

INTERNATIONAL ENERGY AGENCY



*In support of the G8 Plan of Action*

# TOWARDS A SUSTAINABLE ENERGY FUTURE

*IEA programme of work  
on climate change, clean energy  
and sustainable development*

**2008**



INTERNATIONAL ENERGY AGENCY



*In support of the G8 Plan of Action*

# TOWARDS A SUSTAINABLE ENERGY FUTURE

*IEA programme of work  
on climate change, clean energy  
and sustainable development*

*“We will act with resolve and urgency..”*

*(Communiqué, Gleneagles G8 Summit, July 2005)*

## **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-seven 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 promote international collaboration on energy technology.
- 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, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Poland is expected to become a member in 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.

**© OECD/IEA, 2008**

International Energy Agency (IEA),  
Head of Communication and Information Office,  
9 rue de la Fédération, 75739 Paris Cedex 15, France.

*Please note that this publication is subject to specific restrictions that limit its use and distribution. The terms and conditions are available online at <http://www.iea.org/Textbase/about/copyright.asp>*

## TABLE OF CONTENTS

Executive Summary.....	4
<b>ADVICE ON ALTERNATIVE SCENARIOS AND STRATEGIES</b>	
Scenarios: <i>World Energy Outlook</i> .....	8
<i>Energy Technology Perspectives: Scenarios and Strategies</i> .....	11
<b>TRANSFORMING THE WAY WE USE ENERGY</b>	
Energy Efficiency: Cross Sectoral.....	14
Efficient Energy Equipment: Appliances and Lighting.....	18
Efficient and Low-Carbon Buildings.....	21
Efficient and Low-Carbon Industries.....	24
Efficient and Low-Carbon Transport.....	27
Energy Indicators.....	32
<b>POWERING A CLEANER FUTURE</b>	
Cleaner Fossil Fuels.....	35
Carbon Capture and Storage (CCS).....	39
Renewable Energy Markets and Policies.....	42
Renewable Energy Heating and Cooling (REHC).....	44
Grid Integration of Renewables.....	46
Combined Heat and Power (CHP).....	48
<b>PROMOTING NETWORKS FOR RESEARCH AND DEVELOPMENT</b>	
Enhancing Technology Collaboration with Brazil, China, India, Mexico, South Africa and Russia.....	50
Engagement with Industry.....	53

## Executive Summary

### Introduction

This document reports on the outcome of the IEA Secretariat's three-year programme of work in support of the G8 Plan of Action on climate change, clean energy, and sustainable development. This programme was inaugurated at the Gleneagles Summit in 2005, when the G8 leaders asked the IEA to "advise on alternative energy scenarios and strategies aimed at a clean, clever, competitive, energy future". They also asked the IEA to undertake a range of specific tasks.

For each of the 16 IEA work-streams, we present here brief summaries of: key conclusions and findings; source analysis; and proposed next steps. Full details of each project can be accessed through this report's links in the electronic version at:

[http://www.iea.org/G8/2008/G8\\_Towards\\_Sustainable\\_Future.pdf](http://www.iea.org/G8/2008/G8_Towards_Sustainable_Future.pdf).

### The outlook is stark

The scenario analyses of IEA publications *World Energy Outlook* and *Energy Technology Perspectives* yield stark conclusions. We could be on a path to more than doubling current global energy-related CO<sub>2</sub> emissions by 2050. The options exist to change this trend, provided that action is taken urgently. But the contribution that G8 - or IEA - member countries can make on their own is limited. A substantial transformation of the global energy economy is required. To be effective, all major economies need to participate. The costs are significant and strong price signals on CO<sub>2</sub> are essential. As shown in the *World Energy Outlook*, in the absence of major additional investment efforts, oil and gas markets will remain very tight in the decades to come.

### Speeding energy savings

Improving energy efficiency in all sectors of the economy is fundamental and urgent. It has the greatest potential for CO<sub>2</sub> savings and the lowest cost (in most cases negative costs). Energy efficiency can deliver results quickly. But our analysis of recent efficiency trends shows that the past ten years' performance in IEA member countries has declined to about half the rate of improvement in previous decades. A fundamental turn-around is needed.

We propose a set of concrete policy recommendations for promoting energy-efficiency in cross-sectoral activity, buildings, appliances, lighting, transport, industry and power utilities. Many of these measures can be implemented now at low cost. We urge governments to implement these measures and to monitor their impact.

### Optimising energy indicators and statistics

Energy indicators are essential statistical tools for measuring national and international energy efficiency performance and for analysing trends and potential so as to promote improvements. In many parts of the world, however, available data is limited. We recommend that governments put a strong international statistical framework in place so that future policies can be based on sound analysis.

## Helping industry save energy

Drawing on the data currently available, our analysis of the most energy-intensive industries world wide shows that 1.9 - 3.2 gigatonnes (Gt) of CO<sub>2</sub> emissions can be saved each year if these industries adopt international best available practice. Bearing in mind the potential for migration of these industries, an international sectoral approach is needed to deliver these improvements.

## Cutting power sector emissions

Reducing CO<sub>2</sub> emissions from power generation is critical. By retiring the least efficient coal power stations, upgrading middle-ranking plant, while ensuring that all new plant is state-of-the-art and that operating and coal preparation standards are improved, up to 1.7 Gt of CO<sub>2</sub> emissions can be saved each year. We make specific proposals, based on IEA analysis of the global fleet.

Deployment of CO<sub>2</sub> capture and storage (CCS) technology is vital because coal is the least costly and most accessible fuel for some of the most dynamic developing economies. The aim of reducing CO<sub>2</sub> emissions by 50% by 2050 implies that virtually all coal stations will need CCS by then (including some under construction now).

We recommend that at least 20 fully integrated industrial-scale CCS demonstration projects be committed by 2010, with the goal of broad deployment by 2020. Any developer of a new coal power plant should consider now what might be required to retrofit CCS.

Nuclear energy is the largest source of low-emissions electricity (20%), and hence is a very important part of the energy mix in the modelling of our energy-sector scenarios.

## Deploying renewables effectively

In our most optimistic scenario, renewables supply 46% of global power by 2050. But our analysis shows that the cost-effectiveness of government policies has been inconsistent. We propose that governments review their renewables deployment policies in the light of the evidence regarding which approaches have proved most successful.

IEA analysis confirms that high levels of penetration by variable renewables are feasible, so long as modern, sophisticated electric grids are accessible. In many regions, renewable heating and cooling offers significant untapped potential. A tripling of the current contribution of renewables-based heating is feasible and could save between 1 Gt and 1.2 Gt of CO<sub>2</sub> per year, or at least as much CO<sub>2</sub> as 500 million light vehicles emit on the world's roads.

## Transport remains a challenge

De-carbonising transport is more difficult and costly than de-carbonising power generation. In the medium term, cost-effective efficiency improvements of up to 50% are possible. But such savings imply curbing the trend towards heavier vehicles. We recommend continued tightening of fuel-efficiency standards for vehicles.

In the longer term, new technology will be needed to de-carbonise transport. Advanced bio-fuels, hydrogen fuel cells and electric vehicles are all possible options. Today, it is hard to tell which technology or combination of technologies will prevail. They all require much more R&D before they become ready for mass deployment. To achieve a 50% CO<sub>2</sub> reduction

by 2050, one or more of these technologies must be deployed on a large scale by mid-century. This underlines the urgent need to partner with industry to accelerate R&D advances.

## Engaging all major economies and industry

Neither IEA member countries nor the G8 can attain a sustainable energy future without the participation of all economies, especially the major ones. Solutions must be global. Extensive consultation and discussion, for example between energy experts of the IEA and their peers from Brazil, China, India, Mexico and South Africa, have established a framework for closer co-operation and identified rural energisation as one topic for intensified collaboration. The IEA initiative Networks of Expertise in Energy Technology (NEET) has reinforced energy technology collaboration with non-IEA countries. Other initiatives like the sustainable buildings network have strengthened ties between G8 and Plus-Five nations.

As leaders recognised at the Heiligendamm Summit in 2007, private-sector investment is now - and will remain - the primary facilitator for technology deployment and diffusion. At IEA Headquarters in Paris, chief technology officers of more than 30 leading international energy companies publicly stated their willingness to work with the IEA and the G8 towards a more sustainable energy future.

## Next steps

Determined action by individual governments is needed. But so is agreement among all major economies on how best to collaborate at an international level. The following specific efforts are suggested.

- The demanding energy efficiency targets and policies that almost all major countries have adopted must be drawn together and implemented urgently. Progress must be monitored and the global impact of these measures evaluated.
- The IEA publication *Energy Technology Perspectives 2008* offers first attempts at roadmaps for 17 key clean and efficient energy technologies. These roadmaps need to be developed further, under international guidance, drawing together the energy technology programmes of all major economies, and in close consultation with industry and existing technology networks. This can provide the focus for the much closer international collaboration needed to achieve the global energy technology revolution that is now essential.
- Countries must work together to develop better statistics on energy efficiency, government energy R&D programmes and technology deployment so that future policies can be advanced on the basis of sound data and analysis. With governments' support, the IEA is equipped to put the necessary systems in place.

The IEA Secretariat stands ready to support governments in these initiatives.

Within this framework, bearing in mind the need for urgency, we suggest that priority be given to the following tasks.

- Implementation of the set of concrete policy recommendations proposed by the IEA for promoting energy efficiency in buildings, appliances, lighting, transport, industry, power utilities and cross-sectoral areas.

- Continued assessment of energy efficiency policy challenges in order to help countries implement effective measures.
- Promoting commonality and ambition in measures and standards to accelerate the efficiency of energy-using appliances and equipment.
- Enhancing the efficiency of the global fleet of coal power stations.
- Demonstration and deployment of CCS, and international co-ordination of initiatives.
- Enhancing the international spread and effectiveness of policies for the deployment of renewables.
- Expanding the scope and scale of government and private-sector R&D efforts to bring forward low carbon transport options.
- Working to secure international agreement and support for statistical questionnaires on energy efficiency and technology R&D and deployment.

Securing resources is a pressing issue. They will be crucial for developing and deploying efficient, low-CO<sub>2</sub> technologies in the major developing countries as well as developed nations. The IEA can offer analytical support, but the political and financial aspects must be decided by governments.

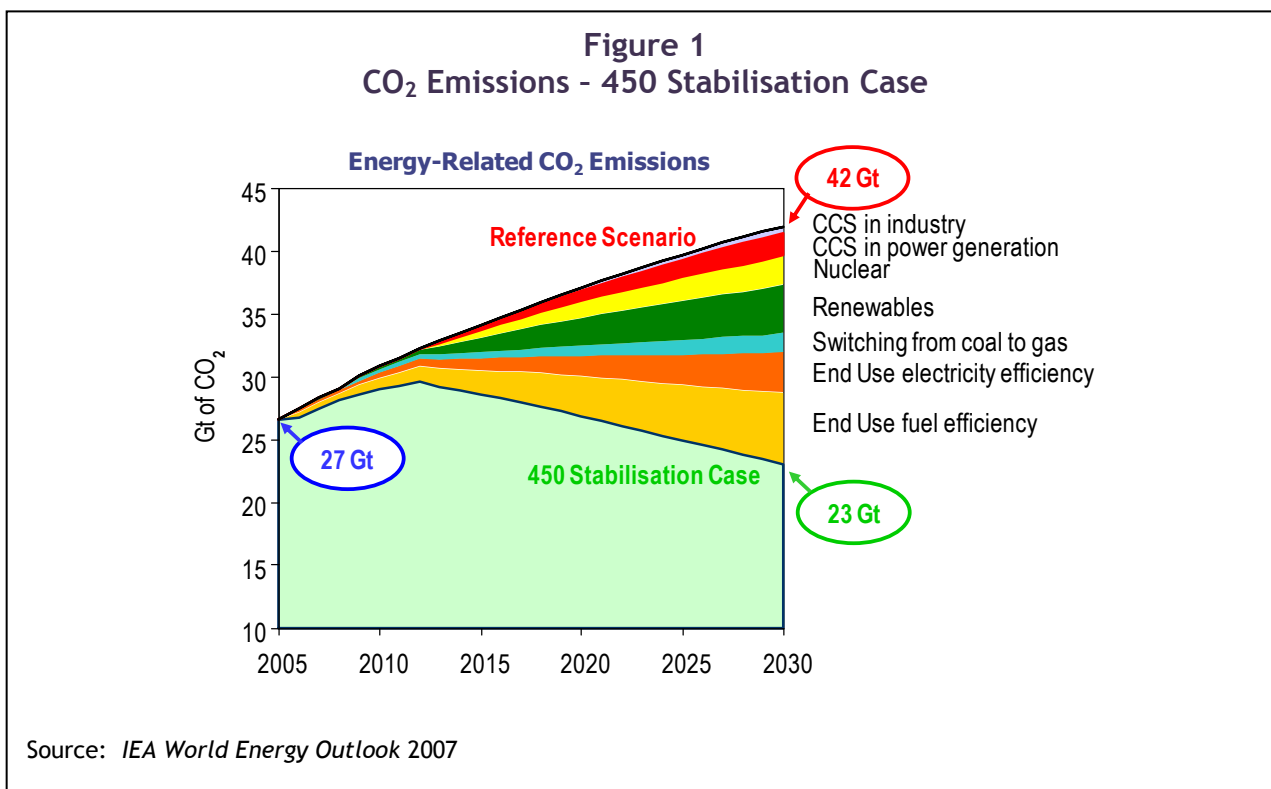
The current IEA Gleneagles programme is now drawing to a close. While much has been accomplished, much remains to be done in almost all areas. We have identified the challenges. We have applied the IEA convening power and mobilised the expertise of its technology network. Our analytical strength has pointed to how the solutions can be found. We must now follow through and help ensure that the solutions become reality.

In the sections that follow, full details on individual IEA projects in support of the G8 Gleneagles Plan of Action will be made accessible through links (indicated by underlining) in the electronic version of this report at: [http://www.iea.org/G8/2008/G8\\_Towards\\_Sustainable\\_Future.pdf](http://www.iea.org/G8/2008/G8_Towards_Sustainable_Future.pdf)

## ADVICE ON ALTERNATIVE SCENARIOS AND STRATEGIES

### World Energy Outlook (WEO)

“The emergence of China and India as major players in global energy markets makes it all the more important that *all* countries take decisive and urgent action to curb runaway energy demand.” (IEA *World Energy Outlook - China and India Insights*, 2007)



### Source analysis

#### Publications

- IEA *World Energy Outlook 2008* (forthcoming).
- IEA [World Energy Outlook: China and India Insights 2007](#).
- IEA [World Energy Outlook 2006](#).

#### Workshops

- [World Energy Outlook 2007 - Coal Trade Workshop](#), Paris, June 2007, in collaboration with Coal Industry Advisory Board.
- [WEO Informal Brainstorming Meeting](#), Paris, May 2007.
- [Joint IEA-OPEC Workshop](#), Bali, May 2007.
- [World Energy Outlook 2007 - China Workshop](#), Beijing, March 2007, in collaboration with Energy Research Institute (Beijing).
- [World Energy Outlook 2007 - India Workshop](#), New Delhi: March 2007, in collaboration with TERI.

