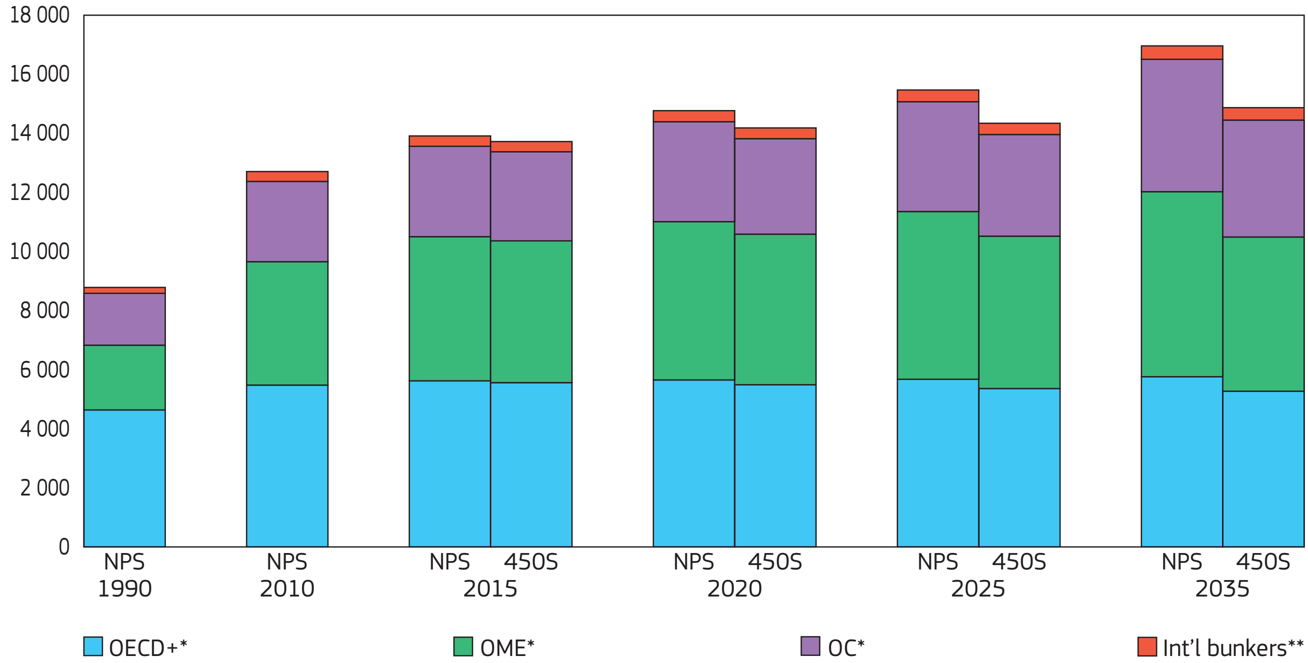
*** Based on a plausible post-2012 climate-policy framework to stabilise the concentration of global greenhouse gases at 450 ppm CO_2-equivalent.

Source: IEA, World Energy Outlook 2011

OUTLOOK FOR WORLD TPES TO 2035

TPES outlook by region

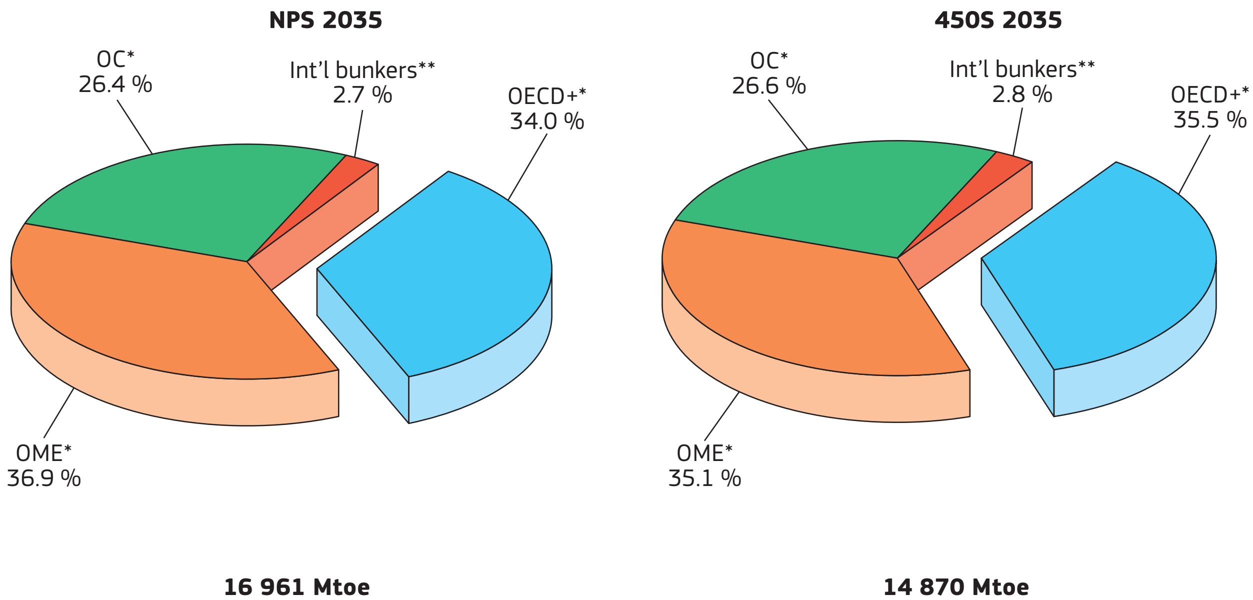
(Mtoe)



NPS: New Policies Scenario
(based on announced policy commitments and plans)

450S: 450 Scenario***
(based on policies under consideration)

Regional shares of TPES in 2035 for New Policies Scenario and 450 Scenario



*Please refer to the geographical coverage section for definitions of the regions.

**Includes international aviation and international marine bunkers.

***Based on a plausible post-2012 climate-policy framework to stabilise the concentration of global greenhouse gases at 450 ppm CO_2-equivalent.

