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Renewable Energies
(part A, Global Markets)

Master Degree in Innovative Technologies in Energy Efficient Buildings for Russian & Armenian Universities and Stakeholders

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M.Fossa short CV

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Research Professor at the University of Genova since 1993 (www.dime.unige.it)
Associate Professor since 2007.
MSc Course in Energy Engineering Coordinator (since 2014, www.en2.unige.it)

Teaching: Applied Thermodynamics and Heat Transfer, Renewable Energies, Solar and Geothermal Energy

Research: author of 130 scientific papers, 600 citations, h index=13 (Scopus)

Visiting appointments:	Cern Geneva, CH (1990-1992, 2001-2003) Univ. Nottingham (2001), UNSW Sydney (2006, 2008, 2010, 2012) as Visiting Professor
Collaborations:	Insa Cethil Lyon, Locie Univ. Savoie Mt Blanc, Cern Geneva, UNSW Sydney, KTH Stockholm
Areas of interest:	Heat Transfer, Geothermal heat pumps two-phase flow, Building Integrated PV modules and Hybrid Solar

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

(Text with EEA relevance)

Article 2

Definitions

(a) 'energy from renewable sources' means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases;

(e) 'biomass' means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste;

ANNEX VII

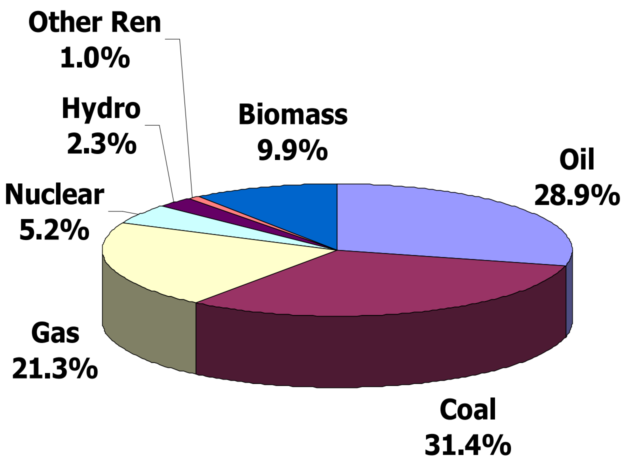
Accounting of energy from heat pumps

The amount of aerothermal, geothermal or hydrothermal energy captured by heat pumps to be considered energy from renewable sources for the purposes of this Directive, E_{RES}, shall be calculated in accordance with the following formula:

$$E_{RES} = Q_{usable} * (1 - 1/SPF)$$

WORLD PRIMARY ENERGY COMSUMPTION (Energy Outlook 2013)

Coal	3773 MTep
Gas	2787 MTep
Oil	4108 MTep
Nuclear	674 MTep
Renewables	1730 MTep



1 Tep (Toe) = ton of equivalent oil, about 42 GJ (11.7MWh, 39.7Mbtu)

World population and grow 1990-2035 (Source: Energy Outlook 2013)

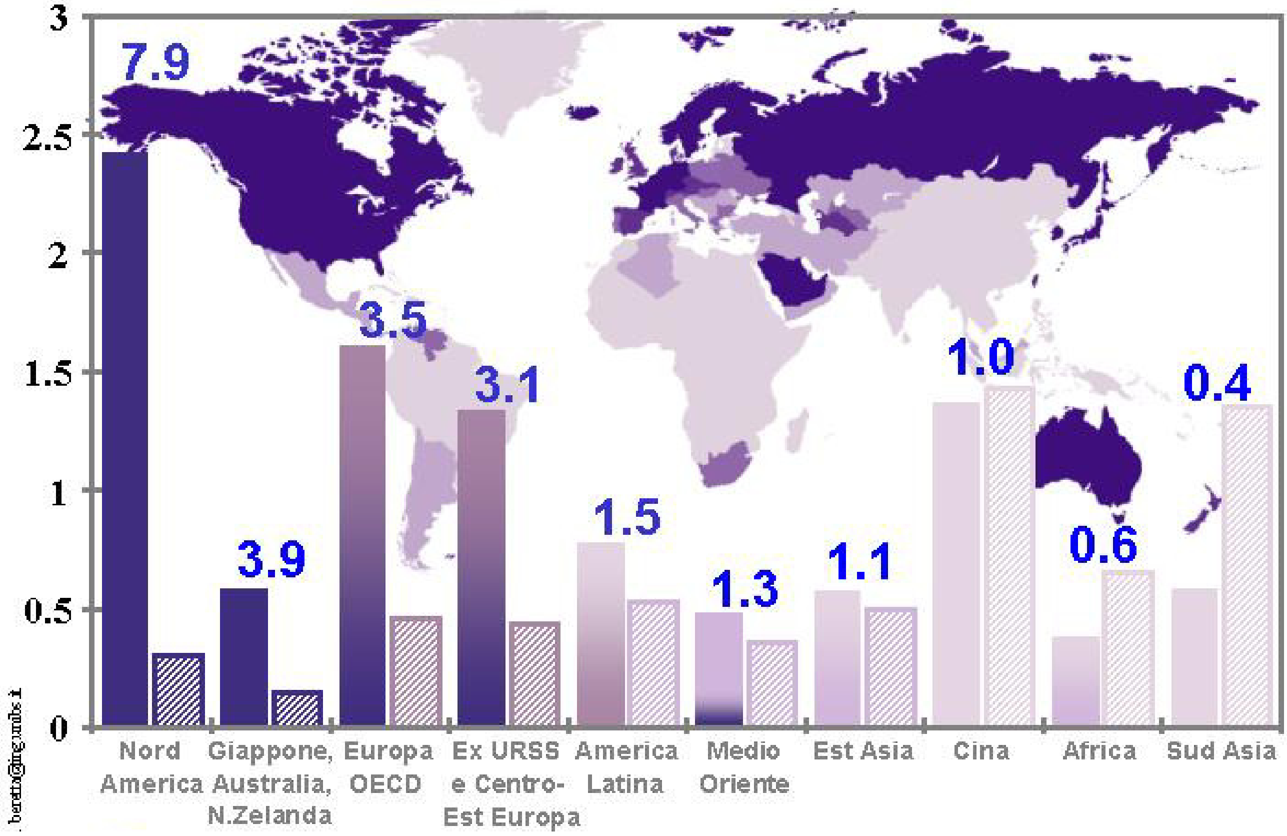
	Population growth*			Population (million)		Urbanisation	
	1990-2011	2011-2020	2011-2035	2011	2035	2011	2035
OECD	**0.7%**	**0.5%**	**0.4%**	**1 245**	**1 379**	**80%**	**86%**
Americas	1.1%	0.9%	0.8%	477	572	82%	88%
United States	1.0%	0.8%	0.7%	316	374	83%	88%
Europe	0.5%	0.4%	0.3%	563	600	75%	81%
Asia Oceania	0.4%	0.2%	0.0%	205	207	89%	93%
Japan	0.2%	-0.2%	-0.3%	128	118	91%	97%
Non-OECD	**1.5%**	**1.2%**	**1.0%**	**5 715**	**7 322**	**46%**	**58%**
E. Europe/Eurasia	-0.1%	0.0%	-0.1%	337	327	63%	68%
Russia	-0.2%	-0.3%	-0.4%	142	129	74%	80%
Asia	1.3%	0.9%	0.7%	3 664	4 343	41%	55%
China	0.8%	0.5%	0.2%	1 351	1 431	51%	73%
India	1.7%	1.1%	0.9%	1 241	1 551	31%	42%
ASEAN	1.4%	1.1%	0.9%	597	737	45%	59%
Middle East	2.4%	1.9%	1.5%	209	297	67%	73%
Africa	2.4%	2.4%	2.3%	1 045	1 790	40%	51%
Latin America	1.4%	1.0%	0.8%	460	564	79%	84%
Brazil	1.3%	0.8%	0.6%	197	226	85%	89%
World	**1.3%**	**1.1%**	**0.9%**	**6 960**	**8 701**	**52%**	**62%**
European Union	0.3%	0.2%	0.1%	508	518	74%	79%

Energy comsumption: data & forecast 2000-2035 (Energy Outlook 2013)

			New Policies Scenario		Current Policies Scenario		450 Scenario	
	2000	2011	2020	2035	2020	2035	2020	2035
Coal	2 357	3 773	4 202	4 428	4 483	5 435	3 715	2 533
Oil	3 664	4 108	4 470	4 661	4 546	5 094	4 264	3 577
Gas	2 073	2 787	3 273	4 119	3 335	4 369	3 148	3 357
Nuclear	676	674	886	1 119	866	1 020	924	1 521
Hydro	225	300	392	501	379	471	401	550
Bioenergy*	1 016	1 300	1 493	1 847	1 472	1 729	1 522	2 205
Other renewables	60	127	309	711	278	528	342	1 164
Total (Mtoe)	**10 071**	**13 070**	**15 025**	**17 387**	**15 359**	**18 646**	**14 316**	**14 908**
Fossil fuel share	*80%*	*82%*	*80%*	*76%*	*80%*	*80%*	*78%*	*64%*
*Non-OECD share***	*45%*	*57%*	*61%*	*66%*	*61%*	*66%*	*60%*	*64%*
CO_2 emissions (Gt)	**23.7**	**31.2**	**34.6**	**37.2**	**36.1**	**43.1**	**31.7**	**21.6**

World primary energy demand and energy-related CO2 Emissions

450 Scenario: a 50% chance of keeping to 2°C the long-term increase in average global temperature.



Primary Energy Consumption per capita, Tep/yr

Oil production and reserves (I)

The units is the Barrel, equal to 42 US gallons (about 159 liters)

Another units is the Tep (Oil equivalent ton, whose energy contents is 42GJ, say some 7 barrels)

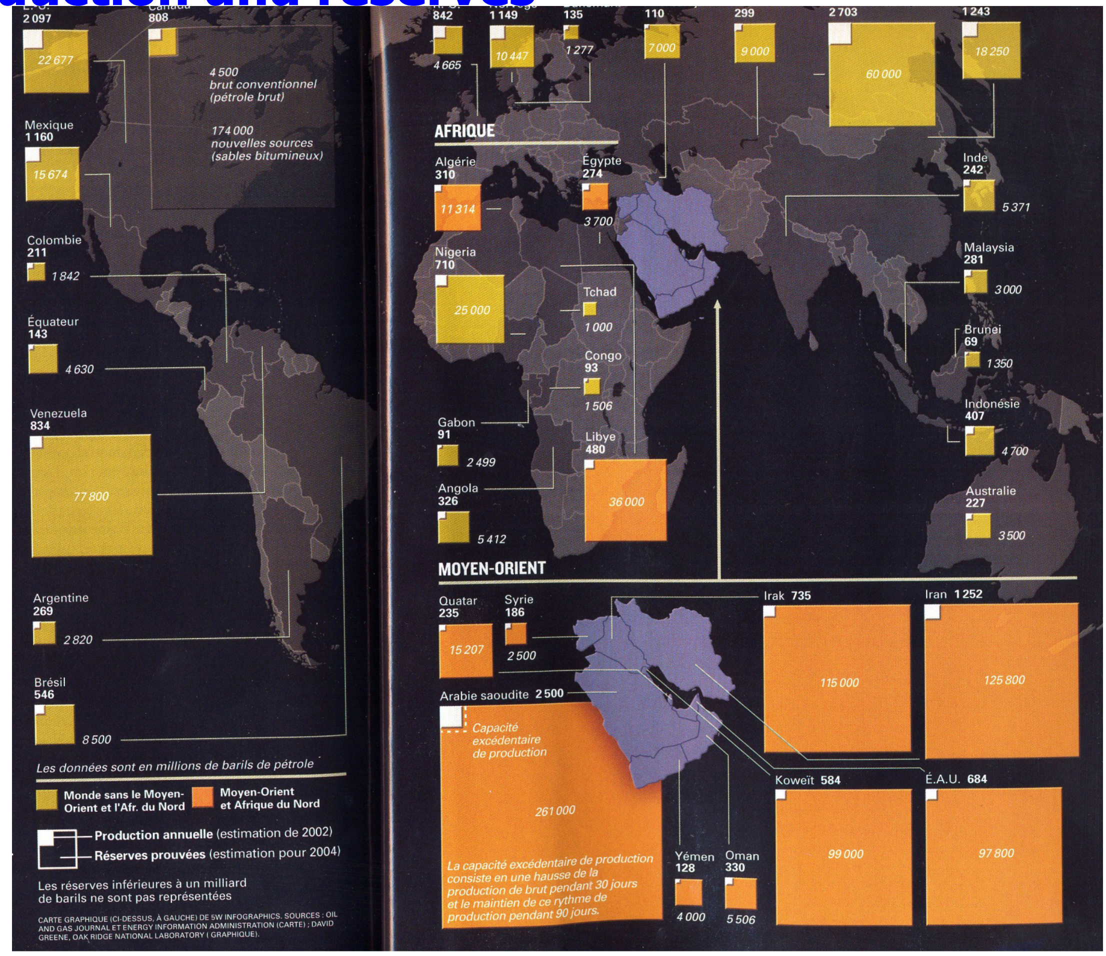
Current comsumption (2010) is 88 Mbarrel/day

Yearly comsumption is 32000 Mbarrel

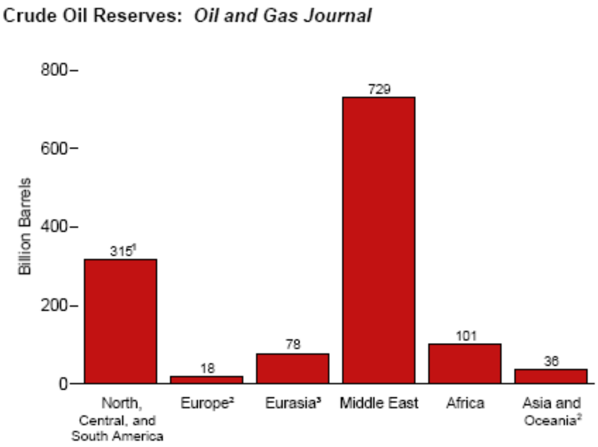
Middle East Production is 6000 Mbarrel/year

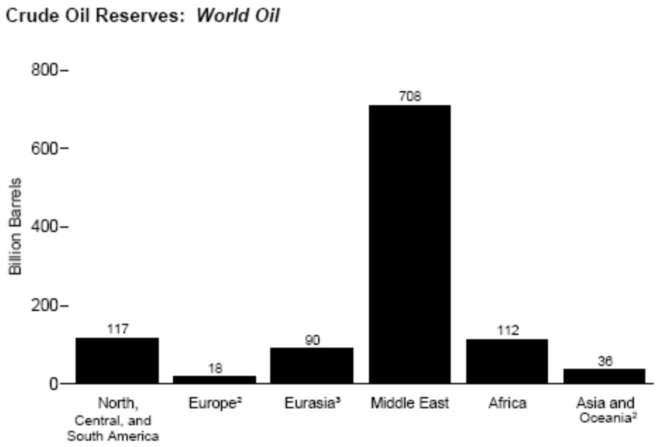
Proved oil reservers in Middle East countres are estimated in 700000 Mbarrel (70% of the whole world reserves..)

