World Energy Resources

2013 Survey

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World Energy Resources

CONTENTS

- INTRODUCTION
- GLOBAL TRENDS IN FOSSIL FUELS
- OTHER ENERGY RESOURCES
- ENERGY EFFICIENCY
- COMPARISONS AND CONCLUSIONS

World Energy Resources

INTRODUCTION

World Energy Resources

- Formerly “WEC Survey of Energy Resources” and “Statistical Year-Book of the World Power Conference”
- First published in 1936 (data from 1933)
- Over 3 million downloads from the WEC website in 2011-2012
- Last 23rd Edition released at the Daegu Congress in October 2013

World Energy Resources

- Growing interdependence between the increasing energy demand and the environment and between countries and regions
- Energy is global and the impacts of its production and use are also global
- Growing role of electricity in the consumption of energy resources, expected to reach 44% of the TPES by 2030
- Today 40% of CO_2 emissions come from electricity production
- 1.3 billion people still do not have access to commercial electricity
- Africa:

  14% of global population consume 3% of global electricity, whereof one country (South Africa) accounts for 40% of the total consumption while its share of Africa's population is only 5%

World Energy Resources 2013

- 12 resource chapters
- independent source of comprehensive energy data and information at the global, regional and national levels
- Energy Efficiency is included as a resource
- Comparison between current resources and those 20 years ago (from WEC report published in 1993)

World Energy Resources

GLOBAL TRENDS IN FOSSIL FUELS (2011)

Global Trends in Fossil Fuels (2011)

Source: World Energy Council, 2013

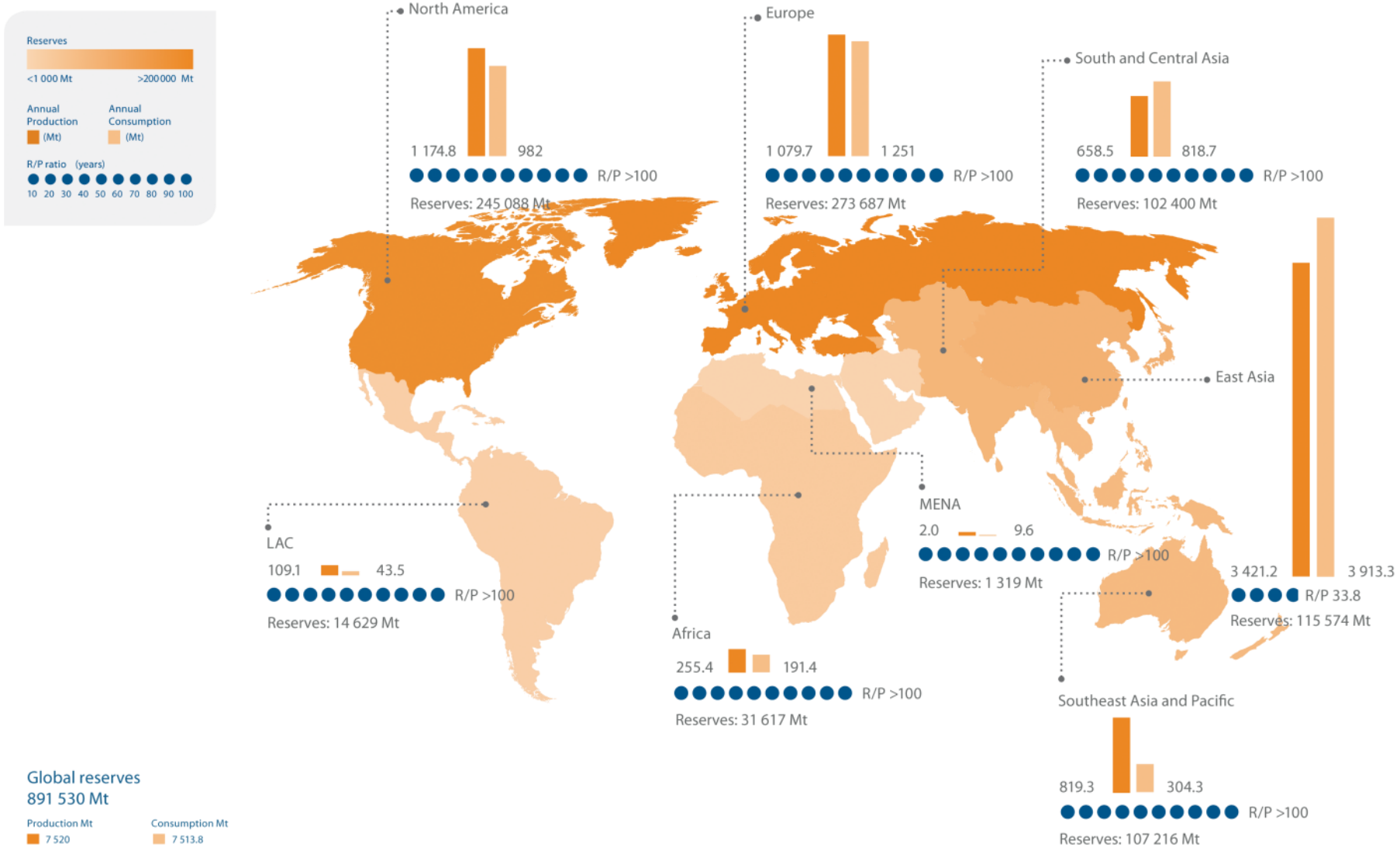
	COAL				OIL				NATURAL GAS			
	Reserves (R) = 891 Gt Consumption (C) = 7.51 Gt Production (P) = 7.52 Gt R/P = 118 years				R = 223 Gt C = 4.15 Gt P = 3.98 Gt R/P = 56 years				R = 210 Tcm C = 3.37 Tcm P = 3.51 Tcm R/P = 60 years			
	R (%)	R/P (years)	P (%)	C (%)	R (%)	R/P (years)	P (%)	C (%)	R (%)	R/P (years)	P (%)	C (%)
Latin America & The Caribbean	2	134	2	0.5	20	116	9	6	3.5	36	6	4
North America (US, Canada)	27	209	16	13	13	44	16	26	5	11	26	26
Europe (including Siberia)	31	250	14	17	6	20	17	21	25	55	28	33
South & Central Asia	11	155	9	11	2	27	5	6	15	44	10	7
East Asia (China, Japan, S.Korea, Taiwan)	13	34	45	52	1	12	5	22	2	28	3	10
Southeast Asia & Pacific	12	130	11	4	1	20	3	6	4	33	7	5
Middle East & North Africa	-	-	-	-	50	79	36	10	41	143	17	13
Africa	4	121	3	2.5	7	47	9	3	4.5	79	4	2

