

SET Plan: il contributo italiano alla iniziativa industriale sulle CCS

Lo Strategic Energy Technology Plan della Commissione Europea fissa la strategia comunitaria per lo sviluppo accelerato delle tecnologie energetiche, in un'ottica di messa a fattor comune delle risorse e dei rischi connessi allo sviluppo di nuove tecnologie, trovando il giusto equilibrio tra cooperazione e competizione. In questo quadro le tecnologie CCS, ritenute di interesse prioritario, rivestono un ruolo trainante con la promozione di iniziative industriali (European Industrial Initiatives) e programmi di ricerca congiunti (Joint Programmes)

■ Giuseppe Girardi

Una delle principali ambizioni della UE è lo sviluppo di una economia *low-carbon*: a questo scopo è stata condivisa una strategia politica volta a conseguire, fra gli altri, gli obiettivi al 2020 in campo climatico ed energetico e lo sviluppo del sistema degli *emission trading*, ed obiettivi più ambiziosi che guardano al 2050. Non esiste una soluzione univoca, una singola misura o tecnologia, ma è necessario il ricorso ad un mix di interventi.

In questo quadro, lo sviluppo di tecnologie energetiche assume un ruolo centrale, ma occorre superare alcuni vincoli di tipo economico legati all'insufficienza di investimenti che ha interessato questo settore dal 1980, i notevoli ritardi nella commercializzazione di nuovi prodotti, ostacoli di tipo legale e amministrativo, e la accettabilità sociale.

Il SET Plan della Commissione Europea, *Strategic Energy Technology Plan*, costituisce la risposta strategica alle grandi sfide del clima e dell'energia che l'Europa intende affrontare attraverso lo sviluppo accelerato delle tecnologie energetiche. Per realizzare questa nuova rivoluzione

industriale, di fronte alla concorrenza di alcuni paesi industrializzati e delle economie emergenti, i paesi dell'Unione dovranno mettere in comune le risorse e condividere i rischi connessi allo sviluppo di nuove tecnologie, trovando il giusto equilibrio fra cooperazione e competizione. Tale sforzo potrà portare ad assumere la leadership mondiale delle tecnologie energetiche, valorizzando così i benefici che questa rivoluzione comporterà.

Il SET Plan si configura, quindi, come strumento di attuazione delle linee di politica energetica e come strumento organizzativo verso assetti più funzionali della cooperazione e dell'integrazione europea nel settore energetico. Sono stati individuati i settori su cui intervenire e gli obiettivi: nel breve-medio termine l'obiettivo è puntare alla riduzione dei costi e migliorare le prestazioni delle tecnologie esistenti, per accelerare la commercializzazione di queste tecnologie; nel lungo termine l'obiettivo è sviluppare una nuova generazione di tecnologie a basse emissioni, più efficienti e meno costose. Sono quindi previste attività di R/D insieme a programmi dimostrativi con il forte coinvolgimento del settore industriale: a tal fine è già stata avviata una forte collaborazione con le piattaforme tecnologiche e con EERA (European Energy Research Alliance).

■ Giuseppe Girardi

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Nell'ambito del SET Plan sono state già avviate alcune iniziative industriali, le EII (*European Industrial Initiatives*) e programmi di ricerca congiunti (*Joint Programmes*). Per le CCS, considerate tecnologie di interesse prioritario, è stato istituito il gruppo europeo *CCS EII Team*, composto da rappresentanti degli Stati membri, dell'industria

e degli *stakeholder*, mentre è stato recentemente approvato il *Joint Programme* sulle attività di ricerca. Nel seguito viene riportato il documento presentato dall'autore, rappresentante italiano nello *CCS EII Team*, nel corso della prima riunione del gruppo, con l'obiettivo di offrire un quadro sintetico della situazione italiana.

■ **Giuseppe Girardi** – *Italian government representative for the EII Team of the CCS Initiative*

European Strategic Plan for Energy Technologies - SET Plan -

Short summary of Italian Contribution to the “European Initiative for the Capture, Transport and Storage of CO₂”

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Bruxelles, May 20th, 2010

1. BACKGROUND

The need to update energy policies worldwide in order to deal with climate change effectively is now unanimously considered a priority by the scientific and political communities as well as by people. It is also unanimously believed that what is needed is an approach integrating energy usage and energy production. Such an approach requires that we speed up the transition towards an economy not any longer based on fossil fuels, but instead on an increased demand / supply efficiency and on renewable sources, while aiming at clean technologies and emissions closer and closer to zero wherever fossil fuels are used.

Therefore the energy and research policy in this field must take the following factors into account:

- fossil fuel demand will stay very high in the coming decades, above all in the Countries with an Emerging Economy;
- the development and widespread commercial deployment of intrinsically zero emission technologies at a competitive cost will take longer;
- it is necessary to act immediately to reduce the emissions into the atmosphere that fossil fuel usage will still bring about.

In Italy this vision is widely agreed, and several measures have been taken in order to achieve the desired goals.