## Key conclusions

- Global energy needs are expected to grow over coming decades, with fossil fuels still the dominant source, sharply pushing up CO<sub>2</sub> emissions and creating dramatic implications for all countries. China and India are the emerging energy giants in this unsustainable future. The consequences for China, India, the OECD and the rest of the world of unfettered growth in global energy demand are, however, alarming.
- If governments around the world stick with current policies - the underlying premise of the Reference Scenario of the *World Energy Outlook (WEO)* - the world's energy needs would be well over 50% higher in 2030 than today. China and India together account for 45% of the increase in demand in this scenario. Globally, fossil fuels continue to dominate the fuel mix. These trends lead to continued growth in energy-related emissions of CO<sub>2</sub> and to increased reliance of consuming countries on imports of oil and gas - much of them from the Middle East and Russia. Both developments would heighten concerns about climate change and energy security.
- Global oil demand in the Reference Scenario is projected to reach 116 million barrels per day in 2030, China and India accounting for more than 40% of the growth. World oil resources are estimated to be sufficient to meet the projected growth in demand to 2030, but output becomes more concentrated in OPEC countries, provided that necessary investment is forthcoming. The OPEC share of world oil supply jumps from 42% now to 52% by 2030. Although new oil production capacity additions are expected to increase over the next five years, it is very uncertain whether they will be sufficient to compensate for the decline in output at existing fields and keep pace with the projected increase in demand. A supply-side crunch in the period to 2015, involving an abrupt escalation in oil prices, cannot be ruled out.
- In the Reference Scenario energy-related CO<sub>2</sub> emissions jump from 27 Gt in 2005 to 42 Gt in 2030. The United States, China, Russia and India contribute two-thirds of this increase. These trends are in line with a long-term temperature increase of up to 6 °C.
- In the Alternative Policy Scenario (which assumes that governments around the world implement policies they are currently considering), global primary energy demand grows by 0.5 percentage points less per year than in the Reference Scenario. Global oil demand in this Scenario is slightly above 100 mb/d in 2030. Energy-related CO<sub>2</sub> emissions stabilise in the 2020s. With continued emissions reductions, these trends are consistent with a temperature increase of 3 °C above pre-industrial levels.
- In a “450 Stabilisation Case”, which describes a notional pathway of energy use that is consistent with an increase in temperature to a maximum of 2.4 °C (the smallest increase in any of the IPCC scenarios), energy-related CO<sub>2</sub> emissions peak in 2012 and then fall sharply below today's levels in 2030. Emissions savings come from improved efficiency in fossil fuel use in industry, buildings and transport, switching to nuclear power and renewables, and the widespread deployment of CCS in power generation and industry. Exceptionally strong and immediate policy action, on an unprecedented scale, would be essential for this to happen. The costs of this transition would be very substantial in the energy sector.

## Next steps

- *World Energy Outlook 2008 - 1) Oil and gas supply prospects*  
WEO will investigate oil prospects in depth, looking at some 250 oil and gas fields on a field-by-field basis to assess notably:
  - their contribution to future oil and gas supply;
  - investment difficulties and possibilities for joint ventures;
  - quality of oil;
  - technology and its implications.

A [high-level workshop](#) on these topics was held in Paris in April 2008.

- *World Energy Outlook 2008 - 2) Climate change*  
In addition to providing environmental implications of usual WEO scenarios, this study will analyse various post-2012 architecture options. For each option it will investigate the implications for the energy sector, including energy security and financing/investment decisions. It will also address ways of attracting engagement of developing countries, especially China and India, in the framework. The WEO 2008 will also look into non-CO<sub>2</sub> gases and will analyse the opportunities for major cities to play a leading role in reducing energy use and CO<sub>2</sub> emissions. A [high-level workshop on climate change](#) was organised in Copenhagen in April 2008, hosted by the Danish Government.
- *World Energy Outlook 2008 - 3) Energy poverty: focus on Africa*  
The WEO 2008 will look at energy poverty issues in energy-rich countries on the continent of Africa. A [high-level workshop](#) on this subject was held in Maputo, Mozambique, in May 2008.

*World Energy Outlook on the IEA website:*  
<http://www.worldenergyoutlook.org/>

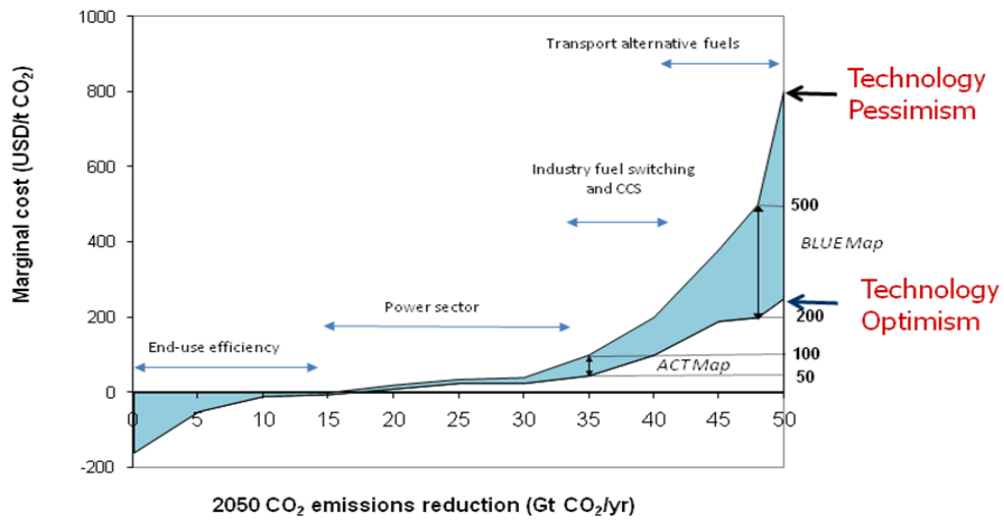
## ***Energy Technology Perspectives (ETP): Scenarios and Strategies***

“A global revolution is needed in ways that energy is supplied and used ... A dramatic shift is needed in government policies ... Unprecedented levels of co-operation among all major economies will also be crucial...” *Energy Technology Perspectives - Scenarios & Strategies to 2050*, IEA 2008.

### **Key conclusions**

- With current policies, CO<sub>2</sub> emissions will rise at an accelerating rate and concerns over security of supply will intensify. We urgently need to decouple CO<sub>2</sub> emissions from the growth of energy demand and economic activity.
- This will require a global revolution in the way that energy is supplied and used. Efficient and clean energy technologies will be at the heart of the effort. Higher levels of energy efficiency, combined with deployment of carbon capture and storage, renewables and nuclear power on a massive scale, and the development of carbon-free transport, will all be necessary.
- Technologies that already exist, or are in advanced development, can bring global CO<sub>2</sub> emissions back to current levels by 2050 at costs that are within our reach. The total additional investment needed to stabilise emissions is around USD 17 trillion for the period 2005-2050. However, emissions stabilisation may not be enough to prevent dangerous climate change.
- Reducing CO<sub>2</sub> emissions by 50% in 2050 compared to current levels represents a much tougher challenge. CO<sub>2</sub> emissions would need to peak within the next two decades, implying a rapid change of direction. The costs would be both much higher and more uncertain. Options with a cost of up to USD 200/t CO<sub>2</sub> would be needed, possibly even USD 500/t without successful development of new technologies. The average cost among options would be between 38 USD/t and 117 USD/t. Additional investment needs up to 2050 would be in the order of USD 45 trillion, which equals about 1% of cumulative GDP for this period. Fuel savings would offset part of these investments.
- A huge effort of research, development and demonstration will be needed. Initial roadmaps have been developed for 17 key energy technologies. International collaboration is essential to further develop these roadmaps and accelerate the development and global deployment of sustainable energy technologies.
- There is also an urgent need for governments to bring forward a range of regulatory- and market-based policies to create a clear, predictable, long-term framework to promote CO<sub>2</sub> reductions across all sectors.

**Figure 2**  
**What it Costs to Reduce Energy-Related CO<sub>2</sub> Emissions**  
**(Marginal Cost)**



Source: *Energy Technology Perspectives*, IEA, 2008

### Source analysis

#### Publications

- IEA [Energy Technology Perspectives - Scenarios and Strategies to 2050](#) (2008).
- IEA [Energy Technology Perspectives - Scenarios and Strategies to 2050](#) (2006).

#### Workshops

- [Deploying Demand Side Energy Technologies](#), Paris, October 2007.
- [International Workshop on Technology Learning and Deployment](#), Paris, June 2007.

#### ETP 2008 Roadmap Key Technologies

##### Supply Side

- CCS fossil-fuel power generation
- Nuclear power plants
- Onshore and offshore wind
- Biomass integrated-gasification combined-cycle and co-combustion
- Photovoltaic systems
- Concentrating solar power
- Coal: integrated-gasification combined-cycle
- Coal: ultra-supercritical
- Second-generation biofuels

##### Demand Side

- Energy efficiency in buildings and appliances
- Heat pumps
- Solar space and water heating
- Energy efficiency in transport
- Electric and plug-in vehicles
- H<sub>2</sub> fuel cell vehicles
- CCS in industry, H<sub>2</sub> and fuel transformation
- Industrial motor systems

## Next steps

Future work will focus on the following.

- *Energy Technology Perspectives 2010*.
- Assessing sectoral potentials in greater detail.
- Deepening the dialogue with industry on the development of the economic framework for technology deployment.
- Encouraging increased government spending for fundamental RD&D, better co-ordinated industry, government and academic RD&D efforts.
- Helping to develop an international technology co-operation programme, building on existing networks and working with industry to further develop and implement the roadmaps for the 17 key technologies that have been identified.

*Energy Technology Perspectives* on the IEA website:  
<http://www.iea.org/Textbase/techno/etp/index.asp>

## TRANSFORMING THE WAY WE USE ENERGY

### Energy Efficiency: Cross Sectoral

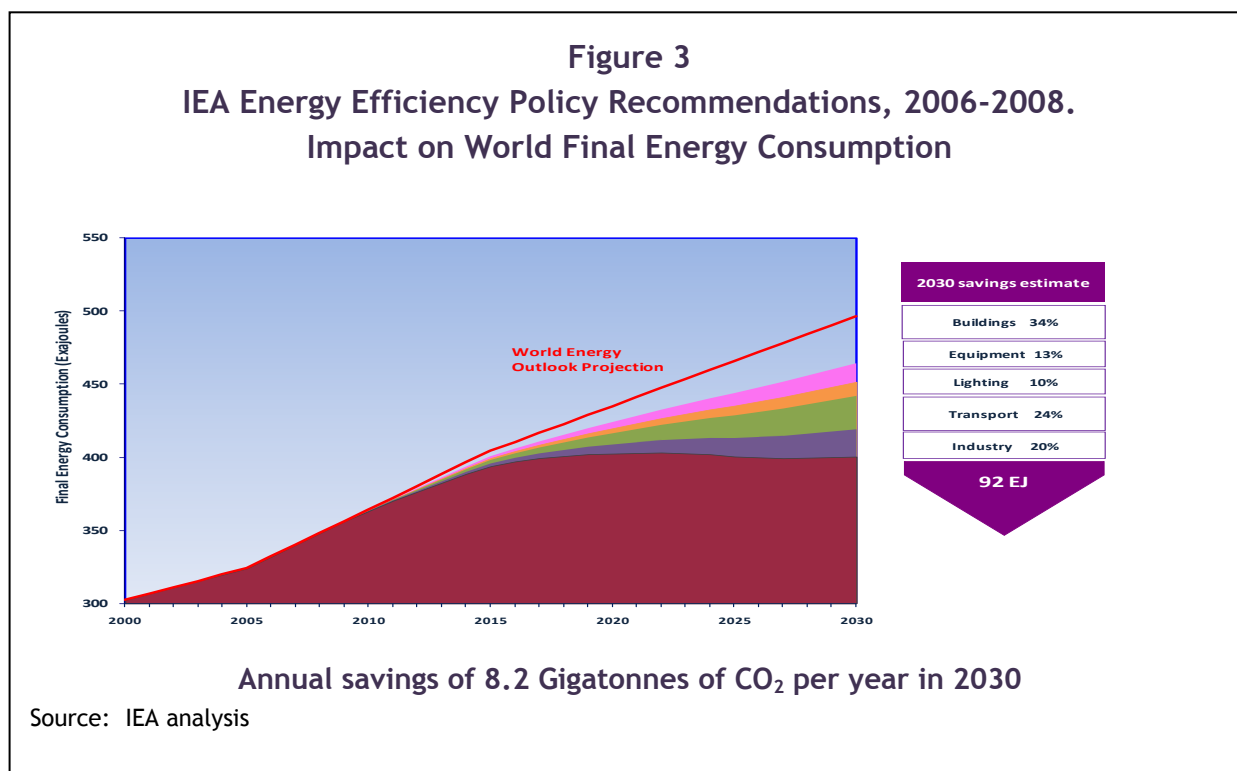
#### Concrete policy recommendations for promoting energy efficiency

A key focal point in the follow-up to the G8 Gleneagles Plan of Action (GPOA) has been the development of "concrete recommendations" on energy efficiency policies. These have been presented and endorsed at subsequent G8 Summits in 2006 and 2007. The recommendations have drawn on detailed analysis undertaken by the Secretariat and supported by publications, workshops and policy dialogues with key stakeholders. More recommendations are under preparation and will be submitted for consideration at the Hokkaido Summit.

The consolidated set of recommendations presented by the IEA Secretariat to the G8 Summits in 2006, 2007 and 2008 cover 25 fields of action across seven priority areas: cross-sectoral activity; buildings; appliances; lighting; transport; industry and power utilities. Together, the recommendations, all of which passed strict criteria when being developed, set out an ambitious roadmap for improving energy efficiency on a global scale. The criteria specified that each recommendation should:

- be likely to save a large amount of energy at low cost;
- address existing market imperfections or barriers;
- address a significant gap in existing policy; and
- be supported by a high degree of international consensus.

Full global implementation of the IEA proposed actions could save around 8.2 GtCO<sub>2</sub>/yr by 2030. This is equivalent to one fifth of global reference scenario energy-related CO<sub>2</sub> emissions in 2030 (see Figure 3).



The recommendations are presented in the box below.

### Summary of Consolidated Energy Efficiency Recommendations Prepared by the IEA for the G8 under the Gleneagles Plan of Action

The IEA recommends policy action in the following areas.

