



UNIVERSITÀ
DEGLI STUDI
DI TRIESTE



Dipartimento di
Ingegneria
e Architettura



INTRODUZIONE - FONTI DI ENERGIA

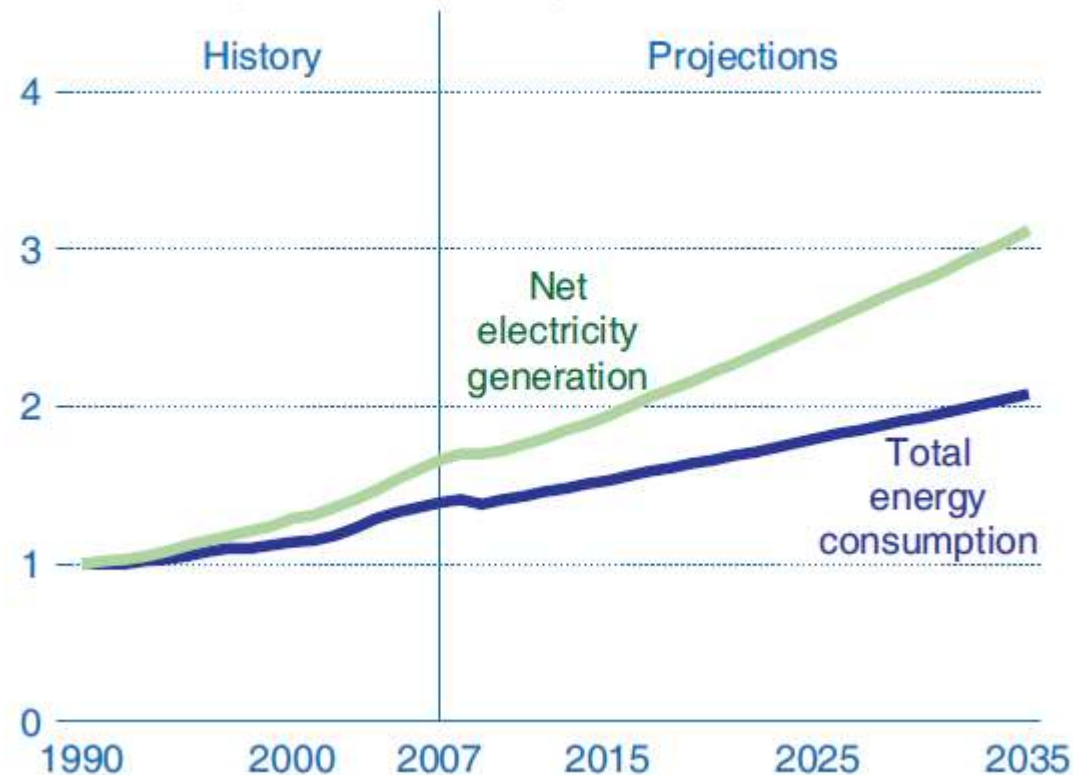
Corso di MACCHINE [065IN]
Corso di MACCHINE MARINE [100IN]

Prof. Rodolfo Taccani

A.A. 2022-2023

Domanda di energia mondiale

Figure 67. Growth in world electric power generation and total energy consumption, 1990-2035 (index, 1990 = 1)



Energy Information Administration.
International Energy Outlook 2010

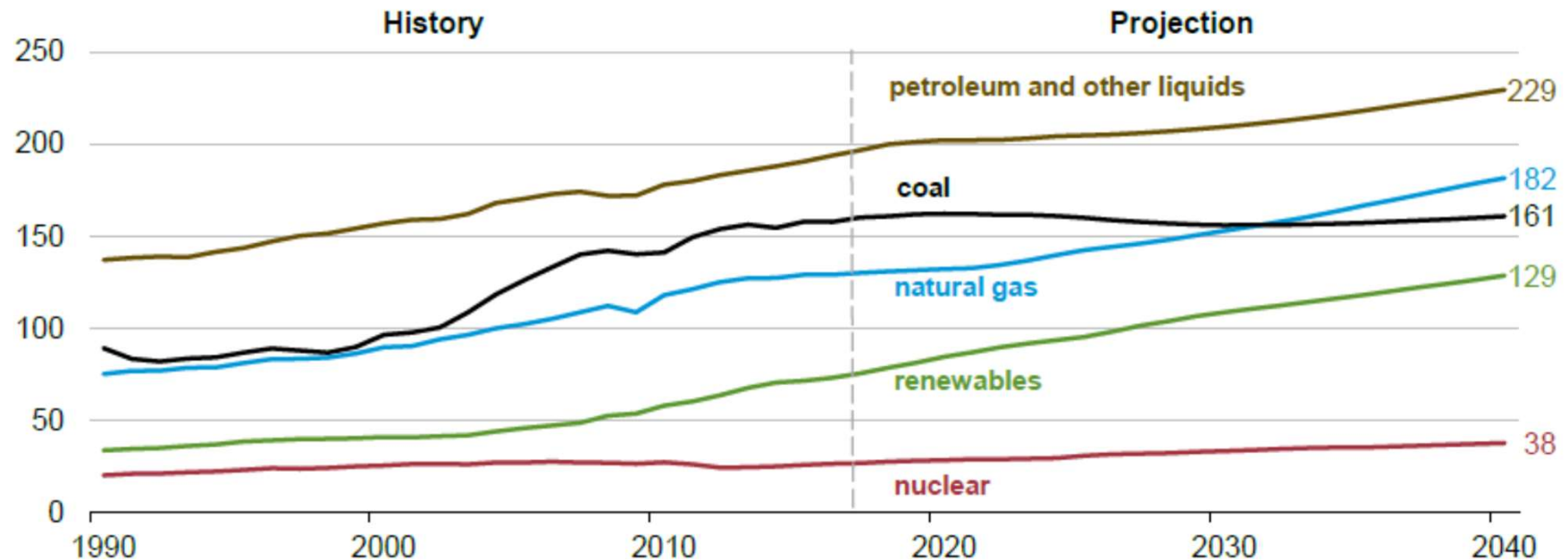
Domanda di energia mondiale

World energy consumption increases for fuels other than coal

IEO2018 Reference case

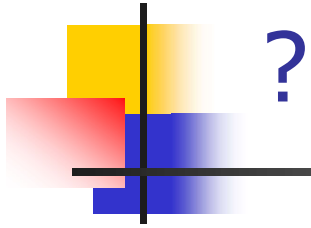
world energy consumption by energy source

quadrillion Btu



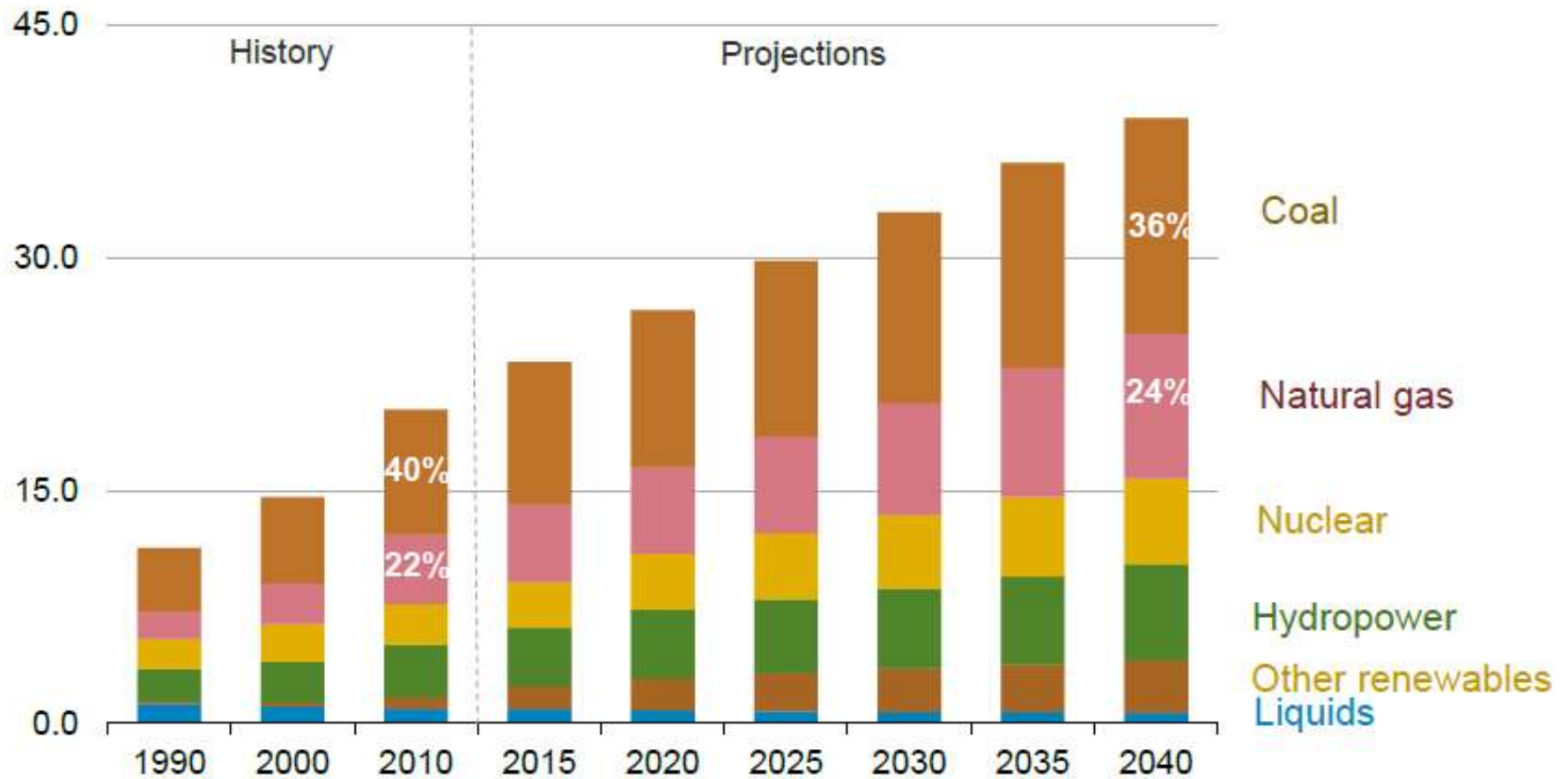
Source: EIA, International Energy Outlook 2018

<https://www.eia.gov/beta/international/>



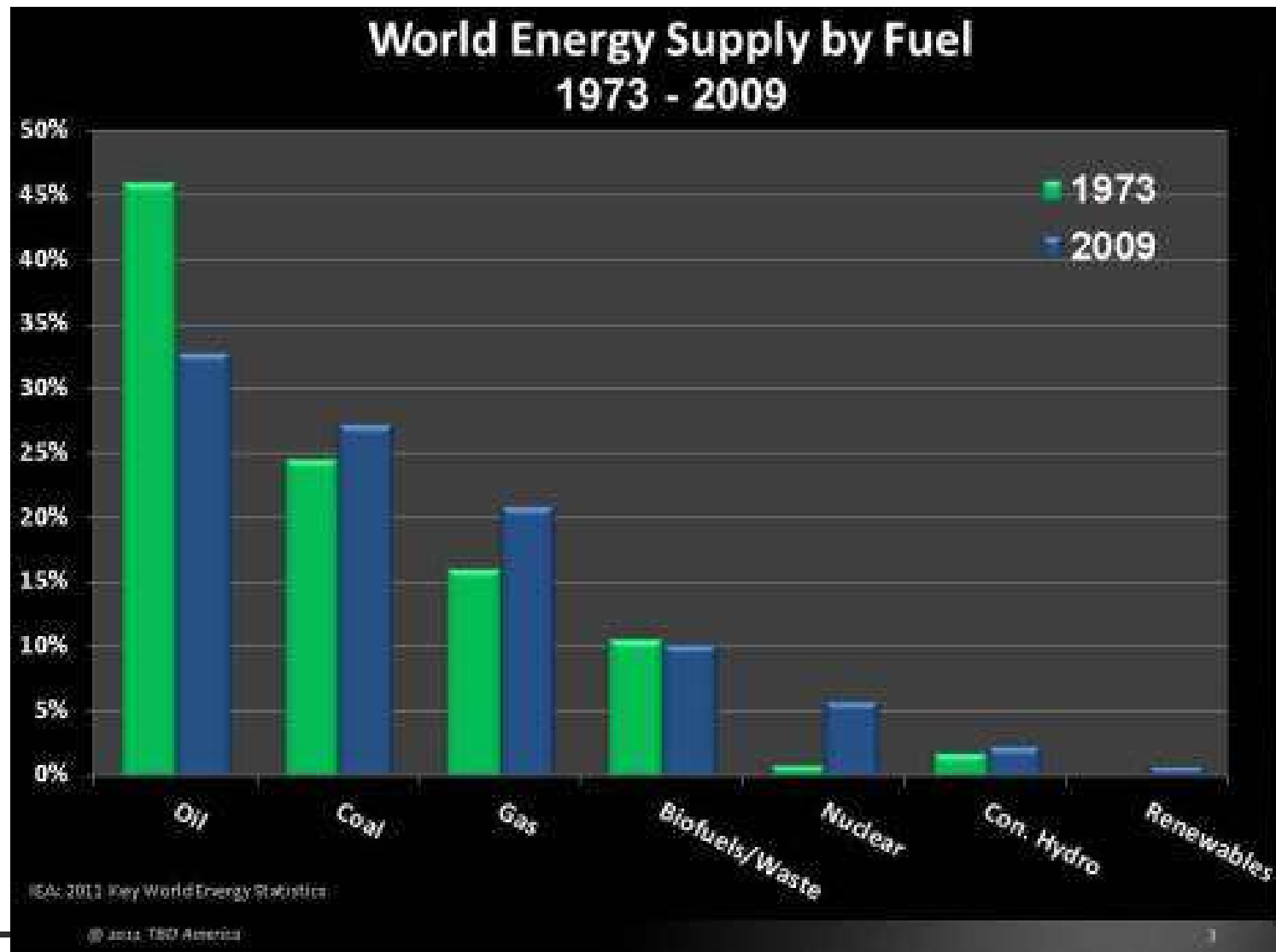
Where does electricity come from?

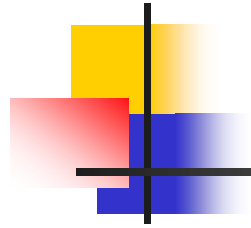
world electricity generation by fuel
billion kilowatthours



Source: EIA, International Energy Outlook 2013

Where does ENERGY come from (1973)

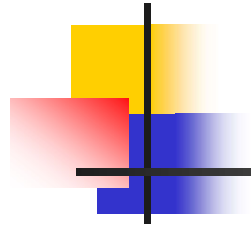




Iniziamo con un messaggio di ottimismo

*il mondo ha più risorse energetiche oggi
di quante ne abbia mai avute nel passato*

World Energy Resources
2013 Survey: Summary



Iniziamo con un messaggio di ottimismo

*il mondo ha più risorse energetiche oggi
di quante ne abbia mai avute nel passato*

World Energy Resources 2013 Survey: Summary

Dobbiamo essere grati ai combustibili fossili: sono stati, sono e continueranno per molti decenni a essere il principale motore propulsivo dello sviluppo. I progressi tecnologici nel loro utilizzo sono stati formidabili, sia in termini energetici, sia, ancora di più, in termini ambientali.

Europe's electricity providers face an existential threat

Oct 12th 2013 | [From the print edition](#)

The
Economist

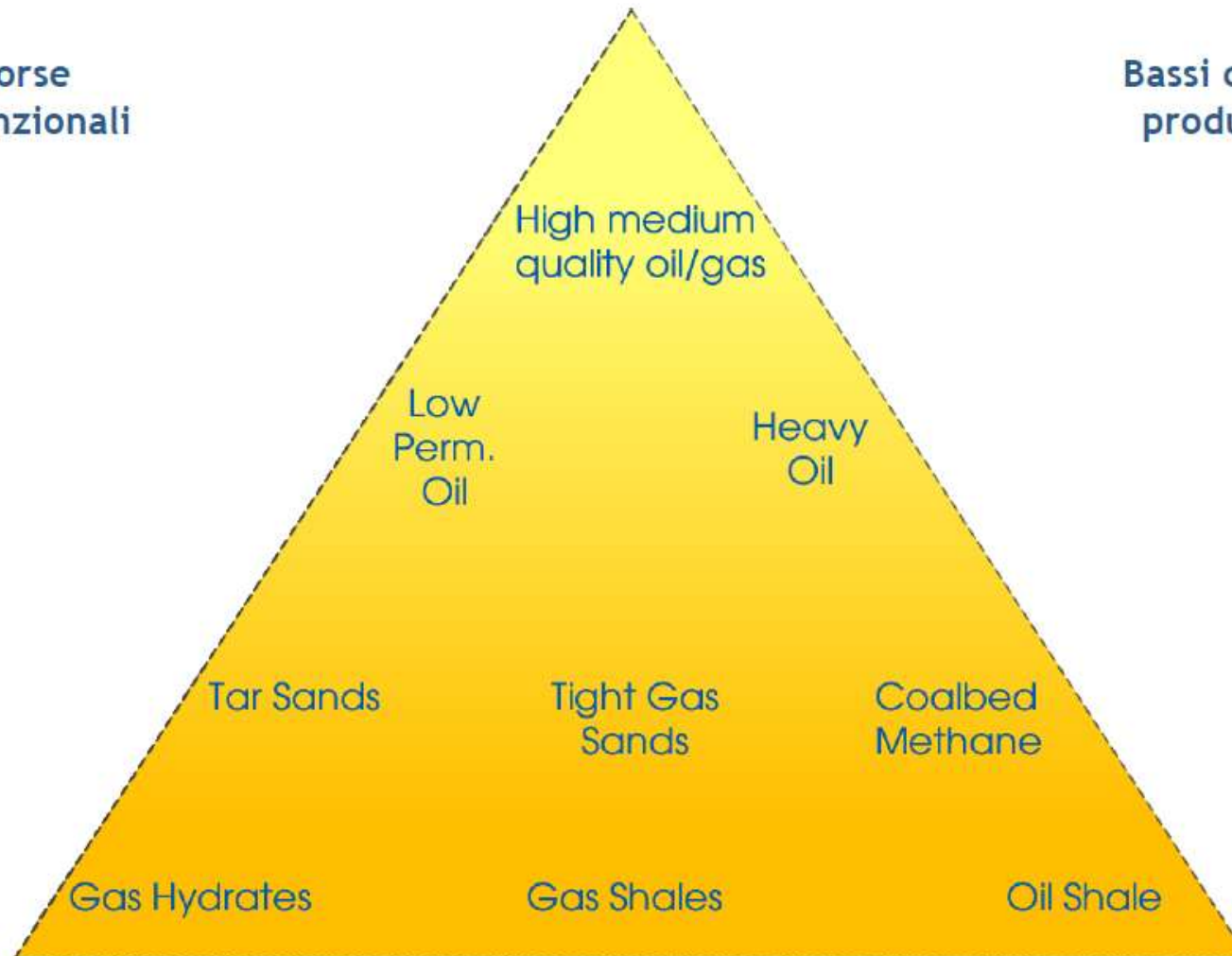


ON JUNE 16th something very peculiar happened in Germany's electricity market. The wholesale price of electricity fell to minus €100 per megawatt hour (MWh). That is, generating companies were having to pay the managers of the grid to take their electricity. It was a bright, breezy Sunday. Demand was low. Between 2pm and 3pm, solar and wind generators produced 28.9 gigawatts (GW) of power, more than half the total. The grid at that time could not cope with more than 45GW without becoming unstable. At the peak, total generation was over 51GW; so prices went negative to encourage cutbacks and protect the grid from overloading.....

