INTERNATIONAL ENERGY AGENCY

Findings of Recent IEA WORK 2007

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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-six of the OECD thirty 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 the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The Slovak Republic and Poland are likely to become member countries in 2007/2008. 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.

The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.
The European Commission takes part in the work of the OECD.

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FOREWORD

This new edition of "Findings of Recent IEA Work" provides a sample of the Agency's activities since its 2005 Ministerial meeting. Each page focuses on a specific subject or project, including references to IEA work that will be of use to governments, academics, journalists and the wider public. This volume is not all-inclusive, but seeks to highlight IEA efforts to respond to the concerns of its member countries and identify ways to overcome the energy challenges we face.

Since the last meeting of IEA energy ministers in May 2005, the global energy picture has changed. Hurricane Katrina devastated production and refining infrastructure in the Gulf of Mexico, highlighted our continued vulnerability to supply disruptions. IEA members responded quickly and effectively and the oil market was stabilised. However, continued geopolitical uncertainty in some producer regions and investment hurdles in both producing and consuming countries recurrently remind us that energy security remains a priority. These concerns were highlighted more broadly by power blackouts in IEA member countries and gas disputes between Russia and several transit countries. Sustained high energy prices – above levels of recent years – strained the global economy, though demand continued to grow.

Another notable development has been the emerging consensus that climate change is not only caused by human activity, but occurring more rapidly than expected. Because energy production and use account for more than 80% of greenhouse gas emissions, solutions must be found that provide continued access to affordable energy to drive our economies and also protect our environment. To this end, the IEA ministers and the G8 have asked the IEA to make concrete recommendations to achieve a "clean, competitive and clever energy future." Energy efficiency is a vital first step, but strong commitment to research, development and deployment of technology is essential for the longer term.

As we tackle these twin challenges of energy security and climate change, we must not act individually or in blocs. We must work beyond the borders of the IEA, engaging and co-operating with major producing countries like Russia and the OPEC members as well as emerging consumers like China and India. For global problems, we need global answers. We hope that the work presented in this book helps to identify some of these answers.

Claude Mandil

Executive Director of the IEA

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EMERGENCY RESPONSE STRATEGIES AND MECHANISMS

KEY MESSAGES

- On 2 September 2005, the 26 IEA member countries agreed to take collective action in response to the interrupted oil supplies caused by hurricane damage in the Gulf of Mexico, by making available to the market the equivalent of 60 million barrels of oil through emergency response measures.
- Since IEA member countries responded rapidly, flexibly and credibly, this collective action had an immediate calming effect on the market. IEA emergency response policies and measures will be further strengthened by the lessons learned from the response, improving on the ability of member countries to respond collectively to future challenges.
- The IEA has continued its peer reviews to strengthen the overall emergency response capabilities of each member country. Over the past two years, 20 Emergency Response Reviews (ERRs) have completed the 2001-2006 review cycle.
- Workshops including near-term risks, scenario exercises, and tools for evaluating the economic impacts of oil crises, have been conducted through joint SEQ/SOM sessions in order to keep member countries updated and trained in emergency preparedness.
- The IEA will continue to monitor and assess its emergency capabilities and response measures, extending emergency preparedness co-operation world-wide.

Hurricane Katrina

On 2 September 2005, the IEA Executive Director announced that all 26 IEA member countries were taking collective action in response to the oil supplies disruption caused by Hurricane Katrina. IEA member and candidate countries with the support of the EU Commission agreed to make available to the market the equivalent of 60 million barrels of oil for an initial period of 30 days.

While the net loss of crude, other liquids and refined products totaled some 168 million barrels by the end of 2005, the IEA collective action successfully reinforced market functions by providing real barrels to relax the market tightness. The impact of the Hurricanes was smoothly addressed by a combination of the IEA collective action, sharply lower demand, worldwide refinery and logistic flexibility, and additional efforts by producer countries.

Overall, key elements to the success of the collective action:

- IEA member countries' holdings of not only crude, but also quantities of product stocks, were essential to meeting this specific supply disruption;
- rapid and efficient decision-making in member countries, permitting immediate action by the Secretariat;
- the volume of timely and accurate oil market information and assessments;
- timely and credible IEA messages to the public, before and during the supply disruption;
- personnel in capitals trained in collective emergency response, data and risk assessment;
- and dialogue and information sharing amongst all major global stakeholders, *e.g.* market players and major producing and consuming countries outside IEA.

REFERENCES

The Emergency Response Reviews of IEA Member Countries: The Netherlands, Australia, New Zealand, Italy, Denmark, Sweden, Hungary, Spain, Canada, United States, Turkey, Czech Republic, Norway, Japan, France, Korea, Switzerland, Austria, and Germany.

The Emergency Response Reviews of IEA Candidate Countries: Slovak Republic.

IEA Gas Security Workshop, Paris, June 2006.

GLOBAL OIL MARKET SECURITY

KEY MESSAGES

- Continuing tightness and volatility in the oil market is underpinned by capacity constraints, growing demand and geopolitical unrest. The evolution of emergency policies and mechanisms must remain closely related to developments in global market trends and sociopolitical events.
- In recognition of the importance of IEA non-member countries' emergency response capabilities, the IEA continues to work closely with key countries, including China and India, on emergency response policies and the development of strategic oil stocks.
- In 2006, the IEA was particularly involved with China, India, the ASEAN countries as well as new EU members.

SUMMARY

The oil market in 2006 was characterised by high oil prices, increasing demand in Asia, reduced spare production capacity in the Middle East and increased political uncertainties in the world. Such a combination of factors greatly amplifies the potential effect of an oil supply disruption. For this reason, oil security continues to be a core mission for the IEA.

An assessment of the near-term risks to the oil market was the first phase of the Third IEA Emergency Response Training and Disruption Simulation Exercise, conducted in 2004. Joint committee sessions in 2006 followed up on this work, where industry and financial experts identified key risks in the oil supply chain, given the current conditions of a tight supply/demand balance, low spare production capacity and high price volatility.

Growing Asian demand is a critical feature of the global oil market today and, consequently, security of supply is an issue of increasing concern to affected countries. China and India have shared information with IEA member countries whilst making some progress in preparations to build strategic oil stocks. China, already reported to have started filling strategic reserves, hosted with the IEA a Joint Oil Security Workshop in Beijing in October 2006. The event was successful and both parties agreed on the importance of enhancing global emergency response capabilities to protect oil supply security.

Following up on the agreement, high-ranking Chinese officials joined IEA official events such as the Joint SEQ/SOM sessions held in Paris in November 2006 and the IEA Governing Board Seminar in Sydney, December 2006, entitled "China and India: Energy Insights from the Asia Pacific". Both occasions were extremely useful in further deepening the mutual partnership between China and the IEA.

The IEA will continue to collaborate on emergency preparedness and reinforce dialogue with key IEA non-member countries in all areas of the world.

REFERENCES

China-IEA Joint Workshop on Oil Security, Beijing, October 2006.

Chinese official participation in Joint SEQ/SOM sessions, Paris, November 2006.

IEA Governing Board seminar "China and India: Energy Insights from the Asia Pacific", Sydney, December 2006.

WORLD ENERGY OUTLOOK 2006

KEY MESSAGES

- The world is facing twin energy-related threats: that of not having timely and secure supplies of energy at affordable prices and that of environmental harm caused by consuming fossil fuels. G8 leaders, at their summits in Gleneagles in July 2005 and St. Petersburg in July 2006, called on the IEA to "advise on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future". The *World Energy Outlook 2006* (WEO-2006) responds to that request.
- Global primary energy demand in the *WEO-2006* Reference Scenario is projected to increase by 53% between 2004 and 2030. Fossil fuels remain the dominant source of energy, accounting for 83% of the overall increase in energy demand. Global energy-related CO_2 emissions increase by 55% between 2004 and 2030, or 1.7% per year.
- In the *WEO-2006* Alternative Policy Scenario, world primary energy demand in 2030 is about 10% lower than in the Reference Scenario. The policies and measures in this Scenario, aimed at increasing energy efficiency and reducing dependence on fossil fuels, yield financial savings that far exceed the initial extra investment cost for consumers. Energy-related CO_2 emissions are cut by 16% in 2030 compared to the Reference Scenario.

SUMMARY

Global primary energy demand in the Reference Scenario, which assumes that government policies do not change, is projected to increase at an average annual rate of 1.6% from 2004 to 2030. Over 70% of the increase in demand over the projection period comes from developing countries, with China alone accounting for 30%. Coal use in the Reference Scenario rises significantly faster than in *WEO-2005*. Power generation accounts for 81% of the increase in coal use to 2030; and of the total increase, 86% comes from developing Asia, particularly China and India. Global energy-related CO_2 emissions reach 40 gigatonnes in 2030, an increase of 14 Gt over the 2004 level. Developing countries account for over three-quarters of the increase in global CO_2 emissions between 2004 and 2030.

In the Alternative Policy Scenario, policies and measures that governments are currently considering aimed at enhancing energy security and mitigating CO_2 emission are assumed to be implemented. Policies that encourage the more efficient production and use of energy contribute almost 80% of the avoided CO_2 emissions. The policies that are most effective in reducing emissions also yield the biggest reductions in oil and gas imports. Nuclear power, where accepted, could make a major contribution to reducing dependence on imported gas and curbing CO_2 emissions.

Meeting the world's increasing hunger for energy requires massive investment in energy-supply infrastructure. The Reference Scenario projections in the *WEO-2006* call for cumulative investment of just over USD 20 trillion (in year-2005 dollars) over 2005-2030. Investment in the Alternative Policy Scenario is USD 560 billion lower, because demand-side investments in end-use equipment and buildings is more than outweighed by the investment avoided on the supply side.

REFERENCE

IEA (2006), *World Energy Outlook 2006*, OECD/IEA, Paris.

WORLD ENERGY OUTLOOK 2005: MIDDLE EAST AND NORTH AFRICA INSIGHTS

KEY MESSAGES

- The greater part of the world's remaining oil and gas reserves lie in the Middle East and North Africa (MENA) region. They are relatively under-exploited and are sufficient to meet rising global demand for the next quarter century and beyond.
- Substantial investments are needed in the upstream hydrocarbons sector in MENA countries. In the *WEO-2005* Deferred Investment Scenario, much lower MENA oil production drives up the international price of oil.
- The need for more comprehensive and transparent data on oil and gas reserves in the MENA region is a pressing concern.

SUMMARY

In the *WEO* Reference Scenario, MENA share of world oil production would jump from 35% in 2004 to 44% in 2030. MENA production would outpace growth in domestic demand, allowing the region's net oil exports to rise by three-quarters over the *Outlook* period, from 22 mb/d in 2004 to 25 mb/d in 2010 and 39 mb/d by 2030. Desalination plants will be increasingly relied upon to meet freshwater needs, especially in Saudi Arabia, the UAE, Kuwait, Qatar, Algeria and Libya. Energy use in such plants will account for more than a quarter of the total increase in fuel use in the power and water sector in these countries. Desalination capacity there will more than triple over 2003-2030, requiring investment of USD 39 billion. More than half of new power generation capacity will be in combined water-and-power (CWP) plants.

Rapidly expanding populations, steady economic growth and heavy subsidies will continue to drive up energy demand in MENA itself. Most MENA countries will continue to rely almost exclusively on oil and natural gas to meet their energy needs.

A Deferred Investment Scenario shows how global energy markets will evolve if upstream oil investment in each MENA country was to increase much more slowly over the projection period than in the Reference Scenario reflecting, for example, supply contract policies by OPEC producers. This could also reflect government decisions to limit budget allocations to the industry or constraints on the industry's ability or willingness to invest in upstream projects. The Deferred Investment Scenario results in an international crude oil price that will be USD 13 higher in 2030, or USD 21 in money of the day – an increase of almost one-third. World energy demand would be reduced by around 900 Mtoe, or 6%, in 2030 compared with the Reference Scenario, as a result of higher prices and lower GDP growth. MENA oil production would fall by 15 mb/d, or 30%, in 2030 compared with the Reference Scenario. The cumulative value of MENA oil and gas export revenues over 2004-2030 would be USD 1 000 billion lower than in the Reference Scenario.

However, consuming country policies could curb demand growth and reduce the world's reliance on MENA oil and gas. The *WEO* Alternative Policy Scenario demonstrates that if governments were to implement new policies they are considering today, aimed at addressing environmental and energy-security concerns, fossil-fuel demand and CO_2 emissions would be significantly lower.

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CURRENT TRENDS IN OIL AND GAS INVESTMENT

KEY MESSAGES

- Capital spending by the world's leading oil and gas companies increased sharply in nominal terms over the first half of the current decade and, according to company plans, will rise further to 2010. But most of this increase is explained by higher costs, so that the increase in capacity is likely to be modest.
- Higher investment in real terms is needed now to ensure growth in upstream and downstream capacity beyond 2010.

SUMMARY

The *World Energy Outlook 2006* takes an in-depth look at trends in global oil and gas investment. It finds that the ability and willingness of major oil and gas producers to step up investment in order to meet rising global demand are not obvious. While capital spending by the world's leading oil and gas companies increased sharply in nominal terms over the first half of the current decade, investment in 2005, expressed in cost inflation-adjusted terms, was only 5% above that in 2000. Planned upstream investment to 2010 is expected to boost slightly global spare crude oil production capacity. But actual capacity additions could be smaller on account of shortages of skilled personnel and equipment, regulatory delays, cost inflation, higher decline rates at existing fields and geopolitics.

If major oil and gas company plans are fully implemented over the next few years, oil and gas investment would rise from USD 340 billion in 2005 to USD 470 billion in 2010 in nominal terms. In real terms, investment would be 40% higher in the second half of the decade than in the first. The upstream is expected to absorb almost two-thirds of total capital spending, of which two-thirds will go to maintaining or enhancing production at existing fields. The five years to 2010 will see an unprecedented increase in capital spending on new LNG projects, and world LNG capacity will almost double if these projects are all completed on time.

Over the long term, maintaining growth in production capacity will require more investment in real terms. Future projects are likely to be smaller, more complex and remote, involving higher unit costs. Slowing production declines at mature giant fields will require increased investment in enhanced recovery.

REFERENCE

IEA (2006), *World Energy Outlook 2006*, OECD/IEA, Paris.

ENERGY POLICIES OF IEA COUNTRIES 2005 AND 2006 REVIEW

KEY MESSAGES

- In 2005 and 2006, energy security of supply and energy efficiency were the objects of renewed attention, reflecting factors such as very high and considerably more volatile energy prices, increased energy demand in major non-member countries and continued geopolitical concerns in the Middle East. Hurricane Katrina led to a co-ordinated reserve release by the IEA, the second one in its history, helping to calm the markets at a critical point.
- *Energy Policies of IEA Countries* 2005 and 2006 focused on how the 3E's (Energy security, Environmental protection and Economic growth) can be simultaneously ensured. The 2005 edition contained a special chapter on good practices, the 2006 volume on energy efficiency policies, both aiming to promote the most effective measures amongst IEA member governments.

SUMMARY

The years 2005-2006 can be characterised by acute energy policy challenges, including volatile energy markets, a prolonged activation of IEA coordinated stock draw after Hurricane Katrina, and continued geopolitical tensions in a number of producing countries. The macroeconomic impact of extremely high energy prices raised concerns while natural gas supply security crises in Europe in January 2006 further sharpened the focus on supply. Accelerating indications of global climate change increased pressure to curb greenhouse gas emissions.

Energy security remains a fundamental goal of the IEA, but today the security considerations have become more broadly defined. The IEA focus has been expanded from oil to other forms of energy, such as natural gas, renewables, and electricity, as well as energy efficiency. Reliable access to energy supply needs to be compatible with other policy objectives, namely the pursuit of greater economic efficiency in the energy sector and the mitigation of environmental consequences of energy production and use.

Achieving all these objectives simultaneously presents a daunting task for member governments. While market reforms should, in principle, reinforce energy security, they also depend on the design of reforms and incentives for investors. Actions to reduce GHG emissions, meanwhile, could have profound implications on energy markets and energy security. In short, the challenges for energy policy makers have become far more complex than in 1974, and energy policy needs to be conducted along multiple axes at the same time.

In the 2006 review, the IEA examines trends in energy markets, including an updated analysis of energy demand and supply, energy prices and energy-related CO_2 emissions, based on the in-depth reviews over the past four years covering all 26 member countries. It highlights key policy trends across both member and non-member countries in energy security, energy market reform, climate change mitigation, energy efficiency, renewables and energy R&D. A special chapter on energy efficiency compares the most successful efficiency policies of member countries. While they have made considerable progress in pursuing the shared goals, governments still need to make their energy policies more effective.

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IEA (2006), *Energy Policies of IEA Countries: 2006 Review*, OECD/IEA, Paris.

IEA OIL MARKET REPORT

KEY MESSAGES

- The IEA Oil Market Report (OMR) covers short-term developments in the world oil market. It provides the first opportunity to examine the latest OECD statistics and gives up to 18-month projections for global oil supply and demand.
- The OMR highlights changing trends in oil demand, with world data and forecasts.
- It features supply data for OPEC countries, as well as production on a field-by-field basis (when available) for OECD countries and over 50 other oil-producing countries.
- End-user, spot and futures price developments in crude and products are analysed, as well as developments in regional crude and product prices: Northwest Europe, Mediterranean, United States Gulf Coast, West Africa, North Sea, Middle East and Asia.
- The OMR gives details of the latest refinery crude throughputs for OECD countries and calculations of net product worth and refining margin trends for Northwest Europe, the Mediterranean, the United States West and Gulf Coasts, Singapore and China.
- It includes comprehensive coverage of industry and government-controlled stock data in each OECD region (and selected OECD countries) for crude oil, gasoline, middle distillates and fuel oil, in both barrels and days of forward demand.
- A user guide and an annual statistical supplement, containing historical background data, are produced in conjunction with the August issue of the OMR.

SUMMARY

Over the last 20 years, the IEA Oil Market Report has become essential reading for all those involved in oil market decision-making, forecasting, analysis and planning. It provides extensive coverage of market fundamentals: demand, supply, prices, refinery activity and OECD stocks. Forecasts of oil demand and supply are summarised in a World Balance Table, with extensive detail of the underlying analysis provided in supplementary tables. The OMR provides comprehensive coverage and analysis of the oil market based on timely data submitted to the IEA by member governments each month. An annual statistical supplement is published in order to provide readers with a longer perspective of the evolution of the oil market than the short-term developments covered by the OMR. A condensed version of the Report in Russian is available on the IEA website. The Report is published under the responsibility of the Executive Director and Secretariat of the IEA. Although some of the data are supplied by member governments, largely on the basis of information received from oil companies, neither governments nor companies necessarily share the Secretariat's views or conclusions in the OMR.

REFERENCES

Oil Market Report, IEA, Paris.

www.oilmarketreport.org

IEA MEDIUM-TERM OIL MARKET REPORT

KEY MESSAGES

- The IEA new Medium-Term Oil Market Report (MTOMR) looks at developments in supply, demand, biofuels and refining over the next five years, providing a bridge between the *Oil Market Report* (OMR) and the *World Energy Outlook* that gives a long-term outlook to 2030.
- The MTOMR looks in depth at world oil market issues on the cusp of the investment horizon, alerting policy makers to potential issues that may need to be addressed in the coming years. The work was conducted at the request of the G8, and involved the construction of new models on supply, demand and refining to enable medium-term forecasts to be kept up-to-date throughout the year. The main report is published mid-year, with an interim report early in the new year.
- The Report uses similar detail to the OMR, looking at demand on a product-by-product basis for every country in the world. The analyses, where possible, also look in detail at the supply potential from individual fields and refineries.