R (%) = % of the total global reserves
C (%) = % of the total global consumption
P (%) = % of the total global production
R/P (years) = reserves to production ratio

Extractable unconventional gas 500tcm

Extractable unconventional oil 350 Gt

Coal

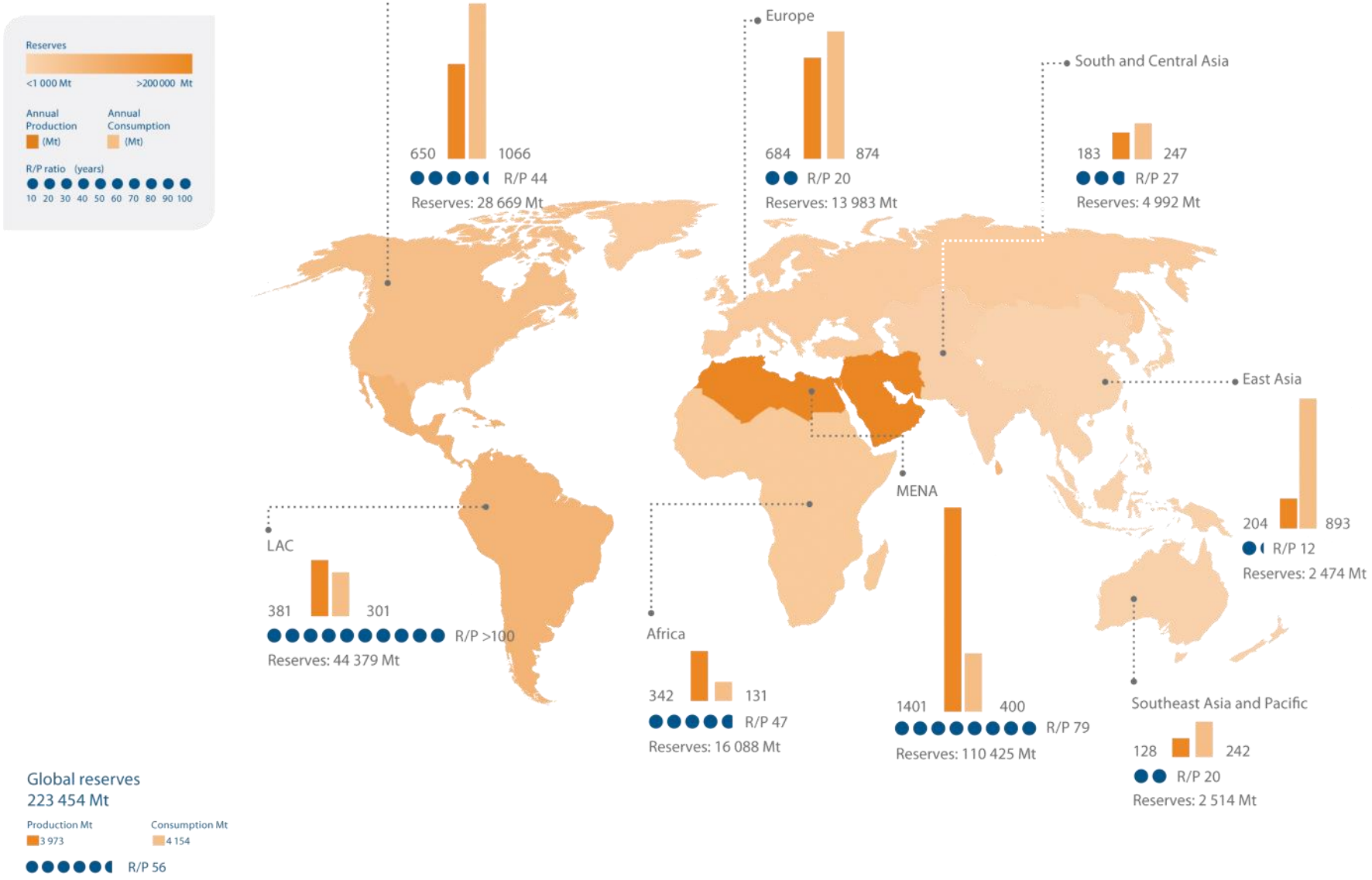


Coal

World Coal reserves	Reserves (Mt)		Production (Mt)		2011 R/P
Top 5 countries	**2011**	**1993**	**2011**	**1993**	**years**
United States of America	237 295	168 391	1 092	858	> 100
Russian Federation	157 010	168 700	327	304	> 100
China	114 500	80 150	3 384	1 150	34
Australia	76 400	63 658	398	224	> 100
India	60 600	48 963	516	263	> 100
Rest of World	245 725	501 748	1 805	1 675	> 100
World Total	**891 530**	**1 031 610**	**7 520**	**4 474**	**> 100**

Benefits	Drawbacks
Wide geographic distribution	High emissions of CO_2, particulates and other pollutants
Stable and predictable costs	Not suitable for peaking generation units
New technologies for coal improve efficiency and environmental performance	CCS/CCUS have negative impact on thermal plant efficiency and costs