SELECTED INDICATORS FOR 2010

Region/ country/ economy	Population (million)	GDP (billion 2005 USD)	GDP (PPP) (billion 2005 USD)	Energy prod. (Mtoe)	Net imports (Mtoe)	TPES (Mtoe)	Elec. cons.([a]) (TWh)	CO_2 emissions ([b]) (Mt of CO_2)
World	6 825	50 942	68 431	12 789	—	12 717 ([c])	19 738	30 326 ([d])
OECD	1 232	37 494	37 113	3 879	1 672	5 406	10 246	12 440
Middle East	205	1 196	2 346	1 635	-1 024	606	715	1 547
Non-OECD Europe and Eurasia	338	1 533	3 514	1 769	-629	1 132	1 492	2 606
China	1 345	4 053	9 417	2 209	367	2 431	3 980	7 311
Asia	2 229	3 217	9 072	1 360	231	1 524	1 796	3 331
Non-OECD Americas	455	2 197	4 200	769	-172	583	907	1 065
Africa	1 022	1 252	2 769	1 168	-468	682	603	930
Albania	3.20	10.73	24.57	1.62	0.56	2.08	5.67	3.76
Algeria	35.47	115.79	266.75	150.52	-109.00	40.37	36.40	98.57
Angola	19.08	54.05	105.89	98.92	-82.90	13.67	4.73	16.62
Argentina	40.41	253.74	580.43	78.85	-2.01	74.63	117.38	170.24
Armenia	3.09	5.91	15.15	0.87	1.70	2.45	4.97	4.04
Australia	22.55	874.48	824.79	310.62	-185.63	124.73	226.96	383.48
Austria	8.39	327.21	296.83	11.76	21.37	33.84	70.11	69.34
Azerbaijan	9.05	28.33	80.70	65.44	-52.67	11.84	14.52	24.67
Bahrain	1.26	17.73	26.79	17.72	-6.80	9.78	12.38	23.62
Bangladesh	148.69	81.47	221.30	25.81	5.69	31.05	41.47	52.98
Belarus	9.49	42.90	118.57	4.19	23.39	27.73	33.82	65.33
Belgium	10.88	399.92	357.48	16.04	54.27	60.86	91.39	106.43
Benin	8.85	5.25	12.60	2.05	1.76	3.65	0.88	4.50
Bolivia	9.93	11.95	43.19	16.74	-9.37	7.32	6.12	14.06
Bosnia and Herzegovina	3.76	12.60	27.62	4.37	1.95	6.40	11.69	19.91
Botswana	2.01	11.85	25.01	1.10	1.18	2.26	3.18	4.60
Brazil	194.95	1 092.73	1 960.36	246.37	24.84	265.62	464.70	387.66
Brunei	0.40	9.99	18.41	18.56	-15.30	3.31	3.49	8.21
Bulgaria	7.54	32.95	86.65	10.57	7.27	17.86	33.73	43.83
Cambodia	14.14	8.69	27.83	3.62	1.44	5.02	2.07	3.76
Cameroon	19.60	19.20	40.34	8.41	-1.48	7.11	5.32	5.03
Canada	34.11	1 203.89	1 202.02	397.83	-149.72	251.84	516.59	536.63
Chile	17.09	138.70	232.68	9.21	22.27	30.92	56.43	69.71
China	1 338.30	3 837.73	9 122.24	2 208.96	335.74	2 417.13	3 937.92	7 269.85
Colombia	46.30	183.19	392.93	105.46	-71.75	32.24	46.87	60.67
Congo	4.04	7.85	15.40	17.32	-15.64	1.47	0.59	1.66

([a]) Gross production + imports – exports – losses.
([b]) CO_2 emissions from fuel combustion only. Emissions are calculated using the IEA's energy balances and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.
([c]) TPES for world includes international aviation and international marine bunkers as well as electricity and heat trade.
([d]) CO_2 emissions for world include emissions from international aviation and international marine bunkers.

Selected Indicators for 2010

TPES/pop. (toe/capita)	TPES/GDP (toe/000 2005 USD)	TPES/GDP (PPP) (toe/000 2005 USD)	Elec. cons./pop. (kWh/capita)	CO_2/TPES ($t CO_2$/toe)	CO_2/pop. ($t CO_2$/capita)	CO_2/GDP ($kg CO_2$/2005 USD)	CO_2/GDP (PPP) ($kg CO_2$/2005 USD)	Region/country/economy
1.86	0.25	0.19	2 892	2.38	4.44	0.60	0.44	World
4.39	0.14	0.15	8 315	2.30	10.10	0.33	0.34	OECD
2.96	0.51	0.26	3 493	2.55	7.56	1.29	0.66	Middle East
3.35	0.74	0.32	4 414	2.30	7.71	1.70	0.74	Non-OECD Europe and Eurasia
1.81	0.60	0.26	2 958	3.01	5.43	1.80	0.78	China
0.68	0.47	0.17	806	2.19	1.49	1.04	0.37	Asia
1.28	0.27	0.14	1 992	1.83	2.34	0.48	0.25	Non-OECD Americas
0.67	0.54	0.25	591	1.36	0.91	0.74	0.34	Africa
0.65	0.19	0.08	1 771	1.81	1.17	0.35	0.15	Albania
1.14	0.35	0.15	1 026	2.44	2.78	0.85	0.37	Algeria
0.72	0.25	0.13	248	1.22	0.87	0.31	0.16	Angola
1.85	0.29	0.13	2 904	2.28	4.21	0.67	0.29	Argentina
0.79	0.41	0.16	1 606	1.65	1.31	0.68	0.27	Armenia
5.53	0.14	0.15	10 063	3.07	17.00	0.44	0.46	Australia
4.03	0.10	0.11	8 358	2.05	8.27	0.21	0.23	Austria
1.31	0.42	0.15	1 605	2.08	2.73	0.87	0.31	Azerbaijan
7.75	0.55	0.37	9 813	2.41	18.71	1.33	0.88	Bahrain
0.21	0.38	0.14	279	1.71	0.36	0.65	0.24	Bangladesh
2.92	0.65	0.23	3 563	2.36	6.88	1.52	0.55	Belarus
5.59	0.15	0.17	8 397	1.75	9.78	0.27	0.30	Belgium
0.41	0.70	0.29	99	1.23	0.51	0.86	0.36	Benin
0.74	0.61	0.17	616	1.92	1.42	1.18	0.33	Bolivia
1.70	0.51	0.23	3 110	3.11	5.29	1.58	0.72	Bosnia and Herzegovina
1.13	0.19	0.09	1 586	2.03	2.29	0.39	0.18	Botswana
1.36	0.24	0.14	2 384	1.46	1.99	0.35	0.20	Brazil
8.31	0.33	0.18	8 757	2.48	20.58	0.82	0.45	Brunei
2.37	0.54	0.21	4 471	2.45	5.81	1.33	0.51	Bulgaria
0.36	0.58	0.18	146	0.75	0.27	0.43	0.13	Cambodia
0.36	0.37	0.18	271	0.71	0.26	0.26	0.12	Cameroon
7.38	0.21	0.21	15 145	2.13	15.73	0.45	0.45	Canada
1.81	0.22	0.13	3 301	2.25	4.08	0.50	0.30	Chile
1.81	0.63	0.26	2 942	3.01	5.43	1.89	0.80	China
0.70	0.18	0.08	1 012	1.88	1.31	0.33	0.15	Colombia
0.36	0.19	0.10	145	1.13	0.41	0.21	0.11	Congo

