Oil & Gas Science and Technology – Rev. IFP, Vol. 59 (2004), No. 3, pp. 323-330

Research and Development Actions to Reduce CO_2 Emissions within the European Union*

P. Dechamps and P.A. Pilavachi[1]

1 European Commission, DG-Research, 200, Rue de la-Loi, B-1049 Brussels - Belgium
e-mail: pierre.dechamps@cec.eu.int - petros.pilavachi@skynet.be

* Presented by P.A. Pilavachi on 2/10/03 at the "Entretiens IFP" in Rueil-Malmaison

Résumé — Actions de recherche et développement visant à réduire les émissions de CO_2 dans l'Union européenne — Cet article décrit les actions de recherche mises en place par la Direction générale pour la recherche de la Commission européenne dans la mitigation des émissions de CO_2. Les aspects de politique globale relatifs au changement climatique ainsi que des considérations de politique énergétique sont présentés. L'utilisation des sources d'énergie renouvelables et des combustibles fossiles dans la fourniture énergétique primaire est discutée. Elle conduit à la politique de l'Union dans la recherche de gestion du carbone provenant de l'utilisation des combustibles fossiles. Le portefeuille actuel de projets de l'Union dans le domaine de la capture et la séquestration du CO_2 est présenté, de même que son évolution récente ou future. Un survol de l'implication de la Commission dans une série d'actions de coopération et de coordination internationale est également exposé.

Abstract* — *Research and Development Actions to Reduce CO_2 Emissions within the European Union — *This paper describes the research actions put in place by the Directorate General of Research of the European Commission (EC) in the field of the mitigation of CO_2 emissions. Global policy for climate change mitigation and the associated energy policy considerations are presented. The use of renewables and fossil fuels within the overall energy mix are discussed, leading to European Union research policy for fossil fuel carbon management options. The European Union's (EU) current and proposed RTD project portfolio for CO_2 capture and sequestration is then given. An overview of the involvement by the EC in complementary international cooperation and coordination activities is also presented.*

INTRODUCTION

Sustainable development and world-class economic competitiveness are central objectives for the European Union. These overriding needs are reflected in the European Union's research priorities in order to implement sustainable development, with energy as a key aspect. The three strategic objectives for energy are:

- to reduce greenhouse gas and pollutant emissions;
- to secure a future sustainable and diversified energy supply through the increased use of new and renewable energy sources;
- to ensure a competitive European industry.

In order to achieve an impact in the medium to long term, considerable RTD effort is required to implement a sustainable energy system with clean energy sources, carriers and conversion technologies that are economically attractive and technically robust. Within this scenario, fossil fuel use will be required to fulfil a long-term transitional role prior to the increasing introduction of new and renewable energy sources. However, if fossil fuels are to be part of this sustainable energy scenario then the need for near-zero emissions fossil fuel systems will be required. Accordingly, the development of CO_2 capture and sequestration systems associated with fossil fuel power plants is a key priority within the RTD framework programmes of the European Union.

Within the context of global environmental policy issues and initiatives, this paper provides an overview of such RTD activities together with comments on the complementary international cooperation and coordination actions by the EC.

1 GLOBAL ENVIRONMENTAL POLICY ISSUES

Worldwide, there is increasing concern regarding climate change issues related to Green House Gas (GHG) emissions. It is also recognised that global issues require global responses. This approach has been reflected in the Kyoto Protocol, with many major nations agreeing to limit greenhouse gas emissions in the period up to 2012. Thus the European Union intends to decrease its GHG emissions by 8% in 2008-2012 compared to 1990 under the Kyoto Protocol. This will be achieved through a burden sharing agreement between Member States taking into account the fuel mix and situation pertaining within each State. The EU is making reasonable progress so far, although there is still uncertainty on whether a reduction by 8% will be achieved in the designated timescale. Entry into force of the Protocol is subject to the ratification by countries representing at least 55% of total CO_2 emissions. After the US withdrawal, this means that Russia should ratify and thus has in effect the future of the Protocol in its hands.

