



International
Energy Agency

WORLD ENERGY OUTLOOK

EXECUTIVE SUMMARY

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
 - Improve transparency of international markets through collection and analysis of energy data.
 - Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
 - Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

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Czech Republic
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Germany
Greece
Hungary
Ireland
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Japan
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Luxembourg
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The European Commission also participates in the work of the IEA.

“If we don’t change direction soon, we’ll end up where we’re heading”

There are few signs that the urgently needed change in direction in global energy trends is underway. Although the recovery in the world economy since 2009 has been uneven, and future economic prospects remain uncertain, global primary energy demand rebounded by a remarkable 5% in 2010, pushing CO₂ emissions to a new high. Subsidies that encourage wasteful consumption of fossil fuels jumped to over \$400 billion. The number of people without access to electricity remained unacceptably high at 1.3 billion, around 20% of the world’s population. Despite the priority in many countries to increase energy efficiency, global energy intensity worsened for the second straight year. Against this unpromising background, events such as those at the Fukushima Daiichi nuclear power plant and the turmoil in parts of the Middle East and North Africa (MENA) have cast doubts on the reliability of energy supply, while concerns about sovereign financial integrity have shifted the focus of government attention away from energy policy and limited their means of policy intervention, boding ill for agreed global climate change objectives.

This Outlook assesses the threats and opportunities facing the global energy system based on a rigorous quantitative analysis of energy and climate trends. The analysis includes three global scenarios and multiple case studies. The central scenario for this *Outlook* is the New Policies Scenario, in which recent government policy commitments are assumed to be implemented in a cautious manner – even if they are not yet backed up by firm measures. Comparison with the results of the Current Policies Scenario, which assumes no new policies are added to those in place as of mid-2011, illustrates the value of these commitments and plans. From another angle, comparison is also instructive with the 450 Scenario, which works back from the international goal of limiting the long-term increase in the global mean temperature to two degrees Celsius (2°C) above pre-industrial levels, in order to trace a plausible pathway to that goal. **The wide difference in outcomes between these three scenarios underlines the critical role of governments to define the objectives and implement the policies necessary to shape our energy future.**

Short-term uncertainty does little to alter the longer-term picture

Despite uncertainty over the prospects for short-term economic growth, demand for energy in the New Policies Scenario grows strongly, increasing by one-third from 2010 to 2035. The assumptions of a global population that increases by 1.7 billion people and 3.5% annual average growth in the global economy generate ever-higher demand for energy services and mobility. A lower rate of global GDP growth in the short-term than assumed in this *Outlook* would make only a marginal difference to longer-term trends.

The dynamics of energy markets are increasingly determined by countries outside the OECD. Non-OECD countries account for 90% of population growth, 70% of the increase in economic output and 90% of energy demand growth over the period from 2010 to 2035.

China consolidates its position as the world's largest energy consumer: in 2035 it consumes nearly 70% more energy than the United States, the second-largest consumer, even though, by then, per-capita energy consumption in China is still less than half the level in the United States. The rates of growth in energy consumption in India, Indonesia, Brazil and the Middle East are even faster than in China.

Global investment in energy supply infrastructure of \$38 trillion (in year-2010 dollars) is required over the period 2011 to 2035. Almost two-thirds of the total investment is in countries outside of the OECD. Oil and gas collectively account for almost \$20 trillion, as both the need for upstream investment and the associated cost rise in the medium and long term. The power sector claims most of the remainder, with over 40% of this being for transmission and distribution networks.

The age of fossil fuels is far from over, but their dominance declines. Demand for all fuels rises, but the share of fossil fuels in global primary energy consumption falls slightly from 81% in 2010 to 75% in 2035; natural gas is the only fossil fuel to increase its share in the global mix over the period to 2035. In the power sector, renewable energy technologies, led by hydropower and wind, account for half of the new capacity installed to meet growing demand.

Steps in the right direction, but the door to 2°C is closing

We cannot afford to delay further action to tackle climate change if the long-term target of limiting the global average temperature increase to 2°C, as analysed in the 450 Scenario, is to be achieved at reasonable cost. In the New Policies Scenario, the world is on a trajectory that results in a level of emissions consistent with a long-term average temperature increase of more than 3.5°C. Without these new policies, we are on an even more dangerous track, for a temperature increase of 6°C or more.

Four-fifths of the total energy-related CO₂ emissions permissible by 2035 in the 450 Scenario are already “locked-in” by our existing capital stock (power plants, buildings, factories, etc.). If stringent new action is not forthcoming by 2017, the energy-related infrastructure then in place will generate all the CO₂ emissions allowed in the 450 Scenario up to 2035, leaving no room for additional power plants, factories and other infrastructure unless they are zero-carbon, which would be extremely costly. Delaying action is a false economy: for every \$1 of investment avoided in the power sector before 2020 an additional \$4.3 would need to be spent after 2020 to compensate for the increased emissions.