The Italian Energy policy foresees, in the medium-short term: diversify the energy suppliers, diversify routes and the related infrastructures, support the international dialogue between producers and consumers, increase energy efficiency both in electricity generation and in end-uses, diversify energy sources; while, in the medium-long term: emphasize energy diversification while coping with environmental concerns, continue the process of liberalization of the electricity market towards retail market, increase security of energy supply, reduce energy prices and tariffs, streamline the authorization procedures.

In this context we are now adopting three technological carbon management options:

- reduce carbon intensity, increasing renewables and fuel swithing;
- improve efficiency, acting on demand side and supply side
- sequester carbon, mainly applying CCS technologies and enhancing natural sinks

2. CCS TECHNOLOGY OUTLOOK: OUR VIEW IN ITALY

The usage of renewable energy, of advanced transport systems including hydrogen and fuel cells, the re-launch of nuclear power with new design and, above all, energy efficiency stay the main aims of policies dealing with greenhouse gas emission.

However, it is widely believed by now that resorting to CCS is one of the options available today to be used if we are to contribute significantly to emission reduction in the short and medium term.

Italy reckons that CCS techniques have to be adopted in order to contribute to reduce emissions by about 20% by the year 2050 in a scenario for the year 2050 where emissions are 50% lower than today's levels.

Our view is that the technologies needed for CO₂ capture, transport and storage are mostly known and some of that have been used for decades with a different purpose of a merely commercial nature (as in Enhanced Oil Recovery), although they were never related to the aim of reducing CO₂ emissions.

On the other hand, a strong demonstration programme on a commercial scale, also in Italy, is needed which verify its effectiveness and safety, as well as lot of medium-long term R&D work for lowering the costs and increase global efficiency.

However, some important questions have not been answered; these regard the scenario of regulations and authorizations, above all concerning the phases of CO₂ transport and geological storage, and the problem of social acceptability of the entire CCS process.

As far as **capturing CO₂** is concerned, the consensus is unanimous: we can point out neither the best nor the

most promising capture technology available today. Therefore, we must act upon a double temporal horizon: on one hand is the need to implement *demonstrative installations* by the year 2020 so that we can verify the possibility of a quick transition to the commercial stage. On the other hand is the need to pursue *research activities* leading to further developments after the year 2020, aiming at significant cost reductions (especially for the capture) and at the increase of the overall efficiency.

Looking at **CO₂ transport** via pressurized pipelines, technologies are mostly those used for the transport of natural gas, also regarding the pressure levels (around 80 bar). In such conditions CO₂, unlike natural gas, is generally in its state of supercritical fluid. In the USA, where CO₂ transport is typically intended for EOR use and it happens in areas with little population, this part is substantially considered fully developed. In the European context, and in Italy too, which may involve densely populated areas and a fluid with chemical characteristics (with regard to its content of water and impurities) which are variable depending on the separation and conditioning processes that follow, higher design costs may be required.

With regard to **CO₂ storage**, from the technological and scientific viewpoint, we know most of the elements needed in the CCS geological sequestration.

Many types of formations are suitable for CO₂ storage for very long time. CO₂ can be injected in its supercritical condition (which happens at about 800 m below the surface) into porous formations containing fluids (deep saline aquifers) or into reservoirs where hydrocarbons are running out. The third trapping option regards those coal seams which are otherwise unmineable by the classic mining methods. When CO₂ is injected in them, it binds itself to the carbon better than methane: if the latter is present it is then released.

The evaluations of the sedimentary basins and of the known fields of hydrocarbons are not well known in Italy, even if a lot of data have been collected during the time by Eni, a crucial work has been done in this

field during last years by several organizations, and several experimental activities have been started. Furthermore, other methods other than geological ones have been started to be studied, specially that related to the usage of CO₂.

Regarding the **regulatory aspects**, many positive steps have been made to include CCS techniques into international protocols. The regulatory framework is destined to evolve rapidly, above all thanks to the recent European Directive 2009/31/EC of 23 April 2009 on CO₂ Geological Storage, which binds the member states, inter alia, to report on the implementation state of the Directive on the national level in June 2011.

In Italy the transposition of that directive has been started and will be realized through a base law followed by various administrative acts; a draft text of a base law is ready for consultation with stakeholders. There are two key issues to be addressed, scope of consultation with regions and geological database. The process should be completed by the end of 2010.

As for **public acceptance**, recent research indicates that more than 90% of the population is considering greenhouse effect mitigation an important factor to pursue with determination because of its implications on climate change. However most of the people who were interviewed on the subject did not know or were not fully aware of the potential of CCS for greenhouse effect mitigation. The lack of awareness of the population regarding CCS makes it imperative that correct information from reliable sources is made available to the public.

A communication strategy addressing a wide and varied group of people to whom CCS is a concern is essential to prevent positions which are extremely anti-CCS, irrational or effectively opposing the objective from monopolizing the debate: in Italy several initiatives have been launched to this end.

