UNDER EMBARGO

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World Energy Outlook

EXECUTIVE SUMMARY

2009

International Energy Agency

World Energy Outlook 2009

Since *WEO-2008*, the economic downturn has led to a drop in energy use, CO_2 emissions and energy investment. Is this an opportunity to arrest climate change or a threat that any economic upturn might be stifled at birth?

What package of commitments and measures should the climate negotiators at the UN Climate Change Conference (COP 15) in Copenhagen put together if they really want to stop global temperatures rising? How much would it cost? And how much might the developed world have to pay to finance action elsewhere?

How big is the gas resource base and what is the typical pattern of production from a gas field? What does the unconventional gas boom in the United States mean for the rest of the world? Are we headed for a global gas glut? What role will gas play in the future energy mix? And how might the way gas is priced change?

All these questions and many others are answered in *WEO-2009*. The data are extensive, the projections more detailed than ever and the analyses compelling.

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-eight of the thirty OECD member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on international oil markets.
- To provide data on other aspects of international energy markets.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies, including relating to climate change.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea (Republic of)
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

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The past 12 months have seen enormous upheavals in energy markets around the world, yet the challenges of transforming the global energy system remain urgent and daunting. The global financial crisis and ensuing recession have had a dramatic impact on the outlook for energy markets, particularly in the next few years. World energy demand in aggregate has already plunged with the economic contraction; how quickly it rebounds depends largely on how quickly the global economy recovers. Countries have responded to the threat of economic melt-down as a result of the financial crisis with prompt and co-ordinated fiscal and monetary stimuli on an unprecedented scale. In many cases, stimulus packages have included measures to promote clean energy with the aim of tackling an even bigger, and just as real, long-term threat — that of disastrous climate change.

How we rise to that challenge will have far-reaching consequences for energy markets. As the leading source of greenhouse-gas emissions, energy is at the heart of the problem and so must be integral to the solution. The time to act has arrived: the 15th Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen (December 2009) presents a decisive opportunity to negotiate a successor treaty to the Kyoto Protocol — one that puts the world onto a truly sustainable energy path. The *World Energy Outlook 2009* (WEO-2009) quantifies the challenge and shows what is required to overcome it.

The scale and breadth of the energy challenge is enormous — far greater than many people realise. But it can and must be met. The recession, by curbing the growth in greenhouse-gas emissions, has made the task of transforming the energy sector easier by giving us an unprecedented, yet relatively narrow, window of opportunity to take action to concentrate investment on low-carbon technology. Energy-related carbon-dioxide (CO_2) emissions in 2009 will be well below what they would have been had the recession not occurred. But this saving will count for nothing if a robust deal is not reached in Copenhagen — and emissions resume their upward path.

Households and businesses are largely responsible for making the required investments, but governments hold the key to changing the mix of energy investment. The policy and regulatory frameworks established at national and international levels will determine whether investment and consumption decisions are steered towards low-carbon options. Accordingly, this *Outlook* presents the results of two scenarios: a *Reference Scenario*, which provides a baseline picture of how global energy markets would evolve if governments make no changes to their existing policies and measures; and a *450 Scenario*, which depicts a world in which collective policy action is taken to limit the long-term concentration of greenhouse gases in the atmosphere to 450 parts per million of CO_2-equivalent (ppm CO_2-eq), an objective that is gaining widespread support around the world.

The financial crisis brings a temporary reprieve from rising fossil-energy use

Global energy use is set to fall in 2009 — for the first time since 1981 on any significant scale — as a result of the financial and economic crisis; but, on current policies, it would quickly resume its long-term upward trend once economic recovery is underway. In our Reference Scenario, world primary energy demand is projected to increase by 1.5% per year between 2007 and 2030, from just over 12 000 million tonnes of oil equivalent (Mtoe) to 16 800 Mtoe — an overall increase of 40%. Developing Asian countries are the main drivers of this growth, followed by the Middle East. Projected demand growth is slower than in *WEO-2008*, reflecting mainly the impact of the crisis in the early part of the projection period, as well as of new government policies introduced during the past year. On average, demand declines marginally in 2007-2010, as a result of a sharp drop in 2009 — preliminary data point to a fall in that year of up to 2%. Demand growth rebounds thereafter, averaging 2.5% per year in 2010-2015. The pace of demand growth slackens progressively after 2015, as emerging economies mature and global population growth slows.

