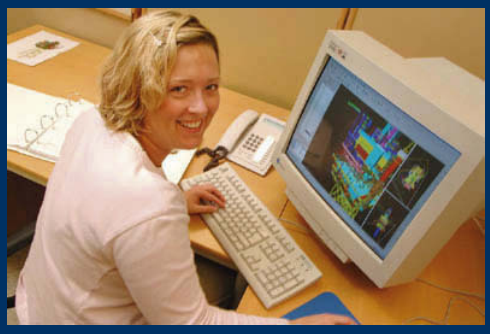
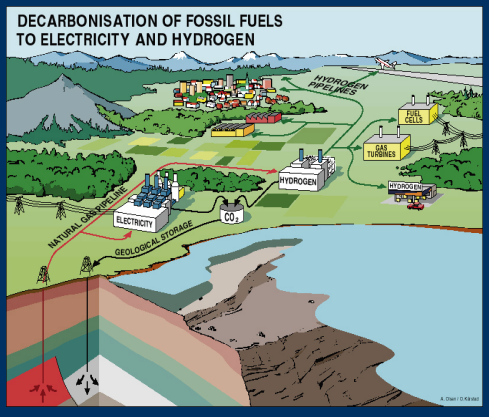
Oil & Gas Industries Technology Master Plan

A contribution to the European Research Area (ERA)





By
Eurogif (European Oil and Gas Innovation Forum)

February 2004

Table of Contents

Executive summary 3

1. Introduction 6
2. Business drivers and industrial opportunities 6
3. The importance of the offshore oil and gas industry 10
4. The importance of R&D for the offshore oil and gas industry 10
5. The need for a co-ordinated, European R&D approach 12
6. Our R&D base – Eurogif thematic networks. 13
7. Technology challenges and opportunities. 14

Appendix 1: 17

Eurogif Thematic Networks and anticipated R&D priorities:

- TN1 Quality, Health, Safety and Environment (TRENDS) 18
- TN2 IST Oil and Gas Technologies and Knowledge Forum 21
- TN3 Floating Structures Technology (FLOATTECH) 22
- TN4 Subsea and downhole production systems (SEARCH) 24
- TN5 Smart reservoir net. 26
- TN6 Materials (Not launched, incorporated in other TN's) 28
- TN7 Environmental Gas Technology. 29
- TN8 CO2 Net. 30

Glossary 32

Executive summary

This is the Technology Master Plan (TMP) of the European Oil and Gas Innovation Forum (Eurogif). It sets out the research and technology development priorities of the European service and supply industry,which makes up the membership of Eurogif. The purpose of the Technology Master Plan is to identify a set of R&D priorities that will enable the European Service & Supply Industry in co-operation with the operators, universities and research institutes to develop the technology needed to find and produce fossil energy with a minimum of discharge and emissions, whilst also developing ways to use fossil fuels more intelligently through decarbonisation and CO2 Management.

This Technology Master Plan is based on the priorities developed in the thematic networks organised by Eurogif in the 5th Framework Programme (FP5), with additional themes and priorities added to ensure that oil and gas can both satisfy the energy needs in the short to medium term with improved environmental performance, and also provide a bridge to the longer term objectives of the hydrogen economy.

The World Energy, Technology and climate policy Outlook (WETO2030) projects an increase in world energy demand of 1.8%/year between 2000 and 2030. The world energy system will continue to be dominated by fossil fuels with almost 90% of total energy supply in 2030. Oil will remain the main source of energy (34%) followed by gas then coal (28%). A 100% increase is projected for natural gas, which in 2030 would represent one quarter of world energy supply, with power generation providing the bulk of the increase.

New renewable energies will only account for 4% of the world energy mix. The nuclear energy share is limited by public and political acceptance issues as well as the time needed to develop, qualify, get acceptance and deploy safer and more efficient technologies.

In the EU, natural gas is expected to be the second largest energy source, behind oil but ahead of coal and lignite. Nuclear and renewable energies would altogether represent slightly less than 20% of EU energy supply.

As energy drives the economy, the industry will have to respond to two major challenges:

1. How to find and develop sufficient resources to ensure security of energy supply.
2. How to conceive and deploy solutions to limit emissions associated with fossil fuels.

The European oil and gas industry has developed, over the last 30 years, the technologies needed to enable the North Sea to provide 43% of the oil and 64% of the gas consumed in Europe in 2000. European companies have achieved a 20% share of a very competitive 150 billion euro global services and supplies market, while retaining 70% of the European market, thereby contributing significantly to the European balance of trade and employment.

EUROGIF, with support from FP5, has brought together 170 companies, research institutes and universities in thematic networks. The key challenges and business opportunities will be found within the areas of mature fields, deep and ultra deep water, natural gas and non-conventional reservoirs, including decarbonisation and the transition to the hydrogen economy. A private-public partnership in this area can result in a major step on the road to sustainable development and position EU companies as leaders in providing the relevant enabling technologies to the worldwide market.

EUROGIF has therefore developed this Technology Master Plan with respect to both finding and developing the oil and gas resources needed to satisfy global energy demand and developing technologies enabling the use of fossil fuels with less CO2 and NOx emissions.

The key technology challenges regarding **security of supply** are:

- **Getting more from fields in production**.

These "mature fields" today account for over 70% of the world wide oil and gas production. Innovative and cost effective technologies should be developed to substantially increase the rate of recovery from todays average of 35% to over 50% for oil and 75 % for gas, optimize the efficiency of operation and maintenance while minimizing the environmental impact. This will have a major effect on reserve renewal rate as 1% improvement on the drainage of reservoir would provide an additional 2 years of supply. Extending the life of existing fields is important as premature shutdown can preclude development of new fields as the necessary infrastructure will have been abandoned.

- **Exploitation of deep and ultra deep offshore reservoirs.**

At present, a mere 2% of prospective resources have been explored in deep and ultradeep waters. A study made by IFP concluded that 40% of the oil & gas will come from water depths to 500m, 20% between 500 and 1500m and 40% from 1500 to 3000m. New solutions will be needed to exploit ultra deep resources, including such solutions as smart subsea systems coupled to floating production units with natural gas conditioning and conversion taking place offshore.

- **Non conventional fossil energy resources.**

While the development focus in the short to medium term will be on conventional oil and gas, in the longer term the non conventional resources like heavy oils and tar sands with an estimated potential of 650 Gt, natural gas hydrates with an estimated potential of 10.000 Gt, as well as coal base and coal mine methane resources should be researched and characterized for future development.

With the forecast increase in demand for fossil energy, we will have a corresponding increase in greenhouse gas emissions unless steps are taken to **decarbonise the fuel**. There are three key solutions:

- **Migration to natural gas**.

Switching from coal, oil and orimulsion to natural gas provides real environmental benefits by way of reduced emissions. To enable a global migration to natural gas, further technological developments should be made along the whole gas chain. This should include production, conditioning including conversion to LNG, transportation and distribution to user communities in an efficient and economical fashion. Special attention should be given to technologies for cleaner centralized/decentralized power generation by way of high efficiency turbines, microturbines, decentralized CHP and the use of CNG/LNG in transport systems.

- **CO_2 capture and storage:**

The CO_2 , which is produced at the well site together with oil and natural gas, could be treated and reinjected on site in the reservoir. At central power generation plants, it could be captured, conditioned and transported for injection in depleted Oil & Gas reservoirs, deep saline aquifers or used economically for Enhanced Oil Recovery (EOR). Research efforts are also needed to evaluate the possibility for CO_2 mineralization at central power generation plants.

- **Migration to hydrogen:**

  The fossil energy industry has the opportunity to be the key contributor to the transition towards the hydrogen economy. Technologies will have to be developed for production from fossil sources (mainly natural gas), conditioning , storage, distribution and conversion.

  Future production of hydrogen from fossil fuels will be combined with the technologies for capture, use and storage of CO_2. The conversion to electricity and heat will be carbonless and optimized through the utilization of fuel cells on all segments of the industry: stationary, mobile and portable.

  All the technologies developed for hydrogen storage and distribution infrastructure will be extremely beneficial to the deployment of renewable energies, alleviating their major drawback of geographic distribution and intermittent operation.

Successful development of new technologies to achieve both security of energy supplies and attain long-term goals of a fully integrated hydrogen economy will necessitate a massive investment in R&D. The EU goal of achieving a step by step shift towards a fully integrated hydrogen economy based on renewable energy sources by the middle of the century can only be achieved through transitional phases, development of fossil fuels and renewable energy sources and international co-operation.

Strong public support will be a key enabler in the implementation of the European energy strategy. EUROGIF will play a major role in the definition of the priorities of the 2nd phase of FP6 and the forthcoming FP7. In parallel, EUROGIF will continue its effort to develop and have labeled an oil and gas Eureka cluster, EUROGIA, as well as seeking to promote Joint Industry Projects with contribution from national programmes.

Turning policy into reality will require a strong commitment to public/private partnerships which will allow the European energy industry to further develop industrial capabilities and global competitiveness.

1.Introduction

EUROGIF, the European Oil and Gas Innovation Forum, was formed in 1996 by major companies and industry associations representing more than 2500 organisations of the European oil and gas equipment and supply industry (i.e.; large Companies, SME's and research establishments etc). The Eurogif mission is to stimulate innovation, pan-European collaboration and technological progress to improve industry competitiveness within the context of sustainable development. EUROGIF membership comprises:

- Major companies across the whole service & supply industry, such as Saipem SpA (Italy), CGG, Saipem SA, Schlumberger, Technip-Coflexip (France), Aker Kvaerner (Norway) Fugro, IHC Calland(the Netherlands), Izar (Spain). Working together and with the SME community, this forms the critical mass required for the innovative development of new technology.

- European industry associations such as the French GEP, the Italian Assomineraria, the Dutch IRO, the Norwegian TBL and the British Energy Industries Council (EIC) which represent the wider community of companies, large and small, as well as providing a link to the national research programmes and a channel to disseminate information and engage companies in R&D.