The European Climate Change Programme (ECCP) was also established to identify the most promising and cost-effective routes. With regard to the practicalities of reducing GHG emissions, this will be achieved through a combination of the more rational use of energy in all sectors together with a switch to lower carbon fuels including a greater introduction of (zero carbon) renewable energy sources. Indeed at the Johannesburg World Summit on sustainable development, it was reaffirmed that increasing the use of clean renewable energy will have multiple benefits for rich and poor countries alike, with a positive outcome likely to arise from increasing the global share of renewable energy sources. However, as is noted below, the use of fossil fuels will continue to dominate the energy mix for a variety of reasons and as such there is a need to ensure that fossil fuel systems become more energy efficient and have less adverse environmental impact.

For fossil fuel utilisation systems, the drive will be towards near zero emission power plant and for such units the currently proposed way forward is to introduce CO_2 capture and sequestration techniques with the existing systems. Such techniques are not yet cost effective in the Kyoto horizon, but the results so far are promising. Thus, further RTD is worthwhile. Mitigation costs are high although they vary according to the technology to be used and even within the same technology there may be differences in costs [1], as shown in Figure 1.

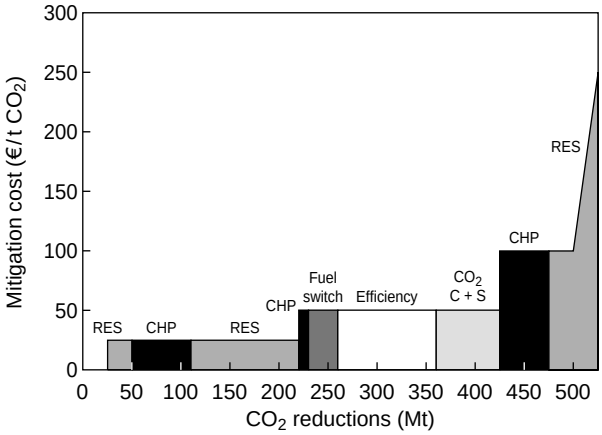

Figure 1

Cost effectiveness of CO_2 reduction technology *(source: ECCP).*

With regard to GHG, the European Commission has proposed that, from 2005, mandatory emissions limits are placed on all big industrial and energy intensive businesses on a continent-wide scale. It also envisages a EU-wide emissions trading scheme (a directive is in preparation) that is tailored to suit the Kyoto Protocol. This will draw in five

industry sectors across twenty-five EU Member States and the three EEA States (Iceland, Lichtenstein and Norway). The scheme will cover power generation over 20 MW, including industrial installations, such as refineries, coke ovens, cement, metals, minerals and the pulp and paper industries (but not the chemicals sector) except for hazardous or municipal waste burners. It is also proposed that a linking directive should be developed that would bring CDMs and joint initiatives credits within the emissions trading umbrella. For CO_2 capture and sequestration, it is deemed essential that the use of such technologies can receive credits in the context of these two directives. It would appear that this should be the case since neither directive refers to any particular technology while defining emissions as releases to atmosphere. However, the position needs to be clarified. About half of the EU's total CO_2 emissions will be covered by the scheme, with 5000 firms taking part. It will cover all greenhouse gases but only CO_2 will be traded in the first instance as it accounts for 80% of emissions in the EU. The other gases will be traded from 2008 onwards when the scheme will be extended to other sectors and chemicals will almost certainly be brought in.

In the post-Kyoto scenario, more significant reductions of CO_2 will be needed. On the basis of current climate models, it has been suggested that a maximum 2°C increase in global temperatures could be accommodated, which would equate to an atmospheric CO_2 concentration level of some 450 ppmv. On the basis of 1990 levels this would require 50% to 60% less emissions of CO_2 by 2050. This would need to come not only from developed economies but also from economies in transition since in the latter case even if per capita emissions are relatively low, total emissions will become ever more significant. Any post-Kyoto negotiation process will need to recognise the right to development of less developed and transitional economies.