Fossil fuels remain the dominant sources of primary energy worldwide in the Reference Scenario, accounting for more than three-quarters of the overall increase in energy use between 2007 and 2030. In absolute terms, coal sees by far the biggest increase in demand over the projection period, followed by gas and oil. Yet oil remains the single largest fuel in the primary fuel mix in 2030, even though its share drops, from 34% now to 30%. Oil demand (excluding biofuels) is projected to grow by 1% per year on average over the projection period, from 85 million barrels per day in 2008 to 105 mb/d in 2030. All the growth comes from non-OECD countries: OECD demand actually falls. The transport sector accounts for 97% of the increase in oil use. As conventional oil production in countries not belonging to the Organization of the Petroleum Exporting Countries (OPEC) peaks around 2010, most of the increase in output would need to come from OPEC countries, which hold the bulk of remaining recoverable conventional oil resources.

The main driver of demand for coal and gas is the inexorable growth in energy needs for power generation. World electricity demand is projected to grow at an annual rate of 2.5% to 2030. Over 80% of the growth takes place in non-OECD countries. Globally, additions to power-generation capacity total 4 800 gigawatts (GW) by 2030 — almost five times the existing capacity of the United States. The largest additions (around 28% of the total) occur in China. Coal remains the backbone fuel of the power sector, its share of the global generation mix rising by three percentage points to 44% in 2030. Nuclear power output grows in all major regions bar Europe, but its share in total generation falls.

The use of non-hydro modern renewable energy technologies (including wind, solar, geothermal, tide and wave energy, and bio-energy) sees the fastest rate of increase in the Reference Scenario. Most of the increase is in power generation: the share of non-hydro renewables in total power output rises from 2.5% in 2007 to 8.6% in 2030, with wind power seeing the biggest absolute increase. The consumption of biofuels for transport also rises strongly. The share of hydropower, by contrast, drops from 16% to 14%.

Falling energy investment will have far-reaching consequences

Energy investment worldwide has plunged over the past year in the face of a tougher financing environment, weakening final demand for energy and lower cash flow. All these factors stem from the financial and economic crisis. Energy companies are drilling fewer oil and gas wells, and cutting back spending on refineries, pipelines and power stations. Many ongoing projects have been slowed and a number of planned projects have been postponed or cancelled. Businesses and households are spending less on new, more efficient energy-using appliances, equipment and vehicles, with important knock-on effects for the efficiency of energy use in the long term.

In the oil and gas sector, most companies have announced cutbacks in capital spending, as well as project delays and cancellations, mainly as a result of lower cash flow. We estimate that global upstream oil and gas investment budgets for 2009 have been cut by around 19% compared with 2008 – a reduction of over $90 billion. Oil sands projects in Canada account for the bulk of the suspended oil capacity. Power-sector investment is also being severely affected by financing difficulties, as well as by weak demand, which is reducing the immediate need for new capacity additions. In late 2008 and early 2009, investment in renewables fell proportionately more than that in other types of generating capacity; for 2009 as a whole, it could drop by close to one-fifth. Without the stimulus provided by government fiscal packages, renewables investment would have fallen by almost 30%.

Falling energy investment will have far-reaching and, depending on how governments respond, potentially serious consequences for energy security, climate change and energy poverty. Any prolonged downturn in investment threatens to constrain capacity growth in the medium term, particularly for long lead-time projects, eventually risking a shortfall in supply. This could lead to a renewed surge in prices a few years down the line, when demand is likely to be recovering, and become a constraint on global economic growth. These concerns are most acute for oil and electricity supplies. Any such shortfalls could, in turn, undermine the sustainability of the economic recovery. Weaker fossil-fuel prices are also undermining the attractiveness of investments in clean energy technology (though recent government moves to encourage such investment, as part of their economic stimulus packages, are helping to counter this effect). Cutbacks in energy-infrastructure investments also threaten to impede access by poor households to electricity and other forms of modern energy.