Oil

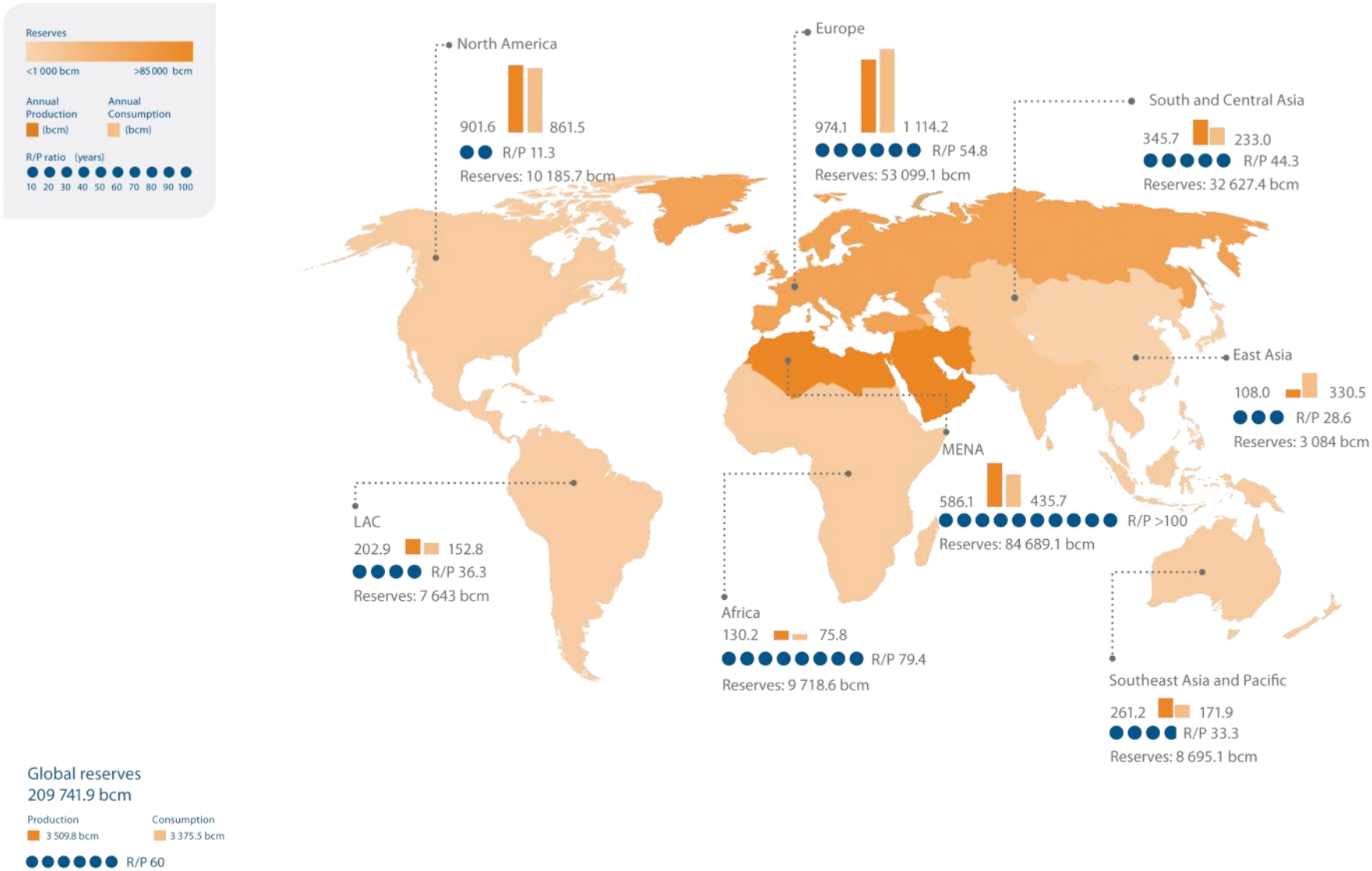


Oil

World Crude oil reserves	Reserves (Mt)		Production (Mt)		2011 R/P
Top 5 countries	**2011**	**1993**	**2011**	**1993**	**years**
Venezuela	40 450	9 842	155	129	> 100
Saudi Arabia	36 500	35 620	526	422	69
Canada	23 598	758	170	91	> 100
Iran	21 359	12 700	222	171	96
Iraq	19 300	13 417	134	29	> 100
Rest of World	82 247	68 339	2 766	2 338	30
World total	**223 454**	**140 676**	**3 973**	**3 179**	**57**

Benefits	Drawbacks
Currently indispensable for road transport and petrochemical industries	High price volatility
Leading tradable commodity	Geopolitical tensions related to areas of greatest reserves
Flexible, easy to transport fuel	Market dominated by leading oil producers (OPEC and large NOCs)

Natural gas



Gas

Natural gas reserves	Reserves (bcm)		Production (bcm)		2011 R/P
Top 5 countries	**2011**	**1993**	**2011**	**1993**	**years**
Russian Federation	47 750	48 160	670	604	71
Iran	33 790	20 659	150	27	> 100
Qatar	25 200	7 079	117	14	> 100
Turkmenistan	25 213	2 860	75	57	> 100
Saudi Arabia	8 028	5 260	99	36	81
Rest of World	69 760	57 317	2 407	1 438	22
World Total	**209 741**	**141 335**	**3 518**	**2 176**	**55**

Benefits	Drawbacks
Cleanest of fossil fuels	Fields increasingly in remote areas
Flexible and efficient fuel for power generation	High upfront investment requirement for transport and distribution system
Increasing proved reserves (reassessments and shale gas)	Increasingly long supply routes and high cost of infrastructure

World Energy Resources

OTHER RESOURCES

Global Nuclear Sector as of March 10th, 2011 – the day before Fukushima

Source: IAEA

Reactors in operation or under construction as of March 10th, 2011				
	In operation(1)		Under construction(2)	
	No.	GW	No.	GW
Europe	195	170.02	19	16.94
North America	124	114.62	1	1.17
Asia	117	85.75	43	42.82
South America	4	2.82	2	1.94
Africa	2	1.8	0	0
World Total	**442**	**375**	**65**	**62.87**

(1) For the main part of reactors in operation, extension of life for around 20 years.