2 INTERNATIONAL PROJECTIONS AND COMPARISONS FOR ENERGY USE

Following on from the previous point, various scenarios and projections have been made. A key study is the so called WETO Report [2], supported by the EU, which examined the world energy, technology and climate policy outlook in order to provide assistance to decision makers in defining their long term policies. Two of the key results arising from this work are as follows:

– If no specific policy initiatives and measures are taken, world CO_2 emissions are expected to double by 2030 and, with a share of 90%, fossil fuels will continue to dominate the energy system.

– As the largest growing energy demand and CO_2 emissions originate from developing countries, Europe will have to intensify its cooperation, particularly in terms of technology transfer.

The former point is shown in Figure 2, taken from the WETO study [2]. Complementary work by the IEA [3] also indicates that on a global scale, coal demand for power generation is expected to double over the period to 2030, with the major increase arising within economies in transition. The IEA estimates that 4500 GW of new power plant will be required, of which coal fired plant is expected to be 40% of this with natural gas providing the very great of the remaining capacity. These projections arise from the recognition that the use of renewables can only be accelerated in the medium to long term both in developed and developing countries.

With regard to carbon intensity compared to GDP, the WETO report indicates that the EU is amongst the lowest, as shown in Figure 3.

There are also scenarios and projections for CO_2 emissions per capita. Here, the EU is above the world

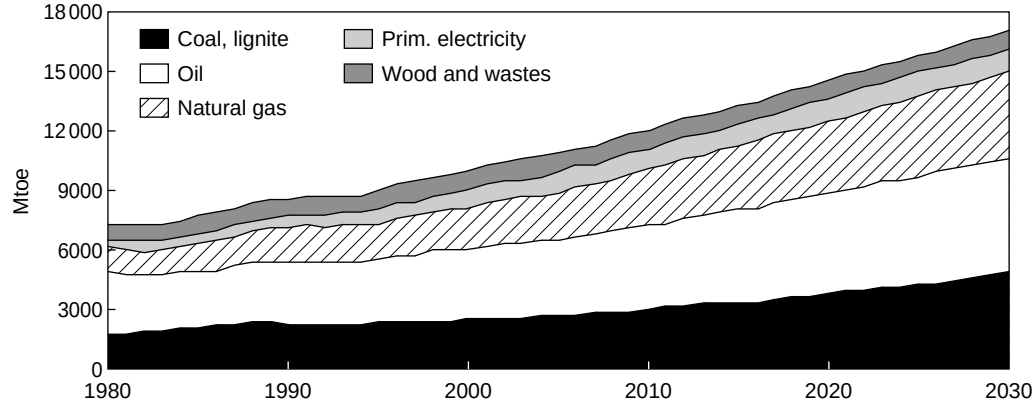

Figure 2

Scenarios and projections *(source: WETO)*.

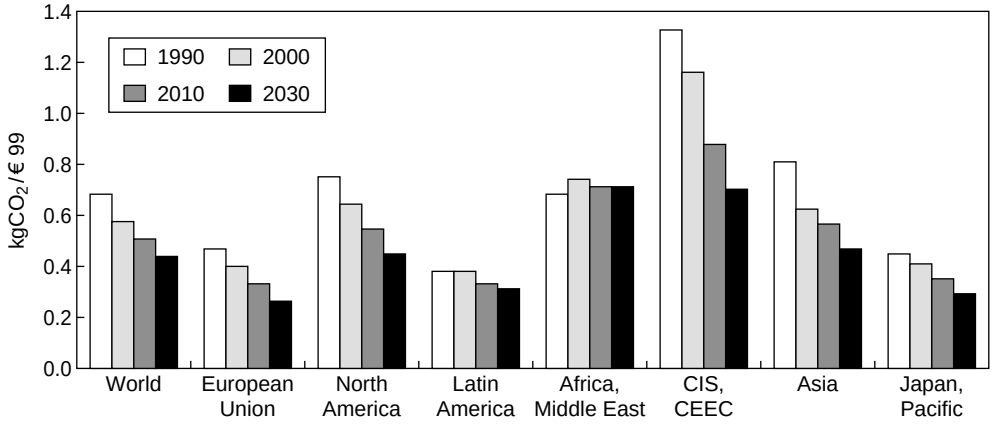

Figure 3

Carbon intensity of GDP *(source: WETO).*

average but below some other continents, as shown in Figure 4.