The financial crisis has cast a shadow over whether all the energy investment needed to meet growing energy needs can be mobilised. The capital required to meet projected energy demand through to 2030 in the Reference Scenario is huge, amounting in cumulative terms to $26 trillion (in year-2008 dollars) – equal to $1.1 trillion (or 1.4% of global gross domestic product [GDP]) per year on average. The power sector requires 53% of total investment. Over half of all energy investment worldwide is needed in developing countries, where demand and production are projected to increase fastest. With little prospect of a quick return to the days of cheap and easy credit, financing energy investment will, in most cases, be more difficult and costly in the medium term than it was before the crisis took hold.

Current policies put us on an alarming fossil-energy path

Continuing on today's energy path, without any change in government policy, would mean rapidly increasing dependence on fossil fuels, with alarming consequences for climate change and energy security. The Reference Scenario sees a continued rapid rise in energy-related CO_2 emissions through to 2030, resulting from increased global demand for fossil energy. Having already increased from 20.9 gigatonnes (Gt) in 1990 to 28.8 Gt in 2007, CO_2 emissions are projected to reach 34.5 Gt in 2020 and 40.2 Gt in 2030 – an average rate of growth of 1.5% per year over the full projection period. In 2020, global emissions are 1.9 Gt or 5% lower than in the Reference Scenario of *WEO-2008*. The economic crisis and resulting lower fossil-energy demand growth account for three-quarters of this improvement, while government stimulus spending to promote low-carbon investments and other new energy and climate policies account for the remainder. Preliminary data suggest that global energy-related emissions of CO_2 may *decline* in 2009 – possibly by around 3% – although they are expected to resume an upward trajectory from 2010.

Non-OECD countries account for all of the projected growth in energy-related CO_2 emissions to 2030. Three-quarters of the 11-Gt increase comes from China (where emissions rise by 6 Gt), India (2 Gt) and the Middle East (1 Gt). OECD emissions are projected to fall slightly, due to a slowdown in energy demand (resulting from the crisis in the near term and from big improvements in energy efficiency in the longer term) and the increased reliance on nuclear power and renewables, in large part due to the policies already adopted to mitigate climate change and enhance energy security. By contrast, all major non-OECD countries see their emissions rise. However, while non-OECD countries today account for 52% of the world's annual emissions of energy-related CO_2, they are responsible for only 42% of the world's cumulative emissions since 1890.

These trends would lead to a rapid increase in the concentration of greenhouse gases in the atmosphere. The rate of growth of fossil-energy consumption projected in the Reference Scenario takes us inexorably towards a long-term concentration of greenhouse gases in the atmosphere in excess of 1 000 ppm CO_2-eq. The CO_2 concentration implied by the Reference Scenario would result in the global average temperature rising by up to 6°C. This would lead almost certainly to massive climatic change and irreparable damage to the planet.

The Reference Scenario trends also heighten concerns about the security of energy supplies. While the OECD imports less oil in 2030 than today in the Reference Scenario, some non-OECD countries, notably China and India, see big increases in their imports. Most gas-importing regions, including Europe and developing Asia, also see their net imports rise. The Reference Scenario projections imply an increasingly high level of spending on energy imports, representing a major economic burden for importers. Oil prices are assumed to fall from the 2008 level of $97 per barrel to around $60 per barrel in 2009 (roughly the level of mid-2009), but then rebound with the economic recovery to reach $100 per barrel by 2020 and $115 per barrel by 2030 (in year-2008 dollars). As a result, OECD countries as a group are projected to spend on average close to 2% of their GDP on oil and gas imports to 2030. The burden is even

higher in most importing non-OECD countries. On a country basis, China overtakes the United States soon after 2025 to become the world's biggest spender on oil and gas imports (in monetary terms) while India's spending on oil and gas imports surpasses that of Japan soon after 2020 to become the world's third-largest importer. The increasing concentration of the world's remaining conventional oil and gas reserves in a small group of countries, including Russia and resource-rich Middle East countries, would increase their market power and ability to influence prices.