Region/ country/ economy	Population (million)	GDP (billion 2005 USD)	GDP (PPP) (billion 2005 USD)	Energy prod. (Mtoe)	Net imports (Mtoe)	TPES (Mtoe)	Elec. cons.([a]) (TWh)	CO_2 emissions ([b]) (Mt of CO_2)
Costa Rica	4.66	24.77	48.35	2.44	2.39	4.65	8.64	6.54
Côte d'Ivoire	19.74	18.33	33.63	10.45	-0.90	9.57	4.14	5.81
Croatia	4.42	46.90	71.32	4.22	4.49	8.54	16.85	19.03
Cuba	11.26	54.98	62.31	5.28	5.87	10.98	14.63	30.03
Curaçao and Sint Martin	0.20	2.68	2.40	0.00	3.56	1.68	1.08	3.82
Cyprus	0.80	19.18	20.87	0.09	2.93	2.44	5.16	7.22
Czech Republic	10.52	148.58	248.64	31.62	11.41	44.11	66.50	114.48
Dem. Rep. of the Congo	65.97	9.28	20.53	24.08	-0.17	23.76	6.28	3.07
Denmark	5.55	256.13	178.81	23.33	-3.65	19.25	35.10	47.02
Dominican Republic	9.93	47.90	83.26	1.94	6.48	8.34	14.32	18.55
Ecuador	14.47	44.02	104.16	27.37	-14.18	12.10	15.26	30.10
Egypt	81.12	121.04	449.70	88.38	-14.06	73.26	130.44	177.60
El Salvador	6.19	18.35	37.04	2.26	2.02	4.19	5.30	5.87
Eritrea	5.25	1.06	2.57	0.58	0.16	0.74	0.27	0.49
Estonia	1.34	13.90	22.27	4.93	0.85	5.57	8.66	18.47
Ethiopia	82.95	20.15	77.46	31.43	2.12	33.20	4.50	5.37
Finland	5.36	205.30	168.93	17.31	18.03	36.40	88.40	62.92
France	64.85	2 208.62	1 923.46	135.57	132.09	262.29	502.94	357.81
Gabon	1.51	9.87	20.32	14.30	-12.55	2.13	1.51	2.65
Georgia	4.45	8.25	20.26	1.31	1.85	3.12	7.76	4.94
Germany	81.76	2 945.78	2 732.53	131.35	203.11	327.37	590.06	761.58
Ghana	24.39	14.75	35.97	6.73	2.82	9.32	7.26	9.49
Gibraltar	0.03	1.05	0.91	0.00	2.61	0.17	0.18	0.52
Greece	11.31	243.23	273.92	9.45	21.30	27.62	59.32	84.28
Guatemala	14.39	32.54	61.76	7.54	3.05	10.26	8.16	10.31
Haiti	9.99	4.32	9.96	1.61	0.70	2.29	0.24	2.13
Honduras	7.60	11.58	26.74	2.22	2.40	4.57	5.10	7.30
Hong Kong	7.07	215.62	294.83	0.05	31.68	13.79	41.87	41.47
Hungary	10.00	109.27	169.58	11.05	15.11	25.67	38.77	48.95
Iceland	0.32	16.40	10.42	4.43	1.09	5.37	16.36	1.92
India	1 170.94	1 246.73	3 762.86	518.67	181.44	692.69	754.61	1 625.79
Indonesia	239.87	377.28	930.65	381.45	-172.61	207.85	153.83	410.94
Iran	73.97	230.67	773.05	349.12	-135.38	208.37	196.20	509.00
Iraq	32.32	38.84	102.34	126.05	-87.48	37.80	37.90	104.50
Ireland	4.48	202.33	161.05	1.98	13.04	14.40	26.96	38.66
Israel	7.62	164.14	198.17	3.85	20.18	22.91	52.27	68.06
Italy	60.48	1 765.29	1 637.93	29.79	148.21	170.24	325.65	398.47
Jamaica	2.70	11.14	18.60	0.46	2.81	3.05	3.30	7.96
Japan	127.38	4 578.55	3 895.26	96.79	409.22	496.85	1 069.84	1 143.07

([a]) Gross production + imports – exports – losses.
([b]) CO_2 emissions from fuel combustion only. Emissions are calculated using the IEA's energy balances and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.

TPES/pop. (toe/ capita)	TPES/GDP (toe/000 2005 USD)	TPES/ GDP (PPP) (toe/000 2005 USD)	Elec. cons./pop. (kWh/ capita)	CO_2/TPES ($t CO_2$/toe)	CO_2/pop. ($t CO_2$/ capita)	CO_2/GDP ($kg CO_2$/ 2005 USD)	CO_2/GDP (PPP) ($kg CO_2$/ 2005 USD)	Region/ country/ economy
1.00	0.19	0.10	1 855	1.41	1.40	0.26	0.14	Costa Rica
0.48	0.52	0.28	210	0.61	0.29	0.32	0.17	Côte d'Ivoire
1.93	0.18	0.12	3 808	2.23	4.30	0.41	0.27	Croatia
0.98	0.20	0.18	1 299	2.73	2.67	0.55	0.48	Cuba
8.36	0.63	0.70	5 388	2.27	18.99	1.43	1.59	Curaçao and Sint Martin
3.04	0.13	0.12	6 426	2.95	8.99	0.38	0.35	Cyprus
4.19	0.30	0.18	6 323	2.60	10.89	0.77	0.46	Czech Republic
0.36	2.56	1.16	95	0.13	0.05	0.33	0.15	Dem. Rep. of the Congo
3.47	0.08	0.11	6 329	2.44	8.48	0.18	0.26	Denmark
0.84	0.17	0.10	1 442	2.22	1.87	0.39	0.22	Dominican Republic
0.84	0.27	0.12	1 055	2.49	2.08	0.68	0.29	Ecuador
0.90	0.61	0.16	1 608	2.42	2.19	1.47	0.39	Egypt
0.68	0.23	0.11	855	1.40	0.95	0.32	0.16	El Salvador
0.14	0.70	0.29	52	0.66	0.09	0.47	0.19	Eritrea
4.16	0.40	0.25	6 465	3.32	13.79	1.33	0.83	Estonia
0.40	1.65	0.43	54	0.16	0.06	0.27	0.07	Ethiopia
6.79	0.18	0.22	16 484	1.73	11.73	0.31	0.37	Finland
4.04	0.12	0.14	7 756	1.36	5.52	0.16	0.19	France
1.42	0.22	0.11	1 005	1.24	1.76	0.27	0.13	Gabon
0.70	0.38	0.15	1 743	1.58	1.11	0.60	0.24	Georgia
4.00	0.11	0.12	7 217	2.33	9.32	0.26	0.28	Germany
0.38	0.63	0.26	298	1.02	0.39	0.64	0.26	Ghana
5.51	0.16	0.19	5 710	3.06	16.86	0.50	0.58	Gibraltar
2.44	0.11	0.10	5 245	3.05	7.45	0.35	0.31	Greece
0.71	0.32	0.17	567	1.01	0.72	0.32	0.17	Guatemala
0.23	0.53	0.23	24	0.93	0.21	0.49	0.21	Haiti
0.60	0.39	0.17	671	1.60	0.96	0.63	0.27	Honduras
1.95	0.06	0.05	5 923	3.01	5.87	0.19	0.14	Hong Kong
2.57	0.23	0.15	3 877	1.91	4.89	0.45	0.29	Hungary
16.88	0.33	0.52	51 447	0.36	6.04	0.12	0.18	Iceland
0.59	0.56	0.18	644	2.35	1.39	1.30	0.43	India
0.87	0.55	0.22	641	1.98	1.71	1.09	0.44	Indonesia
2.82	0.90	0.27	2 652	2.44	6.88	2.21	0.66	Iran
1.17	0.97	0.37	1 172	2.76	3.23	2.69	1.02	Iraq
3.22	0.07	0.09	6 023	2.69	8.64	0.19	0.24	Ireland
3.01	0.14	0.12	6 858	2.97	8.93	0.41	0.34	Israel
2.81	0.10	0.10	5 384	2.34	6.59	0.23	0.24	Italy
1.13	0.27	0.16	1 222	2.60	2.94	0.71	0.43	Jamaica
3.90	0.11	0.13	8 399	2.30	8.97	0.25	0.29	Japan