- Organisations, such as Scottish Enterprise (SE) and the Industry Technology Facilitator (ITF) in Scotland and the Norwegian R&D Team (FoUTN),.

In the period 1999 to 2002 Eurogif initiated the development of a number of Thematic Networks (TN's) representing the upstream oil-and gas value chain. The purpose was to engage the industry in identifying technology gaps with a view to selecting priority actions that would meet the needs of the offshore oil and gas service and supply industry ,explore all available opportunities that provide incentives to trans-national collaborative research work whilst contributing to the EU policy objectives on sustainable development and security of supply. Four of these TN's have been co-financed by the EC under FP5 with a three year workprogramme involving more than 170 organisations, contractors, SME's, Research Institutes and universities from 17 European countries (including Russia).

This Technology Master Plan supports the principles and policies outlined in the following key EU policy statements:

- ✓ Communication to the Council and the European Parliament on the development of energy policy for the enlarged European Union, its neighbours and partner countries, COM(2003) 262 final.
- ✓ Communication from the Commission, Investing in research: an action plan for Europe, COM(2003) 226 final, which advocates a significant increase in R&D investments.

The Plan seeks to bring together the thinking, expected results and recommended research priorities from the thematic networks and Eurogif members in a coherent plan. It highlights the market opportunities and challenges facing the industry and gives a roadmap to technological advances that can be achieved through a successful public-private partnership.

2. Business drivers and industrial opportunities.

The oil and gas industry has undergone a substantial restructuring over the last few years. Globalisation has led to mergers and acquisitions, not only among the operators, but also in the service and supply industry. The operators have increasingly focused on their core businesses of exploration, production and sale of product, and been less willing to take the financial risks inherent in the development and testing of new technology. There is an increasing tendency for operators to want to buy field tested technology wherever they can acquire it, be it in Europe or from the USA or Far East.

The risks and responsibilities for developing new technology at a pace to match new challenges in terms of deep water, hostile environments, difficult reservoir and new transport solutions have been forced down into

the supply chain, and the suppliers have had no choice but to accept the challenge. This has happened at the same time that the industry is striving to improve health, safety and environmental performance.

The demand for energy will continue to increase in spite of efforts to achieve greater energy efficiency according to a recently published EU study : “World energy, technology and climate policy outlook” (WETO 2030):

- ✓ World oil production is projected to increase by 65% to 120 mill. bbl/day in 2030, with three quarters of the increase coming from OPEC countries. OPEC will account for 60% of oil supplies in 2030 compared to 40% in 2000.
- ✓ Gas production is projected to double between 2000 and 2030, with one third of total production originating in the CIS in 2030, the remaining production being almost equally allocated between other regions.
- ✓ Coal production is also expected to double between 2000 and 2030, with most of the growth taking place in Asia and Africa, where more than half the coal will be extracted from.
- ✓ Electricity production will increase steadily at an average rate of 3% per year. More than half the production in 2030 will be provided by technologies that emerged in the 1990’s and afterwards, like combined cycle gas turbines, advanced coal techniques, nuclear and renewables. New renewables will double its share from 2% in 2000 to 4% in 2030, mainly because of production from wind.

The projected EU energy consumption is shown in Figure 1. Natural gas increases strongly at the expense of coal, lignite and oil. By 2030 oil will have a share in EU of 39% while gas will have increased to 27%, mainly through continued fuel switching and use in electricity production as shown in Figure 2.

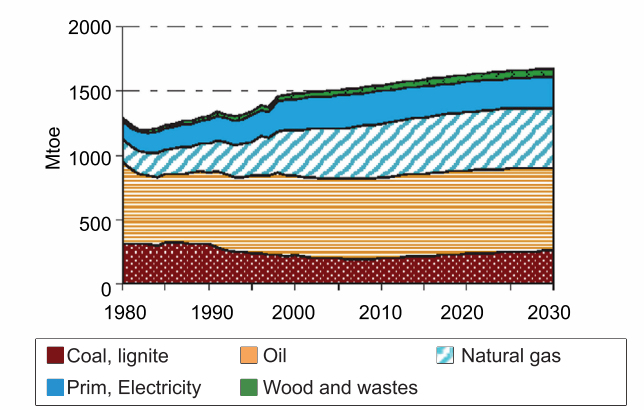


Figure 1 - EU energy consumption 2030

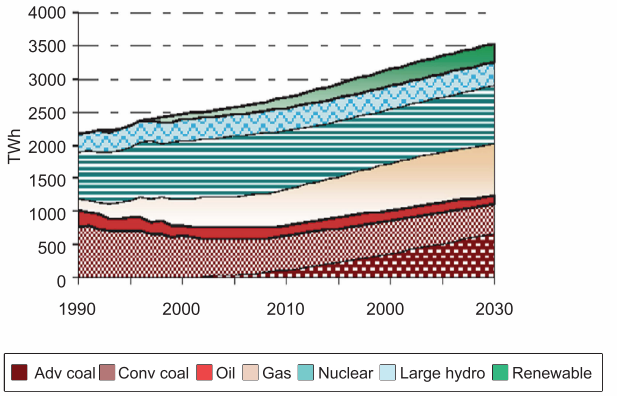


Figure 2 - EU electricity generation by fuel

The continued increase in demand has led to a greater global activity for the oil and gas industry and significant opportunities for European companies, provided they are competitive in terms of providing the right solutions to the right price. European companies are competitive in Gulf of Mexico, Brazil, West of Africa and the Far East, but are meeting increasingly aggressive competition from US companies backed by strong financial and political support. In the North Sea, through the application of new technologies, we have been able to produce ever more oil and gas with a steady improvement in environmental performance, as shown in Figure 3. With further development, this will be of great interest in the global areas rich in gas resources as shown in Figure 4.

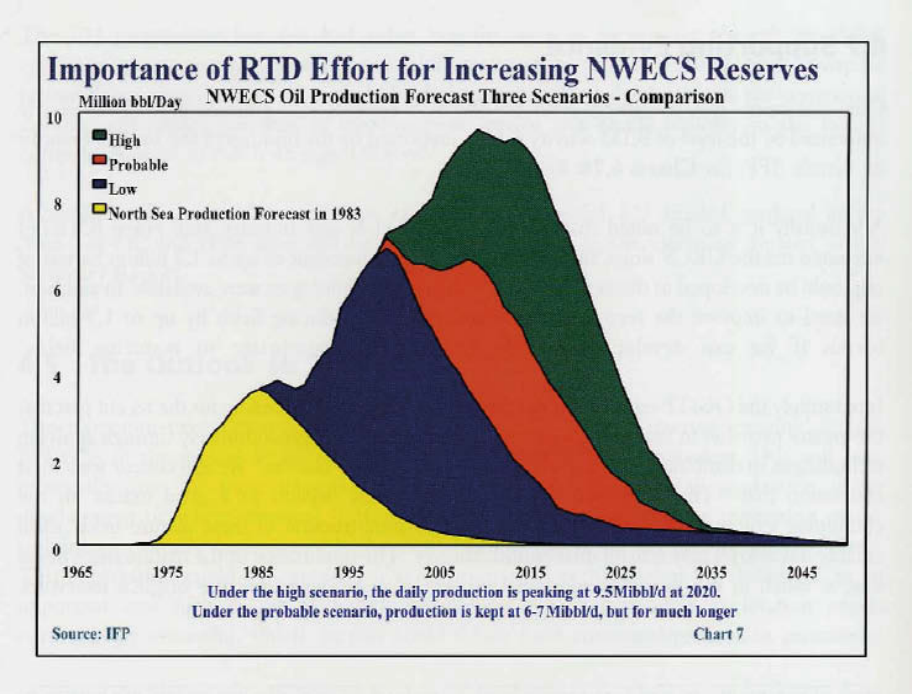


Figure 3 - New technologies, extended production

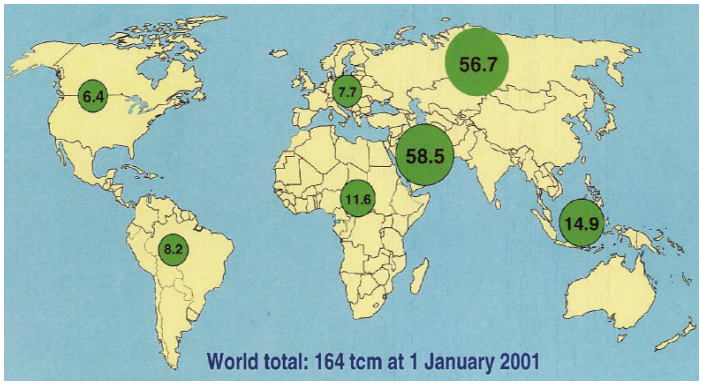


Figure 4 - World gas reserves

The ultimate remaining resources in terms of gas have been estimated by IEA to be between 453 and 527 tcm. In Europe, the investment we make in new technology will enable us to find more oil and gas resources and develop these in a safe, efficient and more environmentally friendly way. A large part of the natural gas resources shown in Figure 4 will require new technology and more efficient transport systems for commercial development. This applies, in particular, to the resources in the Arctic areas and in ultra deep water. Resolving these challenges will make a significant contribution to the security of supply objectives set in the recent EU Green Paper on Energy.

The global hunt for new oil and gas resources is leading us into ever deeper waters and harsher environments with new challenges to people, procedures and production equipment. The accellerating trend is shown in Figure 5. In terms of sustainable development, gas will provide the bridge to the hydrogen economy as shown in Figure 6:

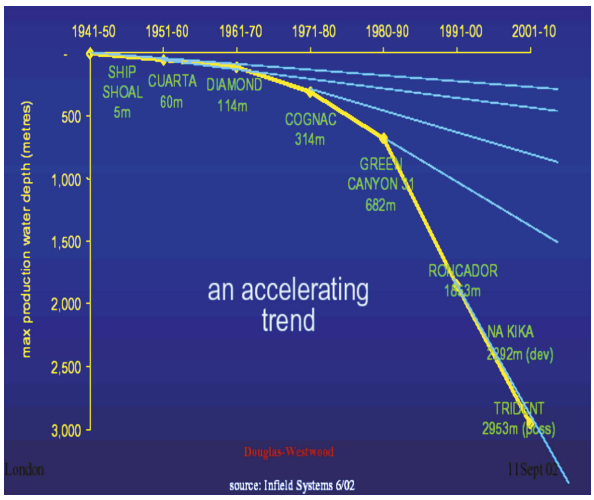


Figure 5 - Deepwater oil and gas developments.

