WORLD ENERGY COUNCIL
CONSEIL MONDIAL DE L'ÉNERGIE
For sustainable energy.

World Energy Resources

2013 Survey: Summary

WORLD ENERGY COUNCIL
CONSEIL MONDIAL DE L'ÉNERGIE

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Foreword

As energy is the main 'fuel' for social and economic development, and since energy-related activities have significant environmental impacts, it is important for decision-makers to have access to reliable and accurate data in an user-friendly format. WEC has for decades been a pioneer in the field of energy resources and every three years publishes its flagship report Survey of Energy Resources (SER) which is released during the World Energy Congress. *World Energy Resources* (WER) 2013 is the new title of this publication and in fact is the 23rd edition for the Survey of Energy Resources. The survey is recognised worldwide as the premier source of information on global energy resources. Its reputation and value since the first edition in 1933 rest on two main factors: the study presents unbiased data and facts from an independent and impartial organisation, and the second factor is the sheer amount of resource and other key energy data together with analysis of technological, economic and environmental aspects assessed on global, regional and country levels.

The 2013 report covers all fossil resources (coal, oil, both conventional and unconventional and gas, both conventional and unconventional), and the main renewable and transitional resources: peat, nuclear and uranium, hydro power, biofuels and waste, wind, solar, geothermal and marine energies. This edition also discusses energy efficiency as a strategic 'energy resource' because every unit of energy saved – a so-called 'negajoule' – is less expensive than producing the same amount of energy.

Each of the 12 chapters is organised in three sections: an introduction covering technical, economic and market issues; detailed tables with global, regional and country data for proved reserves and production followed by country notes. The information comes from a variety of international sources, including the contributions of resource experts and data from the WEC Members Committees. The new structure of the energy sector post-market liberalisation and privatisation has made it difficult to access data and other information as companies and other organisations consider the majority of data as "confidential and commercially sensitive."

An extra feature of this 2013 survey is a review of the energy resources evolution over the past 20 years. The results of the current WEC work are compared to the projections made by the WEC in its milestone report, *Energy for Tomorrow's World*, published in 1993. The 2013 Summary also looks at the main factors that have influenced the development of the global energy sector the most over the past two decades.

The world around us has changed significantly over the past 20 years. The following principal drivers have been shaping energy supply and use:

- sharp increase in the price of oil since 2001 after 15 years of moderate oil prices
- financial crisis and slow economic growth with drastic reduction in energy consumption in large economies
- shale gas in North America
- Fukushima Daiichi nuclear accident
- The volatile political situation in the energy supplying countries in the Middle East and North Africa, "The Arab Spring"
- lack of global agreement on climate change mitigation
- collapse of CO_2 prices in the European Emissions Trading System
- exponential growth in renewables, in particular in Europe due to generous subsidies for producers which can become a problem instead of an opportunity
- deployment of 'smart' technologies
- energy efficiency potential still remaining untapped
- growing public concerns about new infrastructure projects, including energy projects and their impact on political decision-making process

I am grateful to all those who have helped to produce the 2013 report, including Study Group Members, WEC Member Committees, leading energy institutions and individual experts. My special thanks for the coordination, guidance and management to the WEC Secretariat with excellent and highly professional contributions from Elena Nekhaev, Director of Programmes, and Paul Benfield, Senior Project Manager.

Alessandro Clerici
Executive Chair, WEC World Energy Resources

Chair	**Alessandro Clerici** **CESI S.p.A.** Italy
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Study Group Members

Bongani Thusi
Ministry of Natural Resources and Energy – Swaziland
Swaziland

Brigitte Svarich
Energy Council of Canada
Canada

Fabian Melon
PricewaterhouseCoopers (PwC)
Germany

Fabio Emiro Sierra Vargas
National University of Colombia
Colombia

Firouzeh Amini
Iran

Gerardo Rabinovich
Argentina

Greg Schmidt
Energy Council of Canada
Canada

Iulian Iancu
Government of Romania
Romania

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Jose Antonio Tagle
IBERDROLA
Spain

Klaus Hammes
Swedish Energy Agency
Sweden

Luca Lo Re
BNL Clean Energy AG
France

Marc Florette
GDF SUEZ
France

Mark Bohm
Suncor Energy Inc.
Canada

Michael W. Howard
EPRI
United States of America

Mostafa Tavanpoor Paveh
Iran

Pasquale Monti
Enel GreenPower
Italy

Paul Cheliak
Canadian Gas Association
Canada

Roland Luebke
German Coal Association
Germany

Sandra Scalari
ENEL S.p.A.
Italy

Sylvain Hercberg
EDF Energy plc
France

Tiina Koljonen
Technical Research Centre of Finland (VTT)
Finland

Uwe Maaßen
Deutscher Braunkohlen Industrie Verein e.V.
Germany

Volker Breisig
PricewaterhouseCoopers (PwC)
Germany

Wayne Chodzicki
KPMG LLP
Canada

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Introduction

This summary of the World Energy Resources report is primarily based on the results of the WEC's work programme since the World Energy Congress in Montreal in 2010. Focusing on energy resources, the summary also takes into account relevant insights from WEC Member Committees and other studies and programmes, such as Energy Efficiency Policies and Technologies, Performance of Generating Plant, Cost of Energy Technologies conducted together with Bloomberg New Energy Finance, Energy Trilemma, World Energy Scenarios to 2050 and other reports (www.worldenergy.org/publications).

The World Energy Council has been producing the Survey of Energy Resources report since 1933. This 23rd edition of the Survey will be published under the new title World Energy Resources (WER). Over decades the report has been the most widely recognised and authoritative publication on global energy resources and millions of copies of the report have been downloaded from the WEC website. The survey covers:

Coal

Oil

Natural Gas

Uranium & Nuclear

Hydro Power

Bioenergy & Waste

Wind

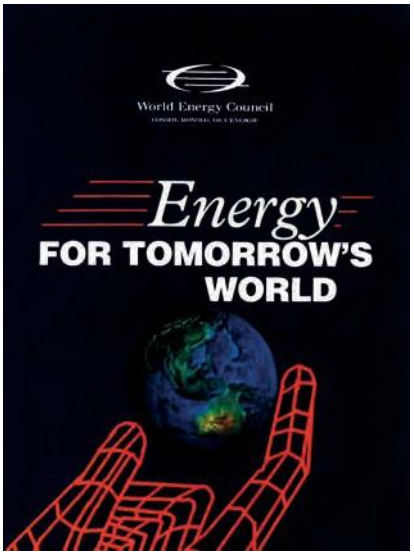
Solar PV

Geothermal

Peat

Marine Energies

Energy Efficiency



'The WEC Report presents energy issues of global importance in a responsible and balanced manner, providing a most useful contribution to the debate on these topics.'

John S Jennings, Managing Director, Royal Dutch Shell/Shell Group

'This report is a major statement that not only signals a broadening of perspectives of the global energy community, which the WEC effectively represents, but also a landmark in addressing issues of sustainable development.'