Expanding access to modern energy for the world's poor remains a pressing matter. We estimate that 1.5 billion people still lack access to electricity — well over one-fifth of the world's population. Some 85% of those people live in rural areas, mainly in Sub-Saharan Africa and South Asia. In the Reference Scenario, the total number drops by only around 200 million by 2030, though the number actually increases in Africa. Expanding access to modern energy is a necessary condition for human development. With appropriate policies, universal electricity access could be achieved with additional annual investment worldwide of $35 billion (in year-2008 dollars) through to 2030, or just 6% of the power-sector investment projected in the Reference Scenario. The accompanying increase in primary energy demand and CO_2 emissions would be very modest.

Limiting temperature rise to 2°C requires a low-carbon energy revolution

Although opinion is mixed on what might be considered a sustainable, long-term level of annual CO_2 emissions for the energy sector, a consensus on the need to limit the global temperature increase to 2°C is emerging. To limit to 50% the probability of a global average temperature increase in excess of 2°C, the concentration of greenhouse gases in the atmosphere would need to be stabilised at a level around 450 ppm CO_2-eq. We show how this objective can be achieved in the 450 Scenario, through radical and co-ordinated policy action across all regions. In this scenario, global energy-related CO_2 emissions peak at 30.9 Gt just before 2020 and decline thereafter to 26.4 Gt in 2030 — 2.4 Gt below the 2007 level and 13.8 Gt below that in the Reference Scenario. These reductions result from a plausible combination of policy instruments — notably carbon markets, sectoral agreements and national policies and measures — tailored to the circumstances of specific sectors and groups of countries. Only by taking advantage of mitigation potential in all sectors and regions can the necessary emission reductions be achieved. OECD+ countries (a group that includes the OECD and non-OECD EU countries) are assumed to take on national emission-reduction commitments from 2013. All other countries are assumed to adopt domestic policies and measures, and to generate and sell emissions credits. After 2020, commitments are extended to Other Major Economies — a group comprising China, Russia, Brazil, South Africa and the Middle East.

The reductions in energy-related CO_2 emissions required in the 450 Scenario (relative to the Reference Scenario) by 2020 — just a decade away — are formidable, but the financial crisis offers what may be a unique opportunity to take the necessary steps as the political mood shifts. At 30.7 Gt, emissions in 2020 in the

450 Scenario are 3.8 Gt lower than in the Reference Scenario. In non-OECD countries, national policies currently under consideration, along with sectoral approaches in transport and industry, yield 1.6 Gt of emission abatement. But this abatement will not happen in the absence of an appropriate international framework. The challenge for international negotiators is to find instruments that will give the right level of additional incentive to ensure that the necessary measures are implemented. With national policies, China alone accounts for 1 Gt of emissions reductions in the 450 Scenario, placing the country at the forefront of global efforts to combat climate change. The remaining reductions in 2020 are delivered by OECD+ countries through an emissions cap in the power and industry sectors, domestic policies, and by financing, through the carbon market, additional abatement in non-OECD countries. In 2020, the OECD+ carbon price reaches $50 per tonne of CO_2. The financial and economic crisis has temporarily slowed the lock-in of high-carbon energy technologies. With the prospect of demand picking up over the next few years, it is crucial to put in place an agreement providing clear economic signals to encourage the deployment of low-carbon technologies.

With a new international climate policy agreement, a comprehensive and rapid transformation in the way we produce, transport and use energy — a veritable low-carbon revolution — could put the world onto this 450-ppm trajectory. Energy needs to be used more efficiently and the carbon content of the energy we consume must be reduced, by switching to low- or zero-carbon sources. In the 450 Scenario, primary energy demand grows by 20% between 2007 and 2030. This corresponds to an average annual growth rate of 0.8%, compared with 1.5% in the Reference Scenario. Increased energy efficiency in buildings and industry reduces the demand for electricity and, to a lesser extent, fossil fuels. The average emissions intensity of new cars is reduced by more than half, cutting oil needs. The share of non-fossil fuels in the overall primary energy mix increases from 19% in 2007 to 32% in 2030, when CO_2 emissions per unit of GDP are less than half their 2007 level. Yet, with the exception of coal, demand for all fuels is higher in 2030 than in 2007, and fossil fuels remain the dominant energy sources in 2030.