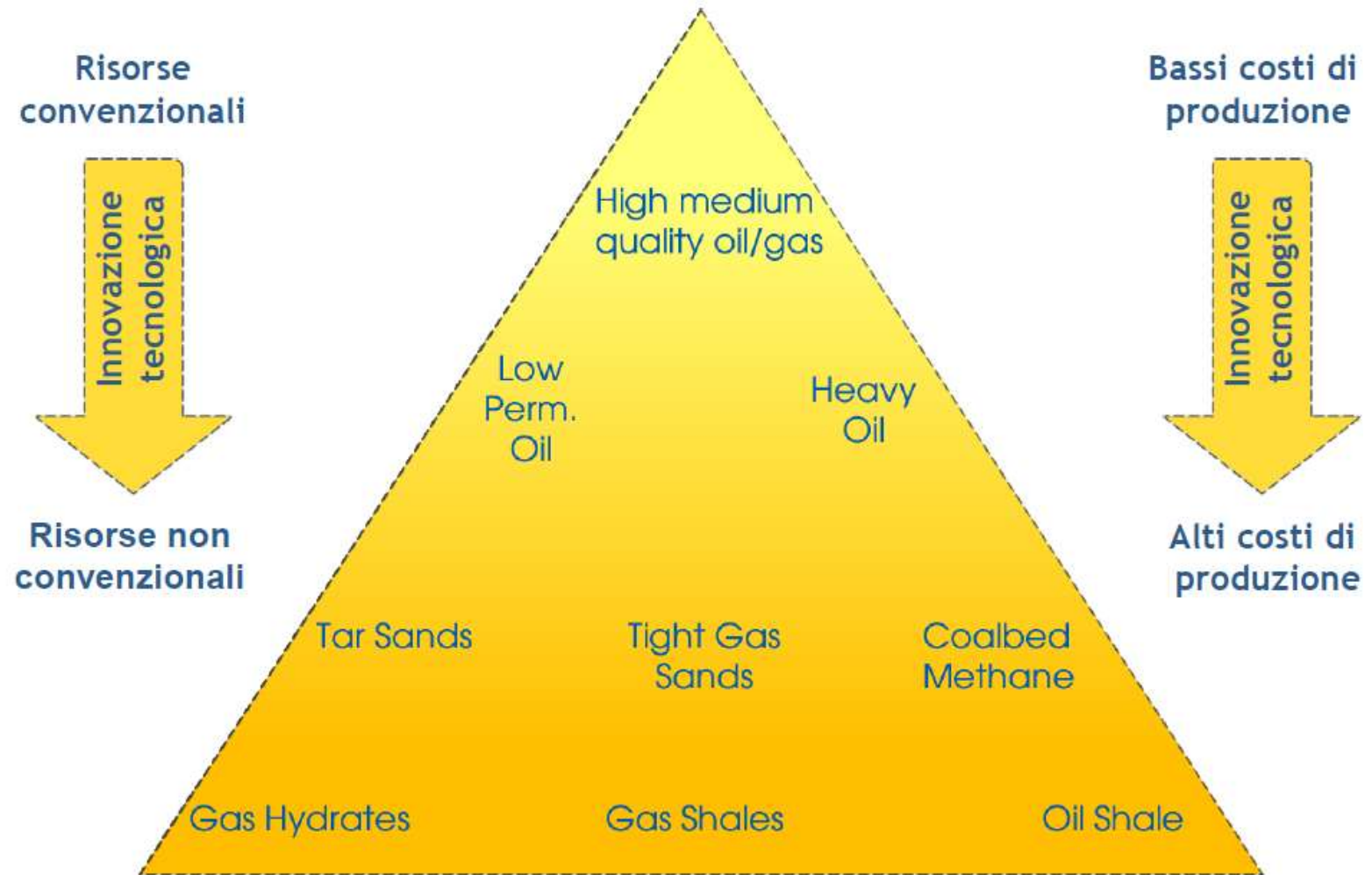
Andando verso la base del triangolo le risorse aumentano

Risorse
convenzionali

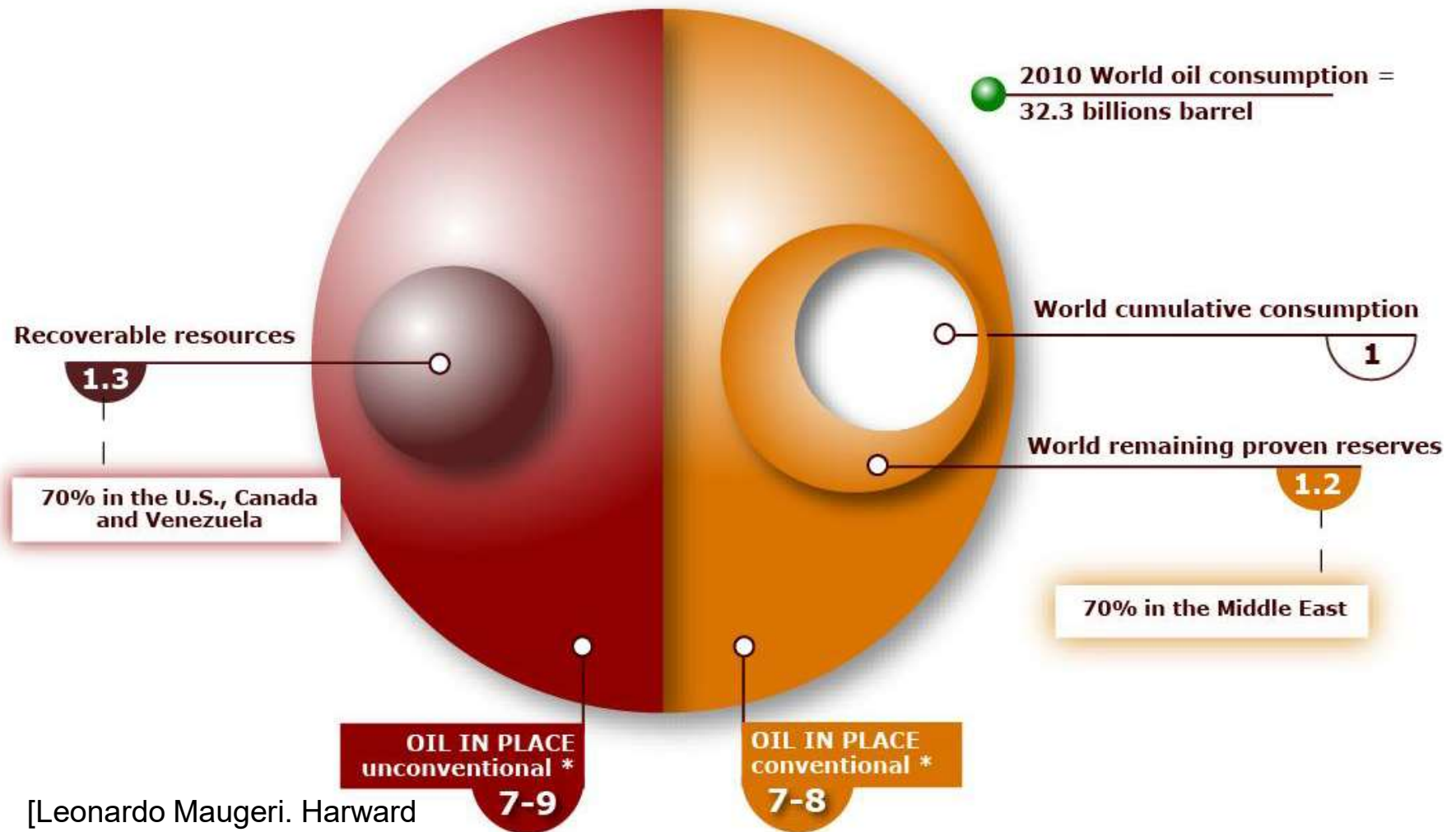
Bassi costi di
produzione



Andando verso la base del triangolo le risorse aumentano



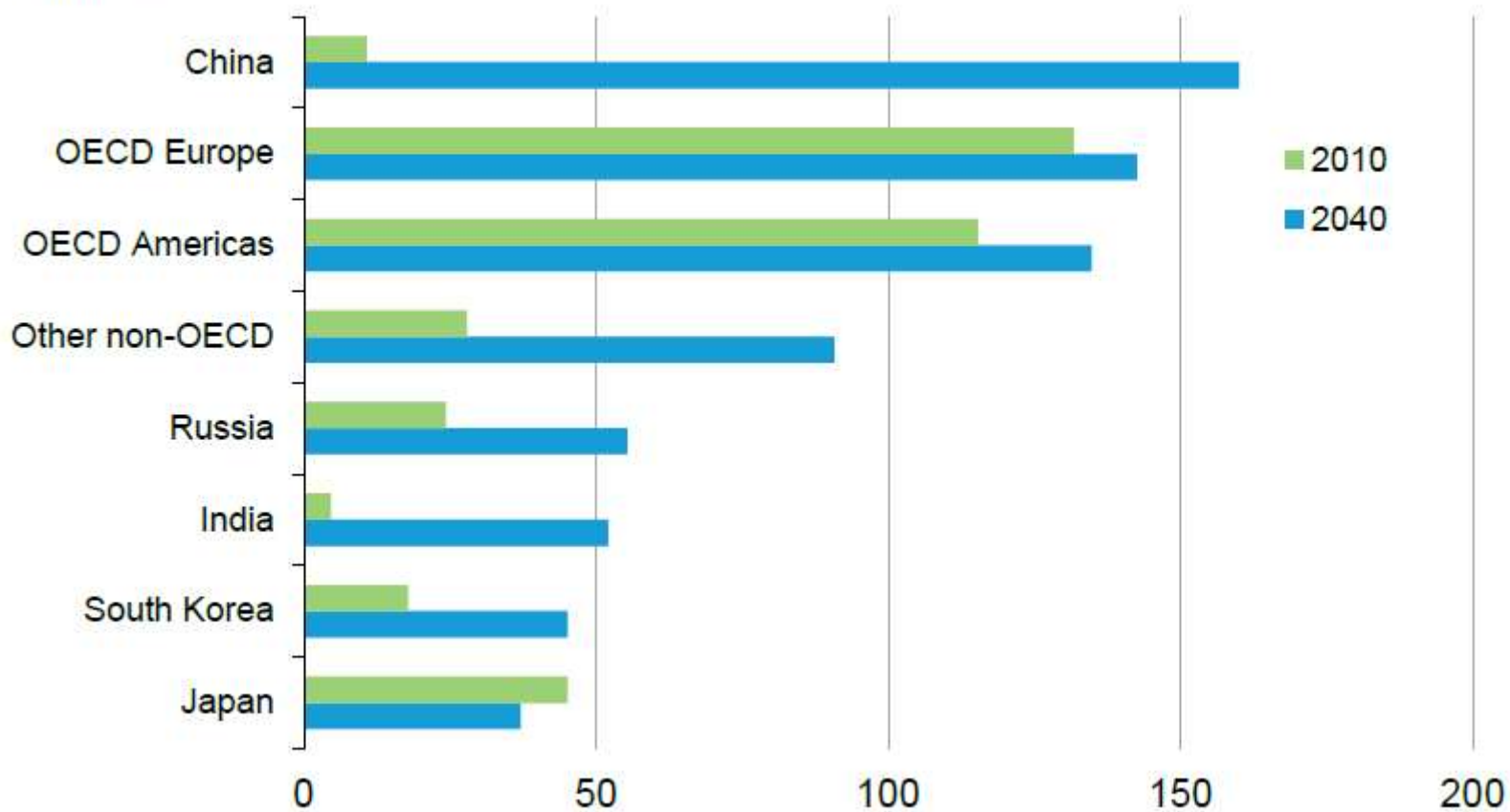
Le risorse di idrocarburi sono enormi: si inizia a non parlare più di picco del petrolio



[Leonardo Maugeri. Harvard Kennedy School]

China accounts for more than 40 percent of the global net increase in nuclear capacity

world nuclear electricity generating capacity, 2010 and 2040
gigawatts

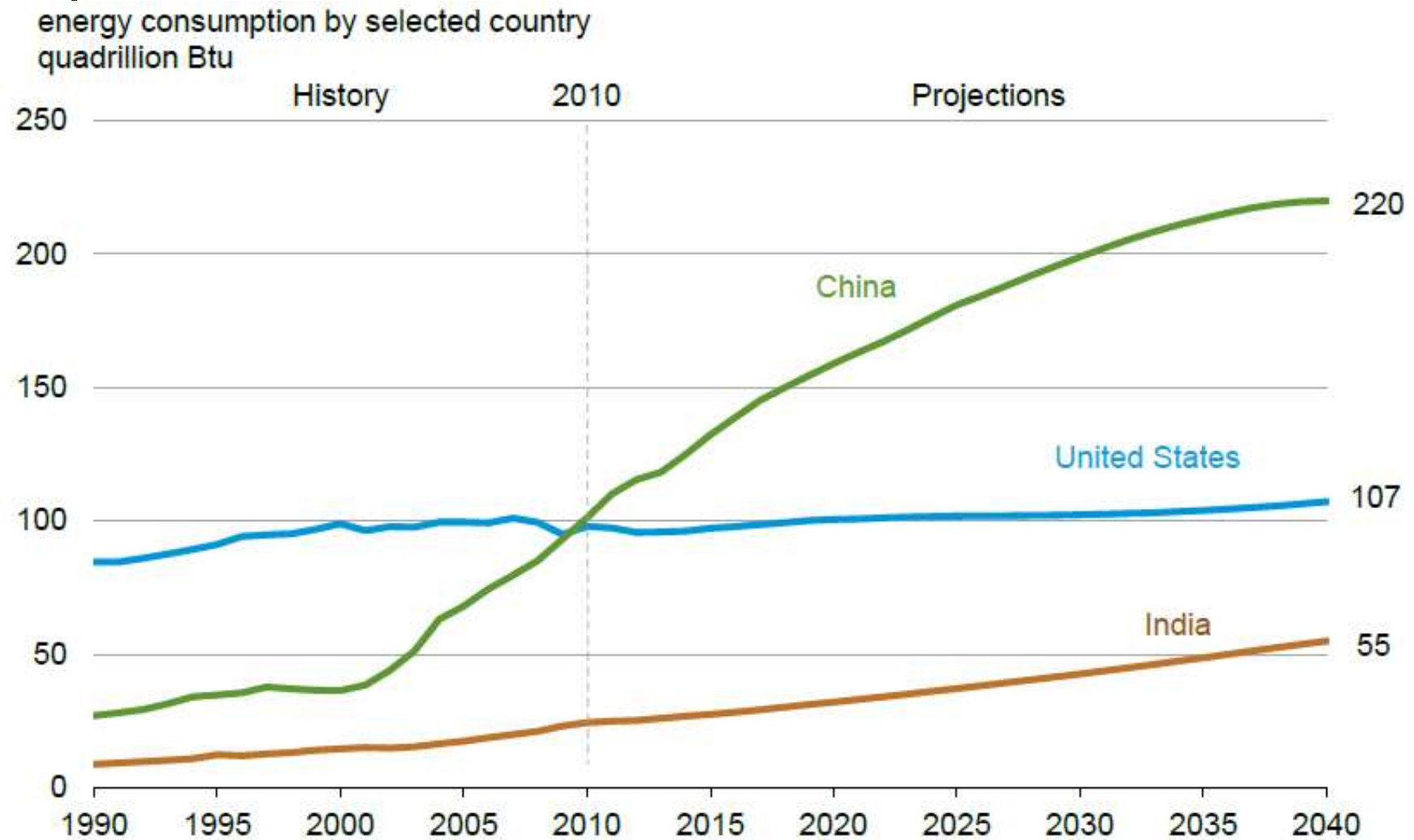


Source: EIA, International Energy Outlook 2013

L'Organizzazione per la cooperazione e lo sviluppo economico (OCSE) (in inglese Organisation for Economic Co-operation and Development (OECD); in francese Organisation de coopération et de développement économiques (OCDE)) è un'organizzazione internazionale di studi economici per i paesi membri, paesi sviluppati aventi in comune un sistema di governo di tipo democratico ed un'economia di mercato. L'organizzazione svolge prevalentemente un ruolo di assemblea consultiva che consente un'occasione di confronto delle esperienze politiche, per la risoluzione dei problemi comuni, l'identificazione di pratiche commerciali ed il coordinamento delle politiche locali ed internazionali dei paesi membri¹.



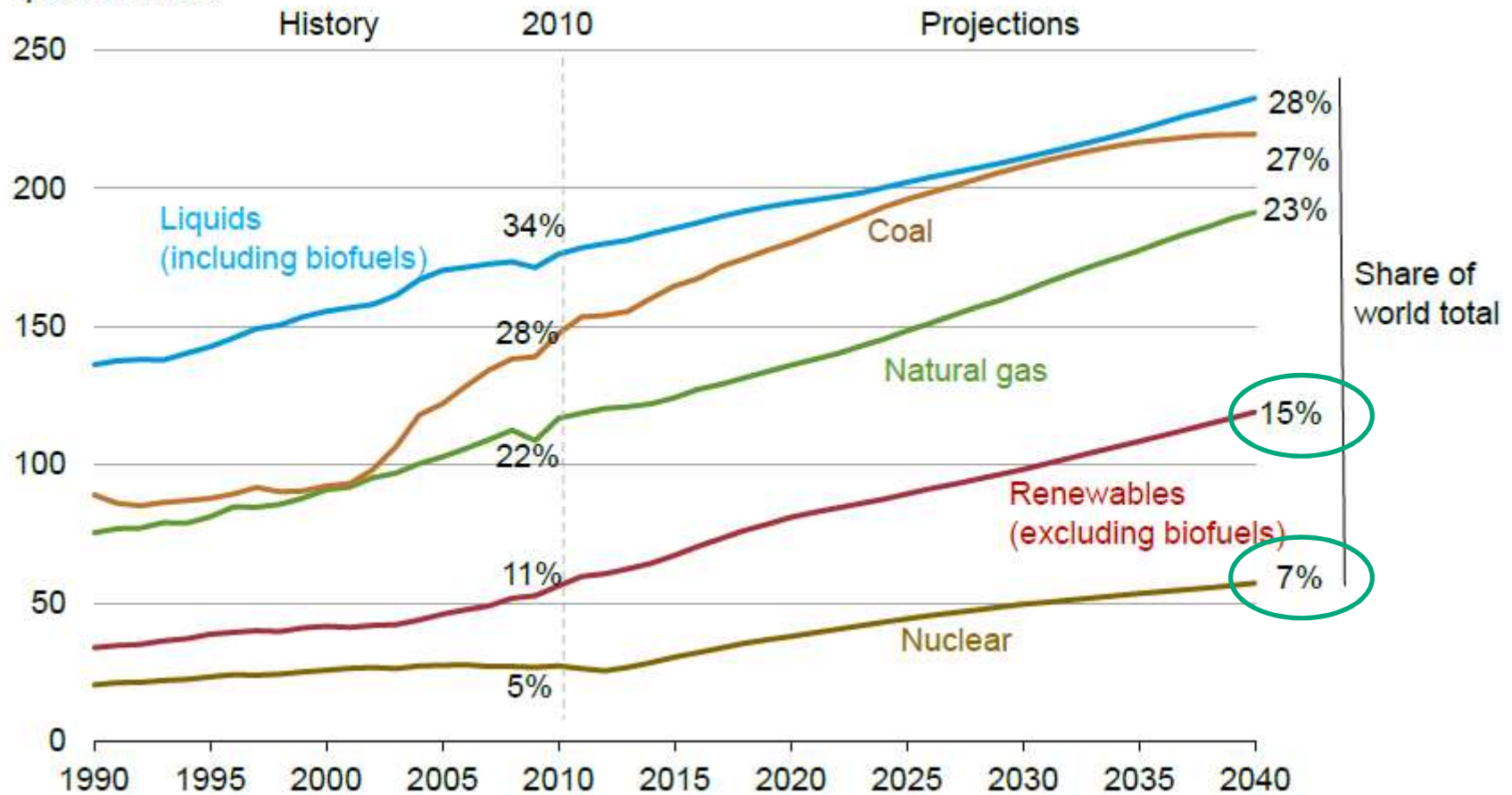
By 2040, China's energy use will be double the U.S. level; India's a little more than half despite its faster GDP growth