SUMMARY

A bulge in non-OPEC supply growth between 2006 and 2009 as well as ongoing OPEC investment leads to an increase in OPEC spare capacity, but in 2010 and 2011 new non-OPEC supply-side additions begin to lag behind strong growth in demand. OPEC spare capacity is expected to build modestly from 2.2-3.6 mb/d in 2006 to 3.4-5.2 mb/d by 2011, but should remain low as a proportion of global demand. Non-OPEC supply growth is expected to average 1.3 mb/d per annum over the next five years, with Brazil, Russia, the Caspian republics, Angola, North America and non-OPEC NGLs accounting for most of the gains. Increased project risks remain in many countries due to rising costs and geopolitical issues.

Global demand growth, based on IMF and OECD economic forecasts, is expected to remain above the long-term trend for the coming five years as non-OECD countries take an increasing share of oil consumption growth. Non-OECD oil consumption is projected to increase at more than five times the rate of growth in the OECD between 2006 and 2011 as demand in the mature economies steadies. Oil demand growth remains driven by transportation fuels, while fuel oil continues to be substituted where possible. Natural gas remains the fuel of choice for power generation, but availability and cost issues have prompted a switch to coal. Investment in new refinery capacity and upgrading capacity is expected to outpace demand growth.

World biofuels production is expected to treble from its 2005 levels by 2011, with sharp gains seen in Brazil, US and Europe. Biofuel production remains policy-driven, and the IEA forecast remains conservative due to the uncertain economics.

Refinery capacity and upgrading additions should go some way to removing the fuel oil overhang, and addressing seasonal gasoline tightness in the Atlantic Basin. Relatively, diesel and jet fuel remain in tighter supply.

REFERENCES

Bi-annual *Medium Term Oil Market Report*, IEA, Paris.

www.oilmarketreport.org

OIL MARKET REPORT WEBSITE WWW.OILMARKETREPORT.ORG

KEY MESSAGES

- In the effort to provide the most up-to-date oil market trends and add transparency to the market, the IEA *Oil Market Report* (OMR) website is an internet portal offering further coverage of in-depth analysis on short-term oil market developments provided by the Report.
- This web service is a perfect complement to the macro analysis in the Report. For each section of the OMR, a counterpart on the website with drop-down boxes enables the rapid selection of topics. The charts also come with a choice of options that allow subscribers to look at developments according to their analytical need.
- The information is downloadable in PDF format and can be copied and pasted into other documents for use in presentations and essays.

SUMMARY

In addition to providing a PDF of the latest OMR, the website, through over 3 000 charts covering all aspects of oil market fundamentals, provides greater detail. The charts reflect the latest data contained in the OMR and allow subscribers to go beyond the broad market trends presented in the Report.

The service was officially launched in September 2003, accompanied by a mirror public access site. Monthly updates to www.oilmarketreport.org are reserved for OMR subscribers for two weeks following the release of the Report, but are then made available for all visitors via the public site at http://omrpublic.iea.org.

The organisation of the website mirrors that of the OMR. Information is searchable by section (supply, demand, stocks, prices, refinery activity, trade and market overview), location (regions, individual countries) and products (gasoline, distillates, crude oil etc.). In addition to over 3 000 downloadable charts and the latest OMR, the website supports a full archive of previous OMRs going back to 1990, a Russian version of the OMR, special features, presentations, a publication schedule and OMR contacts.

REFERENCE

www.oilmarketreport.org

IEA NATURAL GAS MARKET REVIEW 2006 AND 2007

KEY MESSAGES

- The IEA *Natural Gas Market Review* is a new annual series. It was launched in 2006 to respond to the 2005 IEA ministerial request to increase work on natural gas security.
- Strong demand growth to 2010 is driven by OECD countries and, increasingly, developing countries. However, there is a serious risk of underinvestment in gas production and transportation necessary to meet this demand.
- OECD countries are increasingly looking to imports as domestic production reaches a plateau and falls. Imports from Russia will remain essential but there are concerns about upstream investment. The differences in their investment climates have been the key factor in explaining the rise of Qatar and the fall of Indonesia as exporters of liquid natural gas (LNG).
- The current decade is seeing the rise of the LNG tanker – the LNG market worldwide will double in size from 2004 to 2010. The increased flexibility of LNG over pipelines is linking the three distinct IEA regional markets towards a global gas market.

SUMMARY

Natural gas already accounts for a quarter of IEA energy requirements while imports to all IEA regions are now a "fact of life" and will increase. Three quarters of gas reserves lie within the regions of the former USSR and the Middle East. Strategic gas stocks are one possibility to counter eventual future import disruptions, but this would require significant investment to be built as well as efficient regional/global gas markets if gas stocks were to be as effective as IEA oil stocks. A rapid expansion of LNG trading is driving the emergence of such a global market, but IEA policy makers must reform their domestic gas markets if they are to benefit from this change in the gas industry.

New gas-fired power plants still drive the projected increase in gas consumption in IEA countries. The relative cleanliness and public acceptability of gas mean that it still has many advantages – accounting for the vast majority of new capacity in the IEA from 2000 to 2010. Beyond 2010, there is considerable uncertainty in factors that will have a great impact on the choice of plant: the cost of CO_2 and the acceptance of nuclear power. Meanwhile, policy-makers need to assess the interaction of local power markets and globalising gas markets.

Russia continues to be the largest producer and exporter of gas in the world. To satisfy its commitment to increase exports as well as its increasing domestic obligations, Russian policy makers must act. Investment in production must be increased, but investment in end-use efficiency must also be improved. Russian domestic gas market reform is of pressing urgency but, despite this, the weakest link in the Russian gas supply chain is its growing reliance on gas imports from the Caspian region in general and Turkmenistan in particular.

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IEA Increased Transparency in Natural Gas Information Workshop, Paris, June 2006.

IEA Gas Security Workshop, Paris, June 2006.

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ENERGY STATISTICS, AN ESSENTIAL COMPONENT OF ENERGY ANALYSIS AND POLICY

KEY MESSAGES

- Detailed, complete, timely and reliable statistics are essential to monitor the global energy situation. Energy statistics on supply, trade, stocks, transformation and demand are the basis for any sound energy policy.
- In view of the importance of energy in world development, one would expect basic energy information to be readily available and reliable. However, this is not the case. Even worse, over the last few years, quality, coverage and timeliness of energy statistics have deteriorated.
- This decline happens at a time when transparency is a policy priority: at the 9th International Energy Forum in Amsterdam in May 2004, energy ministers commended the work done in the Joint Oil Data Initiative, and at their October 2004 meeting, G8 finance ministers called for more action to improve transparency.
- The International Energy Agency has embarked upon a programme to reverse current trends by developing tools to facilitate the preparation and delivery of reliable statistics.

SUMMARY

There are several reasons behind the decline of quality in energy statistics, including liberalisation of energy markets, additional data requests, budget cuts and diminishing expertise. Liberalisation, for instance, has had a double impact on statistics: more companies to survey and more confidentiality issues.

Additional data have been requested from energy statistics offices over recent years, ranging from statistics on renewables to indicators on energy efficiency and data on greenhouse gas emissions. This additional workload occurred at a time when statistics offices in many countries were experiencing a reduction in their resources.

The actions taken by the IEA to improve statistics include raising policy makers' awareness of their importance, strengthening bonds with national administrative and international organisations and facilitating the preparation of reliable statistics. Strengthening the expertise of energy statisticians and rebuilding institutional memory are also key priorities. This is the reason why the IEA, in co-operation with Eurostat, has released an *Energy Statistics Manual*.

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CDs and Electronic Services

For all the above (except Oil, Gas, Coal and Electricity Quarterly Statistics)
Monthly Oil Data Service and JODI World Database at: www.jodidata.org

THE JOINT OIL DATA INITIATIVE (JODI)

KEY MESSAGES

- Enormous progress has been made in promoting oil data quality since the launch of the Joint Oil Data Initiative in 2001, but there are still challenges ahead.
- The International Energy Forum Secretariat (IEFS) coordinates the efforts of the six organizations, the training workshops and the management of the JODI World database and website. More political commitment from all parties in the JODI initiative was promised at the 10th International Energy Forum meeting in Doha in April 2006.
- The JODI World database was launched in November 2005 by King Abdullah of Saudi Arabia. The 6th JODI conference a year later, decided to expand the JODI questionnaire to include more flows and products.

SUMMARY

Six international organisations - APEC, Eurostat, IEA, OLADE, OPEC and UNSD - took up the challenge in early 2001 to improve oil data transparency. They combined their efforts, involved their member countries and launched the JODI, with the aim to provide more reliable and timely monthly oil data from as many producer and consumer countries as possible.

Progress was fast and substantial. Within a short period, more than 85 countries, representing about 95% of world oil demand and supply, as well as many oil companies were involved. The focus has been on participation, timeliness, completeness, quality and accessibility of data. Political support was provided through the presentation of the initiative at the 8th, 9th and 10th International Energy Forum meetings. These meetings raised political awareness of the JODI by showing the difficulties encountered with statistical systems, such as confidentiality issues, reliability etc. Contacts between oil companies, countries and organisations have been multiplied and reinforced, strengthening the producer-consumer dialogue and the commitment to better data.

Following the 5th JODI conference in 2004, the IEFS took on the full coordinating role of the JODI and the management of the JODI world database and the JODI website. Moreover, several training sessions have been organised by the IEFS in coordination with international organisations, like OLADE in Latin America and UNSD in South Africa (early 2007).

The 6th JODI conference, held in Riyadh in November 2006, aimed to evaluate the JODI World database one year after its release. A user survey presented at the meeting showed a need to extend the current database to include missing products and flows. The next challenge therefore is the extension of the JODI questionnaire, in order to obtain a more complete oil balance and improve the data quality. However, the priority remains complete submissions from all the top 30 producers and consumers, including China and India.

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Oil Data Transparency (a database on OECD countries) at www.iea.org

LEARNING FROM THE BLACKOUTS: TRANSMISSION SYSTEM SECURITY IN COMPETITIVE ELECTRICITY MARKETS

KEY MESSAGES

- Electricity reform creates new challenges for maintaining transmission system security and a comprehensive and integrated policy response is needed.
- The legal, regulatory and structural framework must clarify responsibilities for transmission system security and provide strong incentives for compliance, coordination and information exchange. Mandatory reliability standards are a necessary part of such a framework.
- Transmission system security standards must be developed and adapted to the new competitive framework.
- There is great scope for improved system security by investing in technology, people and maintenance.

SUMMARY

Electricity market reform has fundamentally changed the environment for maintaining reliable and secure power supplies. Growing inter-regional trade has placed new demands on transmission systems, creating a more integrated and dynamic network environment with new real-time challenges for reliable and secure transmission system operation. These operational challenges are intensified as spare transmission capacity is absorbed.

The major blackouts that struck North America, Europe and Australia in 2003/04, affecting over 100 million people, raised fundamental questions about the appropriateness of the rules, regulations and system operating practices that are governing transmission system security. Despite the considerable efforts since 2003 to address the weaknesses exposed by the blackouts, it can still be argued that the development of these rules and operating practices have not kept pace with the fundamental changes resulting from electricity market reform. More can and should be done.

The IEA publication *Learning from the Blackouts* presents case studies drawn from these large-scale power cuts. It concludes that a comprehensive, integrated policy response is required to avoid preventable blackouts in the future.

The legal and regulatory arrangements governing transmission system security can be enhanced. In particular, scope exists to clarify responsibilities and accountabilities and to improve enforcement. System operating practices need to give greater emphasis to system-wide preparation to support flexible, integrated real-time system management. Real-time coordination, communication and information exchange, particularly within integrated transmission systems spanning multiple control areas, can, and must be improved.

REFERENCE

IEA (2005), *Learning from the Blackouts: Transmission System Security in Competitive Electricity Markets*, OECD/IEA, Paris.

LESSENING VULNERABILITY TO PRICES AND PROMOTING EFFICIENCY

- THE IMPACT OF HIGHER ENERGY PRICES ON THE GLOBAL ECONOMY
- LESSONS FROM LIBERALISED ELECTRICITY MARKETS
- TACKLING INVESTMENT CHALLENGES IN POWER GENERATION IN IEA COUNTRIES
- PROSPECTS FOR HYDROGEN AND FUEL CELLS
- COAL: RESPONDING TO THE CHALLENGES
- RENEWABLE ENERGY: RD&D PRIORITIES
- RENEWABLE HEATING AND COOLING: FROM RD&D TO DEPLOYMENT
- GLOBAL RENEWABLE ENERGY MARKETS AND POLICIES
- BIOFUELS FOR THE TRANSPORT SECTOR
- IEA ENERGY INDICATORS
- ENERGY EFFICIENCY: CONCRETE RECOMMENDATIONS
- ENERGY EFFICIENT DOMESTIC APPLIANCES AND EQUIPMENT
- ENERGY EFFICIENCY IN BUILDINGS
- EFFICIENCY IN TRANSPORT: TYRES AND OTHER COMPONENTS
- ENERGY EFFICIENCY AND CO_2 EMISSION REDUCTION IN INDUSTRY

THE IMPACT OF HIGHER ENERGY PRICES ON THE GLOBAL ECONOMY

KEY MESSAGES

- The growing insensitivity of oil demand to price accentuates the potential impact on international oil prices of a supply disruption. The share of transport demand – which is price-inelastic relative to other energy services – in global oil consumption is projected to rise in the Reference Scenario of the *World Energy Outlook*. As a result, oil demand becomes less and less responsive to movements in international crude oil prices.
- Oil prices still matter to the economic health of the global economy. Although most oil-importing economies around the world have continued to grow strongly since 2002, they would have grown even more rapidly had the price of oil and other forms of energy not risen - by an average increment of 0.3 percentage points per year since 2002.
- This price insensitivity has implications for the range of policy choices in effectively addressing climate change.

SUMMARY

The price of crude oil imported into IEA countries averaged just over USD 50 per barrel in 2005, almost four times the nominal price in 1998 and twice the 2002 level. Prices continued to rise strongly through to mid-2006. Real prices paid by most final energy consumers have increased far less than international prices in percentage terms, because of the cushioning effect of taxes and distribution margins and, in some countries, subsidies and a fall in the value of the dollar. We estimate that consumption subsidies in non-OECD countries amount to over USD 250 billion per year.

Strong demand for energy, driven by exceptionally fast economic growth, has helped drive up oil and other energy prices since 1999, but there are signs that higher prices are now beginning to curb demand growth. All the same, oil demand is becoming less sensitive to changes in final prices as consumption is increasingly concentrated in transport, where demand is least price-elastic. Income remains the primary driver of demand for oil, gas, coal, and electricity, demand for all of which has continued to grow strongly, with incomes, in most regions.

The loss of real income and the adverse impact on the budget deficits and current account balances of importing countries due to higher energy prices were proportionately greatest for the most heavily indebted poor countries.

The eventual impact of higher energy prices on macroeconomic prospects remains uncertain, partly because the effects of recent price increases have not fully worked their way through the economic system. There are growing signs of inflationary pressures, leading to higher interest rates. The longer prices remain at current levels or the more they rise, the greater the threat to economic growth in importing countries.

There are major benefits for importing countries, in terms of price, security and economic welfare, of reducing reliance on imported oil and gas. This requires policies to stimulate indigenous production of hydrocarbons and alternative sources of energy and improve energy efficiency. The removal of energy subsidies and economically efficient pricing and taxation policies can play a major role in achieving this goal.

REFERENCE

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LESSONS FROM LIBERALISED ELECTRICITY MARKETS

KEY MESSAGES

- Electricity market liberalisation has delivered considerable economic benefits.
- Liberalisation is a long process that will only come to successful fruition with on-going and committed government involvement.
- Establishing truly independent regulators and system operators precedes a competitive framework.
- A framework for cost-reflective prices is the corner-stone of a responsive competitive market and is built through effective regulation and market design. Muted price signals, through, for example, price caps leads to muted market responses.
- Removing barriers to retail-switching and to active demand participation empowers and protects consumers.

SUMMARY

Reliable access to affordable electricity supply with acceptable environmental impacts can only be achieved with comprehensive and carefully balanced policy actions to establish the necessary incentive-based framework. To that end, liberalisation of electricity markets is a development path and policy option that has been implemented or considered in all IEA member countries.

Through competition in liberalised markets, incentives are created to drive for more efficient operation of electricity systems and more efficient investment decisions in terms of timing, sizing, site and choice of technology. Even if liberalised markets leave critical policy challenges un-resolved, the transparency created by competition tends to improve the framework for targeted policy actions to address issues such as environmental quality and reliability.

After up to ten years' experience with liberalised electricity markets, and even longer in some cases, important lessons can now be drawn from some pioneering countries and regions. Theoretical principles for successful liberalisation can now be augmented with more qualified policy prescriptions based on real-world experience. This work focuses on experiences from the UK, the Nordic countries, Australia and the north-east of the United States.

Even if some pioneering markets have operated with considerable success for a number of years, liberalisation has shown itself not to be a single event, but rather a long process that requires on-going government commitment. No markets are perfect, and they will continue to evolve and develop to match the needs of electricity systems – systems that are at the same time undergoing considerable change.

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TACKLING INVESTMENT CHALLENGES IN POWER GENERATION IN IEA COUNTRIES

KEY MESSAGES

- There is insufficient investment being made in new power generation capacity to replace ageing plants and to meet increasing demand.
- Governments urgently need to reduce policy and regulatory uncertainty for investors; if left unchanged, underinvestment will continue.
- Competition is a powerful tool that governments should promote to give incentives for investments at the right place, at the right time, in the right amount and using the right technology. Cost-reflective prices are the corner stone.
- Ambiguity on long-term policy decisions on, for example, climate change abatement inhibits investors taking a long-term view; we need to open a window of opportunity now to ensure development towards a cleaner generation portfolio.
- Delays caused by slow, inefficient or ambiguous licensing and approval procedures frustrate markets.

SUMMARY

All IEA countries face a new investment cycle in power generation. Many new uncertainties create risks for investors that are leading to under-investment – too little, too late, in the wrong location and with the wrong technology. Liberalisation of markets can be one of these uncertainties, but it may be greatly reduced and not deliver available benefits if it is not implemented whole-heartedly and backed by on-going government commitment. With effective competition there is great scope for the improved use of existing resources, effectively delaying the need for new investments without undermining reliability.

The real underlying investment uncertainties include CO_2, delays in power plant licensing, public resistance to nuclear power, uncertainty about policies to reduce government support for specific generation technologies or policies on energy efficiency. These are areas where governments are best placed to set the framework for effective regulation and to make decisions that are as clear as possible for the long term, without undermining credibility. Competitive markets are essential to effectively balancing efficiency, reliability and environmental responsibility.

Government action is urgently needed to reduce regulatory uncertainty. Governments must establish effective competitive markets and give clear policy direction in those areas where markets fail to take environmental costs or security of supply sufficiently into account.