1. The IEA recommends action on energy efficiency *across sectors*. In particular, the IEA calls for action on:
  - 1.1 Measures for increasing investment in energy efficiency;
  - 1.2 National energy efficiency strategies and goals;
  - 1.3 Compliance, monitoring, enforcement and evaluation of energy efficiency measures;
  - 1.4 Energy efficiency indicators;
  - 1.5 Monitoring and reporting progress with the IEA energy efficiency recommendations themselves.
2. *Buildings* account for about 40% of energy used in most countries. To save a significant portion of this energy, the IEA recommends action on:
  - 2.1 Building codes for new buildings;
  - 2.2 Passive Energy Houses and Zero Energy Buildings;
  - 2.3 Policy packages to promote energy efficiency in existing buildings;
  - 2.4 Building certification schemes;
  - 2.5 Energy efficiency improvements in windows.
3. *Appliances and equipment* represent one of the fastest growing energy loads in most countries. The IEA recommends action on:
  - 3.1 Mandatory energy performance requirements or labels;
  - 3.2 Low-power modes, including standby power, for electronic and networked equipment;
  - 3.3 Televisions and “set-top” boxes;
  - 3.4 Energy performance test standards and measurement protocols.
4. Saving energy by adopting efficient *lighting* technology is very cost-effective. The IEA recommends action on:
  - 4.1 Best practice lighting and the phase-out of incandescent bulbs;
  - 4.2 Ensuring least-cost lighting in non-residential buildings and the phase-out of inefficient fuel-based lighting.
5. About 60% of world oil is consumed in the *transport* sector. To achieve significant savings in this sector, the IEA recommends action on:
  - 5.1 Fuel-efficient tyres;
  - 5.2 Mandatory fuel efficiency standards for light-duty vehicles;
  - 5.3 Fuel economy of heavy-duty vehicles;
  - 5.4 Eco-driving.
6. In order to improve energy efficiency in *industry*, action is needed on:
  - 6.1 Collection of high quality energy efficiency data for industry;
  - 6.2 Energy performance of electric motors;
  - 6.3 Assistance in developing energy management capability;
  - 6.4 Policy packages to promote energy efficiency in small and medium-sized enterprises.
7. *Energy utilities* can play an important role in promoting energy efficiency. Action is needed to promote:
  - 7.1 Utility end-use energy efficiency schemes.

## Source analysis

The following summarises outputs from IEA work on cross-sectoral energy efficiency policy.

### Publications

- [Mind the Gap - Quantifying Principal-Agent Problems in Energy Efficiency](#) (2007).
- Information paper [Financing Energy Efficient Homes: Existing Policy Responses to Financial Barriers](#) (2007).
- A position paper: [International Standards to Develop and Promote Energy Efficiency and Renewable Energy Sources](#) (IEA/ISO, 2007).
- [Promoting Energy Efficiency Investments: Case Studies in the Residential Sector](#) (2008).

The Secretariat has also undertaken a wide range of advisory and promotional tasks designed to help countries to understand and implement energy efficiency policies. They include the following.

- A workshop on [Scaling-up Energy Efficiency: Bridging the Action Gap](#) (Paris, April 2007).
- A workshop on [Meeting Energy Efficiency Goals: Enhancing Compliance, Monitoring and Evaluation](#) (Paris, February 2008).

## 2008 progress report

One of the IEA concrete policy recommendations for promoting energy efficiency pointed to the need to regularly monitor and report on progress with implementing the IEA recommended suite of policy measures. Consequently, in late 2007 and early 2008, the IEA Secretariat conducted a preliminary assessment of progress with implementation of its recommendations in all G8, G5 and IEA countries. This assessment provided the basis for developing a progress report, which identifies broad trends, developments and areas requiring further improvement, for presentation at the Hokkaido Summit.

Progress in implementing the IEA first set of recommendations presented in 2006 and 2007 varies across countries and between recommendations. A wide span of activity is evident, ranging from measures that substantially implement components of some recommendations, to drafted measures not yet in force, to announcements regarding future development of relevant measures, or to the absence in some cases of any relevant action at all.

No country has fully implemented all of the initial recommendations. Important work thus remains to be done in all G8, IEA and other large economies. Yet numerous examples of positive developments exist, which provide best practice examples of what can be cost-effectively achieved, and which serve to underline the worth of energy efficiency measures as a means of mitigating human-induced climate change, addressing energy security and encouraging sustainable development.

In the case of several of the IEA recommendations, many countries have established a range of pertinent measures. Yet, in most instances, these measures could be updated or further strengthened, and the scope of their application broadened. This applies notably to the recommendations on new and existing buildings, and to those on minimum energy performance and standby power requirements for appliances.

In several areas, such as fuel-efficiency standards for light-duty vehicles or low power modes for electronic equipment, certain countries have introduced voluntary measures. But few or

no instances have been noted of the mandatory requirements which the IEA considers would further help to realise the full potential of energy savings in these sub-sectors.

Across all of the IEA recommended areas of activity, there are instances where policy measures have been drafted or are being considered but have not yet become operational. If properly implemented, these measures could achieve significant savings in the future. This applies more particularly to the recommendations on fuel-efficient tyres, on tyre pressure monitoring systems and international test procedures, as well as on the phase-out of incandescent lamps and on the strengthening of building regulations. The IEA recommends that countries implement these measures as soon as possible.

Finally, enhanced enforcement and compliance procedures remain a universal issue, particularly in the buildings and appliances sub-sectors. The IEA considers such procedures to be a central aspect of successful policy development and implementation in all energy efficiency sub-sectors and encourages all countries to intensify efforts in these areas.

### International co-operative activities

A partnership has been developed with the International Standards Organisation and the International Electrotechnical Commission to identify gaps in existing energy efficiency and renewable energy standards portfolios and to target opportunities to fast-track development of new standards. The standards concerned address standardisation of test procedures, measurement and methodologies. Thus far, these efforts have already led to development of new international work-streams for industrial energy management and biofuels.

### Next steps

#### ***Implement, implement, implement the recommendations!***

The IEA Secretariat has presented a list of high-priority recommendations for improving energy efficiency. Pursuing implementation of these recommendations is a matter of urgency. The IEA continues to assist countries with implementing the recommendations wherever needed.

The IEA Secretariat encourages governments to increase their co-operation with the private sector, and to develop joint instruments to increase levels of investment in energy efficiency.

The IEA Secretariat proposes to continue to analyse energy efficiency policy portfolios and to identify action required to address emerging challenges.

## Efficient Energy Equipment: Appliances and Lighting

Very significant energy savings in electrical equipment are possible through the deployment of commonly available energy-efficient equipment. For example, global implementation of the IEA energy efficiency policy recommendations, which can be achieved without imposing any additional net costs, is estimated to reduce final energy consumption in the equipment and lighting sectors by around 21 EJ by 2030, equivalent to a reduction of around 2.2 Gt of CO<sub>2</sub>.

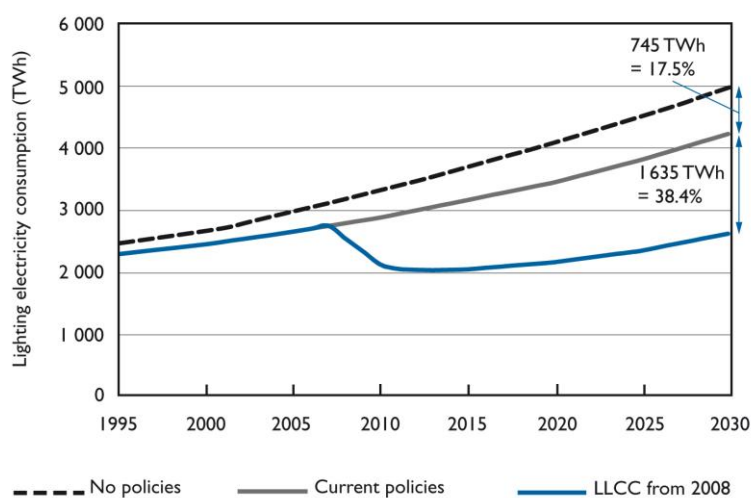
### Key conclusions

- A variety of market barriers prevent deployment of commonly available energy-efficient equipment from occurring spontaneously. Governments need to focus on implementing policies which increase deployment of the most efficient appliances and equipment.
- Far larger potential savings from increased energy efficiency could be realised through the adoption of more aggressive policies, including measures which assumed a positive price for CO<sub>2</sub> emissions.
- Implementation of stricter energy-performance standards and labelling programs represents one of the lowest-cost options for greenhouse gas mitigation. But the geographical and product coverage of such policies is far from comprehensive.
- Minimum energy performance standards and energy labelling have cut energy consumption for major appliances by up to 60% for some products over the past 10 years in many economies without leading to higher appliance prices.
- Many countries are wasting considerable resources by failing to ensure compliance with mandatory and voluntary energy efficiency programmes. Further investment in compliance regimes is needed to ensure that expected energy-saving targets are reached and to maintain the confidence of industry and consumers.

### Source analysis

- Major IEA publications on appliances and lighting have included:
  - [\*Light's Labour's Lost: Policies for Energy-Efficient Lighting\*](#) (2006), which showed that at least 38% of global lighting electricity consumption and almost one billion tonnes of CO<sub>2</sub> emissions can be saved cost-effectively by using lighting equipment that minimises the life-cycle cost of the lighting service through greater energy efficiency. This book has been a springboard for the global move towards phasing-out incandescent lamps.

**Figure 4**  
**Global Lighting Electricity Consumption, 1995-2030**  
**Three Scenarios: No Policies, Current Polices\* and Least Life-Cycle Cost**



\*Reference Scenario, IEA *World Energy Outlook 2004*

Source: *Light's Labour's Lost - Policies for Energy-Efficient Lighting*, IEA, 2006.

- Four information papers:
  - [Experience with Energy Efficiency Regulations for Electrical Equipment](#) (2007).
  - [Can Energy-Efficient Electrical Appliances be Considered 'Environmental Goods'?](#) (with OECD, 2006)
  - [Energy Efficiency of Air Conditioners in Developing Countries and the Role of CDM](#) (2007).
  - [Barriers to Technology Diffusion: The Case of Compact Fluorescent Lamps](#) (with OECD, 2006).
- Substantial sector-specific input within the broader IEA publications *World Energy Outlook*, *Energy Technology Perspectives* and *Energy Use in the New Millennium*.
- The Secretariat has also undertaken a wide range of advisory and promotional tasks designed to help countries to understand and implement the policy recommendations. These include:
  - Establishing a new IEA [Implementing Agreement for Efficient Electrical End-Use Equipment](#) (4E) to provide a mechanism for countries to share information and facilitate co-ordination of international approaches.
  - A workshop on [CFL Quality and Strategies to Phase-out Incandescent Lamps](#) (Paris, February 2007), at which major industrial lamp producers agreed to support the objective, thereby helping trigger the wave of international policy measures in this domain.
  - International Standby Power Conferences in [Australia in November 2006](#), and in [India in April 2008](#); and an international workshop on [Energy Efficient Set-Top Boxes & Digital Networks](#) in Paris in July 2007.
  - Work with international standardisation bodies such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) to

help ensure that the scope and technical adequacy of energy performance test methods are sufficient to meet policy aspirations.

- Delivering testimony to the United States Senate on international developments to phase-out incandescent lighting and similarly informing numerous national policy fora.
- Analysis and policy advice for the major developing countries, including outreach activities and a special report on progress with energy efficiency policy in China and India for the October 2007 IEA Standing Group on Global Energy Dialogue meeting.
- Presentation of the concrete recommendations to numerous conferences worldwide.

## Next steps

Despite the breadth of the work already completed, much more remains to be done if governments are to have at their disposal all the information needed to design and implement effective energy efficiency policies and programmes in this domain.

Future work already in the pipeline includes a new edition of the [Cool Appliances](#) book that will identify key areas of future action. The IEA is also embarking upon an analysis of the implications of international regulatory settings on global demand for higher-efficiency lamps (most importantly compact fluorescent lamps, CFLs).

Potential future areas of work include the following.

- Analysis of policy options for gas appliances and equipment used in commercial buildings.
- Policy options to encourage the deployment of energy-efficient motors and drives.
- Benchmarks for international equipment energy performance.
- Tracking policy impacts on equipment energy efficiency.
- The link with energy performance indicators.
- Design of truly reflective energy-using test procedures.
- Frameworks to strengthen compliance with equipment energy performance policies.

## Efficient and Low-Carbon Buildings

Enormous energy savings are possible in buildings. A large part of this potential is economically within the reach of building owners and users and it can be realised with already commercialised technologies. But many market barriers stand in the way of energy-saving improvements. The IEA estimates that savings of between 18 EJ and 53 EJ against a business-as-usual scenario could be achieved by 2030, and savings of as much as 90 EJ could be achieved by 2050 (*WEO 2006* and *ETP 2008*). Active policies are needed to overcome the many different market barriers.

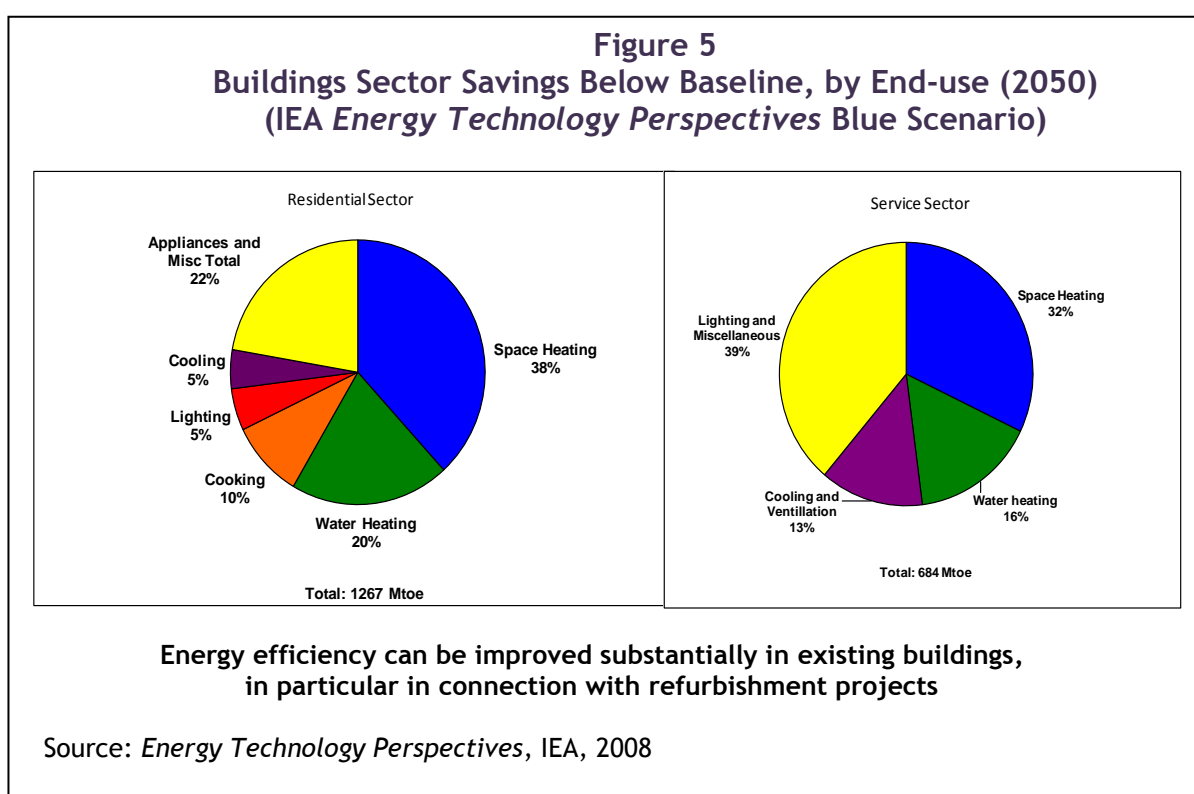
### Key conclusions

- Implementation of greater energy efficiency in buildings represents one of the lowest-cost options for greenhouse gas mitigation. A large part of this potential is possible without additional cost, or even at negative cost.
- Policies that foster wider deployment of energy efficiency in both new and existing buildings are essential.
- The most important measures include mandatory energy-efficiency requirements for new buildings and for the refurbishment of existing buildings.
- Policies are also needed to promote buildings with very low energy consumption (such as passive houses, Zero Energy Building and Zero-Carbon Buildings).
- Improved compliance with mandatory standards is essential for achieving the potential energy savings.
- If very large savings are to be achieved, policies need to ensure that accelerated refurbishment or replacement of the existing building stock occurs, due to low capital stock turnover.
- A policy which consists of a package of measures is the most effective for ensuring energy efficiency in existing buildings.
- Policies are needed to make energy consumption and saving opportunities more visible for users, owners and buyers of buildings. Mandatory certification is an important tool in this regard.
- Windows offer a large potential for savings, both by installation of new and replacement of existing buildings. Policies that promote energy efficiency in windows, including information, certification of windows and glazing, are needed.