Source: EIA, International Energy Outlook 2013

Energy mix over time

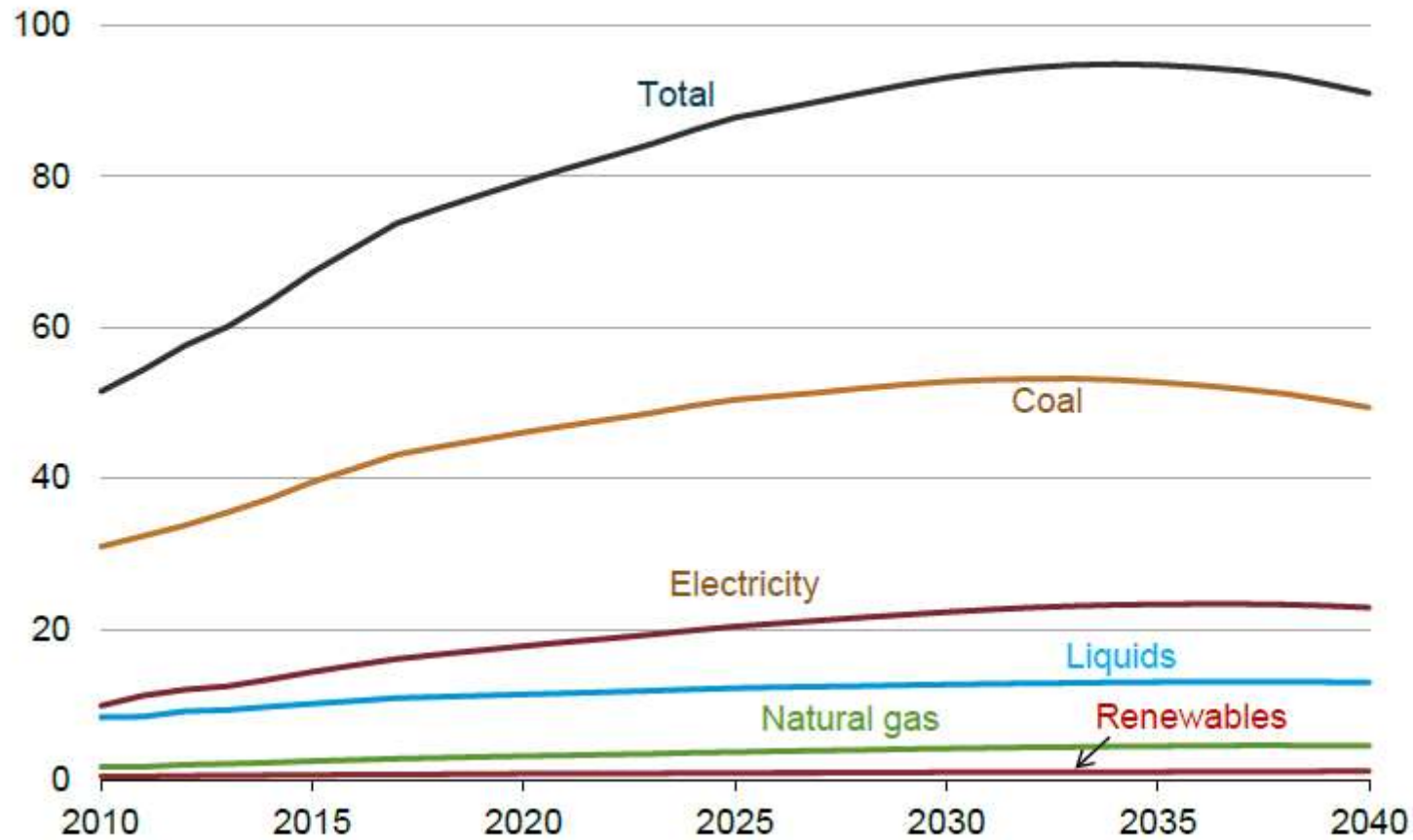
world energy consumption by fuel
quadrillion Btu



Source: EIA, International Energy Outlook 2013

Industrial sector energy consumption in China

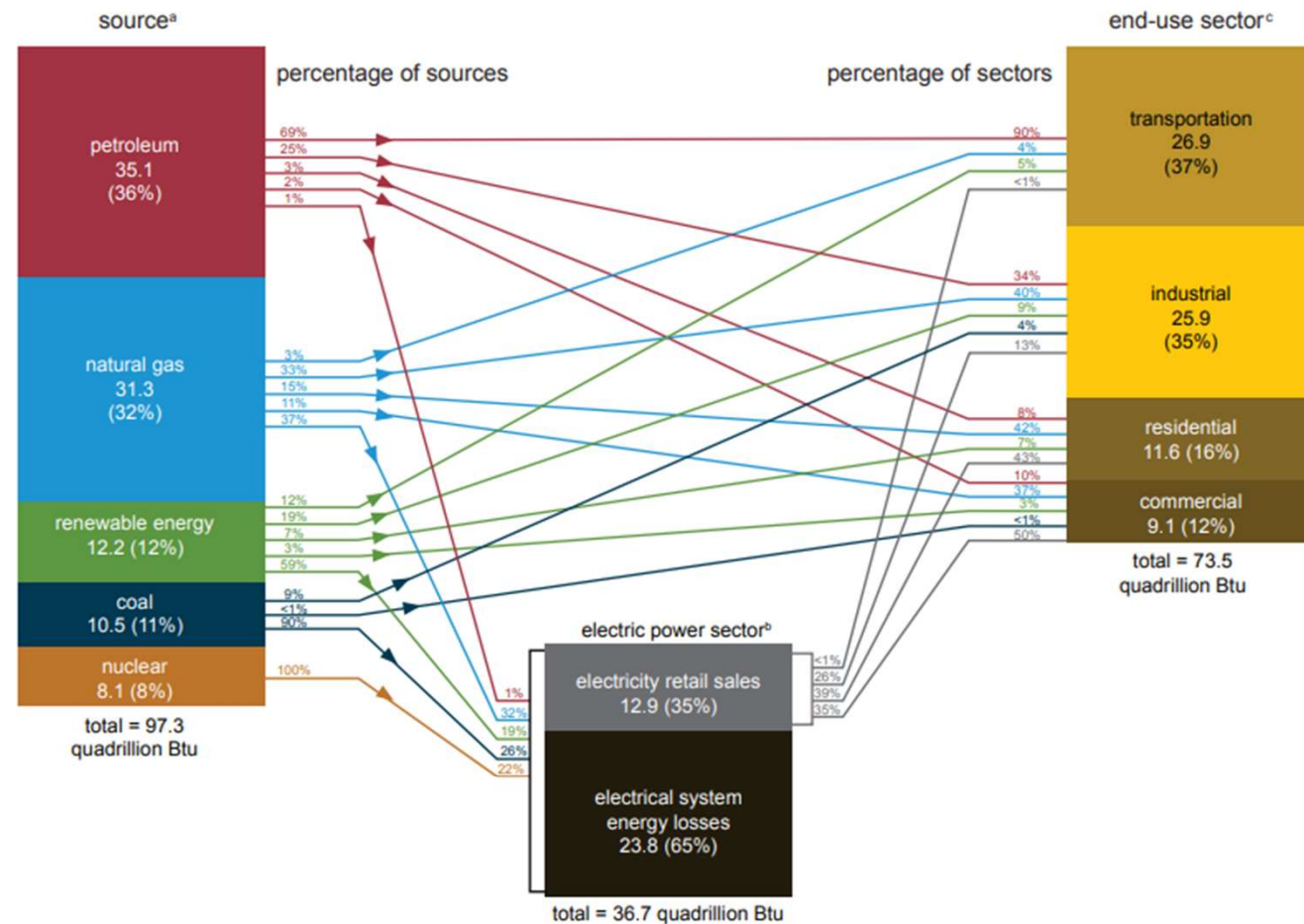
China industrial sector energy consumption by fuel
quadrillion Btu



Source: EIA, International Energy Outlook 2013

U.S. energy consumption by source and sector, 2021

quadrillion British thermal units (Btu)



Sources: U.S. Energy Information Administration (EIA), [Monthly Energy Review](#) (April 2022), Tables 1.3 and 2.1-2.6.

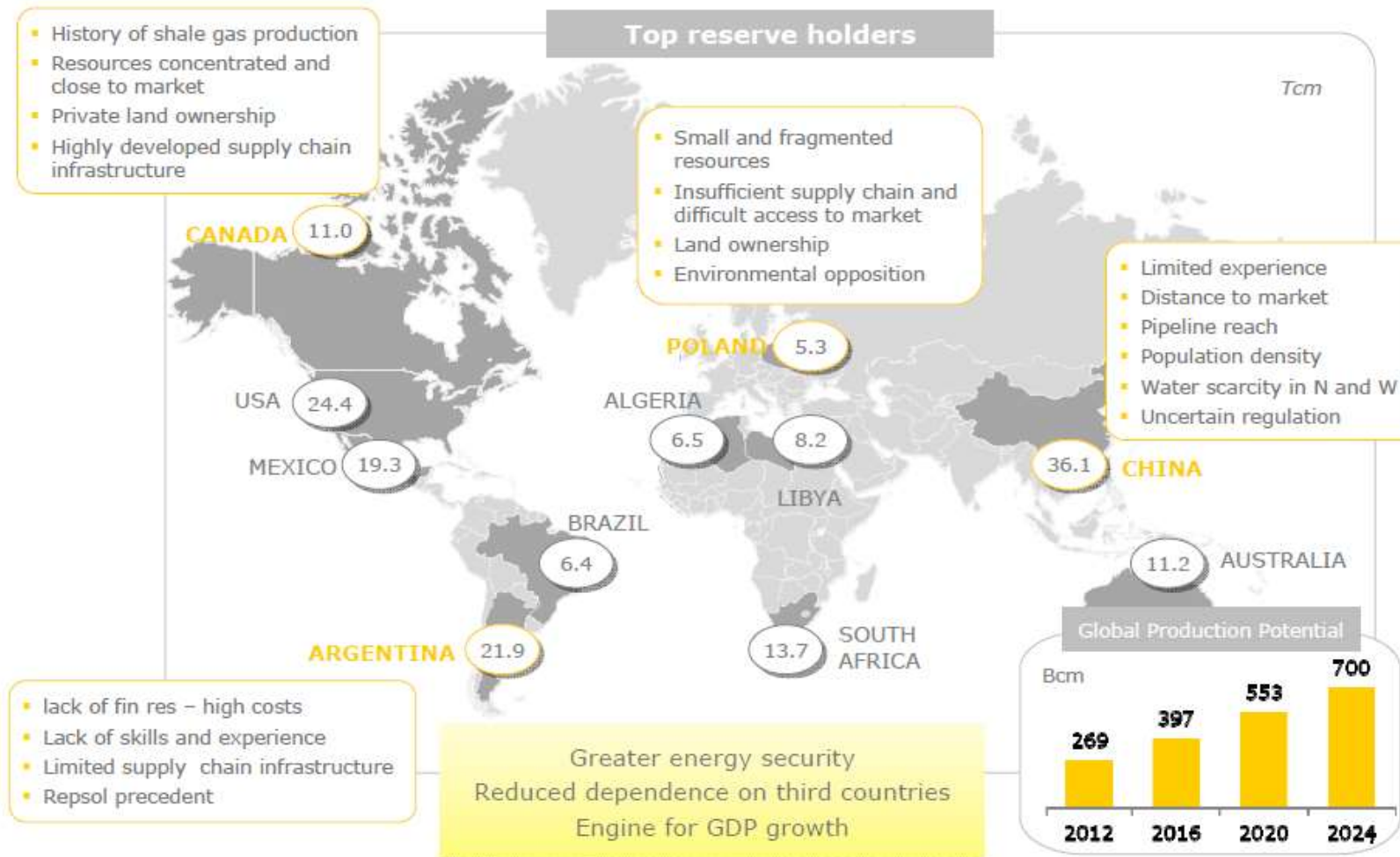
Note: Sum of components may not equal total due to independent rounding. All source and end-use sector consumption data include other energy losses from energy use, transformation, and distribution not separately identified. See "Extended Chart Notes" on next page.

^a Primary energy consumption. Each energy source is measured in different physical units and converted to common British thermal units (Btu). See EIA's [Monthly Energy Review](#) (MER), [Appendix A](#). Noncombustible renewable energy sources are converted to Btu using the "Fossil Fuel Equivalency Approach", see [MER Appendix E](#).

^b The electric power sector includes electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Energy consumed by these plants reflects the approximate heat rates for electricity in [MER Appendix A](#). The total includes the heat content of are electricity net imports, not shown separately. Electrical system energy losses calculated as the primary energy consumed by the electric power sector minus the heat content of electricity retail sales. See Note 1, "Electrical System Energy Losses," at the end of [MER Section 2](#).

^c End-use sector consumption of primary energy and electricity retail sales, excluding electrical system energy losses from electricity retail sales. Industrial and commercial sectors consumption includes primary energy consumption by CHP and electricity-only plants contained within the sector.

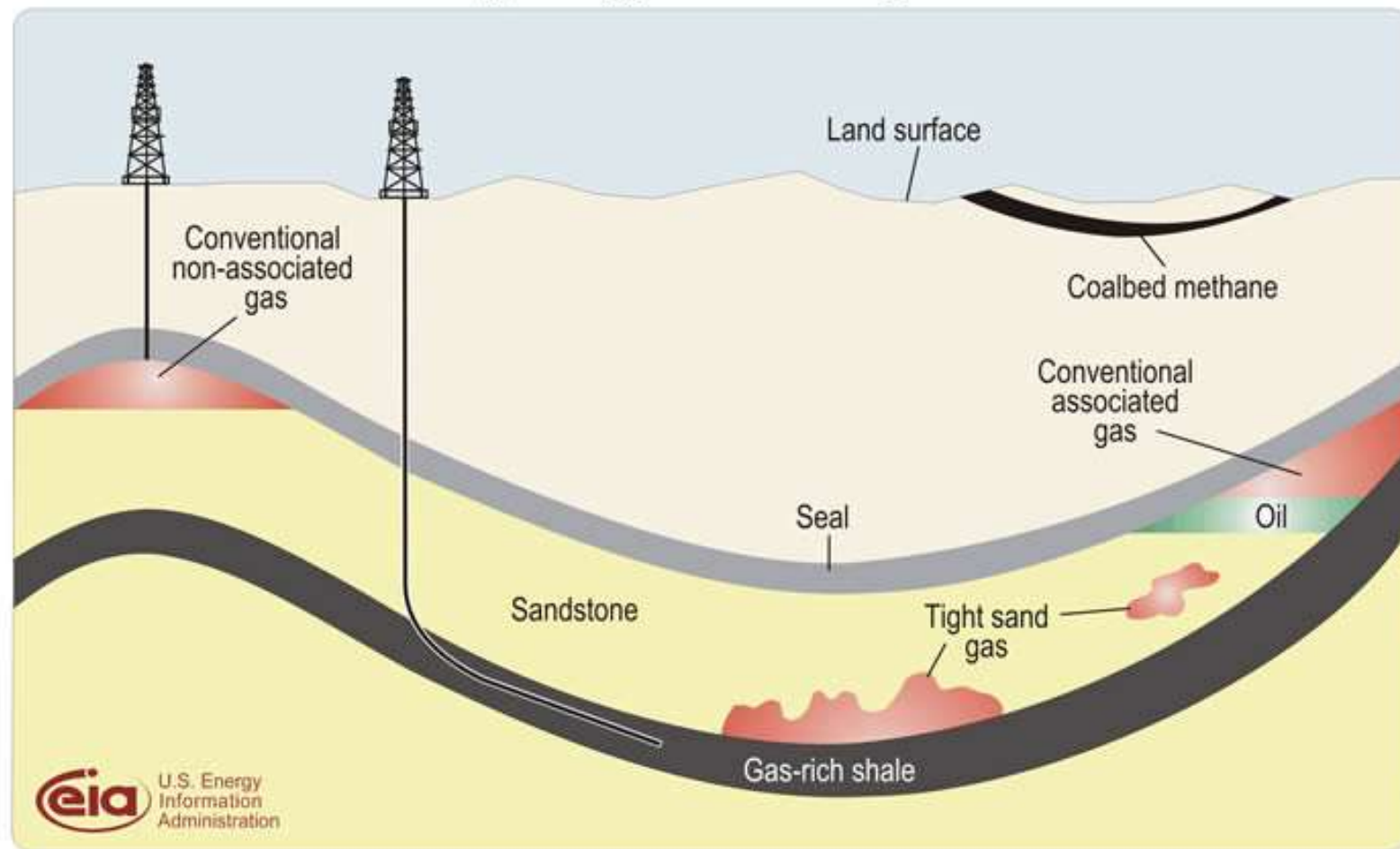
Scenario planning and Shale gas revolution

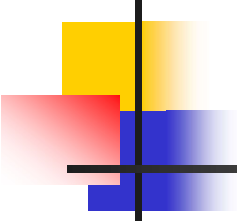


Source: Reuters, Woodmackenzie

Shale gas

Schematic geology of natural gas resources





The evolution of shale gas

1825

- First extraction in Fredonia, NY, in shallow low-pressure fractures

1920's

- First field-scale development of shale gas (Ohio Shale, Kentucky, Antrim Shale, Michigan)

1950's

- Hydraulic Fracturing becomes commercially viable (> 1 million wells)

1970's

- First patent for directional drilling
- First demonstration of massive hydraulic fracturing

1980's

- Horizontal drilling becomes commercially viable
- First large-scale hydraulic fracturing on shale well (Barnett, TX)

1992

- First horizontal shale gas well with hydraulic fracturing (Barnett TX)

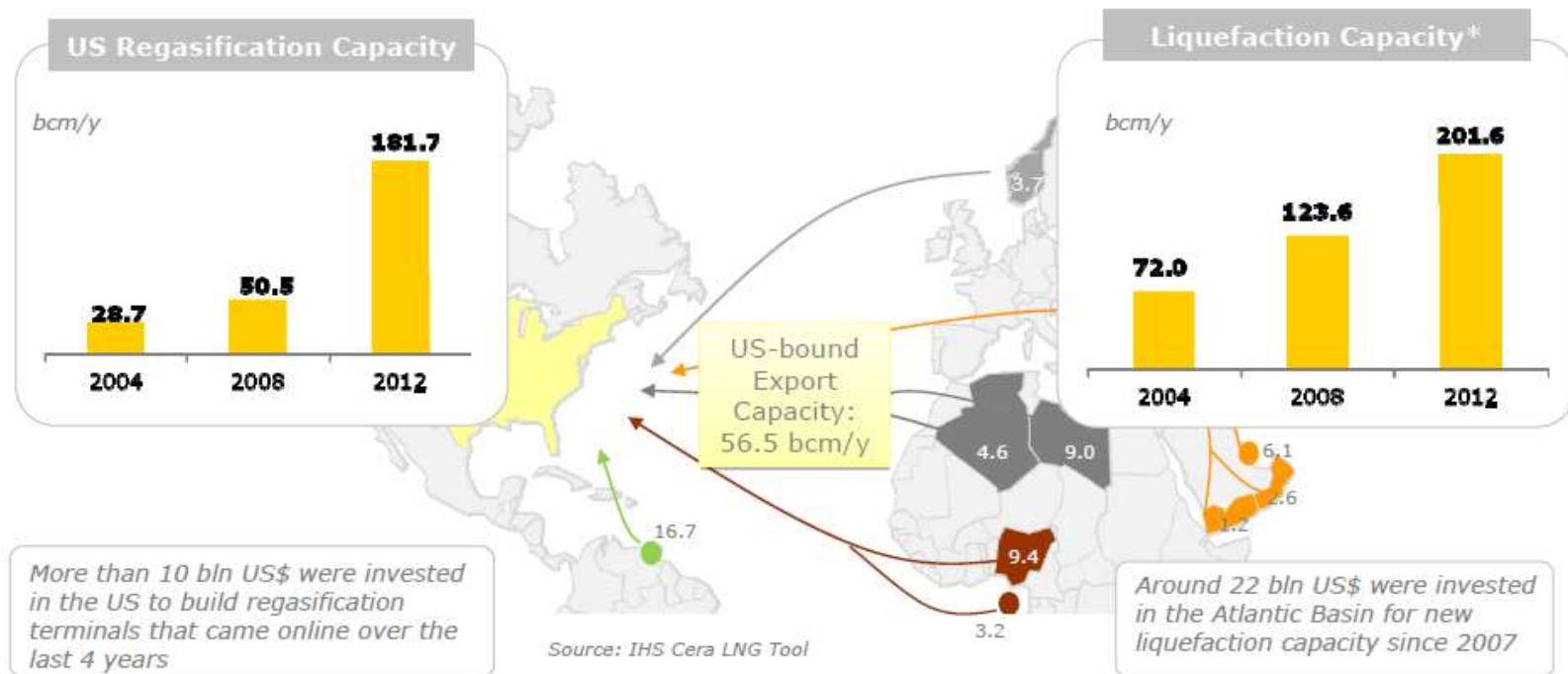
2005

- Shale gas production takes off

In 2012 US shale gas production alone ranks third globally, after US and Russia

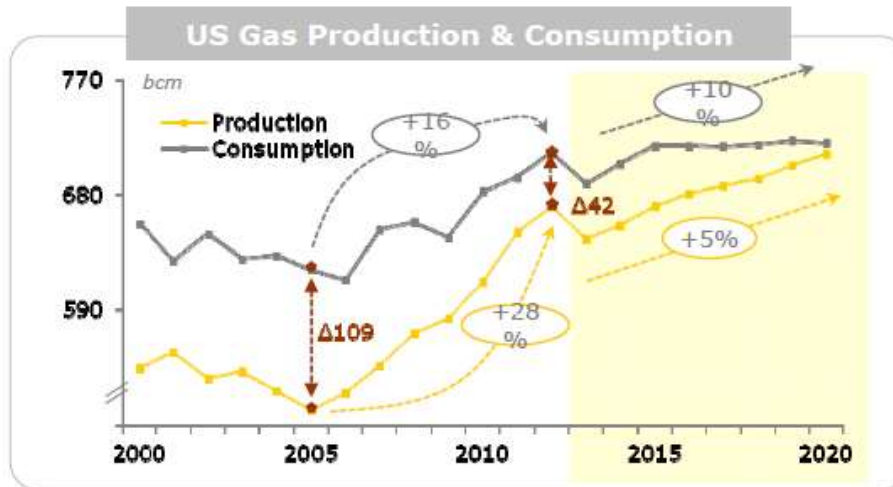
The shale gas phenomenon was unforeseen

- The US expected a sharp decline in domestic gas production and LNG imports were the only solution to cope with gas demand
- Many IOCs invested in the LNG chain as a result of increasing US gas demand forecasts