(2) Countries with reactors under construction are: China - 27 reactors, Russia - 11, India - 5, South Korea - 5, Japan - 2, Slovakia - 2, Bulgaria - 2, Taiwan - 2, Ukraine - 2, Argentina - 1, Brazil - 1, Finland - 1, France - 1, Iran - 1, Pakistan - 1, USA - 1.

Global Nuclear Sector as of March 12th, 2013 – two years after Fukushima

Source: IAEA

Reactors in operation or under construction as of March 12th, 2013				
	In operation(1)		Under construction(2)	
	No.	GW	No.	GW
Europe	185	162.06	17	14.4
North America	124	114.47	3	3.7
Asia	120	87.97	46	47.84
South America	4	2.84	2	2.15
Africa	2	1.8	0	0
World Total	**435**	**370.13**	**68**	**68.09**

(1) For the main part of reactors in operation, extension of life for around 20 years.

(2) Countries with reactors under construction are: China – 28 reactors, Russia – 11, India – 7, South Korea – 4, USA – 3, Japan – 2, Slovakia – 2, Pakistan – 2, Taiwan – 2, Ukraine – 2, Argentina – 1, Brazil – 1, Finland – 1, France – 1, UAE – 1.

Uranium & Nuclear

The uranium resources in mines around the world would be sufficient to fuel today's inefficient reactors for over 100 years at the current production levels of ~2500TWh/year.

Nuclear	Installed Capacity (MW)		Actual Generation (GWh)	
Top 5 countries	**2011**	**1993**	**2011**	**1993**
United States of America	98 903	99 041	799 000	610 000
France	63 130	59 032	415 480	350 000
Japan	38 009	38 038	162 900	246 000
Russian Federation	23 643	19 843	122130	119 000
Korea (Republic)	20 718	7 615	98 616	58 100
Rest of World	119 675	116 726	605 597	722 900
World Total	**364 078**	**340 295**	**2 203 723**	**2 106 000**

Benefits	Drawbacks
High efficiency	High CAPEX and rising compliance costs
Moderate and predictable cost of electricity over the service life	Public concern about operation and final waste disposal
No CO_2 during operation	Liabilities in case of nuclear accident

Hydropower

Hydro Power	Installed Capacity (MW)		Actual Generation (GWh)	
Top 5 countries	**2011**	**1993**	**2011**	**1993**
China	249 000	44 600	714 000	138 700
Brazil	82 458	47 265	428 571	252 804
United States of America	77 500	74 418	268 000	267 326
Canada	75 104	61 959	348 110	315 750
Russian Federation	49 700	42 818	180 000	160 630
Rest of World	412 420	338 204	1 255 121	1 150 750
World Total	**934 733**	**609 264**	**3 193 802**	**2 285 960**

Benefits	Drawbacks
Low operating costs	High CAPEX
No waste or CO2 emissions during operation	Significant land requirement for large plants with dams/lakes
Reliable proven technology	Public resistance due to resettling or micro climate effects

BIOMASSES—BIOENERGY

- The **1,300 MT bioenergies** utilized in 2011 are the main energy resource after fossil fuels and are by far the largest contributor to RES and have a share of **8% of global primary energy resources**

- . More than **85% derive from wood biomasses,** around **8% from agriculture products and about 5% from waste of industries and municipalities**

BIOMASSES—BIOENERGY

- The **solid biofuels** (and those from wood as said before) are still the great majority but in the last 20 years have had an average annual growth of 1%

- **Liquid biofuels and biogas** in the last 20 years have had an AAG of 11% and 15 % respectively

BIOMASSES—BIOENERGY

International trade of biomasses/biofuels even if they are having a sharp increase represent only 2% of the total energy use of biomasses

Even if biofuels and biodiesel have had a strong increase in the last years,they represent to day only the 3 % of the global cosumption of fuels for transports

Increased uses of biomasses for co-combustion with fossil fuels

Bioenergy

TOTAL BIONERGY 1300 Mtoe---INTERNATINAL TRADED AS BELOW in PJ
1MT=42 PJ Source Heinimo et al.2013

Year/Product	2004	2005	2006	2007	2008	2009	2010	2011
Indirect trade	**585**	**640**	**636**	**671**	**606**	**493**	**598**	**648**
Industrial roundwood	450	488	488	507	431	341	404	444
Wood chips and particles	136	152	149	165	175	152	194	204
Direct trade	**203**	**230**	**292**	**337**	**467**	**449**	**438**	**500**
Charcoal	27	31	35		38	39	44	46
Fuel wood	33	35	39	38	38	51	51	60
Wood pellets	26	42	55	50	53	84	120	135
Biodiesel	**0**	**2**	**4**	**33**	**89**	**83**	**97**	**112**
Ethanol	**91**	**85**	**120**	**126**	**178**	**122**	**60**	**69**
Palm oil (and other vegetable oils for biodiesel)	**26**	**34**	**39**	**56**	**71**	**70**	**66**	**78**
World Total	**788**	**870**	**929**	**1009**	**1072**	**942**	**1036**	**1148**