RK Pachauri, Director General, The Energy and Resources Institute (TERI) and Chair of the Intergovernmental Panel on Climate Change (IPCC)

An extra feature of the 2013 report presents an historical perspective on energy resources and a few important energy issues that are based on the comparative analysis of statistics, findings and assumptions and their evolution over the past 20 years. The results of the report are compared to the projections made by the WEC in its milestone report *Energy for Tomorrow's World* published in 1993. That report was produced with significant support from private companies from WEC Member Committees, public utilities, governments, academia and prominent individuals, altogether more than 500 experts representing nearly 100 countries including all of the major energy production and consumption markets. *Energy for Tomorrow's World* firmly put WEC on the map of leading global energy bodies.

2013 is a good moment to stop and look back, particularly since this year WEC is celebrating its 90th birthday. If one had to choose from a number of assumptions which over the past two decades had influenced the development of the global energy sector most, the majority would perhaps pick the environment and especially climate change. Renewable energy would also be at the top of the list of decisive factors. The energy sector looked different until the UN Framework Convention on Climate Change was signed in Rio de Janeiro in 1992. Since then, sustainable development has become one of the principal drivers shaping the energy future of the world.

The energy sector has long lead times and therefore any long-term strategy should be based on sound information and data. Detailed resource data, selected cost data and a technology overview in the main WER report provide an excellent foundation for assessing different energy options based on factual information supplied by the WEC members from all over the world.

What has changed?

The world around us has changed significantly over the past 20 years. Technology has become one of the main drivers of economic and social development. The rapid advancement of Information Technology (IT) all over the world has transformed not only the way we think, but also the way we act. All aspects of human life have been affected by IT and the Internet, in particular. Needless to say that practically all technologies run on electricity and therefore the share of electricity is increasing rapidly, faster than Total Primary Energy Supply(TPES).

Table 1: Key indicators for 1993, 2011 and 2020

Source: 1993, 2020 figures from Energy for Tomorrow's World (WEC, 1995). 2011 figures from World Energy Resources (WEC, 2013). Other renewables 2020 figure from World Energy Scenarios report (WEC, 2013)

	1993	2011	2020	% Growth 1993-2011
World Population, billion	5.5	7	8.1	27%
GDP, trillion USD	25	70	65	180%
TPES, Mtoe	9 532	14 092	17 208	48%
Coal, Mt	4 474	7 520	10 108	68%
Oil, Mt	3 179	3 973	4 594	25%
Natural Gas, bcm	2 176	3 510	4 049	62%
Nuclear, TWh	2 106	2 386	3 761	13%
Hydropower, TWh	2 286	3 229	3 826	29%
Biomass, Mtoe	1 036	1 277	1 323	23%
Other renewables*, TWh	44	515	1 999	n/a
Total Electricity production/year, TWh	12 607	22 202	23 000	76%
Electricity production/year, MWh per capita	2	3	3	52%
Total CO_2 emissions/year, $GtCO_2$	21	30	42	44%
CO_2 emissions/year, tonne CO_2 per capita	4	4	n/a	11%
Energy intensity, koe/2005USD	0.24	0.19	n/a	-21%

* Includes figures for all renewables, except Hydro

Population growth has always been and will remain one of the key drivers of energy demand, along with economic and social development. While global population has increased by over 1.5 billion over the past two decades, the overall rate of population growth has been slowing down. The number of people without access to commercial energy has reduced slightly, and the latest estimate from the World Bank indicates that it is 1.2 billion people.

The only renewable energy resources for which projections were made in 1993 were hydro power and biomass. The contribution of renewables was not very significant in those days, and the rest of the renewables were not taken into consideration individually, but combined into one group called Other Renewables. For comparability, the same resources are included under this heading for 2011. They are however, presented separately in the full World Energy Resources 2013 report.

Table 1 shows the actual values for a number of indicators recorded in 1993, the status of these indicators in 2011 and the projections for 2020 made in *Energy for Tomorrow's World*, High-Growth Scenario A to 2020. The comparison demonstrates that future developments are often underestimated. Even the highest projections made 20 years ago, fall below the reality. What does it mean? It means that the demand for energy might grow significantly faster than expected, and if properly managed, energy resources and technologies should be available to meet this demand.

The changes in the energy industry over the past 20 years have been significant. Looking at the results of the present 2013 WEC World Energy Resources survey, it becomes evident that there are more energy resources in the world today than ever before. However, the increase in resource assessments in 2013, in many cases, can be attributed to new, more efficient technologies. As the international definition used by the United Nations stipulates:

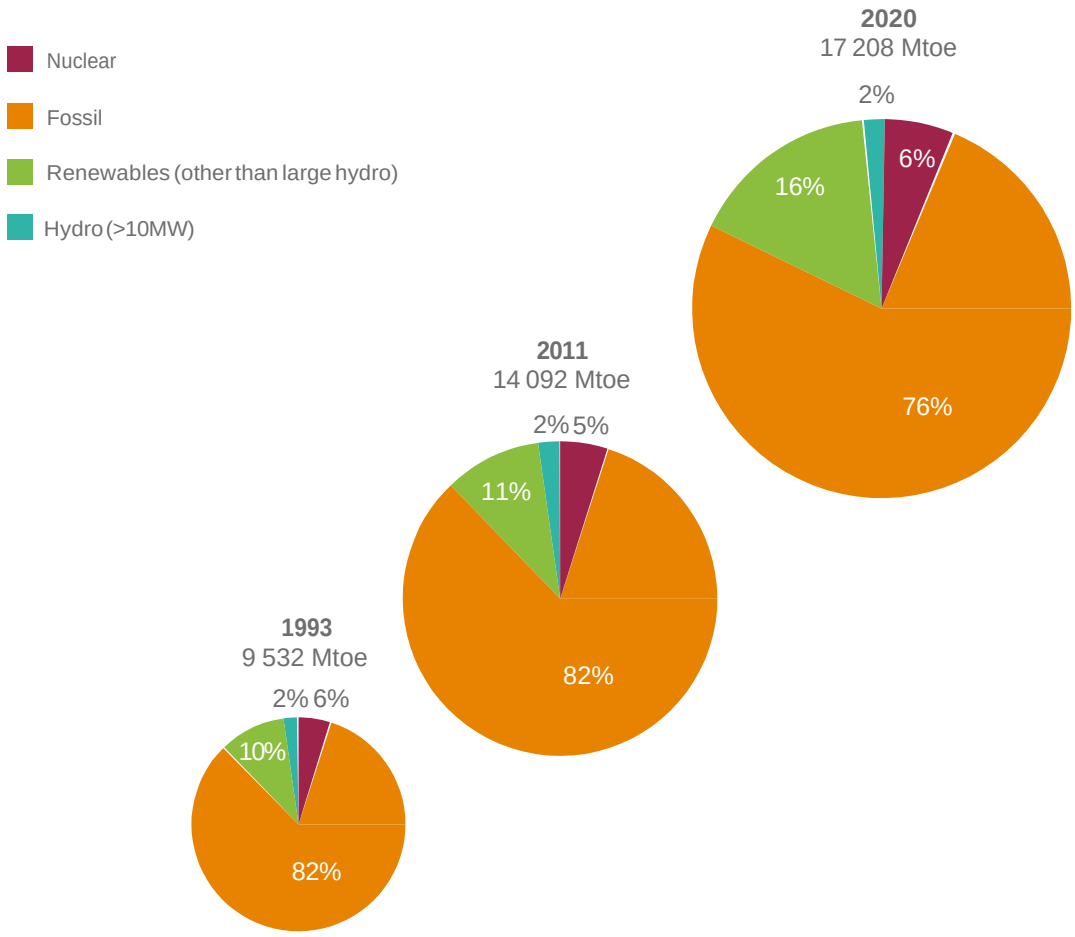
> "Proved recoverable reserves are the quantity within the proved amount in place that can be recovered in the future under present and expected local economic conditions with existing available technology."

