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Implementation of the EU CCS Directive in Europe: results and development in 2013

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Abstract

Directive 2009/31/EC of the European Parliament on the geological storage of carbon dioxide, entered into force on June 25th 2009. By the end 2013 the CCS Directive has been fully transposed into national law to the satisfaction of the EC in 20 out of 28 EU Member States, while six EU countries (Austria, Cyprus, Hungary, Ireland, Sweden and Slovenia) had to complete transposing measures. In July 2014 the European Commission closed infringement procedures against Cyprus, Hungary and Ireland, which have notified the EC that they have taken measures to incorporate the CCS Directive into national law. Among other three countries Sweden has updated its legislation and published a new law in their country in March 2014, permitting CO₂

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storage offshore. The evaluation of the national laws in Poland, which were accepted at national level in November 2013, and Croatia, which entered the EU on 7 July 2013 and simultaneously transposed the CCS directive, is still ongoing in 2014. The first storage permit under the Directive (for the ROAD Project in the offshore Netherlands) has been approved by the EC.

While CO₂ storage is permitted in a number of European countries, temporary restrictions were applied in Czech Republic, Denmark and Poland. CO₂ storage is prohibited except for research and development in Estonia, Finland, Luxembourg, two regions in Belgium and Slovenia due to their geological conditions, but also forbidden in Australia, Ireland and Latvia. The size of exploration areas for CO₂ storage sites is limited in Bulgaria and Hungary. In Germany, only limited CO₂ storage will be permitted until 2018 (up to 4 Mt CO₂ annually).

Several challenges still remain for the large-scale implementation of CCS projects in Europe. These include high investment costs and lack of public and consequently political support for onshore storage (particularly in Denmark, Germany, and The Netherlands). An European atlas matching all storage sites and capacities is still required. Among six projects supported by European Energy Programme for Recovery only Spanish project Compostilla was active and only UK submitted their application for CCS project to the NER300 second call in 2013 receiving support in 2014.

The most active countries in pilot and demonstration projects research and development activities in Europe were Norway and the largest CO₂ emitters in EU (Germany, UK, Italy, France, Spain and The Netherlands). The most promising driving force for CCS implementation is to combine it with CO₂ use, including EOR-CCS, mineral carbonation options and geothermal-CCS, which will cause more trust among Green NGOs and general public. Research on CCUS has started in many countries, including Geothermal-CCS project in France, Norway and Germany.

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1. Introduction

Directive 2009/31/EC of the European Parliament on the geological storage of carbon dioxide, entered into force on June 25th 2009. This directive established a legal framework for the environmentally safe geological storage of CO₂. According to the Directive: “Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by June 25th 2011”, and they “shall ensure” that any storage sites “are operated in accordance with the requirements of this Directive by June 25th 2012” [1].

The aim of this paper is to give an update of the research on the legal status of CCS in Europe, made during EC FP7 project CGS Europe [2], on the development of European CO₂ storage projects and give an indication of the current appetite for CCS amongst European governments.

2. Results

2.1. General progress

By June 25th 2011 transposition of the CCS Directive was accepted by the EC only in Spain, while in July 2011 the Commission sent letters of formal notice for non-communication of national measures to other 26 EU Member States. By the end 2013 the CCS Directive has been fully transposed into national law to the satisfaction of the EC in 20 out of 28 EU Member States, while six EU countries (Austria, Cyprus, Hungary, Ireland, Sweden and Slovenia) had to complete transposing measures [3]. In July 2014 the EC has closed infringement procedures against Cyprus, Hungary and Ireland, which have notified the EC that they have taken measures to incorporate the CCS Directive into national law. Among other three countries Sweden (which temporary banned CO₂ storage until end 2013), has already made changes in the national legislation and in March 2014 published a new law, permitting CO₂ storage offshore.

