

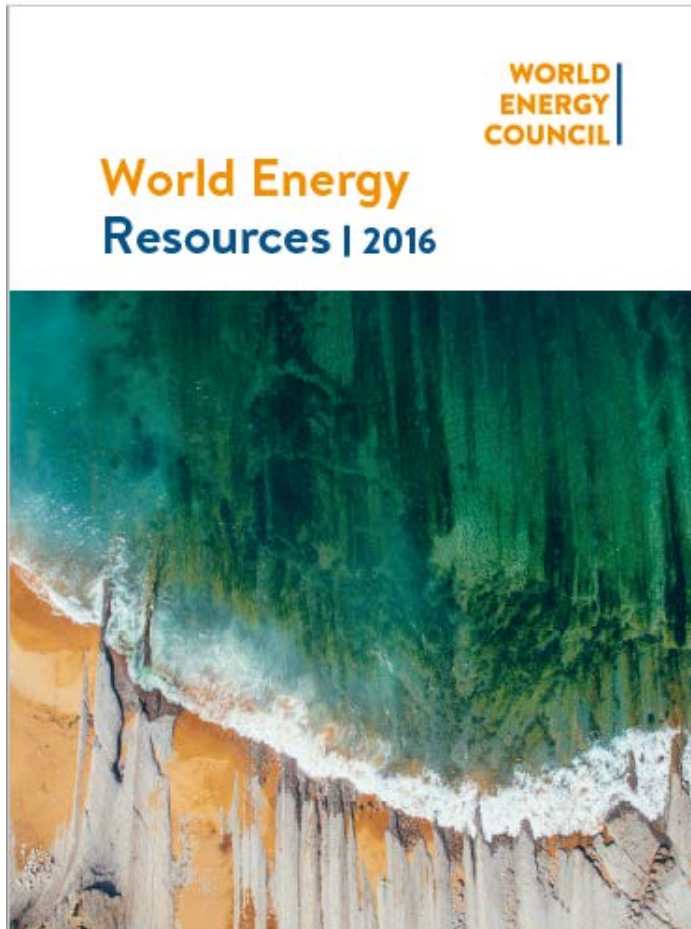
World Energy Resources

Executive Summary

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World Energy Resources 2016



83 years since the first publication in 1933.

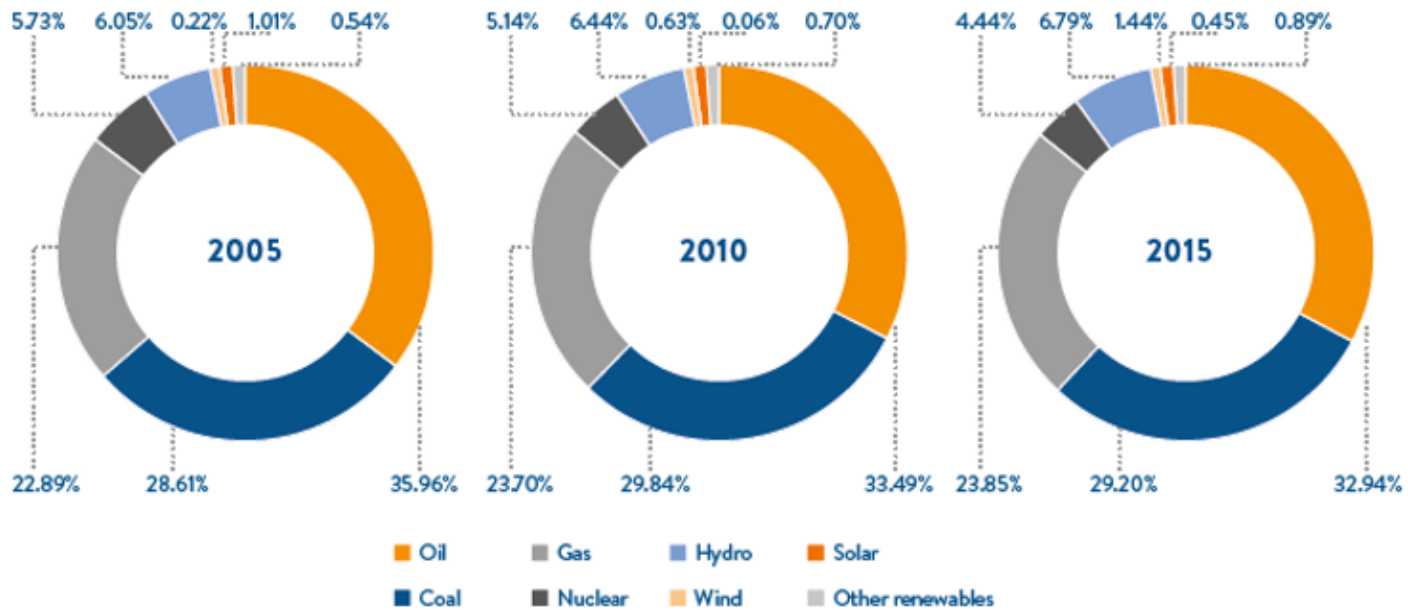
24th edition covers 12 energy resources, together with Carbon Capture and Storage (CCS) and energy-storage as two relevant technologies.

What has changed?