### Source analysis

Development of "concrete recommendations" on energy efficiency policies are a central focus in follow-up to the Gleneagles Plan of Action. These recommendations differ according to whether they apply to new buildings or to existing buildings. The main recommendations for new buildings, along with a more general recommendation for existing buildings, were presented and endorsed at the G8 Summit in Heiligendamm. These recommendations have drawn on detailed analysis undertaken by the IEA Secretariat and supported by publications, workshops and policy dialogues with key stakeholders. More recommendations for existing buildings are being submitted for consideration at the Hokkaido Summit (see under "Energy Efficiency: Cross Sectoral" at the start of the present section "Transforming the Way We Use Energy").

- Major buildings-related publications include:
  - Information papers and working papers:
    - [Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings](#) (2008).
    - [High-Rise Refurbishment: The Energy-Efficient Upgrade of Multi-Story Residences in the European Union](#) (2006).
  - An ongoing study of the energy efficiency of North American building stock (publication expected in 2008).
  - In-depth analysis of the buildings sector is also contained in the *World Energy Outlook, Energy Technology Perspectives* and *Energy Use in the New Millennium*.



- The Secretariat has also undertaken a wide range of advisory and promotional tasks designed to help countries to understand and implement the policy recommendations. These include the following.
  - A workshop in Paris in November 2006 on [Energy Efficiency in Buildings, Meeting the Gleneagles Challenge](#). Based on the workshop's findings, recommendations for energy-efficient buildings were drawn up and adopted by the IEA Governing Board.
  - An India-IEA [Joint Workshop on Energy Efficiency in Buildings and Building Codes](#) in New Delhi, India in October 2006.
  - A workshop on Energy Efficient Buildings and Zero Energy Buildings in Beijing, China, organised in collaboration with the World Business Council for Sustainable Development (WBCSD) in March 2007.
  - Work on developing an international sustainable buildings network, designed to expand collaboration on energy efficiency and sustainability, for both new and

- existing buildings, and to help identify and share international best practice and experience.
- Analysis and policy advice for fast-growing developing countries, including outreach activities.

## Next steps

Future work already in the pipeline will include the following.

- A publication on energy efficiency in existing buildings and further analyses on best practice policies for energy efficiency in existing buildings (publication expected in 2009).
- A leading role for IEA in ongoing work on building a global network on sustainable buildings, as requested by the Heiligendamm Summit.
- Work with major emerging economies on implementation of their energy efficiency policies - focus on setting up case studies in collaboration with the G8 countries and other large energy-consuming nations, in particular with China (given the scale of new construction in China) and Russia (a case study of policies influencing energy efficiency of existing buildings). The potential in both of these countries is substantial. These projects need further funding before they can commence.
- Promoting research and deployment of technologies, which in combination with measures for energy-efficient buildings, can yet further broaden opportunities in buildings and increase the impact of existing measures. The IEA wishes to expand ongoing work relating to research and deployment in this field.

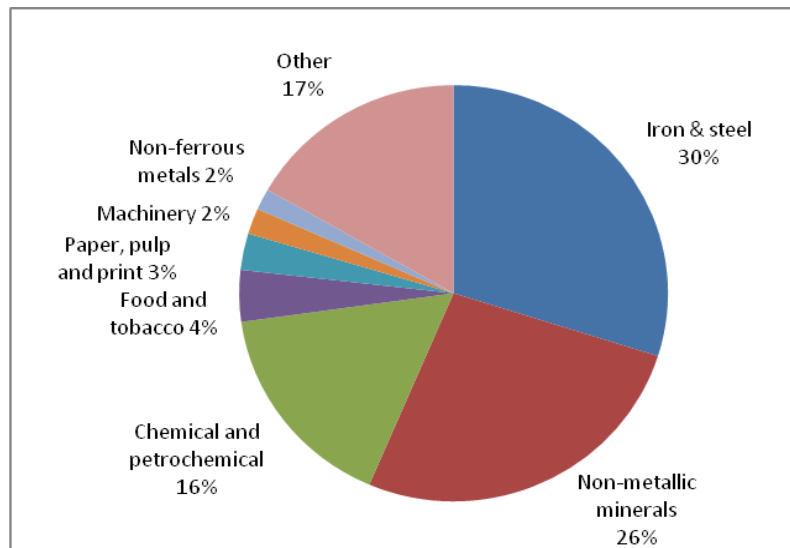
## Efficient and Low-Carbon Industries

If heavy industry applied best available technology everywhere today, energy efficiency would improve by between 18% and 26%. CO<sub>2</sub> emissions would decline by between 1.9 Gt and 3.2 Gt per year. The largest savings potentials can be found in the iron/steel, cement and chemicals/petrochemicals sectors.

### Key conclusions

- Potential for emissions reduction differs among industrial sectors and among world regions. But it is highest, in relative terms, in sectors where energy costs are a relatively small component of total costs. While heavy industry consumes 70% of industrial energy, and light industry 30%, the absolute magnitude of energy savings potential is probably similar.
- Some of the potential for energy efficiency and CO<sub>2</sub> emissions reduction will be realised independently of additional policies. But this will not compensate for growth in production volumes. Assuming unchanged levels of output, with a CO<sub>2</sub> price of USD 50/t and no additional measures, global industrial CO<sub>2</sub> emissions are expected to increase by 42% in 2050 compared to 2005 levels. A CO<sub>2</sub> price of USD 200/t, however, would reduce emissions to 26% below 2005 levels.
- The implementation of CO<sub>2</sub>-reduction measures for the commodity-producing energy-intensive sectors will most likely require an international approach, while those for energy-extensive industries could be dealt with through national approaches.
- An international sectoral approach is needed, notably aimed at limiting carbon "leakage" through geographical re-location.
- Since China accounts for close to half of industrial production in most energy-intensive industry sectors, Chinese participation is crucial for a successful international strategy.
- A number of key technologies and practices need further development. Energy efficiency, CCS and biomass feedstocks deserve special attention. International technology co-operation and government/industry partnerships will be needed to finance and establish the necessary processes and related demonstration projects.
- Better data on industrial energy efficiency and CO<sub>2</sub> indicators, as well as agreed methodologies, are needed.
- Energy management capability needs to be strengthened through development and maintenance of energy management tools, training, certification and quality assurance. Small- and medium-sized enterprises in particular are likely to need encouragement and assistance if their energy savings potential is to be realised.
- Very large cost-effective opportunities for energy savings reside in the domain of industrial electric motors and motor-driven systems. But stronger and better targeted policies will be needed to exploit these opportunities.

**Figure 6**  
**Industrial Direct CO<sub>2</sub> Emissions by Sector, 2005**



**Three sectors account for 70% of industrial CO<sub>2</sub> emissions: iron & steel, non-metallic minerals, chemicals and petrochemicals**

Note: includes coke ovens, blast furnaces and process CO<sub>2</sub> emissions. Excludes emissions in power supply, assumes 75% carbon storage for all petrochemical feedstocks.

Source: IEA statistics.

## Source analysis

### Publications

- [Tracking Industrial Energy Efficiency and CO<sub>2</sub> Emissions](#) (2007).
- [Energy Technology Perspectives 2006](#), Chapter 7: Industry.
- Information paper [Sectoral Approaches to Greenhouse Gas Mitigation - Exploring Issues for Heavy Industry](#), 2007.
- [Energy Technology Perspectives 2008](#), Chapter 16: Industry.
- Information paper [Assessing Measures of Energy Efficiency Performance and their Application in Industry](#) (2008).
- Information paper *Best Practices of Policies and Measures for Energy Efficiency in Industry Sector* (2008), in preparation.
- Information paper *Energy Efficiency in Electric Motors and Drives* (2008), in preparation.

### Workshops

- Workshop on [Industrial Electric Motor Systems](#), Paris, May 2006.
- IEA/WBCSD Workshop on [Energy Efficiency and CO<sub>2</sub> Emission Reduction Potentials and Policies in the Cement Industry](#), Paris, September 2006.
- IEA/WBCSD Workshop on [Energy Efficient Technologies and CO<sub>2</sub> Reduction Potentials in the Pulp and Paper Industry](#), Paris, October 2006.
- UN-FAO/IEA [International Seminar on Energy and the Forest Products Industry](#), Rome, October 2006.
- OECD/IEA/IISI Workshop on [Sectoral Approaches in Steel](#), Paris, November 2006.
- CEFIC/IEA Workshop on [Feedstock Substitutes, Energy Efficient Technology and CO<sub>2</sub> Reduction for Petrochemical Products](#), Paris, December 2006.

- IFA/IEA International Workshop on [Energy Efficiency and CO<sub>2</sub> Reduction Prospects in Ammonia Production](#), Ho-Chi Minh City, Vietnam, March 2007.
- IAI/IEA Workshop on [Energy Efficiency and GHG Emission Reduction in the Aluminium Industry](#), Paris, May 2007.
- IEA/WBCSD Workshop on [Tracking Industrial Energy Efficiency and CO<sub>2</sub> Emissions: The Way Forward](#), Paris, October 2007.
- [Industry Scenarios and Indicators: Expert Review Workshop](#), IEA, Paris, February 2008.
- Workshop on [International Comparison of Industrial Energy Efficiency](#), Beijing, March 2008.
- Workshop on [Sectoral Approaches to International Climate Policy](#), Paris, May 2008.

## Next steps

The next IEA steps will focus on the following.

- A publication on industrial energy use and CO<sub>2</sub> emissions, elaborating on *Energy Technology Perspectives 2008* scenarios and their impact on evolving commodity markets.
- Refining existing industry efficiency and CO<sub>2</sub> intensity analysis, including its policy dimensions.
- Extending and deepening the analysis on barriers to the implementation of effective energy efficiency measures in the industry sector, and on the extent to which these can be accessed through policy measures.
- Together with industry, developing a refined efficiency and indicators dataset providing for country-level comparisons. Mechanisms and interfaces need to be put in place where industrial datasets and IEA datasets are merged and made into consistent indicators.
- Developing a better dataset with wider international coverage. Special focus is needed on Brazil, China, India, Mexico, Russia, South Africa and Ukraine.
- Analysing in greater detail the energy efficiency and CO<sub>2</sub> reduction potential in small and medium-sized enterprises.
- Assessing bottlenecks for application of new technology.
- Further developing technology roadmaps and an international technology co-operation programme, together with industry and governments; assessing the importance of risks (political, technological, financial) for RD&D and demonstration projects.
- Developing a database of best available technology that can serve as a basis for industrial efficiency standards to limit both energy use and CO<sub>2</sub> emissions.
- Establishing demonstration projects for CO<sub>2</sub> capture and storage, notably in iron, cement and ammonia production and in black liquor gasification.
- Assessing the importance of intellectual property rights for the diffusion of new, more efficient technology in developing countries.
- Developing a full end-use assessment of industrial electric motor-driven systems.
- Convening workshops to explore sectoral approaches for heavy industry, covering:
  - Climate policy and competitiveness.
  - Effective incentives for greenhouse gas mitigation.
  - Possible international institutional requirements.

## Efficient and Low-Carbon Transport

Fundamental change is needed for all transport modes - and in all regions - if very low greenhouse gas (GHG) scenarios are to become a reality. IEA analysis shows that relatively cost-effective fuel efficiency improvements of up to 50% are possible for light-duty vehicles by 2030. The potential contributions from improved transport systems planning are also significant. Research, development, demonstration and deployment on alternative fuels such as second-generation biofuels and on advanced vehicle technologies such as fuel cell and electric vehicles must be redoubled if these are to play a major (and sustainable) role by 2030 and beyond.

### Key conclusions

#### *Developing indicators*

Available transport indicators (mainly for IEA countries) show that rates of improvement in efficiency for most kinds of transport have slowed in recent years. Much stronger efforts are needed. Data for travel, vehicle sales, stocks and efficiency, and energy use in developing countries are still very poor. Support is needed to improve data, to better understand trends, and so assist developing nations with policy development. IEA Mobility Modeling (MoMo) project is spearheading efforts to obtain better data but more resources are needed to help speed this effort.

#### *Mandatory fuel-efficiency standards for cars and trucks*

In all countries, appropriate mandatory fuel-efficiency standards are needed for light-duty cars and small trucks if significant transport-sector energy savings are to be achieved. Governments should:

- Introduce new mandatory fuel-efficiency standards for light-duty vehicles if they do not already exist, or where they do exist, make those standards more stringent.
- Announce the more stringent content of the proposed standards as soon as possible.
- Harmonise, where appropriate, as many aspects of the future standards as possible.

In addition, the IEA recommends the creation of a multi-stakeholder global fuel economy initiative that would promote efficiency, identify potential medium- and long-term targets, and provide support for governments in developing and adopting fuel economy policies.

Heavy-duty vehicles account for 30% of worldwide transport fuel use. While the industry has already improved heavy-duty vehicle efficiency significantly, large potential remains for further improvements. For heavy-duty vehicles, governments should introduce:

- Fuel-efficiency standards.
- Related policies including labelling and financial incentives based on the vehicle's fuel efficiency.

Assistance with improving freight logistical systems and multi-modal transfer facilities that can, if well designed, reduce overall truck travel should also be considered.

#### *Fuel-efficient non-engine vehicle components*

There is a strong need for measures that promote efficient vehicle accessories such as headlights, internal lighting, air conditioning systems and tyres, which are generally not well covered by current regulatory systems. The IEA has held workshops and conducted analysis on a number of such technologies. IEA findings notably conclude that fuel-efficient tyres and

adequate tyre maintenance can reduce vehicle fuel consumption by as much as 5% and that international best practice regarding fuel-efficient tyres involves two components.

- Maximum allowable levels of rolling resistance for major categories of tyre.
- Measures to promote adequate levels of tyre inflation.