Benefits	Drawbacks
Domestic Resources suitable for distributed generation	Transportation and processing implications
Proven combustion technologies, including co-firing	Emissions of NOx and SOx
Biofuels as alternative for transport	Energy – Water/Food aspects

BIOMASSES—BIOENERGY

The largest producers/consumers of bioenergy in general are China,India,Nigeria and United States,

The largest producers of biofuels from wood are India,China,Brazil,Ethiopia and Nigeria

The largest producers of liquid biofuels are Brazil (bioethanole) and US (biodiesel)

BIOMASSES—BIOENERGY

The development of biomasses for energy uses must co-exist with a sustainable use of water and lands dedicated to agricolture.And suitable lands dedicated to agriculture must be considered to feed appropiately the world increasing request of food

It is mandatory to avoid crazy incentives for bioenergies which could increase food prices and decrease the relevant production with serious impacts on poor poulations

Geothermal

- Two main technology uses – electricity generation and direct heating —HEAT PUMPS

Geothermal	Electricity generation	
	Installed Capacity (MW)	Annual Output (GWh)
Top 5 countries	2011	2011
United States of America	3 101	15 009
Philippines	1 904	10 311
Indonesia	1 197	9 321
Mexico	886	6 502
Italy	772	5 754
Rest of World	3 052	18 558
World Total	**10 912**	**65 455**

China – largest resource potential

Iceland – highest use of direct heating per capita

Benefits	Drawbacks
Suitable for baseload generation	High CAPEX
Proven technology with high potential	Deep wells (up to 5km)
Wide geographical distribution	Release of small fractions of controllable heavy elements

- Geothermal energy for direct heating (eg Island world record) or for heating and cooling through heat pumps(using thermal sinks of thermal energy close to the surface) is more than 10 times the geothermal energy for electricity production
- Great explosion of heat pumps

Wind

Wind	Installed Capacity (MW)		Actual Generation (GWh)	
Top 5 countries	**2011**	**1993**	**2011**	**1993**
China	62 364	15	73 200	-
United States of America	46 919	1 814	120 177	3 042
Germany	29 071	650	48 883	-
Spain	21 673	52	41 790	117
India	15 880	40	19 475	45
Rest of World	62 142	-	74 087	-
World Total **World Total in 2012**	**238 049** **~282 000**	**-**	**377 612** **~447 000**	**-**

Benefits	Drawbacks
Proven technology, quick installation and dismantling of onshore installations	Intermittency
No fuel required or waste produced	Grid integration challenges
Clean solution for remote areas	Reliance on subsidies

Solar PV

Solar (PV)	Installed Capacity (MW)		Actual Generation (GWh)	
Top 5 countries	**2011**	**1993**	**2011**	**1993**
Germany	25 039		19 340	-
Italy	12 773		10 730	-
United States of America	5 171	360	5 260	897
Spain	4 332		7 386	-
Japan	4 914		5 160	
Rest of World	16 621	-	22 364	-
World total **World total in 2012**	**68 850** **~100 000**	**-**	**70 240** **~100 000**	**-**

Benefits	Drawbacks
High reliability, no moving parts	Intermittency
Quick installation	Grid integration and operation challenges
Suitable solution for remote areas	Some components require toxic materials

Peat

Peat (for fuel)	Production (thousand tonnes)	Consumption (thousand tonnes)
Top 5 countries	**2008**	**2008**
Finland	4 770	7 910
Ireland	3 089	4 140
Belarus	2 944	2 240
Russian Federation	1 287	1 176
Sweden	701	1 065
Rest of World	733	803
World Total	**13 524**	**17 334**

Benefits	Drawbacks
Many uses (electricity, heat, agriculture, etc.)	CO_2 emissions
Major “carbon sinks”	Life cycle assessment issues
Large number of undisturbed peatland globally	Competition for land use

Marine

- **Technologies for the future**
- **Costly**
- **Need further development**

- **Tidal Energy:**
  - Barrages and Lagoons
  - Tidal Current Technologies

- **Wave Energy:**
  - Generation onshore or offshore
  - Equipment submerged or on surface

- **Ocean Thermal Energy Conversion (OETC)**
  - Land-based
  - Shelf-based
  - Floating