The recent shale gas developments in the United States clearly demonstrate this concept and the role of technologies. The enormous resources of shale gas have always been there, but it is only since the introduction of hydraulic-fracturing technology at an economically attractive price, that the gas market revolution has become a reality.

The general message emerging from the 2013 survey confirms that the main fossil fuels: coal, oil and natural gas are plentiful and will last for decades.

Total Primary Energy Supply by resource 1993, 2011 and 2020

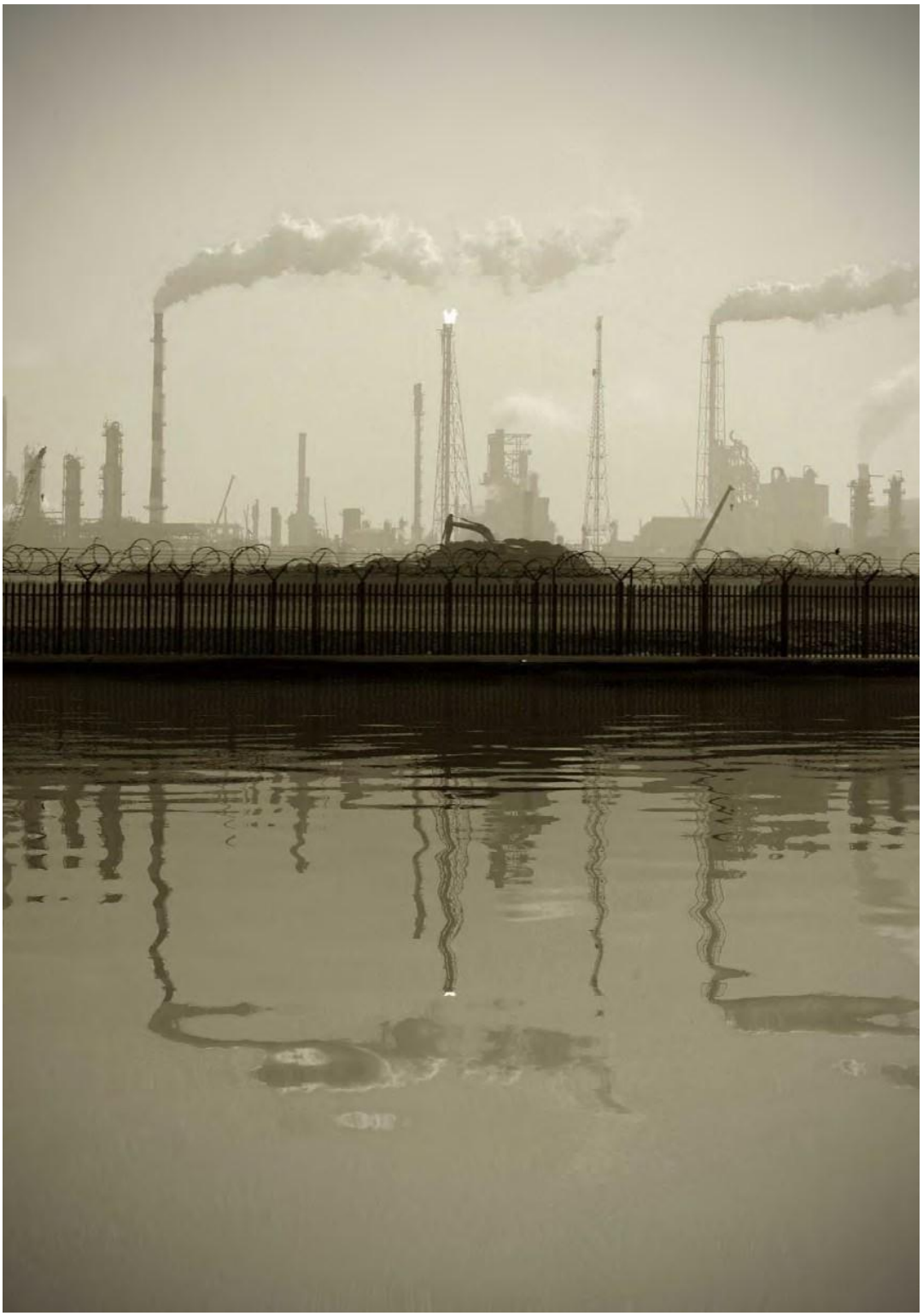
Source: WEC Survey of Energy Resources 1995, World Energy Resources 2013 and WEC World Energy Scenarios to 2050



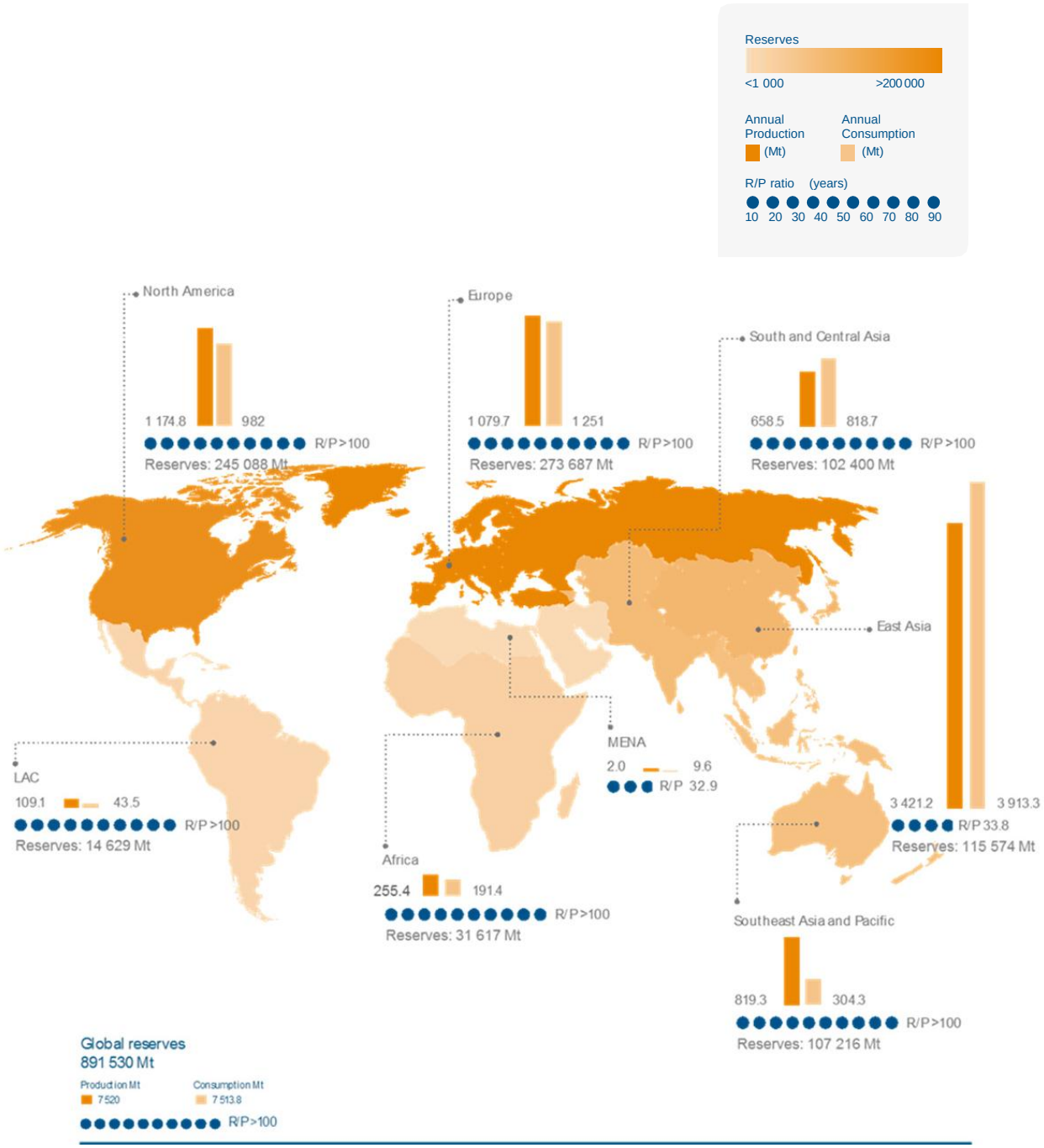
The supply and use of energy have powerful economic, social and environmental impacts. Not all energy is supplied on a commercial basis. Fuels, such as fuelwood or traditional biomass are largely non-commercial. Fuelwood is playing a leading role in the developing countries, where it is widely used for heating and cooking.