Energy efficiency offers the biggest scope for cutting emissions

End-use efficiency is the largest contributor to CO_2 emissions abatement in 2030, accounting for more than half of total savings in the 450 Scenario, compared with the Reference Scenario. Energy-efficiency investments in buildings, industry and transport usually have short pay-back periods and negative net abatement costs, as the fuel-cost savings over the lifetime of the capital stock often outweigh the additional capital cost of the efficiency measure, even when future savings are discounted. Decarbonisation of the power sector also plays a central role in reducing emissions. Power generation accounts for more than two-thirds of the savings in the 450 Scenario (of which 40% results from lower electricity demand). There is a big shift in the mix of fuels and technologies in power generation: coal-based generation is reduced by half, compared with the Reference Scenario in 2030, while nuclear power and renewables make much bigger contributions. The United States and China together contribute

about half of the reduction in global power-sector emissions. Carbon capture and storage (CCS) in the power sector and in industry represents 10% of total emissions savings in 2030, relative to the Reference Scenario.

Measures in the transport sector to improve fuel economy, expand biofuels and promote the uptake of new vehicle technologies — notably hybrid and electric vehicles — lead to a big reduction in oil demand. By 2030, transport demand for oil is cut by 12 mb/d, equal to more than 70% of all the oil savings in the 450 Scenario. Road transport accounts for the vast majority of these transport-related oil savings. A dramatic shift in car sales occurs; by 2030, conventional internal combustion engines represent only about 40% of sales, down from more than 90% in the Reference Scenario, as hybrids take up 30% of sales and plug-in hybrids and electric vehicles account for the remainder. Efficiency improvements in new aircraft and the use of biofuels in aviation save 1.6 mb/d of oil demand by 2030.

New financing mechanisms will be critical to achieving low-carbon growth

The 450 Scenario entails $10.5 trillion *more* investment in energy infrastructure and energy-related capital stock globally than in the Reference Scenario through to the end of the projection period. Around 45% of incremental investment needs, or $4.7 trillion, are in transport. Additional investment (which includes the purchase of energy-related equipment by households in this analysis) amounts to $2.5 trillion in buildings (including domestic and commercial equipment and appliances), $1.7 trillion in power plants, $1.1 trillion in industry and $0.4 trillion in biofuels production (mostly second-generation technologies, which become more widespread after 2020). More than three-quarters of the total additional investment, which is geographically distributed almost equally between OECD+ countries and the rest of the world, is needed in the 2020s. On an annual basis, global additional investment needs reach $430 billion (0.5% of GDP) in 2020 and $1.2 trillion (1.1% of GDP) in 2030. Most of this would need to be made by the private sector; households alone are responsible for around 40% of the additional investments in the 450 Scenario, with most of their extra expenditure directed towards low-carbon vehicle purchases. In the short term, the maintenance of government stimulus efforts is crucial to this investment.

The cost of the additional investments needed to put the world onto a 450-ppm path is at least partly offset by economic, health and energy-security benefits. Energy bills in transport, buildings and industry are reduced by $8.6 trillion globally over the period 2010-2030. Fuel-cost savings in the transport sector amount to $6.2 trillion over the projection period. Oil and gas imports, and their associated bills, in the OECD and developing Asia are much lower than in the Reference Scenario and are lower than in 2008 in OECD countries. Cumulative OPEC oil-export revenues in 2008-2030 are 16% less than in the Reference Scenario, but are still four times their level in real terms of the previous 23 years. Other implications include a big reduction in emissions of air pollutants, particularly in China and India, and in the cost of installing pollution-control equipment.

It is widely agreed that developed countries must provide more financial support to developing countries in reducing their emissions; but the level of support, the mechanisms for providing it and the relative burden across countries are matters for negotiation. There is a wide range of potential funding outcomes. In the 450 Scenario, $197 billion of additional investment is required in 2020 in non-OECD countries; what part of this is contributed by OECD+ is entirely a matter for negotiation. There are various channels through which funds can flow to developing countries. The international carbon market will undoubtedly play an important role. Depending on how the market is structured, primary trading of CO_2 emission reductions between OECD+ and other regions ranges between 0.5 Gt and 1.7 Gt in 2020. A central case sees a carbon price of around $30 per tonne of CO_2 and annual primary trading of around $40 billion. The current Clean Development Mechanism would need extensive reform to cope efficiently and robustly with a substantially increased level of activity. International funding pools are another important channel that could provide a means of increasing financial transfers to developing countries.