Therefore, governments should:

- a) adopt new international test procedures for measuring the rolling resistance of tyres, with a view to establishing labelling, and possibly maximum rolling resistance limits where appropriate, for road-vehicle tyres; and
- b) adopt measures to promote proper inflation levels of tyres; this should include governments, acting in co-operation with international organisations, including the United Nations Economic Commission for Europe (UNECE), making the fitting of tyre-pressure monitoring systems on new road vehicles mandatory.

### ***Eco-driving***

Smart, safe driving techniques can lead to significant fuel savings. In several countries, eco-driving has become an integral part of transport-sector emissions-reduction strategies. In many other countries, however, eco-driving remains on the margins of transport policy development. Therefore, governments should ensure that eco-driving is a central component of government initiatives to improve energy efficiency and reduce CO<sub>2</sub> emissions. Government support for eco-driving should include promotion of driver training and deployment of in-car feedback instruments

### ***Role for new vehicle technologies and fuels***

In order to achieve very low CO<sub>2</sub> in transport, it will be necessary to shift from petroleum fuels to either hydrogen, electricity or advanced biofuels, or to a combination of these fuels. But more research/demonstration/deployment are needed to commercialise these fuels and produce them in a near-zero CO<sub>2</sub>, sustainable manner. Research is also at a critical stage for electric and fuel-cell vehicles and funding should be increased substantially over the next 5-10 years to increase the probabilities of successful development.

### ***Air and maritime travel***

Current international agreements such as the Kyoto Protocol fail to cover international air travel and maritime shipping. The IEA is well positioned to provide analytical support and assistance for a process that assesses international aspects of air and/or maritime transport.

## **Source analysis**

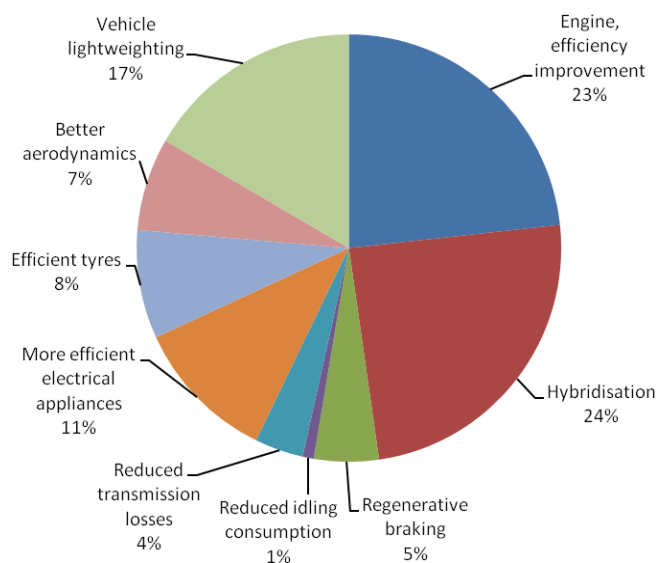
IEA modelling, analysis and expert workshops have led to a set of energy-efficiency policy recommendations relating to the transport sector (see “Energy Efficiency: Cross Sectoral” pages above). These address the need for mandatory fuel-efficiency standards, for energy-efficiency policies covering non-engine components of vehicles, and for eco-driving.

The following have fed into IEA analysis in this field.

- A global/regional technology-rich transport-sector mobility model (MoMo) and indicators of transport and energy use, developed by the IEA in an on-going partnership with the automobile and energy industries. Figure 7 shows a typical output, indicating the share of contributions from various technologies in achieving a 50% improvement in energy efficiency (reduction in energy per kilometre) by 2030.

- Information papers:
  - [Fuel-Efficient Road Vehicle Non-Engine Components - Potential Savings and Policy Recommendations](#) (2007).
  - [Review of International Policies for Vehicle Fuel Efficiency](#)
  - An upcoming book will provide the following.
    - Information on fuel use, fuel-efficiency policies and regulations.
    - Transport-sector global energy outlook with scenarios to 2050.
- Workshops, within a wide range of advisory and promotional tasks designed to help countries to understand and implement the policy recommendations.
  - Three workshops on vehicle components:
    - [Energy Efficient Tyres: Improving the On-Road Performance of Motor Vehicles](#), Paris, November 2005.
    - [Energy Efficiency Through Better Car Components](#), Paris, June 2006.
    - [Cooling Cars with Less Fuel](#), Paris, October 2006.
  - An international workshop on [Fuel Efficiency Policies for Heavy-Duty Vehicles](#), Paris, June 2007.
  - [Workshop on Eco-driving](#), Paris, November 2007.
  - A [Mobility Modelling Workshop](#) with six participating companies, to present results of the Mobility Modelling project, Paris, 2006
  - A workshop in Paris in 2008 on improving transport/energy data and indicators.

**Figure 7**  
**Ways of Improving Fuel Efficiency in Light-Duty Vehicles**  
 (% shares of different solutions in the total 50% savings estimated for 2030 on a full hybrid relative to a gasoline vehicle of 2005)



Source: Analysis in IEA *Energy Technology Perspectives 2008*

## Next steps

The IEA will focus on the following.

- Continuation of the IEA Mobility Modelling project.
  - Development of stronger characterisations of the trucking, aircraft and international shipping sectors.
  - Better representation of emerging economies for all transport modes.
  - Better representation of economic linkages between GDP, fuel and vehicle prices, travel and energy use.
  - Better representation of transportation system and planning-related improvements.
  - Better understanding of the technology and cost benefits for new fuels and vehicles from stronger research, development, demonstration and deployment efforts in IEA countries.
- Further work on transport indicator data development and analysis, focusing on assistance with data development for key fast-developing economies, particularly BRICS countries (Brazil, Russia, India and China) to bring the quality and availability of these countries' data up to levels for IEA countries.
- Continued promotion of wider deployment of fuel-efficient tyres and related devices, in co-operation with relevant international organisations including UNECE/WP29. Work should continue on collecting data necessary for further work on tyre-related energy efficiency issues.
- To foster international co-ordination on fuel efficiency standards, activities should be pursued on outreach and promotion, including:
  - Further collection and dissemination of information on the latest fuel-efficiency policies.
  - Further analysis on effective fuel-efficiency standards.
  - Organisation, with India, of a joint workshop on fuel-efficiency standards in 2008.
- Continued promotion of collaboration in the area of eco-driving with a range of stakeholders, including private-sector and non-governmental organisations. Wider deployment of eco-driving instruments should be sought, in co-operation with relevant international organisations including UNECE/WP29.
- Pursuing a new global fuel economy initiative, in co-operation with several partners: the International Automobile Federation (FIA) Foundation, the OECD International Transport Forum, and the United Nations Environment Programme (UNEP), and involving governments and stakeholders from around the world. It will focus on:
  - Developing a global sectoral strategy for fuel economy improvement and CO<sub>2</sub> reduction for new cars and trucks.
  - Identifying technologies and policies for improving fuel economy and cutting GHG emissions in road transport in OECD and non-OECD countries.
  - Assisting governments in developing programmes, testing and labelling fuel economy of vehicles and aligning policies where applicable.

The effort started with a May 2008 [kick-off workshop in Paris](#), at which an initial action plan was developed for a period of at least 2-3 years.

- New research in the area of biofuels, to better understand sustainability criteria and the global potential for second-generation biofuels to contribute to GHG reductions and energy security in the future.

- Providing analytical support and assistance for efforts in the field of energy-security, GHG reduction and environmental aspects of air transport in partnership with governments, aircraft manufacturers, airlines, air traffic control bodies and organisations like the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO).
- Likewise, supporting similar processes with the international shipping industry, including major shipping companies, ship builders and agencies like the International Maritime Organisation (IMO).

## Energy Indicators

Energy indicators are an important tool for analysing interactions between economic/human activity, energy use and CO<sub>2</sub> emissions. They are particularly relevant for analysing energy efficiency trends and potentials. Many IEA member countries already use energy indicators. These sets of disaggregated measures of how energy is used are moreover attracting increasing interest from other countries. The IEA role is to assist and internationalise these efforts by developing transparent and consistent international databases and methodologies and by collaborating with other international organisations.

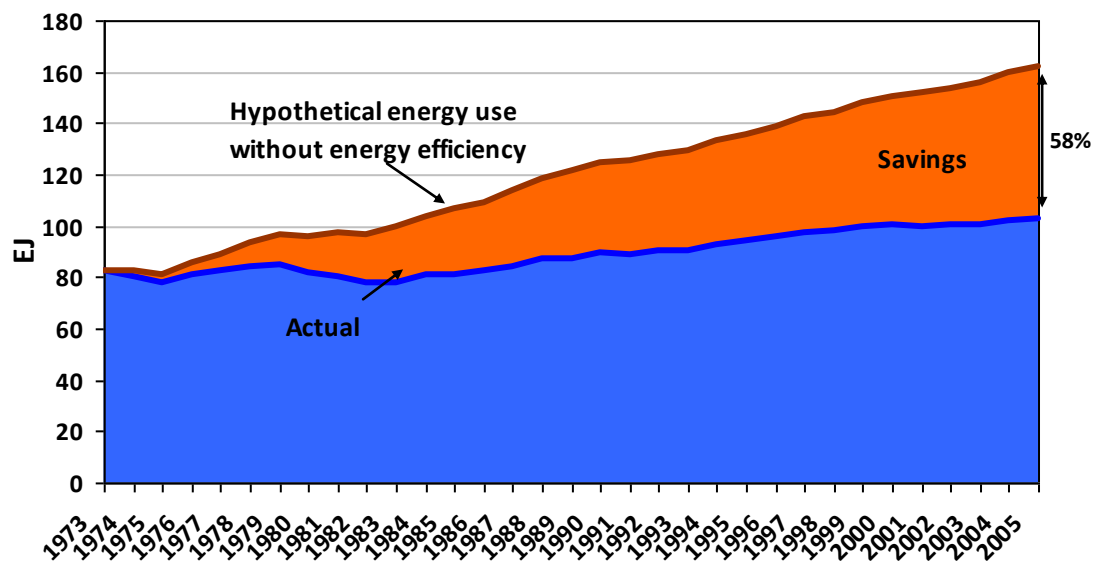
### Key conclusions

- Improvements in energy efficiency over the past three decades have played a key role in limiting global increases in energy use and CO<sub>2</sub> emissions. Analysis for IEA countries shows that, since 1990, improved energy efficiency has led to annual energy savings of more than 16 EJ, which is equivalent to 1.3 Gt of avoided CO<sub>2</sub> emissions and represents an estimated USD 180 billion of energy cost savings. However, the rate at which energy efficiency has improved since 1990 has been much slower than in the previous two decades.
- Significant potential remains for further improvements in energy efficiency across all sectors. Analysis for industry shows that the application of commercial best practice technologies on a global basis could save between 25 EJ and 37 EJ per year (1.9 - 3.2 Gt of CO<sub>2</sub> emissions per year). In public power generation, if all countries produced electricity at current best practice levels then the fuel savings would be around 21 EJ to 29 EJ per year (with CO<sub>2</sub> savings of about 1.8 - 2.5 Gt).
- Accelerating energy efficiency improvements is a crucial challenge for climate policies. Governments must act now to develop and implement the necessary mix of market and regulatory policies, including stringent norms and standards. This should be complemented by efforts to drive down the CO<sub>2</sub> intensity of electricity production by moving towards a cleaner technology mix. The IEA has presented a list of high-priority energy efficiency policy recommendations to help governments increase rates of energy efficiency improvement.
- Detailed, timely and accurate information is vital to monitor current trends in energy efficiency and to target and develop the new policies that will be needed. While there have been some improvements, the poor availability and quality of energy data in many countries and sectors still create an obstacle to developing meaningful indicators. Governments should therefore substantially boost their data-collecting efforts across all sectors to optimise energy-efficiency policy making.

### Source analysis

The IEA has worked to develop in-depth indicators providing “state-of-the-art” data and analysis on energy use, efficiency developments and policy pointers. This effort covers industry, buildings, transport and power generation. Key partners in these activities have included the World Business Council for Sustainable Development, individual industry associations and the Asia-Pacific Partnership on Clean Energy and Climate (on indicators for industry), together with the World Bank (on indicators for key developing countries). Major output includes the following.

**Figure 8**  
**Long-Term Savings from Improvements in Energy Efficiency**  
**(all sectors)**



**If energy-efficiency had not improved in IEA countries over the past 30 years, their total final energy consumption today would be 58% higher.**

Source: *Worldwide Trends in Energy Use and Efficiency*, IEA, 2008.

## Publications

- [Tracking Industrial Energy Efficiency and CO<sub>2</sub> Emissions](#) (2007).
- [Energy Use in the New Millennium: Trends in IEA Countries](#) (2007).
- [Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels](#) - compares energy efficiency of fossil-fired electricity production in major developed and industrialising countries and identifies the technical potential energy and CO<sub>2</sub> savings.
- [Worldwide Trends in Energy Use and Efficiency](#) (2008) - a brochure prepared for the G8 meetings in Japan summarising the IEA indicators work under the Gleneagles Plan of Action, including indicators for all key sectors for both developed and major developing countries.

Workshops (for details, see <http://www.iea.org/G8/industry.asp>).

- Eleven sector-specific workshops examining data availability and indicators development, for sectors including cement, ammonia, petrochemicals, iron and steel, aluminium, pulp and paper, motors, buildings, appliances and transport.
- Four outreach workshops to discuss the development and use of indicators with [China](#), South Africa, Mexico and the [APEC economies](#).

## Databases

- Database of detailed end-use information about the patterns of energy consumption in the manufacturing, household, service and transport sectors of 20 IEA countries for the period 1990 to 2004/5. (For more information: <mailto:energyindicators@iea.org>)

## Next steps

The IEA will encourage countries committed to improving energy efficiency to be active in developing more effective tools, such as energy indicators, to support energy efficiency policy-making and evaluation. Key next steps to achieve these goals are as follows.

- *Improved data reporting.* Achieve this through an agreed system of reporting for major developed and developing countries, working with both governments and industry. The current IEA indicator templates could constitute a starting point to define a joint questionnaire on energy efficiency, similar to the existing five IEA energy statistics questionnaires.
- *Indicators for IEA countries.* Improve the coverage of the existing database, including filling key gaps, notably through the following.
  - Further work on physical indicators for industry.
  - Disaggregation of energy-use data in the service sector
  - More detailed information on appliances.
  - Continued work on resolving inconsistencies between countries regarding data definitions and boundaries.
- *Outreach activities with non-member countries.* Build on the initial work in the fast-expanding large non-IEA economies to support indicator development in these and other key countries, including notably the APEC economies.
- *New indicators.* Mainstream new indicators into the IEA database and so gain more comprehensive data coverage for all IEA countries. Enhance the link between indicators and the assessment of key policies.
- *Implementation.* Encourage countries to use the indicators framework to support the implementation of the IEA energy efficiency policy recommendations.

## POWERING A CLEANER FUTURE

### Cleaner Fossil Fuels

Coal-fired power plants account for a quarter of global CO<sub>2</sub> emissions. An absolute priority is to enhance plant efficiency, which can significantly reduce CO<sub>2</sub> emissions and the volume of coal consumed. Available technology can deliver efficiency improvements of 50%.