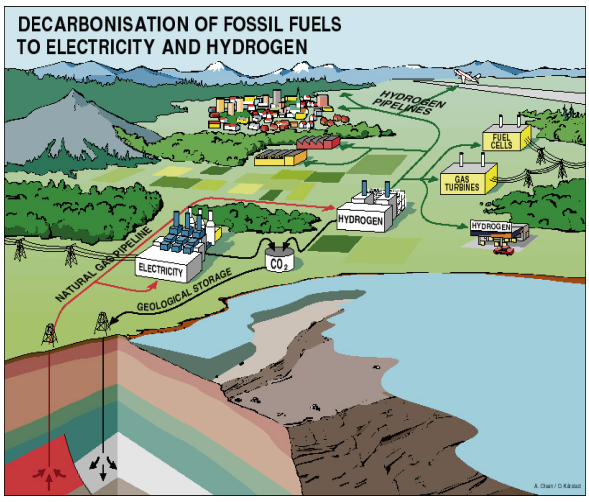


Figure 6 - Natural Gas to electricity and hydrogen.

The key areas of application and industrial exploitation for oil and gas technologies will be:

- Safety, reliability and environmental technologies, systems and procedures.
- Information and communication technologies, system engineering as enablers.
- Seismic, survey, characterisation to enable improved hit rates.
- Smart reservoirs, intelligent fields for improved recovery rates for oil and gas.
- Subsea and downhole production systems, for deepwater, safe and efficient production.
- Floating production systems for deep water, floating LNG, GTL and Methanol solutions.
- Pipeline and transport systems, multiphase and flow assurance.
- Non-conventional oils, such as heavy oil, tar sands, tight gas, CBM, CMM and gas hydrates.
- CO2 management, sequestration or injection in reservoirs for improved recovery rates.
- Gas chain, including hydrogen production, storage, distribution and fuel cell systems engineering.

These challenges are being addressed in the Eurogif thematic networks and R&D priorities and proposals will be generated to convert improved knowledge into commercial technology which will be competitive in the global market. Eurogif believes that it is essential that the EU ensures continuity in financial support to R&D through the successive FP's and other instruments to enhance European private-public partnership and wealth creation.

The pace in development of renewable resources is not progressing as fast as anticipated. We believe application and development of offshore technologies to the field of marine renewables, ie. offshore wind, wave and tidal energy systems can help this sector. The transfer of knowledge and experience, combined with the industrial capability within the cluster should make a real difference.

3. The importance of the oil- and gas industry.

The oil and gas industry in Europe represents one of the more important industry sectors in Europe. It is literally fuelling the economic and social development in Europe, whilst also providing the raw materials and feedstock to associated industries such as petrochemicals and pharmaceuticals. Energy, especially oil and gas, is of vital importance to the prospective member states. Some of these have participated in the Eurogif thematic networks.

The oil and gas industry is not limited to the large oil companies, as often perceived by the public at large, but includes a wide range of associated businesses such as engineering companies, equipment manufacturers, contracting companies, terminals, shipping companies, classification societies, finance, insurance etc., all of them underpinned by a substantial base of knowledge and R&D. The industry is by far the largest user of advanced information and communications solutions and provides the best hope for an accelerated development of renewable energy, especially marine renewables such as offshore wind, tide and waves.

The offshore production in the North Sea supplied 43% of the oil and 64% of the gas consumed in Europe in 2000. With a maturing North Sea and increasing demand for oil and gas, an effort needs to be made to increase the indigenous share, thus reducing import dependency and achieving more flexibility.

European suppliers account for about 70% of the total market in Europe and 20% of a $ 150 bill. global market. Although the industry today employs about 750.000, the European market alone is not big enough to support and grow the industry. Global competition has to be faced and other markets penetrated or European industry will decline and other parties will assume control of our energy technologies and energy resources.

European technology has ensured progressively cleaner and safer exploration and production operations in Europe. Moreover, the technology has the potential to be applied elsewhere in the world with a real contribution to better resource management and improved environmental performance. To maintain this technological edge and improve the competitiveness of the SME's, which represent a large and innovative segment, the R&D investment needs to be more focused, projects need to be clustered and the funding of R&D needs to be increased. The benefits of this will be:

- ✓ Reduced dependency on oil and gas imports from 90% to 70% by 2020 by maximizing the use of indigenous resources, while also improving global environmental performance.
- ✓ Substantial European GDP increase, improved government tax and license income by approx. 1 billion Euro/year due to increased production and extended life of North Sea field developments.
- ✓ Safeguarding and developing 750.000 jobs in Europe, retaining and developing key skills and technologies, thus strengthening the influence on the management of indigenous energy resources and encouraging social and economic development.
- ✓ Helping secure for European industry 70% of the European market, estimated to be $ 50 billion annually and 20% of the global market estimated at $ 150 billion.

4. The importance of R&D for the oil and gas industry.

To maintain the competitive position of Europe vs. the rest of the world, investments are needed in intangible assets like competence and skills. To this effect, R&D is an important means to develop the intellectual capital the European oil and gas industry must develop and retain. The knowledge based society is recognized in the creation of ERA and fully supported by Eurogif.

Through the development of thematic networks representing the upstream supply chain, Eurogif has demonstrated its vision and commitment to the European Research Area. 170 companies, universities and research institutes and regulatory bodies from 17 European countries are actively involved in this work.

The Green Paper “Towards an European strategy for security of energy supply”, prepared by the Commission defines EU strategy:

“The EC long term strategy for energy supply security must be geared to ensuring, for the wellbeing of its citizens and the proper functioning of its economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial), while respecting environmental concerns and looking forward to sustainable developments, as enshrined in Articles 2 and 6 of the Treaty of the EC.”

According to results of the work carried out in the IEA Energy Outlook 2020:

- The gross energy demand in the EU will be 25% higher in 2030 than in 1998.
- Oil and gas will remain the most important fuel with an expected market share of more than 65%.
- Renewable energy penetration will remain low and will fall short of the 12% target.
- CO2 emissions will exceed their 1990 levels by 2010 and will grow thereafter.
- Decommissioning of nuclear plants would make it even more difficult to tackle climate change in the long term.

In a reaction to this scenario, the Green Paper acknowledges the role of research and development:

“Energy technology will be critical in meeting the needs of current and future generations and de-linking economic growth from growing energy demand and environmental degradation, both in the present EU and in an enlarged Europe. In the energy field, technological change does not come cheap, research is expensive and requires a long development and lead in period and the payback is often uncertain. Thus public funding, including from the EC often has a pivotal role in financing basic research, developing innovative technologies and promoting the substantial stock of energy efficient technologies that are close to being competitive.

In Eurogif’s considered opinion, the 6th FP does not follow up this policy statement. Not only has the budget for non-nuclear energy been cut 35% from FP5 to FP6 to 810 mill. Euro, but oil and gas, which are expected to be our major energy sources for the next 30 years, were not retained as priorities.

Investment by the operators in exploration, development and field operations is important and rather steady, in the magnitude of 100 B Euros/year for upstream operations and an additional 70 B Euros for downstream activities.

Figure 7 overleaf, illustrates the decrease of the R&D investment from operators compared with the steadily increasing investment by the 3 major contractors.

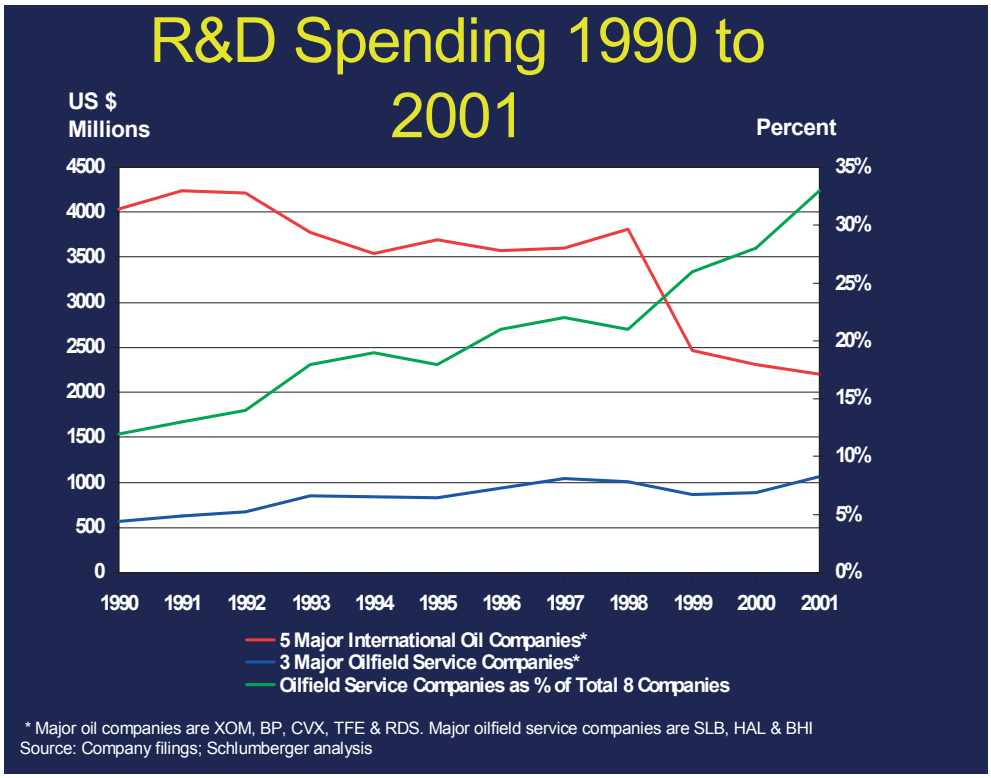


Figure 7 - R&D spending 1990 to 2001

Despite the increased investment by the service sector over the last five years, it can be seen that an increased shortfall in R&D investment has taken place. Today this gap amounts to 1 Bn $ per year, which seriously compromises the successful implementation of the European energy strategy.