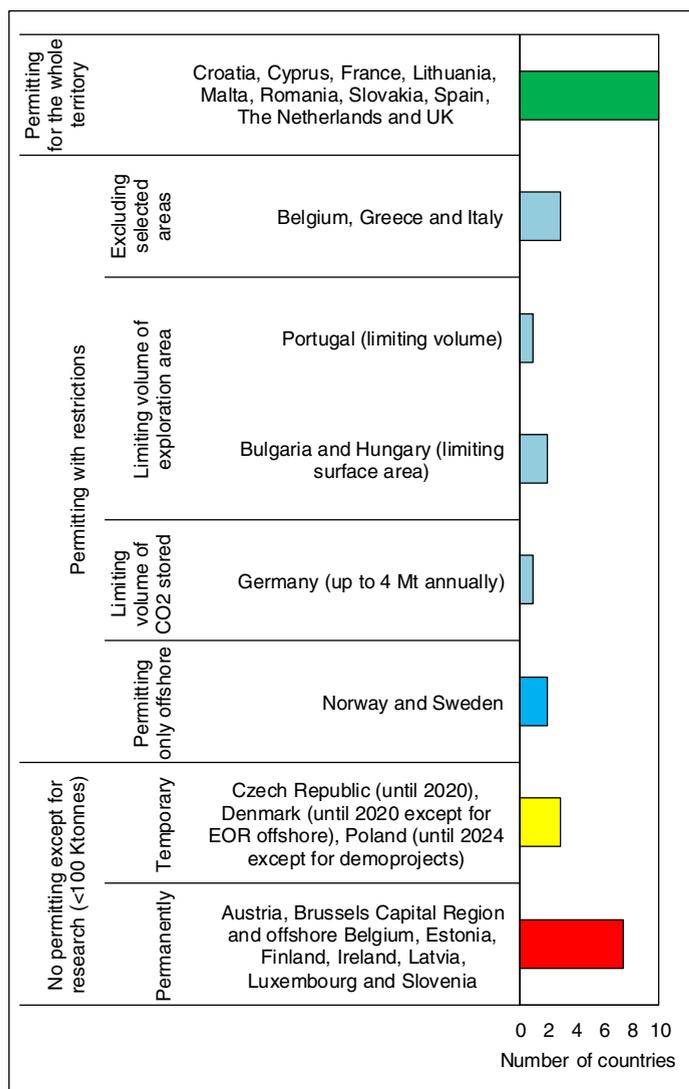
After long discussions in Poland, their CCS law was published in November 2013, as last of the 27 EU countries. Croatia (the 28th EU Member State) entered the EU on 7 July 2013 and simultaneously transposed the CCS directive

as a part of the new Law on Exploration and Exploitation of Hydrocarbons complemented by a new by-law on Permanent Disposal of Gases in Geological Structures. The evaluation of the national laws in Poland and Croatia is ongoing in 2014.

For Norway as an EEA (European Economic Area) country the CCS Directive entered into force on the 1st June 2013. Until now CCS activities has been regulated in Norway under existing acts and regulations for petroleum activities, and two new sets of regulations on transportation and storage of CO₂ on the continental shelf were under preparation in 2013. In 2014 The Ministry of Petroleum and Energy drafted regulations for transport and storage of CO₂ which were available for public consultation up to 28 May 2014. The consultation stated that the added operators-burden for the new regulations is small to negligible compared to the pre-existing regulations.

Turkey as an associated EU Member State has to transpose the Directive at a later date, starting with the preparation process to join ETS (European Emission Trading System) in 2014 [4].

2.2. Permitting of CO₂ storage



While many Member States allow CO₂ geological storage, governments have applied at least temporary restrictions on CO₂ storage in several countries (Fig.1).

In Denmark, regulations have prohibited storage until 2020, with the exception of offshore CO₂-enhanced oil recovery (EOR). CO₂ storage has been temporary banned in the Czech Republic until 2020. CO₂ storage is prohibited in Poland until 2024 except for demonstration projects.

The volume of exploration area for CO₂ storage is limited in three countries. While Portugal limits the volume directly, Bulgaria and Hungary limit the territory of the surface area. In Germany, only limited CO₂ storage will be permitted until 2018 (up to 4 Mt CO₂ annually and maximum 1.3 Mt per one project). CO₂ storage is prohibited except for research and development in Estonia, Finland, Luxembourg, two regions in Belgium (Brussels Capital Region and off-shore Belgium) and Slovenia due to their geological conditions, but also forbidden except for R&D in Austria, Ireland and Latvia.