Region/ country/ economy	Population (million)	GDP (billion 2005 USD)	GDP (PPP) (billion 2005 USD)	Energy prod. (Mtoe)	Net imports (Mtoe)	TPES (Mtoe)	Elec. cons.([a]) (TWh)	CO_2 emissions ([b]) (Mt of CO_2)
Jordan	6.05	16.74	31.19	0.27	7.43	7.20	13.46	18.63
Kazakhstan	16.32	77.25	178.18	156.75	-79.79	75.01	77.17	232.12
Kenya	40.51	23.45	60.01	15.78	4.28	19.56	6.32	10.89
Kosovo	1.82	4.83	12.12	1.86	0.54	2.44	4.71	8.47
Kuwait	2.74	90.04	123.07	133.93	-99.66	33.40	50.14	87.39
Kyrgyzstan	5.37	3.03	10.94	1.18	2.15	2.92	7.49	6.98
Latvia	2.24	15.50	29.02	2.11	1.99	4.41	6.78	8.08
Lebanon	4.23	29.99	53.35	0.21	6.51	6.45	15.09	18.62
Libya	6.36	54.52	100.19	88.55	-69.05	19.15	27.14	51.61
Lithuania	3.32	27.35	51.11	1.52	5.64	6.93	10.75	13.35
Luxembourg	0.51	41.30	34.85	0.13	4.51	4.23	8.53	10.61
FYR of Macedonia	2.06	7.06	18.95	1.62	1.27	2.89	7.40	8.21
Malaysia	28.40	171.82	375.29	85.88	-11.11	72.65	116.94	185.00
Malta	0.41	6.67	9.48	0.00	2.39	0.84	1.73	2.47
Mexico	108.29	920.02	1 406.83	226.36	-43.70	178.11	225.76	416.91
Moldova	3.56	3.50	9.94	0.10	2.48	2.60	3.74	6.11
Mongolia	2.76	3.45	9.98	14.97	-11.14	3.28	4.22	11.87
Montenegro	0.63	2.80	6.42	0.70	0.12	0.82	3.50	2.09
Morocco	31.95	75.55	137.29	0.89	16.43	16.51	24.96	45.95
Mozambique	23.39	9.35	19.77	12.49	-2.22	10.20	10.38	2.50
Myanmar	47.96	20.53	839.06	22.53	-8.64	14.00	6.29	8.00
Namibia	2.28	8.89	13.26	0.32	1.33	1.60	3.38	3.33
Nepal	29.96	10.07	32.22	8.98	1.32	10.22	2.78	3.65
Netherlands	16.61	685.08	614.73	69.76	31.16	83.43	116.47	187.00
New Zealand	4.38	121.30	112.23	16.86	2.85	18.20	41.78	30.86
Nicaragua	5.79	5.82	15.13	1.73	1.33	3.14	2.74	4.46
Nigeria	158.42	155.22	338.31	258.36	-145.39	113.05	21.62	45.90
North Korea	24.35	27.56	103.45	20.70	-2.17	18.53	18.25	62.99
Norway	4.89	316.69	229.33	205.51	-172.31	32.45	123.09	39.17
Oman	2.78	41.41	68.52	72.14	-53.08	20.00	16.51	40.27
Pakistan	173.59	134.80	418.51	64.30	20.30	84.59	79.27	134.64
Panama	3.52	22.37	42.93	0.84	5.60	3.77	6.44	8.40
Paraguay	6.46	9.74	30.00	7.10	-2.38	4.79	7.32	4.69
Peru	29.08	112.19	248.76	19.40	-2.39	19.40	32.15	41.94
Philippines	93.26	131.13	332.06	23.42	18.52	40.48	59.94	76.43
Poland	38.19	382.76	662.57	67.39	32.09	101.45	144.45	305.10
Portugal	10.64	196.13	230.46	5.58	18.83	23.54	52.43	48.15
Qatar	1.76	102.56	135.99	174.10	-150.29	22.51	26.38	66.09
Romania	21.44	114.35	234.35	27.44	7.49	34.99	51.29	75.56
Russia	141.75	905.23	2 010.38	1 293.05	-579.10	701.52	915.65	1 581.37

([a]) Gross production + imports – exports – losses.
([b]) CO_2 emissions from fuel combustion only. Emissions are calculated using the IEA's energy balances and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.