Oil Production and reserves



Oil Production and reserves (II)





(DOE Report, 2005)

Oil in the Artic ?
The meltdown will help our energy thirsty world ?

Oil Production and reserves (IV)

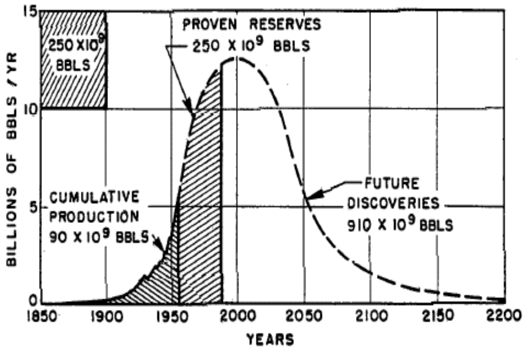
Maximum production capacity with respect to Reserves: P/R=1/15 (??)

Oil “proved” reserves : 200-300 GTep

The increase of the comsumption requires the increase of the available reserves

Based on reserve estimations, the max dayly extraction rate is around 100Mbarrel/day

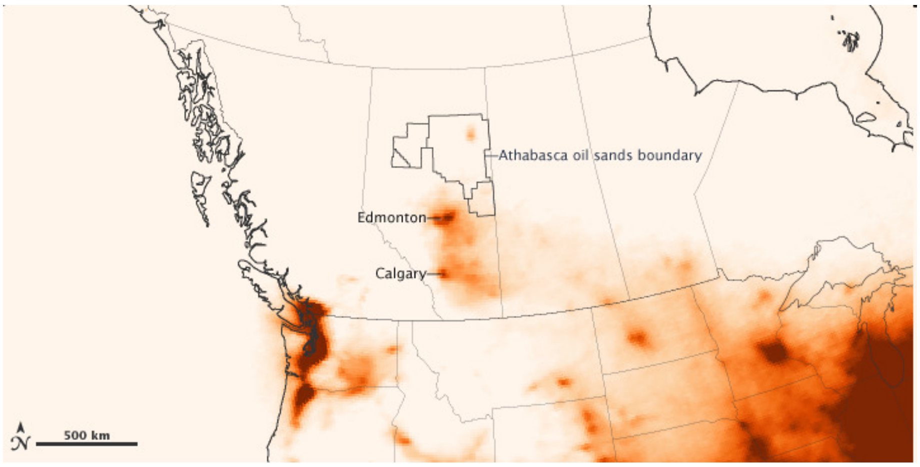
Further beyond it it is necessary to exploit non conventional oil resources (Tar sands, e.g. Canada)



Hubbert Law: Exploitation of a natural resource and its curve of production

Oil Production and reserves (V)

Tar sands or Oil Sands

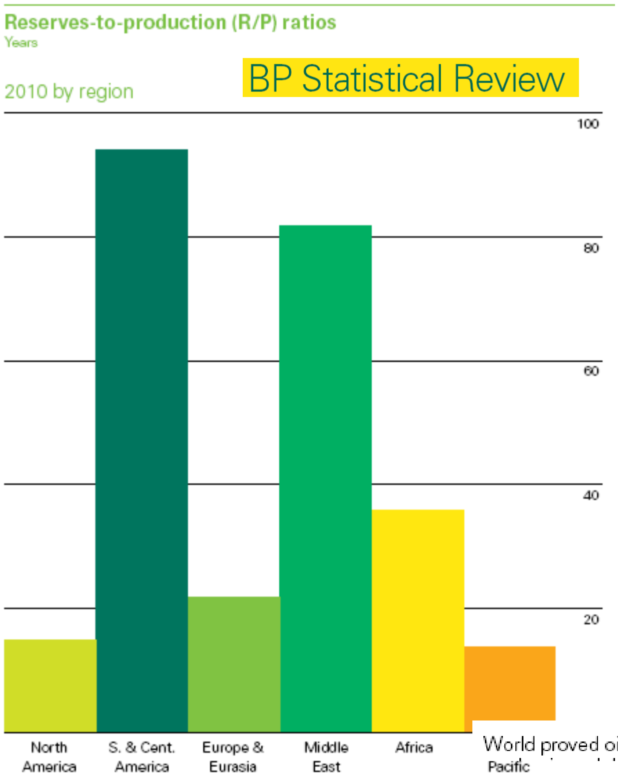


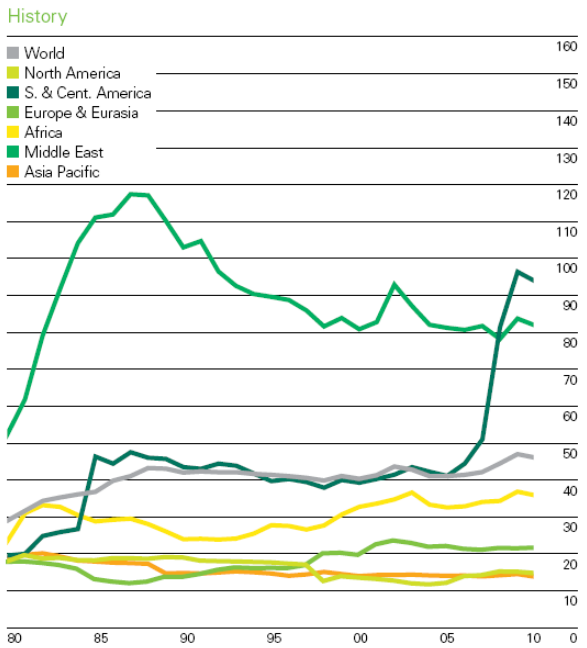
Nasa.gov

the emission of pollutants from oil sands mining operations in Canada’s Alberta Province are comparable to the emissions from a large power plant or a moderately sized city. The emissions from the energy-intensive mining effort come from excavators, dump trucks, extraction pumps and wells, and refining facilities where the oil sands are processed.

The oil sands deposit in northwest Alberta covers about 142,200 square kilometers (54,900 square miles). Only 20 percent of the oil sands lie near the surface where they can easily be mined, while the rest of the oil sands are buried more than 75 meters below ground and are extracted by injecting hot water into a well that liquefies the oil for pumping. About 1.8 million barrels of oil were produced daily in 2010 from the Canadian oil sands.

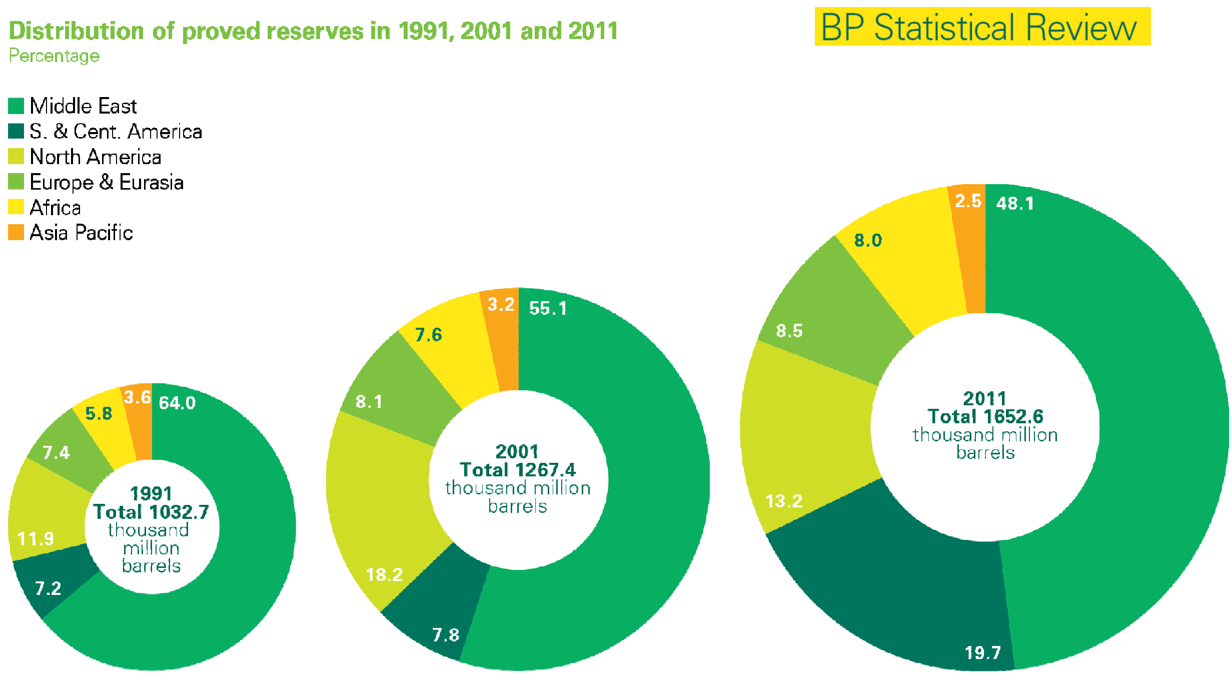
Oil Production and reserves (VI)





World proved oil reserves in 2010 were sufficient to meet 46.2 years of global production,

Oil Production and reserves (VIb)

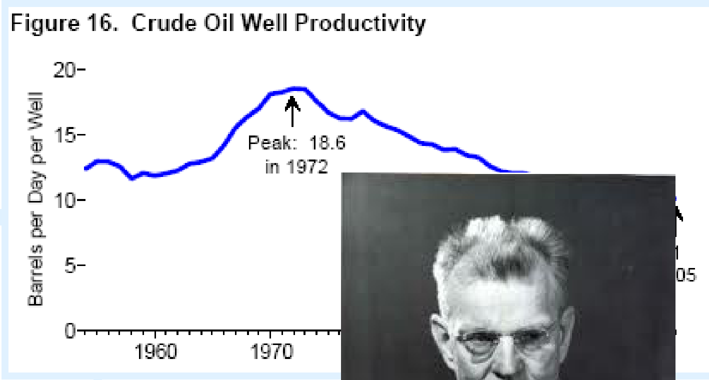


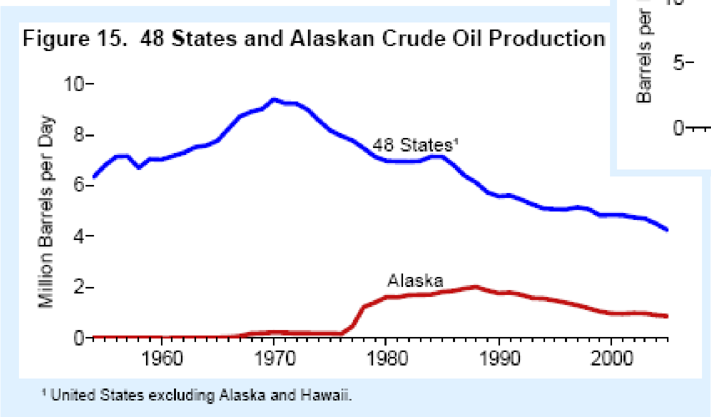
Oil Production and reserves (VII)

Oil extraction in the US (DOE Report)

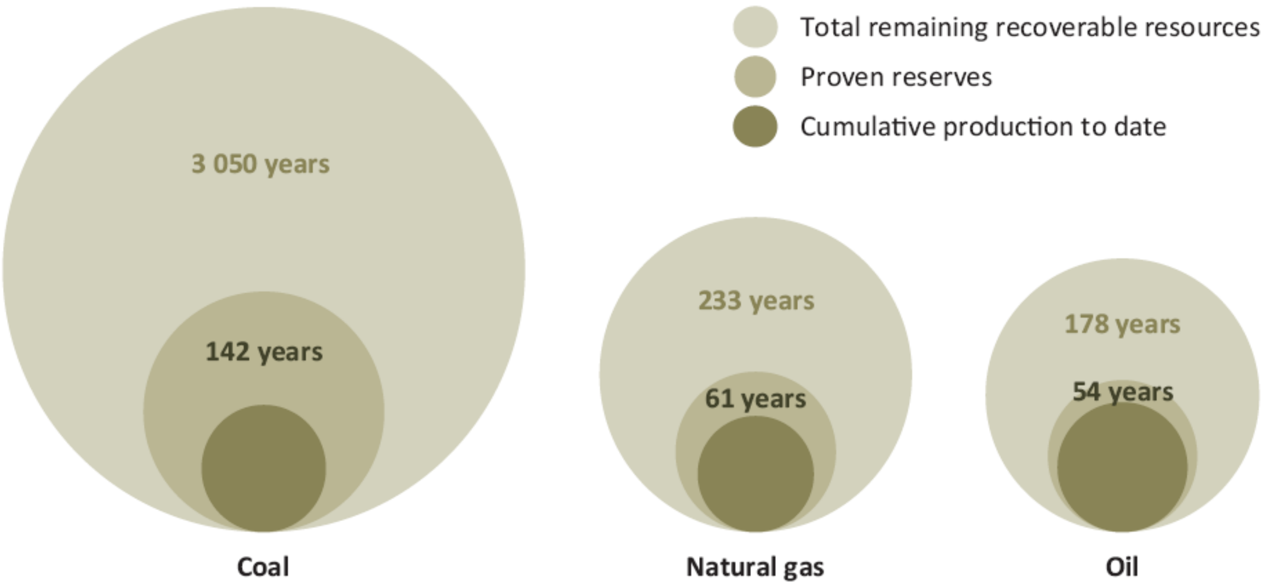
Notice: either the overall oil production or the single well one in this example have shown a typical “through a maximum” profile

(Hubbert law confirmed...)