New energy efficiency measures make a difference, but much more is required. Energy efficiency improves in the New Policies Scenario at a rate twice as high as that seen over the last two-and-a-half decades, stimulated by tighter standards across all sectors and a partial phase-out of subsidies to fossil fuels. In the 450 Scenario, we need to achieve an even higher pace of change, with efficiency improvements accounting for half of the additional reduction in emissions. The most important contribution to reaching energy security and climate goals comes from the energy that we do not consume.

Rising transport demand and upstream costs reconfirm the end of cheap oil

Short-term pressures on oil markets may be eased by slower economic growth and by the expected return of Libyan oil to the market, but trends on both the oil demand and supply sides maintain pressure on prices. We assume that the average IEA crude oil import price remains high, approaching \$120/barrel (in year-2010 dollars) in 2035 (over \$210/barrel in nominal terms) in the New Policies Scenario although, in practice, price volatility is likely to remain.

All of the net increase in oil demand comes from the transport sector in emerging economies, as economic growth pushes up demand for personal mobility and freight. Oil demand (excluding biofuels) rises from 87 million barrels per day (mb/d) in 2010 to 99 mb/d in 2035. The total number of passenger cars doubles to almost 1.7 billion in 2035. Sales in non-OECD markets exceed those in the OECD by 2020, with the centre of gravity of car manufacturing shifting to non-OECD countries before 2015. The rise in oil use comes despite some impressive gains in fuel economy in many regions, notably for passenger vehicles in Europe and for heavy freight in the United States. Alternative vehicle technologies emerge that use oil much more efficiently or not at all, such as electric vehicles, but it takes time for them to become commercially viable and penetrate markets. With limited potential for substitution for oil as a transportation fuel, the concentration of oil demand in the transport sector makes demand less responsive to changes in the oil price (especially where oil products are subsidised).

The cost of bringing oil to market rises as oil companies are forced to turn to more difficult and costly sources to replace lost capacity and meet rising demand. Production of conventional crude oil – the largest single component of oil supply – remains at current levels before declining slightly to around 68 mb/d by 2035. To compensate for declining crude oil production at existing fields, 47 mb/d of gross capacity additions are required, twice the current total oil production of all OPEC countries in the Middle East. A growing share of output comes from natural gas liquids (over 18 mb/d in 2035) and unconventional sources (10 mb/d). The largest increase in oil production comes from Iraq, followed by Saudi Arabia, Brazil, Kazakhstan and Canada. Biofuels supply triples to the equivalent of more than 4 mb/d, bolstered by \$1.4 trillion in subsidies over the projection period.

Oil imports to the United States, currently the world's biggest importer, drop as efficiency gains reduce demand and new supplies such as light tight oil are developed, but increasing reliance on oil imports elsewhere heightens concerns about the cost of imports and supply security. Four-fifths of oil consumed in non-OECD Asia comes from imports in 2035, compared with just over half in 2010. Globally, reliance grows on a relatively small number of producers, mainly in the MENA region, with oil shipped along vulnerable supply routes. In aggregate, the increase in production from this region is over 90% of the required growth in world oil output, pushing the share of OPEC in global production above 50% in 2035.

A shortfall in upstream investment in the MENA region could have far-reaching consequences for global energy markets. Such a shortfall could result from a variety of

factors, including higher perceived investment risks, deliberate government policies to develop production capacity more slowly or constraints on upstream domestic capital flows because priority is given to spending on other public programmes. If, between 2011 and 2015, investment in the MENA region runs one-third lower than the \$100 billion per year required in the New Policies Scenario, consumers could face a substantial near-term rise in the oil price to \$150/barrel (in year-2010 dollars).

Golden prospects for natural gas

There is much less uncertainty over the outlook for natural gas: factors both on the supply and demand sides point to a bright future, even a golden age, for natural gas. Our *Outlook* reinforces the main conclusions of a *WEO* special report released in June 2011: gas consumption rises in all three scenarios, underlining how gas does well under a wide range of future policy directions. In the New Policies Scenario, demand for gas all but reaches that for coal, with 80% of the additional demand coming from non-OECD countries. Policies promoting fuel diversification support a major expansion of gas use in China; this is met through higher domestic production and through an increasing share of LNG trade and Eurasian pipeline imports. Global trade doubles and more than one-third of the increase goes to China. Russia remains the largest gas producer in 2035 and makes the largest contribution to global supply growth, followed by China, Qatar, the United States and Australia.