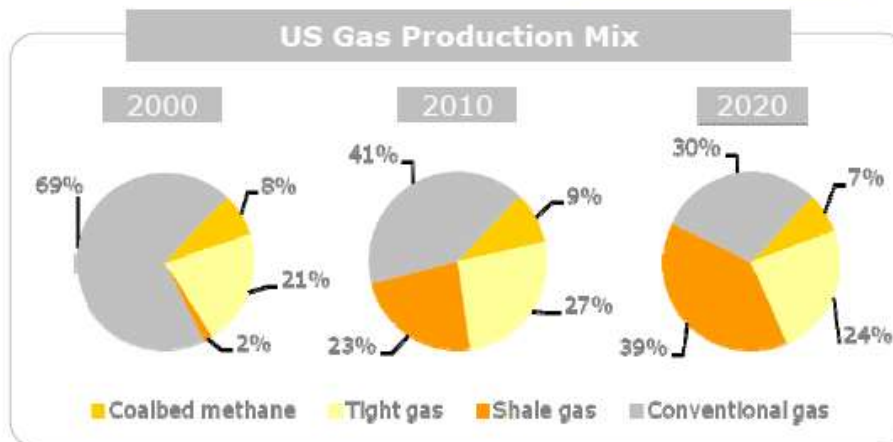


Today the US could have been the second largest LNG importing country after Japan

Shale gas is reshaping US gas market



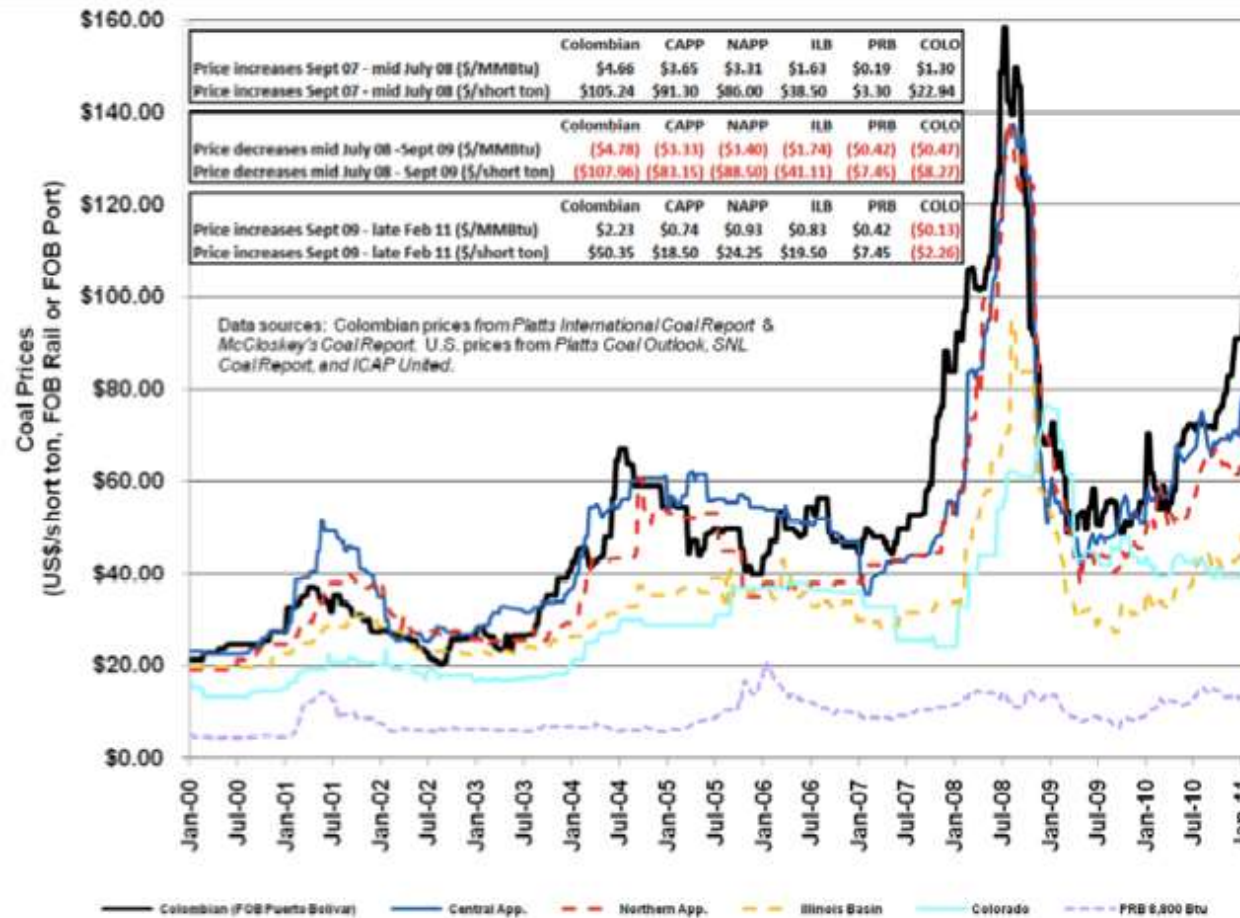
- Shale gas encouraged recovery and then growth of gas consumption after the financial downturn
- Consumption-to-production gap will slim down to less than 10 bcm in 2020
- Production will have to satisfy domestic consumption, to allow for LNG exports



- Shale production was less than 2% of total gas production in 2000 and reached nearly 35% in 2012
- In 2020, shale gas is expected to reach around 40% of total gas production although its growth will decrease to 5% yoy

Source: eia

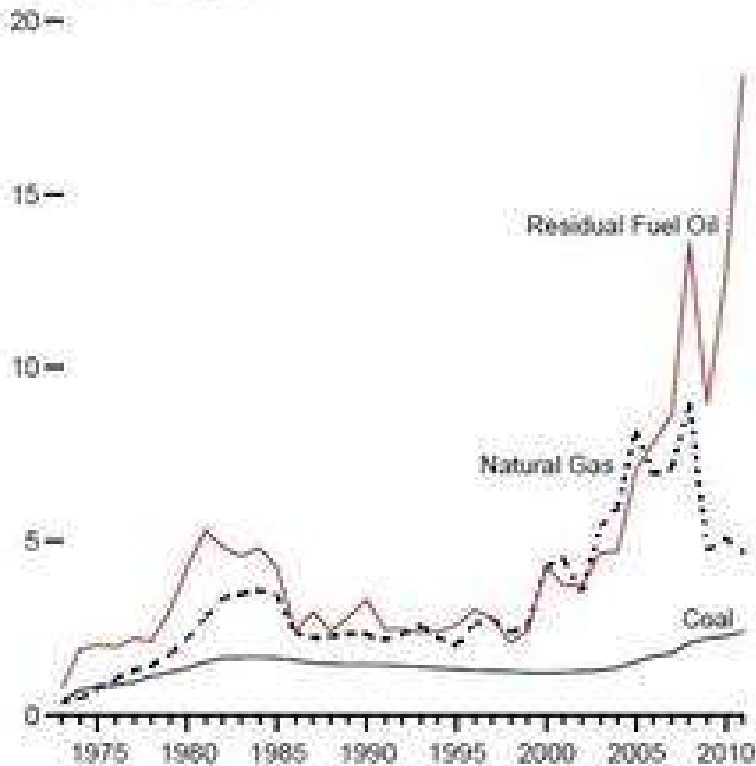
Andamento costi combustibile



Andamento costi combustibile

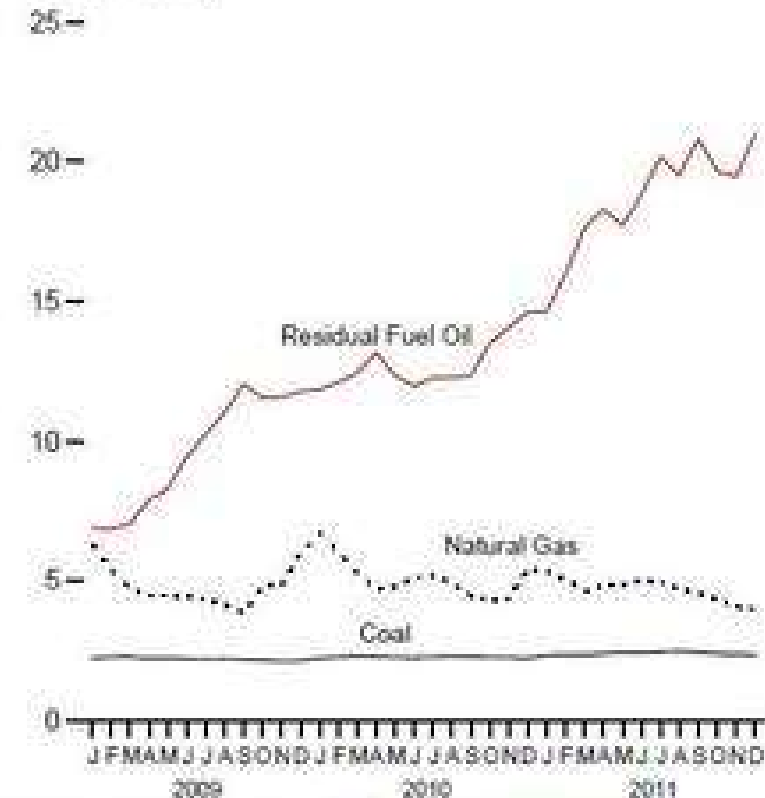
Figure 9.3 Cost of Fossil-Fuel Receipts at Electric Generating Plants
(Dollars* per Million Btu, Including Taxes)

Costs, 1973-2011

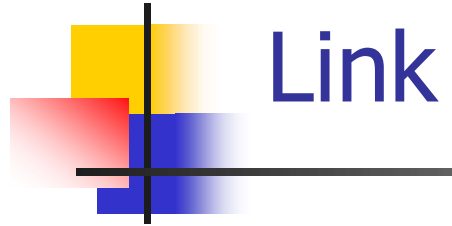


*Prices are not adjusted for inflation. See "Nominal Dollars" in Glossary.

Costs, Monthly



Web Page: <http://www.eia.gov/totalenergy/data/monthly/#prices>
Source: Table 9.10.



Link

- Per esempio

- <https://tradingeconomics.com/commodity/coal>

Coal

2022 Data - 2

Summary

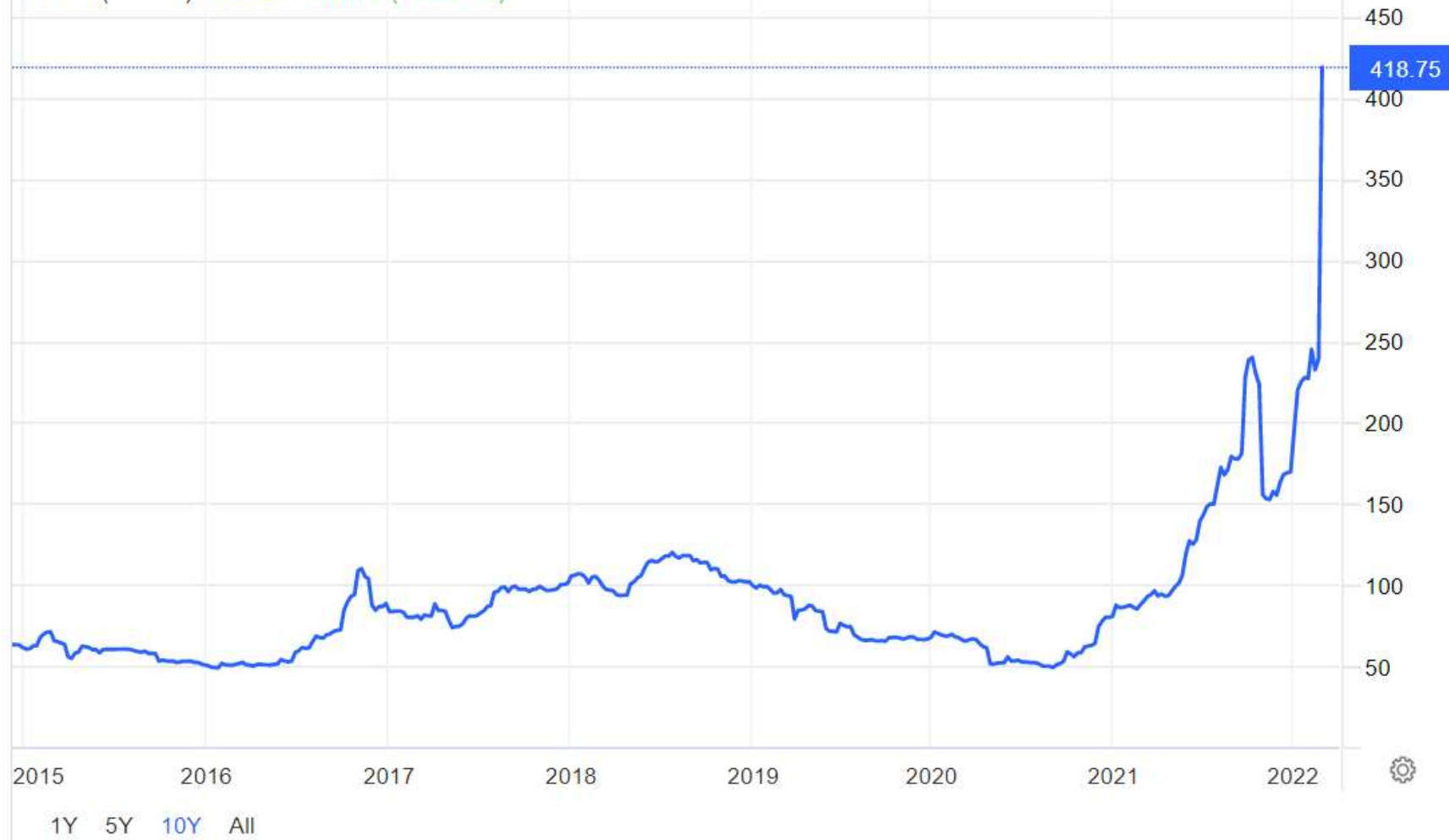
Forecast

Stats

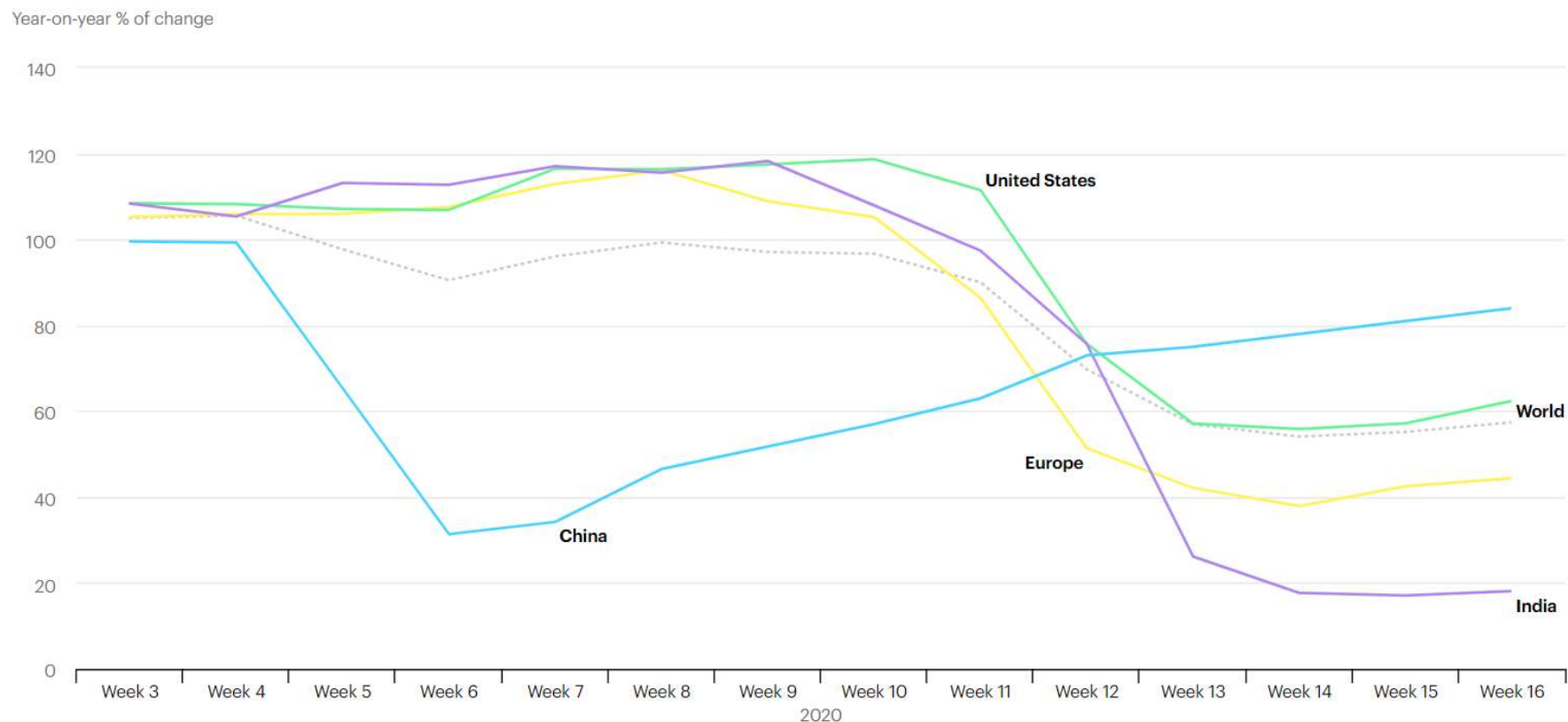
Download ▾

Alerts

Coal (USD/T) 418.75 +179.75 (+75.21%)