3 KEY ENERGY CONSIDERATIONS WITHIN THE EU

Within the European vision of energy sustainability, key issues include the need for security of energy supply and the need to ensure EU industrial competitiveness in a post-Kyoto scenario. These key issues must also be reconciled with environmental protection.

Thus, in this context, within Europe, the EC Green Paper [4] identifies the need to establish a sustainable approach to energy use and management. There is a focus on ensuring diversity of supply while meeting environmental standards and limits through increased use of indigenous renewable energy sources. At the same time, the Green Paper explicitly recognises that doubling the renewables share in the energy supply quota from 6 to 12% and raising their part in electricity production from 14 to 22% is an ambitious objective. Indeed the prevailing view amongst EU energy experts is that the future energy needs of the enlarged EU will require the full range of available fuels (including renewables, nuclear, natural gas, oil and coal) to be utilised on an environmentally acceptable basis to meet the projected overall needs. Such an approach is considered sustainable as it will ensure the necessary diversity and security of supply, provided adequate environmental performance can be achieved. Consequently fossil energy usage will require advanced technologies with near zero emissions. This will mean the use of CO_2 capture and sequestration technologies integrated with the advanced fossil fuel power plant.

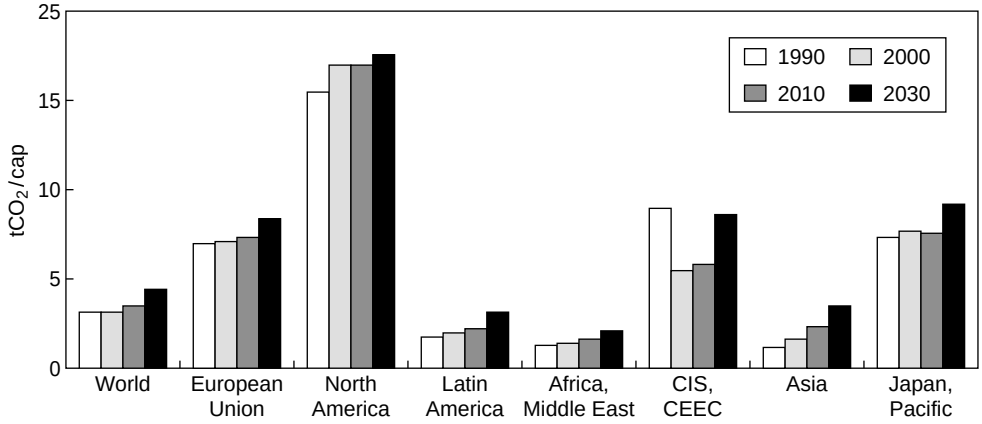

Figure 4

Scenarios and projections. CO_2 emissions per capita. (Source: WETO)

The other key issue is EU industrial competitiveness. EU industry needs to be placed in a position to compete globally in a post-Kyoto scenario. Since the expectation is that there will be a major upsurge in new and retrofit power station construction, based on fossil fuels (and subsequently renewables), the need is to ensure that the EU power generation and associated equipment manufacturers can remain competitive for the supply of fossil energy utilisation systems and components, both for EU markets and on a global basis. Such systems will, in the medium to long term, need to be equipped with CO_2 capture and sequestration techniques.

In the electricity sector alone, 4500 GW of new generating plant will be required by 2030 to meet the increased demand. This represents a major market opportunity for EU industry to supply such export markets, particularly in Eastern Europe, Asia and Australasia, provided that the necessary technology has been developed and proven. Historically, EU industry has supplied close to 50% of the global market and to date has had an enhanced reputation for innovation in the development of advanced systems and components, much of which has arisen from RTD projects supported by the EU. There will be significant competition from industry in the United States and Japan, where Government support for the development of carbon management techniques is significant, with the recognition that the return on such investment is expected to come from increased export of advanced technology.

The other key point to stress is that the introduction of renewables and fossil fuels with CO_2 capture and sequestration are complementary from a timing point of view, from a generation mix point of view and to ease the penetration of hydrogen as an energy vector.