Universal access to commercial energy still remains a target for the future. In many countries, especially in Africa and Asia, the pace of electrification lags far behind the growing demand. It is imperative to address this major challenge without further delays, in particular taking into account the impact access to electricity has on peoples' lives and well-being, economic growth and social development, including the provision of basic social services, such as health and education.

Establishment of energy infrastructure in the least developed countries will need a major effort on behalf of the global energy community. It will also require political, legal and institutional structures, which today do not exist. Rising energy demand, declining public investment and the evolving role of the multilateral financial institutions need increased efforts by governments to change their roles in order to create an enabling business environment to attract private investment, both domestic and international.



Coal



Despite its poor environmental credentials, coal remains a crucial contributor to energy supply in many countries. Coal is the most wide-spread fossil fuel around the world, and more than 75 countries have coal deposits. The current share of coal in global power generation is over 40%, but it is expected to decrease in the coming years, while the actual coal consumption in absolute terms will grow. Although countries in Europe, and to some extent North America, are trying to shift their consumption to alternative sources of energy, any reductions are more than offset by the large developing economies, primarily in Asia, which are powered by coal and have significant coal reserves. China alone now uses as much coal as the rest of the world.

The continuing popularity of coal becomes particularly obvious when compared to the current production figures with those from 20 years ago. While the global reserves of coal have decreased by 14% between 1993 and 2011, the production has gone up by 68% over the same time period. Compared to the 2010 survey, the most recent data shows that the proved coal reserves have increased by 1% and production by 16%. The future of coal depends primarily on the advance of clean coal technologies to mitigate environmental risk factors, CO_2 emissions, in particular. Today Carbon Capture Utilisation and Storage (CCS/CCUS) is the only large-scale technology which could make a significant impact on the emissions from fossil fuels. It is, however, still at the pilot stage and its future is uncertain, mainly because of the high costs and efficiency penalty.

Coal is playing an important role in delivering energy access, because it is widely available, safe, reliable and relatively low cost. One of the major challenges facing the world at present is that approximately 1.2 billion people live without any access to modern energy services. Access to energy is a fundamental pre-requisite for modern life and a key tool in eradicating extreme poverty across the globe.

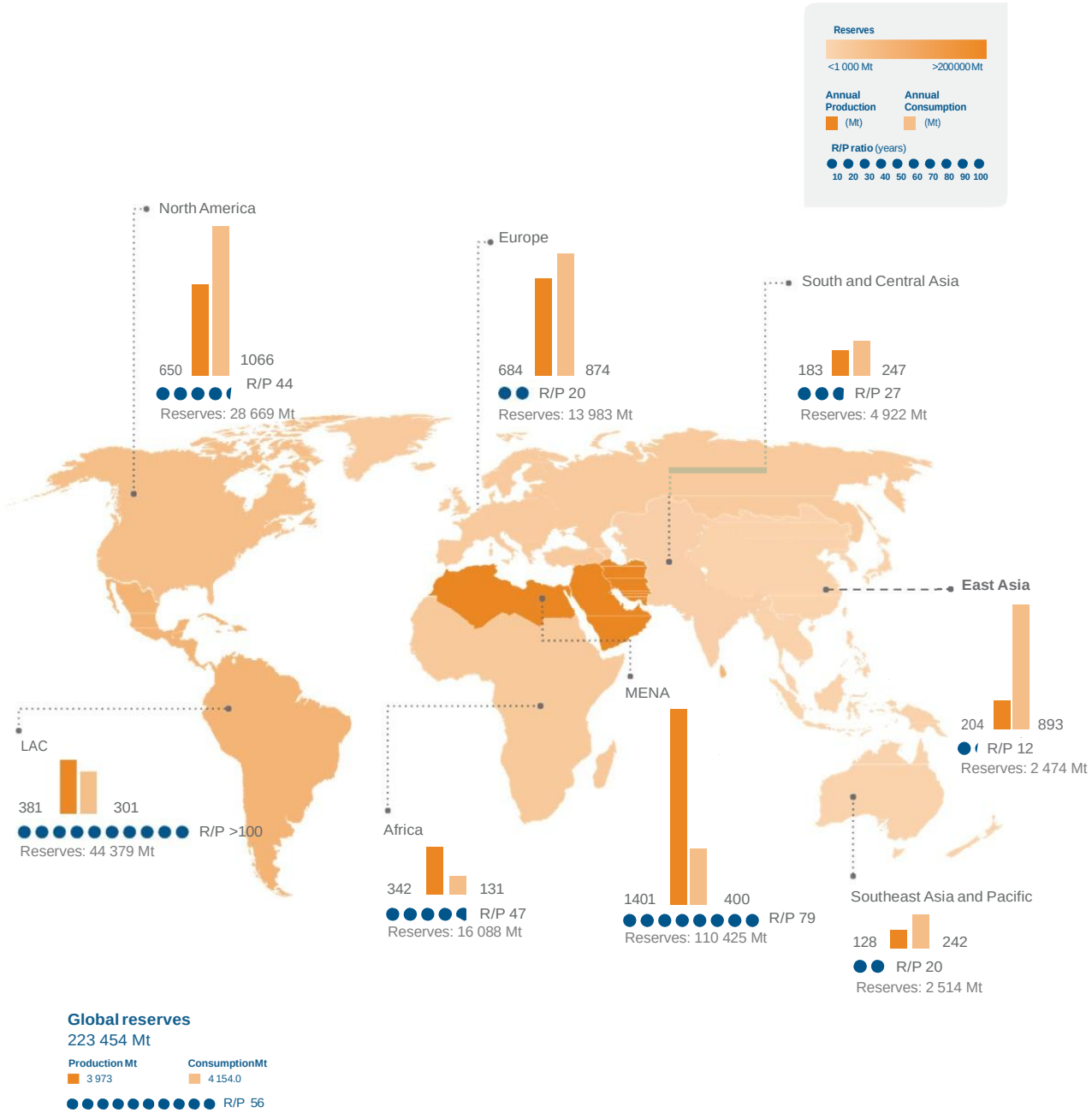
Coal resources exist in many developing countries, and this report demonstrates that many countries with electricity challenges, particularly those in Asia and southern Africa, are able to access coal resources in an affordable and secure way to fuel the growth in their electricity supply. Coal will therefore play a major role in supporting the development of base-load electricity where it is most needed. Coal-fired electricity will be fed into national grids and it will bring energy access to millions, thus facilitating economic growth in the developing world.