Efforts to promote competition and reduce policy uncertainty on, for example, climate change abatement, make little difference if investors cannot get permission to build. Governments must rebalance competing interests in favour of new electricity system infrastructure and offer clearer and faster approval procedures, preferably centred on one approval body – "one-stop-shop" licensing – with clear and short timelines for approval processes.

REFERENCE

IEA (2007), *Tackling Investment Challenges in Power Generation in IEA Countries*, OECD/IEA, Paris.

PROSPECTS FOR HYDROGEN AND FUEL CELLS

KEY MESSAGES

- Hydrogen and fuel cells are among the technology options that may help reduce CO_2 emissions in power generation and in the transport sector, and mitigate the oil dependence in transport. Further R&D however is needed to produce hydrogen through a low-carbon process, to reduce fuel cells costs and to store hydrogen in fuel cell vehicles.
- Assuming that substantial technical progress will be made and that government will implement policies and offer incentives to reduce emissions, the IEA study *Prospects for Hydrogen and Fuel Cells* concludes that market uptake of hydrogen fuel cell vehicles could start after 2020 and achieve 30% of the global stock of vehicles by 2050. Under less optimistic assumptions, fuel cell vehicles are not likely to reach the critical mass for market uptake, and other technologies such as biofuels may play a larger role.
- In power generation, stationary fuel cells - not necessarily fuelled by hydrogen - are already commercial in niche markets such as back up power or off grid installations. In the next decades, they are expected to gain market share in combined heat and power (CHP) generation for buildings and industry. New technologies (photo-electrolysis, fuel cell concepts, solid hydrogen storage) and basic science advances could transform this outlook, but it is too early to assess their potential.

SUMMARY

Fuel cell engines are about twice as efficient as current petrol engines, but their life is only about half as long and large cost reduction is needed for hydrogen fuel cell vehicles to fulfil their potential market. Today's cost of a Proton Exchange Membrane fuel cell (PEM) for a 75kW prototype vehicle is about USD 150 000. Fuel cell producers are confident that, in mass production, they will be able to reduce this cost to USD 7 000 over the next decade. To be competitive, however, the cost needs to be reduced to below USD 3 500. New design concepts and materials will be needed to meet this target. Early niche market opportunities (urban buses, forklifts) could facilitate technology learning and cost reduction. Hydrogen storage in vehicles remains a key issue. Hydrogen storage in solid materials offers advantages, but requires further research.

In the initial stages of a hydrogen economy hydrogen could be produced locally by natural gas reforming or water electrolysis. Local, small size production is fairly expensive at a cost of over USD 6/kg of hydrogen. One kilogram of hydrogen has about the same energy content as one gallon of gasoline, but used in fuel cell engines it delivers about twice the useful energy. Central production of hydrogen from coal gasification with CO_2 capture and storage (CCS) may play a major role once a distribution network is established. Production from nuclear and solar energy may become cost-effective in the longer term. Advanced technologies promise hydrogen at less than USD 1.5-2/kg by 2020-30, depending to some extent on the costs of natural gas and electricity at the time. CCS for centralised production from fossil fuels would add about USD 0.25-0.5/kg. Distribution by pipeline would cost around USD 0.1-0.25/kg, and the costs of the refuelling stations a further USD 0.35-0.7/kg. A transition to a hydrogen based system would require incremental investment in distribution infrastructure of several hundred billion dollars over several decades. This level of investment is not insurmountable but more research, demonstration projects and international standards are needed.

REFERENCE

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COAL: RESPONDING TO THE CHALLENGES

KEY MESSAGES

- Coal industry case studies show that the principles of sustainable development are well understood and widely practiced at the local level. However, coal's greatest challenge – the commercialisation and uptake of low carbon emission technologies – demands stronger leadership from governments and greater commitment from industry.
- A business-as-usual strategy, with traditional efforts to address CO_2 emissions, will not survive the growing political pressure for a clean, clever and competitive energy future. Collaborative action by governments and industry is required to encourage worldwide, co-ordinated RD&D to deliver near-zero CO_2 emissions from coal use in the longer term.
- The coal industry believes that the adoption of clean coal technologies demands a global market for CO_2 credits (rather than imperfect regional markets) without compromising industrial competitiveness, energy security, the fate of existing assets and efforts to improve efficiency of coal use.
- The IEA has joined the coal industry in elevating the clean development and climate change debates to a more open and transparent dialogue, involving non-governmental organisations, government officials, researchers, engineers, investment advisers, environmentalists and other industries.
- Growing coal use in power generation worldwide is today's greatest challenge. To use coal as a source of transport fuels is currently a very carbon intensive process.

SUMMARY

IEA data show coal use growing at its fastest rate since the IEA was established: 5.5% per year since 2000. By 2030, global coal production could reach 4 441 Mtoe under the Reference Scenario published in the IEA *World Energy Outlook*, 48% more than in 2005. Growth is especially strong in China, where 90 GW of coal-fired generation were commissioned in 2006 and coal production will soon exceed 2.5 billion tonnes. The role of coal in the world's primary energy supply is explored in the *Energy Policies of IEA Countries - 2006 Review* and a number of issues are raised for industry and governments: commercial issues, such as prices, infrastructure investment and transport capacity; and environmental issues, which dominate the IEA work on coal. The Agency's Coal Industry Advisory Board (CIAB) has been actively considering these issues and the above key messages are taken from its recent publications and workshops. Urgent steps are needed to address rising CO_2 emissions from coal use through improved efficiency, widespread use of alternatives, and adoption of clean coal technologies incorporating CO_2 capture and storage. Policy measures must recognise that the latter adds to the cost of coal use.

REFERENCES

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Coal for Sustainable Energy: Clean Development and Climate Change, IEA/World Coal Institute Workshop, New Delhi, May 2006.

Meeting Our Energy Needs: Driving Forward Coal's Role in a Clean, Clever and Competitive Energy Future, IEA/CIAB Workshop, Paris, November 2005.

RENEWABLE ENERGY: RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D) PRIORITIES

KEY MESSAGES

- Renewable energy RD&D spending is less than 8% of total IEA energy RD&D. It has not increased for 20 years and is not sufficient to reach some countries' targets. Governments need to strengthen renewable energy RD&D budgets.
- Cost reduction of renewable technologies is still needed to achieve further market penetration.
- RD&D has to complement market deployment policies to realise renewable energy potential.
- Renewable energy RD&D spending and markets are concentrated in few countries.
- RD&D should address both technical and non-technical barriers to deployment.
- Governments & industry need to co-ordinate RD&D and commercial activities.

SUMMARY

The development of more sustainable renewable energy depends on three inter-related elements: resource availability, technology maturity and a receptive policy environment for technology improvements and commercialisation.

Technology advances and cost reduction among almost all renewable technologies are of primary importance, but these must be combined with novel applications and deployment in the context of distributed power generation, global production and trading of fuels, as well as bulk transmission of renewables-generated power.

First-generation technologies are most competitive in locations where the resource endowment is strong. Their future use depends on proper exploitation of the remaining resource potential, particularly in developing countries, and on overcoming challenges related to the environment and social acceptance.

Support for both RD&D and market deployment is essential to development of a second generation of renewable energy technologies. Some of these technologies are commercially available, albeit often with incentives to ensure cost reductions as a result of "market learning." The challenge is to broaden the market base to ensure continued rapid growth worldwide. Strategic deployment in one country reduces technology costs in other countries, contributing to overall cost reductions and performance improvement.

Some of the second-generation renewables, such as wind, have high potential and have already attained relatively low production costs. However, seasonal variability and dispatchability are a challenge to their grid integration. In many cases, first-generation technologies, such as hydropower, can serve to level out variable sources. Together with grid improvements and more advanced load and generation management, it is reasonable to assume that renewables will form part of a much more advanced electricity supply structure in the future.

Third-generation technologies are not yet widely demonstrated or commercialised. They are on the horizon and may have potential comparable to other renewable energy technologies, but still depend on attracting sufficient attention and RD&D funding. These newest technologies include advanced biomass gasification, bio-refinery technologies, concentrating solar power, hot dry rock geothermal power and ocean energy.

REFERENCE

IEA (2006), *Renewable Energy: RD&D Priorities Insights from IEA Technology Programmes*, OECD/IEA, Paris.

RENEWABLE HEATING AND COOLING: FROM RD&D TO DEPLOYMENT

KEY MESSAGES

- Buildings are the largest end-consumer of energy and represent 40% of our energy use.
- Although renewable heating and cooling applications are already widespread in some countries (*e.g.* evacuated tube collectors in China, flat plate collectors in the US), their contribution to the energy sector could be much higher.
- To exploit the full potential of renewable heating and cooling, it is necessary to invest more in Research, Development, Demonstration and Deployment (RDD&D) to further increase their overall efficiency and reduce the technology cost. The integration of systems (including storage) offers opportunities for new applications.
- Policies to encourage the wide and cost-effective deployment of renewable heating and cooling technologies will help increase their market share.
- Policy options for renewable heating and cooling can be further developed within the IEA framework, and best practices elaborated, for instance within the IEA Implementing Agreements.
- Codes and standards for energy technologies require additional efforts from the international community.
- Collaborating with IEA non-member countries will play an important role in broadening the market base for renewable heating and cooling technologies.

SUMMARY

Renewable sources of energy play an increasing role in world total primary energy demand. This has been due to an accelerated technology development and market deployment in some countries. The biggest increase during the last years occurred in the power sector. Because a substantial share of energy is used for space and water heating, and cooling purposes, the share of renewable energy sources in those uses could be increased.

The IEA hosted an expert workshop in 2006, with the purpose of exploring what guidelines and potential initiatives may accelerate technology development and market deployment for renewable heating and cooling. Insights into technological development, existing markets and policies were presented and discussed extensively by high-level experts from various IEA countries. The results of the workshop contributed to the existing expertise within the IEA and provided valuable input for further technological, policy and market analysis. Future focus will include the potential for further efficiency improvements, the integration of different options and additional applications. Since the use of renewables for heating and cooling varies among IEA member countries, the array of supporting policy options will be assessed and best practice examples elaborated. The results of the project will be published in an IEA report in 2007.

REFERENCES

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GLOBAL RENEWABLE ENERGY MARKETS AND POLICIES

KEY MESSAGES

- Renewable energy, including traditional biomass, has doubled together with global energy demand. Its share in world total primary energy supply (TPES) has increased slightly from 13.0% in 1990 to 13.1% in 2004.
- Total renewables supply experienced an annual growth rate of 2.3% over the last 33 years, marginally higher than the annual TPES growth of 2.2%. Since 1990, renewables' average annual growth rate has declined to 1.9%, which is slightly higher than the growth rate of world TPES of 1.8% per annum.
- Due to its widespread non-commercial use in developing countries, solid biomass is by far the largest renewable energy source, representing 10.1% of global TPES including hydro. Wind power has experienced the highest increase of 48% per annum since 1971, followed by solar (28% per annum). Both started from a very low base and recently experienced fast-growing development.
- Renewables are the third largest contributor to global electricity production at 18%. Significant market growth in renewable technologies results from a combination of policies that address specific barriers and/or complement existing policies.

SUMMARY

Because of their heavy non-commercial biomass use, non-OECD regions emerge as the main renewables users, accounting for 78.2% of world total renewables supply. OECD countries represent only 21.8% of world renewables supply while consuming 49.8% of world TPES. However, when looking at "new" renewables (such as geothermal, solar, wind), OECD countries account for most of the production, generating 86.3% of wind, solar and tidal energy in 2004.

The principal constraint in advancing renewable energy over the last few decades has been cost-effectiveness. With the exception of large hydropower, combustible biomass (for heat) and larger geothermal projects (>30 MWe), the average costs of renewable energy are generally not competitive with wholesale electricity and fossil fuel prices. On the other hand, several renewable energy options for specific, small-scale applications can now compete in the marketplace, including hot water from solar collectors and electricity from small hydro and other technologies.

Renewables accounted for almost 18% of global electricity production in 2004, after coal (40%) and natural gas (close to 20%), but ahead of nuclear (16%), oil (7%) and non-renewable wastes. Almost 90% of electricity generated from renewables comes from hydropower plants while close to 6% comes from combustible renewables and waste. Geothermal, solar and wind have now reached 4.5% of renewable generation.

The IEA has continued to work on the identification and inventory of existing national policies and measures related to renewable energy. In 2006, the IEA expanded its Global Renewable Energy Policies and Measures Database to include policy and statistical information on 78 countries. The objective of the database is to provide a platform for enhancing awareness and knowledge of renewable energy policies and measures; to provide basic statistical information on countries' progress to date; and to strengthen the capacity of policy makers and other renewable energy stakeholders to develop new policies, according to their strategic energy objectives.

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IEA Global Renewable Energy Policies and Measures Database at renewables.iea.org

BIOFUELS FOR THE TRANSPORT SECTOR

KEY MESSAGES

- Biofuels have the potential to improve energy supply security significantly. Today they represent 2-3% of total global transport fuel supply, but the production of "first generation" biofuels is growing rapidly and they will make a larger contribution by 2030.
- The CO_2 emissions reduction benefits of biofuels depend on their feedstock and production process. Sugar-based ethanol and "second-generation" biofuels result in a small fraction of CO_2 emissions compared to petroleum products, while lower benefits are associated with starch-based ethanol produced from corn or wheat and to a lesser extent with biodiesel produced from vegetable oil.
- Sugar-based ethanol can be produced in Brazil for around USD 35/bbl and is the only widely produced biofuel fully competitive with gasoline at current oil prices; "second-generation" biofuels are not yet cost-competitive, but technological developments are occurring rapidly.

SUMMARY

Biofuels can be a cost-competitive option to improve energy supply security during times of relatively high oil prices and offer the opportunity to reduce vehicle CO_2 emissions. Biofuels have most commonly been blended with petroleum products, but Brazil – where ethanol from sugar cane is produced in large volumes and can meet over 30% of total gasoline demand – has successfully introduced high ethanol fuel blends, suitable for use in vehicles with only limited modifications at very low cost ("flex-fuel" technology). Over six million of these flex-fuel vehicles are now in operation worldwide (1.2 million in Brazil).

Biofuel production which is growing rapidly, mainly in Brazil and in the US, relies on "first-generation" cereal or sugar crops for ethanol and vegetable oil crops for biodiesel. Amongst these options, sugar-based ethanol (that can be produced in Brazil for around USD 35/bbl) is the only widely produced biofuel fully competitive with gasoline at current oil prices. Other solutions remain relatively expensive and energy inefficient. Sugar-based ethanol also offers important CO_2 emission benefits on a well-to-wheels, life-cycle basis. Biodiesel from vegetable oil offers lower benefits and the current cereal based-ethanol pathway only reduces well-to-wheel CO_2 emissions by roughly 10-15% with respect to gasoline.

"Second-generation" biofuels are derived from lignocellulosic feedstocks and have the potential to significantly expand the range and quantity of feedstocks available, also offering superior well-to-wheels emission benefits. Crops suitable for second-generation biofuels can be grown on non-arable land, limiting competition with food crops. However, in spite of considerable research investments, fully commercial production of these more advanced biofuels has not yet been achieved, but technological developments are occurring rapidly.

According to the Reference Scenario of the *World Energy Outlook 2006* first generation biofuels could meet 4% of world road-transport fuel demand by 2030 and up to 7% of road-fuel use in an Alternative Policy Scenario.

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IEA ENERGY INDICATORS

KEY MESSAGES

- Energy indicators analyse the interactions between human activity, energy use and CO_2 emissions. They are particularly important for evaluating energy efficiency developments.
- Many IEA member countries already employ these disaggregated measures of how energy is used, and there is increasing interest from other countries as well. The IEA role is to improve and internationalise indicators use through the promotion of transparent, consistent international databases beyond the membership of the Agency.
- IEA energy indicators show that member countries have achieved significant energy savings since the first oil price shock in 1973 and that energy savings has slowed significantly since the late 1980s. Achieving greater energy efficiency is central to putting mankind on a sustainable energy path. Indicators will judge our progress.

SUMMARY

Since 1997, the IEA has developed energy indicators as a tool for understanding energy-use. Indicators assist member countries analyse factors behind changes in energy use and CO_2 emissions. Indicators (and the associated databases) also reveal key couplings between energy use, energy prices and economic activity. This insight is crucial for understanding past and present energy efficiency policies and for designing more effective future action. Data developed for the IEA indicators work are also used for IEA analytic activities, such as the World Energy Outlook and Energy Technology Perspectives publications and various energy efficiency and energy technology projects within the Secretariat. Important insights from the IEA project on indicators are highlighted in the recent IEA publication *30 Years of Energy Use in IEA Countries: Oil Crises and Climate Challenges*.

Indicators work as a key element of the IEA response to the G8 Gleneagles Programme of Action. Current and new generation energy indicators provide "state-of- the- art" data and analysis of energy use across all end-use sectors, as well as energy efficiency developments in both IEA and non-member countries. Essential to this work is greater transparency and better quality energy-use data for meaningful comparison of energy and emissions developments across countries, and to measure progress in emissions reductions and efficiency improvements within one country over time. The IEA is working with member countries and the European Commission to promote better collection of consistent data. The IEA is also assisting key non-member countries e.g. Brazil, China, India, Russia and South Africa to improve their energy statistics and to adopt the use of energy indicators. This effort includes work with other international organisations such as APEC (Asia-Pacific Economic Co-operation), the World Bank and the International Atomic Energy Agency.

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ENERGY EFFICIENCY: CONCRETE RECOMMENDATIONS

In April 2006, the IEA recommended four energy efficiency policies for implementation by G8 leaders. These proposals stem from requests made by IEA Energy Ministers and the G8 Heads of State in 2005 for the IEA to provide detailed energy efficiency policy advice, particularly in the transport, industry, appliances and building sectors. The following provides excerpts from the 'concrete recommendations':

Standby power recommendation: limit standby power use to 1-Watt

The IEA concludes that international best practice consists of a "horizontal" limit on standby combined with the regulatory limit of 1-Watt. The IEA recommends that all countries adopt the same 1-Watt limit and apply it to all products covered by the International Electrotechnical Commission definition with limited exceptions.

Set-top boxes recommendation: minimum energy efficiency standards for television «set-top» boxes and digital television adapters

The IEA concludes that international best practices with respect to energy efficient set-top boxes are policies that establish a minimum efficiency standard for Digital Television Adaptors. These regulations should specify the maximum power levels while "on" and "off", and ensure that the consumer can easily switch the unit to the lower power level. A second aspect of best-practice is to ensure that government-subsidized units meet higher efficiency requirements.

Lighting recommendation: adopt best practice in lighting energy efficiency

The IEA recommends that the G8 endorse the objective of across-the-board best practice in lighting. If adopted and implemented, the IEA estimates that the energy used for lighting in 2015 could be cut by one third in most economies. The commitment would be for each country to develop and adopt a specific plan of action that would be reported to the G8. These plans would naturally reflect the unique characteristics of each country but all would strive to achieve the cost-effective savings potential in their economy.