#### Key conclusions

World wide, coal-fired power plant efficiency averages around 28%<sup>1</sup>. Implementation of the suggested measures from IEA work carried out in support of the G8 Gleneagles Plan of Action could result in replacement of some 300 GW, and retrofit of some 200 GW older coal-fired power plant capacity, also in ensuring that all new plant is state-of-the-art. This could, if fully implemented, lead to a reduction of up to 1.7 Gt per annum of CO<sub>2</sub> emissions - which is roughly one-quarter of global annual CO<sub>2</sub> emissions from coal-fired power and heat production alone - and a reduction in coal consumption of at least 0.5 Gt per annum.

To improve the operating efficiency of the global fleet of coal-fired power plants - and thereby significantly reduce CO<sub>2</sub> emissions - it is recommended that governments focus on the following policy approaches.

- Ensure that all newly built coal-fired units are state-of-the-art supercritical<sup>2</sup> or ultra-supercritical units with efficiency of no less than 40%, depending on coal quality, site conditions and grid capacity. Consideration should also be given to Integrated Gasification Combined Cycle (IGCC) plants as these become more commercially available. Developers should consider what might be required for retrofit with CCS, avoiding steps that might make this unnecessarily difficult.
- Ensure that all coal-fired units of below 300 MW capacity using sub-critical technology and aged 25 years be gradually replaced by larger units, preferably using supercritical or ultra-supercritical technology. When applying these criteria, the performance records of the units and the country-specific power supply/demand situation should be taken into account. In choosing technologies, both pulverised-fuel (*pf*) fired and circulating fluidised bed (CFB) units should be considered, depending on coal quality, site conditions and grid capacity. Consideration should also be given to IGCC plants as these become more commercially available. Governments should consider urgent action to ensure substantial progress by 2015, and complete replacement by 2020.
- Consider assessing for upgrading or replacement - preferably to 40%-efficiency - all sub-critical units even less than 25 years old which have efficiencies of under 30%, subject to appropriate country-specific techno-economic assessment, including CCS readiness.
- Foster international co-operation to diffuse advanced technologies in developing countries to replace or upgrade older units, as recommended in the two preceding paragraphs. This co-operation should also be extended to the adoption of best practice in power plant operation and should involve international financial institutions.
- Together with utility owners in national jurisdictions, address the financial gaps and incentives needed for the replacement or upgrading of older units, as identified above. Full use should be made of existing methodologies for high-efficiency coal-fired plants

<sup>1</sup> Net, Higher Heating Value, 2004 data.

<sup>2</sup> Sub-critical, supercritical and ultra-supercritical are engineering terms relating to boiler temperature and pressure conditions.

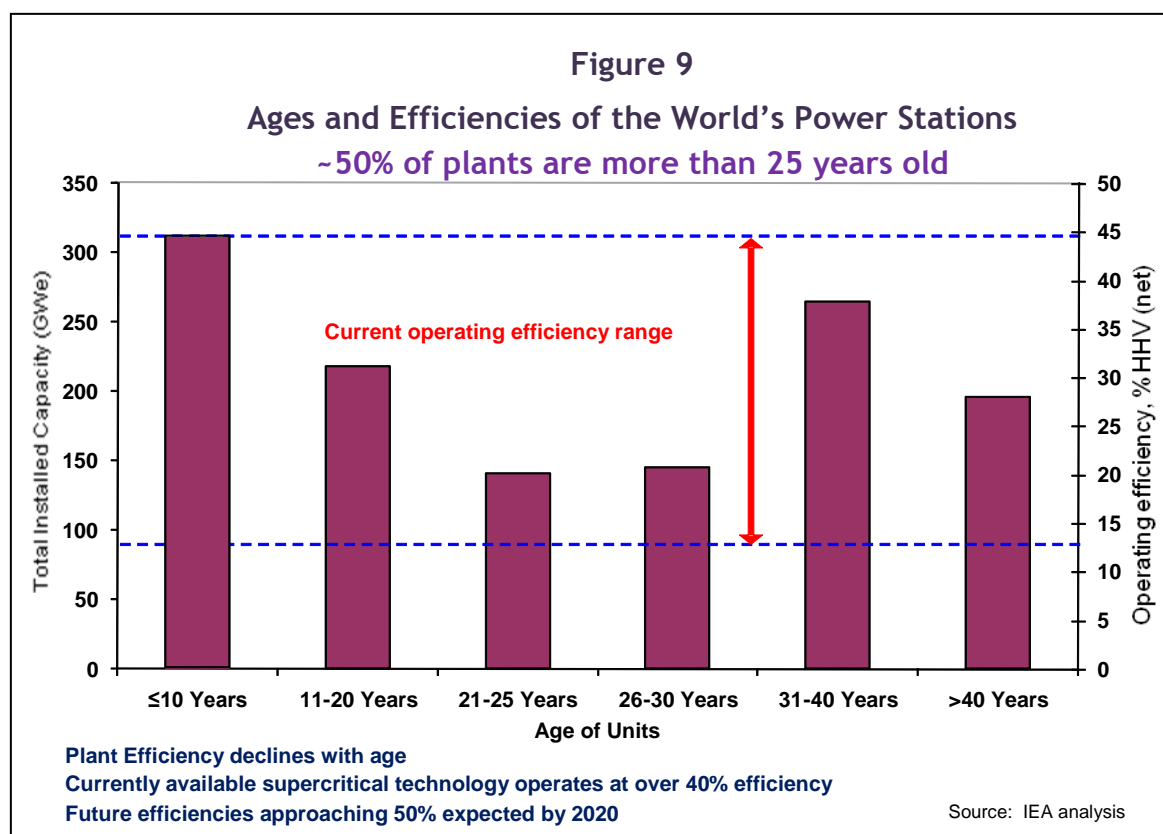
under the Clean Development Mechanism (CDM) and support should be given to the development of new CDM methodologies for the retrofit of existing plants and for CCS.

- Encourage regular scheduled maintenance and coal quality control in all fossil fuel-fired plants within their jurisdiction and foster international co-operation for doing likewise in other countries.
- Consider establishing a dedicated funding mechanism to facilitate pre-financing of expenditure for capacity building and introduction of best practices, based on plant performance improvement programmes, including benchmarking and operation and maintenance practices. These programmes could be implemented by IEA in collaboration with the private sector and financial institutions. The pre-financed expenditure could be repaid by the benefiting utilities from the savings made as a result of performance improvements.
- Together with the private sector, address how to accelerate development and demonstration efforts targeting higher efficiency, notably through programmes such as the European Union's COMTES700, the United States Department of Energy/Electric Power Research Institute advanced materials programme, and programmes on efficient lignite drying technologies and advanced CFB development. From a CCS perspective, such efforts should also be directed towards accelerating development and demonstration of oxy-fuel, pre- and post-combustion technologies.
- Promote international co-operation with developing countries on high-quality systems for gathering statistics on emissions and efficiency. Such systems should allow for improved access to data for quality-control efforts, for studying emissions trends and for determining compliance.
- Foster international co-operation with developing countries to promote renovation of electricity grids with advanced technologies and high-voltage transmission lines to minimise transmission and distribution losses. This effort should involve international financial institutions.
- Advance co-operation between governments and utilities in countries with large reserves of high-ash or high-moisture coals to improve the quality of coal power station fuel through improved coal beneficiation technology. Where feasible, governments should also promote cogeneration when new units are planned.
- Encourage innovation amongst plant personnel in site-specific operational matters and promote international efforts to enhance power plant education by training operators, equipment manufacturers and plant administrators in developing countries where needed.

### Source analysis

- Updated IEA Clean Coal Centre (IEACCC) global database with in-depth information on several thousand power units.
- Reports, in preparation, comprising: an assessment of the potential for upgrading and replacing coal-fired plant in the major coal-using economies; a methodology to reconcile differences in regional efficiency reporting standards; and an overview of potential for technology development.
- [\*Fossil Fuel-Fired Power Generation - Case Studies of Recently Constructed Coal - and Gas-Fired Power Plants\*](#), published by IEA in 2007.

- Workshop at which progressive results have been disseminated: [International G8 Expert Workshop on Clean Coal Technologies](#), Leipzig, March 2007.
  - IEA Clean Coal Centre Third International Conference on Clean Coal Technologies for our Future, [CCT2007](#), Sardinia, May 2007.
  - IEA Working Party for Fossil Fuels meetings in Brasilia in July 2007 and in Paris in December 2007.
  - Workshop [What's needed to facilitate upgrading or replacement of older coal-fired plants](#), Paris, January 2008.



### Next steps

- Should the governments require, the IEA is willing to work jointly with the leading power sector companies and organisations to monitor the operating efficiency and reliability of the existing fleet, newly built and refurbished coal-fired units. The IEA will collate and analyse inputs from participating organisations and disseminate the results. These results, among others, will demonstrate the value of plant performance improvement in economic and environmental terms that can be achieved almost immediately, and assess the effectiveness of the refurbishment activities. The work will also involve monitoring development of technology and equipment aiming at efficiency improvement and policy prescription on an ongoing basis to accelerate such developments.
- Audit of at least two older coal-fired power station units in at least two major emerging coal-using economies to identify opportunities for improvements, such as fuel beneficiation, plant refurbishment and adoption of best practice in plant operation. It is envisaged that for this activity collaboration has to be forged with external organisations (e.g. the World Bank, Asia-Pacific Partnership, German Agency for Technical Co-

operation [GTZ]), who are engaged in similar activity on various scales in China and India. IEA undertook similar work in 2004 in China, and now has the added advantage of having significant analytical ability and up-to-date information on coal-fired plants resulting from the work under the G8 Gleneagles Plan of Action. The analysis provides the basis for concrete refurbishment activities and for highlighting the potential of applying cutting-edge technology.

- Further continuous updating of the IEACCC database with most recently commissioned plants and plants for which construction authorisation has been awarded. This update will include all fossil-fuel fired plants, where possible, including CHP plants.
- A continuation of IEA work on case studies of recently constructed coal and gas-fired plant. This is necessary to demonstrate the improved performance of the large number of supercritical and ultra-supercritical plants that have been commissioned since 2004, and it will serve as an updated benchmark for best practice in plant operation and plant performance.
- Four international workshops - at least one in each of two emerging economies and a final one at the IEA Secretariat. Input will be provided at 3-6 key international events.
- Analytical work at the Secretariat to formulate policy prescription for the following.
  - Stimulating investments in efficient power plants.
  - Assessment of the full fuel chain - from upstream mining, fuel beneficiation (ash reduction, drying included in case of high-moisture coal) to downstream ash utilisation - to identify the efficiency improvements that can be made in the entire chain of fuel use.
  - Better operational practice to reduce fuel use.
  - Promoting capacity building in major developing countries.
  - Promoting international co-operation to form technology partnerships and foster private investment in clean technologies.

## Carbon Capture and Storage (CCS)

CCS in the power and industrial sectors can achieve substantial reductions in CO<sub>2</sub> in a world faced with increased demand for fossil fuels.

### Key conclusions

The 450ppm CO<sub>2</sub> stabilisation case of the IEA 2007 *World Energy Outlook* estimates that after 2015 all new fossil-fuel generation would need to be with CCS. This corresponds to some 310 GW of production capacity or some 620 normal-size power plants respectively. This would result in some 1.8 Gt of annual CO<sub>2</sub> savings by 2030.

Deployment of CCS requires the following actions.

#### *Demonstrating CO<sub>2</sub> capture and storage and bridging the financial gap*

The G8 must act now to commit by 2010 to at least 20 fully integrated industrial-scale demonstration projects for the broad deployment of CCS by 2020. Together with the private sector, governments should address the financial gap and risks facing early CCS projects, recognising that market mechanisms alone will not be sufficient for the early deployment of CCS.

#### *Taking concerted international action*

G8 governments, international financial institutions and the private sector should foster international action to partner, financially support, build capacity and share information for large-scale integrated CCS demonstration projects and near-term opportunities to accelerate wider deployment of CCS in developed and developing countries. An early priority should be to include CCS in the CDM in December 2008.

#### *Creating a value for CO<sub>2</sub> for commercialisation of CCS*

Governments should provide long-term policy certainty. This could be achieved through such measures as the introduction of appropriate regional/national instruments to create a value for CO<sub>2</sub>, through emissions trading, tax treatment or other mechanisms by 2010, along with incentives for research, development and demonstration.

#### *Establishing legal and regulatory frameworks*

By 2010, it is essential that governments in countries with major CCS potential, working with relevant international bodies, have established the appropriate legal and regulatory frameworks that are needed for safe, large-scale geological storage of CO<sub>2</sub>. For early projects, solutions for storing CO<sub>2</sub> should be developed, drawing on the various experiences where CO<sub>2</sub> was used for enhanced oil recovery or experiences from scientific programmes.

#### *Communicating with the public*

Public outreach is critical to CCS deployment. Thus, communication and understanding should be fostered. Stakeholders, including governments, must dedicate resources to disseminate information.

#### *Infrastructure*

Perspectives for the availability of a CO<sub>2</sub> transportation infrastructure are key to develop markets for CCS in power production and industrial applications. Plans need to be in place before pilot plants with CCS become operational. Trans-boundary effects need to be taken into account.

### *Retrofit with CO<sub>2</sub> capture*

The IEA believes that any developer of a new fossil fuel power station should have regard to what might be required for retrofit with CCS and should avoid steps that might make this unnecessarily difficult. Some developers have already adopted such a product policy. The IEA Greenhouse R&D Programme has provided a technical study for guidance on capture and storage readiness.

### Source analysis

- Workshops
  - Three workshops, organised with the Carbon Sequestration Leadership Forum (CSLF), on early CO<sub>2</sub> capture and storage opportunities.
    - [Issues Identification Workshop](#), San Francisco, August 2006.
    - [Global Assessment Workshop](#), Oslo, June 2007.
    - [Recommendations Workshop](#), Calgary, November 2007.
- Publications
  - Summary Reports on the IEA/CSLF workshops were produced (see [IEA website](#)). The policy recommendations draw mainly on the outcomes of these workshops, but also on other events.
  - Follow-up publication on early CO<sub>2</sub> capture and storage opportunities - *CO<sub>2</sub> Capture & Storage: A Key Carbon Abatement Option*, (2008, in preparation).
  - Engineering and cost study on capture-ready plant - published in May 2007 by the IEA Greenhouse Gas R&D Programme under the title [CO<sub>2</sub> Capture Ready Plants, Technical Study, Report Number: 2007/4](#).
  - [Legal Aspects of Storing CO<sub>2</sub> - Update and Recommendations](#) (2007).
- Information exchange: May 2008 launch of the [IEA International CCS Regulators' Network](#).
- Policy recommendations to the G8, which include a set of suggestions for policy action on the whole chain of CCS development and deployment and a suggested definition of “capture ready”. Further discussion on the capture readiness concept is needed.
- Contributions to key national and international events and initiatives.
  - The IEA has notably contributed to the following.
    - [International G8 Expert Workshop on Clean Coal Technologies](#), Leipzig, March 2007.
    - IEA Clean Coal Centre Third International Conference on Clean Coal Technologies for our Future, [CCT2007](#), Sardinia, May 2007.
    - [International Workshop on CCS in Power Sector: R&D Priorities for India](#), New Delhi, January 2008.
    - [Eighth International Conference on Greenhouse Gas Control Technologies](#) (GHGT-8), Trondheim, June 2006
  - CSLF events.