This message has been taken onboard by the US Department of Energy. Its current investment of some 5 billion US dollars in technology development to ensure an American hold on the strategic global oil and gas service and supply industry poses an enormous threat to the European service and supplies industry. The European industries, which depend largely on external funding of their research base, urgently requires support in confronting this technological sector, much in the same way the European aerospace industry has required support. Investment in R&D will also underpin the efforts of top research Universities to train high quality graduates representing the future of such an important sector as the energy industry.

5. Need for a co-ordinated, European R&D approach.

The benefits of and the need for a co-ordinated approach to R&D, both for the industry itself and the citizens and institutions in Europe, are highlighted in the Commission's Communication "Making a reality of the European Research Area, Guidelines for EU Research Activities 2002-2006(COM(2000)612).

In this context, Eurogif has set up a Technical Committee consisting of Board Members acting as sponsors for the thematic networks, the network coordinators and representatives of key stakeholders. The objectives of this group are not only to co-ordinate R&D activities across a wide range of projects, but also to define future R&D needs and ways to organize consortiums and access to finance for the necessary development.

The aim of Eurogif and its Technical Committee is to act as the industry interface with the European Commission with respect to R&D in the oil and gas field. This has been recognized by the Commission through the support to Eurogif Thematic Networks.

Eurogif has developed this Technology Master Plan to show how a co-ordinated R&D approach will benefit the society in terms of security of energy supply, improved environmental performance, sustainable jobs and revenue to underpin the welfare and standard of living demanded in Europe. It is by nature a dynamic document that will be updated by the Eurogif Technical Committee as a result of progress in thematic networks, national programmes, or other significant inputs.

Eurogif will seek to use this plan to encourage a greater take up of R&D within the large SME community represented by the industry associations. To this effect Eurogif is, and will remain, actively involved in numerous schemes to support R&D in Europe:

- FP6, policy inputs to Commission and Parliament ahead of mid-term review.
- FP7, policy inputs to achieve a balanced approach for all energy systems.
- Eureka, develop and achieve labelling of a Eureka cluster, Eurogia. A substantial list of projects has already been prepared as a result of a call for expression of interest.
- JIP (Joint Industry Projects), partnerships with oil companies and national R&D programmes.

Eurogif will through its members presently in 17 European countries strengthen the links with national programmes and encourage wider European collaboration.

6. Our R&D base – Eurogif Thematic Networks.

With the responsibility for development of new, cost effective and environmentally friendly technology to meet the industry challenges largely having been transferred from the operators to the service and supply industry, a gap was created in co-ordination as well as in funding of new technology. This problem has not been addressed in the national programmes, which all are under budget constraints and pressures.

Rather than addressing the challenges in the traditional sequence of exploration, production, storage and transport, Eurogif chose to develop a set of thematic networks to bring together the necessary skills and competences to facilitate innovative solutions across the whole value chain, as shown in Figure 8.

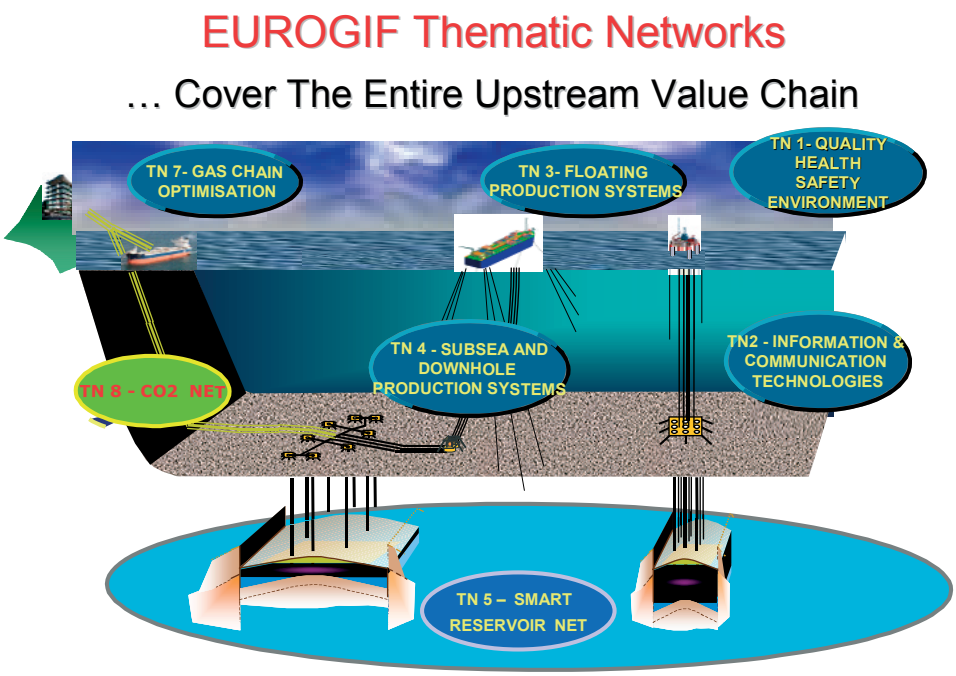


Figure 8 - Eurogif Thematic Networks

The set of Thematic Networks covering the value chain for the offshore oil and gas business was developed with a vision and view towards development needs at the start of FP5. Four networks are well into their three year plans and have started to release state-of-the-art reports and to perform gap analysis with respect to lack of knowledge or R&D activities. Eurogif and the thematic networks aim to:

- ✓ Promote the sustainable development of Europe's hydrocarbon energy industry through collection, development, management and dissemination of the industry knowledge base.
- ✓ Advance the capabilities, underpinning future sustainable energy systems for Europe, focused on high quality, cost effective energy services and diversity of supplies, global industrial competitiveness, reduced environmental impact, enhanced safety, health and social responsibility.
- ✓ Bring together oil/gas/energy companies, contractors, suppliers, facility operators, construction yards, consultants, classification societies, universities, research institutes, government organisations, non-government organisations and facilitate dialogue in a structured but flexible format.
- ✓ Conceive, develop, launch and co-ordinate a wide range of coherent projects in the form of RTD activities, innovative product/process developments, adoption and transfer of best practice, collection, consolidation and exchange of knowledge.
- ✓ Maintain and increase European leadership in the fields of safe and environmentally friendly solutions for a global oil and gas industry.

Appendix 1 gives a summary table of the thematic networks and their work areas as defined in the context of FP5. For each thematic network, future research priorities have also been indicated. These may, however, change as work in the networks progresses over the next 2-3 years.

7 .Technology challenges and opportunities.

7.1 Finding and developing oil and gas resources – security of supplies.

The key challenges and business opportunities in the *short to medium term* for the service and supply industry will be found in three main areas:

- **Mature fields**, which today provide some 70% of the worldwide oil and gas production. Production is gradually declining and fields will be shut down prematurely if technologies for improved recovery and cost effective operation and maintenance are not put in place. In addition to being needed as part of the infrastructure for new fields, it should be noted that on a worldwide basis a 1% improved recovery equates to approximately 2 years energy consumption.
- **Deep and ultra deep waters**, where only 3 mill. km2 of 55 mill. km2 of sedimentary basins of interest have been explored. Institute Francais du Petrole(IFP) has estimated that 40% of the oil and gas will be in water depths from 0-500 meter, 20% between 500 and 1500 meter and 40% from 1500 to 3000 meter. The combination of water depth, environment, reservoirs and lack of infrastructure will require new solutions such as subsea systems combined with floating production and conversion of natural gas.
- **Natural gas**, which previously has been shown to play an increasingly important part in Europe's energy mix. Natural gas enables fuel switching from more CO2 intensive fuels like coal, oil and orimulsion and provides a path to future solutions based on hydrogen. Developing CO2 management technologies to enable capture and commercial use of CO2 should be given priority given obvious uses in enhanced oil recovery and industrial applications. Innovative solutions will be needed to harness vast resources in remote locations and achieve cost effective conditioning and transfer to market, whether by pipelines or LNG carriers.

To enable safe, cost effective and environmentally acceptable solutions in these areas, Eurogif has defined the following set of research priorities:

1. Continued reduction in environmental impact of oil and gas exploration and production towards zero harmful discharge to sea and 30% reduction of emissions to air.
2. Cost effective drilling and exploration methods to accelerate development of new oil and gas field developments.
3. Stimulated recovery and cost effective operations and maintenance, including real time reservoir management and remote operation in order to maximize the value of existing fields in production and enable tie-ins of satellites and marginal fields.
4. Sub-sea and down-hole process systems, combined with long range well stream transport to enable frontier and deep water developments.
5. Deepwater floating production systems inclusive of gas conversion capability for areas without any existing infrastructure or export route for the oil and gas.

In the *medium to long term* it will also be necessary to look at the characterisation and development of non-conventional resources to ensure adequate energy supplies. This will include:

- **Heavy oils and tar sands**, which accounts for an estimated 650 Gt and will require new technological solutions to bring these to market within acceptable price and environmental constraints.
- **Coal mine methane and coal bed methane** could be brought into the world energy mix with the double advantage of both increase in energy supply and reduction in emissions and environmental risks.
- **Gas hydrates**, which offers an interesting prospect in the longer term with its estimate of 10.000 Gt, and as it is widely distributed and many times the remaining natural gas reserves. Ways will have to be found to harvest the hydrates from substantial depths, convert to methane through gasification and integrate into the gas chain for distribution.