3. MAIN FINALIZED R&D ACTIVITIES

Italian research centres and universities have started specific studies and programmes regarding various

aspects of CCS over 10 years ago. Such initiatives have been financed thanks to European (FP5, FP6, FP7) and national funding, essentially from the Ministry of University and Research and from the Ministry of Economic Development. The latter in particular, has financed a vast programme based on a strong synergy between national stakeholders and intended to increase the competitiveness of our industrial system, also via to the Italian participation to international initiatives like the *Carbon Sequestration Leadership Forum* (CSLF) and the European Technological Platform for *Zero Emission Fossil Fuel Power Plants* (ZEP).

Here is a synthetic list of the main projects under way in our country.

3.1 PROGRAMMES FINANCED BY THE ITALIAN GOVERNMENT

INITIATIVES CO-FUNDED BY THE MINISTRY OF UNIVERSITY AND RESEARCH

SOTACARBO “COHYGEN project – pre-combustion technology”

The research program focuses on the production of hydrogen and clean fuel gas (high temperature desulfurization) from coal and CO₂ capture from “syngas” using solvents. A pre-combustion test platform has been constructed; it consists of two main installations: a 5 MWt gasification pilot installation equipped with a gas treatment system, and a smaller one (400 kWt) for hydrogen and electricity generation. Furthermore, research infrastructures and dedicated laboratories became available as a result.

ENEA “ZECOMIX project – pre-combustion technology”

The research program focuses on the study of coal gasification, syngas treatment, CO₂ capture with solid sorbents, H₂ production and burning for power generation by means of a high efficiency gas turbine cycle; the ZECOMIX pilot installation will start by September 2010, operating at a coal feeding rate of 50 kg/h.

ENEA “CARBOMICROGEN project - distributed generation based on hydrogen rich syngas”

The main goal is the study and development of small power generation systems based on syngas generated by coal and/or biomass; these generation systems are also based on the hydrogen obtained from CO₂ capture and the resulting syngas.

INITIATIVES CO-FUNDED BY THE MINISTRY OF ECONOMIC DEVELOPMENT: “CERSE PROGRAM” FOR R&D ON ELECTRICITY SYSTEM

ENEA “Coal fired power plants for electricity and hydrogen combined production project”

The main goals are the following: a) research on pre-combustion capture technologies and CO₂ storage (with ECBM and also CO₂ injection in deep saline aquifers); b) testing on pilot installations; c) to support the national Industry and research system with the aim of increasing their cooperation with a view to their playing a stronger role at the international level; d) to define the Italian national path on CCS; e) to stimulate the cooperation among national stakeholders in order to increase public acceptance.

ENEA “Oxy-combustion for coal fired power installations”

This project, that will be followed by a demonstrative program managed by ENEL, focuses on the development and testing of an innovative combustion system fed with coal slurry, operating at 5 bar with exhaust gas recirculation and utilizing the so-called “flameless combustion”; the main activities are:

- advanced modelling and “LES” simulation code (named HeaRT-MPh) validation;
- combustion system testing with advanced diagnostics;
- development of an advanced pumping system for coal slurry;
- feasibility study for a demonstrative plant fed with Italian (Sulcis) low quality coal.

ENEA/SOTACARBO “Coal gasification with CO₂ capture and storage”

The main goals are: a) to carry out experimental activities on two main test rigs. The first one consists of a coal gasification and CO₂/H₂ separation system operating with a 30 kg/h coal feeding. The second one is a 6 MWt coal gasifier. Their aim are:

- to qualify advanced gas cleaning and CO₂ separation processes, as well as gasification processes using mainly CO₂;
- to study real installations equipped with CO₂ capture systems, with a view to constructing a demonstrative power installation in Sardinia;
- to study the feasibility of CO₂ storage in the Sulcis coal basin.

ERSE “Characterization of CO₂ storage sites”

The project has the objectives of pinpointing areas potentially suitable to CO₂ geological storage, creating a Geographic Information System for the National Inventory of Potential Storage Sites, refining calculation systems and tuning up instrumentation. The project involves also the monitoring of marine sites and activities favouring communication and outreach of the CCS technology.

ERSE “Development of membranes for the separation of hydrogen from syngas”

The main goal is to develop new membranes by chemical deposition of palladium and its alloys on porous media for use in separating hydrogen from syngas. A specially valuable application is the Membrane Shift Reactor, already successfully demonstrated at the laboratory scale.

ERSE “Degradation of a turbogas running on hydrogen rich syngas”

Analyses and modelling are carried out concerning the mechanisms that damage the critical materials (due to heat) in aggressive environments from the thermal, chemical and erosion points of view. Amongst the results obtained, we can mention the modelling to predict the materials life and various non-destructive

methods to estimate of the wear condition of materials.

ERSE “Sorbent solids suitable for the capture from combustion fumes”

A capture system just upstream of the chimneys of existing installations is being studied. At present this can be put into practice using absorption processes in amine solutions. To ERSE is due the concept design and development of an original solution based on solid sorbents able to penalize efficiency significantly less.