Tyres recommendation: implement a fuel-efficient tyre program

The IEA recommends that member countries first identify an agency or ministry to be responsible for managing or coordinating all programs related to fuel-saving tyres. The IEA further recommends the responsible agency undertake the following actions:

- adopt a test procedure for measuring rolling resistance;
- establish a system to disseminate information about rolling resistance (through labels, endorsement schemes, databases, etc.);
- set maximum levels of rolling resistance for major categories of tyres; and
- establish programs to ensure proper inflation and maintenance of tyres (through education, provision of air pumps, tyre pressure measurement systems, etc.).

ENERGY EFFICIENT DOMESTIC APPLIANCES AND EQUIPMENT

KEY MESSAGES

- Concerns over energy security, climate change and higher energy prices have raised awareness of energy efficiency in IEA countries. While this has produced an increase in policy development activity, it has not yet led to a corresponding increase in the implementation of policies, demonstrating that national administrations continue to struggle to find sufficient resources to meet policy aspirations.
- Implementation of stricter standards and labeling programs represents one of the lowest-cost options for greenhouse gas mitigation, and yet the geographic and product coverage of these policies is far from comprehensive. Minimum energy performance standards have cut energy consumption for major appliances by up to 60% over the past 10 years in many economies without leading to higher appliance prices.
- Lighting accounts for 19% of global electricity consumption, more than is supplied by hydro or nuclear power, and gives rise to 1 900 Mt of CO_2 emissions. By 2020, at least 40% of lighting energy use could be saved cost-effectively through the adoption of targeted energy efficiency policies.
- Policies to tackle standby power are increasing, but lag particularly in developing countries, despite rising standby power consumption.
- Industrial electric motors and drives account for about 40% of global electricity demand – roughly 25% of this could be saved cost-effectively by following best practice solutions.

SUMMARY

Light's Labour's Lost: Policies for Energy-Efficient Lighting is the latest IEA end-use analysis. It highlights several cost-effective options for policy intervention for lighting appliances, such as phasing-out incandescent lamps and replacing them with high quality compact fluorescent lamps (CFLs). The 1-Watt target for standby power has achieved a high profile. Nevertheless, the IEA has highlighted the need for increased international co-operation on policy implementation. Australia has become the first country to adopt a horizontal standard, an approach which others are encouraged to follow.

Strong government procurement policies provide leadership to the national community and help create new markets for highly efficient products. Such measures should be widely adopted particularly in relation to energy efficient computers and related equipment. Examination of the impact of regulatory standards for appliances shows that, with sufficient notice, highly effective regulations have been introduced at little or no extra cost. It suggests that the cost of CO_2 mitigation is even lower than predicted by most energy efficiency programs, and this without giving any value to the increase in energy security. With the adoption of the "European Ecodesign Directive" and the US 2005 Energy Policy Act, it is hoped that new minimum energy performance standards regulations will proceed for a wide range of appliances and equipment. Such steps in these influential economies provide an opportunity to deliver greater harmonisation of standards for traded products.

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ENERGY EFFICIENCY IN BUILDINGS

KEY MESSAGES

- Buildings are the largest end users of energy. Energy consumption in buildings accounts for 40% of energy use and buildings' share of energy consumption in developing countries is growing.
- The largest part – close to three-quarters – of the consumption in buildings is used for heating, cooling, ventilation and hot sanitary water.
- New buildings can already today be built to require very little or no energy consumption at all, but the vast majority of new buildings are nowhere near as efficient.
- Existing buildings also have major energy savings potential. Studies show that the total energy consumption of existing buildings could be halved by optimising efficiency through renovation or major refurbishment.

SUMMARY

In November 2006, the IEA staged a workshop on *Energy Efficiency in Buildings, Meeting the Gleneagles' Challenge*. This workshop brought together senior policy makers, industry, experts, NGOs and other stakeholders to consider opportunities and measures. The workshop produced a high consensus on the large savings potentials; the many barriers; and the need for active policies and measures, R&D, technological development and demonstration projects. The IEA is now developing a set of proposals, based on specific recommendations from the workshop, to be considered by the IEA Energy Ministers and the G8 leaders. These include:

- All countries should set and update regularly mandatory energy standards for new buildings.
- Countries should support and encourage the construction of "Zero Energy Buildings" and "Passive houses".
- For existing buildings, governments should implement policies to: provide financial instruments; increase awareness; and make the energy performance of buildings visible in the market place.
- All countries should collect systematic information on energy efficiency in existing buildings and set up a package of initiatives to break down the most important barriers.
- Governments should increase R&D activities for efficiency in buildings and include R&D in development and design of energy efficient buildings.
- International cooperation in R&D and information exchange should be increased. The IEA should play a leading role in this work.

Other IEA work in 2006 reach the same conclusions and document the large saving potentials. In the Alternative Policy Scenario of the World Energy Outlook 2006, buildings account for 40% of the savings in general (or a 444 Mtoe reduction in 2030) and for 68% of the electricity savings. *Energy Technology Perspectives*' MAP scenario projects potential energy savings in the global building stock of 1600 Mtoe by 2050 compared to a baseline scenario. A joint IEA-EuroAce study on European high-rise residential buildings shows that up to 75% of space heating can be saved through efficient refurbishment.

Energy efficiency in buildings was also the subject of a joint IEA-India workshop in New Delhi in October 2006, and of a IEA-METI workshop on in Tokyo in August 2006.

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IEA-MLIT International Workshop on Countermeasures to Urban Heat Islands, Tokyo, August 2006.

ENERGY EFFICIENCY IN TRANSPORT: TYRES AND OTHER COMPONENTS

KEY MESSAGES

- Current test procedures used for vehicle fuel efficiency standards and targets do not accurately measure average on-road vehicle fuel efficiency. Additional policies are required to make the standards and targets more reliable.
- There is now consensus that aggressive policies for promoting deployment of fuel-efficient tyres and proper tyre maintenance could achieve as much as a 5% reduction in overall vehicle fuel consumption.
- When in use, the Mobile Air Conditioning (MAC) of passenger cars increases vehicle fuel consumption by 15-30%. On a yearly basis, "cooling" cars can account for 5 to 10% of total vehicle fuel use. This energy use could be halved through the design of cars with lower solar gain, better control devices and more efficient MAC systems.
- About 1.1 mbd is used for road-vehicle lighting (about 3.2% of all vehicle energy use). Deployment of efficient technologies could reduce the amount of oil needed for this use to less than 0.5 mbd in 2020.

SUMMARY

Despite on-going efforts to better understand real-world driving styles, current test procedures used for standards and targets in major regions do not accurately measure average on-road vehicle fuel efficiency. For example, the effects of low rolling-resistant replacement tyres, accessories including air-conditioners and lights, and drivers' behaviour are generally neglected in test procedures.

Roughly 20% of a motor vehicle's fuel consumption is used to overcome the rolling resistance (RR) of tyres. Additional fuel is required when tyres are under-inflated. However, the purchasing and in-use environment discourages rational decisions regarding efficiency investments and proper maintenance of tyres. Energy efficiency considerations often receive low priority in consumer information programmes because government responsibility for tyres is often widely dispersed among ministries of transportation, industry, and environment. The absence of an internationally recognised procedure to measure RR is an additional impediment to coordinated efforts to improve tyre efficiency. There is now consensus that aggressive policies including establishing a system to disseminate information about RR, setting maximum levels of RR for major categories of tyres and developing programs to ensure proper inflation and maintenance of tyres could achieve as much as a 5% reduction in overall vehicle fuel consumption.

The same kind of policies for vehicle components (developing common energy efficiency standards, dissemination of information through energy labelling) could reduce the fuel use linked to car cooling and lighting. Together with broader efficiency standards for cooling cars and vehicle lighting, these policies combined could be as effective as the policies for tyres.

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ENERGY EFFICIENCY AND CO_2 EMISSIONS REDUCTION IN INDUSTRY

KEY MESSAGES

- In industry, energy efficiency has improved substantially in all sectors and all regions in the past decades. However, in absolute terms, energy use and emissions have increased worldwide. Typically the gap between average energy efficiency and best available technology is 10-30% in key industry sectors. The potential varies across countries depending on the capital stock vintage, energy prices and technology mix. Emerging technologies provide even greater savings.
- Scenario modelling indicates that CO_2 emissions can be halved in 2050, compared to a baseline scenario, at cost below USD 25/t CO_2. This brings emissions back to today's level. Efficiency would account for almost half of the emissions reduction.
- Industry is actively participating in discussions on how to increase efficiency and mitigate emissions.

SUMMARY

The manufacturing industry accounts for approximately one third of global energy use in primary energy terms. The vast majority is used to produce raw materials: chemicals, iron and steel, non-metallic minerals, pulp and paper, and non-ferrous metals. The leaders of the G8 countries have called upon the International Energy Agency to provide better information for this industrial sector.

The IEA has responded with a new industry initiative. A dialogue with industry regarding sectoral approaches and other policy designs has been started. Detailed scenarios of industrial energy use and CO_2 emissions have been developed. New indicators for industrial energy efficiency and CO_2 intensities have been formulated and industrial efficiency trends have been studied on a country-by-country basis. The IEA also analysed the potential for emerging industrial technologies to increase efficiency and reduce CO_2 emissions. Best practice for policies and measures in industry will be developed and the diffusion and deployment of emerging industrial technologies will be considered.

A first analysis of scenarios for industrial energy use and CO_2 emissions for 2050 was part of the *Energy Technology Perspectives 2006: Scenarios & Strategies to 2050*. A new IEA publication on *Indicators for Industrial Energy Use and CO_2 Emissions* will be issued in time for the 2007 G8 summit in Germany.

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REDUCING THE ENVIRONMENTAL IMPACT OF ENERGY

- WORLD ENERGY OUTLOOK: ALTERNATIVE POLICY SCENARIO
- PROSPECTS FOR NUCLEAR POWER
- CO_2 EMISSIONS FROM FUEL COMBUSTION
- EMISSIONS TRADING FOR CLIMATE POLICY
- COMPETITIVE IMPLICATIONS OF THE EUROPEAN CO_2 EMISSIONS TRADING SCHEME
- ENERGY SECURITY AND CLIMATE POLICY INTERACTIONS
- CLIMATE POLICY BEYOND 2012
- SECTORAL APPROACHES TO GREENHOUSE GAS MITIGATION
- ENERGY INVESTMENT UNDER CLIMATE POLICY UNCERTAINTY

WORLD ENERGY OUTLOOK: ALTERNATIVE POLICY SCENARIO

KEY MESSAGES

- The WEO Alternative Policy Scenario shows we can acquire considerable savings in energy demand, energy imports and CO_2 emissions at a lower total investment cost. The savings are attainable through a combination of increased investment in more energy-efficient goods and processes, and different fuel choices in the power and transport sectors.
- There are formidable hurdles to the adoption and implementation of the measures in the Alternative Policy Scenario of the *World Energy Outlook*. In practice, it will take considerable political will to push these policies through, many of which are bound to encounter resistance from some industry and consumer interests. Public opinion, private-sector support and international cooperation are needed to promote more stringent government policy initiatives.

SUMMARY

The Alternative Policy Scenario analyses how the global energy market could evolve if countries were to adopt all of the policies they are currently considering related to energy and CO_2. The aim is to understand how far those policies could take us in dealing with these challenges and at what cost.

In the Alternative Policy Scenario, world primary energy demand in 2030 is about 10%, or 1 690 Mtoe, lower than in the Reference Scenario – roughly equivalent to China's entire energy consumption today. The impact of new policies is felt throughout the period; already in 2015, the difference between the two scenarios is 4%, or 534 Mtoe.

The policies analysed halt the rise in OECD oil imports by 2015. OECD countries and developing Asia become more dependent on oil imports in 2030 compared to today, but markedly less so than in the business-as-usual Reference Scenario. Global oil demand reaches 103 mb/d in 2030 in the Alternative Policy Scenario – an increase of 20 mb/d on 2005 levels, but a fall of 13 mb/d compared with the Reference Scenario. Globally, gas demand and reliance on gas imports are also reduced below the levels of the Reference Scenario.

Energy-related CO_2 emissions are cut by 6.3 Gt, or 16%, in 2030 relative to the Reference Scenario and are already down 1.7 Gt, or 5%, by 2015. OECD emissions peak around 2015 and then decline. Emissions in Japan and the European Union in 2030 are lower than in 2004. Global emissions nonetheless continue to rise, from 26 Gt in 2004 to 32 Gt in 2015, and 34 Gt in 2030.

In aggregate, the new policies and measures analysed yield financial savings that far exceed the initial extra investment cost for consumers – a key result of the Alternative Policy Scenario. Cumulative investment in 2005-2030 along the energy chain – from the producer to the consumer – is USD 560 billion lower than in the Reference Scenario. Investment in end-use equipment and buildings is USD 2.4 trillion higher, but this is more than outweighed by the USD 3 trillion of investment that is avoided on the supply side. The changes in electricity-related investment brought about by the policies included in the Alternative Policy Scenario yield particularly big savings. On average, an additional dollar invested in more efficient electrical equipment, appliances and buildings avoids more than two dollars in investment in electricity supply.

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PROSPECTS FOR NUCLEAR POWER

KEY MESSAGES

- Concerns over energy security, surging fossil-fuel prices and rising CO_2 emissions have revived discussions about the role of nuclear power. Nuclear power – a proven technology for baseload electricity generation – could make a major contribution to reducing dependence on imported oil and gas and curbing CO_2 emissions.
- Interest in building nuclear reactors has increased as a result of higher fossil-energy prices, which have made nuclear power relatively more competitive, and the need to tackle climate change.
- Nuclear power will only become more important if the governments of countries where nuclear power is accepted play a stronger role in facilitating private investment, especially in liberalised markets. Nuclear power plants are capital-intensive, requiring initial investment of USD 2 billion to USD 3.5 billion per reactor.

SUMMARY

In the Reference Scenario of the *World Energy Outlook 2006*, world nuclear power generating capacity increases from 368 GW in 2005 to 416 GW in 2030. As a result, its share in the primary energy mix falls, on the assumption that few new reactors are built and that several existing ones are retired. In the Alternative Policy Scenario, that takes into account all the new measures that governments are currently considering to curb energy use and to reduce CO_2 emissions, greater use of nuclear power contributes significantly to lowering emissions. In this scenario, additional investment in nuclear power raises nuclear power generating capacity to 519 GW by 2030.

New nuclear power plants can produce electricity at a cost of between 4.9 and 5.7 cents per kWh, if construction and operating risks are mitigated. Nuclear power is cheaper than gas-based electricity if gas prices are above USD 4.70 to USD 5.70 per MBtu. It is more expensive than conventional coal, unless coal prices are above USD 70 per tonne or nuclear investment costs are less than USD 2 000 per kW. Nuclear would be more competitive if a cost of carbon emissions was introduced.

Nuclear power generating costs are less vulnerable to fuel-price changes than coal- or gas-fired generation. Moreover, uranium resources are abundant and widely distributed around the globe. These two advantages plus near zero carbon emissions make nuclear power a valuable option for enhancing the security and sustainability of electricity supply.

Economics is not the only factor determining the construction of new nuclear power plants. Safety, nuclear waste disposal and the risk of proliferation are real challenges which have to be solved to the satisfaction of the public, or they will hinder the development of new nuclear power plants.

REFERENCE

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CO_2 EMISSIONS FROM FUEL COMBUSTION

KEY MESSAGES

- Global emissions of CO_2 from fossil fuel combustion increased nearly 28%, from 20.8 billion tonnes (Gt) in 1990 to 26.6 Gt in 2004. In 2004 alone, global CO_2 emissions rose by 5%. This dramatic rise was largely (86%) driven by the energy demand of developing countries. The higher use of coal in power generation mainly contributed to this emissions growth.
- Nearly two-thirds of world emissions in 2004 originated from only ten countries, with the shares of the United States and China far surpassing those of all others. The United States alone generated 22% of world CO_2 emissions, despite a population of less than 5% of the global total. Conversely, China – which contributed 18% of global emissions – accounted for 20% of the world population. Thus, the levels of per capita emissions of these two countries were very diverse, with 4 tonnes of CO_2 per capita for China compared to 20 for the United States.
- In 2004, two sectors – electricity and heat generation, and transport – produced nearly two-thirds of global CO_2 emissions. The emissions of these same sectors also increased at faster rates than global emissions. Generation of electricity and heat was responsible in 2004 for 40% of global CO_2 emissions, as compared to 34% in 1990 (an increase of 53%). By 2030, the demand for electricity is projected to be almost twice as high as in 2004. While electricity and heat generation draws from various energy sources, the transport sector relies almost entirely on oil. In 2004, transport contributed 23% of total CO_2 emissions. Global demand for transport is forecast to grow by 58% by 2030.

SUMMARY

The IEA publication *CO_2 Emissions from Fuel Combustion* contains statistics on CO_2 emissions by sector and by fuel from 1971 to 2004 for more than 140 countries and regions. It provides comparisons between countries and regions made for selected indicators such as: CO_2 emissions per GDP; CO_2 emissions per population; CO_2 emissions per total primary energy supply; and CO_2 emissions per kWh from electricity and heat generation. It also presents the evolution of CO_2 emissions over the last 33 years, highlights regional and sectoral trends, looks at key sources as defined by the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* and provides summary data for CH_4, N_2O, HFC, PFC and SF_6.

A CD-ROM and an online service are available that provide the complete historical series from 1960 to 2004 for Annex II countries and from 1971 to 2004 for other countries. A detailed sectoral breakdown of CO_2 emissions for individual fuels is also offered.

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EMISSIONS TRADING FOR CLIMATE POLICY

KEY MESSAGES

- Domestic or regional emissions trading systems such as the EU Emissions Trading Scheme have introduced the cost of CO_2 in operating and investment decisions of power generation and heavy industry.
- CO_2 prices push up electricity prices charged to industrial users, raising electricity revenues and triggering intense political discussion. Such price increases are nevertheless necessary if generators and end-users alike are to respond efficiently to the constraint on emissions. Raising revenues through auctioned allowances to power generators could be a transitory means to compensate electricity end-users.
- Options exist to extend emissions trading beyond large stationary sources, including transport, although other policy intervention is needed to address barriers to rational energy choices.
- Emissions trading can be combined with different forms of country commitments to encourage broader participation, although institutional capacity in developing countries may limit the feasibility of trading.

SUMMARY

Climate policy raises a number of challenges for the energy sector, the most significant being the transition from a high to a low-CO_2 energy path in a few decades. Emissions trading has become an instrument of choice to manage the cost of this transition, whether used at an international or a domestic level in industrial and power generation sectors. The implementation of the EU emissions trading scheme has created a carbon price that should guide future energy choices in industry and electricity. Governments remain hesitant, however, to let the markets take the lead, in part due to competitiveness concerns. This could undermine the efficiency of trading instruments.

Emissions trading can be extended to a range of energy-using activities, provided that consumers are equipped to respond to a carbon price signal. The inclusion of sectors such as car manufacturing and international aviation can also be envisioned. Linking emissions trading systems with various design features can be done technically, provided political hurdles can be overcome.

The international carbon market can provide an incentive for broader participation in climate mitigation for countries that have no commitments at present, as various sorts of emission goals can alleviate concerns about costs. Under a non-binding target, a developing country could be allowed to sell emission allowances if its emissions were below target but not obliged to buy if emissions were higher. An intensity target could adjust the emission objective to changes in GDP growth. A cap on carbon prices could alleviate concerns on the cost of relying on trading for compliance.