7.2 Reducing emissions – the challenge of decarbonisation.

In parallel with the work and funding required to ensure that the oil and gas service industry in Europe remains competitive and able to deliver energy security of supplies through continuous innovation, a private-public partnership is needed to ensure that the same industry also enables environmental objectives to be attained through a gradual shift towards a fully integrated hydrogen economy. The key challenges and business opportunities will be found in the following areas:

- **Enabling migration to natural gas**, where enabling technologies for efficient power generation will be important, both in terms of central generation with high efficiency turbines and in decentralised systems with micro CHP turbines, as well as technology in wider use in transport by way of CNG, LPG and LNG and technology for the use of natural gas in a wide range of industrial applications.
- **CO2 capture, use and storage.** Although fuel switching from coal, oil and orimulsion to natural gas will give significant environmental benefits, future increased use of hydrocarbons must be coupled to CO2 management. In connection with offshore production of natural gas, the capture of CO2 and storage in saline aquifers have been demonstrated on the Sleipner field in Norway. In the US, CO2 has been captured, transported and used for EOR in small onshore wells. Much work does, however, remain before CO2 can be effectively captured, conditioned and used or stored from large producers such as gas fired power plants or industrial plants like steel mills. Technologies, such as those used in IGCC and GTCC should be improved. Refurbished PF plants with supercritical boilers, oxy-firing, CO2 scrubbers or other novel technologies should be encouraged. Key components

such as scrubbers, high efficiency boilers, sorbents, membranes and compressors, needed to bring the cost down should be further developed.

- **Migration to hydrogen**, which in a balanced and robust energy portfolio offers the best hopes for deep cuts in emissions, provided technologies for large scale hydrogen production are developed. New, renewable energies such as wind, wave, biomass, solar etc. will not on their own enable large scale hydrogen production and deployment. Conversion of natural gas with CO2 management offers the most likely transition, a path that will help align the energy industry with EU environmental objectives. Technologies will have to be developed and qualified with respect to production (partial oxidation, steam reforming), transport (liquids, compressed, mixed with natural gas), storage (compressed gas, hydrides, carbon nanostructures) as well as in connection with systems built around cost effective fuel cells.

It should be noted that all of the technologies developed to enable storage, distribution and the use of hydrogen will be extremely beneficial to the deployment of renewable energies, mitigating the major drawbacks of geographic distribution and intermittent operation.

The Oil and Gas service and supply industry can, in close collaboration with universities and research institutes, develop the technologies needed for a more efficient exploitation of mature fields, deep and ultradeep offshore reservoirs and non-conventional resources, while at the same time ensuring a radical decarbonisation of the energy process through capture and storage of CO2, migration to natural gas and further to hydrogen, which is the ultimate goal of the EU energy strategy.

The Oil and Gas service and supply industry can, however, not do this alone. By organising 170 companies, universities and research institutes from 17 European countries in thematic networks with EU support in FP5, Eurogif and the EU have together made a start on the ERA for oil and gas. To move it forward, to strengthen it and expand it, continued support and opportunities for funding must be made available in both FP6 and FP7, as well as through Eureka and national programmes.

Appendix 1. Eurogif Thematic Networks and anticipated R&D priorities.

The following figure shows the thematic networks, the number of partners and co-ordinator, their work packages and the organisations responsible for leadership of each work package.

Eurogif Thematic Networks(TN), their Work Packages(WP) and Work Package Leaders.			
1 TN1- TRENDS **Quality, Health, Safety, Environment,** **Coordinator: Veritas (Norway)** **65 Partners**	1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9	Environmental Impact Health & Safety Quality & Reliability Social Responsibility Regulations, Codes, Standards Complementary Initiatives Competence and Training New Technological Solutions ICT and QHSE	Marintech South(UK) Bureau Veritas(France) Cranfield University(UK) Foundation, Business, Society(N) Veritas(Norway) D'Appolonia(Italy) MSR(Holland) Schlumberger/Kvaerner Risøe(Denmark)
2 TN2- GOTeK **Information and communications technology** **Coordinator: Schlumberger Sema (Spain)** **24 Partners**	2.1 2.2 2.3 2.4 2.5 2.6 2.7	E-learning/E-training E-work E-business/E-commerce Decisions and Knowledge Standards Data Security New, Advanced Technology	NExT Ltd.(UK) Fireandblast.com(UK) Schlumberger Sema(Sp) IFP(France) CEN/ISSS Schlumberger (France) CGC(France)
3. TN3- FLOATTECH **Floating Production Structures & Systems** **Coordinator: Aker Kvaerner (Norway)** **37 Partners**	3.1 3.2 3.3 3.4 3.5 3.6 3.7	Tools, hydrodyn/structural analysis Mooring and station keeping systems Riser technology Marine Operations Efficient topside facilities Ultra deep floaters Cost effective floating production systems	MCS(Ireland) Veritas(Norway) IFP(France) ComexStoltOffshore(F) AMEC(UK) Saipem s.a(France) AkerKvaerner(Norway)
4. TN4- SEARCH **Sub sea and down hole production systems** **Coordinators: Aker Kvaerner(N) and Saipem(I)** **38 Partners**	4.1 4.2 4.3 4.4 4.5	Flow Assurance Infrastructure development Intervention Systems Pumping and Process Risk Evaluation	IFP(France) ComexStoltOffshore(F) Halliburton(UK) AkerKvaerner(Norway) Kockums(Sweden)
5. TN5-SMART RESERVOIRS **Smart reservoirs and intelligent fields.** **Coordinator: Schlumberger (France)** **51 Partners**	5.1 5.2 5.3 5.4 5.5 5.6 5.7	Well Construction Field Production Field Conversion Systems design, optimisation, modelling Measurement and Control Materials Standards and Regulations	Halliburton(UK) IFP(France) Geostock TNO(Holland) Schlumberger(France) MERL(UK) GEP(France)
6. MATERIALS		Not launched as separate network. Material requirements are reviewed in each of the thematic networks where appropriate.	
7. TN7-ENVIRONMENT GASTECH **Optimisation of gas chain from reservoir to end user.** **Coordinator: Saipem s.a** **38 Partners**	7.1 7.2 7.3 7.4 7.5 7.6	Resource Management Resource Characterisation Gas Treatment Gas Conversion Gas Transport Final Users	Saipem s.a(France) IFP(France) Linde(Germany) AkerKvaerner(Norway) Saipem(Italy) GWI(Germany)
8. TN8- CO2 Net **Coordinator:Technology Initiatives(UK), Statoil(Norway)** **20 Partners**	8.1 8.2 8.3 8.4 8.5 8.6	Network Collaboration Centre of Excellence RTD Strategy Exploitation Training and Education	Technology Initiatives(UK) Novem(Holland) Imperial College(UK) TNO(Holland), GEUS(Denmark) IFP(France) Novem(Holland)

In the following, a brief description is given of each of the thematic networks and their anticipated future R&D priorities.

1. TN1(TRENDS) – Quality, Health, Safety and Environment (QHSE).

The TRENDS network brings together organisations from across Europe to address the present and future challenges in QHSE for the hydrocarbon energy industry. The TRENDS network has 64 partners and 6 observers from 13 countries. The three year programme has a budget of 4.48 M€ of which 2.62 M€ is funded by two EC contracts under FP5.

The overall goal of TRENDS is to identify and address major QHSE challenges associated with the effort to meet Europe's need for a secure, safe and sustainable supply of energy. In the short to medium term this is particularly relevant to the oil and gas industry, given the dominant position of oil and gas in the energy mix. In the medium to long term, similar issues will have to be fully addressed for other energy sources and carriers (i.e. marine renewables and hydrogen).

Further operationalisation of sustainable development and triple bottom line reporting are guiding stars for the work being performed in TRENDS.

Environmental Impact.

The network recognises the progress having been made by the industry in the QHSE area over the last few years through reduced emissions to air, reduced chemical discharge, and cleaner produced water exemplified by 70% capture of VOC under offshore loading, 30% reduced chemical discharge.

With new challenges in terms of deep water, hostile environments, high pressure/high temperature reservoirs and extending production at ageing facilities the network recognises the potential for further improvements. The state-of-the-art report suggests the following gaps in knowledge and research topics:

- ✓ A better understanding of the effect of mixtures of pollutants is important, coupled to the impact in deep and arctic waters and better tools for assessment of chronic/accumulated effects.
- ✓ Models, monitoring, management and decision support should be improved with respect to emissions to air and discharges to sea. Oil spill response capability should be improved.
- ✓ Modelling of CO2 and H2S gas injection should be improved and combined with underground monitoring after injection to ensure a stable state without leakage.

The final goal in the environmental area is to arrive at solutions and systems that leave no footprints (zero tolerance philosophy).

Health and Safety (WP2)

Although both operators and service and supply companies have gone to considerable lengths to improve health and safety aspects of the work, unnecessary accidents and injuries are still happening. Most of these can be attributed to culture and human factors, although other factors could be mechanical/material failure or environmental. Several recent reports indicate an increase in the risk levels for offshore activities. It is of uttermost importance to change this back to a development of continued decrease in risks and incidents to ensure sustainable operations in the future. Suggested areas for further work:

- Continued assessment of human factors, seek improvements in individual behaviour and attention to health and safety.

- Improve management by better understanding and systems for processing data (i.e. improved emergency response methods, improved fire fighting).
- Identify critical issues that can be improved through technological solutions (i.e. improved fire and explosion resistant wall structures, identification and classification of nominal explosion overpressures).
- Assess the true costs and benefits of improving HSE

Quality and reliability.

As exploration and production moves into deeper water, more hostile environments and tried and tested platform technology has to be replaced by floating production systems and sub-sea installations and production, quality and reliability must be improved to achieve cost effective and safe operations. Extending the life of existing platforms also places a premium on quality and reliability. The state-of-the-art report suggests further work with respect to:

- ✓ Improved understanding of implication of 2002 version of ISO 9001, combined with a commitment to continued improvement.
- ✓ Development of a risk based approach with numerical targets and tools to measure progress for quality management.
- ✓ Mechanisms to identify early life failures, information on hazard rates, root cause analysis of data and improved recording systems and performance indicators.
- ✓ Feedback to designers and lessons learned databases.