Additionally, CO₂ storage is not permitted in seismically active areas in Italy, and in Greece in areas where the storage complex extends beyond Greek territory.

Offshore CO₂ storage is permitted in Sweden according to the new law efficient from March 2013, and in Norway regulated by existing petroleum exploration laws.

Fig. 1. Permitting CO₂ storage in European countries.

2.3. Exploration and storage permits

Member States that allow geological CO₂ storage in their country have implemented the Article 4(3) of the CCS Directive, determining the suitability of a storage site through a characterisation and assessment of the potential storage complex and surrounding area pursuant to criteria specified in Annex I. According to Article 5(1) exploration permits should be issued by Member States to conduct such assessment. Exploration permits allow for injection tests needed for characterisation of sites. Exploration permits are always required in Bulgaria, the Czech Republic, Germany, the Flemish Region, Hungary, Lithuania, Poland, Slovakia and Sweden. Exploration permits are only required where there is too little information to apply for a storage permit in Denmark, France, Luxembourg, the Netherlands, Romania, Spain and UK. As required in Articles 5(2-4) of the CCS Directive, most Member States allow exploration permits to be open to all entities possessing the necessary capacities, exploration permits to be granted for a limited volume area, and if there are no conflicts between exploration for CO₂ storage and other activities. Several Member States have already issued exploration permits. Exploration permits for potential storage sites (regulated by existing and new laws) have been awarded in the Czech Republic, Poland, Spain, France and the UK (offshore), and the first storage permit under the Directive (for the ROAD Project in the offshore Netherlands) has been approved by the EC, with a review of the permit required closer to the operation date.

2.4. Amendment of existing EU Directives and transboundary issues

The CCS Directive has amended six existing EU Directives in order to protect the environment and human health from the risks connected to geological storage of CO₂. All EU Member States, communicated the EC for their transposing measures, made amendments in four of their existing instruments regulated by the (1) EIA (Environmental Impact Assessment) Directive, (2) Waste Framework Directive, (3) Industrial Emission Directive and (4) Large Combustion Plant Directive. Member States which allow CO₂ storage in their countries also amended laws regulated by (5) Water Framework Directive and (6) Environmental Liability Directive (Articles 31-35 and 37, [1],[3]). The CCS directive encourages bilateral agreements between countries to arrange for transboundary CO₂ transport in order to circumvent the London Protocol prohibiting the export of CO₂ as waste.

As a result, capture and transport of CO₂ stream is covered by national instruments regulated by (1) and (3); CO₂ captured and transported for the purpose of geological storage is excluded from the national waste regulations (2), and operators of combustion plants with capacity of 300 MW or more should assess conditions and demonstrate that the plant is built “capture-ready” (4) in all the Member States. CO₂ is allowed for injection into saline reservoirs according to instruments regulated by (5) and operation of CO₂ storage sites is allowed according to amendments made in instruments regulated by (6) in countries permitting CO₂ storage [3].

Many countries addressed in their regulations transboundary transport of CO₂ and transboundary storage sites or complexes, but only three countries (Germany, The Netherlands and the UK) have an experience of such transboundary cooperation in the North Sea Basin Task Force, developed common principles for managing and regulating the transport, injection and CO₂ storage in the North-Sea sub-seabed [5]. Furthermore, the Netherlands has been in consultation with Denmark on a project that envisages CO₂ captured in the Netherlands being transported to the Danish continental shelf to be used for enhanced oil recovery (EOR). The Norwegian company SARGAS was planning a project to transport CO₂ captured in Norway to Lithuanian onshore oil fields (in Cambrian reservoir sandstones) for EOR-CCS. Two pilot injections have been already made in Lithuania in 2013, investigating potential of CO₂ to be used for EOR [6].