Natural gas will play a key role whatever the policy landscape

With the assumed resumption of global economic growth from 2010, demand for natural gas worldwide is set to resume its long-term upwards trend, though the *pace* of demand growth hinges critically on the strength of climate policy action. Constraints on the rate at which low-carbon technologies can be deployed, and the low carbon content of gas relative to coal and oil, mean that gas demand will continue to expand, even in the 450 Scenario. In the Reference Scenario, global gas demand rises from 3.0 trillion cubic metres (tcm) in 2007 to 4.3 tcm in 2030 – an average rate of increase of 1.5% per year. The share of gas in the global primary energy mix increases marginally, from 20.9% in 2007 to 21.2% in 2030. Over 80% of the increase in gas use between 2007 and 2030 occurs in non-OECD countries, with the biggest rise occurring in the Middle East. India and China see the most rapid *rates* of increase. The power sector is expected to remain the largest driver of gas demand in all regions.

The outlook to 2015 differs markedly from the longer-term picture. Although only partial and preliminary data on gas demand are available for 2008 and early 2009, it is likely that, worldwide, primary gas demand will fall in 2009 – perhaps by as much as 3% – as a result of the economic contraction. On the assumption that the economy begins to recover by 2010, global demand is projected to rebound. On average, it grows by 2.5% per year between 2010 and 2015. Supply capacity is set to grow faster.

In the 450 Scenario, world primary gas demand grows by 17% between 2007 and 2030, but is 17% lower in 2030 compared with the Reference Scenario. Demand continues to grow in most non-OECD regions through to 2030, but some regions see a decline after 2020. Measures to encourage energy savings, by improving the efficiency of gas use and encouraging low-carbon technologies, reduce gas demand. This more than offsets the enhanced competitiveness of gas against coal and oil in power generation and end-use applications that results from higher carbon prices and regulatory instruments. Gas demand in OECD countries generally peaks by

around the middle of the projection period in this scenario and then declines through to 2030, as generators switch investment mainly to renewables and nuclear power capacity. The United States sees higher gas use than in the Reference Scenario in the last decade of the *Outlook* period, largely because gas becomes more competitive against coal.

Gas resources are huge but exploiting them will be challenging

The world's remaining resources of natural gas are easily large enough to cover any conceivable rate of increase in demand through to 2030 and well beyond, though the cost of developing new resources is set to rise over the long term. Proven gas reserves at the end of 2008 totalled more than 180 tcm globally – equal to about 60 years of production at current rates. Over half of these reserves are located in just three countries: Russia, Iran and Qatar. Estimated remaining recoverable gas resources are much larger. The long-term global recoverable gas resource base is estimated at more than 850 tcm (including only those categories of resource with currently demonstrated commercial production). Unconventional gas resources – mainly coalbed methane, tight gas (from low-permeability reservoirs) and shale gas – make up about 45% of this total. To date, only 66 tcm of gas has been produced (or flared).

The non-OECD countries as a whole are projected to account for almost all of the projected increase in global natural gas production between 2007 and 2030. The Middle East sees the biggest increase in output (and in exports) in absolute terms: that region holds the largest reserves and has the lowest production costs, especially when the gas is produced in association with oil. Iran and Qatar account for much of the growth in output. Africa, Central Asia (notably Turkmenistan), Latin America and Russia also see significant growth in production. Inter-regional gas trade is projected to grow substantially over the projection period, from 677 bcm in 2007 to around 1 070 bcm in 2030 in the Reference Scenario and just over 900 bcm in the 450 Scenario. OECD Europe and Asia-Pacific see their imports rise in volume terms in both scenarios.

The rate of decline in production from existing gas fields is the prime factor determining the amount of new capacity and investment needed to meet projected demand. A detailed, field-by-field analysis of the historical gas-production trends of nearly 600 fields (accounting for 55% of global production) indicates that close to half of the world's existing production capacity will need to be replaced by 2030 as a result of depletion. This is the equivalent of twice current Russian production. By then, only about one-third of total output comes from currently producing fields in the Reference Scenario, despite continuing investment in them. Decline rates for gas fields once they have passed their peak are lower for the largest fields and higher for offshore fields than for onshore fields of similar size. The observed average post-peak decline rate of the world's largest gas fields, weighted by production, is 5.3%. Based on these figures and estimates of the size and age distribution of gas fields worldwide, the global production-weighted decline rate is 7.5% for all fields beyond their peak – a similar rate to oilfields.