CNR “Innovative technologies for the improvement of the environmental performance of powdered coal power plants”

The activity of this research programme consists of two strains: a) the development of advanced diagnostic techniques for the monitoring of the pollutants typically associated with coal combustion and for studying the impact of the coal type utilized; b) the development and/or implementation of technologies for the reduction of the pollutant load upstream and downstream of the combustion system, including: the characterization of the process of de-volatilization and combustion of the particles as a function of the characteristic of the coal, the pre-treatment of the coal powder and the treatment of flue streams for the reduction of pollutants.

INITIATIVES CO-FUNDED BY THE MINISTRY OF ECONOMIC DEVELOPMENT: “INDUSTRY 2015 PROGRAM”

ENEL/ENEA “MILD combustion project”

The main goal is to develop and test MILD combustion in different industrial sectors, because of its higher efficiency, strong reduction of NO_x and particulate emission; it involves several industrial operators (mainly power generation and steel industry) as well as research organizations working on heating furnaces, gas turbines, boilers, and oxygen fired coal power installations. An experimental program on a 6 MWt pilot installation coal oxyfiring with CO₂ capture is ongoing.

3.2 INTERNATIONAL PROGRAMMES WITH THE PARTICIPATION OF ITALIAN PARTNERS

Weyburn (Weyburn CO₂ monitoring project)

(completed: INGV, Sapienza Università di Roma)

A project which aims at refining the injection and monitoring techniques for the CO₂ utilized for Enhanced Oil Recovery (EOR) at the Weyburn oil field. The CO₂ originates in a coal gasification plant and is transported up to its storage site via a pipeline having a length of 330 km.

NASCENT (Natural analogues for the geological storage of CO₂) completed; G.A.I.A. Srl, OGS)

It is thematic network, which aims at helping companies, industry and research agencies working on the development, evaluation, and spreading of CO₂ capture and storage techniques as acceptable tools for climate change mitigation. Twenty-nine organizations from nine European countries adhered to it.

CASTOR (CO₂: from cCApture to STORage)

completed; EniTecnologie S.p.A., GSV S.p.A., OGS)

Project for the optimization of post-combustion CO₂ capture techniques using low concentrations, low pressures and high volumes. As for the storage, 4 potential sites with different characteristics have been analyzed, both on land and at sea (Casablanca, Snohvit, K12B e Atzbach-Schwanenstadt).

INCA-CO₂ (INternational Co-operation Actions on CO₂ capture and storage) completed; OGS)

The goal is to support European stakeholders in their international initiatives, and to provide European politicians and decision-makers with a coherent view of international initiatives.

GeoCapacity (Assessing European capacity for geological storage of CO₂) (completed; Eni, OGS)

The aim of the project is to identify and evaluate the major CO₂ emission sites in Europe, existing infrastructure for its transportation via pipelines and suitable storage sites in geological formations: saline aquifers, depleted hydrocarbon fields and deep coal

seams. A first collaboration has been started with China. An estimate has been made of the "actual" CO₂ storage capacity in all the countries examined.

DYNAMIS (Towards H2 and electricity production with CO₂ capture and storage) (completed; ENEL)

The project aims at analyzing effective pathways to construct large hydrogen production installations, with consequent storage of the CO₂ produced in the process. It is part of the European initiative HYPOGEN involving, as an intermediate step, the construction of test infrastructures for the joint production of electricity and hydrogen from fossil fuels, with permanent CO₂ storage.

CO₂GeoNet (European Network of eExcellence on the geological storage of CO₂) (completed, carries on as an Association; OGS, Sapienza Università di Roma)

It links 13 research institutions of 7 European nations and employing over 250 researchers to do studies about CO₂ geological storage. Its main aim is to foster a gradual and lasting integration among its partners until a "virtual institutie" comes to life, competitive at the world level with similar foreign institutions. In 2008 the members founded the Association CO₂GeoNet. OGS manages its General Secretariat.

CO₂ReMoVe (CO₂ geological storage: Research Into Monitoring And Verification technology) underway; OGS, Sapienza Università di Roma)

The project aims at improving the techniques for: monitoring of storage sites and of leakages at the surface and through the wells; predicting the long-term behaviour of the stored CO₂; evaluating the risks for various sites and at different temporal scales; preparing guidelines for the industry and central and local authorities.

MovECBMm (Monitoring and verification of ECBM) (underway; Carbosulcis, OGS, Rome University)

The project aims at monitoring and checking the CO₂ storage capacity in a deep coal seam. Its components

are: the study of the processes of adsorption in the coal matrix; the development of models to optimize methane production; the improvement to the best possible degree of the techniques for monitoring CO₂ and methane while they migrate in a reservoir.

CCP and CCP2 (CO₂ Capture Project) (underway; Eni SpA)

It is an initiative of 8 major oil companies and three government organizations who promote and carry out study and research to: reduce marginal uncertainty of CCS, both technical and economical; reduce capture costs by 20-30%; identify and tackle the critical aspects of geological storage; create operational standards; develop modalities to share information and shorten the time needed for a widespread application of CCS.