Unconventional gas now accounts for half of the estimated natural gas resource base and it is more widely dispersed than conventional resources, a fact that has positive implications for gas security. The share of unconventional gas rises to one-fifth of total gas production by 2035, although the pace of this development varies considerably by region. The growth in output will also depend on the gas industry dealing successfully with the environmental challenges: a golden age of gas will require golden standards for production. Natural gas is the cleanest of the fossil fuels, but increased use of gas in itself (without carbon capture and storage) will not be enough to put us on a carbon emissions path consistent with limiting the rise in average global temperatures to 2°C.

Renewables are pushed towards centre stage

The share of non-hydro renewables in power generation increases from 3% in 2009 to 15% in 2035, underpinned by annual subsidies to renewables that rise almost five-times to \$180 billion. China and the European Union drive this expansion, providing nearly half of the growth. Even though the subsidy cost per unit of output is expected to decline, most renewable-energy sources need continued support throughout the projection period in order to compete in electricity markets. While this will be costly, it is expected to bring lasting benefits in terms of energy security and environmental protection. Accommodating more electricity from renewable sources, sometimes in remote locations, will require additional investment in transmission networks amounting to 10% of total transmission investment: in the European Union, 25% of the investment in transmission networks is needed for this purpose. The contribution of hydropower to global power generation remains at around 15%, with China, India and Brazil accounting for almost half of the 680 gigawatts of new capacity.

Treading water or full steam ahead for coal?

Coal has met almost half of the increase in global energy demand over the last decade. Whether this trend alters and how quickly is among the most important questions for the future of the global energy economy. Maintaining current policies would see coal use rise by a further 65% by 2035, overtaking oil as the largest fuel in the global energy mix. In the New Policies Scenario, global coal use rises for the next ten years, but then levels off to finish 25% above the levels of 2009. Realisation of the 450 Scenario requires coal consumption to peak well before 2020 and then decline. The range of projections for coal demand in 2035 across the three scenarios is nearly as large as total world coal demand in 2009. The implications of policy and technology choices for the global climate are huge.

China's consumption of coal is almost half of global demand and its Five-Year Plan for 2011 to 2015, which aims to reduce the energy and carbon intensity of the economy, will be a determining factor for world coal markets. China's emergence as a net coal importer in 2009 led to rising prices and new investment in exporting countries, including Australia, Indonesia, Russia and Mongolia. In the New Policies Scenario, the main market for traded coal continues to shift from the Atlantic to the Pacific, but the scale and direction of international trade flows are highly uncertain, particularly after 2020. It would take only a relatively small shift in domestic demand or supply for China to become a net-exporter again, competing for markets against the countries that are now investing to supply its needs. India's coal use doubles in the New Policies Scenario, so that India displaces the United States as the world's second-largest coal consumer and becomes the largest coal importer in the 2020s.

Widespread deployment of more efficient coal-fired power plants and carbon capture and storage (CCS) technology could boost the long-term prospects for coal, but there are still considerable hurdles. If the average efficiency of all coal-fired power plants were to be five percentage points higher than in the New Policies Scenario in 2035, such an accelerated move away from the least efficient combustion technologies would lower CO₂ emissions from the power sector by 8% and reduce local air pollution. Opting for more efficient technology for new coal power plants would require relatively small additional investments, but improving efficiency levels at existing plants would come at a much higher cost. In the New Policies Scenario, CCS plays a role only towards the end of the projection period. Nonetheless, CCS is a key abatement option in the 450 Scenario, accounting for almost one-fifth of the additional reductions in emissions that are required. If CCS is not widely deployed in the 2020s, an extraordinary burden would rest on other low-carbon technologies to deliver lower emissions in line with global climate objectives.

Second thoughts on nuclear would have far-reaching consequences

Events at Fukushima Daiichi have raised questions about the future role of nuclear power, although it has not changed policies in countries such as China, India, Russia and Korea that are driving its expansion. In the New Policies Scenario, nuclear output rises by more than 70% over the period to 2035, only slightly less than projected last year. However, we

also examine the possible implications of a more substantial shift away from nuclear power in a Low Nuclear Case, which assumes that no new OECD reactors are built, that non-OECD countries build only half of the additions projected in our New Policies Scenario and that the operating lifespan of existing nuclear plants is shortened. While creating opportunities for renewables, such a low-nuclear future would also boost demand for fossil fuels: the increase in global coal demand is equal to twice the level of Australia's current steam coal exports and the rise in gas demand is equivalent to two-thirds of Russia's current natural gas exports. The net result would be to put additional upward pressure on energy prices, raise additional concerns about energy security and make it harder and more expensive to combat climate change. The consequences would be particularly severe for those countries with limited indigenous energy resources which have been planning to rely relatively heavily on nuclear power. It would also make it considerably more challenging for emerging economies to satisfy their rapidly growing demand for electricity.