There are also synergies between CO_2 capture and sequestration applied to fossil fuel and renewables (in this instance biomass) plants. For example, biomass utilisation in itself is seen as CO_2 neutral. Consequently, should CO_2 capture and sequestration be applied to biomass plants, this would in effect result in negative CO_2 emissions. There are also various technical advantages in the co-utilisation of biomass with solid fossil fuels in large scale power plant, which again can also result in CO_2 credits in a tax/trading environment.

4 EU CARBON MANAGEMENT RTD POLICY ISSUES

Within Europe, the challenge is to establish a sustainable energy system that will allow the preservation of equilibrium for ecosystems while also encouraging economic development. The medium to long term objective is to develop and establish new and renewable energy sources and energy vectors, such as hydrogen and electricity, which are affordable, clean and can be readily integrated into a long-term sustainable energy supply and demand structure. It is also recognised that the RTD necessary to achieve such objectives requires resources beyond the capacity of any one Member State. Indeed, the pressure of international competition necessitates an integrated European response. Work toward this goal started within the EU Fifth Framework Programme and this will be taken forward and consolidated within the Sixth Framework Programme that is now implemented.

Within this vision, it is recognised that fossil fuels will continue to be used for the foreseeable future and it is therefore imperative that cost effective solutions are required to establish near zero emissions technologies of a high environmental standard. Accordingly, the capture and sequestration of CO_2 associated with cleaner fossil fuel power plants is deemed to be an essential factor for fossil fuels to be part of the sustainable energy scenario. The approach, which is a priority topic within FP6 (2002-2006), will include both cost effective, safe and environmentally compatible disposal options together with the technology for CO_2 capture thereby enabling cleaner and more efficient fossil fuel plants [5].

There are significant costs involved in CO_2 capture and sequestration, of which capture represents 70-80% of total costs. Therefore, the primary RTD objective for the EU is to decrease the cost of capture. The target is to reduce the costs of CO_2 capture from 50-60 € down to 20-30 €/t of CO_2 captured, whilst aiming at achieving capture rates above 90%. Methods include pre-combustion capture (applicable to gasification systems); post-combustion capture and oxyfuels combustion.

There is also a strong need to assess both the reliability and long term stability of CO_2 sequestration in order to map geological storage potential, determine safety aspects and to build public confidence to ensure acceptability. CO_2 sequestration options of interest to the EU include geological based storage in aquifers, depleted oil and gas reservoirs (with the possibility of enhanced oil recovery) and deep un-mined coal beds (that offer the benefit of enhanced coal bed methane recovery). In addition, there are certain chemical techniques and other innovative ways that appear to be promising. At present, the EU's Sixth Framework Programme does not support sequestration in oceans and biospheric sinks such as forests and algues, because of the risk potential associated with the degrees of uncertainty in such techniques.

The EU also recognises that while the sustainable energy economy is under development, for a transition period, hydrogen is likely to be mostly produced from fossil fuels. For fossil fuel based gasification technologies, when CO_2 is removed from the gas stream the fuel that remains is hydrogen. Thus within the FP6 RTD Programme, there is strong complementarity between the work on capture and sequestration of CO_2 for from fossil fuels and another strategic priority, namely the development of new technologies for energy carriers such as hydrogen [5].

5 THE CURRENT AND PROPOSED EU RTD PORTFOLIO ON CARBON CAPTURE AND SEQUESTRATION

The current portfolio of EU funded research projects is summarised in Table 1.

This indicates that the EU is contributing some 16 M€ to support nine projects. This contains two projects on CO_2 capture, six projects covering CO_2 sequestration and sequestration monitoring and one Thematic Network. An overview of each project is given below.

AZEP

This highly innovative project is carrying out research to develop a new chemical process for the capture of CO_2 from combustion gases in power plant. The project also aims at reducing the cost of pre-combustion capture of CO_2. If successful, it will provide a process for producing an almost pure stream of liquid CO_2 for subsequent storage and as such it complements the various CO_2 sequestration projects in this area.