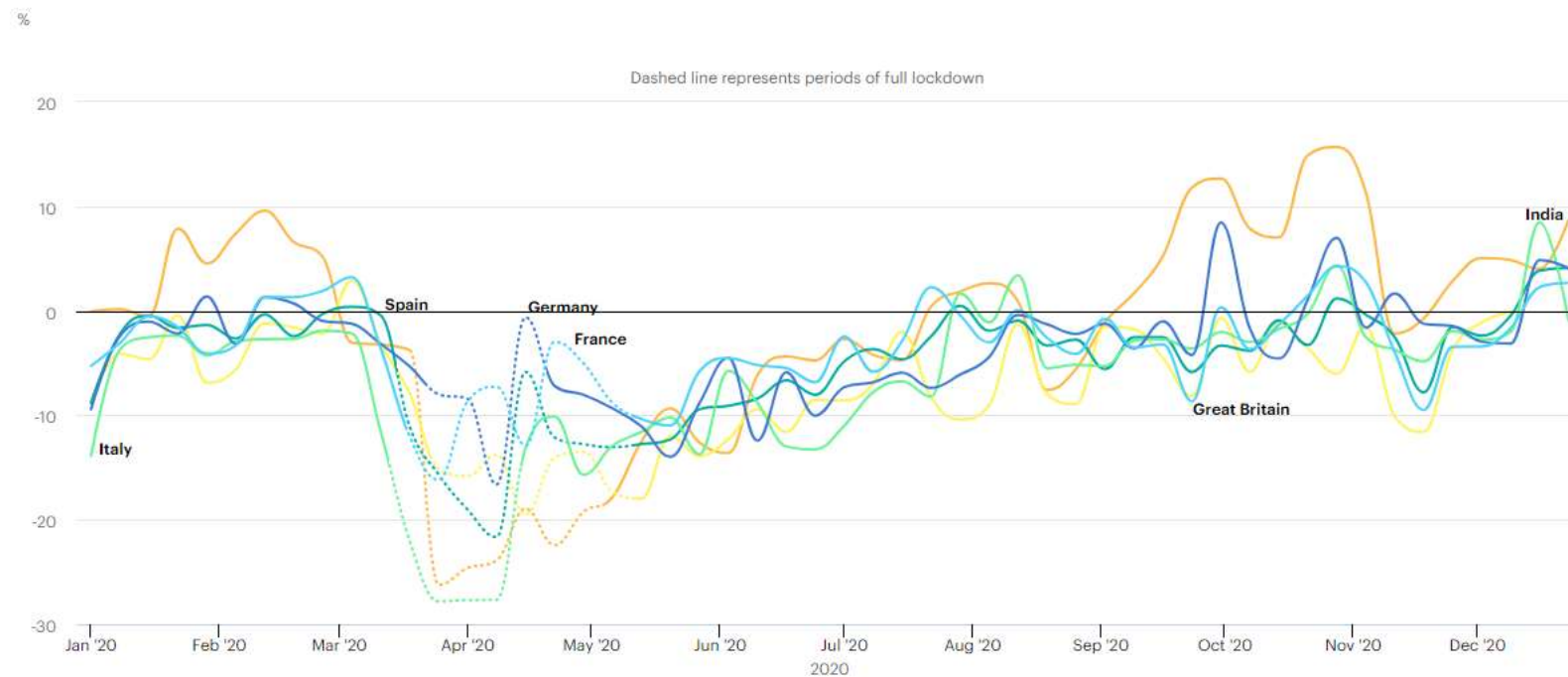


Evolution of road passenger transport activity in selected countries in early 2020- covid



2020 IEA

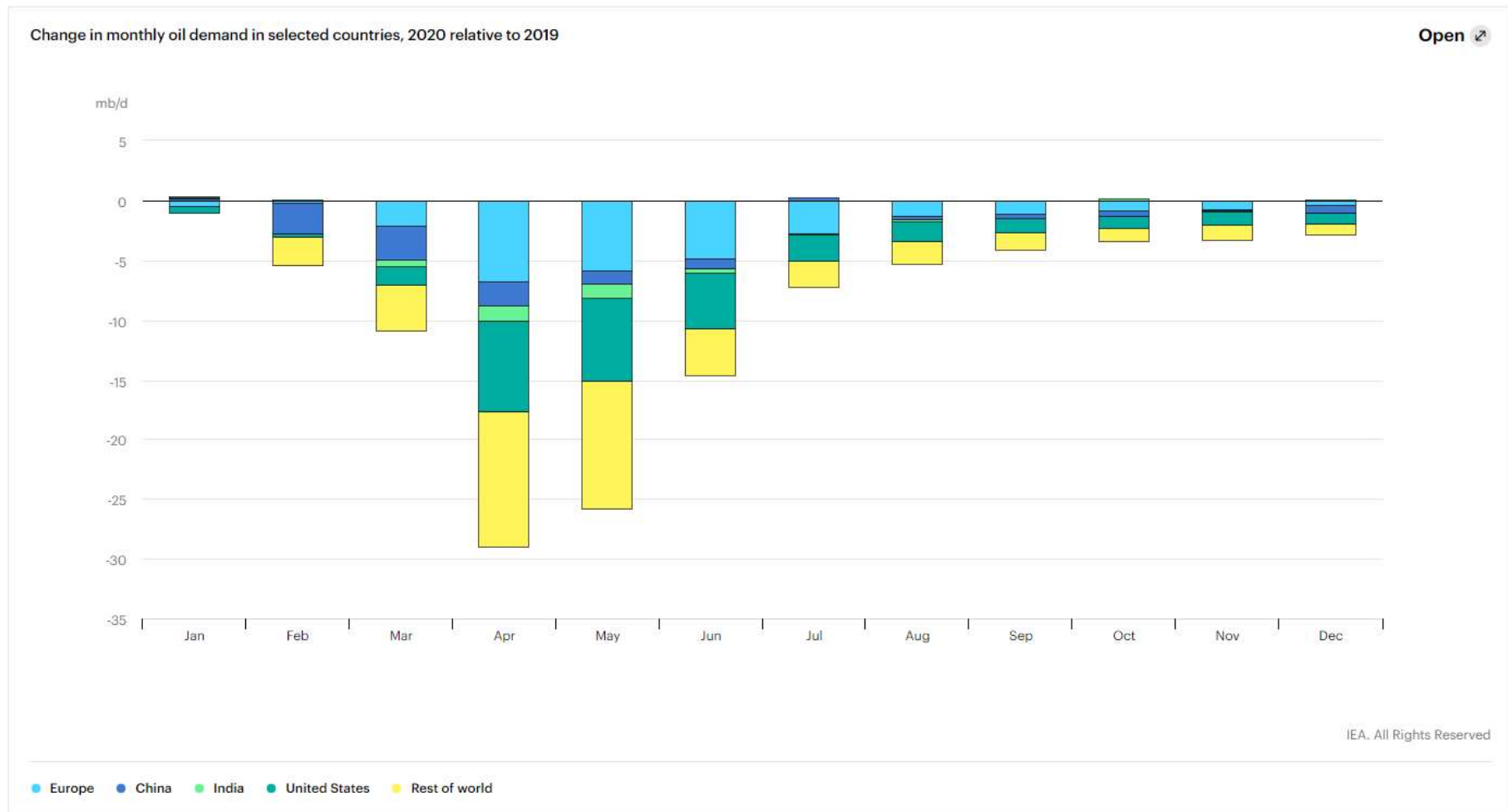
Evolution of road passenger transport activity in selected countries in early 2020- covid



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● France ● Germany ● Italy ● Spain ● Great Britain ● India