RISCS (Research into Impacts and Safety in CO₂ Storage) (starting; OGS, Sapienza Rome University)

RISCS will develop the knowledge base necessary both to storage site operators and regulators to evaluate the potential impacts of leakages on near surface ecosystems, both in terrestrial and marine environments. Such information will also support policy makers, politicians and the general public in their assessments of the feasibility, long-term benefits and consequences of large-scale CO₂ capture and storage deployment.

SOCRATES (Scale One CO₂ Recovery And Trapping Engineering Studies) (under negotiation; Ansaldo Energia, ENEL, Eni, OGS, Saipem, Università di Padova)

Socrates aims to develop technical and economic viable integrated concepts for coal zero emission power installations in view of large scale demonstration in 2015-2020. The integration will cover all the components needed to set up the CCS demonstration. Two test cases will be analyzed in depth: an 850 MW IGCC power installation at Teesside, north east of England, and a full scale power installation (3x660 MW units) with post-combustion CO₂ capture, transport and geo-

logical storage, near Porto Tolle, northern Adriatic sea, Italy.

Other projects, with Italian partners, have terminated their evaluation phase:

- **CO₂Care** (CO₂ Site Closure Assessment Research): with OGS.
- **SiteChar** (Characterisation of European CO₂ storage): with OGS, La Sapienza Rome University, ENEL.
- **Cal-Pilot** (Demonstration of Carbonate Looping for CO₂): with University of Naples.

4. MAIN PILOT AND DEMONSTRATION PROJECTS UNDER WAY AND CLOSE TO STARTING

We will indicate the main projects on individual technologies and on the entire CCS cycle which are of industrial interest and have a demonstration nature; some of them are already under way.

4.1 PROJECTS MANAGED BY ENEL AND ENI

ENEL - Brindisi post combustion capture pilot plant

A first post-combustion capture (via amine scrubbing) project involves the construction of a pilot installation to be installed at the Brindisi Sud coal power plant. The CO₂ produced will be liquefied and stored by a cryogenic system; it will be transported by way (230 trucks per year) and stored by Eni at the Cortemaggiore site. The plant is composed by a flue gas pre-treatment section (able to remove completely the particulate and the SO₃ and to reduce SO₂ level below 20 mg/Nm³) and by a CO₂ separation unit. The facility will capture about 2.5 t/h of CO₂, treating a flow of flue gases of 10.000 Nm³/h. It is also foreseen to build in Brindisi a closed loop CO₂ pilot pipeline to develop knowledge to be used in demo design. CO₂ injection will start in Summer 2011. It will help the Porto Tolle demo project.

ENI - pilot project of injection into a depleted hydrocarbon field

Eni has run various studies and preliminary evaluations as part of the design of surface infrastructure for



CO₂ injection and monitoring in the Cortemaggiore field (Piacenza). Eni has also analyzed the legal and social aspects linked to the storage. The injection of 8,000 tonnes of CO₂ per year will follow over a 3 year period (24.000 tonnes of CO₂ in three years), followed by two years of post injection monitoring. Studies on the utilization of the CO₂ will also be run in order to increase the recovery factor from Italian hydrocarbon fields.

ENI-ENEL -Agreement for the development of CCS techniques

The agreement involves a joint study on the potential for CO₂ geological storage in Italy and the implementation of the first Italian CCS project: ENEL is busy with the construction of a pilot CO₂ postcombustion capture installation; the CO₂ will be liquefied in situ and transported to Cortemaggiore, where Eni will inject it into the depleted field. A joint study for a CCS demonstration project of 1 Mt/year is also involved.

ENEL - Porto Tolle demonstration project (ZEPT: Zero Emission Porto Tolle)

The Porto Tolle project is part of a wider programme aimed at large scale application of post-combustion. This technology applies the chemical absorption to remove the CO₂ contained in flue gases from power.

The demo plant will treat a flow of flue gases of 810,000 Nm³/h, corresponding to around 250 MWe, equivalent to about 40% of flue gases that are emitted from a unit of 660 MWe to produce about 1 Mt/y of CO₂, which will be transported by pipeline to the storage site and injected into underground reservoirs. This project, besides fully demonstrating this technology on an industrial scale, so as to provide a commercial solution for new installations after 2020, will test the possibility of retrofitting highly efficient coal-fired groups. This experience will benefit the entire area of southern Europe where geological storage is possible, mainly in deep saline aquifers. Enel was awarded funding of up to €100 million for Porto Tolle from the European Commission's European Economic Recovery Plan in December 2009. The demonstration plant is due to be

ready by 2012 with storage of CO₂ starting in 2015

Oxy combustion project - Brindisi pilot plant (ENEL)

The project regards the "flameless" combustion of coal in an atmosphere of oxygen, carbon dioxide and water vapour, at temperatures of about 1500 to 1700 °C and pressures up to 4 bar. Such process, developed and licensed to ITEA and being used at the present moment on a 5 MWt pilot installation, will be tested on a second installation with a power of 48 MWth.