3. Driving forces and barriers for implementation

Several matters have influenced political decisions in the countries, the process and results of the CCS Directive transposition. These include national CO₂ emissions, CO₂ storage capacity, public awareness, perception and financial problems and maturity of CCS technology. National GHG emissions and commitments of European countries signed Kyoto Protocol to reduce their emissions first by 2008-2012 (5-8% below 1990 levels), and then in 2013-2020 (20 percent below 1990 levels) are important in developing national climate mitigation strategies.

3.1. National CO₂ emissions

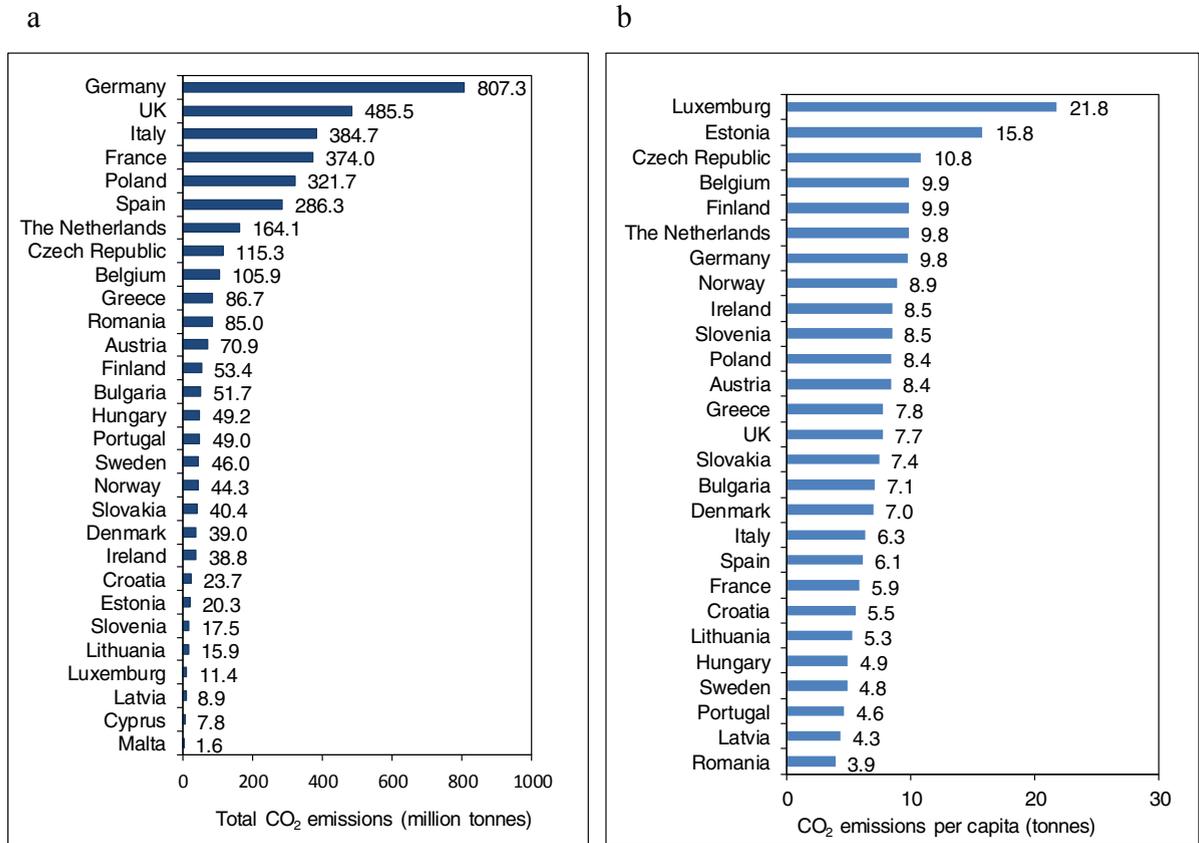


Fig. 2. European CO₂ emissions in 2012: (a) Total CO₂ emissions in 29 European countries; (b) CO₂ emissions per capita in 27 European countries (data from <http://edgar.jrc.ec.europa.eu/>).