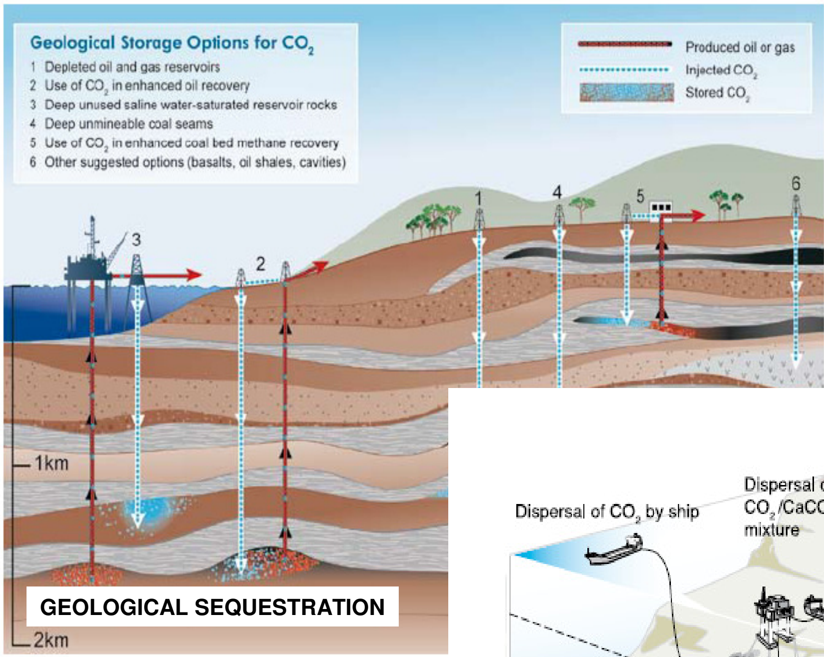




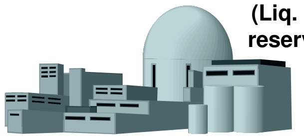
Primary energy, reserves and cumulative production (Energy Outlook, 2013)



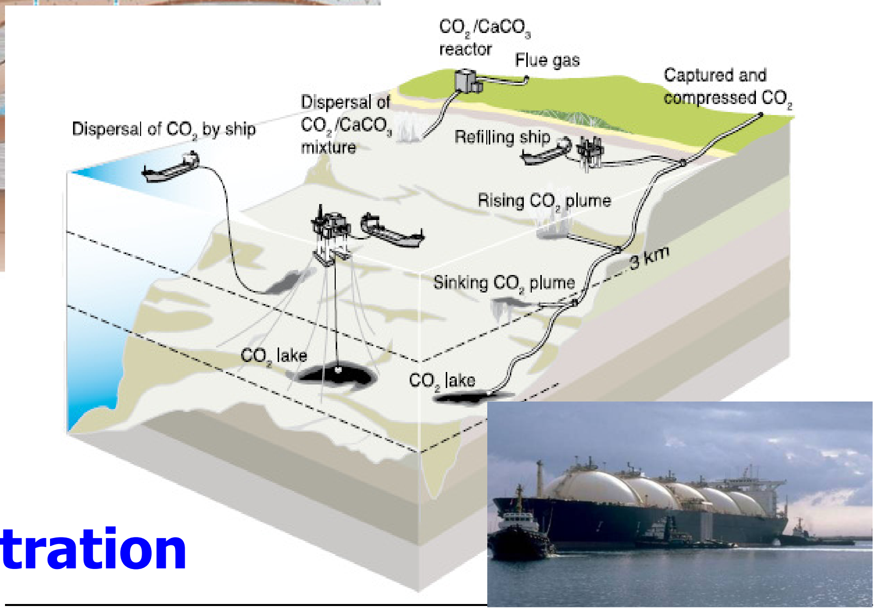
Coal is still abundant but highly pollutant in terms of greenhouse emissions.
CO2 sequestration (Carbon Sequestration) can be the solution for sustainable coal exploitation?



POWER STATION (Liq. CO_2 reservoir)



DEEP SEA SEQUESTRATION

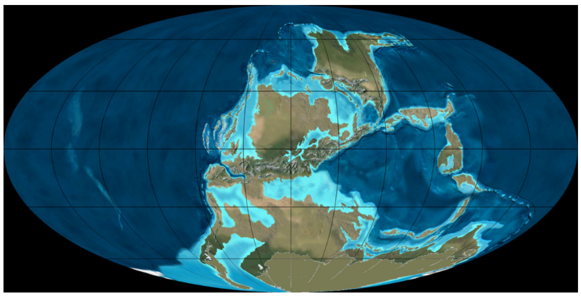


Carbon sequestration

Primary energy demand scenarios

WHEN ALL FOSSIL FUELS WERE OVER
ALL CARBON WOULD HAVE BEEN REALEASED TO ATMOSPHERE
TO PRE-CARBONIFER LEVELS (or so..)

At the beginning of the Carboniferous Period (400 millions yrs ago) the Earth is a warm platet (T ave 22°C) and no ice caps are present at poles.



CO2 concentration is above 1000 ppm.

CONSUMPTIONS AND GREENHOUSE GAS EMISSIONS

Burning one kg of oil yields 3.1 kg of CO_2

Burning one kg of natural gas yields 2.3 of CO_2

CO_2 concentration in atmosphere was 280ppm on year 1900

CO2 concentration in atmosphere on year 2000 was 370ppm, now (2016) is 400

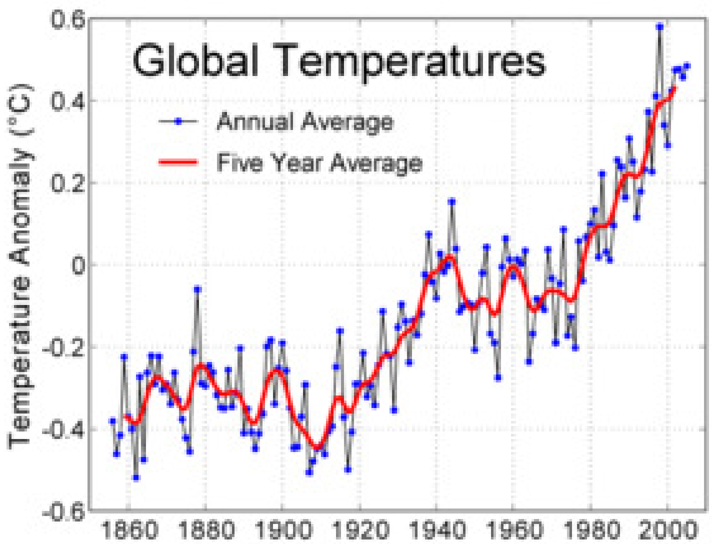
CO2 lifetime is 150 yrs, before being fixed in ocean masses

World Global Temperatures (I)

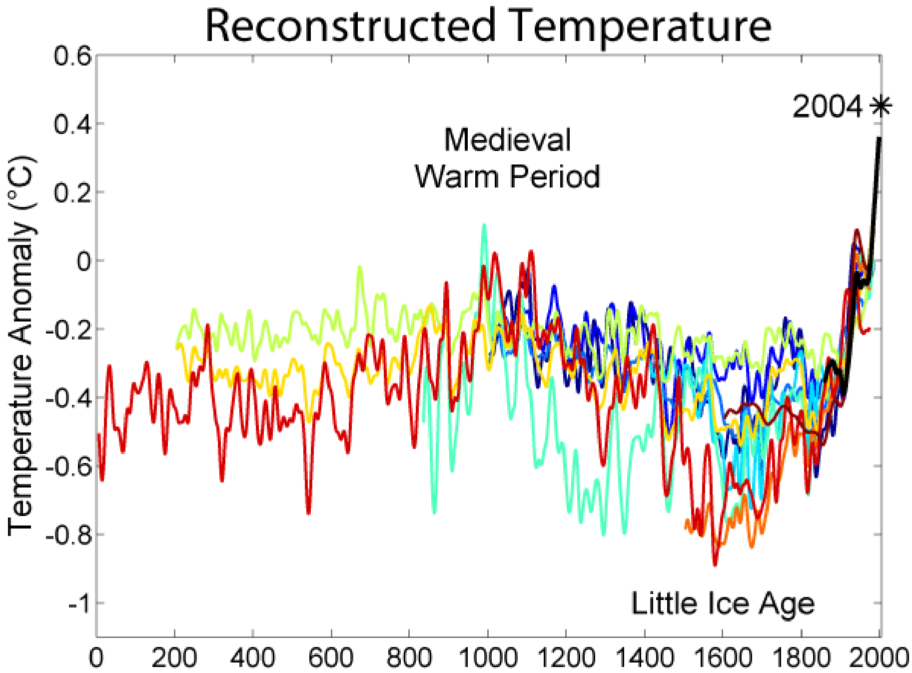
Geological periods have been characterized by climate changes and temperature changes. Typically these variations have been 1-1.5°C every 1000 yrs

At the end of Ice Age periods temperature rises up to 0.15-0.2°C per 100 yrs have been estimated

In the last 50 yrs, the atmosphere temperature rise was 0.7°C, say some 14°C per 1000 yrs

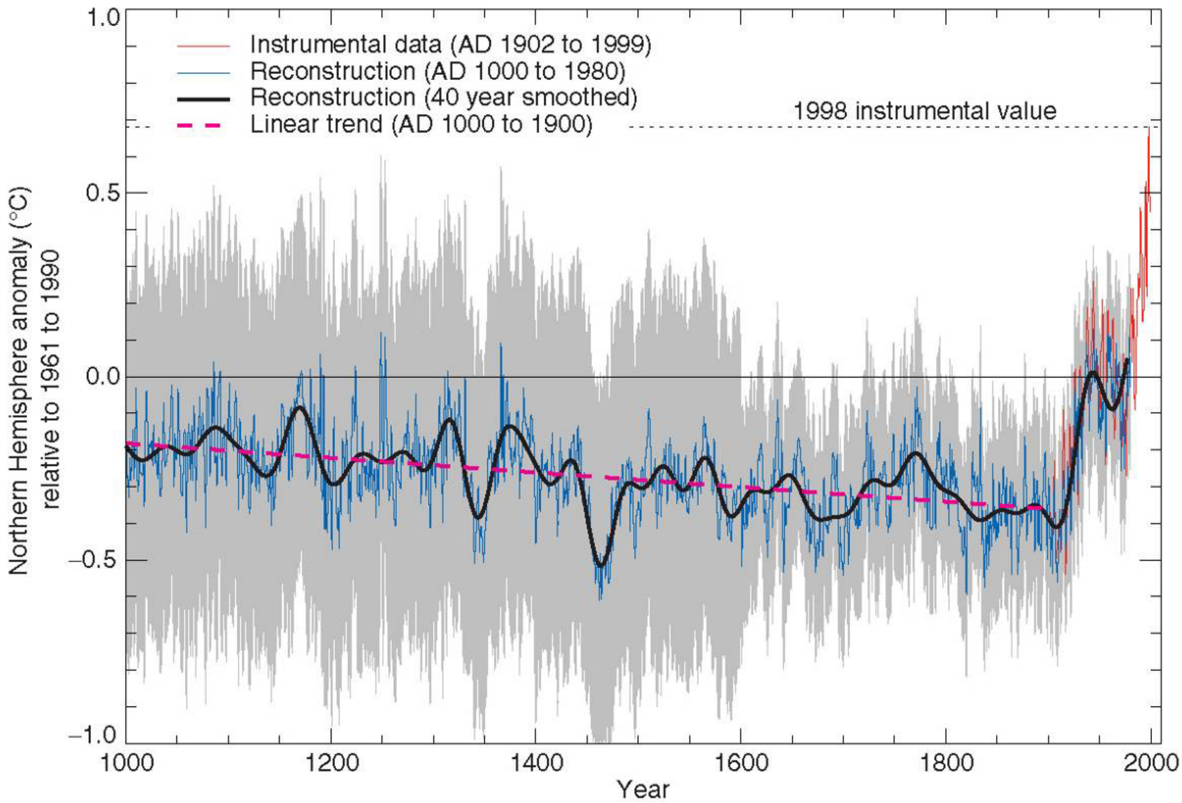


Global Temperatures (II)



(dark blue 1000-1991): P.D. Jones, K.R. Briffa, T.P. Barnett, and S.F.B. Tett (1998). , *The Holocene*, 8: 455-471. **(blue 1000-1980):** M.E. Mann, R.S. Bradley, and M.K. Hughes (1999). , *Geophysical Research Letters*, 26(6): 759-762.
(light blue 1000-1965): Crowley and Lowery (2000). , *Ambio*, 29: 51-54. Modified as published in Crowley (2000). , *Science*, 289: 270-277.
(lightest blue 1402-1960): K.R. Briffa, T.J. Osborn, F.H. Schweingruber, I.C. Harris, P.D. Jones, S.G. Shiyatov, S.G. and E.A. Vaganov (2001). , *J. Geophys. Res.*, 106: 2929-2941.
(light green 831-1992): J. Esper, E.R. Cook, and F.H. Schweingruber (2002). , *Science*, 295(5563): 2250-2253.
(red 1-1979): A. Moberg, D.M. Sonechkin, K. Holmgren, N.M. Datsenko and W. Karlén (2005). , *Nature*, 443: 613-617.

Global Temperatures (III)



Sustainable Development
The Strategies:

1) **Efficiency enhancement in conventional power plants**

2) **Energy saving addressed policies**

3) **Increase the use of renewable energies**

Strategies
2) Energy saving addressed policies
(Energy savings in buildings)

Heating, cooling and ventilation in developed country buildings account for about 35% of the overall primary energy consumption

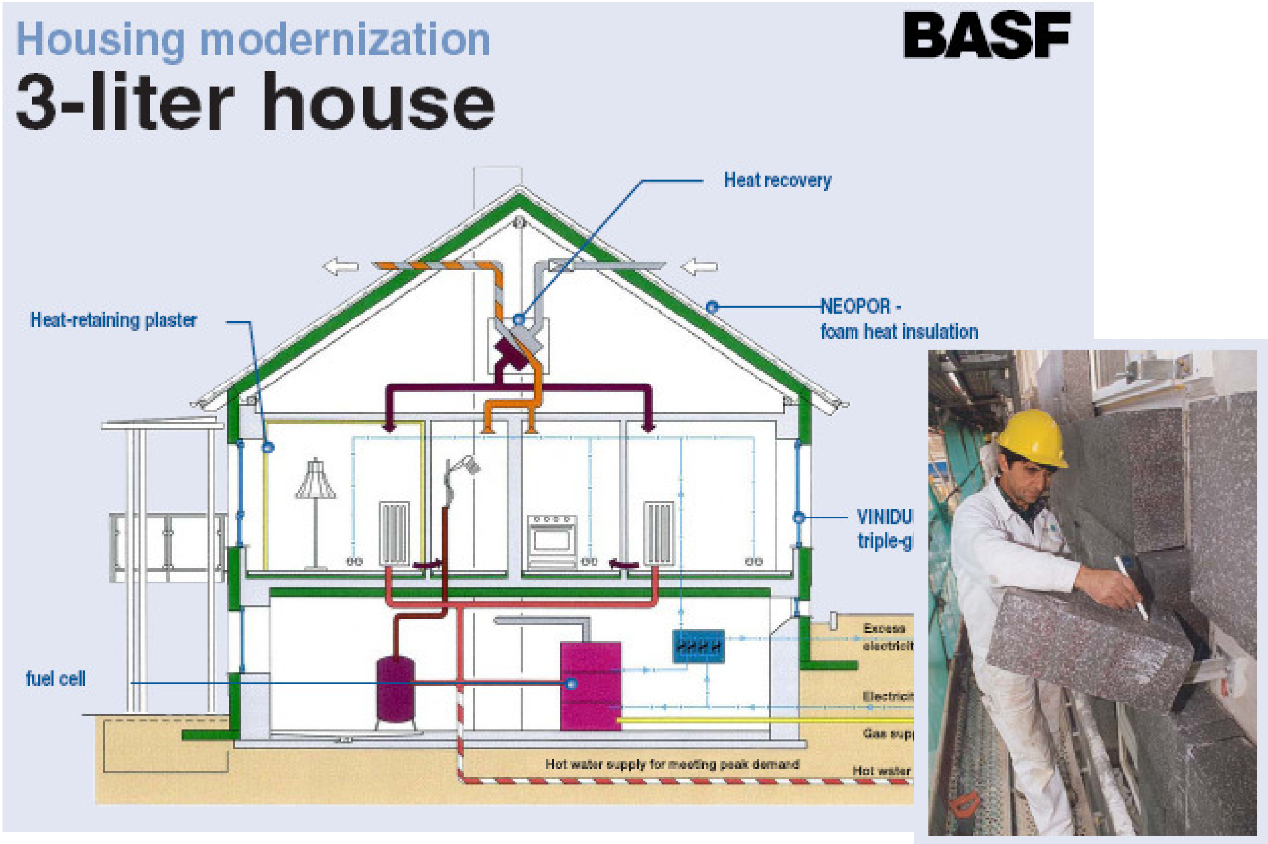
UE has addressed since 2001 a great effort in the direction of reducing the energy consumption and CO2 emissions in buildings in terms of