TPES/pop. (toe/ capita)	TPES/GDP (toe/000 2005 USD)	TPES/ GDP (PPP) (toe/000 2005 USD)	Elec. cons./pop. (kWh/ capita)	CO_2/TPES (t CO_2/toe)	CO_2/pop. (t CO_2/ capita)	CO_2/GDP (kg CO_2/ 2005 USD)	CO_2/GDP (PPP) (kg CO_2/ 2005 USD)	Region/ country/ economy
1.19	0.43	0.23	2 226	2.59	3.08	1.11	0.60	Jordan
4.60	0.97	0.42	4 730	3.09	14.23	3.00	1.30	Kazakhstan
0.48	0.83	0.33	156	0.56	0.27	0.46	0.18	Kenya
1.34	0.50	0.20	2 592	3.47	4.66	1.75	0.70	Kosovo
12.20	0.37	0.27	18 318	2.62	31.93	0.97	0.71	Kuwait
0.54	0.96	0.27	1 396	2.39	1.30	2.31	0.64	Kyrgyzstan
1.97	0.28	0.15	3 021	1.83	3.60	0.52	0.28	Latvia
1.53	0.22	0.12	3 569	2.89	4.40	0.62	0.35	Lebanon
3.01	0.35	0.19	4 270	2.70	8.12	0.95	0.52	Libya
2.09	0.25	0.14	3 237	1.93	4.02	0.49	0.26	Lithuania
8.36	0.10	0.12	16 866	2.51	20.98	0.26	0.30	Luxembourg
1.40	0.41	0.15	3 590	2.84	3.99	1.16	0.43	FYR of Macedonia
2.56	0.42	0.19	4 117	2.55	6.51	1.08	0.49	Malaysia
2.03	0.13	0.09	4 182	2.95	5.99	0.37	0.26	Malta
1.64	0.19	0.13	2 085	2.34	3.85	0.45	0.30	Mexico
0.73	0.74	0.26	1 049	2.35	1.72	1.75	0.62	Moldova
1.19	0.95	0.33	1 530	3.62	4.31	3.44	1.19	Mongolia
1.30	0.29	0.13	5 552	2.54	3.31	0.75	0.33	Montenegro
0.52	0.22	0.12	781	2.78	1.44	0.61	0.33	Morocco
0.44	1.09	0.52	444	0.25	0.11	0.27	0.13	Mozambique
0.29	0.68	0.02	131	0.57	0.17	0.39	0.01	Myanmar
0.70	0.18	0.12	1 479	2.07	1.46	0.37	0.25	Namibia
0.34	1.02	0.32	93	0.36	0.12	0.36	0.11	Nepal
5.02	0.12	0.14	7 011	2.24	11.26	0.27	0.30	Netherlands
4.15	0.15	0.16	9 531	1.70	7.04	0.25	0.27	New Zealand
0.54	0.54	0.21	473	1.42	0.77	0.77	0.29	Nicaragua
0.71	0.73	0.33	136	0.41	0.29	0.30	0.14	Nigeria
0.76	0.67	0.18	749	3.40	2.59	2.29	0.61	North Korea
6.64	0.10	0.14	25 177	1.21	8.01	0.12	0.17	Norway
7.19	0.48	0.29	5 934	2.01	14.47	0.97	0.59	Oman
0.49	0.63	0.20	457	1.59	0.78	1.00	0.32	Pakistan
1.07	0.17	0.09	1 832	2.23	2.39	0.38	0.20	Panama
0.74	0.49	0.16	1 134	0.98	0.73	0.48	0.16	Paraguay
0.67	0.17	0.08	1 106	2.16	1.44	0.37	0.17	Peru
0.43	0.31	0.12	643	1.89	0.82	0.58	0.23	Philippines
2.66	0.27	0.15	3 783	3.01	7.99	0.80	0.46	Poland
2.21	0.12	0.10	4 929	2.05	4.53	0.25	0.21	Portugal
12.80	0.22	0.17	14 995	2.94	37.57	0.64	0.49	Qatar
1.63	0.31	0.15	2 392	2.16	3.52	0.66	0.32	Romania
4.95	0.77	0.35	6 460	2.25	11.16	1.75	0.79	Russia

Region/ country/ economy	Population (million)	GDP (billion 2005 USD)	GDP (PPP) (billion 2005 USD)	Energy prod. (Mtoe)	Net imports (Mtoe)	TPES (Mtoe)	Elec. cons.([a]) (TWh)	CO_2 emissions ([b]) (Mt of CO_2)
Saudi Arabia	27.45	359.75	559.24	538.05	-391.35	169.30	218.68	445.95
Senegal	12.43	10.32	21.58	1.62	2.06	3.38	2.43	5.47
Serbia	7.29	27.86	70.04	10.60	5.23	15.61	31.78	46.05
Singapore	5.08	168.35	263.83	0.40	77.77	32.77	42.17	62.93
Slovakia	5.43	60.06	109.26	6.20	11.36	17.81	28.04	35.00
Slovenia	2.05	39.03	51.32	3.71	3.58	7.21	13.36	15.32
South Africa	49.99	288.46	473.77	162.41	-17.07	136.87	240.09	346.84
South Korea	48.88	1 017.57	1 320.93	44.92	221.05	250.01	481.47	563.08
Spain	46.07	1 181.88	1 242.46	34.24	106.84	127.74	283.56	268.32
Sri Lanka	20.86	33.25	95.02	5.54	4.10	9.87	9.28	13.34
Sudan	43.55	38.96	88.13	34.94	-17.19	16.15	6.13	13.70
Sweden	9.38	400.03	318.76	33.50	19.68	51.28	140.10	47.57
Switzerland	7.79	411.66	294.12	12.64	14.95	26.21	63.97	43.83
Syria	20.45	36.61	96.93	27.67	-4.38	21.73	38.96	57.76
Taiwan	23.18	446.36	742.34	12.96	100.42	109.28	237.33	270.22
Tajikistan	6.88	3.19	13.35	1.51	0.83	2.31	13.79	2.73
Tanzania	44.84	19.71	56.24	18.68	1.52	20.08	3.49	5.98
Thailand	69.12	210.09	530.37	70.56	51.45	117.43	155.07	248.45
Togo	6.03	2.46	5.40	2.23	0.53	2.69	0.68	1.17
Trinidad and Tobago	1.34	18.76	30.96	44.96	-23.58	21.35	7.91	42.79
Tunisia	10.55	40.50	90.37	8.08	1.70	9.63	14.24	21.95
Turkey	72.85	564.32	912.80	32.23	73.91	105.13	180.21	265.88
Turkmenistan	5.04	13.41	37.42	46.29	-24.66	21.31	12.12	52.68
Ukraine	45.87	90.58	276.55	76.00	42.17	130.50	162.83	266.59
United Arab Emirates	7.51	211.22	318.14	176.29	-97.09	62.13	82.96	154.00
United Kingdom	62.18	2337.59	2020.94	148.77	60.63	202.51	356.96	483.52
United States	310.11	13 017.00	13 017.00	1 724.51	533.57	2 216.32	4 143.40	5 368.63
Uruguay	3.36	23.49	43.31	2.04	2.56	4.17	9.28	6.45
Uzbekistan	28.16	21.49	78.65	55.15	-11.36	43.79	47.08	100.22
Venezuela	28.83	174.55	316.40	192.71	-116.30	76.95	94.77	183.04
Vietnam	86.94	74.29	249.92	65.87	-7.28	59.23	89.94	130.46
Yemen	24.05	20.73	57.12	19.77	-11.98	7.17	5.98	21.65
Zambia	12.93	9.80	18.11	7.48	0.64	8.12	8.06	1.94
Zimbabwe	12.57	4.95	3.35	8.60	1.00	9.60	12.85	9.07

([a]) Gross production + imports – exports – losses.
([b]) CO_2 emissions from fuel combustion only. Emissions are calculated using the IEA's energy balances and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*.