The Kyoto Protocol and countries' obligations to cut CO₂ emissions compared to 1990 is commonly a key reference point for national climate and energy policies in the studied countries. Therefore the latest available data for total national CO₂ emissions and emissions per capita is reported and compared here (Figs. 2 a, b). According to Emission Database for Global Atmospheric Research (EDGAR) of European Commission Joint Research Centre the world total CO₂ emissions without transport in 2012 was 34.45 Gt (<http://edgar.jrc.ec.europa.eu/>).

The emissions of 27 EU Member States were in total 3.74 Gt, of which 3.02 Gt were produced by the 15 old EU Member States. Among the 29 evaluated countries (28 EU Member States and Norway) the highest total emissions, in the range of 160-810 Mt, were from Germany, UK, Italy, France, Poland, Spain and The Netherlands (Figs. 2a, 2b). The highest total emissions among new member states were in Czech Republic (115 Mt), the lowest in Malta, Cyprus and Latvia (1.6-8.9 Mt). Belgium, Romania, Greece, Austria, The Netherlands, Hungary, Finland, Bulgaria and Portugal produced emissions in the range of 50-106 Mt (Fig.2a). Average global CO₂ emissions per capita in 2012 were 4.88 t, while in 27 EU Member States they were 7.42 t. Among EU countries the highest CO₂ emissions per capita in 2012 were in Luxemburg, Estonia and Czech Republic and the lowest in Romania and Latvia. Countries with high total emissions and per capita are Germany, Czech Republic, The Netherlands and Belgium. CO₂ emissions per capita were also higher than EU average in UK, Greece, Austria, Poland, Slovenia, Ireland and Norway and Finland.

3.2. Storage capacity

Estimates of CO₂ storage capacity were undertaken in the studied countries in the EU FP5 GESTCO project, EU FP6 GeoCapacity project and also in independent national projects in several countries. The EU GeoCapacity project estimated European storage capacity to be conservatively 127 Gt CO₂, comprising 97 Gt in saline formations, 20 Gt in hydrocarbon fields and 1 Gt in coal seams. Storage capacity was estimated by the CGS Europe project partners as “sufficient at national level” in 17 countries [2]. The Norwegian partners in this project consider that Norway could potentially offer capacity to other countries for cross-border storage [4]. Storage capacity was estimated as “insufficient” in five countries, “not identified” in Estonia and Finland and “not yet estimated” in Sweden and Austria. Rough estimates of storage potential in Sweden published in 2013 was more than 15 Gt in onshore and offshore areas [8]. There is still no Europe wide storage atlas which uses a common methodology to map and calculate storage potential.

3.3. Public acceptance

Local public protests against CCS which have had an impact on adoption of the directive have occurred at several proposed storage sites in Germany [4]. Strong resistance to CCS by Green NGOs is apparent in Germany, Denmark and Poland. Protest from some environmental NGOs has taken place in the UK. The influence of Green NGOs on public opinion is high in Germany and Poland, and is thought to be at least partially responsible for the long lasting debates in these countries [2]. In Denmark the opposition of the local environmental NGOs was so high that it resulted in prohibition of CO₂ storage onshore until at least 2020. In UK, the opposition of environmental NGOs was not so clear-cut, and did not affect the role of CCS in overall UK climate and energy policy, which provides significant support for future CCS demonstration projects. Strong public opposition to the developed onshore projects in the Netherlands caused cancelation of these activities and only offshore projects are now supported by the government and industry. The cancelation of the Barendrecht project by the Dutch government is an example of such case.

3.4. Financial matters

3.4.1. Cost of CCS projects and financial mechanisms

The high investment cost of CCS projects, as a typical feature of all the new and innovative technologies, is one of the well-known hurdles for the implementation of the large-scale CCS projects worldwide. In addition to exploration, construction and operating costs, operators must carry out monitoring of injection facilities, the storage complex and the surrounding environment based on a monitoring plan to be submitted as part of the storage permit application (Article 13). After closure of the storage sites the operator remains responsible for monitoring, reporting and corrective measures in case of leakages until transferring of the storage site to legal authority. Most Member States laws require a monitoring period of at least 20 years between the closure of the site and the transfer of responsibility, while some Member States have defined for longer periods of 30-40 years.