Unconventional gas changes the game in North America and elsewhere

The recent rapid development of unconventional gas resources in the United States and Canada, particularly in the last three years, has transformed the gas-market outlook, both in North America and in other parts of the world. New technology, especially horizontal-well drilling combined with hydraulic fracturing, has increased productivity per well from unconventional sources — notably shale gas — and cut production costs. This supplement to supply, combined with weak demand following the economic crisis and higher than usual storage levels, has led to a steep drop in US gas prices from an average of almost $9 per million British thermal units (MBtu) in 2008 to below $3/MBtu in early September 2009, cutting liquefied natural gas (LNG) import needs and putting downward pressure on prices in other regions. The fall in North American prices has inevitably reduced drilling activity, but production has held up remarkably well, indicating that marginal production costs have fallen steeply. Our analysis shows that new unconventional sources of supply have the potential to increase overall North American production at a wellhead cost of between $3/MBtu and $5/MBtu (in year-2008 dollars and drilling and completion costs) for the coming several decades, though rising material costs and rig rates are expected to exert upward pressure on unit costs over time. The high decline rates of unconventional gas will also require constant drilling and completion of new wells to maintain output.

The extent to which the boom in unconventional gas production in North America can be replicated in other parts of the world endowed with such resources remains highly uncertain. Outside North America, unconventional resources have not yet been appraised in detail and gas production is still small. Some regions, including China, India, Australia and Europe, are thought to hold large resources, but there are major potential obstacles to their development in some cases. These include limitations on physical access to resources, the requirement for large volumes of water for completing wells, the environmental impact and the distance of resources from the existing pipeline infrastructure. In addition, the geological characteristics of resources that have not yet been appraised may present serious technical and economic challenges to their development. In the Reference Scenario, unconventional gas output worldwide rises from 367 bcm in 2007 to 629 bcm in 2030, with much of the increase coming from the United States and Canada. The share of unconventional gas in total US gas production rises from over 50% in 2008 to nearly 60% in 2030. In Asia-Pacific (outside Australia) and Europe, output is projected to take off in the second half of the projection period, though the share of unconventional gas in total production in those regions remains small. Globally, the share of unconventional gas rises from 12% in 2007 to 15% in 2030. This projection is subject to considerable uncertainty, especially after 2020; there is potential for output to increase much more.

A glut of gas is looming

The unexpected boom in North American unconventional gas production, together with the current recession's depressive impact on demand, is expected to contribute to an acute glut of gas supply in the next few years. Our analysis of trends in gas demand and capacity, based on a bottom-up assessment of ongoing investment and capacity additions

from upstream, pipeline and LNG projects, points to a big increase in spare inter-regional gas transportation capacity. We estimate that the under-utilisation of pipeline capacity between the main regions and global LNG liquefaction capacity combined rises from around 60 bcm in 2007 to close to 200 bcm in the period 2012-2015. The utilisation rate of this capacity drops from 88% to less than three-quarters. The fall in capacity utilisation is likely to be most marked for pipelines; the owners of new LNG capacity are likely to be more willing to offer uncontracted supplies onto spot markets at whatever price is needed to find buyers, backing out gas that would otherwise have been traded internationally by pipeline (though the volume guarantees in long-term, take-or-pay contracts will limit somewhat the extent to which buyers will be able to reduce their offtake of piped gas).