Emissions trading allows a transparent allocation of effort among participants while leaving markets to achieve the overall environmental goal at least cost. However, emissions trading systems, in spite of their setting a price on emissions that encourage reductions, may not suffice in addressing the long-term aspects of climate policy; in particular, they may not trigger the required R&D efforts. If these mechanisms are to succeed in driving least-cost strategies, they must tend to the long capital cycles of the energy sector and the need for a long-term price signal.

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COMPETITIVE IMPLICATIONS OF THE EUROPEAN CO_2 EMISSIONS TRADING SCHEME

KEY MESSAGES

- The introduction of a cap-and-trade system in Europe's heavy industry and power generation has created a CO_2 cost and raised competitiveness concerns.
- CO_2 prices push up electricity prices charged to industrial users, raising electricity revenues and triggering intense political discussion. Such price increases are nevertheless necessary if generators and end-users alike are to respond efficiently to the constraint on emissions.
- Industry's ability to pass on the carbon cost to consumers is a critical, and much debated, element in the assessment of the effects of emissions trading schemes on industrial competitiveness.

SUMMARY

The EU Emissions Trading Scheme (ETS) is embedded in the broader regime created by the Kyoto Protocol, but applies only to a subset of countries and industrial activities. In some cases, these activities face competition from countries without emission constraints. The introduction of the scheme has sparked the quick growth of the EU carbon market. The price of carbon has become another cost component that large energy users must take into account. Among these users, power generation is by far the largest and includes the cost of CO_2 allowances in operational decisions, with direct effects on electricity prices. The IEA researched the effects of CO_2 prices on electricity prices, in light of the various electricity market mechanisms existing in Europe. It also documented emerging strategies developed by industry to secure electricity supply and pricing instruments that are more suited to industry's needs.

An intense debate has raged among power producers, energy-intensive industries, and governments on the legitimacy of electricity price increase as a result of the CO_2 constraint. The rationale of trading systems remains to pass the cost of externalities (here CO_2 emissions) to encourage lower use. In the end, a CO_2 trading mechanism should first and foremost trigger changes in generation towards less CO_2-emitting production. This hinges on the long-term signal provided by governments to power generators, and on how allowances are allocated to generators to avoid locking in more CO_2 intensive plants.

The IEA also completed a series of analyses on the competitiveness implications of the EU ETS with a study on the refinery industry. It showed limited effects of the scheme on the refinery industry's competitiveness, as European environmental requirements for fuels create a product market specific to the region.

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ENERGY SECURITY AND CLIMATE POLICY INTERACTIONS

KEY MESSAGES

- While energy security and climate change are key government objectives, policies are not always formulated to achieve both concurrently.
- The interaction between countries' climate change policy objectives and their energy security goals has not been assessed in a systematic way to maximise results. The IEA has developed a quantitative approach that makes this possible.
- Governments should use this tool when debating the effects of future policy intervention in areas with possible repercussions on energy security.

SUMMARY

Energy security and climate change mitigation are important objectives of IEA governments' energy policy. Which policies can achieve and maximise the realisation of both of these goals? The IEA publication *Energy Security and Climate Change Mitigation*: *Tools for Policy Makers* offers an unprecedented analytical approach to quantify which measures are effective under varying conditions.

The study reviews interactions between energy security and climate change mitigation policies. Its purpose is not to fully assess policy measures taken in energy security or climate change, but to evaluate the performance of climate policy tools against energy security objectives. The rigorous quantitative approach developed by the IEA should guide policy makers towards policies that achieve both energy security and climate change mitigation as effectively as possible.

Under business-as-usual conditions, the analysis shows a worsening trend for both CO_2 emissions and energy security in most of the five European countries used as case studies (Czech Republic, France, Italy, the Netherlands and the United Kingdom). It tests various climate policies (penetration of non-fossil fuel power generation, switching from coal to gas, enhanced end-use energy efficiency, biofuels in transport) against countries' exposure to fossil fuel market concentration. These tests indicate that policies deemed acceptable to reduce CO_2 emissions or to improve energy security may not be as effective when considered from both angles.

The IEA urges countries to undertake a systematic review of the energy security implications of their climate policy initiatives. The tools elaborated in this report should shed an objective light on challenges and opportunities that lay ahead for countries, as they develop sustainable energy policies.

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CLIMATE POLICY BEYOND 2012

KEY MESSAGES

- There is much discussion of the best approaches for mitigating climate change. One key objective is to engage as many participants as possible.
- A single international emissions trading system can accommodate several types of emission objectives including: fixed and binding targets, dynamic targets, non-binding targets, targets with price caps, and sector-wide targets.
- In reducing uncertainty on compliance cost, flexible targets may favour more ambitious targets by a greater number of countries. This outcome matters more for long-term climate change mitigation than certainty on short-term emission levels.

SUMMARY

In 2005, the Annex I Expert Group on the UNFCCC, supported by the IEA and the OECD, published several papers considering a variety of options for future commitments to mitigate climate change after the first period of the Kyoto protocol ends, in 2012. Most suggested ways to alleviate concerns expressed about uncertain costs associated with Kyoto-type, relatively short-term fixed and binding targets on greenhouse gas (GHG) emissions. By the same token, in a world where climate policy could be coordinated by an international carbon market, these options would facilitate the adoption of targets by a greater number of countries including all major emitters.

The analyses showed that several types of targets could be proposed to countries at different stages of development and still allow full-fledged emissions trading between participants. These are fixed and binding targets, dynamic (*e.g.* indexed on GDP) targets, non-binding targets allowing the sale of excess allowances with no obligation to buy if emissions are above, binding targets with price caps, and sector-wide targets. Emissions trading could also be based on other types of quantitative targets, but the capacity of each to be mixed with other forms of targets is questionable.

A modelling exercise with a mixture of these options showed that a possible emissions spike caused by unexpected GDP growth in a very large developing country with a non-binding target would of course increase its emissions and thus, those of the world. This would not, however, result in much higher carbon prices in other countries, as a result of higher international energy prices.

Finally, an IEA working paper considered the following question: should one favour the certainty in achieving emission goals or the degree of ambition of such goals? Fixed targets provide full certainty on emission levels but entail unknown costs. More flexible targets provide less certain results but help control costs and thus may facilitate the adoption of relatively more ambitious goals. Because climate change is a cumulative issue, the analysis shows that the certainty on short-term levels matters much less than the ambition of the targets – and the capacity of the climate policy beyond 2012 to cover a larger portion of global greenhouse gas emissions.

REFERENCES

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IEA (2005), "Approaches for Future International Co-operation", Information Paper, OECD/IEA, Paris.

IEA (2005), "New Commitment Options: Compatibility with Emissions Trading", Information Paper, OECD/IEA, Paris.

IEA (2005), "Climate Mitigation: Integrating Approaches for Future International Co-operation", Information Paper, OECD/IEA, Paris.

SECTORAL APPROACHES TO GREENHOUSE GAS MITIGATION

KEY MESSAGES

- Governments and industry are keenly interested in international efforts to reduce greenhouse gases due to concerns about the potential impact on economic competitiveness. One proposal would consist in shifting the Clean Development Mechanism (CDM) from a project- to a sector-based approach to expand CO_2 credits from developing countries.
- Sectoral crediting could increase carbon credit flows, but may worsen the competitive situation of industries in countries with commitments vis-à-vis those countries that would benefit from carbon finance to modernise their industry.
- Much research is needed to evaluate the feasibility of international sectoral approaches, including the types of commitments and the institutional implications of engaging stakeholders in the private sector.

SUMMARY

Energy-related CO_2 emissions from industrial sectors are rising fast in developing countries without commitments to reduce greenhouse gases. In the meantime, Kyoto signatories are implementing policies to abate emissions from the same industrial sectors, with implications for costs. The resulting distortions in competitiveness have led to policy work on ways to engage industrial activities in greenhouse gas (GHG) mitigation, including those in developing countries, via specific sectors. Under the aegis of the Annex I Expert Group on the UNFCCC, the IEA and the OECD have done intensive research in evolving to a broader Sector-Based Clean Development Mechanism (CDM). While this is a way to drive more climate-friendly technologies in developing countries, it may not alleviate concerns of competitiveness. Credits for emissions that could be avoided would amount to a subsidy, rewarding installations that have lagged behind in energy performance. The current lessons from CDM also suggest that moving to a much larger scale may represent a challenge for administrations in developing countries.

Options other than crediting reductions in developing countries are envisaged under "sectoral approaches". The IEA is researching the implications of this shift in emphasis and conducting case studies on the possibility of designing and applying this new approach to the iron and steel, cement, aluminium and power generation sectors.

REFERENCES

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IEA (2006), "Sectoral Crediting Mechanisms for Greenhouse Gas Mitigation: Institutional and Operational Issues", Information Paper, OECD/IEA, Paris.

IEA (2005), "Sectoral Crediting Mechanisms: An Initial Assessment of Electricity and Aluminium", Information Paper, OECD/IEA, Paris.

IEA (2005), "Exploring Options for 'Sectoral Crediting' Mechanisms", Information Paper, OECD/IEA, Paris.

IEA/ENEL Workshop on Sectoral Approaches to Greenhouse Gas Mitigation in the Power Sector, Rome, October 2006.

Steel Committee Meeting, IEA-IISI-OECD, Paris, November 2006.

ENERGY INVESTMENT UNDER CLIMATE POLICY UNCERTAINTY

KEY MESSAGES

- Incentives to invest in low carbon technologies may require carbon prices higher than projected during times of greater policy uncertainty. Electricity prices may rise in response to policy uncertainty.
- Changing from a 5-year to a 10-year allocation for CO_2 allowances could encourage faster investment and lower overall compliance costs.
- Repeated allocation of carbon allowances could trigger undesirable cyclical investment patterns. A possible solution may be a rolling 10-year allocation.
- The option to retrofit coal-based power plants with carbon capture and storage may be a reasonable hedge for coal plants under climate policy uncertainty.

SUMMARY

Climate change policies are being introduced or actively considered in all IEA member countries, modifying the investment conditions and technology choices in the energy sector. Many of these policies are at a formative stage, and policy uncertainty is currently high. For some power sector companies, risks associated with climate change policy uncertainty may rank amongst the most important, when making new investments.

This work identifies the conditions under which climate policy risks may be significant and where they are less significant, and what can be done in terms of policy design to reduce the effects of policy uncertainty. The IEA work explores also the sensitivity of different investment decisions to different risks including: energy price volatility, operation and maintenance costs, and delayed construction periods. The analysis compares the effects of climate policy uncertainty with fuel price uncertainty, showing the relative importance of these sources of risk for different technologies in different market types. Extensive consultation with power companies and financial investors is presented, giving views on the importance of climate policy risk, how it is managed, and how it might affect investment behaviour. The implications for policy makers are drawn out, allowing the key messages to be transferred into policy design decisions.

REFERENCES

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DEVELOPING ENERGY TECHNOLOGY

- ENERGY TECHNOLOGY PERSPECTIVES
- ADVANCED ELECTRICITY NETWORKS
- CO_2 CAPTURE AND STORAGE TECHNOLOGIES
- BASIC SCIENCE AND FUTURE ENERGY TECHNOLOGIES
- INTERNATIONAL COLLABORATION IN ENERGY TECHNOLOGY
- OIL AND GAS SUPPLY TECHNOLOGIES AND ENERGY SECURITY
- THE ROADMAP TO FUSION POWER
- LIGHT'S LABOUR'S LOST: POLICIES FOR ENERGY-EFFICIENT LIGHTING
- TRANSPORT TECHNOLOGIES TO REDUCE OIL CONSUMPTION AND EMISSIONS
- NETWORKS OF EXPERTISE IN ENERGY TECHNOLOGY (NEET)
- TECHNOLOGY DEVELOPMENT AND DIFFUSION

ENERGY TECHNOLOGY PERSPECTIVES

KEY MESSAGES

- The world is not on a sustainable energy path. CO_2 emissions have increased by more than 20% over the last decade.
- In an IEA Baseline Scenario (*Energy Technology Perspectives*, ETP), CO_2 emissions are prospected to attain almost two and a half times the current level by 2050, surging transport demand will put continued pressure on oil supply, while the carbon intensity of the world's economy will increase due to greater reliance on coal for power and for the production of liquid transport fuels.
- This alarming outlook, however, can be changed. The ETP Accelerated Technology scenarios (built on the *World Energy Outlook*'s Alternative Scenario with projections to 2030), demonstrate that by more aggressively deploying technologies that already exist or are under development, the world could be brought on to a much more sustainable energy path. The scenarios show how energy-related CO_2 emissions can be returned to 2003 levels by 2050.
- In the most optimistic scenario, greater efficiency and lower costs for second-generation biofuels, renewable and nuclear electricity generation technologies as well as breakthroughs in hydrogen, fuel cells and carbon capture and storage can reduce CO_2 emissions by 16% below 2003 levels.

SUMMARY

The Reference Scenario of the *World Energy Outlook*, extended to 2050 in the *Energy Technology Perspectives* (ETP) Baseline Scenario, clearly shows that the world is not on a sustainable energy path. In the ETP Baseline Scenario, CO_2 emissions increase by 137% by 2050, due to significant growth in the demand for fossil fuels.

Other ETP scenarios demonstrate how a range of energy efficiency policies, increased energy R&D and deployment programmes, and the introduction of a CO_2 reduction incentive of USD 25/t CO_2 worldwide from 2030 could return CO_2 emissions to around today's level by 2050. They would also have significant energy security benefits, halving the expected growth in oil and electricity demand by 2050. Savings from liquid fuels would equal more than half of today's global oil consumption, offsetting about 56% of the growth in oil demand foreseen in the Baseline scenario.

The substantial changes demonstrated in these scenarios are grounded in:

- Strong energy efficiency gains in the transport, industry and buildings sectors.
- Electricity supply becoming significantly decarbonised as the power-generation mix shifts towards nuclear power, renewables, natural gas and coal with CO_2 capture and storage (CCS).
- Increased use of biofuels for road transport.

Nevertheless, even in the ACT scenarios, fossil fuels still supply most of the world's energy in 2050. Except in the most optimistic scenario, demand for oil, coal and natural gas are all greater in 2050 than they are today. Investment in conventional energy sources will, therefore, remain essential.

The cost of achieving a more sustainable energy future is not high, but requires substantial effort and investment by both the public and private sectors. Accelerating progress in energy efficiency is indispensable. The recent slowdown in energy savings in OECD countries must and can be reversed.

Public and private support will be essential. Unprecedented co-operation will be needed between the developed and developing nations, and between industry and government. The task is urgent. It must be carried out before a new generation of inefficient and high-carbon energy infrastructure is locked into place.

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IEA (2006), *World Energy Outlook 2006*, OECD/IEA, Paris.

ADVANCED ELECTRICITY NETWORKS

KEY MESSAGES

- Advanced electricity networks must meet increasing demand for reliable electricity supply. There is growing demand for power quality and transfer requiring the integration of complex and more diversified generating sources.
- Today's available technologies need to be more widely used. More advanced infrastructure, technologies and systems are needed to modernise and enhance the security of existing electricity systems and to lay the groundwork for future networks.
- Parties are unlikely to make the needed investments without a clear policy framework and sometimes incentives. Technology development is stimulated by supportive policy, economic and regulatory frameworks.

SUMMARY

Electricity system reliability is essential to energy security. Yet the capacity and reliability of electricity transmission and distribution (T&D) systems are challenged by the new competitive environment complicated by ageing equipment, increasing trade, complex system operations and market rules, network congestion and difficulties in obtaining transmission rights-of-way. Rising demand for the high-quality power needed to run a digital economy, and the integration of more distributed and intermittent generation sources pose further challenges.

Tomorrow's electricity infrastructure and control systems will have to handle larger, more complex and possibly more distant loads and network interconnections. They will need to recognise and dispatch small-scale generating components. The performance of power systems decreases, however, as size and complexity of networks increase. Advanced technologies and new approaches to system management are needed to modernise and enhance the reliability and security of electricity networks.

Promising technologies include advanced information systems for observing and assessing grid behaviour and real-time controls. Technology development is needed in such areas as superconducting cables and equipment, advanced power flow and control technologies with rapid response capabilities. Existing technologies can play a more significant role if costs are reduced. Long-term, system-wide investments will be needed to put these technologies into place. Policy, economic and regulatory frameworks provide the incentives and speed progress towards a power delivery system worthy of the 21st century.

The IEA *Offshore Wind Experiences* concluded that there is significant potential for sharing of transmission lines and costs of offshore wind. As offshore wind farms become larger and further offshore, allocation of these costs will be critical. Governments will need to establish clear rules for access to grids. Electricity Networks Analysis, Research and Development (ENARD), an international collaborative project, was launched in 2006 under the auspices of the IEA. ENARD provides an international forum for information exchange, analysis and collaborative research across a range of transmission and distribution network issues.

REFERENCE

IEA (2005), "Offshore Wind Experiences", Information Paper, OECD/IEA, Paris.

CO_2 CAPTURE AND STORAGE TECHNOLOGIES

KEY MESSAGES

- Carbon dioxide capture and storage (CCS) is a key CO_2 abatement option for the future.
- National policies should:
  - facilitate the development of CCS technologies through support of R&D and demonstration projects;
  - facilitate the establishment of legal and regulatory frameworks for CCS projects, including support to develop and deploy long-term and reliable monitoring, measurement and verification technologies and procedures;
  - create a balanced policy framework that recognises the potential of CCS along with that of other climate mitigation technologies; and
  - support public awareness campaigns.

SUMMARY

The CO_2 concentration in the atmosphere may be managed effectively by employing a portfolio of technologies. CO_2 capture and storage (CCS) in power generation, industry and fuel transformation could account for 20% of CO_2 savings (IEA estimates show that 6.5 Gt of CO_2 could be captured and stored annually in 2050). However, there are still barriers to overcome. Costs of CCS technology must be reduced, particularly for CO_2 capture, and in the short-term, an intensification of R&D and medium- to large-scale demonstration efforts will be required. The IEA Secretariat estimates that at least ten major power plants with CCS technology need to be operating by 2015, in order to demonstrate the different capture technologies for natural gas and coal and prove storage retention in different geological structures. There is a need for relevant policy, legal and regulatory frameworks to be put in place and for clear and predictable economic incentives in the medium and longer term. Transparency and high quality information is a prerequisite for favourable public reception.

In its work on CCS, the IEA co-operates closely with the Working Party on Fossil Fuels, relevant Implementing Agreements, particularly the IEA Greenhouse Gas R&D Programme and the IEA Clean Coal Centre, the IEA Coal Industry Advisory Board (CIAB) and the Carbon Sequestration Leadership Forum (CSLF).

Responding to a call from the G8, the IEA and the CSLF agreed to hold a series of workshops during 2006 and 2007 on near-term opportunities for CCS. The first workshop took place in San Francisco, California in August 2006, where the main issues related to early opportunities of CCS were identified. These issues will be assessed in a follow-up workshop in Norway in June 2007. A third workshop on recommendations for the G8 is planned for October/November 2007 in Canada.

There is an urgent need to define the criteria for ensuring that new coal-fired plants, especially those burning pulverised coal, will be "capture ready". This is to avoid construction of high CO_2 emissions infrastructure for the generation to come. As a part of the G8 Plan of Action, the Secretariat is working on this issue with the IEA GHG R&D Programme. The development of legal and regulatory frameworks for carbon dioxide storage is being pursued by the Secretariat with the CSLF. Highly successful workshops were held in 2004 and 2006.