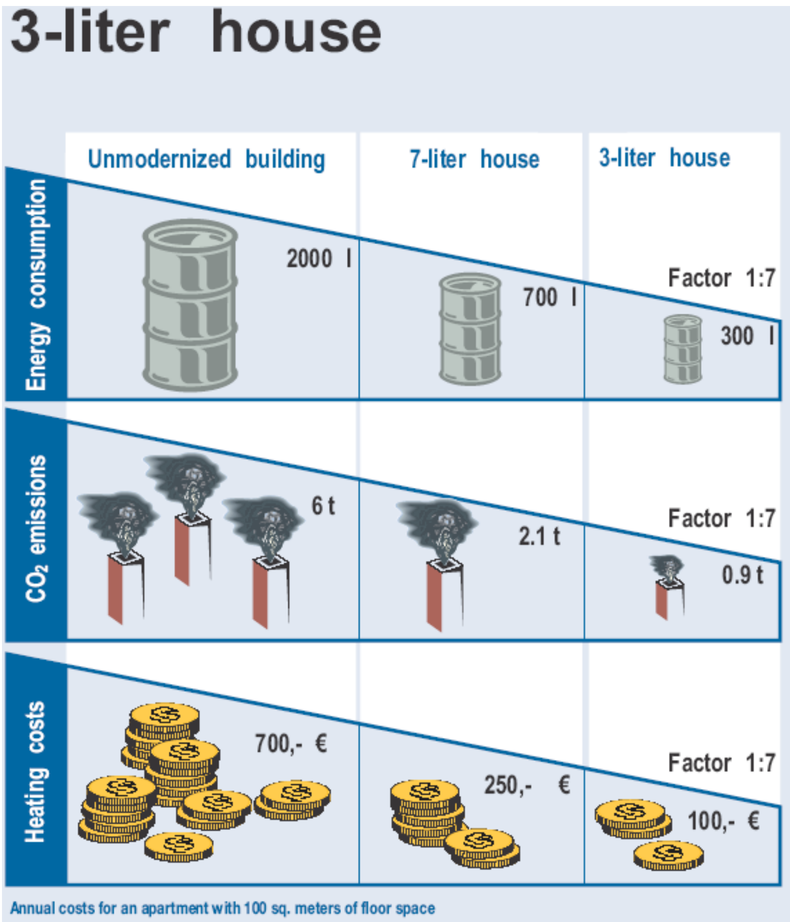
-Increasing the efficiency of the heating systems (e.g. by using heat pumps)

- Enhancing the thermal performance of the building envelope (insulation)

-Stimulating the use of the Renewable energies in buildings

A leading project (year 2001..)





3L/(year m^2)= 30kWh/year m^2)

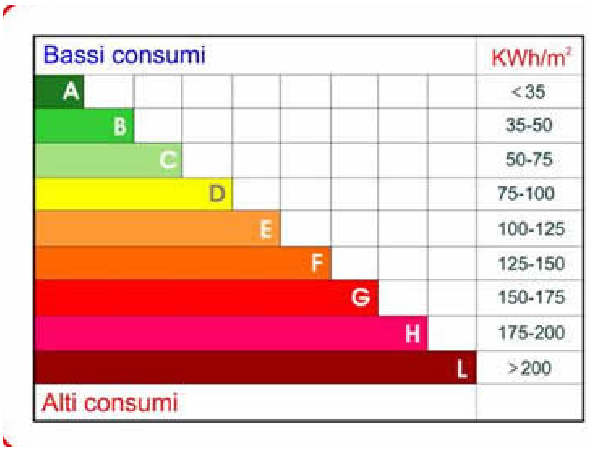
3L house introduces the concept of Energy Demand per surface unit and per year

This building, taking into account the local climate conditions, allows consumptions equal to about 1/10 of the corresponding demand of an existing italian building

Energy savings in building through Energy Certifications

Italian laws

EU Directive 2002/91/CE
Dlgs 192/2005
Dlgs 311/2006



Energy certification for buildings is the procedure for assessing the building energy performance in terms of primary energy requirements.

The scale is in terms of kWh/m² year

Envelope dispersions and heat production and distribution system performance are evaluted

Non Renewable energy is accounted separately from primary energy global needs

The final goal: the Zero Energy building

Some DEFINITIONS

A zero-energy building, also known as a zero net energy (ZNE) building, net-zero energy building (NZEB), or net zero building, is a building with zero net energy consumption and zero carbon emissions on a given period, typically one year.

Life cycle assessment is not included in energy balances at building level

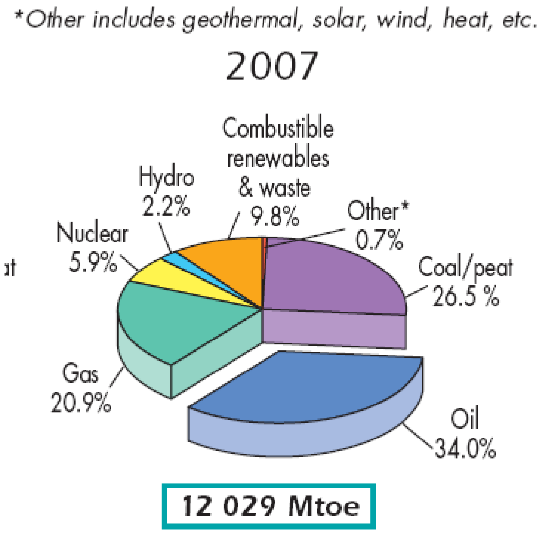
The renewable energy markets

Renewable energies in the World (I)

In 2003 renewable resources covered 13.3% of world demand with 1.404 Mtep out of 10.6MTep Mtep (IEA, DOE). In that year the energy demand was covered for 34,4% by oil, 24,4% by coal, 21,2% by gas and 6,5% by nuclear plants.

Solid biomasses are the most important contribution to renewable energy in the world, with some 77,5% of RE production.

Apart biomass, hydro power is the second relevant voice in RE panier



Fonti: Enea 2005, IEA-DOE 2005

Renewable energies in the World (2011)

World renewable energy use by type and scenario

	2011
Primary energy demand (Mtoe)	**1 727**
United States	140
Europe	183
China	298
Brazil	116
Share of global TPED	*13%*
Electricity generation (TWh)	**4 482**
Bioenergy	424
Hydro	3 490
Wind	434
Geothermal	69
Solar PV	61
Concentrating solar power	2
Marine	1
Share of total generation	*20%*
Heat demand*(Mtoe)	**343**
Industry	209
Buildings* and agriculture	135
Share of total final demand	*8%*
Biofuels (mboe/d)**	**1.3**
Road transport	1.3
Aviation***	-
Share of total transport	*2%*
Traditional biomass (Mtoe)	**744**
Share of total bioenergy	*57%*
Share of renewable energy demand	*43%*

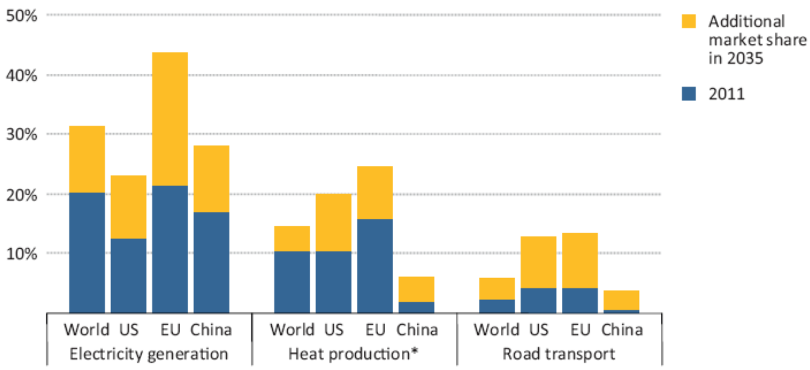
Fonti: IEA 2013 Outlook

TPED = total primary energy demand

M.Fossa,

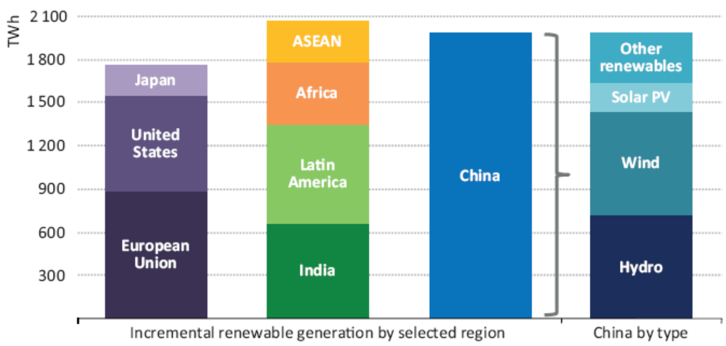
Renewable energies in the World: the future

Figure 6.1 ▷ Renewable energy share in total primary energy demand by category and region in the New Policies Scenario, 2011 and 2035



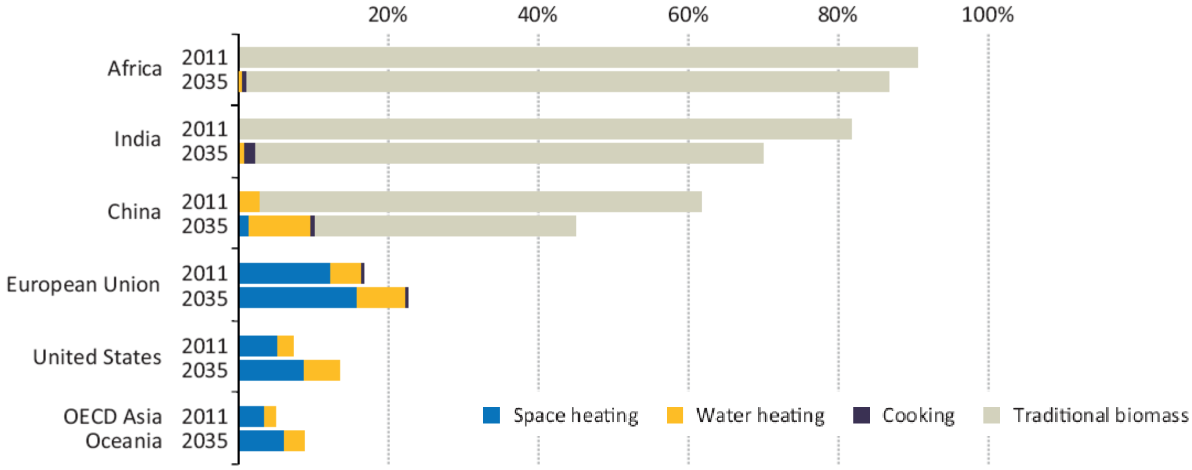
* Excludes traditional biomass. Note: US = United States; EU = European Union.

Figure 6.2 ▷ Incremental electricity generation from renewables in selected regions, 2011-2035



Renewable Heat in the World

Figure 6.5 ▷ Share of renewables in heat production in the residential sector for selected regions in the New Policy Scenario



Most of the contribution of renewables to heat production comes from biomass used in developing countries.The use of traditional biomass for heat amounted to 744 Mtoe in 2011 and made up 18% of total global energy use for heat. Such use is often unsustainable because of the low burning efficiency and related pollution

More modern and efficient technologies for bioenergy, geothermal and solar thermal are playing an increasing role in heat supply and met 8% of total global demand for heat in 2011. (Source: IEA Outlook 2013)

Hydro Power Market

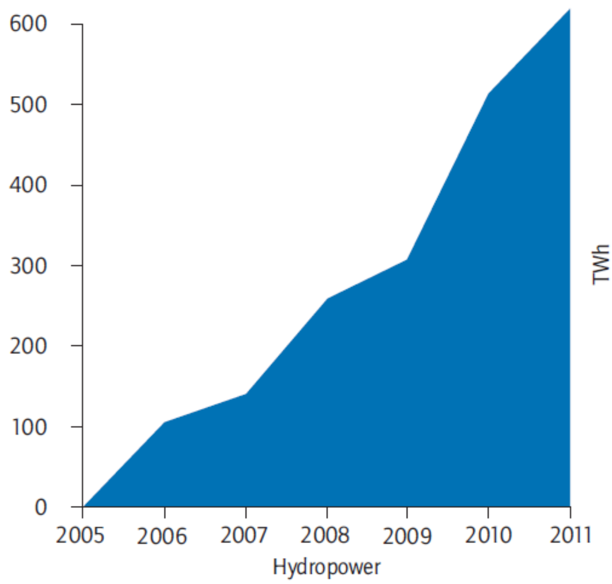
Hydro Power in the World

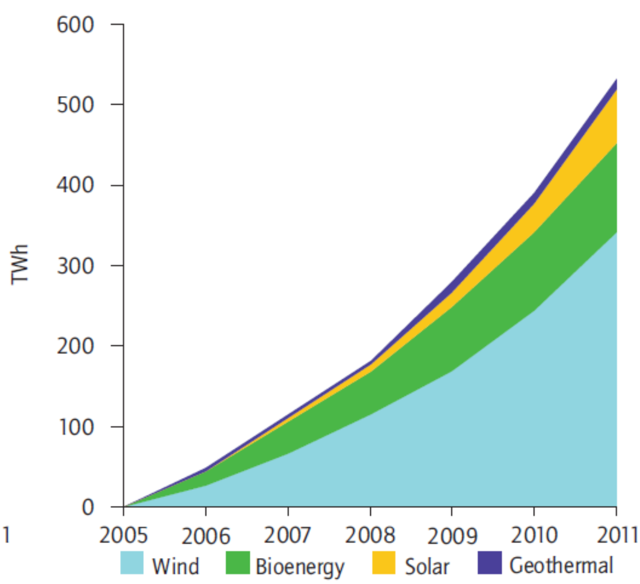
Country	Hydro electricity (TWh)	Share of electricity generation (%)
China	694	14.8
Brazil	403	80.2
Canada	376	62.0
United States	328	7.6
Russia	165	15.7
India	132	13.1
Norway	122	95.3
Japan	85	7.8
Venezuela	84	68
Sweden	67	42.2

Share of hydropower	Countries	Hydropower Generation (TWh)
≈100%	Albania, DR of Congo, Mozambique, Nepal, **Paraguay**, Tajikistan, Zambia	54
>90%	**Norway**	126
>80%	**Brazil**, Ethiopia, Georgia, Kyrgyzstan, Namibia	403
>70%	Angola, Columbia, Costa Rica, Ghana, Myanmar, **Venezuela**	77
>60%	**Austria**, Cameroon, **Canada**, Congo, Iceland, Latvia, Peru, Tanzania, Togo	38; 351
>50%	Croatia, Ecuador, Gabon, DPR of Korea, **New Zealand**, Switzerland, Uruguay, Zimbabwe	25; 36

Hydro power share in the world, year 2010 from IEA Report.