According to Articles 19-20 two financial guarantees are required from operators, financial security for the period before the transfer of responsibility and financial contribution for the period after the transfer of responsibility. The latter financial contribution will cover the cost of monitoring for a period at least of 30 years. Additional financial requirements were made into law in some Member States. For example a financial contribution for monitoring costs for at least 50 years after the transfer of responsibility is required in the Czech Republic.

3.4.2. European instruments supporting CCS projects

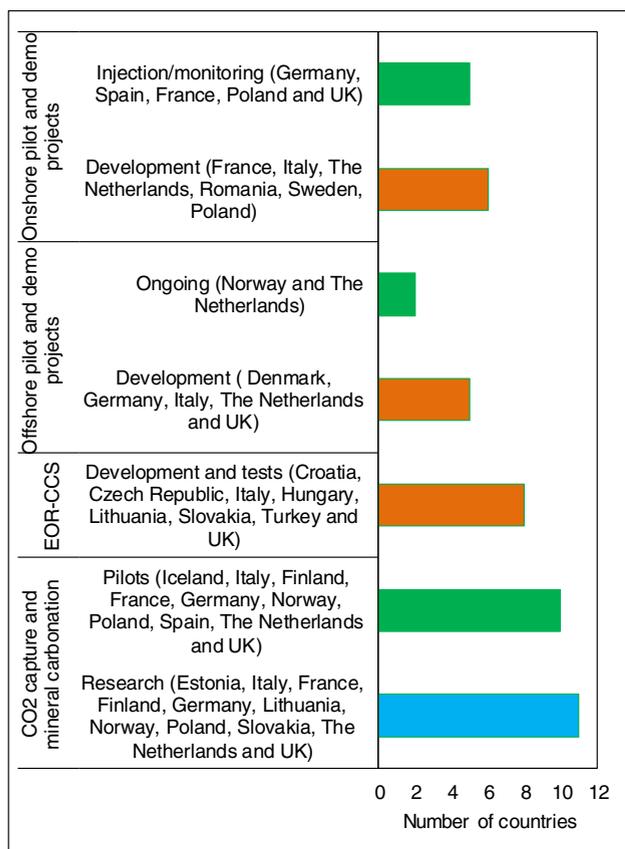
Under the European Energy Programme for Recovery (EPR) six CCS projects (from Germany, UK, the Netherlands, Poland and Spain) were initially supported. The German project Jämschwalde was terminated by Vattenfall in February 2012, due to the lack of a regulatory framework and public acceptance problems. The Polish project Belchatow was terminated in May 2013 due to the financial problems, technical risks and failure of the

Member State to timely transpose the CCS Directive with the resulting lack of the suitable regulations and public acceptance. The Italian project Porto Tolle was terminated in August 2013 due to delays in project execution caused by problems with environmental permit for the Porto Tolle power plant and financial problems. None of the three remaining projects (DON Valley - UK, ROAD - The Netherlands and Compostilla - Spain) has adopted the Final Investment Decision (FID) by the end of 2013[7]. However the ROAD project is the most advanced and successful ongoing CCS project in Europe and have already got the first European storage permit accepted by EC. The Spanish Compostilla Project OXYCFB300 has completed in 2013 the first pilot phase funded by € 180 million from EEPR and is waiting for the FID by the main operating company Endesa to start the second full scale demonstration phase.

On 18 December 2012, the European Commission released the outcome of the competition for the first call of the European NER300 funding programme. No CCS projects were awarded funding under this call. Most of the 11 CCS projects were not confirmed by the Member States concerned, and therefore were not considered viable for funding awards. Member States were unable to confirm the projects for various reasons. In some cases there were funding gaps, while in others the projects were not sufficiently advanced to allow for confirmation within the timeframe of the first call for proposals. The European Commission promised that € 275 million envisaged for CCS projects in the first call remained available to fund projects under the second phase of the NER300 programme.