## Next steps

The IEA will be guided by the following.

- The IEA together with the CSLF should assess the implementation of the action described above and the more detailed recommendations from IEA/CSLF workshops on an ongoing basis. This assessment will include further actions that could be taken by the G8 to further accelerate the exploitation of near-term CCS opportunities.
- The IEA should organise a workshop to discuss an internationally shared concept on CO<sub>2</sub> capture readiness. A report, including policy recommendations on possible policy action and incentives should be prepared.
- The IEA should prepare a more regionally-detailed assessment of CO<sub>2</sub> storage potentials and look into possible matching with major stationary CO<sub>2</sub> sources.
- The IEA should include in its next scenarios on CCS more regional details, which are appropriate to analyse opportunities and barriers.
- The IEA should work with the CSLF towards the development of internationally reviewed technical and legal principles for storing CO<sub>2</sub> for the implementation in national legal and regulatory frameworks.
- IEA should continue to contribute to key international and national events by sharing and disseminating its findings, including events to communicate CCS opportunities and challenges to the public.
- The IEA should facilitate the exchange of information among demonstration projects and long-term R&D in collaboration with international partnerships such as the CSLF and IEA Implementing Agreements.

In addition to the G8 and major developing countries, Norway and, potentially, other large oil and gas producers, are key players in development of CCS.

## Renewable Energy Markets and Policies

IEA scenarios see renewable energy technologies making an increasingly important contribution to reducing CO<sub>2</sub> emissions. In line with the 450ppm stabilisation case in the IEA *World Energy Outlook 2007*, renewables would contribute close to 4 Gt/year of CO<sub>2</sub> reductions by 2030. According to IEA *Energy Technology Perspectives 2008*, they would cut back around 10 Gt/year by 2050.

### Key conclusions

- To date, only a limited set of countries have implemented effective support policies for renewables and there is a large potential for improvement.
- The adherence to key policy design principles and the consistency of measures, rather than the implementation of specific policy types, determines the effectiveness and efficiency of renewable energy policies.
- Renewable policy design should reflect five fundamental principles.
  - The removal of non-economic barriers, such as administrative hurdles, grid access, electricity market design, lack of training and information, and the tackling of social acceptance issues with a view to overcoming them, in order to improve market and policy functioning.
  - The need for a predictable and transparent support framework to attract investment.
  - The introduction of transitional incentives, decreasing over time, to foster and monitor technological innovation and move technologies quickly towards market competitiveness.
  - The development and implementation of appropriate incentives guaranteeing a specific level of support to different technologies, based on their degree of technology maturity, in order to exploit the significant potential of the large basket of renewable energy technologies over time.
  - The due consideration of the impact of large-scale penetration of renewable energy technologies on the overall energy system, especially in liberalised energy markets, with regard to overall cost efficiency and system reliability.
- The main objective of policies is to bring a portfolio of renewable energy technologies into the mainstream in an evolved market, *i.e.* to lead the smooth transition from the current system, in which many renewables need subsidies, to a future fully competitive level playing field taking into account carbon prices and other external costs of energy technologies.

The IEA recommends that governments:

- Realise the urgency to implement effective support mechanisms in order to exploit the major potential of renewable energy technologies to improve energy security and tackle climate change.
- Remove and overcome non-economic barriers as a first priority to improve policy and market functioning.

- Recognise the substantial potential for improvement of policy effectiveness and efficiency, and learn from good practice.
- Focus on coherent and rigorous implementation of the above five key policy design principles, with the aim of maximising long-term cost efficiency within the context of national and local circumstances.
- Create a level playing field by pricing greenhouse gas emissions and other externalities appropriately in the market.
- Move towards a combination framework of incentive schemes in function of technology maturity level in order to foster renewable energy technologies' smooth transition towards mass market integration, progressively employing market forces.

### Source analysis

Publication: [Deploying Renewables: Principles for Effective Policies](#), October 2008 (contents summarised in a brochure). The book contains detailed analysis of the cost effectiveness of policies for promoting renewables in different parts of the world and draws conclusions.

### Next steps

The IEA will focus on the following.

- Deepening the existing analysis of policy effectiveness, both by region and by sector. Regional foci include Africa, Latin America, Russia and the Commonwealth of Independent States, and ASEAN countries. Expanding analysis of policy impact indicators and non-economic barriers.
- Estimating external benefits of renewables - including reduction of GHG and of regional air pollution, employment effects - as well as the possible environmental costs of the large-scale diffusion of renewables in the electricity, transport and heating sectors.

## Renewable Energy Heating and Cooling (REHC)

A joint study by the IEA Secretariat and the IEA Implementing Agreement on Renewable Energy Technology Deployment has demonstrated the substantial untapped potential of Renewable Energy Heating and Cooling (REHC) technology.

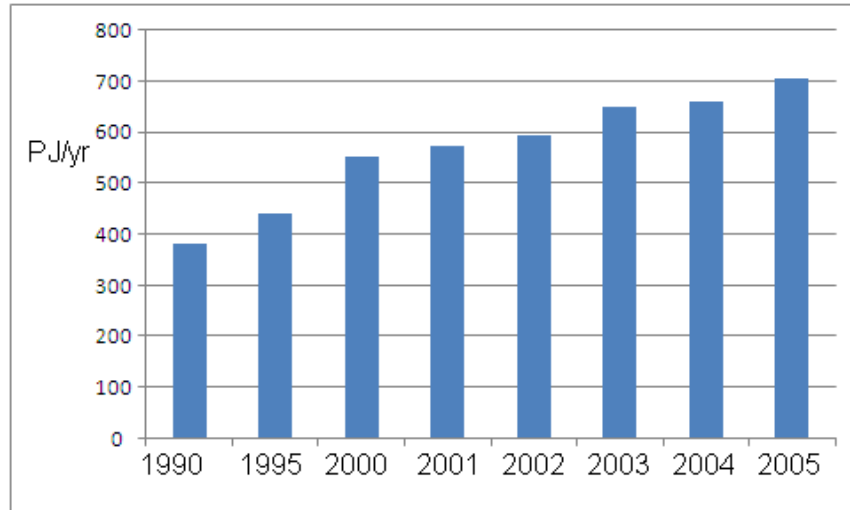
### Key conclusions

- The heating and cooling demands of homes, factories and other commercial buildings make up between 40% and 50% of total global final energy demand. Of this, renewable energy contributes between 1% and 2%, mainly from bioenergy, and excluding ambient heat pumps, which are normally classified as energy efficiency devices in the building sector.
- The IEA calculates that, if the present amount of renewables-based heating from biomass, solar and geothermal were tripled - displacing some of the world's existing or planned gas- or coal-combustion heating - such switches would reduce global CO<sub>2</sub> emissions by between 1 Gt and 1.2 Gt per year, or at least as much CO<sub>2</sub> as 500 million light vehicles emit on the world's roads.
- There is evident potential for reducing the cost of most REHC technologies by 2030 through learning experience, mass production and improved performance.
- Governments should take strong action - particularly where renewable energy resources are readily available - to increase the deployment of commercially available and cost competitive REHC technologies and to further the development of those that are at an early market stage.
- If the contribution from the leading countries identified could be replicated by other countries with similar resources as a result of implementing similar well designed, cost effective, supporting policies, then there is good potential to obtain market expansion and triple the current global contribution by 2020.

The IEA recommends the following.

- Governments should pursue national policies, including incentives, regulations, labelling, minimum performance standards, training, and support for relevant RD&D, to facilitate the deployment of REHC technologies. Planning difficulties and skill shortages - for tradespeople and installers - may represent important barriers that need to be addressed. Where high retail prices persist - for instance for small geothermal ground heat pumps - governments need to consider stronger deployment policies.
- While the most appropriate policies vary from country to country, evidence suggests that a comprehensive package of measures can be most effective. The most effective policies have often proved to be those where parallel investments were made in guidance and education programmes in order for stakeholders (including building owners making personal investment decisions) to better understand the benefits that REHC has to offer.
- Mandatory regulations should be considered for the deployment of the most cost-effective REHC options. For instance, in sunny regions, governments could consider making solar water heaters mandatory for new buildings.

**Figure 10**  
**Global Commercial Heat Demand from Renewables**  
(including biomass combustion and the direct use of solar thermal and geothermal heat when available on-site)



NB: direct use of heat from biomass combustion on site is not included in the data but, even excluding traditional use of biomass for cooking and heating, it is likely to increase the total demand by 5- to10-fold.

Source: *Renewables for Heating and Cooling - Untapped Potential*, IEA, 2007.

## Source analysis

Publication: [Renewables for Heating and Cooling - Untapped Potential](#) (2007). Available as a free download at [www.iea.org](http://www.iea.org).

## Next steps

Future IEA work will focus on the following.

- Improved data are needed to measure the cost effectiveness of policies more accurately. IEA will encourage governments to improve the quality of national data. As REHC technologies are dispersed, this may require the use of user surveys and national sales data.
- The IEA now intends to more accurately evaluate the future costs for REHC technologies, to use more reliable data to assess their mitigation potential on a regional basis, and to explore further policy development opportunities at national levels for selected countries, based on the level of maturity of specific technologies.

## Grid Integration of Renewables

Renewable electricity technologies include both "firm" and "variable" generation types. Variability - as with wind, photovoltaic or tidal power - brings new challenges to power systems at high penetrations. A number of flexibility tools can enable networks and markets to integrate large quantities of variable renewables more efficiently. The need for those tools can even be reduced through a system-wide approach that integrates many dispersed, variable plants with uncorrelated output in a way that substantially "smoothes" aggregated variability.

### Key conclusions

- There is no intrinsic "ceiling" to variable renewables' potential. The potential of a region/country depends on the flexibility of its power system - its ability to quickly balance fluctuations in supply and demand. This in turn depends on the design and operation of networks, of the supply portfolio and of electricity markets. Forecasting accuracy and the scale of the balancing area are important factors.
- International and regional trade of electricity enhances the capacity of power systems to manage fluctuating output efficiently, while bringing additional benefits to the market as a whole.
- Variability costs are nominal at low share, increasing with penetration - particularly in isolated/small markets (developing world, islands) - and with the distance between the resource and demand.
- Networks are globally inadequate. They are aging fast. Weaker networks need reinforcement. State-of-the-art technologies are not being adopted quickly enough. An example is real-time monitoring of weather-related changes in the temperature of existing lines, to measure the effect on transmission capacity at any given moment. This alone can increase capacity by up to 50%, compared to when line rating is assigned and fixed in advance.
- Early, system-wide planning is crucial to identify synergies and avoid administrative/licensing delays. New transmission infrastructure can be delayed by as much as 10 years by public opposition.
- Choice of strategy to increase network and market flexibility, and so foster greater use of variable renewables, will depend on regional/national circumstances. Tools include larger supply-and-demand balancing-areas, flexible international interconnection, additional flexible generation, demand side measures, trading closer to real-time, and storage. Experience suggests that such measures can be of benefit to electricity markets as a whole.
- Equal and open access to networks is critical, and the unbundling of generation and transmission companies can be important to achieve this.

## Source analysis

A free, downloadable pdf and printed report, [Empowering Variable Renewables: Options for Flexible Electricity Systems](#) (for release in summer 2008); a pdf background report; and three workshops:

- [Integration of Renewables into Electricity Grids](#), Paris, November 2006
- [Grid Integration of Renewable Energy: Technology Status and Priorities](#), Paris, May 2007.
- [Trading and Transmission of Renewable Electricity: a Roundtable](#), Berlin, October 2007.

## Next steps

To calibrate the potential for variable renewable capacity in a given market, flexibility requirements - and the potential of measures to respond to these requirements - could be quantified, possibly in terms of megawatts. On this basis, a subsequent step would be to identify OECD and developing countries/regions against a “Flexibility Index” that would indicate their level of flexibility, and potential to adopt variable renewables. A country seeking to increase its variable renewables share could then more readily identify the challenges it is likely to face by examining the experiences of a country/region with similar characteristics.

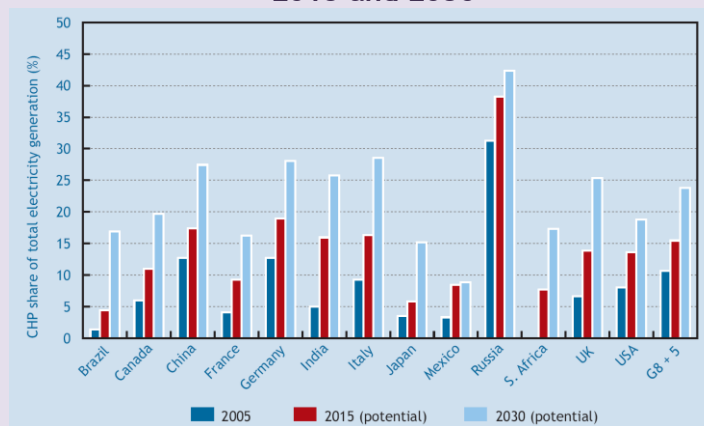
## Combined Heat and Power (CHP)

CHP is a proven set of energy technologies that deliver an important portion of our global energy needs, with strong potential for expansion worldwide.

### Key conclusions

- New IEA analysis demonstrates that there is potential to more than double the use of CHP in G8 and certain other large economies by 2030. This would result in a 10% reduction in these countries' CO<sub>2</sub> emissions from new power generation facilities, or 950 Mt CO<sub>2</sub>/ year.
- However, despite policy makers' attention, only a few countries have been successful in advancing CHP beyond 10% of electricity generation.
- A number of policies have been successful at advancing CHP. In most cases, CHP is less in need of additional financial incentives and more in need of removal of barriers that prevent CHP from competing equally.
- Policy makers and industry would benefit from additional education and outreach to educate them about the potential for GHG reduction, energy savings and cost savings associated with CHP investment.
- There are strong opportunities for CHP in fast-expanding non-IEA economies in particular, including district heating & cooling with CHP and industrial CHP, as well as residential/commercial CHP.

**Figure 11**  
**CHP Potentials in an Accelerated CHP Scenario**  
**- 2015 and 2030**



Source: *Combined Heat and Power: Evaluating the Benefits of Greater Global Investment*, IEA, 2008.

The IEA recommends that governments take the following steps.

- Conduct a national CHP-potential study, taking into account industrial, commercial/residential and district heating and cooling CHP opportunities.
- Conduct a parallel CHP barrier study, identifying environmental, utility-access and other barriers that prevent equal treatment of decentralised generation in the form of CHP.
- Learn from the examples of the countries which have implemented comprehensive successful CHP policies.