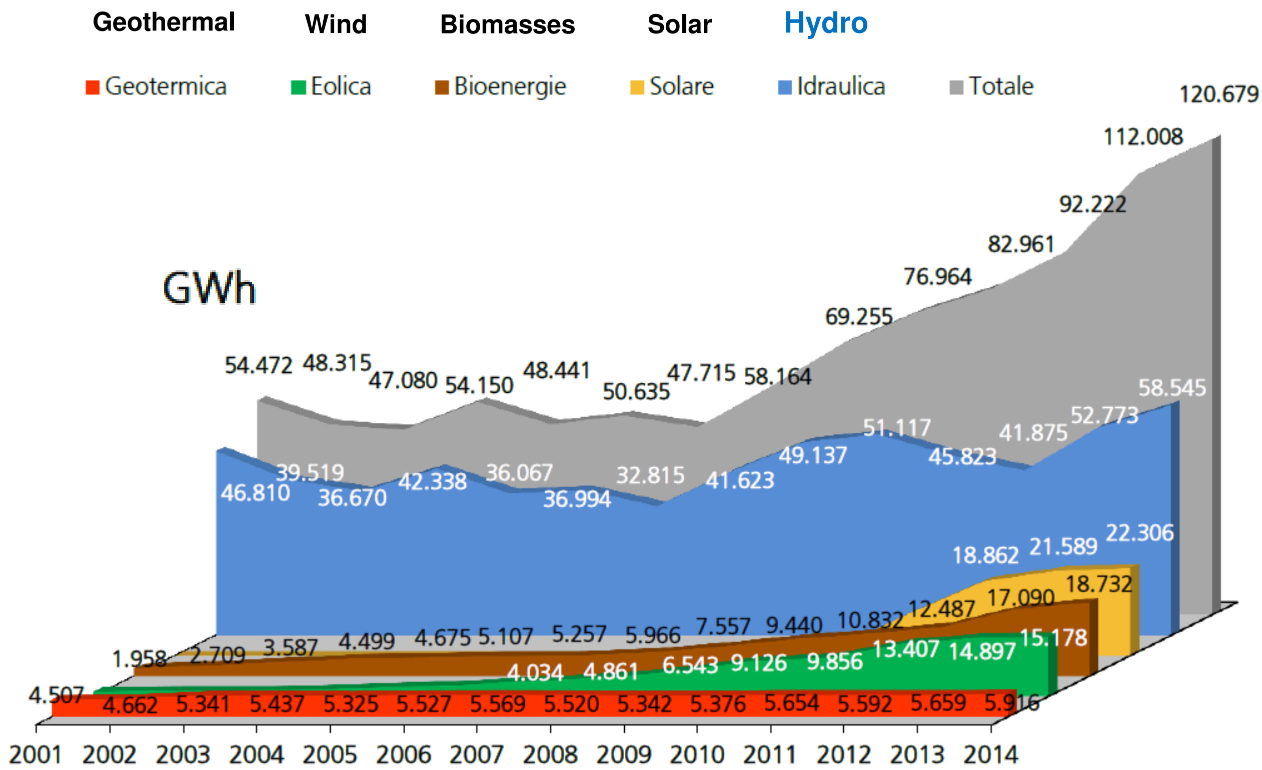
Hydro Power in the World





Hydro power production growth and comparison with other renewable resources (Source: IEA Report 2012).

Renewable electric energy in Italy



Renewable electric energy in Italy

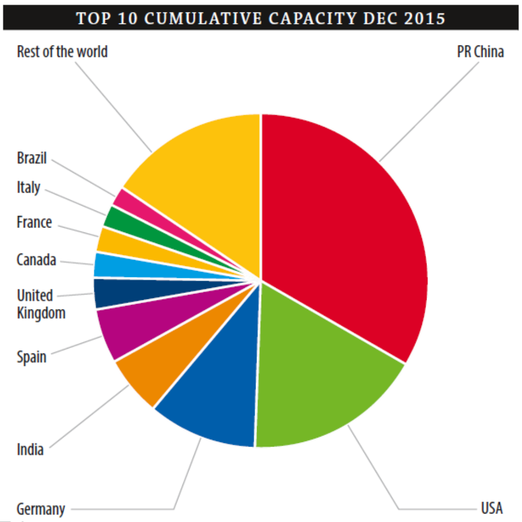
Fonte	Ore di utilizzazione			
	2011	2012	2013	2014
Idraulica	2.531	2.322	2.881	3.183
Eolica	1.563	1.855	1.793	1.767
Solare	1.325	1.312	1.241	1.210
Geotermica	7.324	7.243	7.321	7.206
Bioenergie*	3.799	3.817	4.318	4.586

* Esclusi gli impianti ibridi

Productivity (kWh/$kW_{nominal}$) of different Renewable energy plants in Italy.

Wind Power Market

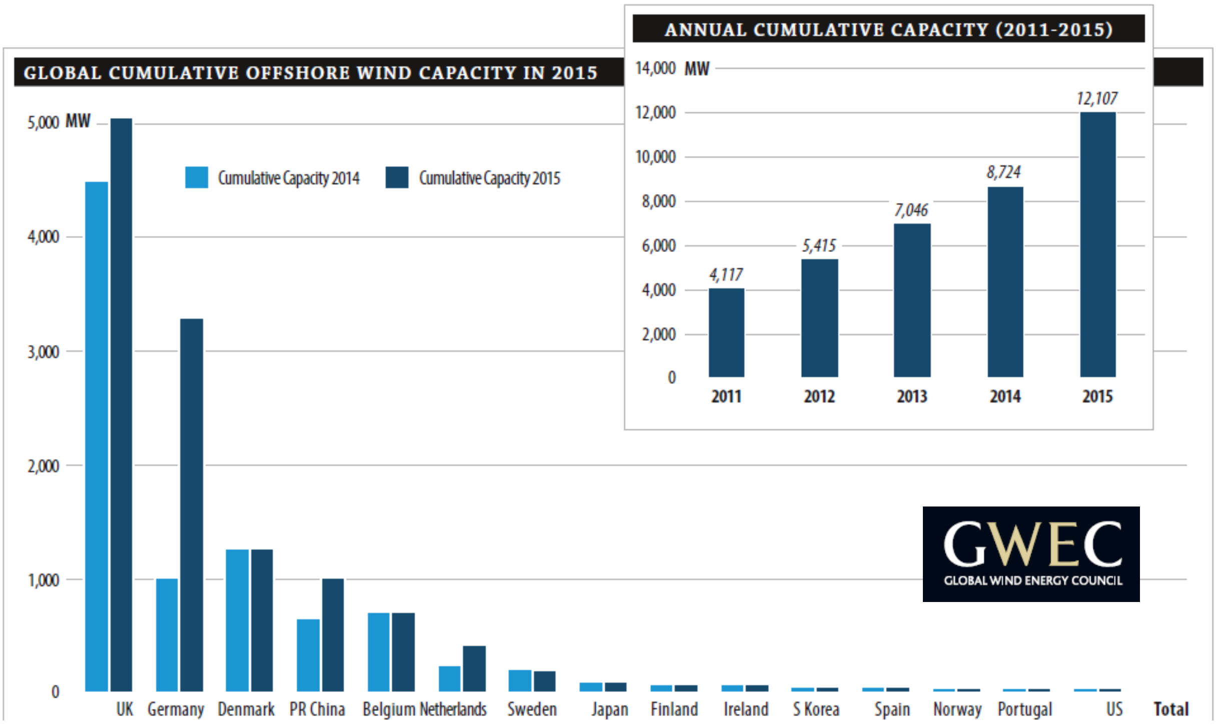
Wind Power worldwide



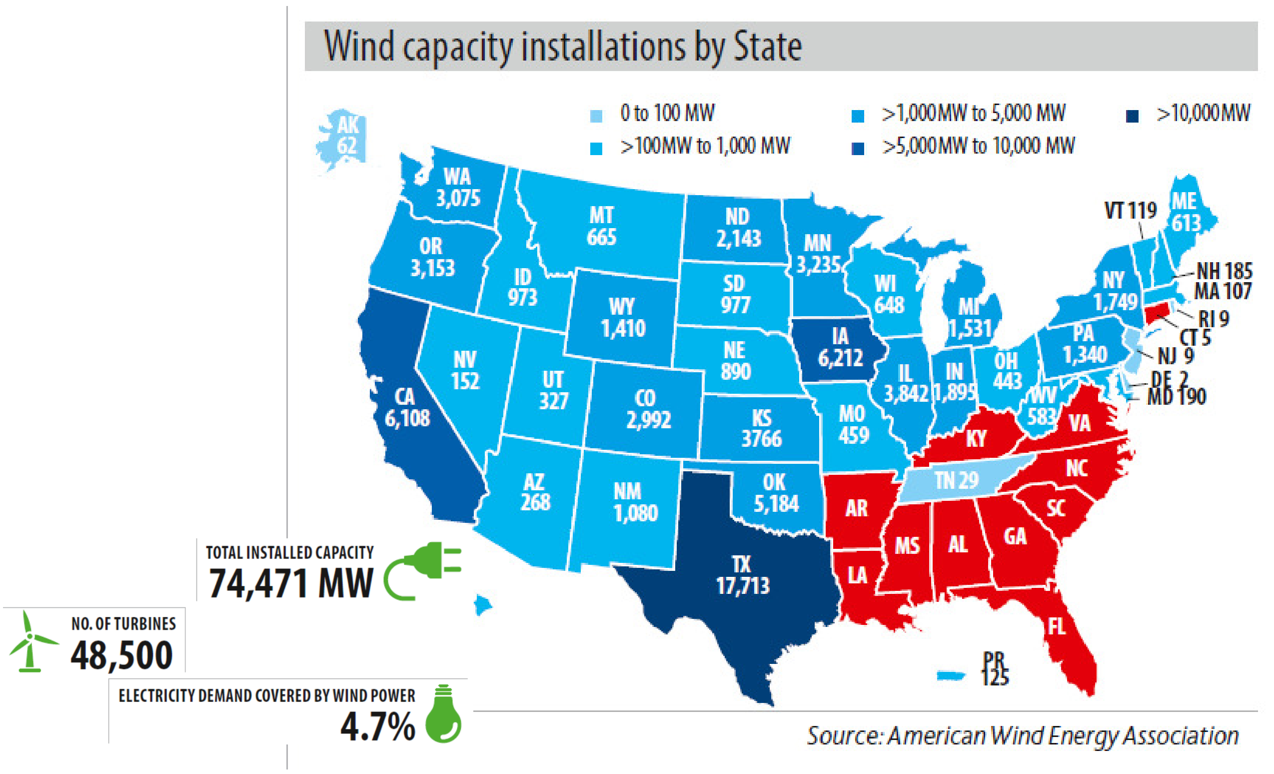
Country	MW	% Share
PR China	145,362	33.6
USA	74,471	17.2
Germany	44,947	10.4
India	25,088	5.8
Spain	23,025	5.3
United Kingdom	13,603	3.1
Canada	11,205	2.6
France	10,358	2.4
Italy	8,958	2.1
Brazil	8,715	2.0
Rest of the world	67,151	15.5
Total TOP 10	**365,731**	**84.5**
World Total	**432,883**	**100**

Source: GWEC

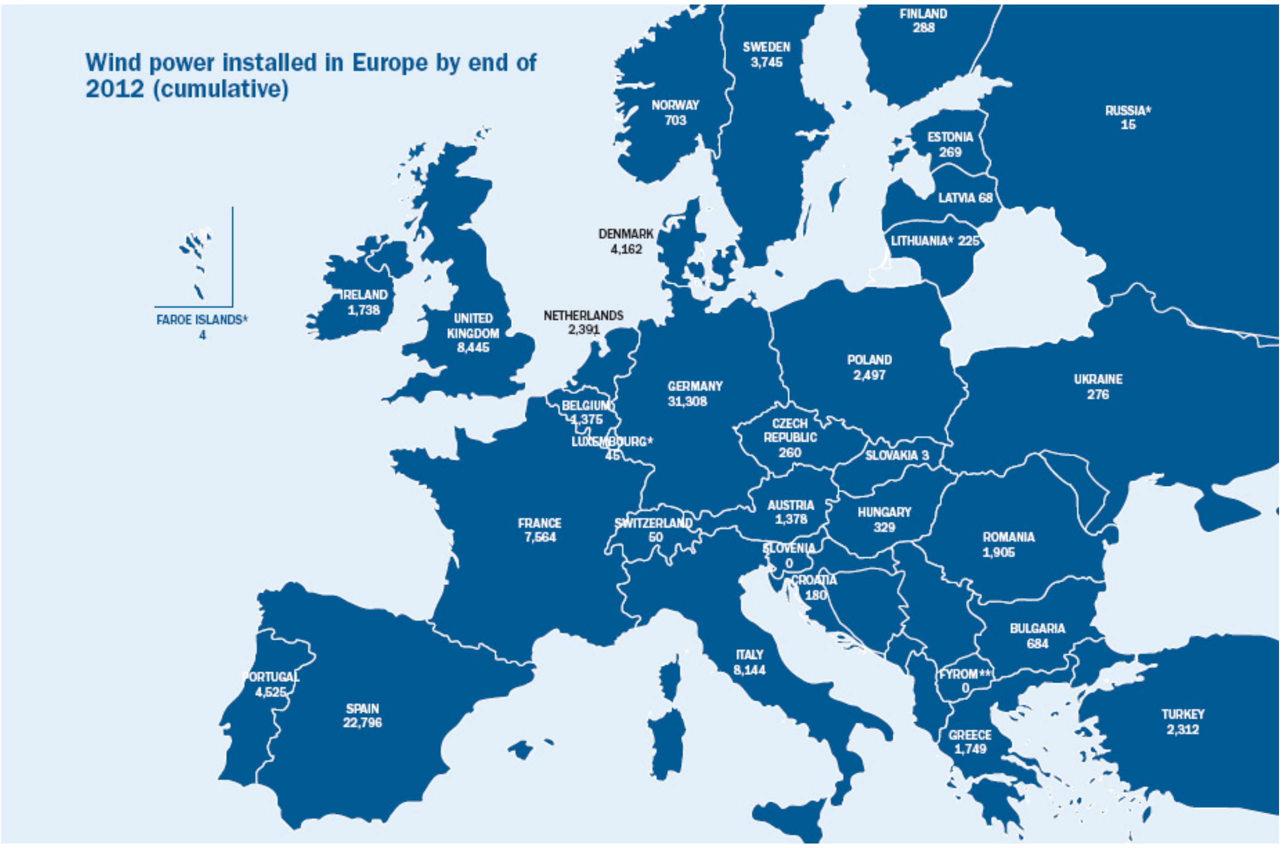
Wind Power worldwide (offshore plants)