TPES/pop. (toe/capita)	TPES/GDP (toe/000 2005 USD)	TPES/GDP (PPP) (toe/000 2005 USD)	Elec. cons./pop. (kWh/capita)	CO_2/TPES ($t CO_2$/toe)	CO_2/pop. ($t CO_2$/capita)	CO_2/GDP ($kg CO_2$/2005 USD)	CO_2/GDP (PPP) ($kg CO_2$/2005 USD)	Region/country/economy
6.17	0.47	0.30	7 967	2.63	16.25	1.24	0.80	Saudi Arabia
0.27	0.33	0.16	195	1.62	0.44	0.53	0.25	Senegal
2.14	0.56	0.22	4 358	2.95	6.31	1.65	0.66	Serbia
6.46	0.19	0.12	8 306	1.92	12.39	0.37	0.24	Singapore
3.28	0.30	0.16	5 164	1.97	6.45	0.58	0.32	Slovakia
3.52	0.18	0.14	6 520	2.12	7.48	0.39	0.30	Slovenia
2.74	0.47	0.29	4 803	2.53	6.94	1.20	0.73	South Africa
5.12	0.25	0.19	9 851	2.25	11.52	0.55	0.43	South Korea
2.77	0.11	0.10	6 155	2.10	5.82	0.23	0.22	Spain
0.47	0.30	0.10	445	1.35	0.64	0.40	0.14	Sri Lanka
0.37	0.41	0.18	141	0.85	0.31	0.35	0.16	Sudan
5.47	0.13	0.16	14 939	0.93	5.07	0.12	0.15	Sweden
3.37	0.06	0.09	8 216	1.67	5.63	0.11	0.15	Switzerland
1.06	0.59	0.22	1 905	2.66	2.82	1.58	0.60	Syria
4.71	0.24	0.15	10 237	2.47	11.66	0.61	0.36	Taiwan
0.34	0.72	0.17	2 004	1.18	0.40	0.86	0.20	Tajikistan
0.45	1.02	0.36	78	0.30	0.13	0.30	0.11	Tanzania
1.70	0.56	0.22	2 243	2.12	3.59	1.18	0.47	Thailand
0.45	1.09	0.50	113	0.44	0.19	0.48	0.22	Togo
15.92	1.14	0.69	5 896	2.00	31.91	2.28	1.38	Trinidad and Tobago
0.91	0.24	0.11	1 350	2.28	2.08	0.54	0.24	Tunisia
1.44	0.19	0.12	2 474	2.53	3.65	0.47	0.29	Turkey
4.23	1.59	0.57	2 403	2.47	10.45	3.93	1.41	Turkmenistan
2.84	1.44	0.47	3 550	2.04	5.81	2.94	0.96	Ukraine
8.27	0.29	0.20	11 044	2.48	20.50	0.73	0.48	United Arab Emirates
3.26	0.09	0.10	5 741	2.39	7.78	0.21	0.24	United Kingdom
7.15	0.17	0.17	13 361	2.42	17.31	0.41	0.41	United States
1.24	0.18	0.10	2 763	1.55	1.92	0.27	0.15	Uruguay
1.55	2.04	0.56	1 672	2.29	3.56	4.66	1.27	Uzbekistan
2.67	0.44	0.24	3 287	2.38	6.35	1.05	0.58	Venezuela
0.68	0.80	0.24	1 035	2.20	1.50	1.76	0.52	Vietnam
0.30	0.35	0.13	249	3.02	0.90	1.04	0.38	Yemen
0.63	0.83	0.45	623	0.24	0.15	0.20	0.11	Zambia
0.76	1.94	2.87	1 022	0.94	0.72	1.83	2.71	Zimbabwe

Sources: Energy data: IEA.
Population: OECD/World Bank.
GDP and GDP (PPP) (in 2005 USD): OECD/World Bank/CEPII (Paris).

GENERAL CONVERSION FACTORS FOR ENERGY

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	107	1	3.968×10^{7}	11630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

CONVERSION FACTORS FOR MASS

To:	kg	t	lt	st	lb
From:	multiply by:				
kilogramme (kg)	1	0.001	9.84×10^{-4}	1.102×10^{-3}	2.2046
tonne (t)	1 000	1	0.984	1.1023	2 204.6
long ton (lt)	1 016	1.016	1	1.120	2 240.0
short ton (st)	907.2	0.9072	0.893	1	2 000.0
pound (lb)	0.454	4.54×10^{-4}	4.46×10^{-4}	5.0×10^{-4}	1

CONVERSION FACTORS FOR VOLUME

To:	US gallon	UK gallon	bbl	ft^3	l	m^3
From:	multiply by:					
US gallon (gal)	1	0.8327	0.02381	0.1337	3.785	0.0038
UK gallon (gal)	1.201	1	0.02859	0.1605	4.546	0.0045
barrel (bbl)	42.0	34.97	1	5.615	159.0	0.159
cubic foot (ft^3)	7.48	6.229	0.1781	1	28.3	0.0283
litre (l)	0.2642	0.220	0.0063	0.0353	1	0.001
cubic metre (m^3)	264.2	220.0	6.289	35.3147	1000.0	1

SELECTED COUNTRY-SPECIFIC NET CALORIFIC VALUES

Steam coal*

	toe/tonne
China	0.522
United States	0.541
India	0.563
Indonesia	0.573
South Africa	0.563
Australia	0.552
Russia	0.600
Kazakhstan	0.444
Colombia	0.650
Poland	0.547

* Steam coal for the top 10 producers in 2011.