The development, qualification and implementation of new technology needs to be governed by better application of existing risk/reliability tools, which will require both education in tools and training. The reluctance by operators to be first users of new technology can be mitigated by a number of factors that have been identified.

Extending the life of existing facilities to achieve additional production and opportunities to tie-in satellite fields or smaller fields in the general area produces a new set of problems that will have to be resolved (i.e. insufficient information from inspection and maintenance, better models for life extension and risks associated with decommissioning).

Corporate Social Responsibility (CSR).

Corporate social responsibility has been defined as the commitment by business to contribute to sustainable economic development, working with employees, their families, the local community and society at large to improve their quality of life.

A central proposition in CSR is the triple bottom line, where economic, environmental and social performance should be monitored and reported. The CSR work package will seek to enhance competence and integrate CSR in everyday business by:

- ✓ Mapping and enhancing CSR awareness and competence.
- ✓ Document and analyse practices and management systems to ensure CSR across the offshore energy companies and their supply chain.
- ✓ Recommending actions for improved CSR, potential new practices.
- ✓ Extend the development of improved approaches

Supporting activities.

To underpin the four key work packages, TRENDS also performs work with respect to Regulations, Codes and Standards (WP5), Complimentary initiatives (WP6) ,Competence and training (WP7), From

QHSE to CSR Management (WP8a), New technological solutions(WP8b), Use of ICT for improved QHSE solutions(WP9), Stakeholder dialogue (WP10) as well as ensuring dissemination of RTD results through Eurogif and national networks.

The work in TRENDS has identified areas for improvement, both specific areas and interesting cross links between different areas, such as:

- ✓ Risk management (incorporating impact of new technology, ageing facilities and life extension).
- ✓ Development of the supply chain.
- ✓ Human and organisational factors, including training and competence.
- ✓ Development and application of codes and standards.
- ✓ Use of performance indicators to improve QHSE performance and competitiveness.
- ✓ Ageing and life extension
- ✓ Qualification of new technology

Some chosen projects are being implemented within the scope of TRENDS. A web portal on codes and standards and web based courses are examples of these. The network will also produce R&D policy inputs as well as inputs to standards, regulation and legislation.

2. TN2(GOTek) - IST Gas and Oil Technologies and Knowledge Forum

The overall objective of GOTek is to establish a coherent forum in the Oil and Gas sector, gathering all major parties involved concerning the use of new technologies with the aim of integrating knowledge management into E-business and E-work. The GOTek network has 24 partners.

The forum will:

- ✓ Explore the needs for new technologies to support and integrate knowledge management.
- ✓ Develop state-of-the-art descriptions and define gaps in knowledge or R&D.
- ✓ Establish guidelines for the appropriate use of new technologies, procedures, purchase selection-criteria, recommend technological paths to follow and duties in maintenance.
- ✓ Establish guidelines for technology providers, expected need in near term, lessons learned, expected market size, suggestions on pricing policy, technology gaps, paths to follow etc.
- ✓ Analyse the effect of IST use in the oil- and gas sector.
- ✓ Explore transfer of knowledge and experience from sectors already using knowledge management effectively.

The selected R&D priorities are:

1. **Knowledge based hydrocarbons**, develop models and scenarios to shape future policies for a knowledge based economy, technology development and deployment strategies, demand for new skills, competencies and associated training requirements, social and economic research on the transition to a knowledge based economy, including support for achieving the social objectives of the Lisbon, Stockholm and Gothenburg agreements.

2. **E-work systems**, investigate the application and future use of E-work systems in order to be able to adapt to new workplace concepts, collaborative working and enhanced creativity. Investigate and develop tools to allow people located in different places to work together in order to achieve significant cost reductions in terms of travel.

3. **E-business/E-commerce models**, investigate the use, building a model for successful implementation. The emphasis in this area will be the adoption of best practices to map out an effective E-business strategy for process improvement, increased productivity and new business development in the oil and gas sector.

4. **ICT practices**, new concepts which can achieve a break through in risk management by means of enhanced decision support systems. Use of knowledge management in network co-operation and training and support operations.

5. **Standards**, assessing the need for standards, define an open platform for standardization and prepare the necessary proposals for CEN/ISSS.

6. **Data security** issues, such as user authentication, information access control and integrity, message confidentiality and digital signatures.

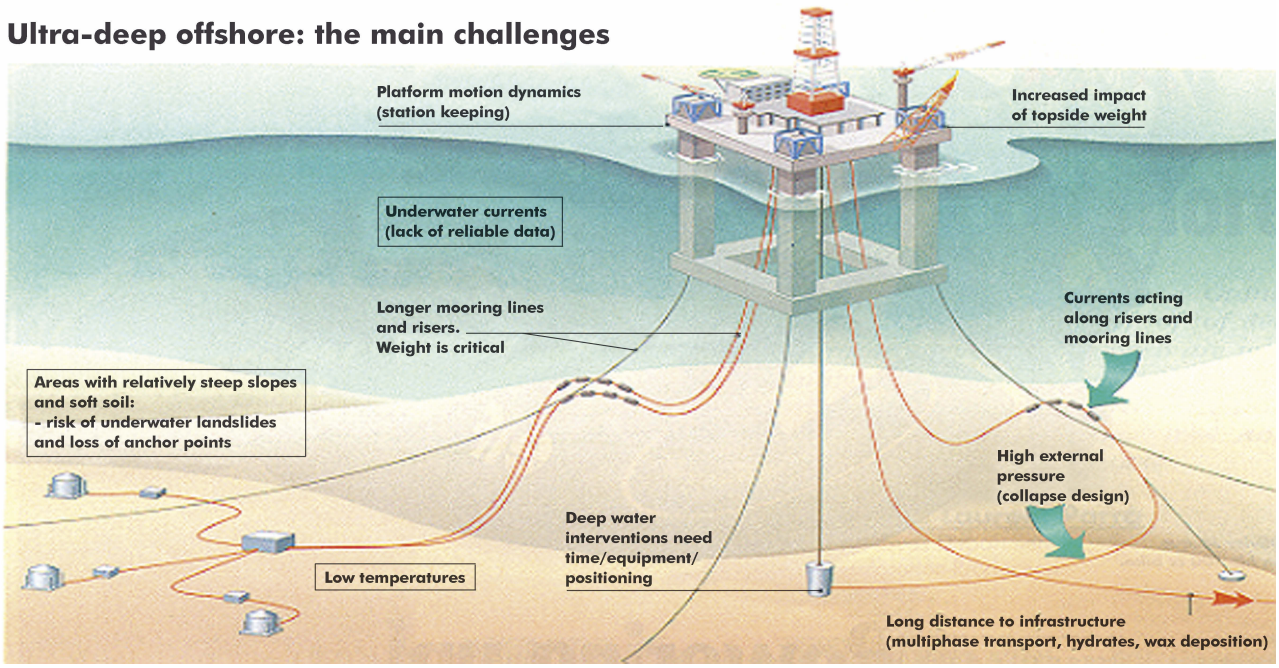
7. **Intelligent sensors**, new, advanced technologies for downhole logging while drilling and for downhole seismic. Permanently installed and remote intelligent sensor networks for monitoring, controlling and optimizing the production phase, including sensors for multiphase flow monitoring, oil/gas and water separation, movement of fluid fronts. Data communication and interpretation/analysis of large data volumes, virtual reality presentation of complex structures in 3D, 4D or 5D environments.

3. TN3(FLOATTECH) – Floating Structures Technology.

The overall objective of the FLOATTECH Thematic network is to map current technology, define state-of-the-art and to identify R&D activities required to achieve safe and cost-effective floating systems for energy production. The network activities are framed within a cluster of European suppliers, contractors, offshore yards, classification societies, energy/oil companies, research institutes and universities as a means to improve European competitiveness in the global market. The FLOATTECH network was initiated in 2001 with 37 participants and 4 observers from 11 European countries (France, Spain, Portugal, Italy, Greece, Netherlands, UK, Ireland, Denmark, Finland and Norway). The activities in the network are partly funded by EC under FP5 Growth, with a total amount of 1.5 M€.

As exploration and production moves into deeper waters and areas where pipeline infrastructures are less well developed, the demand for floating production systems are set to increase significantly. Europe holds a technological edge due to the advanced developments in the North Sea, but needs to further develop skills, capabilities and capacity to meet the increased competition from non-European companies with significant political backing due to security of supplies issues.

The network has been subdivided into groups that have concentrated on the following R&D priorities:



1. **Tools for hydrodynamic and structural analysis** of offshore structures, including model testing and full-scale instrumentation and validation.

2. **Cost effective mooring and station keeping**, dynamic positioning systems and technology, including winches, mooring lines and anchors. Tools for design, rules and regulations and procedures for qualification of new materials such as the long-term durability of synthetic mooring lines.

3. **Riser technology** for deep and ultra deep waters, including new and advanced materials. All types of risers for drilling, production and import/export including floating pipelines, ie: rigid and flexible risers, monitoring, light weight/high strength materials, flow assurance with heating and insulation.

4. **Marine operations** associated with installation or removal of floating production systems, including mooring and riser systems and removal of fixed platforms.

5. **Efficient topside facilities** including drilling, processing, utility systems, living quarters with focus on project execution methodology and cost reductions in Capex and Opex. Standardisation, rules and regulations, maintenance and modifications.

6. **Ultra deep floaters** in water depths below 2000 metres with focus on total concepts, including FPSO/Barges with surface trees and drilling, new and innovative floater concepts, risk assessment methodology, environmental impact in arctic regions and new frontiers, qualification needs.

7. **Cost effective floating production** systems with focus on TLP, Deep draft floaters, FPSO and semi designs, turret and swivel technology and systems integration into total concepts.