Coal reserves: top 5 countries

	Reserves (Mt)		Production (Mt)		2011 R/P
Country	**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**

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

Oil



The oil crisis in the 1970s and 1980s resulted in long queues outside petrol stations and the sky-rocketing price of oil. In the following years, heated discussions about “peak oil” were based on the expectation of the world running out of oil within a few decades. Now in 2013, the peak oil issue is not making headlines any longer, however since oil is a finite resource this issue will return in the future. Global oil reserves are almost 60% larger today than 20 years ago, and production of oil has gone up by 25%.

If the unconventional oil resources, including oil shale, oil sands, extra heavy oil and natural bitumen are taken into account, the global oil reserves will be four times larger than the current conventional reserves. Oil still remains the premier energy resource with a wide

range of possible applications. Its main use however, will be shifting towards transport and the petrochemical sector. In future oil's position at the top of the energy ladder will face a strong challenge from other fuels such as natural gas. The oil resource assessments have increased steadily between 2000 and 2009, and about a half of this increase is due to the reclassification of the Canadian oil sands and the revisions undertaken in major OPEC countries: Iran, Venezuela and Qatar. Compared to the 2010 survey the proved oil reserves increased by 37% and production by 1%.

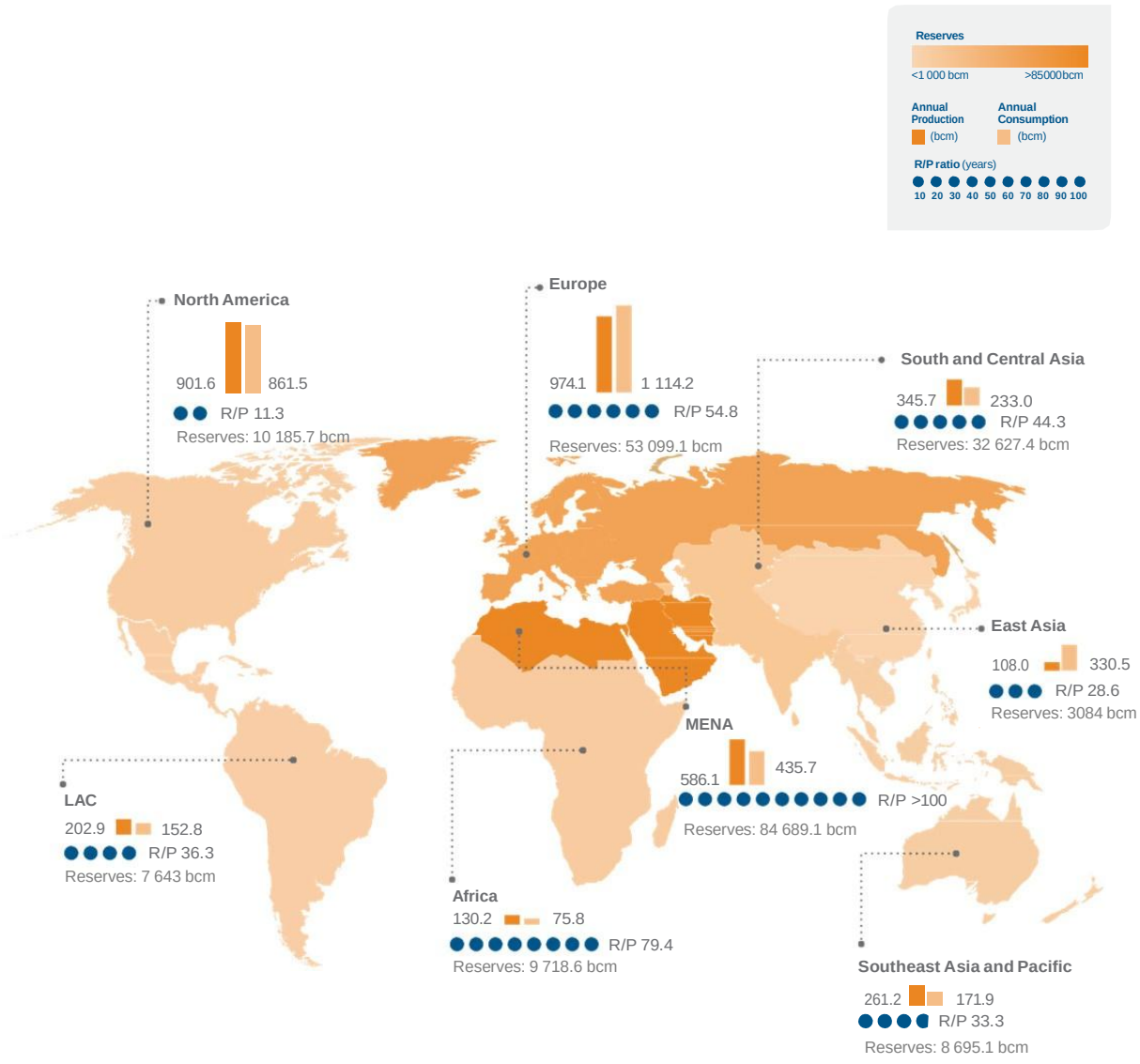
Oil is a mature global industry which offers the market participants opportunities for good economic returns. The balance between returns on capital and host countries' interests is a delicate matter. A number of countries, for political reasons, have limited the access of international companies.

Crude oil reserves: top 5 countries

	Reserves (Mt)		Production (Mt)		R/P
Country	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**	**56**

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



Global reserves
209 741.9 bcm

Production 3 509.8 bcm
Consumption 3 375.5 bcm
R/P 60

Natural gas is yet another fossil fuel resource that will continue making significant contribution to the world energy economy. The cleanest of all fossil-based fuels, natural gas is plentiful and flexible. It is increasingly used in the most efficient power generation technologies, such as, Combined Cycle Gas Turbine (CCGT) with conversion efficiencies of about 60%. The reserves of conventional natural gas have grown by 36% over the past two decades and its production by 61%. Compared to the 2010 survey, the proved natural gas reserves have grown by 3% and production by 15%.