4.2 PROJECTS MANAGED BY OTHER INDUSTRY

SOTACARBO/CARBOSULCIS - CBM and ECBM CO₂ storage in the Sulcis coal basin pilot project

The project has the objective of evaluating the feasibility of methane recovery (CBM) and of CO₂ storage (ECBM) in vast parts of the Sulcis coal basin, in South-West Sardinia, which are not suitable for mining activities. Once the characterization of the basin has been completed through studies, analyses of existing data and experimentation, the second stage will follow, with the aim of defining all the remaining aspects for the construction of a pilot injection and storage installation.

SULCIS - 400 MWe coal fired demo plant with CO₂ capture and storage

In the framework of the new Italian energy policy - Government and Parliament approved on July 2009 the Law n.99 "Regulations for the development and internationalization of enterprises and on the subject of energy" - an important initiative has been approved consisting in the realization in Sardinia Sulcis area of a medium size (400 MWe) power plant, firing the Sulcis coal and adopting CCS technologies; the CO₂ captured will be compressed, transported and stored in unminable coal seams as well as in the underlying aquifers. The project is aimed at demonstrating capture and permanent storage of the CO₂ emitted by power plants fed with a poor quality coal.

That law states also national public funding mecha-

nisms and project financing procedures; the regional Government of Sardinia supports this project from the political point of view and will participate to public funding. A detailed feasibility study has been already concluded (by Sotacarbo and ENEA).

SOTACARBO/ENEA - Pre combustion and coal to liquid zero emission pilot project

The main goal is, starting from the existing infrastructures, to realize (in the research area of Sotacarbo-Sardinia) an integrated pilot plant for testing advanced technologies for sustainable use of coal: it consists of a main gasification station and two main units, the first one to demonstrate a low emission coal-to-liquid process, and the second one to demonstrate pre-combustion carbon capture technology for combined generation of electricity and hydrogen; the CO₂ captured in the whole process will be injected into coal beds (ECBM) managed by Carbosulcis (coal mine industry) and into the underlying aquifers. In this context the Sardinia region will allocate a concession for the management of the coal mine involving the production of electric power, making the capture and storage of the emitted CO₂ an integral part of the concession itself.

TECHINT - Post-combustion CCS on gas fired power installation feasibility study for demo plant

The main goal is to apply post-combustion CO₂ capture to an existing 120 MWe gas fired co-generative power installation operated by Tenaris at Dalmine steel industry; the feasibility study is finalized. ENEA, ERSE and University of Milan are the research organizations involved.

5. COOPERATION AGREEMENTS (UNDERWAY OR DESIRABLE) AT THE EUROPEAN OR INTERNATIONAL LEVEL

Italy takes part, either directly or via its industry and research centres, in the most important European and international initiatives on CCS:

■ CARBON SEQUESTRATION LEADERSHIP FORUM (CSLF)

- ZEP EUROPEAN TECHNOLOGY PLATFORM
- GLOBAL CARBON CAPTURE AND STORAGE INSTITUTE (GCCSI)
- BILATERAL AGREEMENT ITALY-USA ABOUT CCT AND CCS
- EUROPEAN ENERGY RESEARCH ALLIANCE (EERA)
- EUROPEAN FRAMEWORK PROGRAM ON R&D (FW)
- ECCSEL (EUROPEAN CARBON DIOXIDE CAPTURE AND STORAGE LABORATORY INFRASTRUCTURE)

Its many cooperation agreements underway can increase, and offer opportunities to accelerate the application of CCS in Italy and to extend the action range of Italian enterprises and research centres.

- CARBON SEQUESTRATION LEADERSHIP FORUM (CSLF)

The CSLF is an international initiative at government department level, presently involving 22 nations beside the EU. These represent over 3,5 billion people, or 60% of the entire world's population. The mission of CSLF is to facilitate the development and application of CCS technologies through international collaborations, which aim at overcoming the main technical, economical and environmental obstacles, while promoting public awareness and international regulatory and financial improvement.

Italy has always taken part to all the CSLF meetings with its official representatives in the Policy Group and in the Technical Group respectively, and with representatives of stakeholders. Such commitment has allowed our Country, even though it lacks a clear strategy in the sector and a national path, to maintain a strict relationship with all the main international organizations involved.

- ZEP EUROPEAN TECHNOLOGY PLATFORM

Founded in 2005, the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP) is a unique coalition of stakeholders united in their support for CO₂ Capture and Storage (CCS) as a key technology for combating climate change: European utilities, petroleum companies, equipment suppliers, research organizations, academics and environmental NGOs are involved.

Italian stakeholders have a seat in the Advisory Council and participate to the technical Work Groups and Taskforces.

- GLOBAL CARBON CAPTURE AND STORAGE INSTITUTE (GCCSI)

GCCSI is an organization, borne out of an initiative of the Australian Government, whose aim is to marshal public and private resources to spread CCS techniques.