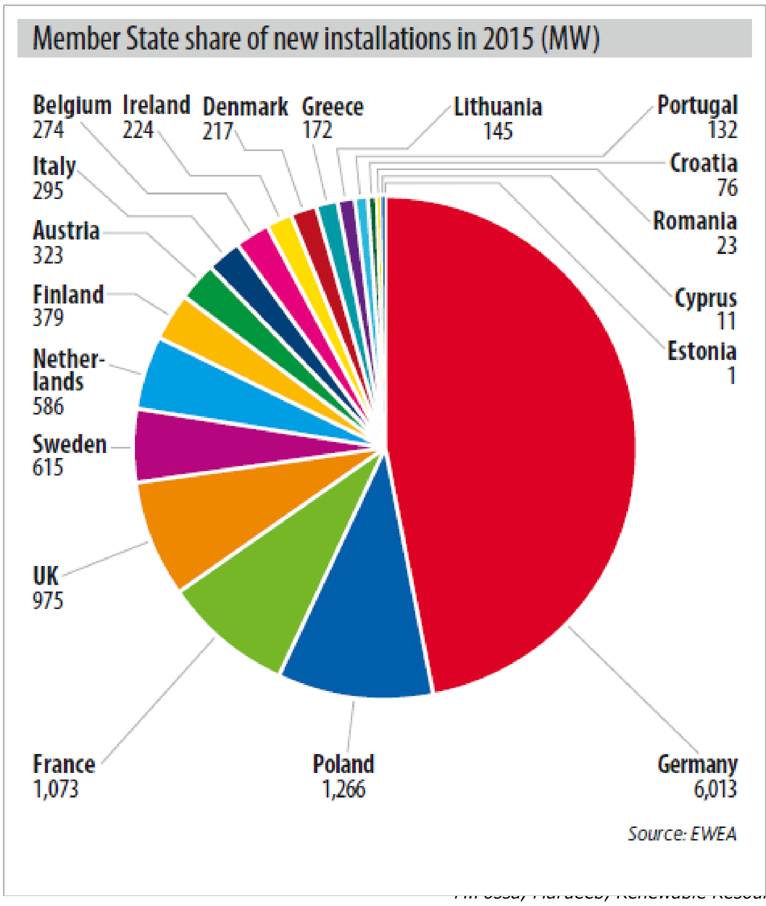
Wind Power in the USA



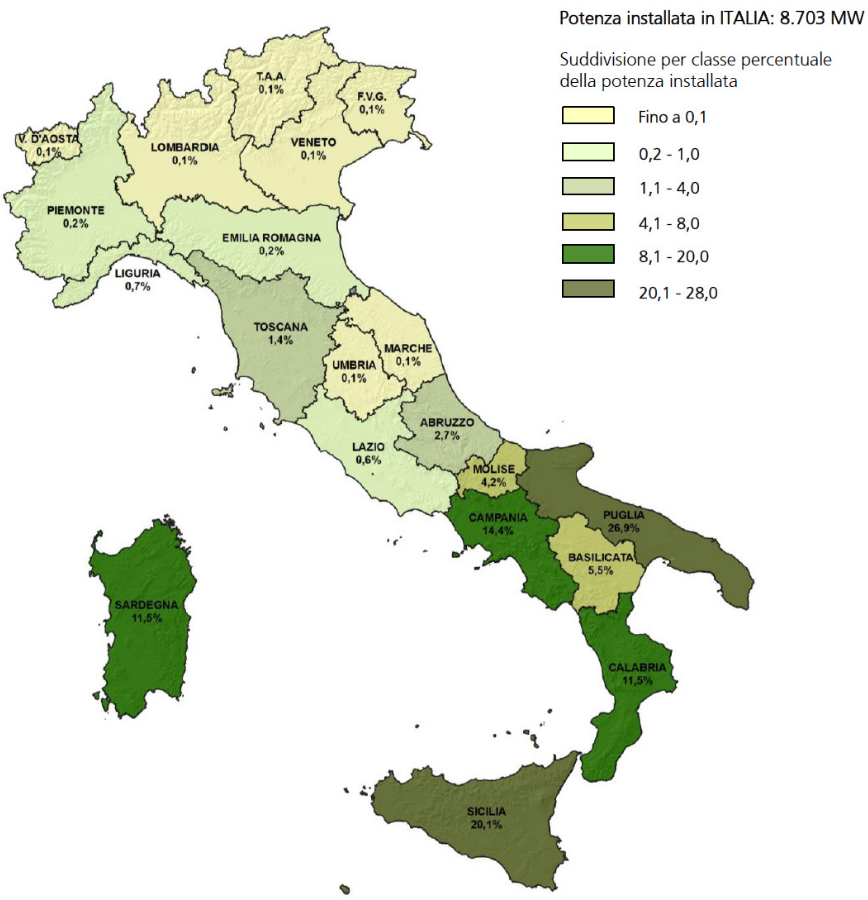
Wind Power in Europe



Wind Power in Europe



Wind Power in Italy



GSE Gestore Servizi Elettrici

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Solar Market and technologies

Technologies for renewables: solar thermal (I)

Solar Thermal is a well known technology for converting solar power into thermal power. Low Temperature devices (Solar Collectors) are spread worldwide and they typically employ water solutions or air. High temperature solar concentrators focus the light onto point or linear targets at concentration ratios up to hundred times. Low temperature collectors are mainly devoted to Domestic Hot Water (DHW) production, while high temperature plants are addressed to thermodynamic conversion (grid connected electric plant). A recent Italian examples regarding solar concentration is the Archimede Plant (http://www.enel.it/eventi/priolo/ progettoArchimede.asp?m=2), in Sicily (Priolo Gargallo) whre a solar field made by 360 parabolic mirrors and employing molten salts as thermal fluid.

Technologies for renewables: solar thermal (II)

High temperature solar concentrators: The Spain plants

Spanish manufacturer Abengoa Solar has the world's biggest portfolio of operating plants and of plants under construction. It already runs 13 Concentrated Solar Plants in Spain with a combined capacity of 570 MW (2 tower plants and 11 parabolic trough plants) and a 150-MW hybrid solar-gas plant at Hassi R'mel in Algeria (with a 20-MW solar component). In 2010 Abengoa delivered the Ain Bni Mathar plant in Morocco, another hybrid solar-gas facility (470 MWwith a 20-MW solar component).

CSP sector faces strong competition from the photovoltaic sector and its ability to slash its production costs through economies of scale.

(Solar Power Barometer and Eurobserv'ER 2013)


Gemasolar (20 GW), seule centrale à tour mise en service en Europe en 2011.
Gemasolar (20 MW), the only plant with central receiver commissioned in Europe in 2011.

Technologies for renewables: solar thermal (II)

(Solar dreams..)

Solar Towers are something in between low temperature plants and concentrating systems. Prototype tower in Manzanares, Spain, produced electric energy since july 1986 to february 1989, with a peak power of 50 kWe. Receiving area has a diameter of 240m and an area of 46.000m^2. Operating temperature is about 70°C

The tower is 10min in diameter and 195m high

Cost of prototype, about 1M(US$)

Technologies for renewables: solar thermal (III)

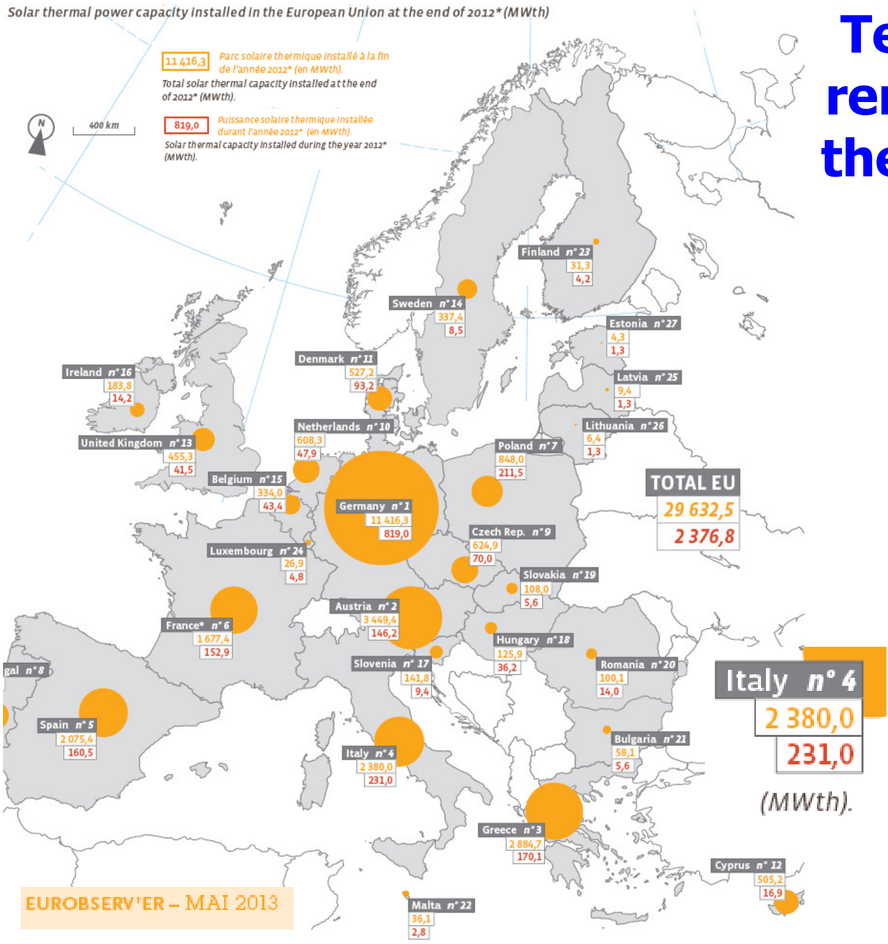
Solar collectors can be classified according to the transparent cover type into the families:

-*Flat Plate collectors:* they represent the most common solution for residential applications and they have plane glasses and plane absorbers

-*Unglazed collectors*, are the most simple version of solar collector and only the absorber surface is present. They are typically made by plastic materials and their use is limited to low temperature applications in good insolation conditions

Evacuated Tube collectors are conceived for minimizing the heat losses to the environment. The core of the system is a double glazing cylindrical glass where vacuum is made at the glass enclosure in order to suppress the natural convection and reduce the overall heat transfer coefficient

Technologies for renewables: solar thermal collectors



Technologies for renewables: solar thermal collectors (II)

Annual installed solar thermal surfaces in 2011 per collector type (m²) and power equivalent (MWth)

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Pays	Capteurs vitrés. *Glazed collectors*				
	Capteurs plans vitrés *Flat plate collectors*	Capteurs sous vide *Vacuum collectors*	Capteurs non vitrés *Unglazed collectors*	Total (m²)	Puissance équivalente (en MWth) *Equivalent power (MWth)*
Germany	1 080 000	190 000	20 000	1 290 000	903,0
Italy	331 500	58 500		390 000	273,0
Spain	249 730	17 250	8 610	275 590	192,9
Poland	187 000	66 500		253 500	177,5
Austria	221 495	8 694	5 700	235 889	165,1
France*	200 813	17 537	6 625	224 975	157,5
Greece	228 500	1 500		230 000	161,0

Annual installed solar thermal surfaces in 2012 per collector type (m²) and power equivalent (MWth)*

Technologies for renewables: solar collectors (III)

Pays *Country*	Capteurs vitrés. *Glazed collectors*: Capteurs plans vitrés *Flat plate collectors*	Capteurs vitrés. *Glazed collectors*: Capteur sous vide *Vacuum collectors*	Capteurs non vitrés *Unglazed collectors*	Total (m²)	Puissance équivalente (en MWth) *Equivalent power (MWth)*
Germany	977 500	172 500	20 000	1 170 000	819,0
Italy	290 400	39 600		330 000	231,0
Poland	216 168	85 906		302 074	211,5
Greece	241 500	1 500		243 000	170,1
Spain	213 060	12 623	3 591	229 274	160,5
France**	197 474	15 000	6 000	218 474	152,9
Austria	200 800	5 590	2 510	208 900	146,2
Denmark	133 122	0	0	133 122	93,2
Czech Republic	37 000	13 000	50 000	100 000	70,0
Portugal	90 896			90 896	63,6
Netherlands	42 470		26 000	68 470	47,9
Belgium	50 500	11 500	0	62 000	43,4
United Kingdom	47 893	11 382		59 275	41,5
Hungary	44 200	5 800	1 650	51 650	36,2
Cyprus	22 373	1 544	166	24 083	16,9
Ireland	14 057	6 250	0	20 307	14,2
Romania	20 000			20 000	14,0
Slovenia	10 596	2 897	0	13 493	9,4
Sweden	8 251	3 006	910	12 167	8,5
Slovakia	6 500	1 000	500	8 000	5,6
Bulgaria	8 000			8 000	5,6
Luxembourg	6 835			6 835	4,8
Finland	6 000			6 000	4,2
Malta	4 000			4 000	2,8
Latvia	1 800			1 800	1,3
Lithuania	1 800			1 800	1,3
Estonia	1 800			1 800	1,3
Total EU 27	**2 894 995**	**389 098**	**111 327**	**3 395 420**	**2 376,8**

* Estimation. *Estimate.* ** Département d'outre-mer inclus. *Overseas department included.* Les décimales sont séparées par une virgule. *Decimals are written with a comma.* Source: EurObserv'ER 2013.