REFERENCES

IEA (2006), *Energy Technology Perspectives: Scenarios and Strategies to 2050*, OECD/IEA, Paris.

IEA (2005), *Legal Aspects of Storing CO_2*, OECD/IEA, Paris.

IEA/CSLF 2nd Workshop on Legal Aspects of Storing CO_2, Paris, October 2006.

IEA/CSLF Workshop on Near-Term Opportunities for Carbon Dioxide Capture and Storage, San Francisco, August 2006.

BASIC SCIENCE AND FUTURE ENERGY TECHNOLOGIES

KEY MESSAGES

- One of the biggest single challenges for this century will be providing sustainable energy for 10 billion people worldwide since current technology cannot provide it.
- This challenge is all the more daunting because research into energy technologies by both government and industry has not been rising, but rather falling – the advances that are needed will only be possible through increased focus (and funding) for basic science research and applied energy R&D.
- Despite progress in basic science and success in applied energy R&D programmes, research integration between science and applied energy programmes has, to date, been unsuccessful.
- The IEA is exerting leadership in this area by bringing together government, private sector and academic experts from the realms of science, policy, and technology, to take on the challenges of accelerating long-term energy innovation.

SUMMARY

Since its launch in 2004, the International Energy Agency's Ad Hoc Group on Science and Energy Technologies (AHGSET) has addressed the importance of linkages between basic science and energy technology R&D.

One of the central activities of AHGSET is to sponsor workshops, bringing together key stakeholders from the scientific, energy technology and public policy domains to explore what energy technologists need from basic scientists (demand pull) and what the results of basic science can contribute to energy technologists' needs (science mining).

In the autumn of 2005, the AHGSET workshop "Strengthening the Critical Connections between Science and Energy Technology Programmes" built on findings to date and developed a strategy for the future. The United Kingdom is planning the next AHGSET workshop, which will focus on materials, for April 2007.

AHGSET is also exploring avenues for education of a broader audience about the next-generation scientific breakthroughs that are needed to achieve a sustainable energy future. In December 2006, AHGSET produced its first brochure, available for downloading on the IEA website. This brochure was designed to educate policymakers, industry, academic institutions and the public about the importance of increasing research opportunities and linkages for these breakthrough energy technologies.

REFERENCES

AHGSET website at http://www.iea.org/Textbase/about/ahgset.asp

IEA (2006), *Science for Today's Energy Challenge: Accelerating Progress for a Sustainable Energy Future*, OECD/IEA, Paris.

INTERNATIONAL COLLABORATION IN ENERGY TECHNOLOGY

KEY MESSAGES

- For more than 30 years, IEA international energy technology co-operation has been a fundamental building block in facilitating progress of new or improved energy technologies.
- The IEA international technology network continues to grow, bringing together participants from governments, industry, academia and other organisations from around the world.

SUMMARY

Ensuring energy security and addressing climate change issues in a cost-effective way are main challenges of energy policies and in the longer term will be solved only through technology cooperation. To encourage collaborative efforts to meet these energy challenges, the IEA created a legal contract – Implementing Agreement – and a system of standard rules and regulations. This allows interested member and non-member governments or other organisations to pool resources and to foster the research, development and deployment of particular technologies.

Participants in Implementing Agreements benefit from greater project scale, reduced cost and duplication of work, accelerated development and deployment, harmonised standards, strengthened national RD&D capabilities, information sharing and networking.

As of 31 March 2007, there were 41 Implementing Agreements, with several thousand participants from 72 countries, organisations or companies advancing technologies in the following areas:

- **Cross-Sectional Activities:** Climate Technology Initiative, Energy Technology Data Exchange, Energy Technology Systems Analysis Programme.
- **End Use Buildings:** Buildings and Community Systems, District Heating and Cooling, Energy Storage, Heat Pumps.
- **End Use Electricity:** Demand Side Management, Electricity Networks, High-Temperature Super-conductivity.
- **End Use Industry:** Emissions Reduction in Combustion, Industrial Energy-Related Technologies and Systems.
- **End Use Transport:** Advanced Fuel Cells, Advanced Materials for Transportation, Advanced Motor Fuels, Hybrid & Electric Vehicles.
- **Fossil Fuels:** Clean Coal Centre, Clean Coal Science, Enhanced Oil Recovery, Fluidised Bed Conversion, Greenhouse Gas, Multiphase Flow Sciences.
- **Fusion:** Environmental Aspects Fusion Power, Fusion Materials, Large Tokamaks, Nuclear Technology Fusion Reactors, Plasma Wall Interaction in TEXTOR, Reversed Field Pinches, Spherical Tori, Stellarator, Poloidal Field Diverters (ASDEX Upgrade).
- **Renewable Energies:** Bioenergy, Deployment, Geothermal, Hydrogen, Hydropower, Ocean, Photovoltaics, SolarPACES, Solar Heating & Cooling, Wind.

Implementing Agreements typically undertake several RD&D projects simultaneously, disseminating the results through publications, international specialised seminars and websites.

REFERENCES

IEA (2007), *Energy Technologies at the Cutting Edge*, OECD/IEA, Paris.

IEA Technology Agreements web page at www.iea.org/techagr.

OIL AND GAS SUPPLY TECHNOLOGIES AND ENERGY SECURITY

KEY MESSAGES

- To meet projected hydrocarbon demand growth, the oil and gas industry must exploit resources that are beyond the limits of currently available technologies. A combination of technology development and capital investment is required to achieve those targets.
- Technologies need to be fast-tracked to increase recovery, access frontier reservoirs and produce from non-conventional deposits.

SUMMARY

The IEA *World Energy Outlook* projects that, under a business-as-usual scenario (Reference Scenario), demand for oil and natural gas will grow by over 50 % over the next three decades. Even in the Alternative Scenario, global energy demand will still increase by 37%. As it becomes technically more demanding to develop the world's remaining hydrocarbon resources and to bring them to consumer markets, the oil and gas industry faces a new, diverse set of business and technological challenges. The key question is not the limit of geological resources, as five to ten trillion boe (barrels of oil equivalent) can be considered recoverable depending on technological progress and long-term price scenarios. Instead, deciding factors will be the policies and investments in technology, capital and skills that will make such reserves economically recoverable.

The IEA publication *Resources to Reserves: Oil and Gas Technologies for the Energy Markets of the Future* analyses the requirements to increase recovery rates in existing fields from the current value of 35 % for oil by improved reservoir management technologies and wider introduction of enhanced oil recovery techniques such as CO_2 injection. A number of new major fields have been found in areas with challenging access, *e.g.* the Arctic, deep and ultra-deep water, deeply buried and complex reservoirs. To facilitate projected production growth from non-conventional resources, such as heavy oil, bitumen and tar sands, oil shales and non-conventional gas, investment in RD&D and HSE practices, encompassing the upstream, midstream and downstream sectors is required.

Less than one percent of technically recoverable non-conventional oil has been produced to date. In addition to the current recovery methods, a number of alternative production techniques needs to be investigated. They will require appropriate incentives to be fast-tracked. Monetisation of stranded and tight gas resources implies optimisation of the production and transportation chain; *Resources to Reserves* also presents emerging options for stranded gas.

Oil accessibility is compared graphically to oil prices to show the volumes of conventional and non-conventional exploitable resources. Companies' investment decisions need to be based on higher long-term prices than the ones currently used (USD 20-25/bbl) if they are to have the desired impact on oil recoverability. The analysis concludes that a framework favourable to investment in new resources, including appropriate licensing, taxation, royalties and support for demonstration projects should be provided.

REFERENCES

IEA (2006), *World Energy Outlook 2006*, OECD/IEA, Paris.

IEA (2005), *Resources to Reserves: Oil and Gas Technologies for the Energy Markets of the Future*, OECD/IEA, Paris.

THE ROADMAP TO FUSION POWER

KEY MESSAGES

- In November 2006, China, the European Union, Japan, Korea, India, Russia and the United States signed the *ITER Agreement* and agreed to the construction of the EUR 5 billion ITER facility to demonstrate that energy from fusion is scientifically and technically feasible. It is the largest international project in energy science and technology.
- A cluster of multinational R&D activities will complement the ITER project and pave the way to a next step, the construction of a demonstration plant for electricity production (DEMO). The IEA contributes to the international fusion research activity through its Fusion Power Coordinating Committee (FPCC) and eight international co-operation programmes (Implementing Agreements).

SUMMARY

The "fusion roadmap" aims to connect the first fusion power plant (DEMO) to the electricity grid in 30 years. This timetable requires a strong governmental commitment. The ITER project in Cadarache, France, will demonstrate the feasibility of fusion by producing up to 500 MW thermal power for periods of hundreds to thousands of seconds, eventually up to steady-state operation. It will provide the full-scale physics and test the basic technologies of a fusion power plant. ITER will take ten years to construct and 20 years for the experimental programme. Experiments in smaller fusion facilities will complement the ITER programme. In the meantime, the fusion technology programme will develop concepts, components and materials for DEMO. The fusion power plant will produce higher fusion power and neutron irradiation than ITER, and tritium self-sufficiency. It will therefore need advanced materials that are currently under development. Key to this development is therefore the International Fusion Material Irradiation Facility (IFMIF) that should be run in parallel with ITER to ensure timely material qualification for DEMO construction. One or more DEMO power plants are expected to be built to demonstrate reliable electricity generation from fusion at a level of several hundreds megawatts. DEMO plants could pave the way to commercial exploitation of fusion energy in the second half of the century.

Fusion has fundamental characteristics that make it attractive as a major long-term energy source. It holds the promise of emission-free and secure energy. The fuels required - lithium and deuterium (an isotope of hydrogen) - are readily available and widespread. Experiments have shown that the fusion process is *inherently* safe. The fusion reaction produces no nuclear waste and fusion plants have limited stocks of energy and radioactive materials. Potential release and hazard to the public in the case of accident would be very limited. To minimise radio-activation of materials during operation, special materials are being developed that may be disposed of as inert waste, recycled, or given shallow-land disposal in less than 100 years after use. Proliferation issues are also limited in comparison with nuclear fission. The cost of fusion electricity will largely depend on advances on fusion physics, technologies, materials and the optimisation of power plant concepts. Fusion economics will benefit from all policies that support low-carbon or carbon-free energy sources.

REFERENCE

IEA (2006), "From ITER to Power Plants: The Roadmap to Fusion Power", Fusion Brief for the IEA Governing Board, Paris.

LIGHT'S LABOUR'S LOST: POLICIES FOR ENERGY-EFFICIENT LIGHTING

KEY MESSAGES

- Lighting accounts for 19% of global electricity consumption, but 39% of this could be saved cost-effectively by the widespread adoption of efficient-lighting technologies.
- Energy is currently wasted through the use of inefficient lighting technologies, poor control of lighting systems leading to lighting of unoccupied spaces; significant failures in the recommendations and practices regarding installed lighting levels.
- Fully realising the cost-effective potentials from 2008 to 2030 would cumulatively save USD 2.6 trillion in overall lighting service costs worldwide and avoid both 16 billion tonnes of CO_2 emissions and 28 000 TWh of electricity consumption (6% of all electricity consumption over this timeframe).
- A mix of policy measures need to be implemented to realise these savings including minimum efficiency standards for lamps and ballasts, building code requirements for lighting systems, and financial incentives to overcome split incentives and other market-failures.

SUMMARY

In 2006 and in support of the G8 Plan of Action, the IEA released the first global assessment of energy consumption in lighting, *Light's Labour's Lost: Policies for Energy-Efficient Lighting*. This study reveals that lighting accounts for 19% of global electricity consumption, more than is delivered by nuclear or hydro power, and is responsible for 1 900 Mt of CO_2 emissions (equal to about 70% of the emissions from the world's cars). There are many proven high-quality energy-efficient lighting technologies on the current market but their level of adoption is much less than rational economic behaviour would imply. As a result, were end-users to only purchase equipment that provided a high quality lighting service but minimised the combined cost of purchasing and operating the lighting system over its lifetime, total global lighting energy demand would be almost 40% lower than under current trends. However, efficient lighting remains underexploited as there are still multiple market barriers. If these are to be overcome, stronger policies need to be implemented. These policies should be designed to enable the following results:

- Phase out inefficient electric lighting technologies (*e.g.* incandescent lamps, T12 and halophosphor T8 linear fluorescent lamps, mercury vapour lamps, low efficiency ballasts) in favour of higher efficiency alternatives (*e.g.* compact fluorescent lamps, T5 and triphosphor T8 lamps, sodium or ceramic metal halide lamps, electronic ballasts);
- Increase use of lighting controls (presence sensors, daylight dimming, etc.);
- Reduce unjustifiably high recommended lighting levels in some countries; and
- Substitute fuel-based lighting in off-grid communities with stand-alone high efficiency alternatives, which would help meet major development objectives, as well as saving energy and reducing CO_2.

REFERENCES

IEA (2006), *Light's Labour's Lost: Policies for Energy-Efficient Lighting*, OECD/IEA, Paris.

IEA (2006), "Barriers to Technology Diffusion: The Case of Compact Fluorescent Lamps", Information Paper, OECD/IEA, Paris.

TRANSPORT TECHNOLOGIES TO REDUCE OIL CONSUMPTION AND EMISSIONS

KEY MESSAGES

- Several low-cost technologies to reduce oil consumption and greenhouse gas (GHG) emissions in transport are available today, both on-board the individual vehicle and for transport systems. These applications have the potential to reduce oil consumption in transport by 30-50% over the next 25 years.
- Government policies are necessary to support the deployment of these fuel-saving technologies.

SUMMARY

The transport sector consumes the bulk of oil products. It also has the fastest growing greenhouse gas emission profile (particularly in developing countries, where oil consumption growth will soon outstrip that in OECD countries) and is a major source of local pollution. However, several low-cost technologies can reduce its fuel use and GHG emissions. Efficient diesel engines are already widely used in vehicles sold in Europe, but their sales share is still low in other world regions. Large improvements are expected for gasoline engines, thanks to the introduction of new engine developments. Light materials and more compact engines can lead to lighter and more fuel-efficient vehicles, and efficiency gains can be obtained with improved appliances (*e.g.* air conditioning systems), as well as energy-efficient tyres. Larger fuel savings can be derived from hybrid electric powertrains, since they allow recuperating energy through regenerative brakes and a stable engine speed. Full hybrids offer the largest savings; they bear the advantage of leading to lower emissions of local pollutants and, in their plug-in configuration, also have the potential to enable the use of electricity as fuel in cars.

The IEA analysis shows that a very large portion of these fuel efficiency gains would be cost-effective for the customers. However, improved efficiency requires significant changes in the way vehicles are marketed. In the past two decades, a small fraction of the potential fuel economy benefits was used to improve vehicle efficiency, while a large part was dedicated to increase the performance of vehicles that kept becoming heavier and more powerful. Government policies, such as fiscal incentives and fuel-efficiency standards, are necessary both to support the deployment of fuel-saving technologies and to discourage on-going increases in vehicle size, weight and power.

Other solutions, like diagnostic equipment indicating fuel consumption, optimal gear changes or tyre pressure – or other equipment such as cruise controls – can further reduce fuel use. Technologies such as telematics and electronic systems also contribute to fuel savings by improving the overall logistics of travel, saving also drivers' time.

In addition to vehicle technologies, new fuels like natural gas, LPG and biofuels can all be used in conventional engines (requiring varying degrees of modification). Other fuel carriers, namely hydrogen, can also power vehicles, but their relative cost and incompatibility with current vehicles places their widespread use at least one to two decades into the future. Further development and cost reductions in fuel cell vehicles and related technologies are also needed, including fuel cell stack systems, controller systems, hydrogen storage on-board vehicles and battery systems.

REFERENCES

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NETWORKS OF EXPERTISE IN ENERGY TECHNOLOGY (NEET)

KEY MESSAGES

- As part of their pledge to secure a "clean, clever and competitive energy future" in the Gleneagles Plan of Action, the G8 leaders in 2005 invited the IEA to help activate dynamic worldwide networks for energy technology research and development, and specifically to "raise the profile of existing research networks and encourage broader participation where appropriate; and seek ways to improve the current arrangements of collaboration between developed and developing country participants in existing networks".
- The NEET Initiative is the IEA's answer to this request. Through fact-finding missions to the so-called "Plus Five" countries (China, South Africa, Brazil, Mexico, India) and Russia, the IEA seeks to identify the key energy technologies these countries will turn to in the near to medium future.
- The goal of these NEET workshops is to initiate exchange and collaboration with the "Plus Five" countries and Russia, in areas of mutual interest and to strengthen pre-existing ties.

SUMMARY

The IEA Technology Network and specifically the Committee on Energy Research and Technology (CERT), IEA Working Parties and Implementing Agreements have already begun reaching out to the "Plus Five" countries.

The CERT issued its first invitation to Mexico to participate as an observer in its 44th CERT meeting on 15-16 June 2006. Following Mexico's participation, the CERT invited South Africa to participate as an observer in its 46th CERT meeting on 13-14 February 2007. It will now consider inviting China to attend one of its next meetings as an observer.

Through the NEET Initiative, the IEA has been seeking to engage the "Plus Five" in the Working Parties and Implementing Agreements. Indeed, NEET workshops will be held in the "Plus Five" and will serve as platforms where the IEA Technology Network can discuss with key relevant local partners, the benefits of international collaboration. Such NEET events may ultimately, strengthen existing ties between the "Plus Five" and the interested Working Parties and Implementing Agreements.

The Renewable Energy Working Party (REWP) and the Working Party on Fossil Fuels (WPFF) have invited the "Plus Five" countries to attend meetings.

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IEA NEET website at www.iea.org/NEET

NEET Workshop on Energy Technology Collaboration, Johannesburg, February 2007.

TECHNOLOGY DEVELOPMENT AND DIFFUSION

KEY MESSAGES

- International technology collaboration can help in the quest for clean and competitive energy systems. It provides a framework for co-operation on energy and climate change challenges in which a diversity of players can participate to learn from technical and operational solutions and failed approaches of others.
- Barriers block diffusion of some technologies. For example, policies to support solar thermal technology lag behind those for promoting other renewable energy technologies in most countries. Despite affordable costs, its considerable potential is often ignored. Compact fluorescent lamp (CFL) technology is now sufficiently mature to replace most types of incandescent lamps.
- International collaboration can assist governments in developing a framework for essential private sector investment to improve the environmental performance and uptake of energy technologies.

SUMMARY

Since 2003, the Annex I Expert Group has investigated issues related to technology development and diffusion with an emphasis on international collaboration. Recent work analyses the barriers to diffusion of specific technologies with case studies on solar thermal and CFLs. The papers and case studies point out that there is little information to support that technology collaboration alone leads to emission reductions on the scale needed to mitigate climate change. To improve the environmental performance of energy technologies and accelerate their uptake, governments need a portfolio approach that includes technology and complementary economic and social policies that provide a framework for essential private sector investment. International collaboration can help in the quest by speeding momentum, sharing risks, exchanging knowledge and resources, sharing learning investments and harmonising standards.