Comprehensive state-of-the-art reports have been prepared, identifying the technological gaps both on short and long term. Further, the groups have identified proposed projects/ programmes that will be a means to regain/strengthen European leadership with floating structures technology.

4. TN4 (SEARCH) -Subsea & Downhole Production Systems.

This network brings together expertise from across Europe to develop the functional technology targets required to develop cost effective, environmentally safe subsea and downhole production systems for enhanced hydrocarbon recovery. The focus is on compact and integrated solutions:

- ✓ Incorporating installation and maintenance requirements in the design.
- ✓ Meeting the challenges of deep and ultra deep water exploitation of hydrocarbons.
- ✓ Featuring high level reliability and availability with minimum lifecycle costs.

The planning of this network attracted 43 partners from 10 countries. The application for EC funding was unsuccessful, largely due to the fact that subsea production of hydrocarbons was seen as a competitor to the initiative of developing new renewables such as wind, wave, biomass etc. The subsea area is, however, a vital area for Europe to remain market leaders and alternative funding methods are being explored for the network. Research priorities have, nevertheless, been defined and will be pursued by means of FP6, Eureka or Joint Industry Projects (JIP's).

The selected R&D priorities are:

1. **Flow assurance** applied to subsea production with a view to reducing costs and increasing the safety, and environmental performance of subsea transport systems. This should include work in the areas of chemical inhibitors for hydrates,wax, asphalts, scales and corrosion. Insulating materials, heating and plug removal by physical means should be examined. Management of sand problems such as erosion and deposition/entrainment should be assessed, combined with sensor solutions and monitoring should be considered. Improved design tools for risk analysis and flow assurance should be developed together with improvement of real time monitoring and control systems.

2. **Subsea Infrastructure,** including all aspects of pipelines and flowlines. Design and installation of pipelines and flowlines in ultra deep waters(below 3000 metres) will require further development of design, installation and ancillary equipment. Safety, reliability and maintainability will be key considerations and remote repair and maintenance methods to achieve flow assurance with procedures to mitigate problems and limit accidental leakage or spills should be developed. Decommissioning of subsea equipment should be considered in terms of the cleaning of pipelines, preservation and reuse as well as removal of pipelines and structures.

3. **Subsea intervention/installation & retrieval systems and tooling** will be a challenge in the deep water and hostile environments faced for future exploration and production. Well established API/ISO standards exist for ROV's while AUV is an emerging technology, which requires standardisation to avoid the problems experienced with ROV's. Improved visualization systems, both accoustic and visual will be important at greater depths. Improved control systems, both MMI systems for ROV's and automatic systems for AUV's capable of handling complex missions should be developed. Deepwater navigation and positioning is at the heart of all intervention tasks. New technologies such as spread spectrum acoustics, acoustic networking, inverted DGPS systems should be developed and standardized to achieve noise reduction in underwater positioning systems.

4. **Pumping and process** will have to be addressed with a view to achieving improved recovery rates and reduced environmental impact. The network will review state-of-the-art in pressure boosting

devices such as pumps and compressors, fluid separation systems, control and instrumentation and power distribution systems. The subsea separation system on Troll Pilot has demonstrated the benefits of both recovery and reduced discharge, but the enabling technologies must be further developed and qualified for deep and ultra deep waters.

5. **Risk evaluation** will have to be comprehensive for deep water systems. An overall risk management methodology should be developed with input from TN1 TRENDS, where risk, reliability and qualification of new technology is being addressed. The overall methodology needs to take account of all risks, such as new technology risks and how these are quantified and resolved, operational risks and consequences of deepwater failure, project risks in terms of time and cost overruns caused by the complexity of an integrated system consisting of drilling and well completion, sub-sea facilities, flow-lines, risers and export facilities, HSE risks in terms of health and safety and the marine environment.

5. TN5 SMART RESERVOIR NET.

The Smart Reservoir Network (SRN) aim is to bring together pan-European stakeholders, decision-makers, operators and suppliers on an equal basis, to address the present and future challenges in the sub-surface aspects of hydrocarbon energy reservoirs from geological study, field exploration, field production then field conversion.

The objective of SRN is to determine technology needs to increase hydrocarbon recoverable reserves in a safe environment and under economical constraints. It will mainly focus on the reservoir management (Smart Reservoir) in new deep-water fields as well as in mature fields.

The SRN started in January 2003, it consists of 57 members from 12 member states that represent a major part of the present EU and new member states. The three-year program has a budget of 1.9 M€ of which 1.5 M€ is funded by the EC under "FP5 Energie".

The main work packages are focused on the international state of the art and future technology needs regarding:

- ✓ **Well construction**. Potential solutions to deep-water reservoirs such as drilling with small pressure margin (with for example the help of dual gradient drilling), improved geosteering, expandable casings and completion multilaterals should be assessed.
  In terms of the mature fields, the objective is to increase recovery ratio and extend field life, the technologies of under-balanced drilling (for example improved coiled tubing drilling) and extended reach drilling, casing drilling, should be further developed. In-fill drilling is still the most efficient method to increase recovery.

- ✓ **Field production,** where cost effective, enhanced production is the common denominator in meeting the challenges of deep and ultra deep reservoirs, high temperature and high pressure reservoirs, marginal fields and mature fields. The most likely answers will lie in the areas of downhole instrumentation, real time control systems, efficient processing of large amounts of data, 3D visualisation and decision support systems. Combined effective solutions to de-man platforms and enable remote operation from shorebased control centres will help drive down costs and improve health and safety.

- ✓ **Field conversion***,* which addresses decommissioning issues after production and potential future uses of the reservoirs as underground storage for natural gas or CO2. To enable practical, environmentally acceptable solutions, further technological development within wells and injection, measurement and integrity monitoring, storage management etc.

To underpin and support the main work packages, additional work packages have been defined with respect to systems design, optimization and modelling, measurement and control, materials and standards and regulations.

Although the network has only recently been established and funded, and thus is at a very early stage of its work program, potential R&D priorities can be assumed:

1. **Improved well construction and formation measurements,** such as better control of well trajectory, improved capability for drilling extended reach wells, deeper measurements for geosteering, improved images while drilling, high temperature electronics, better understanding of well stability, durable and high quality formation isolation,

2. **Reservoir characterization technologies,** such as high resolution surface seismic open-hole logging (deep and azimuthal), cased-hole logging to locate by-passed oil, well testing,

3. **Reservoir monitoring** through permanently installed transducers for down hole pressure, flow rate and temperature. Passive seismic in the well bore to track noise generated directly or indirectly by fluid flowing in the formation.

4. **Standards** to process and integrate hardware systems as well as measurements taken by different technologies and service companies and methods to improve visualisation of data with improved decision support.

5. **Improved controls** over the life of the well and reservoir exploitation with respect to seismic operation, drilling, well construction and production. Particular attention should be given to remote control and operation of multiple wells and the design and use of injection wells.

6. **Materials,** where knowledge and developments in materials, their reaction to chemicals, range of operating conditions and design of components must be developed. Materials for extreme temperatures and pressures and aggressive environment (H2S, CO2) must be qualified. Improving performance of seals over the life of the field will be important. Use of new materials such as polymers, composites and ceramics should be developed and qualified for proper use in this industry

6. TN6 - Materials

Not launched as separate network. Material requirements are reviewed in each of the thematic networks where appropriate.

7. TN7 – Environmental Gas Technology.

The environmental gas technology network consists of 38 partners. The proposed initial budget is 2.7 M€ without funding by the EC through FP5 Energie.

The three year programme for the network has a strong environmental focus linked to the gas chain from production to end use. Finding ways to reduce emissions from production, transport, storage and use is a priority. The following thematic priorities have been defined:

- ✓ Energy efficient and clean production, transport, and storage. Innovative and cost effective conversion of natural gas to cleaner products such as methanol and hydrogen and associated technologies required to achieve more extensive fuel switching from coal and oil.

- ✓ Exploiting the potential of new developments in information and communications technologies in connection with measurement, monitoring and control of the long range pipeline transport of natural gas and the storage of natural gas and CO2.

The main work packages comprise resource characterisation, gas treatment, gas conversion, gas transport and final use of natural gas.

The potential R&D priorities are:

1. **Resource characterisation,** improved methods and technologies for detection of gas reservoirs in geologically complex areas, detection of hydrate accumulations, remote methods for confirming gas presence in subsurface structures, monitoring of long term integrity of geological structures.

2. **Gas treatment,** improved methods and technologies for dehydration, de-acification and gas contaminant removal.

3. **Gas conversion,** with focus on LNG, GTL, chemical conversion and power generation. Solutions will be sought for stranded gas(gas without present export routes) by means of offshore conversion. Offshore “power islands” with CO2 management and disposal/use should be evaluated. Chemical conversion to syngas as a means to hydrogen, fertilizers, syn-crude, olefins/ethylene/propylene, methanol, MTBE and carbon black should be considered.

4. **Gas transport** will take place over longer distances with varying environmental conditions. Further work needs to be done on limit state design criteria, pipe/soil interaction, reserve strength in ageing and corroded pipelines, welding/installation of HP pipelines, deep water technologies and materials, monitoring and control, pigging/maintenance, commissioning/decommissioning. Non conventional transportation, such as hydrates, CNG, absorbed gas etc.

5. **End use,** which should cover both new concepts for underground storage near high consumption areas and all aspects of the end use of natural gas, such as hydrogen storage/distribution, use of fuel cells, CHP, fuel switching from coal/oil to cleaner natural gas or hydrogen, efficient burning systems (low Nox, limited CO2 emissions) etc.

8. TN-8 CO2 Net. EUROPEAN CARBON DIOXIDE THEMATIC NETWORK

Presentation

The European Carbon Dioxide Network was conceived in 1996. It first received European Commission funding in October 2000 and was taken under the auspices of Eurogif in March 2001. The European Commission (EC) is funding a further three year programme CO_2NET2 from 2002 to 2005.

The Network currently has 55 organisations in 16 European countries as members and an associate member in Australia. All of the projects related to CO_2 capture and geological storage, which are receiving European Commission funding are also members of the Network.