The exploration, development and transport of gas usually requires significant upfront investment. Close coordination between investment in the gas and power infrastructure is necessary.

In its search for secure, sustainable and affordable supplies of energy, the world is turning its attention to unconventional energy resources. Shale gas is one of them. It has turned upside down the North-American gas markets, and is making significant strides in other regions.
The emergence of shale gas as a potentially major energy source can have serious strategic implications for geopolitics and the energy industry. The most credible studies put the global shale gas resource endowment at 456 tcm. There are about 700 known shales worldwide in more than 150 basins. At present only a few of these shales have had properly assessed production potentials, most of those are in North America. The potential volumes of shale gas are enormous and this is likely to reshape significantly the gas markets and LNG markets worldwide.

Natural gas reserves: top 5 countries

	Reserves (bcm)		Production (bcm)		R/P
Country	**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	69 761	57 317	2 398.8	1 438	22
World Total	**209 742**	**141 335**	**3 509.8**	**2 176**	**60**

Benefits	Drawbacks
Cleanest of fossil fuels	Fields increasingly off-shore and 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

Uranium and Nuclear

The nuclear industry has a relatively short history: the first nuclear reactor was commissioned in 1954. Uranium is the main source of fuel for nuclear reactors. Worldwide output of uranium has recently been on the rise after a long period of declining production caused by oversupply following nuclear disarmament. The present survey shows that total identified uranium resources have grown by 12.5% since 2008 and they are sufficient for over 100 years of supply based on current requirements.

Total nuclear electricity production has been growing during the past two decades and reached an annual output of about 2 600TWh by the mid-2000s, although the three major nuclear accidents have slowed down or even reversed its growth in some countries. The nuclear share of total global electricity production reached its peak of 17% by the late 1980s, but since then it has been falling and dropped to 13.5% in 2012. In absolute terms, the nuclear output remains broadly at the same level as before, but its relative share in power generation has decreased, mainly due to Fukushima nuclear accident.

Japan used to be one of the countries with a high share of nuclear (30%) in its electricity mix and high production volumes. Today, none of its 54 reactors is in operation. The rising costs of nuclear installations and lengthy approval times required for new construction have had an impact on the nuclear industry. The slowdown has not been global, as new countries, primarily in the rapidly developing economies in the Middle East and Asia, are going ahead with their plans to establish a nuclear industry.

Nuclear Power: top 5 countries 2011

Nuclear	Installed Capacity (MW)		Actual Generation (GWh)	
Country	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	122 130	119 000
Korea (Republic)	20 718	7 615	98 616	58 100
Rest of World	119 675	116 726	787 777	722 900
World Total	**364 078**	**340 295**	**2 385 903**	**2 106 000**

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

Hydro Power

Hydro power provides a significant amount of energy throughout the world and is present in more than 100 countries, contributing approximately 15% of the global electricity production. The top 5 largest markets for hydro power in terms of capacity are Brazil, Canada, China, Russia and the United States of America. China significantly exceeds the others, representing 24% of global installed capacity. In several other countries, hydro power accounts for over 50% of all electricity generation, including Iceland, Nepal and Mozambique for example. During 2012, an estimated 27–30GW of new hydro power and 2–3GW of pumped storage capacity was commissioned.

In many cases, the growth in hydro power was facilitated by the lavish renewable energy support policies and CO_2 penalites. Over the past two decades the total global installed hydro power capacity has increased by 55%, while the actual generation by 21%. Since the last survey, the global installed hydro power capacity has increased by 8%, but the total electricity produced dropped by 14%, mainly due to water shortages.

Hydro Power: top 5 countries

Hydro Power	Installed Capacity (MW)		Actual Generation (GWh)	
Country	2011	1993	2011	1993
China	231 000	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	430 420	338 204	828 437	1 150 750
World Total	**946 182**	**609 264**	**2 767 118**	**2 285 960**

Benefits	Drawbacks
Low operating costs	High CAPEX
No waste or CO_2 emissions	Significant land requirement for large plants with dams/lakes
Simple proven technology	Public resistance due to relocation or micro climate effects

Wind

Wind is available virtually everywhere on earth, although there are wide variations in wind strengths. The total resource is vast; estimated to be around a million GW 'for total land coverage'. If only 1% of this area was utilised, and allowance made for the lower load factors of wind plants (15–40%, compared with 75–90% for thermal plants) that would still correspond, roughly, to the total worldwide production of all electricity-generating plants in operation today.

World wind energy capacity has been doubling about every three and a half years since 1990. Total capacity at the end of 2011 was over 238GW and annual electricity generation around 377TWh, roughly equal to Australia's annual electricity consumption. China, with about 62GW, has the highest installed capacity while Denmark, with over 3GW, has the highest level per capita. Wind accounts for about 20% of Denmark's electricity production. It is difficult to compare today's numbers with those two decades ago.

As governments begin to cut their subsidies to renewable energy, the business environment becomes less attractive to potential investors. Lower subsidies and growing costs of material input have a negative impact on the wind industry in recent years. Not all planned projects have been implemented.

Wind power: top 5 countries

Wind	Installed Capacity (MW)		Actual Generation (GWh)	
Country	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	**238 049**	–	**377 613**	**–**

Benefits	Drawbacks
Well-known technology, quick installation and dismantling of onshore installations	Intermittency
No fuel or waste costs	Grid integration challenges
Clean solution for remote areas	Reliance on subsidies

Solar PV

Solar energy is the most abundant energy resource and it is available for use in its direct (solar radiation) and indirect (wind, biomass, hydro, ocean etc.) forms. Even if only 0.1% of this energy reaching the Earth could be converted at an efficiency of 10%, it would be four times larger than the total world's electricity generating capacity of about 5 000GW. The statistics about solar PV installations are patchy and inconsistent. The tables below presents the values for 2011 but comparable values for 1993 are not available.

The use of solar energy is growing strongly around the world, in part due to the rapidly declining solar panel manufacturing costs and lavish subsidies, in particular in Europe. For instance, between 2008–2011 PV capacity has increased in the USA from 1 168MW to 5 171MW, and in Germany from 5 877MW to 25 039MW. The anticipated changes in national and regional legislation regarding support for renewables are likely to moderate this growth.

League tables reserves: top 5 countries

Solar (PV)	Installed Capacity (MW)		Actual Generation (GWh)	
Country	**2011**	**1993**	**2011**	**1993**
Germany	25 039	–	19 340	–
Italy	12 773	–	10 730	–
United States of America	5 171	360	5 260	897
Japan	4 914	–	5 160	–
Spain	4 332	–	7 386	–
Rest of World	16 621	–	5 002	–
World Total	**68 850**	**–**	**52 878**	**–**

Benefits	Drawbacks
High reliability, no moving parts	Intermittency
Quick installation and dismantling	Grid integration challenges
Suitable solution for remote areas	Use of toxic materials in some models

Bioenergy and waste

Bioenergy is a broad category of energy fuels manufactured from a variety of feedstocks of biological origin and by numerous conversion technologies to generate heat, power, liquid biofuels and gaseous biofuels. The term “traditional biomass” mainly refers to fuelwood, charcoal, and agricultural residues used for household cooking, lighting and space-heating in developing countries.