At the G8 Environmental Summit, held in April 2008 at Syracuse, a "Memorandum of Understanding", part of the Italian-Australian agreement for the cooperation of the development of CCS technologies, was signed by ENEL and the Australian minister for Agriculture Fisheries And Forestry, which implies that ENEL will join the Global Carbon Capture and Storage Institute (GCCSI) as a founding member.

Other organizations - as ENEA - expressed interest in becoming member of GCCSI.

- BILATERAL AGREEMENT ITALY-USA ABOUT CCT AND CCS

As part of the bilateral conference Italy - USA, held in may 2009, an agreement has been signed between Italy (Department of Economic Development) and USA (Secretariat for Energy) concerning clean coal and CCS. The sectors of cooperation between Italy and United States pertain: the exchange of experience and researchers, the coordination and monitoring of joint projects, the development of innovative technologies, the protocols to pinpoint sites suitable for CO₂ storage, and actions to increase public awareness.

In a recent meeting (Rome, April 2010) the SULCIS Project has been analyzed at the end to start a cooperation between Italy and USA.

- EUROPEAN ENERGY RESEARCH ALLIANCE (EERA)

Ten leading European Research Institutes have taken up the challenge to found a European Energy Research Alliance (EERA). The key objective of EERA is to accelerate the development of new energy technologies by designing and implementing Joint Research Programmes in support of the Strategic Energy Technolo-

gy (SET) plan. The EERA aims to strengthen, expand and optimise EU energy research capabilities through the sharing of world-class national facilities in Europe and the joint implementation of pan-EU programmes. ENEA is one of the founding members, and other Italian research centres participate to its joint programmes.

- EUROPEAN FRAMEWORK PROGRAM ON R&D (FW)

Some Italian organizations have been partner of different projects, starting from the 5° FW.

During the 6° FW, the Network of Excellence CO₂GeoNet was created. This is today the largest virtual institute in the world when the number of researchers is considered, all of them busy with the study of CO₂ geological storage.

Research centres, universities and various Italian industrial stakeholders have taken part in the past EU financed projects (as described in a previous chapter), so 7° FW can offer an opportunity to progress and to extend the Italian presence in the context of European research.

- ECCSEL (EUROPEAN CARBON DIOXIDE CAPTURE AND STORAGE LABORATORY INFRASTRUCTURE)

ECCSEL addresses the need for powerful European research infrastructures with CCS. This requires major and strategic upgrading of existing CCS research infrastructures, the development of new unique laboratories, a goal-oriented approach, as well as the strengthening of the networks that comprise the European CCS laboratories. Such research infrastructure will enhance European competitiveness about CCS technologies, contribute to make work on this topic systematic and to improve the safety of Europe's energy plants. The ECCSEL proposal has been endorsed by ESFRI (European Strategy Forum on Research Infrastructures) and is going to receive support from the EC to help define the elements and rules that can make it function as a multi-centre European infrastructure of the highest level.

OGS and ENEA are main partners of ECCSEL, and others (La Sapienza University of Rome, ENEL, ..) support the project

6. STRENGTHS OF THE ITALIAN SYSTEM

The main strength lies in the new energy policy adopted by Italian Government and Parliament, with the approval on July 2009 of the Law n.99 on “Regulations for the development and internationalization of enterprises and on the subject of energy”. It promotes innovation in energy sector – by adopting project financing, three years RDD Plan, and fixing priority on CCS, nuclear and energy efficiency – and foresees a national action plan.

Looking in detail, Art. 38 bears initiatives that promote research and experimentation in various areas of the energy field, amongst which the capture and storage of the CO₂ produced and released by power plants.

To such end a working plan will be approved which aims at:

- allowing the implementation of demonstrative projects on the capture and permanent storage of the CO₂ emitted by thermoelectric power plants and the implementation, albeit experimental, of permanent storage of CO₂ into suitable deep geological formations, also with the aim of an improved exploitation;
- realizing a coal fired with CCS demo plant, and ensuring that the Sardinia region allocates a concession for the management of the Sulcis coal mine involving the production of electric power, making the capture and storage of the emitted CO₂ an integral part of the concession.

The second strength is the starring of the main Italian industrial subjects, above all ENEL and Eni, which have started demonstrative projects of the greatest importance, but also Sotacarbo, Carbosulcis ITEA, Techint, and others, that has launched important demonstrative initiatives (both at pilot and industrial scale) and feasibility studies involving, albeit with different stages of development, the three technologies for the capture and the main modalities for CO₂ storage.

The third strength is the research and development capability in the main public bodies and in Universities.

These possess a great potential in terms of expertise, laboratories / installations, and a great potential for networking both with industry and with central decision-makers to expand national policies, putting our Country in line with the nations which so far have been the most active in the CCS field. In this context, the role the research system can play in starting actions to get the correct information across to the public on the nature of CCS techniques, also with the involvement of NGOs, is not negligible.

Another important side is the large quantity of geophysical data available for many parts of the Italian territory. These data are owned by the oil companies and are of great value for assessing an overall CO₂ storage capacity in Italy, based on sounding geological and geophysical evidences.