It is clustered with EC Thematic Networks in the Power and Coal sectors, namely CAME-GT and Powerclean and the Co-ordinated Action Member States Initiative - FENCO.

Objectives and problems to be solved

As its prime objectives, CO_2NET facilitates research collaboration at European and national level on carbon capture and geological storage; assesses and defines R&D strategy for new activities and demonstrations and facilitates exploitation and dissemination of results to the technical community. It provides information to the EU and national governments towards policy making.

By mapping the Centres of Excellence to develop the European Research Area "Virtual Centre of Excellence" for CO_2, it makes an important technological step towards decarbonisation of fossil fuels, emissions reduction and the hydrogen economy.

Training material and educational activity developments help increase public awareness and acceptability.

Assessing best practice lays the foundations for benchmarking and standardisation.

The foundations are laid and the European core of the Virtual Centre of Excellence for CO_2 is established within CO_2NET2.

Work Programme & Work Packages

Horizontal

Network Management
Web based interactive communication
R&D Database and Collaboration
Mapping of competences
R&D Strategy
Best practice assessment
Training and Education
Exploitation and dissemination

R&D themes

CO2 sources
Capture, zero emissions
Transport
Coal Bed Methane Storage
Enhanced Oil Recovery Storage
Aquifer Storage

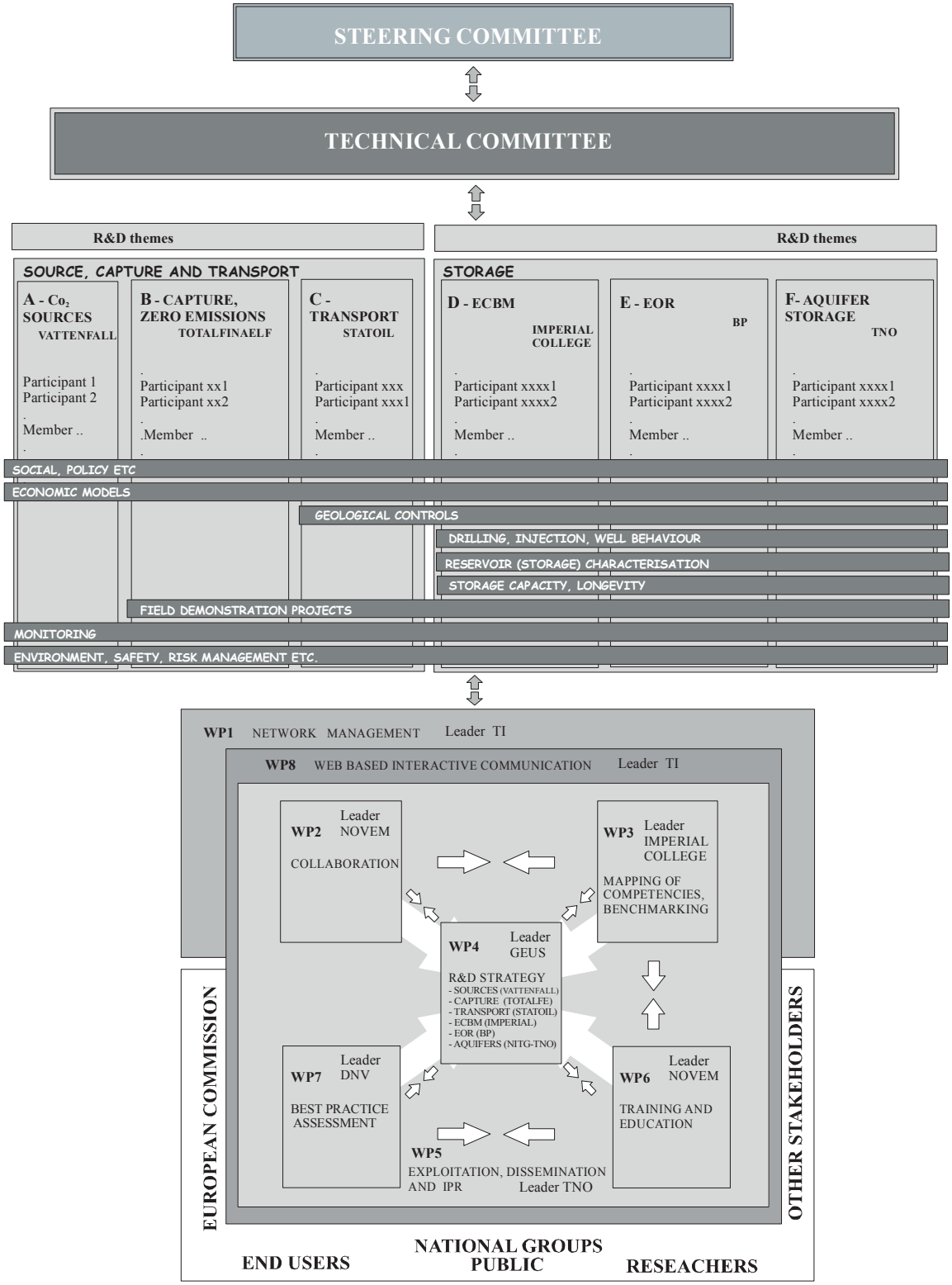
Expected Results and Exploitation Plans

Results include member events to disseminate/discuss results; strategies, associated RTD and potential demonstrations of CO_2 technology towards commercial use; best practice and risk acceptance criteria towards standardisation of CO_2 sequestration; creation of CO_2 Virtual Centre of Excellence, interactive website and real-time information forum for members and public; R&D and competency databases and brochures/educational material for technical experts, NGOs and public to further knowledge and understanding.

By 2006, CO_2NET expects to have:

- Successfully brokered at least one new project to fill gap in R&D, using information from database
- Created the European Research Area "Virtual Centre of Excellence" for CO_2
- Been instrumental in commercial mitigation projects in at least two European countries

The Network Structure, showing Technical Themes and RTD Strategy and Project Programme and inter-relationship between Work Packages are shown diagrammatically below.



GLOSSARY

ASSOMINERARIA	Associazione Mineraria Italiana per Industria mineraria e Petrolifera – an Italian Trade Association
API	American Petroleum Institute
AUV	Autonomous Underwater Vehicle
Bn	Billion
CAME-GT	TN for cleaner & more efficient gas turbines
CAPEX	Capital Expenditure
CBM	Coal Bed Methane
CEN	Comité Européen de Standardisation (European Committee for Standardization)
CHP	Combined Heat & Power
CMM	Coal Mine Methane
CNG	Compressed Natural Gas
CIS	Commonwealth of Independent States
$C0_2$	Carbon Dioxide
CSR	Corporate Social Responsibility
DGPS	Digital Ground Positioning System
EC	European Community
ERA	European Research Area
EIC	Energy Industries Council – a UK Trade Association
EOR	Enhanced Oil Recovery
EU	European Union
EUREKA	Transnational R&D funding programme
EUROGIA	A Eureka Cluster
EUROGIF	European Oil and Gas Innovation Forum
FENCO	Clean Fossil Energy Coalition (UK-Germany initiative)
FLOATTECH	Floating Structures Technology – a EUROGIF Thematic Network (TN3)
FoUTN	Norwegian R&D Team
FP/FP 5/FP 6	EU Framework Programmes for Research and Technological Development
FPSO	Floating Production Storage and Off-loading (vessel)
GDP	Gross Domestic Product
GEP	Groupement des Enterprises Parapétrolières et Paragazières - Oil and Gas Industry French Supplier Council – a French Trade Association

GOM	Gulf of Mexico
GOTek	Information Technologies for a Sustainable Energy Industry – a EUROGIF Thematic Network (TN2)
Gt	Giga (10^9) Tons
GTCC	Gas Turbine Combined Cycle
GTL	Gas to Liquid
H2S	Hydrogen Sulphide
HP	High Pressure
HSE	Health Safety & Environment
ICT	Information & Communication Technology
IEA	International Energy Agency
IFP	Institut Français de Pétrole
IGCC	Integrated Gasification Combined Cycle
IRO	Industriële Raad voor de Oceanologie – a Dutch Trade Association
ISO	International Standards Organisation
ISSS	Information Society Standardization System
IST	Information Society Technologies (Part of EC FP5)
ITF	Industry Technology Facilitator – A UK organisation
JIP	Joint Industry Project
LNG	Liquified Natural Gas
Mill.bbl/day	Million Barrels of Oil per Day
MMI	Manufacturing Management Information
MTBE	Methyl Tertiary Butyl Ether – A major lead-free hydrocarbon product
Mtoe	Million Tons Oil Equivalent
NGO	Non-Governmental Organisation
NOx	Nitrogen Oxide
OPEC	Organisation of the Petroleum Exporting countries
OPEX	Operational Expenditure
PF	Pulverised Fuel (Used in Power Generation plants)
Powerclean	TN on Sustainable Fossil Fuels
QHSE	Quality Health Safety & Environment - Thematic Network (TN1)
R&D	Research & Development
ROV	Remotely Operated Vehicle
RTD	Research & Technology Development
SE	Scottish Enterprise – a UK organisation

SEARCH	Subsea & Downhole Production Systems - a EUROGIF Thematic Network (TN4)
SME	Small and Medium Enterprises
SRN	Smart Reservoir Net – a EUROGIF Thematic Network (TN5)
TBL	Teknologibedriftenes Landsforening – Federation of Norwegian Manufacturing Industries
tcm	Trillion (10^{12}) cubic Metres
TLP	Tension Leg Platform
TMP	EUROGIF Technology Master Plan
TNs	Thematic Networks
TWh	Terra Watt Hours
TRENDS	Health, Quality, Safety and Environment for a Sustainable Energy industry – a EUROGIF Thematic Network (TN1)
VOC	Volatile Organic Compounds
WETO 2030	World Energy, Technology and Climate Policy Outlook 2030 – A EU Commission Research document
WP	Work Package – a subset of a collaborative project, e.g. part of a Eurogif TN

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