Change in monthly oil demand in selected countries, 2020 relative to 2019

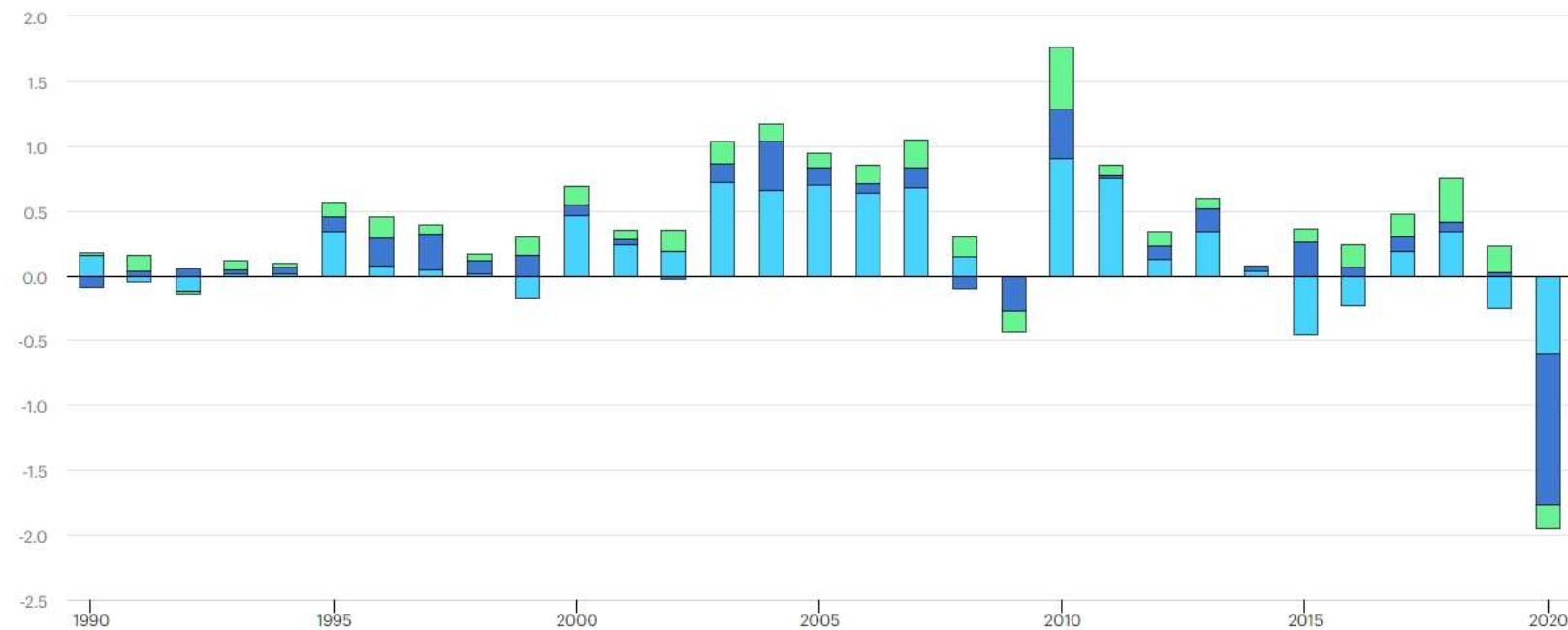


Change in CO2 emissions by fuel, 1990-2020

Download chart ↓

Cite Share

Gt CO2

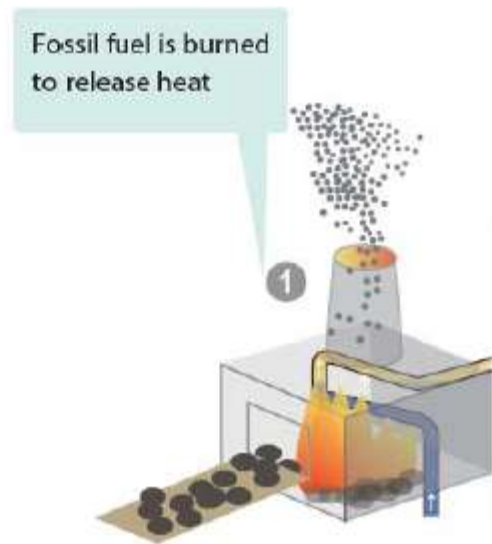


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● Coal ● Oil ● Gas

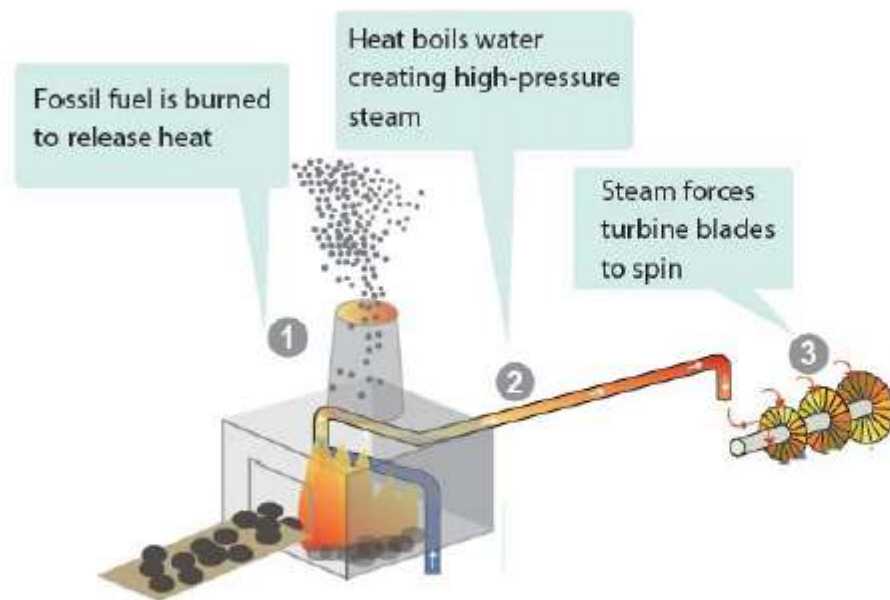
Electricity production

Heat



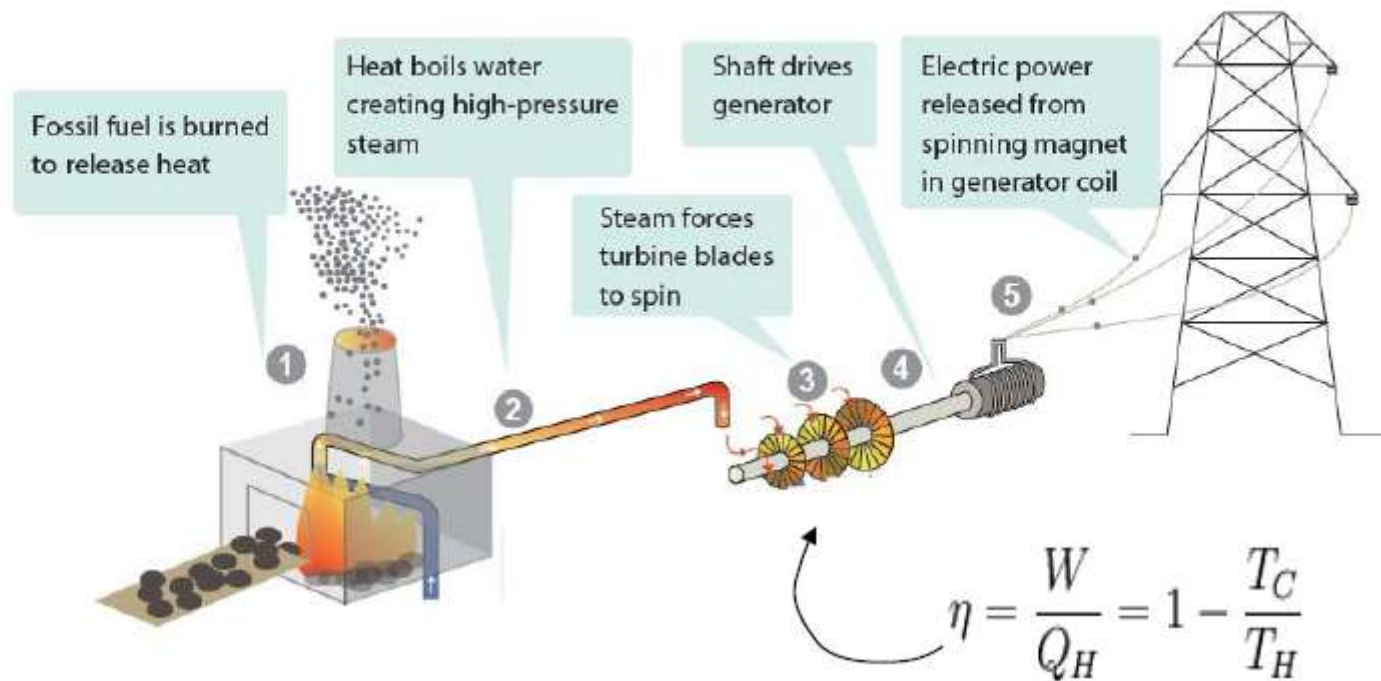
Electricity production

... from heat to steam

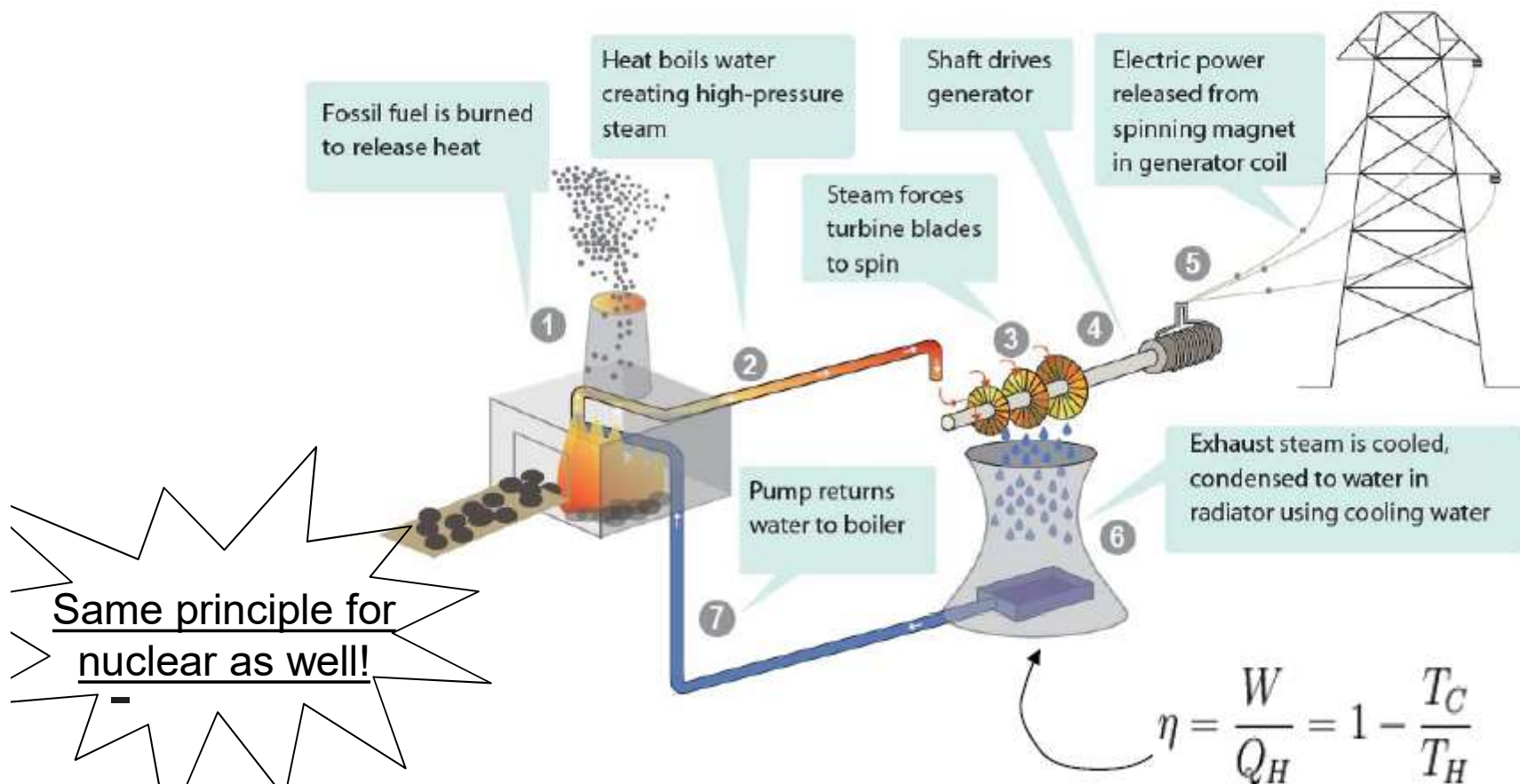


Electricity production

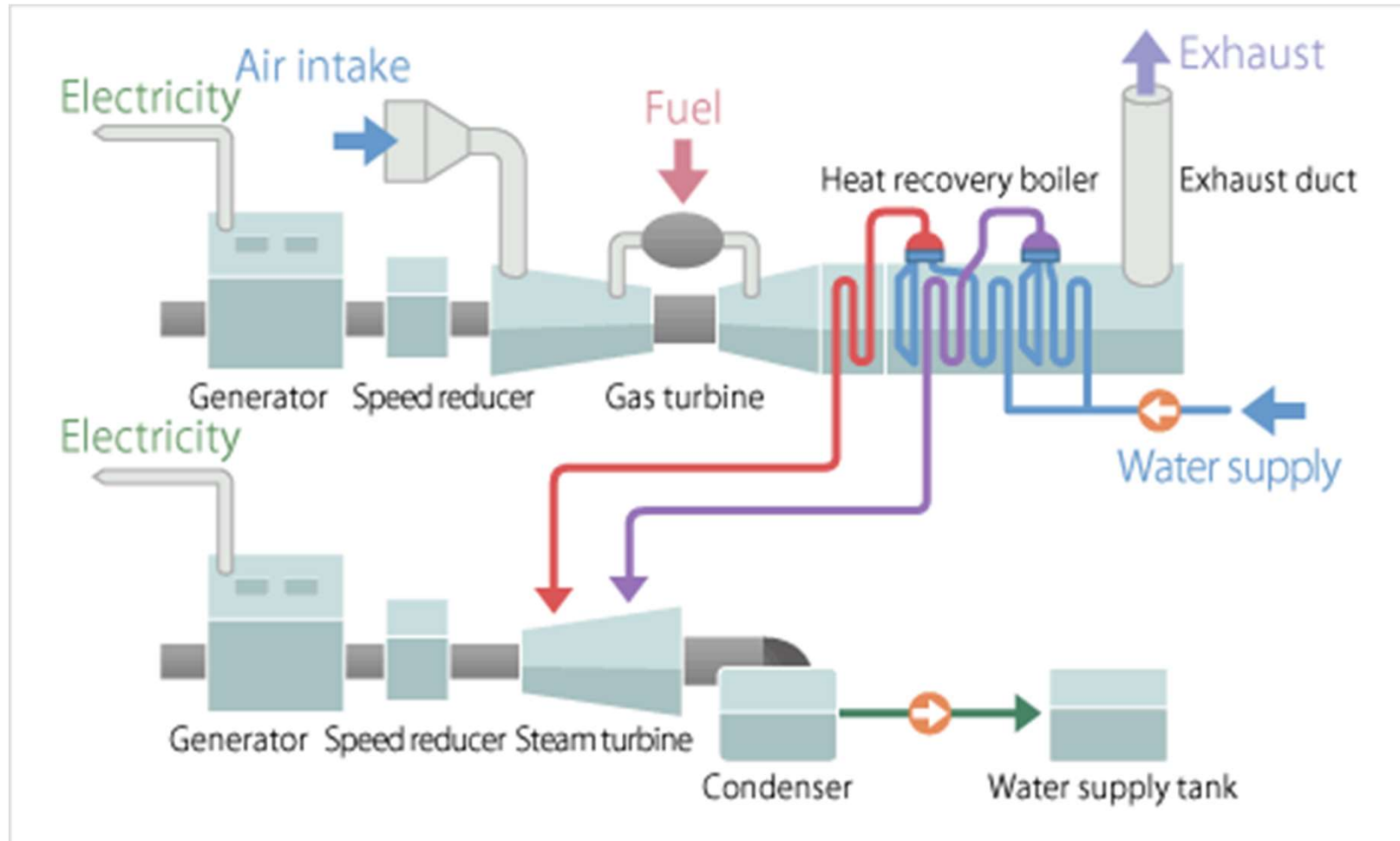
... from steam to electricity



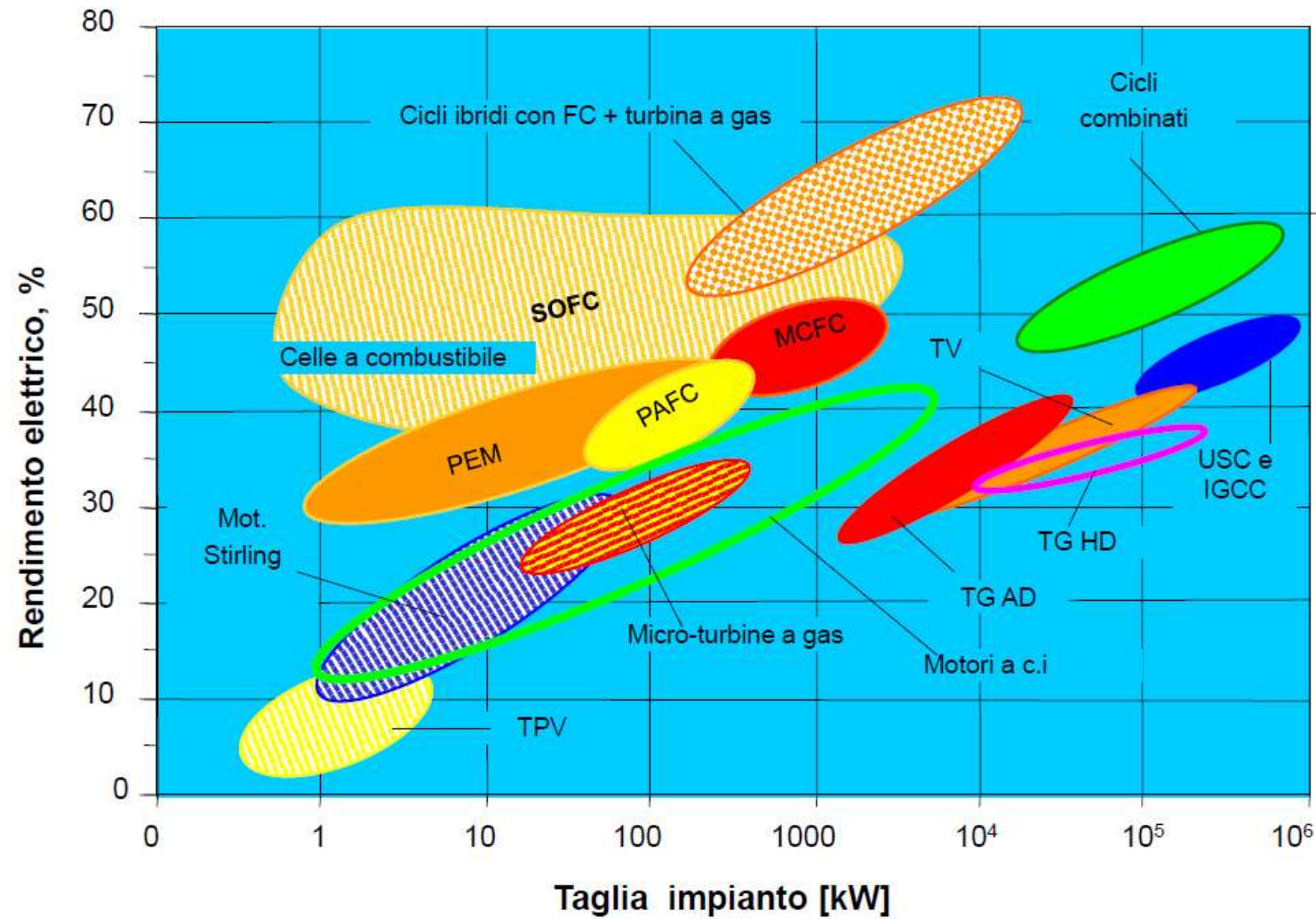
Electricity production



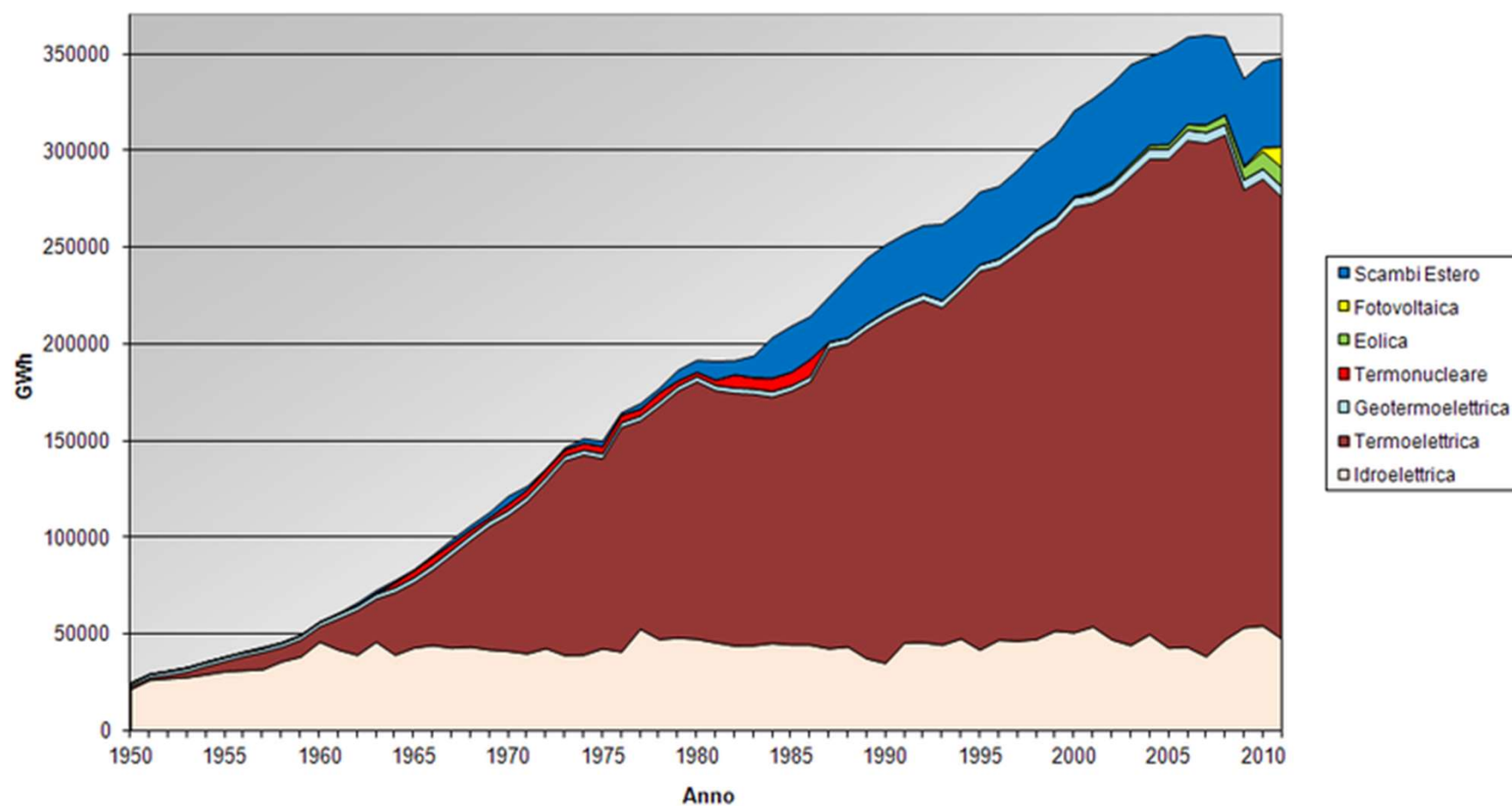
Combined cycle



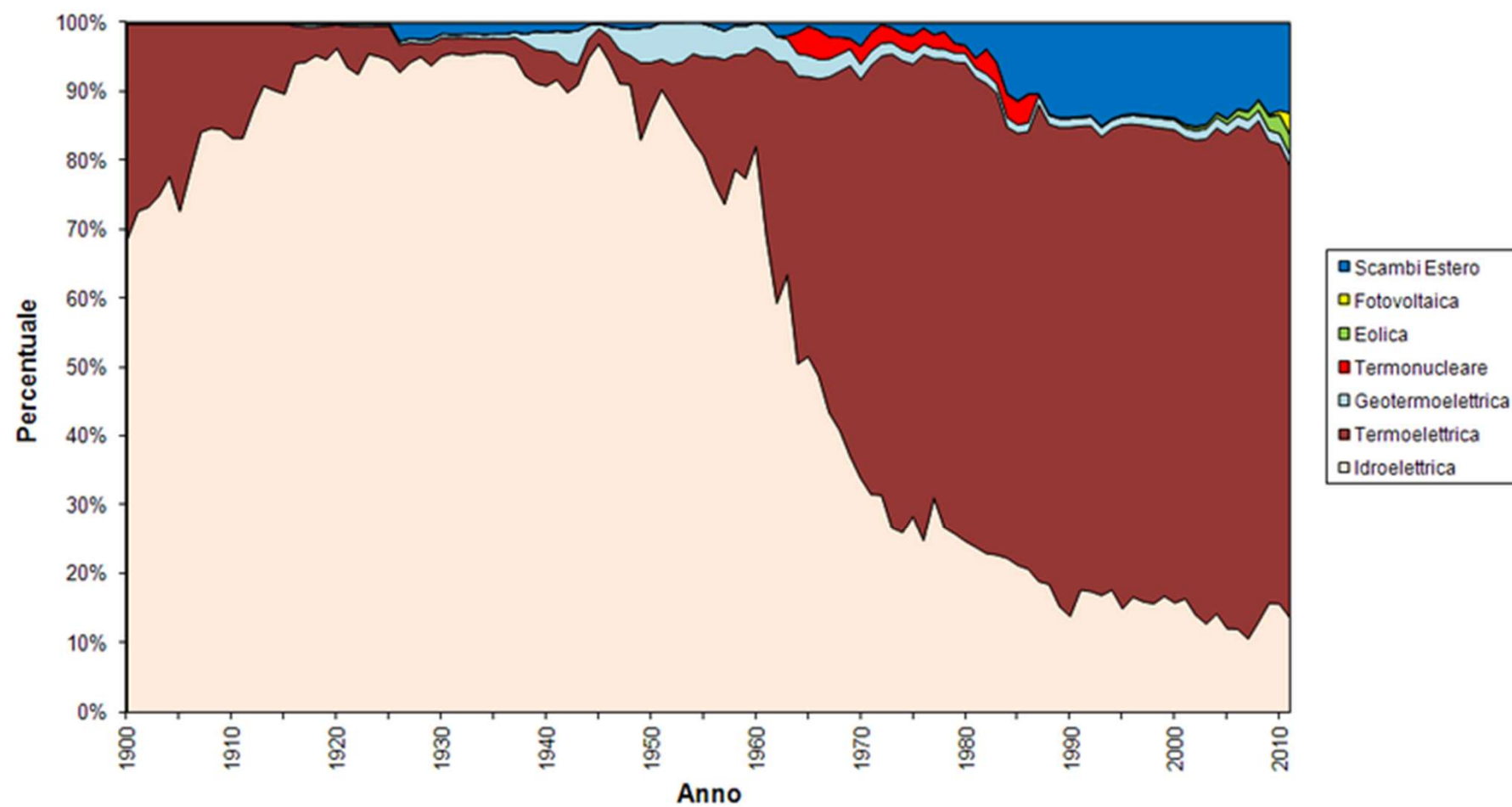
Impianti di generazione



Riepilogo Storico della Produzione di Energia in Italia



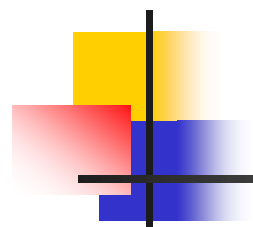
Riepilogo Storico Variazione Percentuale Fonti - Italia



Potenza nominale
ed efficiente degli
impianti
termoelettrici
in Italia al 31
dicembre 2010

Corso di Impiego industriale
dell'energia 2020-2021

Sezioni	Produttori				
	Potenza nominale		Potenza efficiente		
	n.	Motori primi MW	Generatori MVA	Lorda MW	Netta MW
A) Impianti con sola produzione di energia elettrica					
combustione interna (CI)	774	784,4	974,1	767,5	739,7
-fino a 25	774	784,4	974,1	767,5	739,7
turbine a gas (TG)	46	2.488,9	3.028,1	2.479,8	2.458,3
-fino a 25	17	142,7	162,6	134,6	133,2
-oltre 25 fino a 50	6	186,0	246,1	185,0	180,0
-oltre 50 fino a 100	19	1.666,6	2.059,4	1.666,6	1.655,2
-oltre 100 fino a 200	4	493,6	560,0	493,6	490,0
a vapore a condensazione (C)	134	21.714,6	25.225,2	21.595,5	19.709,7
-fino a 25	54	468,3	564,1	446,7	395,0
-oltre 25 fino a 50	5	193,8	285,5	193,8	174,8
-oltre 50 fino a 100	14	985,5	1.228,2	985,5	913,1
-oltre 100 fino a 200	21	3.327,0	3.907,5	3.314,5	3.070,8
-oltre 200 fino a 500	28	8.880,0	10.250,0	8.795,0	8.102,2
-oltre 500	12	7.860,0	8.990,0	7.860,0	7.053,8
ciclo combinato (CC)	53	23.589,8	30.654,2	23.049,2	22.604,9
-fino a 25	4	48,7	60,9	46,0	44,5
-oltre 50 fino a 100	2	120,0	157,9	120,0	117,0
-oltre 100 fino a 200	1	115,5	144,6	115,5	113,0
-oltre 200 fino a 500	33	12.779,4	17.657,1	12.437,2	12.213,6
-oltre 500	13	10.526,2	12.633,8	10.330,5	10.116,9
turbo espansione (TE)	12	37,4	42,6	34,8	33,2
-fino a 25	12	37,4	42,6	34,8	33,2
ripotenziato (RP)	8	5.317,6	6.160,0	5.317,6	5.068,4
-oltre 200 fino a 500	4	1.737,6	2.040,0	1.737,6	1.594,4
-oltre 500	4	3.580,0	4.120,0	3.580,0	3.474,0
altro genere (V)	7	167,3	204,4	165,7	158,7
-fino a 25	5	53,3	64,3	51,7	50,4
-oltre 25 fino a 50	1	42,0	50,0	42,0	39,9
-oltre 50 fino a 100	1	72,0	90,0	72,0	68,4
Totale A	1.034	54.100,1	66.288,5	53.410,0	50.772,9



Autoproduttori				
Sezioni	Potenza nominale		Potenza efficiente	
	Motori primi	Generatori	Lorda	Netta
n.	MW	MVA	MW	MW
77	127,5	155,6	123,3	119,1
77	127,5	155,6	123,3	119,1
5	36,8	42,8	36,8	36,1
5	36,8	42,8	36,8	36,1
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
14	211,4	276,7	207,1	195,4
9	54,9	68,7	50,6	47,5
5	156,5	208,0	156,5	147,9
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
1	58,0	73,3	58,0	55,3
-	-	-	-	-
1	58,0	73,3	58,0	55,3
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
13	124,2	162,0	116,1	113,0
13	124,2	162,0	116,1	113,0
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
2	14,0	18,4	13,6	12,9
2	14,0	18,4	13,6	12,9
-	-	-	-	-
-	-	-	-	-
112	572,0	728,8	554,9	531,8