World Energy Resources

ENERGY EFFICIENCY

Energy Efficiency

- **Primary Energy Production** 14 000 MTEP
- **Final Consumption** 8 500 MTEP

40% is lost

To be effective it is necessary to take into account the entire energy value chain up to final consumption:

- extraction of primary energy
- transformation
- transport and distribution
- processing in machinery equipment for final uses

PLUS CHANGE OF HABITS

Energy Efficiency

The average **efficiency of world thermal power plants** is less than 33%

- If all coal and gas plants would have the present BAT (Best Available Technologies), the world could save at least:
  - 30% of the coal consumed every year to produce electricity and avoid 500 GW of coal plants
  - 30% of the gas consumed every year to produce electricity and avoid 300 GW of gas plants
  - 3 billion tonnes CO_2 / year

Energy Efficiency

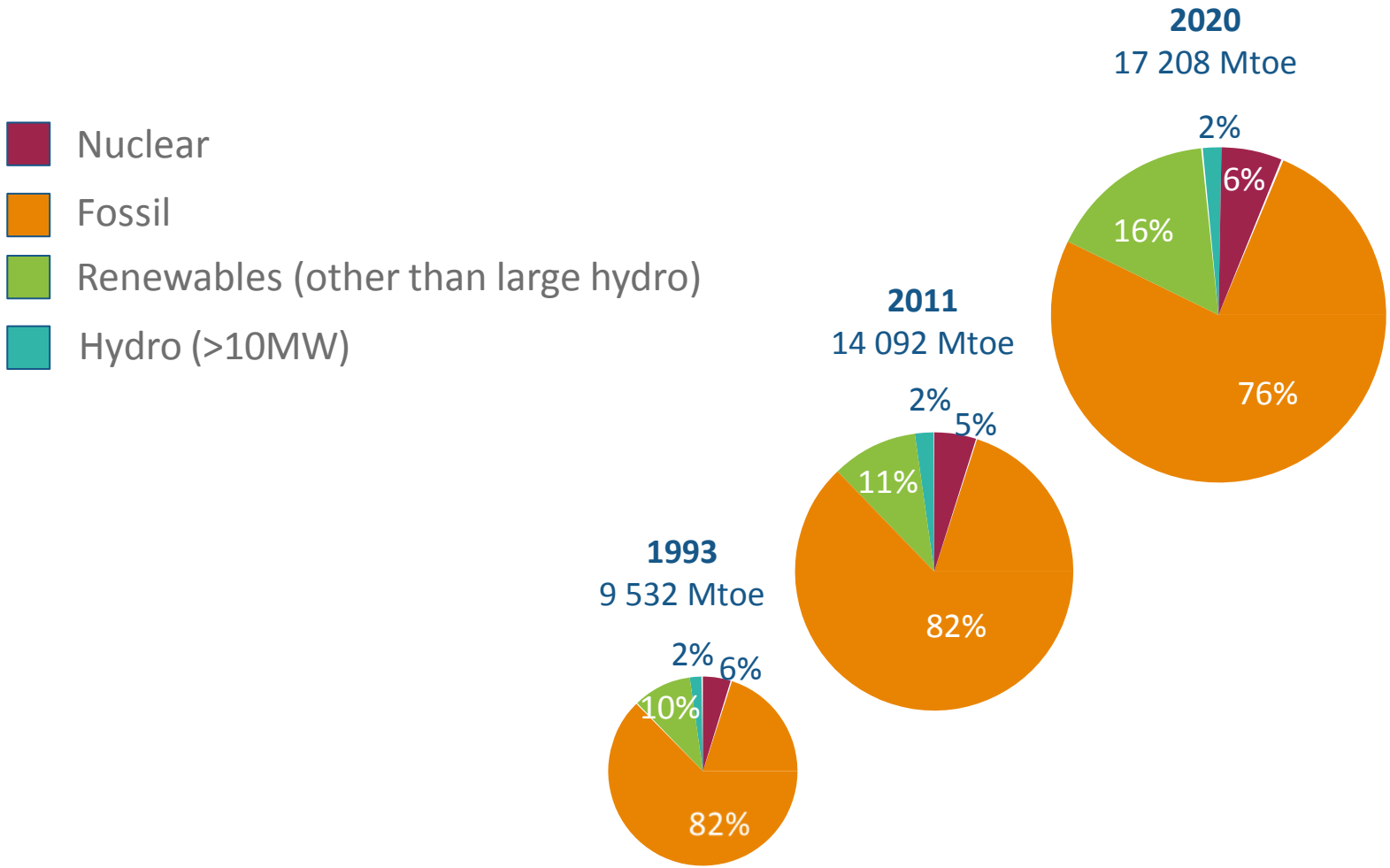
- **Electric motors** consume ~10,000 TWh p.a. which is equivalent to about 50% of total global electricity consumption
- By replacing old motors with new more efficient models, if necessary equipped by invertors, the world could save at least:
  - 1,000TWh of electricity per year (approx. total annual consumption of Japan)
  - 200GW of installed generation capacity (approx. 4 times peak demand capacity in Italy) and
  - 600,000 tonnes CO_2 / year