The industrial use of raw materials for production of pulp, paper, tobacco, pig iron so on, generates byproducts such as bark, wood chips, black liquor, agricultural residues, which can be converted to bioenergy.

In the biofuels area, the two prime examples of Brazil and the United States demonstrate the possibilities for the use of biofuels in road transport. At present the share of biofuels for mobility is about 2% of the world total and it is expected to reach 5% by 2030.

Biogas and biomass are traditionally used for heating, but recently a remarkable increase in their use for electricity production has taken place in some countries, as combustion technologies become more efficient.

When it comes to waste, the incinerators are primarily designed for reduction of the growing volumes of waste to alleviate waste disposal, not for production of electricity. Therefore, waste’s contribution to primary energy supply will remain minimal, although some interesting applications are emerging, for instance in district heating systems.

The share of bioenergy in TPES has been estimated at about 10% in 1990. Between 1990 and 2010 bioenergy supply has increased from 907 to 1240 Mtoe as a result of growing energy demand. New policies to increase the share of renewable energy and indigenous energy resources are also driving demand. However, it is difficult to make accurate comparisons with earlier figures because of poor availability and low level of standardisation of data.

Benefits	Drawbacks
Domestic resource	Transportation and processing implications
Proven simple combustion technologies	Need for control of emissions of NO_x / SO_x
Biofuels as alternative for transport	Energy – Water/food aspects

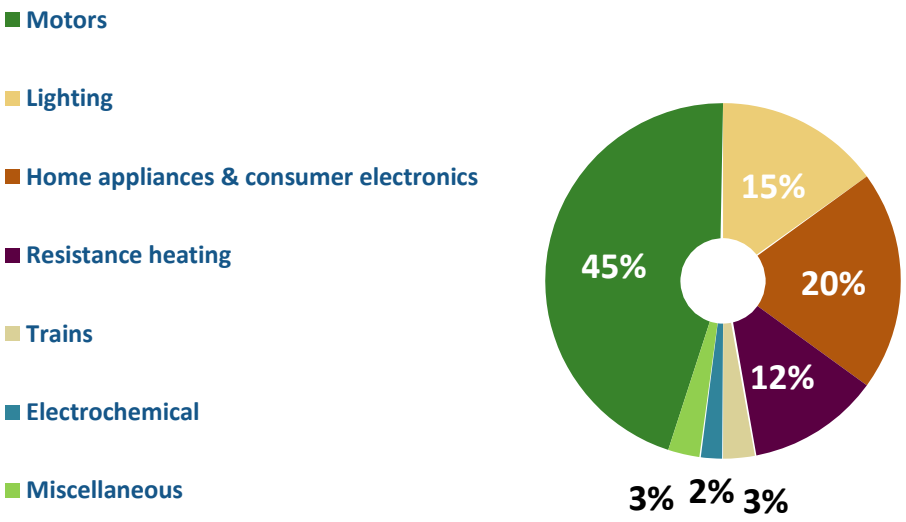
Energy efficiency

Energy efficiency is an important component of the energy economy. It is often called an “energy resource”, because it helps to decrease the use of primary energy resources and achieve considerable savings. There is tremendous potential for energy efficiency improvements along the entire energy value chain. The 2013 WEC report, *World Energy Perspective: Energy Efficiency Technologies* provides some quantitative indicators for the various phases of the value chain and for specific industries. However, energy efficiency is not just a matter of using efficient technologies; the solutions should also take into account economic aspects. Energy efficiency technologies will be widely used only when economically viable, within their lifetime, and when there are no implementation barriers.

Examples of energy efficiency improvement potential for main technology groups:

- In Oil & Gas exploration the energy efficiency of the electric system, which today is 20%, could be increased up to 50%.
- In power generation the average efficiency of power plants is 34% for coal-fired installations compared with best available technology of 46% for coal and 61% for gas-fired units.
- In transmission and distribution electricity losses reach up to 5-12% and above in some countries.
- Buildings account for nearly 40% of the total energy consumption globally and it is estimated that potential energy savings in buildings could reach between 20 and 40%.

Global electricity demand by application



Three main sectors which account for approximately 80% of the total electricity consumption in the industrialised countries:

- motors (45%)
- lighting (15%)
- home appliances and consumer electronics (20%)

In some developing countries with large industries and outdated electrical equipment, the share of electricity consumed by motors is even higher. Globally electric motors consume about 9 000TWh/year, but more advanced models could save about 1 000TWh and reduce CO_2 emissions by 1Gt per year. This equals the total annual electricity consumption of a country like Japan.

Ambitious goals for energy efficiency are reaching beyond purely technical solutions to encompass cost-effectiveness, financing, acceptance, innovation and environmental impact assessment. The profitability of investing in energy efficiency technologies is often questioned. Unbiased comprehensive studies of energy efficiency solutions including cost/ benefit assessments could help to promote understanding of the potential benefits. Energy efficiency requires a long-term commitment, and the financing framework should take this into account. The loan terms should cover the entire lifetime of the solution.

Cost of generation technologies

A recent joint WEC-BNEF (Bloomberg New Energy Finance) study demonstrates the levelised cost of electricity (LCOE) for a number of mainstream technologies. LCOE is the price that must be received per unit of output as payment for producing power in order to reach a specified financial return – or to put it simply, the price that project must earn per megawatt hour in order to break even. The LCOE calculation standardises the units of measuring the life cycle costs of producing electricity thereby facilitating the comparison of the cost of producing one megawatt hour for each technology. The simple formula for this calculation is shown below:

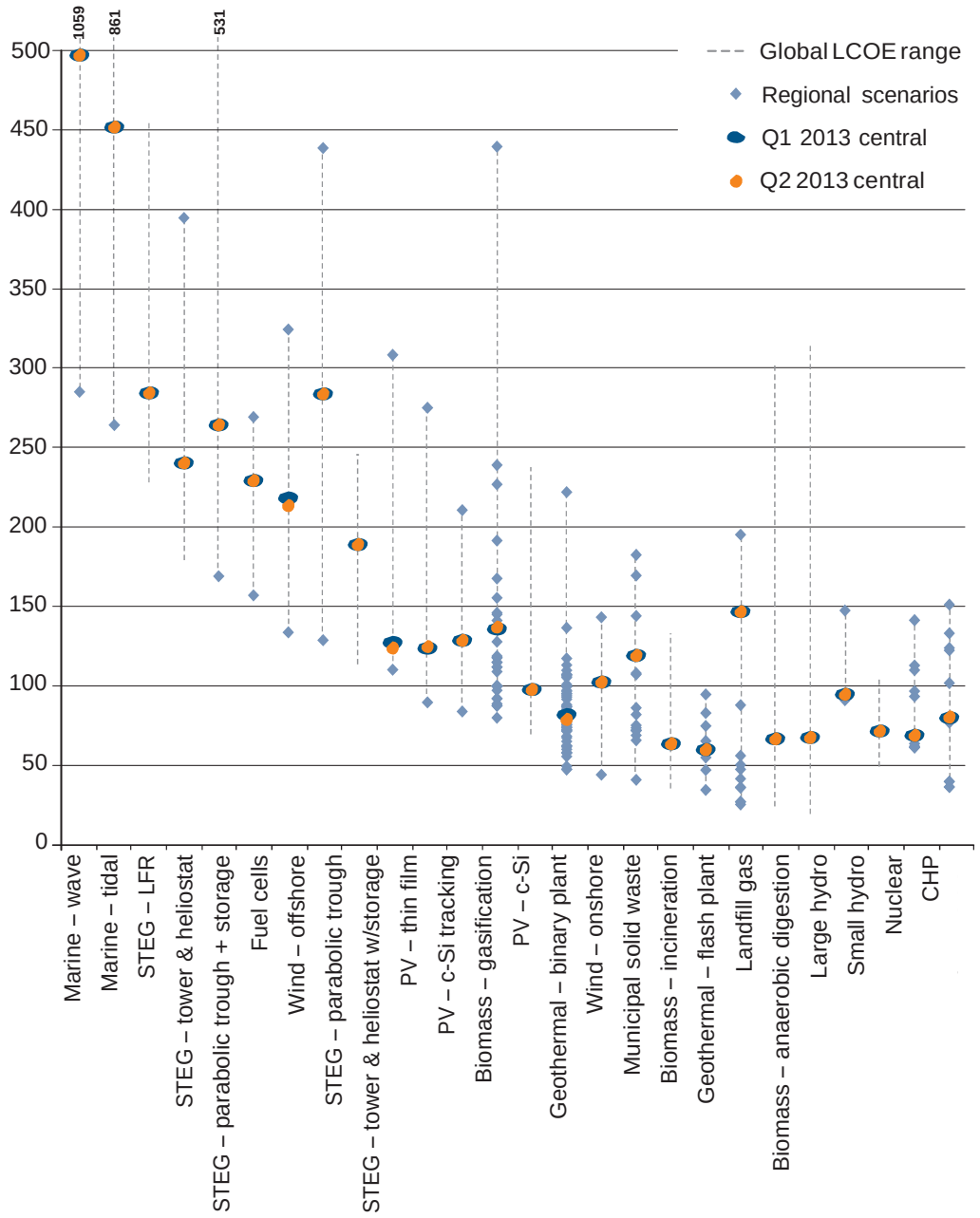
$$\text{LCOE} = \frac{\text{Annualised capex + fixed O\&M + variable O\&M + tax}}{\text{8 760 hours * resource factor * efficiency * availability}}$$

The LCOEs presented in the report reflect the actual costs of each technology and exclude all subsidies and support mechanisms. This makes it possible to compare the total costs of each technology on an equal basis, but does not represent the net costs faced by developers in the market and additional costs of volatility. Environmental costs are not taken into consideration, neither are other system integration costs.

The figures used reflect the most recent data available for costs from Q1 and Q2 2013.

Global levelised cost of energy in Q2 2013 (USD/MWh)

Source: Bloomberg New Energy Finance.
Note: forecast is from BNEF New Normal forecast scenario from the BNEF Global Renewable Energy Market Outlook: http://about.bnef.com/presentations/global-renewable-energy-market-outlook-2013-fact-pack-2/



The road ahead

Demand for energy will continue to grow for decades to come. Population increases and a growing rate of electrification will place huge requirements on energy supplies. Global primary energy demand could increase by 50% by the middle of the century. At least 80% of this increase is expected to come from developing countries. The total primary energy demand of China alone is expected to double by 2035, and that of India to increase by almost 150% during the same period. Both countries with huge populations and high economic growth are expected to dominate the global consumption of energy resources in the coming years.

Key messages

The key messages emerging from the World Energy Resources survey 2013:

- The changes in the energy industry over the past 20 years have been significant. The growth in energy consumption has been higher than anticipated even in the high-growth scenarios. The energy industry has been able to meet this growth globally assisted by continuous increases in reserves' assessments and improving energy production and consumption technologies. The results of the 2013 WEC World Energy Resources survey show that there are more energy resources in the world today than 20 years ago, or ever before.

- It is obvious that moving away from fossil fuels will take years and decades, as coal, oil and gas will remain the main energy resources in many countries. Fuel-switching does not happen overnight. The leading world economies are powered by coal: about 40% of electricity in the United States and 79% of the electricity in China is generated in coal-fired thermal plants. These plants will continue to run for decades. The main issue for coal is the CO_2 penalty.

- Contrary to the expectations of the world running out of oil within a few decades, the so called notion of 'peak oil' which prevailed 20 years ago, has almost been forgotten. The global crude oil reserves are almost 60% larger today than in 1993 and the production of oil has gone up by 20%. If the unconventional oil resources such as oil shale, oil sands, extra heavy oil and natural bitumen are taken into account, the oil endowment of the world could be quadrupled. An increasing share of oil will be consumed in the rapidly growing transport sector, where it will remain the principal fuel.

- Natural gas is expected to continue its growth spurred by falling or stable prices, and thanks to the growing contribution of unconventional gas, such as shale gas. In addition to power generation, natural gas is expected to play an increasing role as a transport fuel.

- The future of nuclear energy is uncertain. While some countries, mainly in Europe, are making plans to withdraw from nuclear, other countries are looking to establish nuclear power generation. The future of nuclear depends to a large degree on public acceptance, costs and liabilities.

- The development of renewables, excluding large hydro, has been considerably slower than expected 20 years ago. Despite the exponential growth of renewable resources in percentage terms, in particular wind power and solar PV, renewable energy still accounts for a small percentage of TPES in most countries. Their share of energy supply is not expected to change dramatically in the coming years. The continuing growth of renewables depends on subsidies and other support provided by governments.
- Integration of intermittent renewables in the electricity grids also remains an issue, as it results in additional costs for the system and thus higher electricity bills.
- Energy efficiency helps address the “energy trilemma” and provides an immediate opportunity to decrease energy intensity. This will achieve energy savings and reduce the environmental impacts of energy production and use.

Finally, demand for energy will continue to grow. Even if global energy resources seem to be abundant today, there are other constraints facing the energy sector, above all, significant capital investment in developing and developed economies is needed. The environment and climate, in particular, pose an additional challenge. Clean technologies will require adequate financing, and consumers all over the world should be prepared to pay higher prices for their energy than today. Energy is global and to make the right choices, decision makers should look at the global picture and base their decisions on a thorough life cycle analysis and reliable energy information. World Energy Council has been and remains the prime reference institution for energy resource assessments, independent of geopolitics.

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The World Energy Council (WEC) is the principal impartial network of leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all. Formed in 1923, WEC is the UN-accredited global energy body, representing the entire energy spectrum, with more than 3000 member organisations located in over 90 countries and drawn from governments, private and state corporations, academia, NGOs and energy related stakeholders. WEC informs global, regional and national energy strategies by hosting high-level events, publishing authoritative studies, and working through its extensive member network to facilitate the world's energy policy dialogue.

Further details at **www.worldenergy.org** and **@WECouncil**

World Energy Council
Regency House 1–4 Warwick Street
London W1B 5LT United Kingdom T
(+44) 20 7734 5996
F (+44) 20 7734 5926
E info@worldenergy.org
www.worldenergy.org

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