ITALIA				
Sezioni	Potenza nominale		Potenza efficiente	
	Motori primi	Generatori	Lorda	Netta
n.	MW	MVA	MW	MW
851	911,9	1.129,7	890,8	858,7
851	911,9	1.129,7	890,8	858,7
51	2.525,7	3.070,8	2.516,6	2.494,4
22	179,5	205,3	171,4	169,3
6	186,0	246,1	185,0	180,0
19	1.666,6	2.059,4	1.666,6	1.655,2
4	493,6	560,0	493,6	490,0
148	21.926,1	25.502,0	21.802,6	19.905,2
63	523,3	632,8	497,3	442,5
10	350,3	493,5	350,3	322,7
14	985,5	1.228,2	985,5	913,1
21	3.327,0	3.907,5	3.314,5	3.070,8
28	8.880,0	10.250,0	8.795,0	8.102,2
12	7.860,0	8.990,0	7.860,0	7.053,8
54	23.647,8	30.727,5	23.107,2	22.660,3
4	48,7	60,9	46,0	44,5
3	178,0	231,2	178,0	172,3
1	115,5	144,6	115,5	113,0
33	12.779,4	17.657,1	12.437,2	12.213,6
13	10.526,2	12.633,8	10.330,5	10.116,9
25	161,6	204,6	150,9	146,2
25	161,6	204,6	150,9	146,2
8	5.317,6	6.160,0	5.317,6	5.068,4
4	1.737,6	2.040,0	1.737,6	1.594,4
4	3.580,0	4.120,0	3.580,0	3.474,0
9	181,3	222,8	179,3	171,6
7	67,3	82,8	65,3	63,3
1	42,0	50,0	42,0	39,9
1	72,0	90,0	72,0	68,4
1.146	54.672,1	67.017,4	53.965,0	51.304,8



Energy consumptions

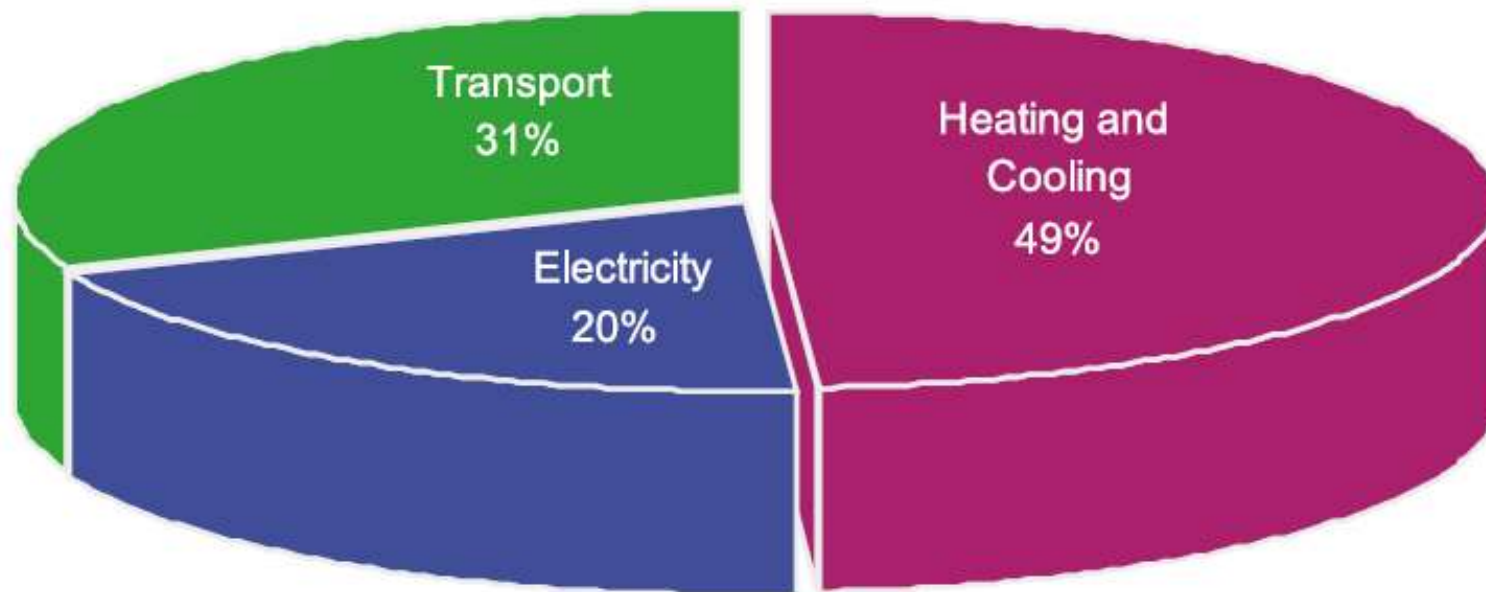
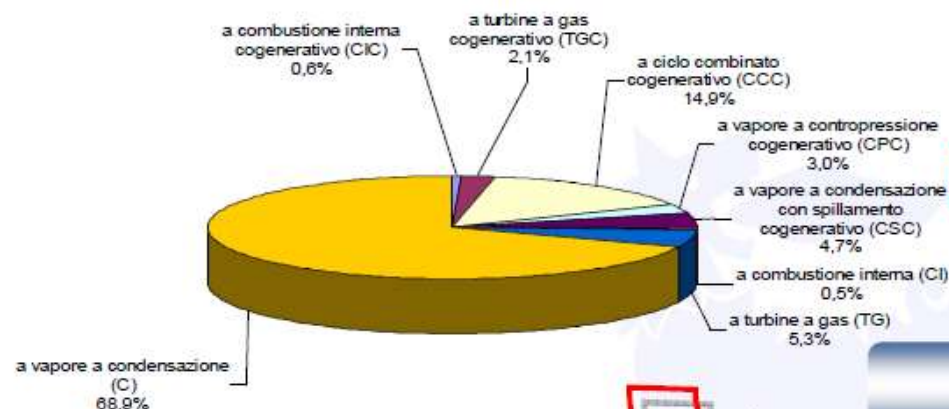


Figure 7: Final Energy demand in the European Union. (Source: EREC, 2006)

Produzione elettrica in Italia dal 1999 al 2008

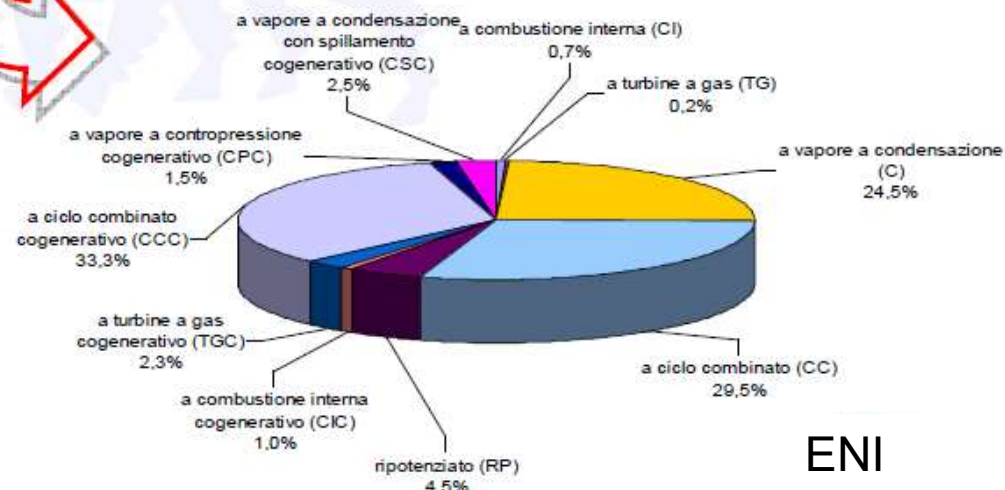
Produzione totale 208.481 GWh



► Largo utilizzo del **Ciclo Rankine** – vapore a condensazione

► Limitate applicazioni **TG** e **cicli combinati cogenerativi**

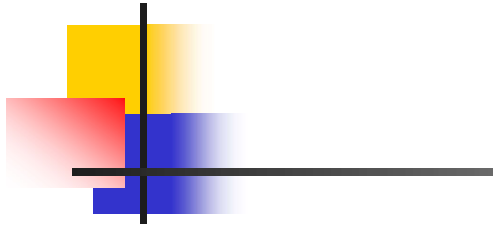
Produzione totale 264.743 GWh



► Forte espansione del **ciclo combinato** sia **cogenerativo** che a **condensazione**

► **Repowering** ed interventi di **efficientamento** del parco esistente

ENI



Producers, net exporters and net importers of electricity



Producers*	TWh	% of world total
People's Rep. of China	4 716	21.3
United States	4 327	19.6
Russian Federation	1 053	4.8
India	1 052	4.8
Japan	1 043	4.7
Canada	637	2.9
Germany	602	2.7
France	557	2.5
Brazil	532	2.4
Korea	520	2.4
Rest of the world	7 087	31.9
World	22 126	100.0

2011 data

Net exporters	TWh
France	56
Paraguay	46
Canada	37
Russian Federation	23
Czech Republic	17
People's Rep. of China	13
Bulgaria	11
United Arab Emirates	8
Sweden	7
Ukraine	6
Others	58
Total	282

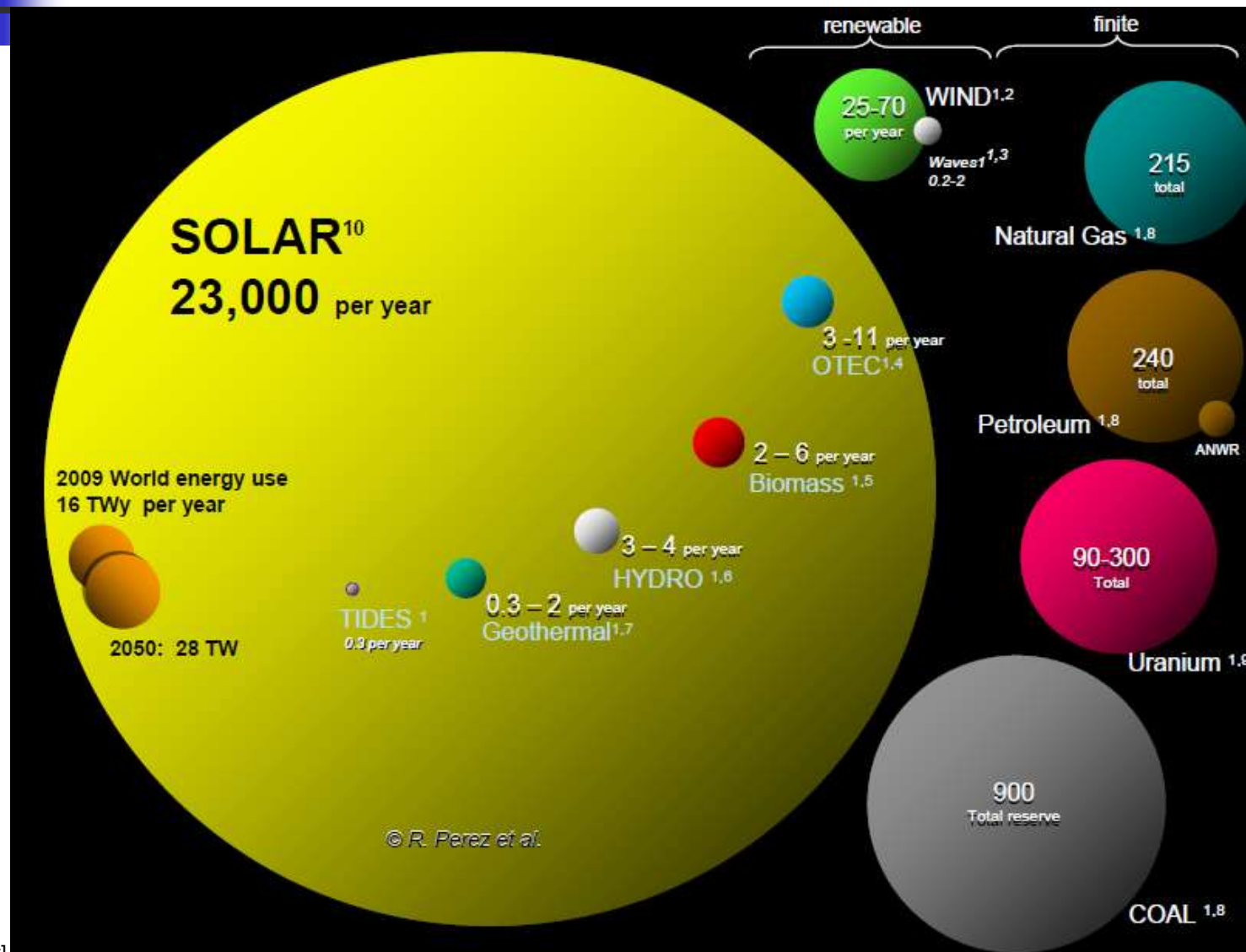
2011 data

Net importers	TWh
Italy	46
United States	37
Brazil	36
Finland	14
Argentina	10
Netherlands	9
Thailand	9
Hong Kong (China)	8
Austria	8
Croatia	8
Others	97
Total	282

*Gross production minus production from pumped storage plants. 2011 data

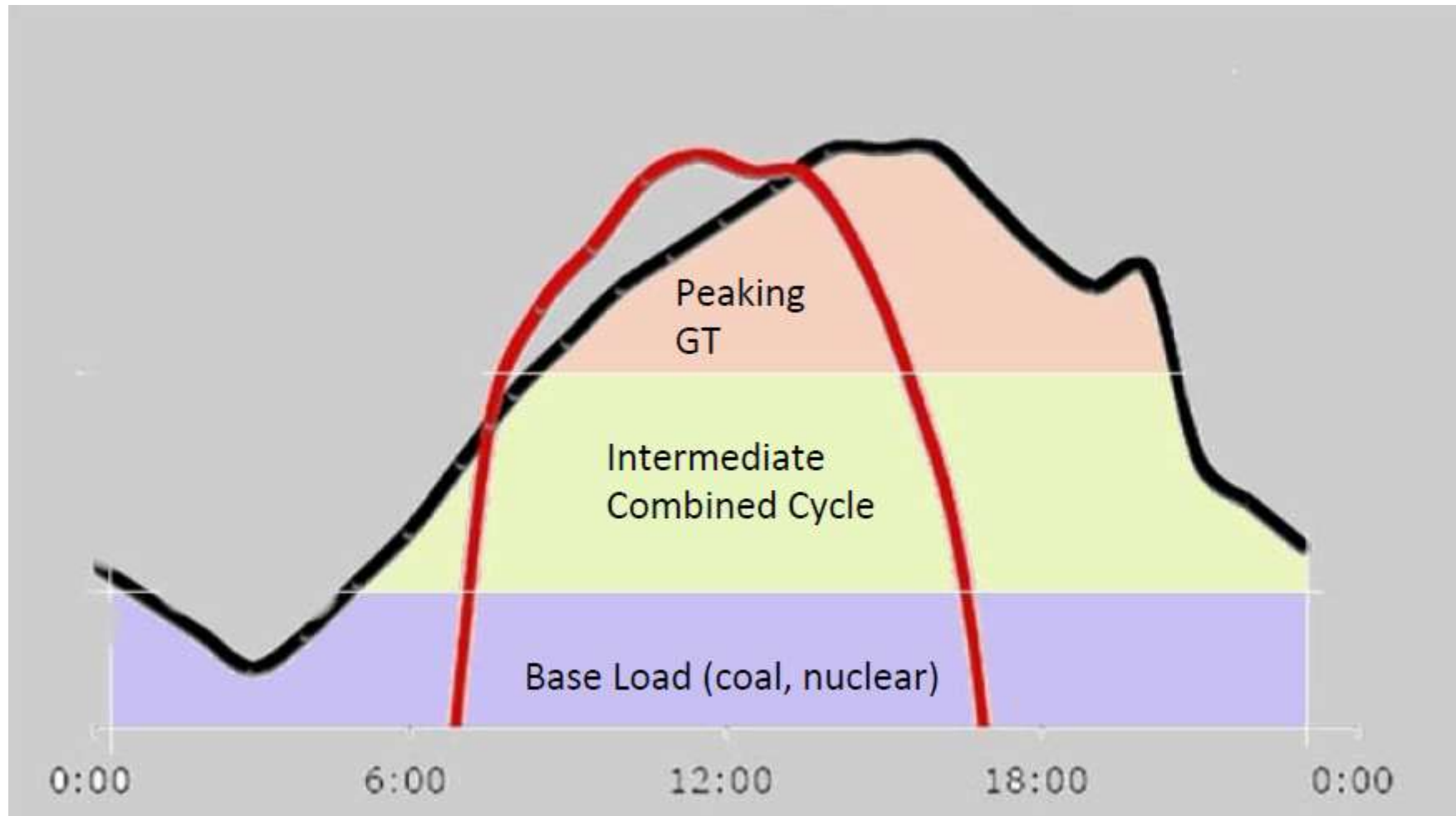
[IEA 2013]

Fonti rinnovabili di energia...



[Richard Perez]