Only one CCS project (White Rose Carbon Capture and Storage Project, developed by Capture Power, UK) applied for funding in the second phase of the programme. A funding award decision of up to €300 million under the NER300 programme was announced on the 8 July 2014. Located on land adjacent to the existing Drax Power Station, near Selby in North Yorkshire, the 426 MW new build power plant will burn coal with the potential to co-fire sustainable biomass, while 90% of all the CO₂ produced by the plant will be captured and transported by pipeline for permanent off-shore storage beneath the North Sea seabed.

3.5. Progress in 2013 and further prospects



Although numerous projects have been, and continue to be cancelled, pilot, demonstration or commercial-scale CO₂ storage projects have been developed onshore in France (Lacq) and was ongoing in Germany (Ketzin – abandoned and monitoring phase is ongoing in 2014) [9], and offshore in Norway (Sleipner and Snøhvit) [10] and The Netherlands (K12-B).

Additionally, several storage projects are under development (Fig.3). The pilot storage project of Hontomin (Spain) is also active, injection and monitoring wells have been drilled and several tests are being performed there. The GETICA CCS demonstration project in Romania has stalled and is waiting for financing and for the establishment of the project implementation company (composed of the capture, transport and storage operators).

The most active countries in pilot and demonstration projects research and development (R&D) activities in Europe are Norway and Germany, UK, Italy, France, Spain and The Netherlands. The last EU Member States also produce the highest in Europe total CO₂ emissions.

Fig. 3. Current activities in CO₂ storage projects research and development in European countries (green bars show ongoing activities, orange is for developing projects and blue is for research).

The CCS Directive has been fully transposed in the UK. There is significant appetite for CCS within government. Government, via the UK Carbon Capture and Storage (CCS) Commercialisation Competition is ready to make available £1 billion in capital funding, together with additional operational funding through the UK Electricity Market Reforms, to support the design, construction and operation of the UK's first commercial-scale CCS projects. As part of the government's CCS commercialisation programme, two multi-million pound FEED studies for full chain demonstration projects with offshore storage on the UK Continental Shelf are in progress. These are for the White Rose and Peterhead CCS projects. The first Carbon Storage Licence has been awarded to National Grid Carbon which has drilled a well within the area of this licence.

Research on CCUS has started in many countries, including Geothermal-CCS project in France, Norway and Germany. Norway established a Centre for Innovation for increased oil Recovery in 2013. Regional and local CO₂ transport and recompression systems have been completed in Croatia for onshore CO₂-EOR project Ivanic with the first injection planned for spring 2014 and re-injection of the produced CO₂ at the next stage. Pilot injections for CO₂-EOR activities were started in Lithuania, were under preparation in Hungary, and are currently discussed for the North-Sea area, and is under R&D in Czech Republic (Fig.3).

First preparation phase for national pilot CO₂ injection project was started and completed in Sweden [11] and new scenarios for demo projects were discussed in Poland. CO₂ capture and mineral carbonation R&D activities are ongoing in Estonia, Italy, France, Finland, Germany, Poland, Slovakia, Switzerland, The Netherlands and UK.

4. Conclusions

- The enabling legislation for CCS in Europe is mostly complete, accepted by EC in 23 countries and is likely to be fully finalized within 2014.
- The most active in pilot and demonstration projects research and development (R&D) activities in Europe are EU Member States producing the highest total CO₂ emissions (Germany, UK, Italy, France, Spain and The Netherlands) and Norway (European Economic Area Country).
- Several challenges still remain for the large-scale implementation of CCS projects in Europe. These include high investment costs and lack of public and consequently political support for onshore storage (particularly in Denmark, Germany, and The Netherlands). An European atlas matching all storage sites and capacities is still required.
- While offshore storage is successfully demonstrated in Norway with significant storage capacity estimated, it is more expensive than onshore and therefore more complicate to implement.
- The most promising driving force for CCS implementation is to combine it with CO₂ use, including EOR-CCS, mineral carbonation options and geothermal-CCS, which will cause more trust among Green NGOs and general public. Research on CCUS has started in many countries, including Geothermal-CCS project in France, Norway and Germany.

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