The looming gas glut could have far-reaching consequences for the structure of gas markets and for the way gas is priced in Europe and Asia-Pacific. The much-reduced need for imports into the United States (due to improved prospects for domestic production and weaker-than-expected demand) could lead to less connectivity between the major regional markets (North America, Europe and Asia-Pacific) in the coming years. Relatively low North American gas prices are expected to discourage imports of LNG. Assuming that oil prices rise in the coming years — and that there is no major change in pricing arrangements — gas prices will tend to rise in Europe and Asia-Pacific because of the predominance of oil-indexation in their long-term supply contracts, diverging from those in North America. However, sliding spot prices for LNG could increase the pressure on gas exporters and marketers in Europe and Asia-Pacific to move away from, or to adjust, the formal linkage between gas and oil prices in long-term contracts. If the major exporting countries bend to pressure from importers to modify the pricing terms in their long-term contracts and make available uncontracted supplies to the spot market, lower prices would result. This would help to boost demand, especially in power generation (in which some short-term switching capability exists and new gas-fired capacity could be brought on stream within three to four years) and reduce the overhang in supply capacity in the medium term.

ASEAN countries will become a key energy market

The ten countries of the Association of Southeast Asian Nations (ASEAN) are set to play an increasingly important role in global energy markets in the decades ahead. Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam collectively make up one of the world's most dynamic and diverse regions, with an economy as large as Canada and Mexico combined, and a population that exceeds that of the European Union. Their energy consumption is already comparable to that of the Middle East and is set to continue to grow rapidly from a comparatively low per-capita level, fuelled by rapid economic and population growth, and by continuing urbanisation and industrialisation. In the Reference Scenario, ASEAN primary energy demand expands by 76% between 2007 and 2030, an average annual rate of growth of 2.5% — much faster than the average rate in the rest of the world. Reflecting the current economic weakness, demand is projected to grow modestly in the near term, before quickening. Even in the 450 Scenario, demand grows at 2.1% per year. Coupled with the emergence of China and India on the global energy scene, these trends point to a refocusing of global energy activity towards Asia.

Many hurdles will need to be overcome if Southeast Asia is to secure access to the energy required to meet its growing needs at affordable prices and in a sustainable manner. The energy sector in most parts of the region is struggling to keep pace with the rapid growth in demand experienced since the region's recovery from the Asian Financial Crisis of 1997/1998. With only about 1% of the world's proven reserves of oil, the region is heavily dependent on imports and is set to become even more so in the future. It also faces possible natural gas-supply shortages in the decades ahead, despite rapidly growing reliance on coal-fired power generation. While parts of Southeast Asia have relatively abundant renewable sources of energy, various physical and economic factors have left a significant share of it untapped. A total of $1.1 trillion needs to be invested in energy infrastructure in the ASEAN region in 2008-2030 in the Reference Scenario, more than half in the power sector. In the 450 Scenario, total investment needs are $390 billion higher. Financing is a major challenge, exacerbated by the recent global financial crisis, which has forced energy companies to cut back on capital spending and delay or cancel projects. At the same time, access to modern energy services still remains limited in some pockets of the region: it is estimated that 160 million people have no access to electricity today, though this number drops to 63 million by 2030 in the Reference Scenario.

Turning promises into results

The upcoming UN Climate Change Conference in Copenhagen will provide important pointers to the kind of energy future that awaits us. Whatever the outcome, implementation of the commitments that are made — then or later — will remain key. The road from Copenhagen will undoubtedly be as bumpy as the road leading up to it. It will need to be paved with more than good intentions. The IEA has already called on all countries to take action on a large scale — a *Clean Energy New Deal* — to exploit the opportunity the financial and economic crisis presents to effect the permanent shift in investment to low-carbon technologies that will be required to curb the growth of energy-related greenhouse-gas emissions. Recent initiatives by a number of countries within the framework of economic stimulus packages are an important step in this direction. But much more needs to be done to get anywhere near an emissions path consistent with stabilisation of the concentration of greenhouse gases in the atmosphere at 450 ppm and limiting the rise in global temperature to 2°C.

A critical ingredient in the success of efforts to prevent climate change will be the speed with which governments act on their commitments. Saving the planet cannot wait. For every year that passes, the window for action on emissions over a given period becomes narrower — and the costs of transforming the energy sector increase. We calculate that each year of delay before moving onto the emissions path consistent with a 2°C temperature increase would add approximately $500 billion to the global incremental investment cost of $10.5 trillion for the period 2010-2030. A delay of just a few years would probably render that goal completely out of reach. If this were the case, the additional adaptation costs would be many times this figure. Countries attending the UN Climate Change Conference must not lose sight of this. The time has come to make the hard choices needed to turn promises into action.

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