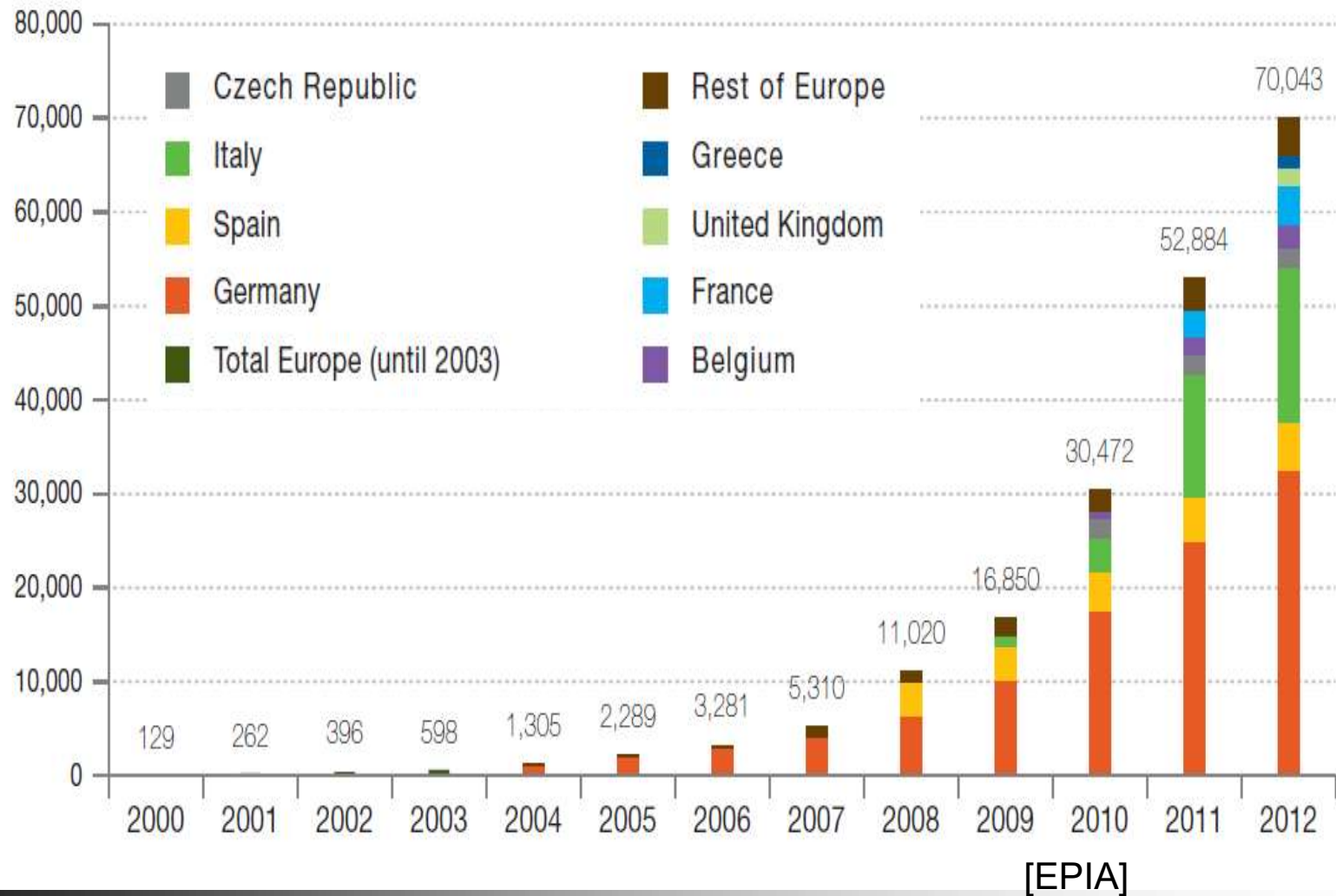
Typical electricity load profile

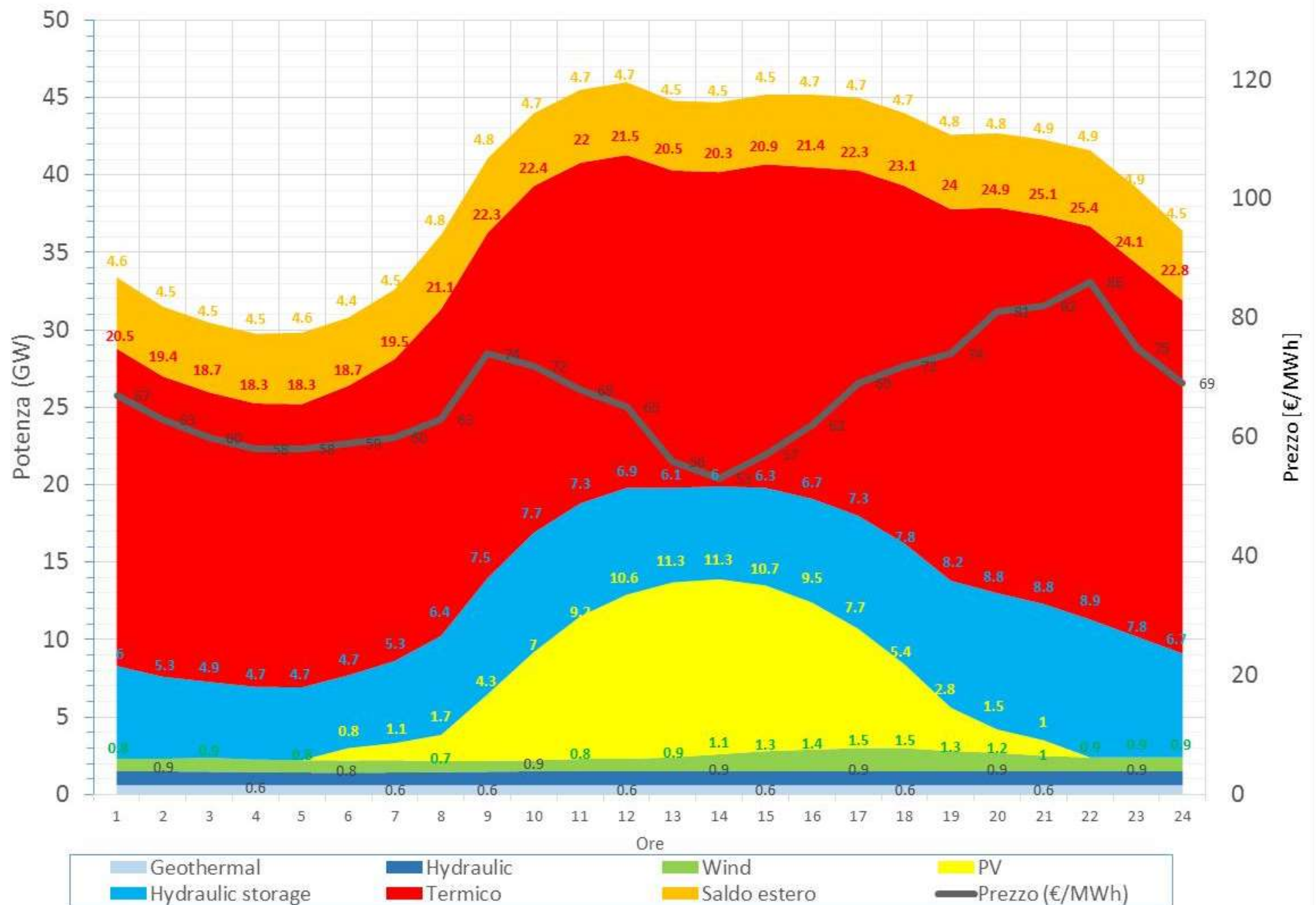


Case study: PV in Italy and Europe



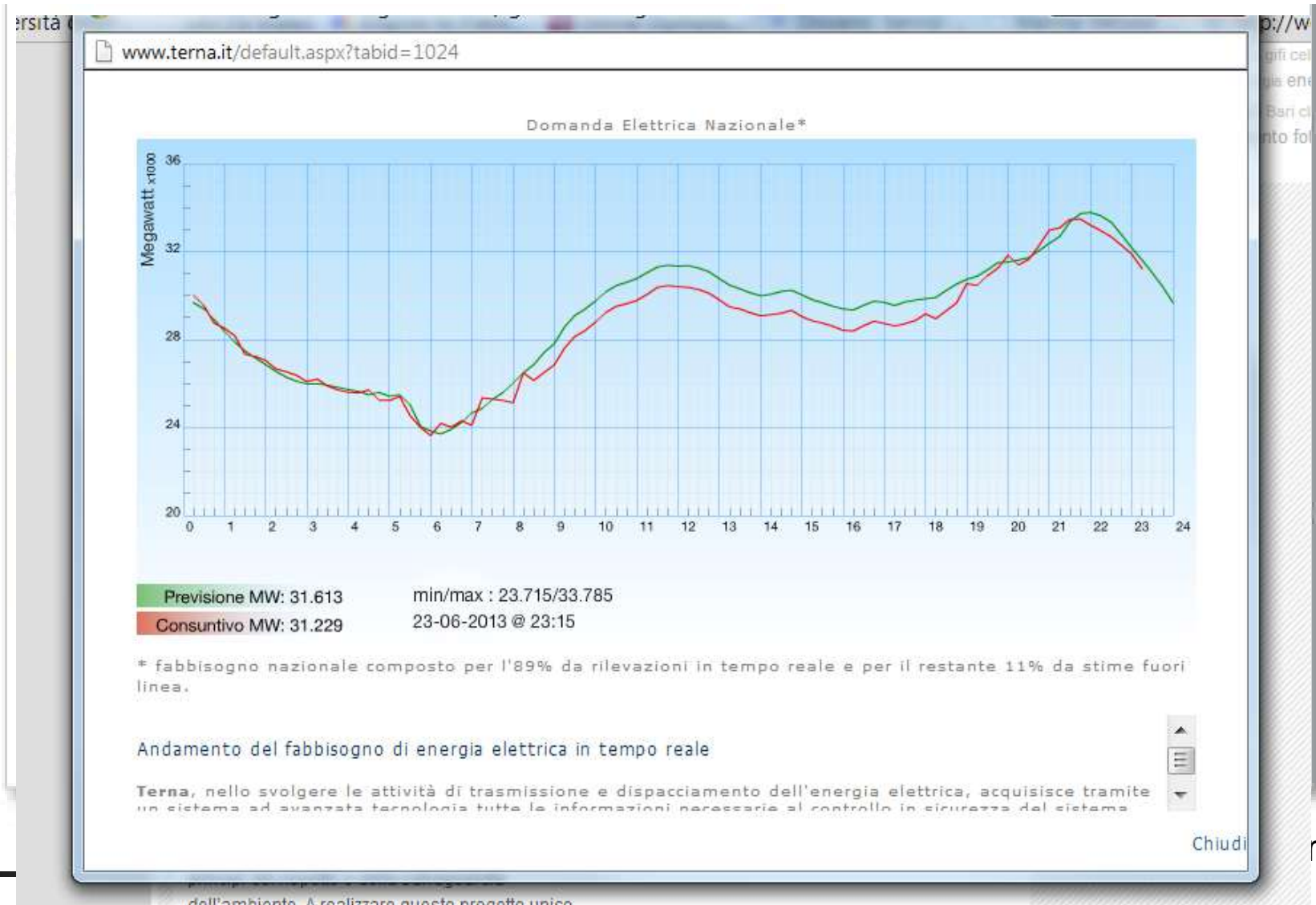
Case study: PV in Italy and Europe





[Elaborated from Terna and
<http://dataenergia.altervista.org/>]

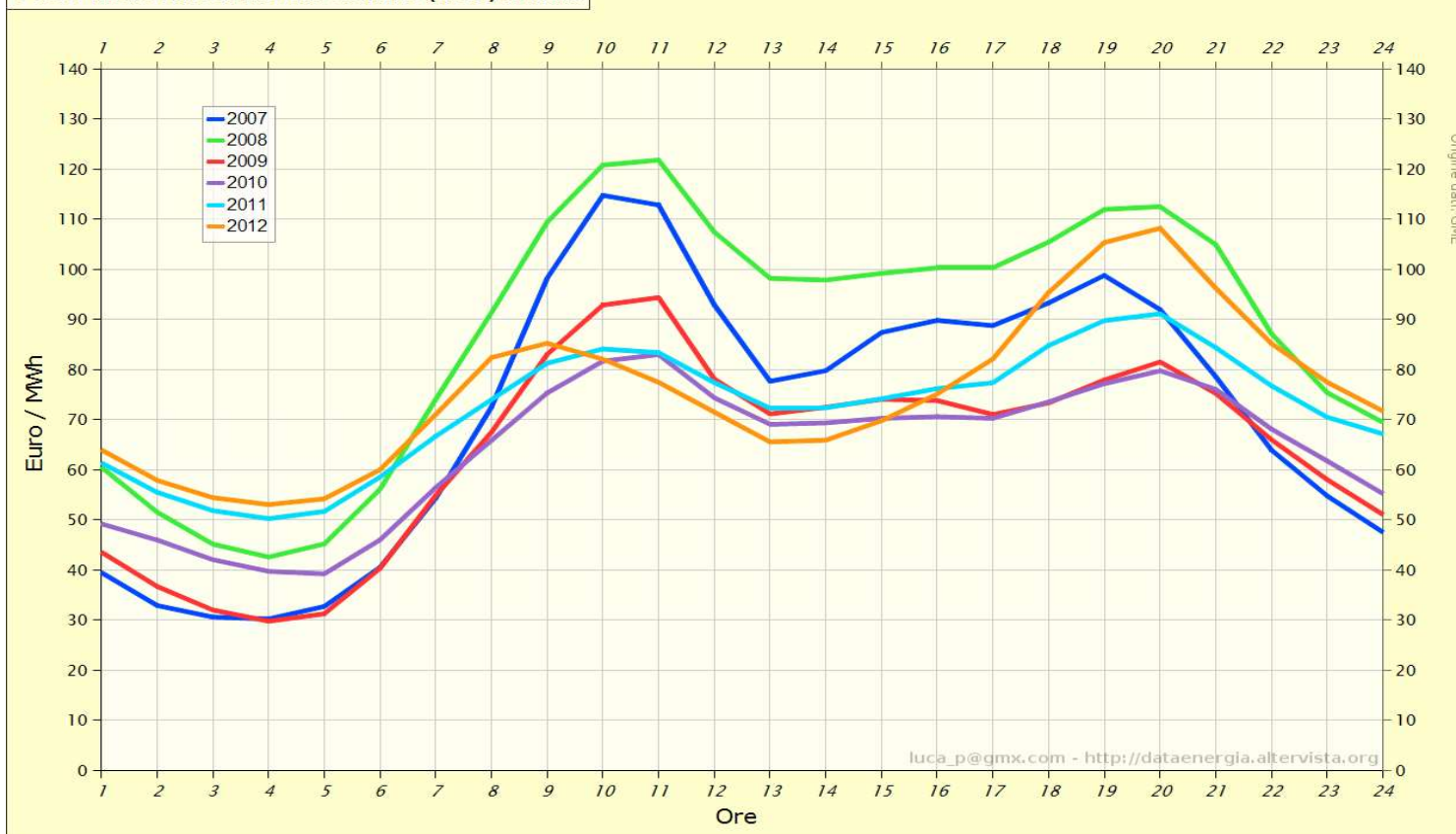
Daily load profile



dell'ambiente. A realizzare questo progetto unico

Italy: electricity price

Prezzi medi orari sul mercato elettrico (MGP) in Italia



[<http://dataenergia.altervista.org/>]

Il contatore fotovoltaico

Totale conto energia

Totale impianti in esercizio

N.° Impianti: 526.463

Potenza (kW): 17.080.255

Costo annuo (€): 6.605.824.828

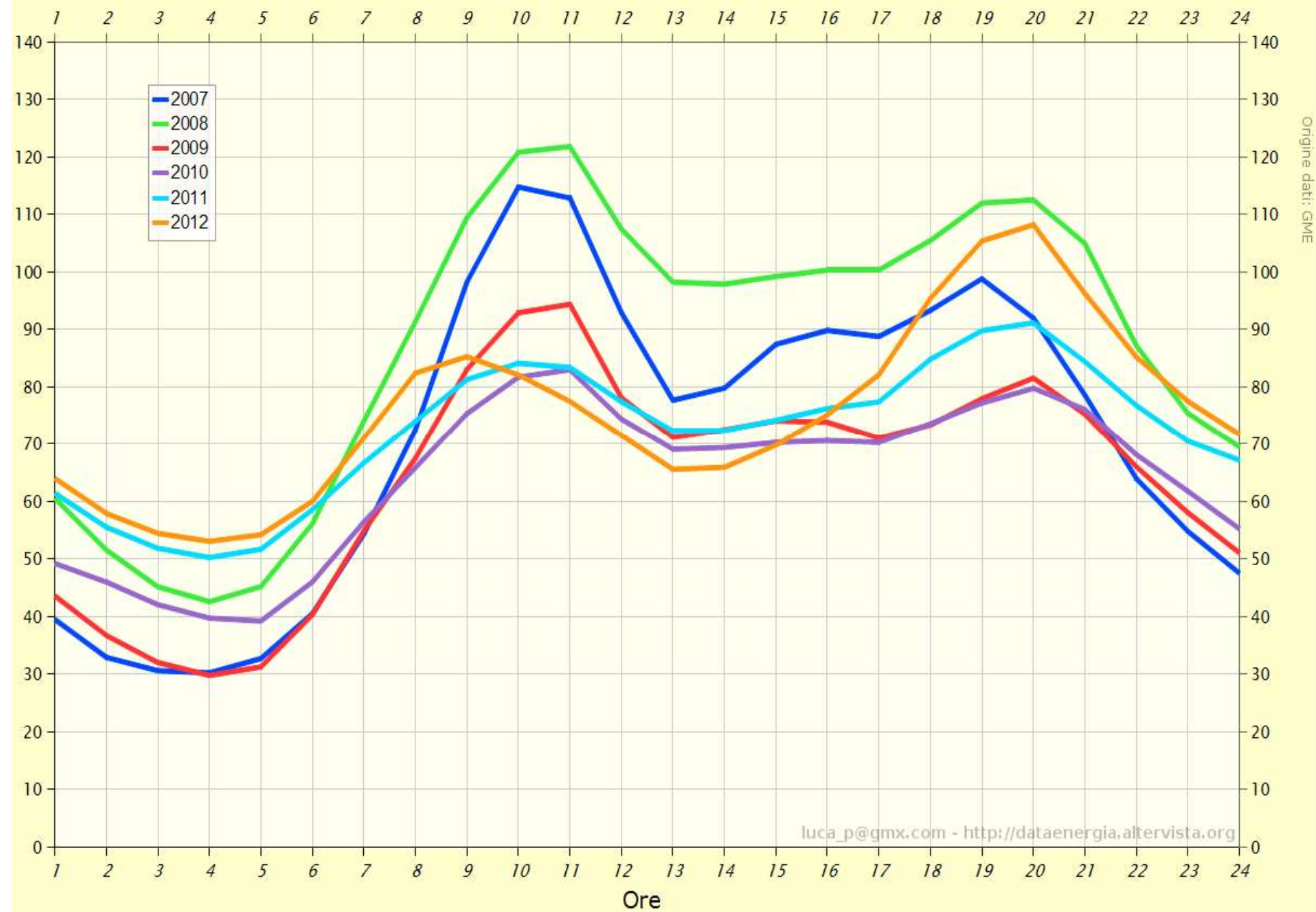
Totale impianti a registro*

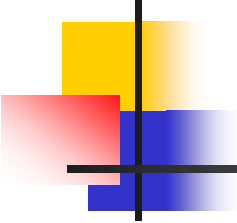
N.° Impianti: 4.779

Potenza (kW): 1.136.326

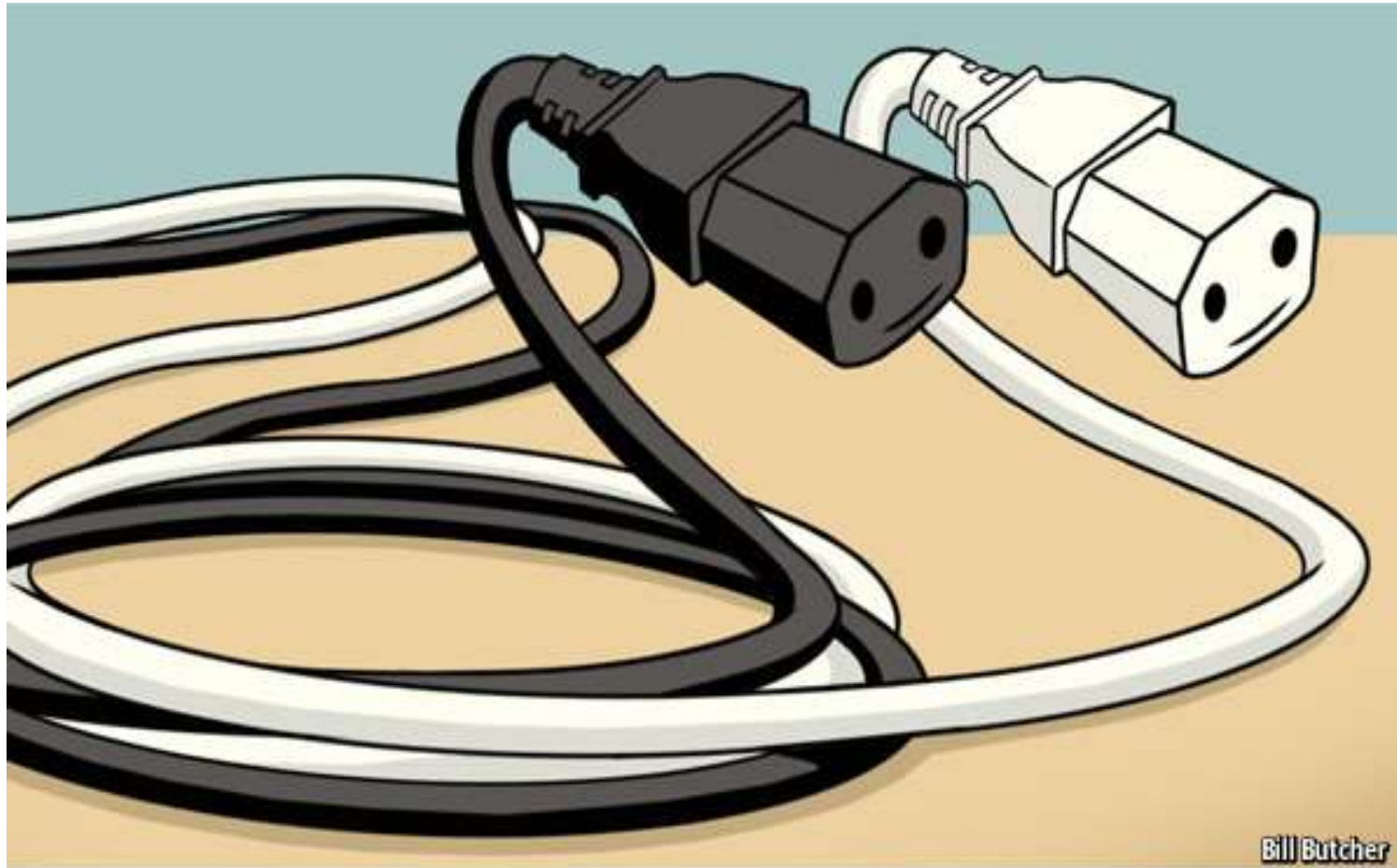
Costo annuo (€): 94.183.695

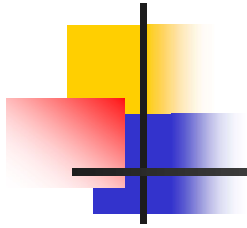
zzi medi orari sul mercato elettrico (MGP) in Italia





... possible? When? How?





Grazie per l'attenzione