The low and mid-temperature solar thermal technologies considered in the case study have reached a degree of technical maturity that makes them reliable, although technical limitations persist. Other barriers include high investment costs, lack of competent installers, "split incentives", permitting and lack of awareness. Energy analysis often neglects the considerable potential of solar thermal. Policies to support solar thermal lag behind those for promoting other renewable energy technologies in most countries.

Improving the efficacy of lighting systems by substituting incandescent lamps with CFLs provides important benefits. The case study discusses the barriers related to high first cost, shortcomings in the early generations of CFLs, incomplete information in the lighting market and the difficulty of altering consumer habits. Policy specific lessons include: lowering the price differential of CFLs with incandescent lamps is effective in supporting market growth; promotional campaigns can be effective but require a high level of co-ordinated involvement from all actors in the lighting market; ensuring quality through certification schemes builds trust in the technology.

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ENGAGING THE WORLD

- THE INTERNATIONAL ENERGY FORUM SECRETARIAT
- ENERGY FOR COOKING IN DEVELOPING COUNTRIES
- RUSSIAN ENERGY POLICY DEVELOPMENTS
- OPTIMISING RUSSIAN NATURAL GAS: REFORM AND CLIMATE POLICY
- UKRAINE: ENERGY POLICY REVIEW
- EURASIAN ENERGY MARKET SECURITY, OIL AND GAS MARKET ACCESS AND INVESTMENT POLICY
- CHINA'S QUEST FOR ENERGY EFFICIENCY
- CHINA'S POWER SECTOR REFORMS: WHERE TO FROM HERE?
- STRENGTHENING OIL SECURITY IN CHINA
- COAL IN CHINA
- INDIA'S QUEST FOR ENERGY SECURITY
- GAS-FIRED POWER GENERATION IN INDIA: CHALLENGES AND OPPORTUNITIES
- LOOKING FORWARD: AN INTEGRATED IEA-ASIA OIL SECURITY PROGRAM
- THE ENERGY SITUATION IN BRAZIL: AN OVERVIEW AND OUTLOOK
- AFRICAN ENERGY: IN-DEPTH REVIEW OF ANGOLA'S ENERGY SECTOR

THE INTERNATIONAL ENERGY FORUM SECRETARIAT

KEY MESSAGES

- The International Energy Forum (IEF) provides an opportunity for the IEA to expand and deepen its contacts with producing countries.
- At the 10th IEF in Doha in April 2006, discussions were carried out on a wide range of issues, including the energy investment climate, energy security, oil and gas prices and the environment, enabling the IEA to develop and communicate its perspective on these issues.
- The first anniversary of the launch of the Joint Oil Data Initiative (JODI) provided an example of cooperation in action, as key regional organisations continued to harmonise their data collection and reporting on both the consumer and producer side.
- The 6th JODI conference in 2006 agreed on the need to expand the remit of the database.

SUMMARY

The IEA carried out further outreach activity in 2006, with the aim of promoting understanding and cooperation with producer countries. The rationale for this effort has become all the more pressing in the current price climate; increasing energy insecurity and market uncertainty have brought to light a number of new (and old) concerns where cooperation between producers and consumers will be essential to reduce uncertainty and help mobilise the investment to meet future demand growth. In particular, the IEA is represented as a non-voting permanent member of the Executive Board of the Riyadh-based International Energy Forum Secretariat (IEFS).

Notable events in 2006 included the 10th meeting of the IEF in Doha, where the IEA participated in discussions on energy security, product and oil availability and the investment climate. The IEA Executive Director highlighted concerns with regard to inadequate investment in upstream development, amidst increasing consumer dependence on core producers in the Middle East and North Africa. The IEA also continued to maintain contacts with producers on a bilateral basis and in other fora to find ways to reduce uncertainty on both sides and help stimulate the investment necessary to satisfy future demand requirements. At a practical level, IEA statisticians put significant work into promoting the Joint Oil Data Initiative (JODI) database which is coordinated by the IEFS and was launched in Riyadh in 2005. The 6th JODI conference in November 2006 reviewed progress so far and saw consensus on the need for more data collection in order to help improve market transparency, provide a more complete picture of the oil balance and improve data quality.

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APEC-EUROSTAT-IEA-IEFS-OLADE-OPEC-UNSD (2006), JODI Manual 2006.

World JODI Database at www.jodidata.org

ENERGY FOR COOKING IN DEVELOPING COUNTRIES

KEY MESSAGES

- In the absence of new policies, the number of people relying on traditional biomass (such as fuelwood, charcoal, agricultural waste and animal dung) to meet their energy needs for cooking, will increase from 2.5 billion today to 2.7 billion by 2030.
- About 1.3 million people die prematurely every year because of exposure to indoor air pollution from biomass – more deaths than those caused by malaria.
- Alternative fuels and technologies are already available at reasonable cost. Moreover, switching from biomass to oil-based fuels would not have a significant impact on world oil demand. Governments have a decidedly important role to play in increasing access to cleaner, more efficient fuels and technologies.

SUMMARY

As part of its bi-annual focus on topics related to energy and development, the *World Energy Outlook 2006* examines trends in household energy use and cleaner cooking options in developing countries. Today, especially in rural areas, 2.5 billion people use fuelwood, charcoal, agricultural waste and animal dung to meet most of their daily energy needs for cooking. In many countries, these resources account for over 90% of household energy consumption.

Use of biomass is not in itself a cause for concern. However, when resources are harvested unsustainably and combustion technologies are inefficient, there are serious adverse consequences for health, the environment and economic development. About 1.3 million people – mostly women and children – die prematurely every year because of exposure to indoor air pollution from biomass. Valuable time and effort is devoted to fuel collection instead of education or income generation. Environmental damage can also result, such as land degradation and regional air pollution.

Two complementary approaches can improve this situation: promoting more efficient and sustainable use of biomass; and encouraging people to switch to modern cooking fuels and technologies. The appropriate mix depends on local circumstances such as per-capita incomes and the availability of a sustainable biomass supply. Even when fuel costs and emissions are considered, the household energy choices of developing countries remain varied.

Vigorous and concerted government action is needed, together with increased funding from both public and private sources. Policies to promote cleaner, more efficient fuels and technologies for cooking must address barriers to access, affordability and supply, and form a central component of broader development strategies.

REFERENCE

IEA (2006), *World Energy Outlook 2006*, OECD/IEA, Paris.

RUSSIAN ENERGY POLICY DEVELOPMENTS

KEY MESSAGES

- Russia is and will remain an energy superpower.
- Although Russia has been a reliable supplier of oil and natural gas for decades, disruptions due to commercial disputes with Ukraine (gas) in early 2006 and Belarus (oil) in early 2007 affected the stability of supply in Europe and has renewed the international focus on energy security.
- Gazprom has premium price customers in the West, a commitment to supply huge new markets in the East and at the same time an obligation to supply Russian citizens. Each of these markets is growing, even as existing Gazprom production is declining.
- The IEA welcomes the establishment of a gas exchange in Russia and recommends the adoption of third-party access to stimulate competition. This, with increasing domestic prices would lead to reduced flaring of associated gas and increased economic rationale for more energy efficiency.

SUMMARY

Given Russia's important role in global oil and gas markets, it is most apt that Russia, during its year as G8 President, chose energy security as a key focus. Over 2006, the IEA has been more vigilant than in the past – not in questioning Russia's intent to remain a reliable energy supplier, but in asking for evidence of Russia's ability to do so. Russia is currently facing major investment decisions in its energy sector. Timely development of East Siberia is increasingly a priority as are other major new gas developments. Amendments to resource taxation introduced in 2007 are a positive step. Yet given the State's tightening grip on production and exports, there is concern that investments will not keep pace with exploration and production challenges ahead – especially in frontier areas.

The IEA is concerned that Gazprom has focused investments on acquiring ownership or control of strategic downstream assets in the past, rather than in its upstream. With the era of "cheap" Central Asian gas over, Gazprom is facing major investment choices to match the decline at its own major gas fields. In this regard, the IEA welcomes Russia's increasing recognition of the role the growing number of independent gas producers play. Huge efficiency gains are possible from more competition in Russia's upstream sector through real third-party access to its gas transmission network. The establishment of a gas exchange in Russia, where up to 10 bcm will be sold at unregulated prices by Gazprom and independent producers, is an important step in the liberalisation of the domestic market. A clear win-win option to reduce pressure on gas deliverability is to slow rising domestic gas demand through intensifying energy-efficiency programmes and through more market-based gas pricing.

Russian oil and gas transit issues continue to arise. A dispute with Ukraine (2006), leading to gas supply disruptions to Europe, was triggered by Gazprom's push to end gas price subsidies to FSU states and its aggressive negotiating tactics to gain control of transit infrastructure. In early 2007, European oil supply from Russia was briefly disrupted due to a dispute with Belarus over oil transit tariffs. The IEA urged for a quick and clear resolution to the oil disruption and reassured markets that a prolonged disruption could be managed by strategic oil stocks. In all of these incidents, the IEA monitored the situation closely, informing its member countries of potential developments which risked leading to emergencies.

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IEA (2006), *Ukraine Energy Policy Review*, OECD/IEA, Paris.

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IEA (2006), *Natural Gas Market Review: Towards a Global Gas Market*, OECD/IEA, Paris.

OPTIMISING RUSSIAN NATURAL GAS: REFORM AND CLIMATE POLICY

KEY MESSAGES

- The world's largest gas producer and exporter, Russia has an enormous energy-saving potential. At least 30 billion cubic meters – a fifth of Russian exports to European OECD countries – could be saved every year by enhanced technology or energy efficiency.
- As the era of low-cost gas in Russia comes to an end, this potential saving is increasingly important for Russia as well as for importing countries. Given the rise in Russian domestic gas prices, efficiency investments are becoming increasingly economic. Already high gas prices for gas exports to Europe provide substantial incentive for Gazprom to enhance its savings abroad.
- Achieving these savings will require linking long-standing energy efficiency goals with energy sector reforms, and climate policy objectives.

SUMMARY

Optimising Russian Natural Gas: Reform and Climate Policy was prepared in support of the G8 Gleneagles Plan of Action. It assesses the potential of reducing leaks, technical losses and ultimately greenhouse gas (GHG) emissions in Russia's gas transmission and distribution sector, as well as the prospects for reducing gas flaring. This work focuses on energy security and reduction of GHG emissions. It identifies the barriers to achieving these critical objectives and points to the structural and regulatory reforms needed to ensure the sustainable functioning of Russia's gas sector as well as the effective implementation of Kyoto mechanisms.

This book describes Russia's emerging climate policy and institutional framework. It identifies the work ahead before the country can become eligible for the Kyoto Protocol's flexibility mechanisms and financing options for GHG reductions. Tapping the full potential of energy savings and emission cuts will require a more competitive environment in the gas sector to attract timely investments. Systematic under investment in maintenance and refurbishment in Russian gas infrastructure has created a large potential for GHG emission reductions. These potential savings would be attractive for any country seeking to use "flexibility mechanisms" to meet their emissions reduction targets.

With the era of "low-cost" gas over, and an uncertain relationship with Turkmenistan ahead, Gazprom is facing major choices. It has existing premium price export customers to the West, a commitment to supply huge new markets to the East and at the same time an obligation to provide for the Russian economy. Each of these markets is growing, but existing Gazprom production is declining. The IEA is concerned that these factors will begin to affect Russia's position as a secure and reliable supplier. A clear win-win option to reduce pressure on gas deliverability is a strategy to slow rising domestic gas demand through intensifying energy-efficiency programmes and more market-based gas pricing. Energy-efficiency targets have been the centrepiece of Russia's energy strategy, yet low domestic gas prices to date and lack of metering equipment have stymied progress. The synergies between more efficient use of gas resources and GHG emission reductions are clear in Russia, and could be exploited through the Kyoto Protocol mechanisms. This would reinforce Russia's role as a reliable supplier of natural gas in the coming decades. However, structural and regulatory reform is needed to ensure the efficiency of Russia's gas sector, as well as to enable an effective implementation of Kyoto Protocol mechanisms.

REFERENCE

IEA (2006), *Optimising Russian Natural Gas: Reform and Climate Policy*, OECD/IEA, Paris.

UKRAINE: ENERGY POLICY REVIEW

KEY MESSAGES

- Ukrainian energy policy is driven by the country's strong desire to improve energy security and reduce natural gas imports.
- Key areas where the government could reduce its energy dependence through improved policy include energy efficiency, cost-reflective pricing and transparency. Ukraine has one of the most energy intensive economies in the industrialised world, thus energy efficiency represents Ukraine's single best opportunity to improve energy security.
- Ukraine is crucial to providing energy supplies to Europe because of its natural geographic position as a transit country.

SUMMARY

IEA has a long history of cooperation with Ukraine, which includes the publication of a first survey of *Energy Policies of Ukraine* back in 1996. In 2006, IEA published a new book *Ukraine: Energy Policy Review* in English and Ukrainian. The Review was an interactive process, building upon a constructive dialogue between Ukraine and IEA. Key objectives of the current Ukrainian energy policy are improving energy security and reducing energy imports. Today, most of Ukraine's oil and gas – and all of its nuclear fuel – comes from or through Russia.

The Review highlights three key priority areas where the government could reduce its energy dependence through improved policies: energy efficiency, cost-reflective pricing and transparency. Improving energy efficiency represents a major opportunity to increase energy security, reduce imports, improve economic growth and lower its environmental footprint. Ukraine can considerably improve its energy efficiency both through targeted policies and through market-oriented energy pricing. Most Ukrainian domestic energy prices today still do not cover all long-term costs of maintaining and upgrading energy infrastructure in Ukraine, although the gas, electricity and district heating tariffs have grown recently following a significant increase in gas import prices. As there is a a pressing need to invest in upgrading the infrastructure, cost-reflective prices are necessary to attract adequate investment and to provide incentives for needed reform across many areas of the energy sector. Finally, Ukraine could strengthen its energy policy by improving the transparency of energy data and clarifying market rules.

The Review examines the energy sector from many angles, including the policy framework, environmental impact and developments in subsectors such as energy efficiency, oil, gas, coal, electricity, district heating and renewables. The country is particularly reliant on natural gas in its energy balance. Coal is the second largest contributor to the country's energy supply, followed by nuclear and oil. Transit is very important to Ukraine. It is the largest gas transit country in the world by volume and also hosts major oil transit routes due to its geographic location between Russia and Europe. Therefore Ukraine and its energy policy are essential to providing energy supplies to Europe.

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IEA (2006), *Україна: Огляд енергетичної політики 2006* (In Ukrainian), OECD/IEA, Paris.

EURASIAN ENERGY MARKET SECURITY, OIL AND GAS MARKET ACCESS AND INVESTMENT POLICY

KEY MESSAGES

- South Caucasus, Caspian and Central Asian oil and gas are essential to reinforcing energy market security as they contribute to greater diversity of world supplies. At the same time, new complementary routes to new market outlets open greater possibilities to Central Asian producers in accessing downstream markets.
- More and better data is needed on Eurasian oil and gas reserves, production and transport capacity, as well as on pricing mechanisms. Clear information on the development of legal and regulatory systems throughout the region is essential to strengthen investor and consumer confidence and shape overall energy market security.
- Public and private partnerships, the strength of civil society, co-operation with international institutions and visibility to the public can boost investor confidence and lower the costs of large infrastructure projects. Practices established in promoting South Caucasus oil and gas transport systems already in place testify to this and provide examples on how to facilitate new transport systems.

SUMMARY

The Government of Georgia and the IEA co-hosted a roundtable under the auspices of President Mikheil Saakashvili in Tbilisi on 19 to 21 June 2006. The conference was dedicated to evaluating progress to date in South Caucasus oil and gas transportation and prospects for the future. Senior government representatives from regional oil and gas producers, transit and consuming countries joined industry and key international organisations (European Commission, EBRD, EU Council, OSCE, Energy Charter Secretariat and UNECE) to review investment policies and practices, and prospects for additional oil and gas infrastructure. Discussions focused on identifying opportunities and obstacles to strengthening the link between the vast oil and gas potential of the region and world markets.

A follow-up meeting was held at the IEA on 13 and 14 of February 2007 that gathered interdependent producers, consumers and transit countries from Eurasia. In light of short-term gas market tensions in the region, the meeting provided greater insight into and transparency of Caspian gas supply potential. It sought to improve the alignment of policy options with corporate strategies to facilitate gas market diversification through southern corridors. These include Trans-Caspian options for gas shipments into the Italy-Greece-Turkey Interconnector, Nabucco and other new projects to complement established gas flows through Blue Stream and other pan-European networks.

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Eurasian Energy Security Market Access & Investment Policy: "Forging the Link" Workshop, Tbilisi, June 2006.

www.events.ge/forgingthelink

CHINA'S QUEST FOR ENERGY EFFICIENCY

KEY MESSAGES

- China has committed to reducing energy intensity of GDP by 20% between 2005 and 2010, but is already off track, with nearly all provinces missing the 2006 target of 4%.
- Key to reaching the target is a programme aimed at improving efficiency in the 1 000 largest energy-consumers among the country's factories and power plants.
- The government has re-dedicated its efforts to the 20% goal, and international assistance will help, but greater administrative resources and more effective policy tools are badly needed.

SUMMARY

In its 11th Five-Year Plan, China announced it would reduce energy intensity by 20% from 2005 to 2010, tracking progress twice yearly. Despite a high profile rollout, and more than 25 years of experience with energy-efficiency policies, most provinces missed their targets in the first year. Preliminary figures show that fewer than half a dozen provinces met their targets, and nationally energy intensity rose slightly. This has led to renewed urgency for action at all government levels. Still, there appear to be significant obstacles to ultimate success in reaching the targets, which some believe are overly ambitious given the improbability of a rapid change in the manner of economic growth. In 2006, investment once again rose more than twice as fast as GDP, which grew by 10.7%. Heavy industry (which provides the materials needed for investment goods) grew more rapidly than light industry, and industry overall grew faster than any other sector, services included.

National leaders recognise that achieving the 20%-target will depend largely on the performance of industry – by far the largest final energy consumer – and power generators. In March 2006, the central government announced its "Top 1 000 Enterprises Energy Conservation Action Plan", focused on managing energy use at the largest firms in nine industrial and energy transformation sectors which together account for about one third of the country's primary energy use. Advisors to the Chinese government have stated that it will contribute 25% to 50% of the country's progress towards its overall target for reducing energy intensity.

Under the "Top 1 000 Enterprises" programme, designed with reference to experience in IEA member countries and led by the National Development and Reform Commission, each enterprise will sign an agreement containing a target, have its energy use monitored, and it will agree to a plan to improve energy efficiency. Objectives will be set for energy intensities of products (amount of energy used per unit of output), with enterprises variously required to meet "domestic" or "international" benchmarks.

While some enterprises have strong energy management capabilities, many are experiencing difficulties in understanding and complying with the terms of the program. Work in 2007, with significant international assistance including contributions from the IEA, will focus on training and technical standards to assist enterprises and local administrations to implement this programme.

REFERENCE

IEA (2006), "China's Quest for Energy Efficiency and Its 'Top 1 000 Enterprises Programme'", note to the Committee on non-member countries, Paris.

CHINA'S POWER SECTOR REFORMS: WHERE TO FROM HERE?