- The past 15 years have seen unprecedented change in the consumption of energy resources
- Unexpected high growth in the renewables market.
- Growth of unconventional resources
- Improvements in technology evolution for all the resources
- Decrease in energy prices
- Decoupling of economic growth and GHG emissions
- More diversified energy mix achieved
- Growth in community ownership and evolution of micro grids

An outlook over the past 15 years

COMPARATIVE PRIMARY ENERGY CONSUMPTION OVER THE PAST 15 YEARS



Key findings

Solar

- Around 227 Gwe of installed capacity at the end of 2015, producing 1% of all electricity used globally.
- The total capacity for solar heating and cooling in operation in 2015 was estimated at 406 GWth.
- The cost of solar PV associated with balancing the system represents the next great challenge for the industry.

E-storage

- As of end-2015, the global installed storage capacity was 146 GW, consisting of 944 projects.
- There are already around 25 000 residential-scale units in Germany alone.
- Bottom-up projections suggest a global storage market of 1.4 GW/y by 2020, with strong growth in electro-mechanical technologies in particular.

Uranium and Nuclear

- Global uranium production increased by 40% between 2004 and 2013.
- As of December 2015, 65 nuclear reactors were under construction with a total capacity of 64 GW.
- Currently there are more than 45 *Small Modular Reactors* designs under development and four reactors under construction.

Hydropower

- Hydropower is the leading renewable source for electricity generation globally, supplying 71% of all renewable electricity at the end of 2015.
- Undeveloped potential is approximately 10 000 TWh/y worldwide.
- The global hydropower capacity increased by more than 30% between 2007 and 2015 accounting to a total of 1 209 GW in 2015.

Oil

- Oil remained the world's leading fuel, accounting for 32.9% of global energy consumption.
- Roughly 63% of oil consumption is from the transport sector.
- Unconventional oil recovery accounts for 30% of the global recoverable oil reserves and oil shale contains at least three times as much oil as conventional crude oil reserves,.

Wind

- Global wind power generation reached 432 GW in 2015, around 7% of total global power generation capacity (420 GW onshore, 12 GW offshore).
- A record of 63 GW was added in 2015 and total investment in the global wind sector was US\$ 109 billion in 2015.

Coal

- Coal production decreased with 0.6% in 2014 and with a further 2.8% in 2015.
- Coal still provides around 40% of the world's electricity.
- transition to cleaner energy forms and increased competition from other resources are presenting challenges for the sector.
- Asia presents the biggest market for coal and currently accounts for 66% of global coal consumption.

CCS

- CCS is an essential element of any low carbon energy future and industrial future.
- Policy is the main issue, The world's first large-scale application of CO₂ capture technology in the power sector commenced operation in October 2014 at the Boundary Dam power station in Saskatchewan, Canada.
- There are 22 large-scale CCS projects currently in operation or under construction around the world.

Geothermal

- Geothermal global output is estimated to be 75 TWh for heat and 75 TWh for power, but is concentrated on geologic plate boundaries.

Natural Gas

- Natural gas is the second largest energy source in power generation, representing 22% of generated power globally.
- It is the only fossil fuel whose share of primary energy consumption is projected to grow.

Bioenergy

- Bioenergy is the largest renewable energy source with 14% out of 18% renewables in the energy mix and supplies 10% of global energy supply.

Marine

- 0.5 GW of commercial marine energy generation capacity is in operation and another 1.7 GW under construction, with 99% of this accounted for by tidal range.
- The total theoretical wave energy potential is said to be 32 PWh/y

Waste-to-Energy

- Despite Waste-to-Energy (WtE) occupying less than 6% of the total waste management market, the global WtE market was valued at approximately US\$ 25 billion in 2015
- Expected to reach US\$ 36 billion by 2020.

Implications

1. Despite some notable progress, the rate of improvements towards cleaner energy is far slower than required to meet emissions targets. Public acceptance remains a challenge, regardless of the energy source, with an increased ‘Not in my back yard’ (‘NIMBY’) attitude to the development of energy sources. Increased commodity and energy price uncertainty that results in higher risk, and larger investments with long lead times are less appealing.
2. Without diversification and review of business models, national and internal oil and gas companies could struggle over the medium to long term. Incentives assisted renewable energy companies have created a boom in certain countries and regions. However, as incentives are decreased, some companies might not be viable anymore.

3. Rare earth metals used in especially renewable energies, create new dependencies in the value chain and could represent possible future barriers to growth. Change is at its slowest at the moment, but our research identifies that technologies will change a lot quicker and the regulatory system is not fully prepared for this change, which may also become a barrier.
4. Liberalised markets could reach their limit, as the lowest cost generation in the short term can be perceived to provide the highest value. There is a significant need to balance other aspects of the Energy Trilemma such as environmental considerations, including increased resilience and security of supply. This is particularly important for long-term planning in short-term power operations, with the lack and lag of new, expanded, upgraded and smart infrastructure offering the potential to hinder new energy developments.

5. Heat generation and cooling technologies are lagging behind in terms of innovation. Increased use of natural gas combined with decreased use of coal will see energy-associated carbon dioxide emissions from natural gas surpass those from coal. Failure to timeously plan for replacement of decommissioned baseload might pose a risk to energy reliability in some countries.

Thank you

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