Crude oil**

	toe/tonne
Saudi Arabia	1.016
Russia	1.005
United States	1.033
Iran	1.019
China	1.000
Canada	1.022
United Arab Emirates	1.018
Venezuela	1.069
Mexico	1.117
Nigeria	1.021

** Crude oil for the top 10 producers in 2011.

DEFAULT NET CALORIFIC VALUES

Oil products

	OECD Europe*	OECD Americas	OECD Asia Oceania	Non-OECD
	toe/tonne			
Refinery gas	1.182	1.149	1.149	1.149
Ethane	1.182	1.180	1.180	1.180
Liquefied petroleum gases	1.099	1.130	1.139	1.130
Petrol	1.051	1.070	1.065	1.070
Aviation gasoline	1.051	1.070	1.065	1.070
Gasoline-type jet fuel	1.027	1.070	1.065	1.070
Kerosene-type jet fuel	1.027	1.065	1.063	1.065
Kerosene	1.027	1.046	1.025	1.046
Gas/diesel oil	1.017	1.017	1.017	1.034
Fuel oil	0.955	0.960	1.017	0.960
Naphtha	1.051	1.075	1.032	1.075
White spirit	1.041	1.027	1.027	1.027
Lubricants	1.003	1.003	1.025	1.003
Bitumen	0.931	0.955	0.927	0.931
Paraffin waxes	0.955	0.955	0.955	0.955
Petroleum coke	0.764	0.764	0.807	0.764
Non-specified oil products	0.955	0.955	0.955	0.955

*Defaults for OECD Europe were also applied to non-OECD Europe and Eurasia countries.

SELECTED COUNTRY-SPECIFIC GROSS CALORIFIC VALUES

Natural gas*

	kJ/m³
Russia	38232
United States	38192
Canada	38520
Qatar	41400
Iran	39356
Norway	39620
China	38931
Saudi Arabia	38000
Indonesia	40600
Netherlands	33339

* For the top 10 producers in 2011.
Note: to calculate the net calorific value, the gross calorific value is multiplied by 0.9.

CONVENTIONS FOR ELECTRICITY

Figures for electricity production, trade, and final consumption are calculated using the energy content of the electricity (i.e. at a rate of 1 TWh = 0.086 Mtoe). Hydroelectric production (excluding pumped storage) and electricity produced by other non-thermal means (wind, tide/wave/ocean, photovoltaic, etc.) are accounted for similarly using 1 TWh = 0.086 Mtoe. However, the primary energy equivalent of nuclear electricity is calculated from the gross generation by assuming 33 % conversion efficiency (i.e. 1 TWh = (0.086 ÷ 0.33) Mtoe). In the case of electricity produced from geothermal heat, if the actual geothermal efficiency is not known, then the primary equivalent is calculated assuming 10 % efficiency, so 1 TWh = (0.086 ÷ 0.1) Mtoe.

GLOSSARY

Coal/peat *Coal/peat* includes all coal, both primary (including hard coal and lignite) and derived fuels (including patent fuel, coke oven coke, gas coke, BKB (brown coal briquettes), gas works gas, coke oven gas, blast furnace gas and other recovered gases). Peat is also included in this category.

Hard coal *Hard coal* comprises anthracite, coking coal and other bituminous coal.

Steam coal *Steam coal* comprises anthracite, other bituminous coal and sub-bituminous coal.

Crude oil *Crude oil* comprises crude oil, natural gas liquids, refinery feedstocks and additives as well as other hydrocarbons.

Oil products *Oil products* comprises refinery gas, ethane, LPG (liquefied petroleum gas), aviation gasoline, petrol, jet fuels, kerosene, gas/diesel oil, fuel oil, naphtha, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke and other oil products.

Natural gas *Natural gas* includes both 'associated' and 'non-associated' gas.

Nuclear *Nuclear* shows the primary heat equivalent of the electricity produced by a nuclear power plant with an average thermal efficiency of 33 %.

Hydro *Hydro* shows the energy content of the electricity produced in hydropower plants. Hydro output excludes output from pumped storage plants.

Biofuels and waste *Biofuels* and *waste* comprises solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Biofuels are defined as any plant matter used directly as fuel or converted into fuels (e.g. charcoal) or electricity and/or heat. Included here are wood, vegetal waste (including wood waste and crops used for energy production), ethanol, animal materials/wastes and sulphite lyes. Municipal waste comprises wastes produced by residential, commercial and public services, that are collected by local authorities for disposal in a central location for the production of heat and/or power.

Other *Other* includes geothermal, solar, wind, tide/wave/ocean energy, electricity and heat. Unless the actual efficiency of the geothermal process is known, the quantity of geothermal energy entering electricity generation is inferred from the electricity production at geothermal plants assuming an average thermal efficiency of 10 %. For solar, wind and tide/wave/ocean energy, the quantities entering electricity generation are equal to the electrical energy generated. Direct use of geothermal and solar heat is also included here. Electricity is accounted for at the same heat value as electricity in final consumption (i.e. 1 GWh = 0.000086 Mtoe). Heat includes heat that is produced for sale and is accounted for in the transformation sector.

Production *Production* is the production of primary energy, i.e. hard coal, lignite, peat, crude oil, natural gas liquids (NGLs), natural gas, biofuels and waste, nuclear, hydro, geothermal, solar and the heat from heat pumps that is extracted from the ambient environment. Production is calculated after removal of impurities (e.g. sulphur from natural gas).

Imports and exports

Imports and exports comprise amounts having crossed the national territorial boundaries of the country, whether or not customs clearance has taken place.

(a) Oil and natural gas

Quantities of crude oil and oil products imported or exported under processing agreements (i.e. refining on account) are included. Quantities of oil in transit are excluded. Crude oil, NGLs and natural gas are reported as coming from the country of origin; refinery feedstocks and oil products are reported as coming from the country of last consignment. Re-exports of oil imported for processing within bonded areas are shown as exports of product from the processing country to the final destination.

(b) Coal/peat

Imports and exports comprise the amount of fuels obtained from or supplied to other countries, whether or not there is an economic or customs union between the relevant countries. Coal in transit is not included.

(c) Electricity

Amounts are considered as imported or exported when they have crossed the national territorial boundaries of the country.

International marine bunkers

International marine bunkers covers those quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic/international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship. Consumption by fishing vessels and by military forces is also excluded.

International aviation bunkers

International aviation bunkers covers deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic/international split should be determined on the basis of departure and landing locations, and not by the nationality of the airline. For many countries, this incorrectly excludes fuel used by domestically owned carriers for their international departures.

Stock changes

Stock changes reflects the difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory held by producers, importers, energy transformation industries and large consumers. A 'stock build' is shown as a negative number, and a 'stock draw' as a positive number.

Total primary energy supply

Total primary energy supply (TPES) equals production + imports – exports – international marine bunkers – international aviation bunkers ± stock changes. For the world total, international marine bunkers and international aviation bunkers are not subtracted from the TPES.

Transfers

Transfers includes inter-product transfers, products transferred and recycled products.

Statistical differences

Statistical differences includes the sum of the unexplained statistical differences for individual fuels, as they appear in the basic energy statistics. It also includes the statistical differences that arise because of the variety of conversion factors in the coal/peat and oil columns.