Technologies for renewables: solar collectors (IV)

Entreprises représentatives du solaire thermique dans l'Union européenne en 2011
Representatives companies of the European Union solar thermal industry in 2011

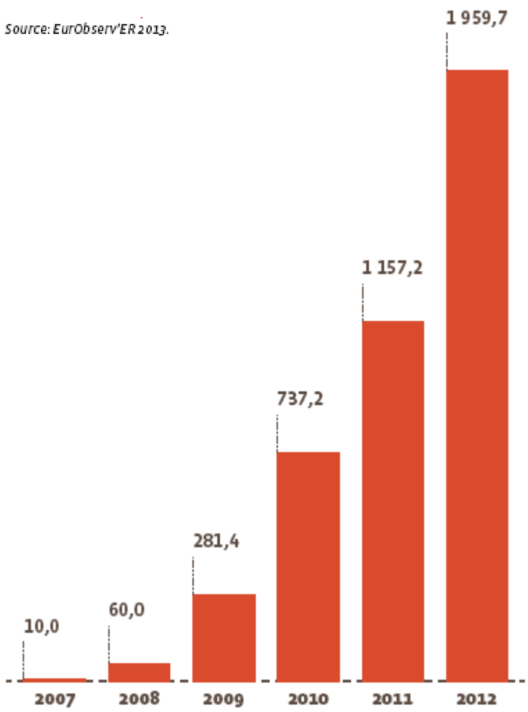
Entreprise *Company*	Pays *Country*	Activité *Activity*	Production en 2011 (m²) *Production in 2011 (m²)***
GreenOneTec	Austria	Fabricant de capteurs plans vitrés et sous vide *Flat plate and vacuum collectors*	700 000
Bosch Thermotechnik	Germany	Fournisseur d'équipements de chauffage dont systèmes solaires *Heating equipment supplier of which solar thermal*	420 000*
Viessmann	Germany	Fournisseur d'équipements de chauffage dont systèmes solaires *Heating equipment supplier of which solar thermal*	350 000
BDR Thermea Group	Netherlands	Fournisseur d'équipements de chauffage dont systèmes solaires *Heating equipment supplier of which solar thermal*	300 000*
Vaillant Group	Germany	Fournisseur d'équipements de chauffage dont systèmes solaires *Heating equipment supplier of which solar thermal*	200 000*
Wolf	Germany	Fournisseur d'équipements de chauffage dont systèmes solaires *Heating equipment supplier of which solar thermal*	150 000*
Thermosolar	Germany	Fournisseur de systèmes solaires thermiques *Solar thermal heating systems supplier*	150 000
Riposol	Austria	Fournisseur de systèmes solaires thermiques *Solar thermal heating systems supplier*	125 000
Kingspan	UK, Germany	Fournisseur de systèmes solaires thermiques *Solar thermal heating systems supplier*	100 000
Ritter Solar	Germany	Fournisseur de systèmes solaires thermiques *Solar thermal heating systems supplier*	100 000

* D'après Sun and Wind Energy 12/2012 (Étude Solrico). Based on Sun and Wind Energy 12/2012 (Solrico Study). ** Estimation. Estimate. Source: EurObserv'ER 2013

Technologies for renewables: solar Concentration

European Union concentrated solar power capacity trend (MWe)

Source: EurObserv'ER 2013.



Technologies for renewables: solar Concentration (II)

Centrales héliothermodynamiques en service à fin 2012. Concentrated solar power plants in operation at the end of 2012.

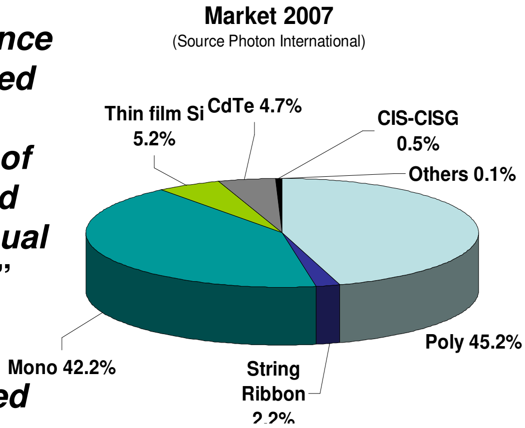
Project	Technology	Capacity (MW)	Commissioning date
Spain			
Planta Solar 10	Central receiver	10	2006
Andasol-1	Parabolic trough	50	2008
Planta Solar 20	Central receiver	20	2009
Ibersol Ciudad Real (Puertollano)	Parabolic trough	50	2009
Puerto Errado 1 (prototype)	Linear Fresnel	1,4	2009
Alvarado I La Risca	Parabolic trough	50	2009
Andasol-2	Parabolic trough	50	2009
Extresol-1	Parabolic trough	50	2009
Extresol-2	Parabolic trough	50	2010
Solnova 1	Parabolic trough	50	2010
Solnova 3	Parabolic trough	50	2010
Solnova 4	Parabolic trough	50	2010
La Florida	Parabolic trough	50	2010
Majadas	Parabolic trough	50	2010
La Dehesa	Parabolic trough	50	2010
Palma del Río II	Parabolic trough	50	2010
Manchasol 1	Parabolic trough	50	2010
Manchasol 2	Parabolic trough	50	2011
Gemasolar	Central receiver	20	2011
Palma del Río I	Parabolic trough	50	2011
Lebrija 1	Parabolic trough	50	2011
Andasol-3	Parabolic trough	50	2011
Helioenergy 1	Parabolic trough	50	2011
Astexol II	Parabolic trough	50	2011
Arcosol-50	Parabolic trough	50	2011
Termesol-50	Parabolic trough	50	2011
Aste 1A	Parabolic trough	50	2012
Aste 1B	Parabolic trough	50	2012
Helioenergy 2	Parabolic trough	50	2012
Puerto Errado II	Linear Fresnel	30	2012
Solacor 1	Parabolic trough	50	2012
Solacor 2	Parabolic trough	50	2012
Helios 1	Parabolic trough	50	2012
Moron	Parabolic trough	50	2012
Solaben 3	Parabolic trough	50	2012
Guzman	Parabolic trough	50	2012
La Africana	Parabolic trough	50	2012
Olivenza 1	Parabolic trough	50	2012
Helios 2	Parabolic trough	50	2012
Orellana	Parabolic trough	50	2012
Extresol-3	Parabolic trough	50	2012
Solaben 2	Parabolic trough	50	2012
Termosolar Borges	Parabolic trough + HB	22,5	2012
Total Spain		1 953,9	
Italy			
Archimede (prototype)	Parabolic trough	5	2010
Total Italy		5	
France			
La Seyne-sur-Mer (prototype)	Linear Fresnel	0,5	2010
Augustin Fresnel 1 (prototype)	Linear Fresnel	0,25	2011
Total France		0,75	
Total EU		1 959,7	

Parabolic trough plants. Centrales solaires cylindro-paraboliques – Central receiver plants. Centrales solaires à tour – Dish Stirling systems. Paraboles solaires Dish Sterling – Linear Fresnel systems. Collecteurs linéaires de Fresnel – HB (Hybride Biomass). Biomasse Hybride. Source: EurObserv'ER 2013.

EUROBSERV'ER – MAI 2013

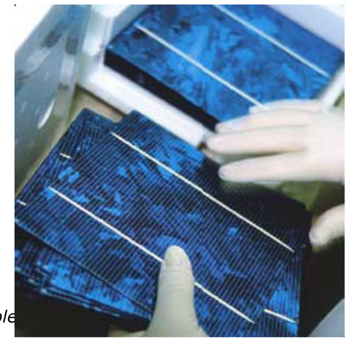
Technologies for renewables: Photovoltaics (I)

"The solar electricity market is still booming since 10 yrs. In the year 2011 the cumulative installed capacity of solar photovoltaic (PV) systems around the world passed the landmark figure of 63000 MWp. Global shipments of PV cells and modules have been growing at an average annual rate of more than 50% for the past few years" (**EPIA**)



PV Plants can be classified into *grid connected* and *stand alone or off-grid*).ones, being the former case nowadays the principal one

The PV cell is the core of the PV module. It is an electronic device that exploit the semiconduction properties of given materials like the Silicon (crystalline and amorphous).



EPIA, The European Photovoltaic Industry Association

Photovoltaics market (V)

Table 1 – Reported PV power capacity in participating IEA PVPS countries as of the end of 2011

Country	Cumulative off-grid PV capacity* (MW)		Cumulative grid-connected PV capacity (MW)		Cumulative installed PV power (MW)	Cumulative installed per capita (W/Capita)	PV power installed during 2011 (MW)	Grid-connected PV power installed during 2011 (MW)
	domestic	non-domestic	distributed	centralized				
AUS	101,8	62	1 236,8	7,4	1 407,9	62,1	837	761
AUT	4,5		182,7		187,2	22,1	91,7	91
BEL					2 000	182,6	963	963
CAN	23,3	37,7	131,6	366,1	558,7	16,0	277,6	276,7
CHE	4,4		204,1	2,6	211,1	26,5	100,2	100
CHN	81,8	36,3	774	2391,9	3 300	2,4	2 500	2 485
DEU			24 820		24 820	303,2	7 500	7 500
DNK	0,3	0,5	15,9	0	16,7	3,0	9,7	9,5
ESP					4 260	92,0	345	345
FRA	29,4		2289	513	2831,4	43,3	1 634,1	1634
GBR					976	15,7	899	899
ISR	3,5	0,3	186	0	189,7	24,1	119,6	119,4
ITA		10	4 208,7	8584,2	12 802,9	210,5	9 304,6	9 303,6
JPN	5,5	97,7	4 741,5	69,2	4 913,9	38,5	1 295,8	1 291,3
KOR	1	5	177,3	629	812,3	16,7	156,7	156,7
MEX	27,4		7,7	2	37,1	0,3	6,5	4,5
MYS	11		2,5		13,5	0,3	0,9	0,9
NLD	5,4		126		131,4	7,9	43	43
NOR					9	1,8	< 1	< 1
PRT	3,2		140,4		143,6	13,6	12,8	12,7
SWE	5,7	0,8	8,87	0,4	15,8	1,7	4,3	3,6
TUR					7	0,1	1	1
USA			2828	1 137	3966	12,6	1 867	1 867

Photovoltaics market (VI)

Table 2 – Cumulative installed PV power (MW) in IEA PVPS countries: historical perspective

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AUS	7,3	8,9	10,7	12,7	15,7	18,7	22,5	25,3	29,2	33,6	39,1	45,6	52,3	60,6	70,3	82,5	104,5	187,6	570,9	1407,9
AUT	0,6	0,8	1,1	1,4	1,7	2,2	2,9	3,7	4,9	6,1	10,3	16,8	21,1	24,0	25,6	27,7	32,4	52,6	95,5	187,2
BEL	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	2000
CAN	1,0	1,2	1,5	1,9	2,6	3,4	4,5	5,8	7,2	8,8	10,0	11,8	13,9	16,8	20,5	25,8	32,7	94,6	281,1	558,7
CHE	4,7	5,8	6,7	7,5	8,4	9,7	11,5	13,4	15,3	17,6	19,5	21,0	23,1	27,1	29,7	36,2	47,9	73,6	110,9	211,1
CHN	~	~	~	~	~	~	~	~	19	23,5	42	52	62	70	80	100	140	300	800	3300
DEU	3	5	6	8	11	18	23	32	76	186	296	435	1105	2056	2899	4170	6120	9914	17320	24820
DNK	~	0,1	0,1	0,1	0,2	0,4	0,5	1,1	1,5	1,5	1,6	1,9	2,3	2,7	2,9	3,1	3,3	4,6	7,1	16,7
ESP	~	~	1	1	1	1	1	2	2	4	7	12	24	49	148	705	3463	3523	3915	4260
FRA	1,8	2,1	2,4	2,9	4,4	6,1	7,6	9,1	11,3	13,9	17,2	21,1	26,0	33,0	43,9	75,2	179,7	380,2	1197,3	2831,4
GBR	0,2	0,3	0,3	0,4	0,4	0,6	0,7	1,1	1,9	2,7	4,1	5,9	8,2	10,9	14,3	18,1	22,5	26,0	69,8	976
ISR	~	~	~	~	~	~	~	~	~	~	~	~	0,9	1,0	1,3	1,8	3,0	24,5	69,9	189,7
ITA	8,5	12,1	14,1	15,8	16,0	16,7	17,7	18,5	19,0	20,0	22,0	26,0	30,7	37,5	50,0	120,2	458,3	1181,3	3502,3	12802,9
JPN	19,0	24,3	31,2	43,4	59,6	91,3	133,4	208,6	330,2	452,8	636,8	859,6	1132,0	1421,9	1708,5	1918,9	2144,2	2627,2	3618,1	4913,9
KOR	1,5	1,6	1,7	1,8	2,1	2,5	3,0	3,5	4,0	4,7	5,4	6,0	8,5	13,5	35,9	81,2	357,6	524,2	655,6	812,3
MEX	5,4	7,1	8,8	9,2	10,0	11,0	12,0	12,9	13,9	15,0	16,2	17,1	18,2	18,7	19,7	20,8	21,8	25,0	30,6	37,1
MYS	~	~	~	~	~	~	~	~	~	~	~	~	~	~	5,5	7,0	8,8	11,1	12,6	13,5
NLD	1,3	1,6	2,0	2,4	3,3	4,0	6,5	9,2	12,8	20,5	26,3	45,7	49,2	50,7	52,2	52,8	56,8	67,5	88	131,4
NOR	3,8	4,1	4,4	4,7	4,9	5,2	5,4	5,7	6,0	6,2	6,4	6,6	6,9	7,3	7,7	8,0	8,3	8,7	9,1	9
PRT	0,2	0,2	0,3	0,3	0,4	0,5	0,6	0,9	1,1	1,3	1,7	2,1	2,7	3,0	3,4	17,9	68,0	102,2	130,8	143,6
SWE	0,8	1,0	1,3	1,6	1,8	2,1	2,4	2,6	2,8	3,0	3,3	3,6	3,9	4,2	4,8	6,2	7,9	8,8	11,4	15,8
TUR	~	~	~	~	~	~	0,2	0,3	0,4	0,6	0,9	1,3	1,8	2,3	2,8	3,3	4,0	5,0	6,0	7
USA	43,5	50,3	57,8	66,8	76,5	88,2	100,1	117,3	138,8	167,8	212,2	275,2	376,0	479,0	624,0	830,5	1168,5	1616	2534	3966
Total	**103**	**127**	**151**	**182**	**220**	**282**	**356**	**473**	**697**	**990**	**1378**	**1866**	**2969**	**4389**	**5850**	**8312**	**14453**	**20758**	**35036**	**63611**

National Incentives addressed to Renewable Energies

(Italy)

GREEN CERTIFICATES (I)

Green Certificates (GCs) are tradable instruments that GSE grants to qualified renewable-energy power plants (IAFR qualification). The GC scheme was first introduced in Italy since 1999, by Legislative Decree 79/99 (decreto Bersani).