World Energy Resources

COMPARISONS AND CONCLUSIONS

Total Primary Energy Supply by resource 1993, 2011 and 2020

Source: WEC Survey of Energy Resources 1995, World Energy Resources 2013 and WEC World Energy Scenarios to 2050



	1993	2011	% Growth 1993-2011
Population, billion	5.5	7.0	**27%**
GDP			
Trillion USD	25	70	180%
TPES Mtoe/year PRODUCTION	9 532	14 092	**48%**
Coal Mt	4 474	7 520	68%
Oil Mt	3 179	3 973	25%
Natural Gas bcm	2 176	3 518	62%
Nuclear TWh	2 106	2 386	13%
Hydro Power TWh	2 286	3 229	41%
Biomass Mt	1 036	1 277	23%
Other renewables* TWh	44	515	more than……1000%
Electricity Production/year			
Total TWh	12 607	22 202	**76%**
Per capita MWh	2	3	52%
CO_2 emissions/year			
Total CO_2 Gt	21	30	44%
Per capita tonne CO_2	4	4	11%
Energy intensity koe/ 2005 USD	0.24	0.19	-21%

World Energy Resources

- There are huge reserves of conventional fossil fuels
- Reserves/Production Ratios (R/P) for the main resources
  - Coal (for over 100 years at current production levels)
  - Oil (>56 years) and Natural gas (>60 years)
  - Plus enormous amounts of unconventional oil and gas

  In addition, over the past 20 years proved reserves have increased by 60% for oil and 48% for natural gas
  - Abundance of fossil fuels will continue for decades (the feared "peak oil" crisis is not likely to happen any time soon)
- The main issues today are not security of supply at global level but
  - Environmental impacts of energy production and use
  - Geographical concentration of fossil resources (oil/gas) in a few specific areas

World Energy Resources

Changes in shares of the leading energy resources in Total Primary Energy Supply		
	Share of total 2012	**Share of total 2002**
Oil	31%	37%
Coal	28%	23.5%
Gas	23%	21%
Biomass	9.5%	9.5%
Nuclear	5%	6.5%
Hydro	2.3%	2.4%
Other renewables	1.2%	Negligible

World Energy Resources

- Apart from new renewable energy sources, coal has had the strongest consumption % growth, since it is used on a large scale in countries like China and India for electricity production
- Oil has been loosing its role as the great leading energy resource, as per cent of the total

Fossil fuels account for 82% of global total energy use of mankind

World Energy Resources

- **Total Global Electricity Production: ~22.000TWh/p.a.**

Coal	40%
Gas	22.5%
Hydro	16.0%
Nuclear	13.0%
Oil	4.0%
Wind	2.4%
Other renewables (including photo voltaics 0.4%)	2.1%

Share of fossil fuels in fuel mix for power generation is 66% and it has grown by 2% over the past 10 years

World Energy Resources

- The main drivers in energy sector over the past 20 years:
  - Emergence of environmental issues but not common approach to emissions reductions; collapse of CO_2 price in EU ETS
  - Continued growth in energy consumption, electricity in particular
  - Explosive increase in renewables and especially Wind and PV, mainly in Europe due to generous government subsidies over the past 10 years; however the share of renewables still remains at about 1% of the total primary energy resource endowment and about 3% in electricity production
  - In 10 years low oil prices of approx. 30USD per barrel have increased significantly since 2001 reaching the average of 100USD

World Energy Resources

- The main drivers in energy sector over the past 20 years:
  - Impact of Fukushima on nuclear industry
  - Financial and economic crisis and its impact on energy consumption trends, in industrialised countries in particular
  - Development of shale gas in the United States with a drop in local gas prices which are 1/3 of gas prices in Europe and 1/5 of those in Far East
  - The “Arab Spring”
  - Energy Efficiency potential which failed to materialise
  - Growing influence of public opinion on energy policies
  - Rapid spread of information technologies in all sectors

Thank you for your attention

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