GRACE

Here, RTD is being undertaken on processes for the capture of CO_2 from non-power producing plants such as refineries. The aim is to produce a step change in the cost of post-combustion adsorption with amines

GESTCO

This study, involving organisations from most Member States, includes geological surveys to study and quantify the CO_2 sequestration potential in terms of sources and sinks in Europe.

CO_2STORE

The aim is to investigate four new potential sites for CO_2 reservoirs, mainly on land. It will continue to undertake reservoir simulations and study geo-chemical reactions in order to develop final-fate prediction models. This study builds on earlier activities by including new seismic observations and introducing differential seismic techniques, better suited for use on land.

NASCENT

This study is examining naturally occurring CO_2 reservoirs to establish the mechanisms that ensure retention of CO_2 over geological periods of time. The results so obtained will have a significant input into establishing the feasibility of sequestration of CO_2. In addition to organisations from the member states, there is also input from the IEA Greenhouse Gas Programme and from partners in the USA.

RECOPOL

This project is designed to provide a larger scale demonstration project of the potential for injecting CO_2 into deep coal seams for storage and in order to displace and collect coal-bed methane for subsequent use. It is being undertaken in a polish coalfield.

WEYBURN

This project provides support for European teams monitoring the behaviour of CO_2 transported by pipeline from the USA and then used for enhanced oil recovery in the mature and well-documented Weyburn oil field in Canada. The work involves collaboration with partners from the USA and Canada.

TABLE 1

The current portfolio of EU funded research projects

European project acronym	Topic	Total cost (M€)	EC funding (M€)	Coordinator
AZEP	Advanced membrane cycles	9.3	3.4	*Siemens*
GRACE	Capture in processes	3.2	2.1	*BP*
GESTCO	Sequestration potential	3.8	1.9	*GEUS*
CO_2STORE	SACS2 follow up on land	2.4	1.2	*Statoil*
NASCENT	Natural storage analogues	3.3	1.9	*BGS*
RECOPOL	Enhanced coal bed methane	3.4	1.7	*TNO*
WEYBURN	Weyburn monitoring	2.2	1.2	*BGS*
SACS2	Monitoring of sleipner	2.1	1.2	*Statoil*
CO_2NET	Thematic network	2.1	1.4	*Technology Initiatives*

SACS2

This project provides support for European teams monitoring the behaviour on CO_2 collected and injected into an aquifer in the North Sea. This is providing valuable data on transport rates, geophysical properties and potential leakage and/or natural sealing mechanisms.

CO_2NET

This is the CO_2 thematic network, which brings together the stakeholders in the field to facilitate the development of CO_2 capture and storage; a safe, technically feasible, socially acceptable mitigation option.

The projects listed above are supported within the Fifth RTD Framework Programme of the EU. In addition, there is funding available for this priority RTD area within FP6. The first FP6 call was published in December 2002, with a budget of 198 M€ for medium to long-term energy research. Assessment of the proposals received was carried out in the Spring 2003 and negotiations are currently under way on a number of proposed projects with contract signatures expected by the end of 2003. The projects under negotiation are summarised in Table 2.

TABLE 2

RTD projects under negotiation

Project acronym	Project type	Topic
ENCAP	IP – Integrated Project	Enhanced capture of CO_2
CASTOR	IP – Integrated Project	CO_2 from capture to storage
CO_2SINK	IP – Integrated Project	*In situ* laboratory for capture and sequestration of CO_2
CO_2GeoNet	NoE – Network of Excellence	Network of excellence on geological sequestration of CO_2
ISCC	STREP – Scientific Technical Research Project	Innovative *in situ* CO_2 capture technology for solid fuel gasification

The proposed support for these projects reflects the commitment by the EU to continue to create and develop the European Research Area. A short description of each project is given below. These future projects represent a total EC funding of the order of 35 M€ and a total cost of the order of 60 M€.

ENCAP

This project has been put forward by major players within the EU power industry to establish the basis for the integration of enhanced CO_2 capture techniques within fossil fuel power plant concepts.

CASTOR

This project builds on earlier work to develop effective, innovative techniques for CO_2 capture and storage.