The world needs Russian energy, while Russia needs to use less

Russia's large energy resources underpin its continuing role as a cornerstone of the global energy economy over the coming decades. High prospective demand and international prices for fossil fuels might appear to guarantee a positive outlook for Russia, but the challenges facing Russia are, in many ways, no less impressive than the size of its resources. Russia's core oil and gas fields in Western Siberia will decline and a new generation of higher-cost fields need to be developed, both in the traditional production areas of Western Siberia and in the new frontiers of Eastern Siberia and the Arctic. A responsive Russian fiscal regime will be needed to provide sufficient incentives for investment. Oil production plateaus around 10.5 mb/d before starting a slight decline to 9.7 mb/d in 2035; gas production increases by 35% to 860 billion cubic metres (bcm) in 2035, with the Yamal peninsula becoming the new anchor of Russian supply.

As the geography of Russian oil and gas production changes, so does the geography of export. The majority of Russia's exports continue to go westwards to traditional markets in Europe, but a shift towards Asian markets gathers momentum. Russia gains greater diversity of export revenues as a result: the share of China in Russia's total fossil-fuel export earnings rises from 2% in 2010 to 20% in 2035, while the share of the European Union falls from 61% to 48%.

Russia aims to create a more efficient economy, less dependent on oil and gas, but needs to pick up the pace of change. If Russia increased its energy efficiency in each sector to the levels of comparable OECD countries, it could save almost one-third of its annual primary energy use, an amount similar to the energy used in one year by the United Kingdom. Potential savings of natural gas alone, at 180 bcm, are close to Russia's net exports in 2010. New energy efficiency policies and continued price reforms for gas and electricity bring some improvements but, in our analysis, do not unlock more than a part of Russia's efficiency potential. Faster implementation of efficiency improvements and energy market reforms would accelerate the modernisation of the Russian economy and thereby loosen its dependency on movements in international commodity prices.

Achieving energy for all will not cost the earth

We estimate that, in 2009, around \$9 billion was invested globally to provide first access to modern energy, but more than five-times this amount, \$48 billion, needs to be invested each year if universal access is to be achieved by 2030. Providing energy access for all by 2030 is a key goal announced by the UN Secretary-General. Today, 1.3 billion people do not have electricity and 2.7 billion people still rely on the traditional use of biomass for cooking. The investment required is equivalent to around 3% of total energy investment to 2030. Without this increase, the global picture in 2030 is projected to change little from today and in sub-Saharan Africa it gets worse. Some existing policies designed to help the poorest miss their mark. Only 8% of the subsidies to fossil-fuel consumption in 2010 reached the poorest 20% of the population.

International concern about the issue of energy access is growing. The United Nations has declared 2012 to be the “International Year of Sustainable Energy for All” and the Rio+20 Summit represents an important opportunity for action. More finance, from many sources and in many forms, is needed to provide modern energy for all, with solutions matched to the particular challenges, risks and returns of each category of project. Private sector investment needs to grow the most, but this will not happen unless national governments adopt strong governance and regulatory frameworks and invest in capacity building. The public sector, including donors, needs to use its tools to leverage greater private sector investment where the commercial case would otherwise be marginal. Universal access by 2030 would increase global demand for fossil fuels and related CO₂ emissions by less than 1%, a trivial amount in relation to the contribution made to human development and welfare.



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WORLD ENERGY OUTLOOK

2011

World Energy Outlook 2011 brings together the latest data, policy developments, and the experience of another year to provide robust analysis and insight into global energy markets, today and for the next 25 years. This edition of the IEA's flagship WEO publication gives the latest energy demand and supply projections for different future scenarios, broken down by country, fuel and sector. It also gives special focus to such topical energy sector issues as:

- **Russia's energy prospects** and their implications for global markets.
- The role of **coal in driving economic growth** in an emissions-constrained world.
- The implications of a possible **delay in oil and gas sector investment** in the Middle East and North Africa.
- How **high-carbon infrastructure "lock-in"** is making the 2°C climate change goal more challenging and expensive to meet.
- The scale of **fossil fuel subsidies** and **support for renewable energy** and their impact on energy, economic and environmental trends.
- A "**Low Nuclear Case**" to investigate what a rapid slowdown in the use of nuclear power would mean for the global energy landscape.
- The scale and type of investment needed to provide **modern energy to the billions of the world's poor** that do not have it.

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