## Source analysis

### Publications

- Report: [\*Combined Heat and Power: Evaluating the Benefits of Greater Global Investment\*](#) (2008). The report contains new IEA data and analysis of current CHP capacity and potential for future growth, along with an assessment of associated energy, economic and environmental benefits.
- Website/report: *CHP: Best Practice Policies and Approaches* (autumn 2008). This follow-up report documents successful policies and measures undertaken by a variety of countries to advance CHP in industry, district heating and cooling, and commercial/residential sectors. It also includes roadmaps for different policy makers in the energy, economic, environmental and utility regulatory areas.
- Country scorecards: The IEA will develop a series of detailed country scorecards for the G8 and other leading economies. These scorecards will highlight the current market and policy environments, assess the potential for expanded use of CHP and district energy, and make recommendations. The first set of scorecards will be issued in July 2008, with others following in 2008 and early 2009.

### Meetings

- Roundtable [\*Global CHP/District Heating and Cooling Policies - Best Practices and Lessons Learned\*](#), Paris, October 2007.
- G20 Side Event organised by Japan Gas Association: *New Challenges of CHP and DHC: The Mission of Combating Global Warming*, 14 March 2008, Chiba, Japan.

## Next steps

The IEA will be guided by the following objectives.

- The IEA should continue to manage the International CHP/DHC Collaborative, performing outreach to inform policy makers and industry about models and examples of policies.
- The IEA should collect and synthesise policy and market best practices in the G8 countries and other major economies, with an eye to providing lessons learned in advancing CHP and district energy.
- The IEA should provide assistance to the fast-expanding non-IEA countries which are considered to have strong CHP potential, helping to undertake detailed CHP potential studies, outreach and education.

## PROMOTING NETWORKS FOR RESEARCH AND DEVELOPMENT

### Enhancing Technology Collaboration with Brazil, China, India, Mexico, South Africa and Russia

Developing and deploying clean, efficient energy technologies presents challenges for many nations around the world. The IEA NEET initiative (Networks of Expertise in Energy Technology) seeks to expand greater participation of all major energy consumer nations in the IEA energy technology collaborative network. To facilitate this, NEET energy technology workshops in non-IEA countries with fast growing economies enable energy technology experts and policy makers to share know-how and experience on technical issues, but also on institutional and market questions.

#### Key conclusions

- In 1973, OECD countries accounted for 61% of global energy demand and 66% of energy-related CO<sub>2</sub> emissions. By 2005, the share of OECD countries in global energy demand and CO<sub>2</sub> emissions had shrunk to 49% and 48% respectively. Soon China will be the largest emitter of CO<sub>2</sub>; by 2015, India will rank third, after the United States. If energy security and climate change issues are to be addressed effectively, emerging economies need to be involved more closely in IEA efforts in these areas.
- The Implementing Agreement collaborative programmes of the IEA technology network are open to full membership by IEA member and non-member countries alike. Most major developing countries already belong to at least one Implementing Agreement. Through the IEA Networks of Expertise in Energy Technology (NEET) Initiative, IEA collaborative activities are seeking to attain genuinely global scope. The IEA technology network has demonstrated its desire to reach out to these non-IEA countries and to discuss how collaboration could be mutually beneficial.
- The work of the NEET Initiative has demonstrated that the fast-expanding non-IEA economies are extremely interested in expanded collaboration with the IEA energy technology network, and with other networks in the field of energy technology. They are clearly eager to identify potential new, as yet unexplored, collaborative opportunities.
- Many contacts between the IEA Implementing Agreements and the fast-developing non-IEA countries have resulted from the NEET outreach effort. Follow-up discussions, visits and collaborative activities have already begun.

#### Source analysis

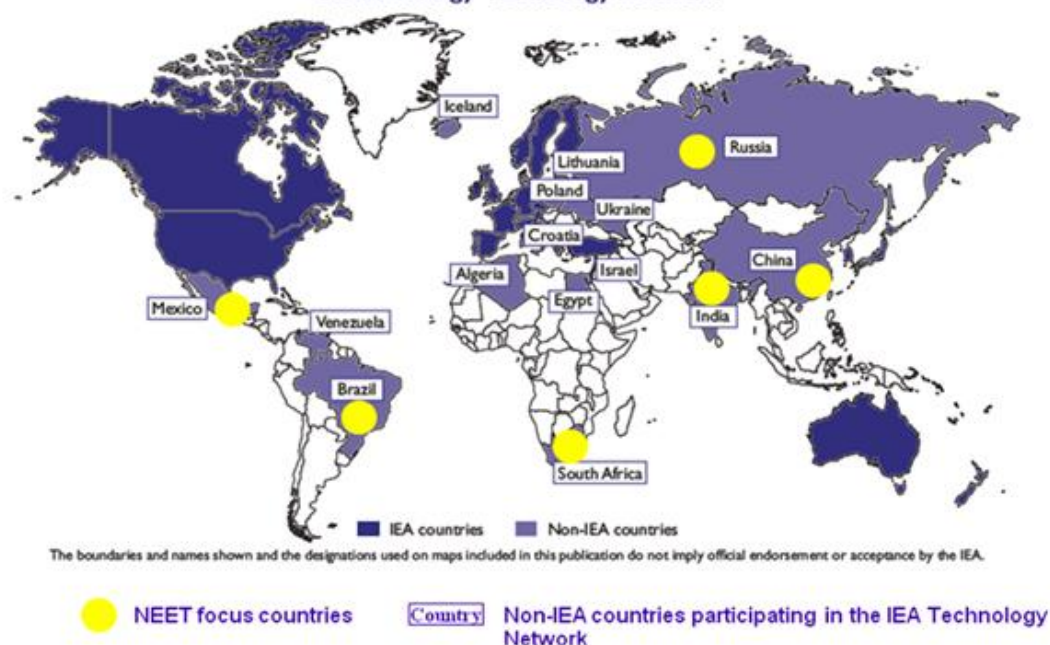
- The [Networks of Expertise in Energy Technology](#) (NEET) Initiative was launched in 2006. To reach out to the major developing economies, NEET workshops on energy technology collaboration have been organised in several of these countries. The objective has been to enable representatives of the international collaborative IEA Implementing Agreements and the IEA Working Parties recognised as relevant to the energy technology strategies of these countries to meet with their local counterparts and discuss opportunities for future collaboration.
- In February 2007, the new South African National Energy Research Institute (SANERI) and the IEA co-organised the [South Africa NEET Workshop](#) on energy technology collaboration. Following this event, South African institutions showed strong interest in

joining six new IEA Implementing Agreements. Internal arrangements in the South African government, necessary for final signatures, are taking place.

- Early in November 2007, the Ministry of Science and Technology (MOST) of China, and the China Coal Research Institute (CCRI), co-organised with the IEA, the [China NEET Workshop](#) on energy technology collaboration. The Implementing Agreements invited to participate in the event were the most relevant to China's 11<sup>th</sup> Five Year Plan. Following this NEET event in China, MOST started to consider the possibility of creating an entity, located in Beijing, to be responsible for liaison with IEA on collaborative efforts.
- In November 2007, the Brazilian Ministry of Mines and Energy (MME) co-organised with the IEA, the [Brazil NEET Workshop](#) on enhancing energy technology collaboration. The MME and other Brazilian institutions are currently identifying areas of mutual interest for collaboration with the IEA. Following an IEA preparatory mission to Brazil, the MME signed the agreement for Brazil to participate in the IEA Hydropower Implementing Agreement.
- A [workshop on "Sustainable Rural Energisation in Major Emerging Economies"](#) took place at the IEA headquarters in Paris on 28-29 May 2008. Co-organized by the IEA NEET team and the German Technical Cooperation body (GTZ), the event was supported by the United Nations Environmental Programme (UNEP) and the Renewable Energy Policy Network for the 21<sup>st</sup> Century (REN21). High level participants from "Plus 5" countries and other targeted emerging-economy countries joined nine IEA Implementing Agreements to explore interest in working more closely together on rural energisation. A strong consensus emerged on the desirability of continued IEA focus on carrying forward this effort, which could culminate in creation of a dedicated Implementing Agreement.

Figure 12

Global Energy Technology Network



Source: IEA

## Next steps

- Plans are in hand for a NEET workshop in Russia, tentatively scheduled for 25-26 September 2008 in Moscow, which will bring together the Implementing Agreements of most interest to Russia and participants from Russian government, industry and R&D institutions. The workshop will be co-organised with the Russian Federal Agency for Science and Innovation and supported by the Russian Ministry of Industry and Energy.
- A NEET workshop in India is in the planning stages, in co-operation with the Planning Commission of India and targeting the second half of 2008. The Implementing Agreements of relevance to India's current and future energy strategy will be invited to present their activities and discuss with Indian institutions the benefits of international collaboration. During this event, Indian stakeholders will have the opportunity to identify the Implementing Agreements where India's participation is most relevant.
- A mission to Mexico is planned for the second half of 2008 with the objective of strengthening Mexico's already strong involvement in the IEA technology network.
- As with any outreach effort, tangible results of this activity take time. While limited resources, time and language barriers can constrain smooth developments, final signatures can also be delayed - as they can also in IEA member countries - for administrative, communication or budgetary reasons. In all its activities, of the NEET team will continue to focus strongly on energetic follow-up to consolidate relationships with existing and new partner countries.

The IEA will encourage governments to:

- Continue fostering international energy technology collaboration between developed and developing countries.
- Support the continued efforts of the IEA NEET Initiative to raise awareness among fast-expanding non-IEA countries of the ongoing work in the IEA energy technology network and its achievements - as well as the activities in other networks - and to encourage their participation.
- Support the IEA NEET Initiative to reach out to other parts of the world with growing energy demand that are not yet fully acquainted with the activities of the IEA energy technology network - notably South America, Eastern Europe, Indonesia and the African continent - and to encourage their participation.
- Encourage major developing countries to consider collaborating together more systematically on areas of joint interest such as rural energisation.
- Encourage broader participation of the private sector and industry, as major drivers of innovation in the IEA energy technology network and other networks.

---

In response to the request from G8 leaders at the 2005 Gleneagles Summit, the IEA has compiled an inventory of international collaborative efforts related to energy technology. It can be found on the IEA website: [www.iea.org/neet](http://www.iea.org/neet). This list does not claim to be all-inclusive.

## Engagement with Industry

There is large potential for stronger engagement with industry, as demonstrated by the statement following the IEA Chief Technology Officer Roundtable at IEA Headquarters in Paris in January 2008.

### Key conclusions

The following are excerpts from the statement following the IEA Chief Technology Officer Roundtable (January 2008).

- As technology leaders we represent companies with major commitments to energy RD&D that take their environmental responsibilities seriously and are, through deployment of new technologies and commercial development, taking leading roles in meeting the energy challenge in a responsible way.
- Urgent government action is needed to facilitate the development and deployment of advanced energy related technology. There is a pressing need to design and implement a range of policy measures that will create clear, predictable, long term economic incentives for carbon reduction in the market.
- It will only be on the basis of such incentives that business will be empowered to undertake the huge investment programmes that are now urgently needed to deliver competitive low carbon energy to consumers on the scale that is required.
- Governments are asked to act now to create the incentives and market conditions, including legal and regulatory frameworks and development of public infrastructure that will enable us to bring these technologies forward. Rigorous energy efficiency standards and building codes - including for new and existing buildings - are also needed to promote energy efficiency and reduce CO<sub>2</sub> intensity, the lowest cost option for reducing CO<sub>2</sub> emissions.
- Governments should increase their support for RD&D to advance basic science and work in partnership with industry to create technology roadmaps to clarify future direction and to speed the deployment of early stage technologies.
- We are willing to work with the G8 and other developed or developing countries through the IEA, or in whatever way is most appropriate, including technology co-operation with companies in developing countries, to promote advanced energy RD&D and to help to bring forward these necessary and fundamental changes to the global energy economy.

### Source analysis

IEA [Chief Technology Officer Roundtable](#) (January 2008) - more than 30 major companies with leading energy technology programmes met to review the global energy technology outlook, based on emerging conclusions of *ETP* and to discuss international collaboration. Together the companies invest over USD 40 billion per annum in R&D. The meeting was held also under the auspices of the World Business Council for Sustainable Development (WBCSD).

Companies participating in this roundtable included:

ABB Ltd., Air Liquide, Alstom, Ansaldo Energia, Areva, Robert Bosch, BP, Centro Ricerche Fiat, DuPont, EDF, Electrolux, Enel, Ford Motor Company, Halliburton, HITACHI, Honda, Hydro-Québec, Iberdrola, Philips, Renault, Royal Dutch Shell, St-Gobain, Sasol, Schlumberger, Sharp, Siemens, Tokyo Electric Power Company, Total, Toyota Motor Europe, United Technologies and Vattenfall.

Joint Statement - companies welcomed the opportunity to work more closely with the IEA and the G8 and agreed on a [statement](#) addressed to G8 leaders for the next summit meeting in Hokkaido in July 2008.

## Next steps

The IEA will focus on the following.

- *Post-Hokkaido industry briefing.* The IEA Secretariat has been requested by industry to provide a briefing on the outcome of the Hokkaido Summit, and to discuss aspects of Hokkaido conclusions in which industry could contribute.
- *Industry collaboration on roadmaps.* Elaborating a work plan together with industry and possibly national governments to deepen the energy technology roadmaps developed for ETP 2008 with an aim to clarify the technology direction and to speed the deployment of early stage technologies.

# The Online Bookshop

International Energy Agency



All IEA publications may be bought  
online on the IEA website:

[www.iea.org/books](http://www.iea.org/books)

You may also obtain PDFs of  
all IEA books at 20% discount.

Books published before January 2007  
- with the exception of the statistics publications -  
can be downloaded in PDF, free of charge  
from the IEA website.

## IEA BOOKS

**Tel: +33 (0)1 40 57 66 90**  
**Fax: +33 (0)1 40 57 67 75**  
**E-mail: [books@iea.org](mailto:books@iea.org)**

International Energy Agency  
9, rue de la Fédération  
75739 Paris Cedex 15, France

### CUSTOMERS IN NORTH AMERICA

Turpin Distribution  
The Bleachery  
143 West Street, New Milford  
Connecticut 06776, USA  
Toll free: +1 (800) 456 6323  
Fax: +1 (860) 350 0039  
[oecdna@turpin-distribution.com](mailto:oecdna@turpin-distribution.com)  
[www.turpin-distribution.com](http://www.turpin-distribution.com)

*You may also send  
your order*

*to your nearest*

*OECD sales point*

*or use*

*the OECD online*

*services:*

[www.oecdbookshop.org](http://www.oecdbookshop.org)

### CUSTOMERS IN THE REST OF THE WORLD

Turpin Distribution Services Ltd  
Stratton Business Park,  
Pegasus Drive, Biggleswade,  
Bedfordshire SG18 8QB, UK  
Tel.: +44 (0) 1767 604960  
Fax: +44 (0) 1767 604640  
[oecdrow@turpin-distribution.com](mailto:oecdrow@turpin-distribution.com)  
[www.turpin-distribution.com](http://www.turpin-distribution.com)







**INTERNATIONAL ENERGY AGENCY**  
9 RUE DE LA FÉDÉRATION, 75739 PARIS CEDEX 15

***[www.iea.org](http://www.iea.org)***