KEY MESSAGES

- As China works towards competitive power markets, in the near-term it should:
  - strengthen the institutional and governance framework;
  - tackle coal pollution from power generation directly and through incentives to investors and consumers; and
  - ensure that prices reflect costs, while strengthening incentives for investment in energy efficiency and grid reliability.
- China needs to review and reaffirm its strategy for power sector reform, and to ensure that there are strong mechanisms for implementation of further reforms.
- Greater transparency, including better data collection and analysis, is the key that will help to unblock further reform progress across all fronts.
- China can leapfrog other reformed jurisdictions by integrating, from the start, energy efficiency and environmental goals into its regulatory framework for power markets.

SUMMARY

Every two years, China adds as much generation capacity as the total in France. While the rate of expansion of China's power sector is unique, its energy sector encounters many challenges that other countries have long grappled with.

The country has already made great progress in liberalising its power sector: China separated generation from transmission and improved distribution systems, experimented with wholesale markets, and established an increasingly independent regulator. Still, important challenges remain; too much electricity is wasted, so too many power plants are being built to meet this demand. Too much fuel is wasted in generating power, and too much pollution is released as a result.

Several near-term actions stand out as priorities. China needs first to strengthen its institutional and governance framework. In addition to clarifying legal structures, it should further define the roles of government agencies, for instance, clearly defining the mandate and enforcement powers of the State Electricity Regulatory Commission (SERC) regarding pricing and oversight of generators, grid companies, and system dispatch and security. Pending establishment of a competition authority, SERC should also develop capacities for identifying and monitoring anti-competitive behaviour. SERC's staffing levels and capacities must be strengthened quickly.

All reform actions should help reduce the environmental consequences of coal, which fuels 70% of China's electricity. At least in the near term, direct support for efficiency is important, including demand side management programs. Power prices that better reflect actual costs would signal investors to choose more efficient equipment and fuels, and consumers to use electricity more wisely. Generation performance standards and higher, better-collected pollution fees would increase the likelihood of cleaner plants being built. If China were to create alternative ways to help vulnerable customers, such as through lifeline support mechanisms for poorer households, then it would be much easier to move towards transparent, cost-reflective pricing.

REFERENCE

IEA (2006), *China Power Sector Reforms: Where to Next?*, OECD/IEA, Paris.

STRENGTHENING OIL SECURITY IN CHINA

KEY MESSAGES

- China has carried through with its plan to build strategic oil storage facilities and has begun filling them as it completes work on its system for administering stocks.
- Greater security is also being pursued through diversification of fuels, through development of biofuels and liquids from coal, and diversification of overseas oil supplies.
- The IEA and China have continued to deepen exchanges on oil security issues.

SUMMARY

In October 2006, the IEA and China held two very successful activities: a training session at the IEA for government and industry statisticians on oil emergency information, and a two-day workshop held in Beijing with Chinese officials and oil companies on oil security.

The IEA trained Chinese oil statisticians in Paris in October 2006 to assist in establishing China's emergency oil data system and to improve oil statistics. After the training session, participants visited strategic oil storage sites in France and the Netherlands.

At the China-IEA Joint Workshop on Oil Security in Beijing in October, the IEA Secretariat and participants from member countries shared their expertise in preparing and responding to oil emergencies, such as the supply disruption caused by Hurricane Katrina in 2005, and the Chinese side appreciated it highly. While the workshop itself resulted in no new revelations of details of China's new SPR system, it helped lay a more solid basis for dialogue and for future policy coordination. Chinese officials participated in the SOM/SEQ joint session in November 2006, and Mr. Zhang Guobao, Vice-Chairman of the National Development and Reform Commission (NDRC) participated in the Governing Board meeting in Sydney 2006.

The workshop made clear that, in many areas, bilateral co-operation is key to helping China build and operate its strategic oil reserve system in a way that contributes to international oil security. Communications from member states may be helpful in demonstrating to China the merits that individual member countries see in voluntary compliance with an internationally co-ordinated scheme for joint action.

In meetings with IEA Secretariat and NDRC, contributions to the case study of China in the next *Oil Supply Security* publication were discussed. Overall China is committted to working with the IEA and to increase transparency, and has stated its willingness to publish more information as it develops its regulatory system.

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Coal-to-Liquids: an Alternative Oil Supply? IEA Coal Industry Advisory Board Workshop, Paris, November 2006.

China-IEA Joint Workshop on Oil Security, Beijing, October 2006.

China-IEA Training on Emergency Preparedness Statistics, Paris, October 2006.

COAL IN CHINA

KEY MESSAGES

- Coal use in China, already larger than in any other country in the world, continues to grow rapidly, and will be a major driver of future global greenhouse gas emissions. The government is taking steps to reduce both energy intensity and dependence on coal, but little change is expected in the near term.
- The new emphasis on coal-to-liquids to replace imported oil threatens to exacerbate emissions and other environmental problems, especially access to clean water.
- Urgent action in law, policy and technology is needed to speed the long-term shift towards cleaner uses of coal and other energy sources.
- All sectors – government, industry, and the academic and NGO community – show increased willingness to engage internationally to improve the way coal is used.

SUMMARY

Worldwide, incremental coal use is and will continue to be driven by large developing countries, China first among them. China used 40% of the estimated 2005 world total, and consumption grew by double digits in 2006, while coal exports fell and imports rose; the country could even become a net coal importer within a few years. China alone will account for 55% of new coal-fired power generation capacity worldwide over the next 25 years, driving the possibility that China will become the world's largest annual emitter of CO_2 by 2010, even as per capita emissions remain far below the levels of OECD countries.

China has been hard pressed to keep up with coal demand, but the impacts of producing and using this energy resource are increasingly obvious, and are acknowledged by the government and by energy companies themselves. The heavy investments in coal mining and transport, and slowing demand from some key sectors, may in the near future alleviate the pressure to obtain coal at almost any cost. Meanwhile, to moderate growth in coal demand it will be essential to improve electricity efficiency, especially in power generation and other transformation, but also in end uses.

The recent focus in Beijing on oil security has led to an emphasis on substitutes, including biofuels and coal-derived liquids. This may introduce a significant new source of coal demand – China's first large-scale plant may be running by the end of 2007 – not to mention new competition for scarce water resources. Liquid fuels from coal are much more carbon-intensive than those refined from oil, so China's greenhouse gas emissions stand to rise even further.

No nation is more in need of carbon capture and storage (CCS) technology than China, yet participation in R&D and information exchanges is still only in the early stages. The IEA and a number of member countries are increasingly engaged with China through bilateral and multilateral channels in exploring the potential for CCS and other cleaner-coal technologies. Successful deployment of promising technologies will depend on China developing a legal and administrative environment that makes it sensible for large energy users to adopt them.

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IEA (2006), *World Energy Outlook 2006*, OECD/IEA, Paris.

INDIA'S QUEST FOR ENERGY SECURITY

KEY MESSAGES

- India achieved a visible presence on the international energy scene in the last 5 years.
- Even in the most optimistic scenario of "equity-oil contribution" (an equity position taken in an upstream asset overseas) towards meeting demand by 2020, India will remain strongly import dependent.
- India's continuing price sensitivity has the potential to limit its role in international energy markets.
- India's first "Integrated Energy Policy" issued in 2006 underlines the high importance given to energy security.

SUMMARY

India's efforts to enhance its energy security, and in particular its oil security, have intensified significantly since 2005. Oil accounts for about 36% of India's total primary energy supply. In 1990, Indian domestic supply met almost 70% of oil demand. However, in 2004 the country imported over 70% of oil demand. India's oil import dependency is expected to increase to over 90% by 2020. India's future oil consumption is likely to originate primarily from the transport sector. India has few practical options for reducing its dependence on petroleum products for transport though the government is promoting several initiatives to introduce alternative fuels.

The "Hydrocarbon Vision 2025", published in 2000, recognises for the first time the challenges in the oil sector and outlines four pillars of achieving oil security: (i) diversification of supply sources; (ii) acquisition of equity oil, (iii) development of alternative fuels and (iv) strategic oil stocks. The Vision also sets out a long-term oil and gas security strategy including an "External policy and oil security" which encourages Indian public sector oil and gas companies for the first time to invest overseas and to build energy relations with resource-rich countries. The ambitious aim is to contribute 60 million tons per year of equity oil and gas to India's consumption in 2025. This would account for less than 25% of India's projected oil consumption for the same year.

However, India's quest for energy security is not only limited to ensuring physical supplies but also aims to address issues of pricing. Implicit in this is the recognition that India is not yet ready to absorb price fluctuations of international energy markets without potential negative consequences on economic growth. The development of an integrated national energy policy was seen as key in the country's quest for energy security and also as essential to meeting the policy objective of providing affordable energy to all. In mid-2005, the Indian Prime Minister took ownership of the initiative and created the "Energy Coordinating Committee" that was tasked with formulating a coordinated policy response cutting across all five energy-related ministries so as to improve the overall energy scenario in the country while addressing energy security concerns. The country's first "Integrated Energy Policy" was issued in September 2006 and will enable the government to take a holistic view of India's energy needs and policy options.

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GAS-FIRED POWER GENERATION IN INDIA: CHALLENGES AND OPPORTUNITIES

KEY MESSAGES

- The overall prospect for the role of gas in India's power sector is positive.
- The power sector must be made financially viable to establish gas as a competitive fuel.
- Power sector reform has to be accompanied by reform of the gas sector.
- There is a need to aggressively expand the gas transmission and distribution system to establish a fully developed country-wide gas grid.

SUMMARY

India has one of the strongest economic growth rates in the world and has sufficient potential to maintain high growth over a sustained period of time. The power sector will be growing in tandem with the economy and India will be able to slowly but steadily integrate its entire population into the commercial energy economy. This will further boost long-term demand for electricity. Given limitations on the use of coal for power generation due to its environmental consequences and quality constraints, gas will play an increasingly important role in India's power sector. In line with India's predicted strong economic growth, the country will need to add over 150 000 MW of additional installed power generation capacity by 2025. Gas is predicted to account for about 20% of generation capacity in that year, up from its current share of 10%. In 2005, all of India's gas-fired power plants required 17bcm/y to operate at a plant load factor of 90%.

India faces several challenges in translating this potential for gas-fired generation into reality. Guaranteeing gas supplies is emerging as one hurdle to attracting investment for gas-fired power generation which is seen as critical to promote clean fuels and to address air pollution. The distorted retail pricing structure in the public power sector currently limits the competitiveness of gas-fired generation at a level of USD 3.5/mmbtu. Another major constraint is the provision of subsidised gas to public gas-fired plants which acts as a disincentive to necessary public investments in increased domestic exploration and gas imports. Furthermore, this perpetuates the distorted retail tariff structure in the power sector.

India will also need to aggressively expand its gas transmission and distribution network, while at the same time putting into place the required legal and regulatory framework for the gas sector. The Petroleum and Natural Gas Regulatory Board Bill was approved in 2006 and the regulator is expected to be in place in early 2007. Gas pricing is however excluded from the authority of the regulator.

The challenges faced are not insurmountable but do require a strong commitment by all sector players. Future attempts by the government to promote gas-fired generation require a concerted effort between the three stakeholders: government, power and gas industry. There is a clear need to create an integrated chain of production, supply and consumption to address issues such as long-term security of fuel supply, fuel pricing (gas and power), and gas quality issues.

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LOOKING FORWARD: AN INTEGRATED IEA-ASIA OIL SECURITY PROGRAM

KEY MESSAGES

- Our major Partners in Dialogue (PDs) are quickly becoming key players in the global oil market. It is increasingly important to involve key PDs, such as China, India and Southeast Asia, in the IEA oil supply disruption response arrangements.
- This integrated IEA-Asia oil security program will build on the momentum to date of IEA initiatives with these countries to achieve a closer harmonisation of oil supply disruption response.

SUMMARY

In the past, IEA member countries have been the primary demand base for global oil supplies, and the IEA emergency planning for oil supply disruptions focussed on its membership. But in the future, if the IEA is to minimise the impact of a global oil supply disruption, it will be crucial to involve the key PDs in a harmonised way in the IEA disruption response arrangements.

These countries include, *inter alia*, China, India and the countries of SE Asia. The IEA initiated joint programs on oil security with China, India, and the Association of SE Asian Nations (ASEAN) in recent years (*i.e.*, with China in 2001; ASEAN in 2003; India in 2004).

The focus of this three-year integrated program will be to build on the momentum and close relations with these key PDs to further increase their policy and technical awareness, their information exchange, and developments on the ground. The six activity areas reflect the joint activities to date and the PDs priorities. These activities will also demonstrate to IEA member countries the value of involving key PDs. This program has received a voluntary contribution provided by the UK Global Opportunities Fund.

Progress to date includes:

- Technical workshops with China, India and ASEAN: 'Best practices for strategic stocks establishment & maintenance'. The IEA-China Workshop was held on 30-31 October, Beijing. China and the IEA agreed to take further steps in exchanging oil market data and analyses, as well as reports on strategic stock developments.
- Review of member country strategic stocks policy, legislation, costing and financing. A comprehensive review of IEA stockholding regimes, including legislation, policy, technical and financial information, is underway.
- Joint meeting of key ASEAN-India-China and IEA member country decision makers in the IEA Standing Committees on Emergency Questions (SEQ) and Oil Markets (SOM). Chinese officials participated as observers at the November 2006 Joint Session of the IEA SEQ/SOM.
- Recurrent 'Emergency Oil Statistics' training of China, India and ASEAN statisticians at the IEA in Paris. One-week training sessions in the development of international standard information and oil data systems, and the sharing oil crisis information are developed. A highly successful course with 10 statisticians from China was held in 2006.

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IEA website page on China, in the "by country" section.

THE ENERGY SITUATION IN BRAZIL: AN OVERVIEW AND OUTLOOK

KEY MESSAGES

- Brazil's domestic oil production has been rising steadily in the last few years, reaching an average 1 778 mb/d in 2006. Still, the predominance of heavy oil reserves in Brazil means that the country is likely to continue to import some light oil for processing at its refineries.
- Following the nationalisation of the hydrocarbon industry in Bolivia, which is currently the source of almost half of Brazil's gas needs, Brazil is ramping up domestic gas production. The success of this strategy will critically depend on sound regulation of the gas sector in order to mitigate Petrobras's market dominance.
- Brazil is the world's lowest-cost producer of ethanol, thanks to a combination of climate, soil and relatively low labour and land costs. Going forward, Brazil would greatly benefit from a clear regulatory framework to mitigate the potential environmental and social impacts of expanding ethanol production.

SUMMARY

Brazil's GDP ranks ninth in the world. The country is the second largest non-OECD economy after China, and the world's fifteenth largest oil producer. Petrobras defines oil self-sufficiency as domestic production being equivalent to the volume of crude that can be processed at the country's refineries to meet demand from the Brazilian market. With this objective, the country is currently investing massively in upstream exploration, but the domestic market needs more refining capacity to meet growing demand. Petrobras' 2007-11 business plan, reaching USD 87.1 billion, is now among the largest capital expenditure plans of any major oil company. The *World Energy Outlook 2006* expects Brazil to remain self-sufficient in oil use on a net basis in the period to 2030, provided that the necessary investment in the upstream oil sector, especially for exploration, is forthcoming.

Natural gas demand has increased considerably over the last few years, as the government kept gas prices low to encourage energy diversification, fuelled by expanding gas imports from Bolivia, which accounted for 42% of Brazil's gas consumption in 2006. In light of the recent nationalisation of the energy sector in Bolivia, Brazil is seeking to reduce dependency on gas imports by accelerating development of the Espírito Santo and Santos basins and by importing LNG. Much more investment will be needed to exploit domestic gas resources and to expand the gas transportation and distribution infrastructure.

Electricity demand in Brazil is growing faster than the economy. The power margin between capacity and average demand began to decline in 2004, and the trend is expected to accelerate in the coming years. The government plans to authorise the building of new large hydropower plants – that accounted for over three-quarters of Brazil's electricity-generating capacity in 2004 – but there are important environmental and financial obstacles. The major challenges will be mobilising investment in electricity infrastructure and resolving environmental issues over the construction of large dams and transmission lines. The power sector will require investments of over USD 250 billion in the Reference Scenario of the *World Energy Outlook 2006* and some USD 200 billion in the Alternative Policy Scenario.

Brazil is the world's second-largest ethanol producer after the United States. To meet rising domestic and export demand for ethanol, the Brazilian government plans to increase productive capacity and to build ports with storage tanks and loading facilities, among other initiatives. Achieving the objective of doubling ethanol production in the next five years will require a sound regulatory framework to mitigate potential environmental and social impacts, and a reliable pricing mechanism. In the *World Energy Outlook 2006*, the share of biofuels in road-transport fuel demand rises from 14% in 2004 to 23% in 2030 in the Reference Scenario and to 30% in the Alternative Policy Scenario.

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AFRICAN ENERGY: IN-DEPTH REVIEW OF ANGOLA'S ENERGY SECTOR

KEY MESSAGES

- While Angola has established oil and gas reserves and is a major player in the world energy market, most Angolan citizens do not have access to reliable energy for their daily lives.
- An integrated approach is needed to provide electricity taking into account both supply and demand.
- In the oil sector, greater stability for existing and future contracts is needed to ensure continued foreign investment and steps should be taken to improve downstream reliability. In addition to this, the government should establish a clear gas development strategy, coordinate the biomass policy between different government authorities, and improve its capability to collect and disseminate relevant energy statistics.

SUMMARY

In 2002, Angola emerged from almost three decades of civil war that left much of its infrastructure destroyed or damaged and a large part of its population displaced. Increasing access to modern energy sources in a sustainable manner could help improve livelihoods directly, as well as indirectly through the promotion of economic development. The Angolan government in 2005 invited the IEA to conduct an in-depth review of its energy sector.

Electricity is the leading indicator of growing prosperity, and Angola's electricity access rate is estimated between 8-20%. The electricity sector requires significant investment, but is not able to generate sufficient funds. Not only do tariffs not cover costs, but collection rates on bills are low. While raising tariffs is important, the procedure should be accompanied by a comprehensive metering system and more effective collection.

As sub-Saharan Africa's second largest oil producer after Nigeria, Angola needs to further strengthen its upstream oil sector by ensuring that the regulatory framework provides sufficient stability for existing contracts and the continued attraction of foreign investment. The government is also encouraged to continue its efforts to improve transparency in the management of oil revenues. To improve the reliability of oil products supply in the downstream sector, the government should continue to liberalise product prices, encourage private companies to engage in oil product distribution, and to invest more in transportation and storage infrastructure.

As the gas sector is particularly underdeveloped in Angola, it will be crucial for the government to present a clear gas development strategy which is supported by a regulatory framework to reduce the risk to potential investors. The IEA furthermore encourages the government to reduce flaring of associated gas, including greater enforcement of existing legislation.

As biomass is used as the sole source of energy for heating and cooking by 80% of Angolans, the IEA suggests that related problems such as deforestation, pollution and health-hazards be tackled within the wider framework of household energy needs, in particular by recognising use of firewood and charcoal as a response to lack of energy alternatives. Since a sound government policy also requires reliable data, the Angolan government should improve its capability to collect, analyse and disseminate relevant statistics in the energy and related sectors.

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IEA Publications, 9 rue de la Fédération, 75739 Paris Cedex 15
Printed in France by the IEA
April 2007