The certificates are titles issued by GSE which correspond to given amount "renewable" electrical energy. Since 2004 (law n. 239 23/08/2004, Legge Marzano) the size of the certificate is <u>50 MWh, while in the original issue the size was </u>100 MWh.

Since 2008, the equivalence is 1GC for 1 MWh. Economic value is for 2014 114€ per GC and it is related to average cost of electricity

The GC support scheme is based on the legislation which requires producers and importers of non-renewable electricity to inject a minimum quota of renewable electricity into the power system every year.

<u>IAFR plants are allowed to emit GC for the first 15 yrs from commissioning</u>

GREEN CERTIFICATES (II)

Producers may apply for GCs after qualifying their plants as renewable-energy power plants/systems (IAFR).

Producers whose plants/systems have a yearly average nominal capacity not exceeding 1 MW (0.2 MW for wind power plants/systems), excluding solar ones, may exercise the right of option between GCs and the all-inclusive feed-in tariff.

The qualification of plants as plants using renewable energy sources ("IAFR" – RES-E) is a pre-requisite to obtain green certificates or the all-inclusive feed-in tariff.

Eligible plants also include:

new, upgraded/repowered, totally/partially renovated and reactivated plants that have been commissioned after 1 April 1999;

co-firing plants that have been commissioned before 1 April 1999 and have operated as hybrid plants after such date.

Apart from for a few exceptions specified in the Ministerial Decree of 18 Dec. 2008, <u>photovoltaic plants are not eligible for these forms of support</u>, as they only benefit from the support referred to in the Ministerial Decree of 19 Dec. 2007

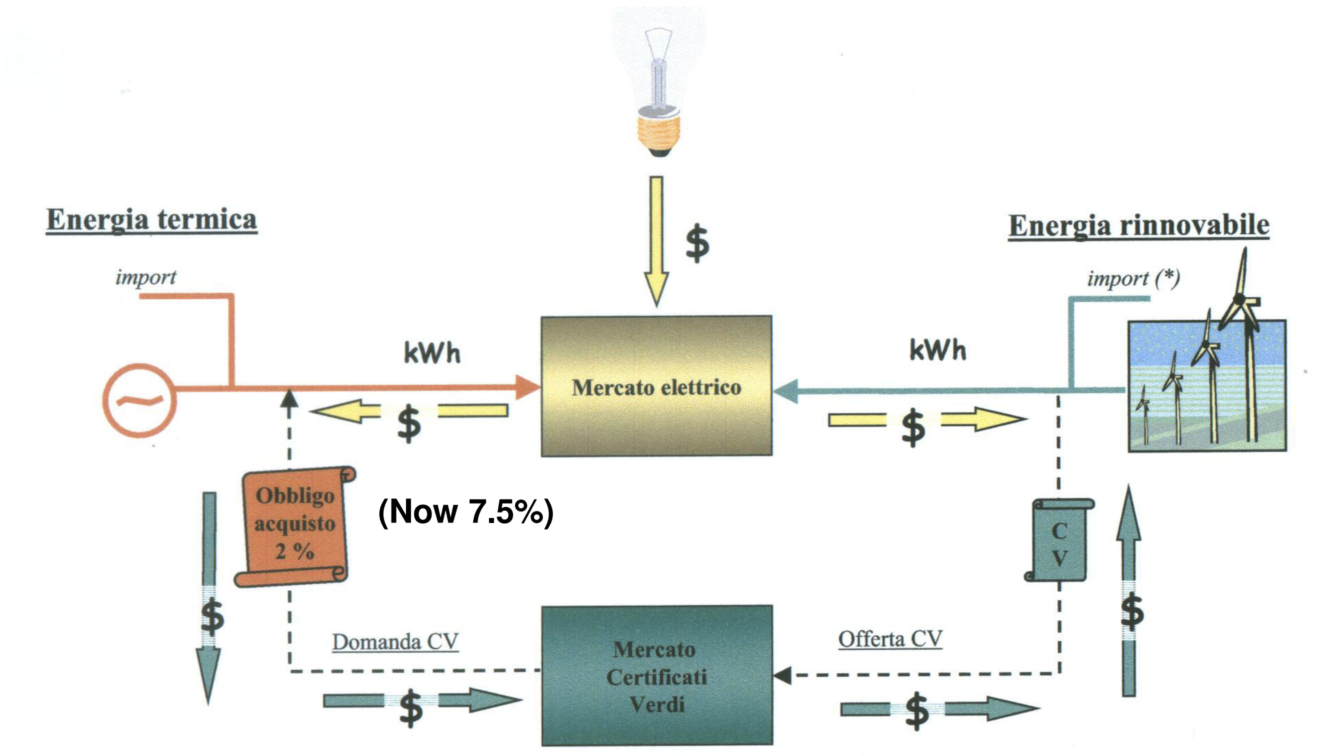
GREEN CERTIFICATES (IIb)

For plants that entered into service after December 31, 2007-of annual average nominal power exceeding 1 MW and 0.2 MW for wind power plants - the GSE releases CVs for 15 years, recognized by multiplying the net energy recognized at the intervention carried out for the constants, differentiated by source, Table 2 of the 2008 Budget Law, subsequently updated by Law 99 of 23/07/2009 as shown below:

(Source: GME Italy)

Source	Multiplicative Factor
1 Wind (plants with a capacity of more than 200 kW)	1.00
1 bis Off-shore wind	1.50
3 Geothermal	0.90
4 Waves and tides	1.80
5 Hydro (other than the one indicated in the previous point)	1.00
6 Biodegradable waste and biomass (other than the one indicated in the following point)*	1.30
7 Biomass and biogases obtained from agriculture, animal husbandry and forestry on a short supply-line basis	1.80
8 Landfill gas, sewage treatment plant gas and biogases (other than the ones indicated in the previous point)	0.80

Green certificate market

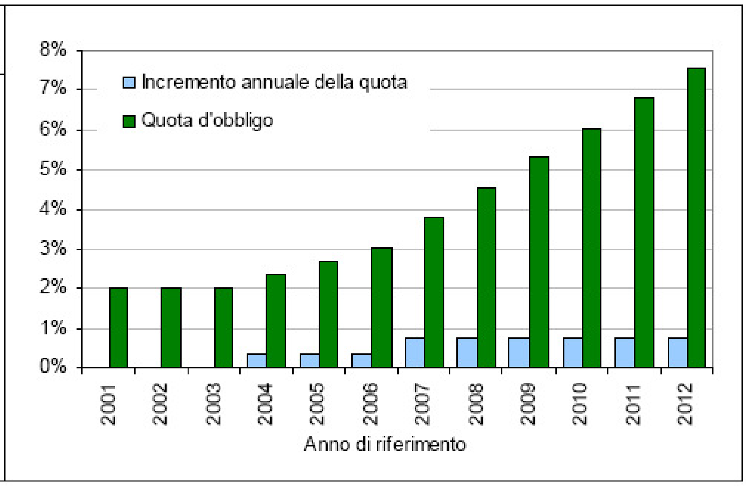


(*) Gli impianti devono essere ubicati in paesi UE che adottano analoghi strumenti di promozione ed incentivazione delle fonti rinnovabili. Per impianti in paesi non UE è necessaria una convenzione tra i gestori della rete (articolo 4

The GC support scheme is based on the legislation which requires producers and importers of non-renewable electricity to inject a minimum quota (“quota d’obbligo” here below) of renewable electricity into the power system every year.

Tabella 1.1 – Incremento annuale della “quota d’obbligo” introdotta dal D.Lgs 79/99

Anno di riferimento	Quota d’obbligo	Anno di assolvimento
2001	2%	2002
2002	2%	2003
2003	2%	2004
2004	2,35%	2005
2005	2,70%	2006
2006	3,05%	2007
2007	3,80%	2008
2008	4,55%	2009
2009	5,30%	2010
2010	6,05%	2011
2011	6,80%	2012
2012	7,55%	2013



ALL INCLUSIVE FEED-IN TARIFF (I)

The all-inclusive feed-in tariff (tariffa onnicomprensiva) is a national scheme applicable to RES-E plants (excluding solar ones) which have a nominal real power of less than 1 MW (200 kW for on-shore wind plants).

The tariff is granted over a period of 15 years, during which its rate remains fixed and based on the amount of electricity fed into the grid, for all plants commissioned by 31 December 2012.

To benefit from this form of support, producers must first ask GSE to qualify their plants as RES-E (“IAFR – Impianto Alimentato a Fonti Rinnovabili”).
It represents an alternative to the green certificates scheme and is differentiated by type of source.

ALL INCLUSIVE FEED-IN TARIFF (II)

Source	All-inclusive feed-in rate ((€cent/kWh)
Wind (P < 200 kW)	30
Geothermal	20
Waves and tides	34
Hydro (other than the one indicated in the previous point)	22
Biomass, biogases and bioliquids complying with Regulation (EC) No 73/2009	28
Landfill gas, sewage treatment plant gas, biogases and bioliquids complying with Regulation (EC) No 73/2009	18

Feed-in tariff scheme for PV (I)

The feed-in scheme is the programme which grants incentives for electricity generated by photovoltaic (PV) plants connected to the grid.

Italy introduced this support scheme in 2005 (Ministerial Decree of 28 July 2005 – 1st feed-in scheme). The scheme is now regulated by the Ministerial Decree of 5 May 2011 (4th feed-in scheme). The 4th feed-in scheme applies to plants commissioned between 1 June 2011 and 31 December 2016.
Under the scheme, PV plants with a minimum capacity of 1 kW and connected to the grid may benefit from a feed-in tariff, which is based on the electricity produced. The tariff differs depending on the capacity and type of plant and is granted over a period of 20 years.

For plants commissioned within 31 December 2012, the scheme (called feed-in premium) provides for a tariff for the electricity produced. The electricity fed into the grid may be purchased by GSE (*ritiro dedicato*) or economically offset with the value of electricity withdrawn from the grid (net metering - *scambio sul posto*)

Starting from the first half of 2013 and on, the tariff will be made up of both the incentives and the value of electricity. A specific tariff will be applied to the self-consumed electricity.

Feed-in tariff scheme for PV (II)

The 4th feed-in scheme (Ministerial Decree of 5 May 2011, published in the Gazzetta Ufficiale of 12 May 2011) applies to plants with a capacity of at least 1 kW, commissioned between 1 June 2011 and 31 December 2016.

Until the end of 2012, a specific tariff (feed-in premium tariff) will be paid for the electricity generated by photovoltaic plants. The tariff will cover a period of 20 years, starting from the plant commissioning date.
This tariff consists of two components: the premium and the price paid for the electricity produced.

Starting from the first half of 2013 and on, the tariff will be made up of both the incentives and the value of the electricity fed into the grid. A specific tariff will be applied to the self-consumed electricity.

The 4th feed-in scheme sets an about 23,000-MW target of PV capacity to be installed at national level.

Under the scheme, feed-in tariffs are planned to be progressively reduced over time, in order to balance the level of public support with the costs of technologies, giving stability and certainty to the market.

Feed-in tariff scheme for PV (III)

The Ministerial Decree of 5 Jul. 2012 (published in "Gazzetta Ufficiale" no. 159 of 10 Jul. 2012) - the so-called 5th feed-in scheme - redefines the rules on support for solar photovoltaic power generation.

The new rules entered into force on 27 Aug. 2012, i.e. 45 calendar days after the publication of the relevant Decision adopted by "Autorità per l'energia elettrica e il gas" (AEEG, the Italian electricity and gas regulator). Under AEEG's Decision (292/2012/r/efr of 12 Jul. 2012), which is based on GSE's data, the indicative yearly cumulative cost of incentives has reached € 6 billion.

The 5th feed-in scheme will cease to have effect 30 calendar days after reaching an indicative cumulative cost of incentives of € 6.7 billion per year

The 4th feed-in scheme is still valid until end 2016 for small residential plants and Public Buildings

(SOURCE: GME Italy)

Feed-in tariff scheme for Concentrated Solar

Feed-in Tariff system in place since 31 December 2012

The FiT for large plants (>2 500 m2) is € 0.32/kWh where the solar fraction is over 85%, € 0.30/kWh from 50 to 85%, and € 0.27€/kWh where is it less than 50%. The Feed-in Tariff will be paid for 25 years and drop by 5% from 2016 onwards and by a further 5% from 2017 onwards. The Feed-in Tariffs for small plants (<2 500 m2) adopt the same solar fraction rules and are € 0.36/kWh, € 0.32/kWh and € 0.30/kWh respectively and apply the same sliding scale rules. Plants with more than 10 000 m2 of receivers will be required to have an energy storage system.

(SOURCE: Eurobserv'er 2014)

Concentrated solar power plants under developement at the beginning of the year 2014

Project	Location	Capacity (MW)	Technology	Commercial date of operation
Italy				
Archetype SW550	Passo Martino, Catania, Sicily	30	Parabolic trough	n.a.
Campu Giavesu	Cossoine, Sassari, Sardinia	30	Parabolic trough	n.a.
Flumini Mannu	Villasor-Decimoputzu, Cagliari, Sardinia	50	Parabolic trough	2016
Gonnosfanadiga – Guspini	Gonnosfanadiga, Medio Campidano, Sardinia	50	Parabolic trough	2017
Bonorva	Giave and Bonorva, Sassari, Sardinia	50	Parabolic trough	n.a.
Repower Reflex	Gela, Sicily	12	Parabolic trough	n.a.
Banzi	Banzi, Basilicate	50	Parabolic trough	n.a.
Lentini	Lentini, Siracusa, Sicily	50	Parabolic trough	n.a.
Calliope	Trapani, Sicily	4	Linear Fresnel	2015
Zeronovantuno 2	Trapani, Sicily	4	Linear Fresnel	2015
Jacomelli	Trapani, Sicily	4	Linear Fresnel	2015
Porthos	Trapani, Sicily	4	Linear Fresnel	2015
Sromboli Solar	Trapani, Sicily	4	Linear Fresnel	2015
Mazara Solar	Trapani, Sicily	50	Central receiver	2017
Total Italy		392		

Thanks for your attention