7. POTENTIAL ROLE OF ITALIAN STAKEHOLDERS IN THE FOUNDING OF EII

Europe, and Italy with it, is a front line competitor on CCS technologies. The research system operators are able to offer respectable competencies and resources, both in medium - long term activities and in industrial programmes. In fact, Italy is offering a wide ranging demonstrative programme:

- ENEL, together with Eni, is pushing a post combustion technology demo plant (Porto Tolle) and an oxy-combustion facility (to be constructed near Brindisi);
- Sotacarbo and ENEA have carried out a feasibility study for a 400 MWe coal fired demo plant with CCS to be realized in Sardinia (Sulcis demo Project);
- Sotacarbo and Carbosulcis, together with ENEA, OGS, Universities, and others, are managing a project aiming at evaluating the feasibility of methane recovery (CBM) and of CO₂ storage (ECBM) in vast parts of the Sulcis coal basin, in South-West Sardinia, which are not suitable for mining activities;
- Sotacarbo and ENEA are carrying out activities on

pre combustion CCS and planned to realize a Pre combustion and coal to liquid zero emission pilot plant with CO₂ capture and storage;

- ITEA has planned Oxy combustion project applied to different sectors – Gioia del Colle pilot plant;
- Techint and Tenaris, together with ENEA and ERSE, have completed a feasibility study to retrofit the Tenaris combined cycle plant (of about 120 MWe) with a CO₂ post-combustion capture system with storage in a well of the Bergamo area.

Therefore Italy is potentially in a position to study and demonstrate, although at different detail levels, all three capture technologies: this is necessary because today there is no technology which is judged to be better than the others, and there are broad possibilities of diverse applications according to the sector and to the various geographic / socio-political conditions.

On top of that, such an approach addresses the diverse needs of diverse industries who want to compete on the global market and utilize their own expertise. Amongst these are companies like ENEL, Eni, Ansaldo, ITEA, Techint, Snamprogetti, Foster Wheeler, Carbosulcis, Sotacarbo, Universities and research centres like ENEA, ERSE, INGV, OGS, Sardegna Ricerche, beside national and local government organizations. Diverse, technologically inclined groups, like Assocarboni, the recently founded CO₂club and environmentalist associations, are fulfilling a growing role.

In conclusion, we have in our Country a broad and diversified set of stakeholders, made up of public and private organizations with different aims who, altogether, can cooperate on one side for the development of

the technologies and their utilization at the industrial level, on the other side to contribute to the advance of general knowledge and of public acceptance.

8. SUMMARY REMARKS

In conclusion we can say that in Italy we have several initiatives, of different sizes and at different levels of development. The main national and European public funding instruments are:

Fund for R&D on Electricity System that collects the electricity bills (<0.03 c€/kWh) for co-funding technology innovation of the electricity system. More than 35 M€ have been already spent (mainly ERSE and ENEA) in the first 3-y programme. The new 3-y programme 2009-11 foresees 30 M€, and has already allocated, up to now, 19 M€.

Law n. 99/09: New Energy Strategy for Promoting innovation in the energy sector; it introduces a project financing mechanism and a first three-years RDD Plan: CCS is a priority in this plan.

Industria 2015 in the area of Areas Energy Efficiency a project on mild oxy-comb has been funded.

PNR: National Research Program for financing medium-long term R&D programmes; the last 3-y programme funded more than 2.5 M€ to Zecomix project on advanced pre-combustion technologies; the next 3-y plan is going to be adopted.

EC public contribution ENEL has already received 100 M€ contribution (EERP), but other contribution is expected (NER300, FP, etc..) in order to achieve a feasible national programme. ●

A first list of Italian main projects to be supported and funded is reported in the following table:

project/ responsible	national contribution						Regional Contribution (Sardinia)	EC Contribution	priority
	Fund for R&D on Electricity System		Law 99/09: New Energy Strategy		National Research Programme				
	already given	to be given	already given	to be given	already given	to be given			
DEMO PROJECTS									
Porto Tolle				X				NER 300	1
ENEL-ENI								other	
Sulcis 400 MWe				X			X	NER 300	2
Sotacarbo/ENEA								other	
PILOT PROJECTS									
Precomb (and coal-to-liquid)	X	X		X			X	other	1
Sotacarbo/ENEA								?	
ECBM-ECBM in Sulcis basin	X	X		X			X	other	1
Carbosulcis-Sotacarbo								?	
Brindisi post comb				X				other	1
ENEL								?	
Oxycomb					to be evaluated			other	
ITEA								?	
MID-LONG TERM R&D									
pre-comb	X	X					X	X	
ENEA-Sotacarbo-ERSE									
post-comb	X	X					X	X	
ERSE-ENEA-ENEL					to be evaluated	to be adopted			
oxy-comb							X	X	
ENEA-ITEA-Sotacarbo-CNR									
ECBM-wells-aquifers	X	X					X	X	
ENI-Carbosulcis-OGS-Univ., ...									