Electricity plants

Electricity plants refers to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs cannot be distinguished on a unit basis) then the whole plant is designated as a CHP plant. Both main activity producers and autoproducer plants are included here.

Combined heat and power plants

Combined heat and power plants (CHP) refers to plants which are designed to produce both heat and electricity, sometimes referred to as cogeneration power stations. If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis. However, if data are not available on a unit basis, the convention for defining a CHP plant noted above is adopted. Both main activity producers and autoproducer plants are included here.

Heat plants

Heat plants refers to plants (including heat pumps and electric boilers) designed to produce heat only, which is sold to a third party under the provisions of a contract. Both main activity producers and autoproducer plants are included here.

Blast furnaces *Blast furnaces* includes inputs to and outputs of fuels from blast furnaces.

Gas works *Gas works* is treated similarly to electricity generation, with the quantity produced appearing as a positive figure in the coal/peat column or the natural gas column after blending with natural gas, inputs as negative entries in the coal/peat and oil products columns, and conversion losses appearing in the total column.

Coke ovens *Coke ovens* includes losses in transformation of coal from primary to secondary fuels and from secondary to tertiary fuels (hard coal to coke and patent fuel, lignite to BKB, etc.).

Oil refineries *Oil refineries* shows the use of primary energy for the manufacture of finished oil products and the corresponding output. Thus, the total reflects transformation losses. In certain cases, the data in the total column are positive numbers. This can be due to either problems in the primary refinery balance or to the fact that the IEA uses regional net calorific values for oil products.

Petrochemical plants *Petrochemical plants* covers backflows returned from the petrochemical industry. Note that backflows from oil products that are used for non-energy purposes (i.e. white spirit and lubricants) are not included here, but in non-energy use.

Liquefaction plants *Liquefaction plants* includes diverse liquefaction processes, such as coal liquefaction plants and gas-to-liquid plants.

Other transformation covers non-specified transformation not shown elsewhere, such as the transformation of primary solid biofuels into charcoal.

Energy industry own use *Energy industry own use* includes the primary and secondary energy consumed by transformation industries for heating, pumping, traction and lighting purposes (ISIC (International Standard Industrial Classification of all Economic Activities) 05, 06, 19 and 35, Group 091 and Classes 0892 and 0721).

Losses *Losses* includes losses in energy distribution, transmission and transport.

Total final consumption *Total final consumption* (TFC) is the sum of consumption by the different end-use sectors. Backflows from the petrochemical industry are not included in final consumption.

Industry *Industry* consumption is specified in the following subsectors (energy used for transport by industry is not included here but reported under transport):

- *Iron and steel industry* (ISIC Group 241 and Class 2431);
- *Chemical and petrochemical industry* (ISIC Divisions 20 and 21) excluding petrochemical feedstocks;
- *Non-ferrous metals basic industries* (ISIC Group 242 and Class 2432);
- *Non-metallic minerals* such as glass, ceramic, cement, etc. (ISIC Division 23);
- *Transport equipment* (ISIC Divisions 29 and 30);
- *Machinery* comprises fabricated metal products, machinery and equipment other than transport equipment (ISIC Divisions 25 to 28);
- *Mining* (excluding fuels) *and quarrying* (ISIC Divisions 07 and 08 and Group 099);
- *Food and tobacco* (ISIC Divisions 10 to 12);
- *Paper, pulp and printing* (ISIC Divisions 17 and 18);
- *Wood and wood products* (other than pulp and paper) (ISIC Division 16);
- *Construction* (ISIC Divisions 41 to 43);
- *Textile and leather* (ISIC Divisions 13 to 15);
- *Non-specified* (any manufacturing industry not included above) (ISIC Divisions 22, 31 and 32).

Transport *Transport* includes all fuels used for transport (ISIC Divisions 49 to 51). It includes transport in industry and covers domestic aviation, road, rail, pipeline transport, domestic navigation and non-specified transport. Fuel used for ocean, coastal and inland fishing (included under fishing) and military consumption (included in other non-specified) are excluded from transport. Note that international marine and international aviation bunkers are also included here for the world total.

Other

Other covers residential, commercial and public services (ISIC Divisions 33, 36–39, 45–47, 52, 53, 55, 56, 58–66, 68–75, 77–82, 84 (excluding Class 8422), 85–88, 90–99), agriculture/forestry (ISIC Divisions 01 and 02), fishing (ISIC Division 03) and non-specified consumption.

Non-energy use

Non-energy use covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. Non-energy use also includes petrochemical feedstocks. Non-energy use is shown separately in final consumption under the heading Non-energy use.

UNIT ABBREVIATIONS

bcm	billion cubic metres	kWh	kilowatt-hour
Gcal	gigacalorie	MBtu	million British thermal units
GCV	gross calorific value	Mt	million tonnes
GW	gigawatt	Mtoe	million tonnes of oil equivalent
GWh	gigawatt-hour	PPP	purchasing power parity
kb/cd	thousand barrels per calendar day	t	metric ton = tonne = 1 000 kg
kcal	kilocalorie	TJ	terajoule
kg	kilogramme	toe	tonne of oil equivalent = 107 kcal
kJ	kilojoule	TWh	terawatt-hour

GEOGRAPHICAL COVERAGE

OECD*	Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States
Middle East	Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates and Yemen
Non-OECD Europe and Eurasia	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the former Yugoslav Republic of Macedonia, Georgia, Gibraltar, Kazakhstan, Kosovo**, Kyrgyzstan, Latvia, Lithuania, Malta, Moldova, Montenegro**, Romania, Russia, Serbia**, Tajikistan, Turkmenistan, Ukraine and Uzbekistan
China	China and Hong Kong
Asia	Bangladesh, Brunei, Cambodia, India, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, North Korea, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam and other Asia
Non-OECD Americas	Argentina, Bolivia, Brazil, Colombia, Costa Rica, Curaçao and Sint Martin, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela and other non-OECD Americas
Africa	Algeria, Angola, Benin, Botswana, Cameroon, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libya, Morocco, Mozambique, Namibia, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Tunisia, Zambia, Zimbabwe and other Africa
OECD+	OECD countries and those EU countries that are not members of the OECD (i.e. Bulgaria, Cyprus, Latvia, Lithuania, Malta and Romania)
OME (Other Major Economies)	Brazil, China, India, Indonesia, Russia and the Middle East
OC (Other Countries)	World excluding OECD+ and OME

* OECD includes Estonia and Slovenia starting in 1990. Prior to 1990, data for these two countries are included in Non-OECD Europe and Eurasia.

** Serbia includes Kosovo from 1990 to 1999 and Montenegro from 1990 to 2004.

Note: The countries listed above are those for which the IEA Secretariat has direct statistics contacts. This document is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. In this publication, 'country' refers to country or territory, as the case may be.

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