CO_2SINK

This project offers the prospect of a large-scale land based detailed study of CO_2 sequestration, with the basis for an *in situ* laboratory being established at the demonstration site.

CO_2GeoNet

This network of excellence is designed to bring together the key research institutes to rationalise and share their resources in order to create a critical mass capable of responding positively to the European challenges for geological sequestration of CO_2.

ISCC

This project will undertake RTD to develop innovative techniques for *in situ* capture of CO_2 appropriate for solid fuel gasification technologies.

6 INTERNATIONAL COOPERATION AND COORDINATION ACTIVITIES

Within the EC, there is a clear recognition that the need to deal with environmental challenges requires an international approach. Accordingly the EC is involved in a wide range of international cooperation and coordination activities that complement the RTD activities that they manage directly.

Thus, the EC takes an active role in the International Energy Agency (IEA) of the OECD. It participates in the "Committee of Energy Research and Technology - CERT" and in the "Working Party on Fossil Fuels - WPFF", with a particular role in the "Zero Emission Technologies - ZETS" strategy.

It also sponsors and participates in the IEA "GHG" Implementing Agreement and in the IEA "Clean Coal Centre" Implementing Agreement.

In addition, the EU, via the EC, has Science and Technology Cooperation Agreements with many countries such as Argentina, Australia, Canada, China, India, Russia, South Africa, the United States and others. The EC has also signed a Memorandum of Understanding with the United States Department of Energy (DoE) and is a Member of the Carbon Sequestration Leadership Forum (CSLF), which is an initiative led by the United States.

Within the EU, the EC is involved in the co-ordination of Member State activities as part of the creation of the European Research Area. At the policy strategy definition level, co-operation may be done through open co-ordination in which Member States voluntarily agree to coordinate amongst themselves in an informal way. With regard to RTD itself, coordination is carried out at the project level through STREPs, IPs, Networking and Coordination actions that are the instruments of the EU Framework Programmes. It may also be carried out at the Programme level through ERA-NET activities. Of relevance here is a project under negotiation to undertake a specific support action for Fossil Energy Concerted Actions. The intention is to establish the feasibility for a subsequent co-ordination action that could create the basis for a unified approach within Europe for the development of near zero emissions technologies and carbon management strategies for fossil fuel power generation.

CONCLUSIONS

The European Union's research priorities include the need to establish sustainable development, with energy as a key aspect, while ensuring EU industrial competitiveness. The future fuel mix is expected to be diverse, thereby ensuring security of supply, and fossil fuels will be part of that mix provided that environmentally acceptable techniques can be established, with the emphasis on carbon management. Accordingly, when considering a post-Kyoto scenario, the development of CO_2 capture and sequestration systems associated with fossil fuel power plants is a key priority within the RTD Framework Programmes of the EU.

There is now a significant RTD Programme that is designed to ensure both cost effective, safe and environmentally compatible disposal options together with the technology for CO_2 capture thereby enabling cleaner and more efficient fossil fuel plants. This is being undertaken by EU industry in collaboration with research institutes and universities. The involvement of EU industry is critical since they are the technology stakeholders that will subsequently have to compete in the global market place.

In addition, there is a clear recognition that the need to deal with global environmental challenges requires an international approach. Accordingly the EC is involved in a wide range of international cooperation and coordination activities that complement the RTD activities that they manage directly.

A great deal of additional information on the European Union is available on the internet.

It can be accessed through the Europa server (http://europa.eu.int).

LEGAL NOTICE

Neither the European Commission, nor any person acting on behalf of the Commission is responsible for the use which might be made of the information contained in this publication. The views expressed here are those of the authors and do not necessarily reflect those of the European Commission.

REFERENCES

1 (2001) European Climate Change Programme, European Commission Report.

2 (2003) World Energy, Technology and climate policy Outlook 2030, WETO. *Official Publication of the EC*, Report EUR 20366, Luxembourg.

3 (2002) World Energy Outlook, IEA.

4 (2000) Towards a European Strategy for the Security of Energy Supply, COM 769 final

5 (2002) First call for FP6 RTD, *Official Journal of the EC*.

Final manuscript received in July 2004