Environmental issues of CO_2 pipelines

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Introduction

One means in the struggle against climate change is the reduction of greenhouse gas (GHG) emissions. The emitted GHG's contain CO_2 (carbon dioxide) up to 80% so the reduction of this element can lead to notable results. One way for this procedure is to separate CO_2 from flue gas at source points of high emission (which are usually power plants), and then allocate it to a subterranean level in different kind of formations by carbon capture and storage (CCS) technology. The separation site and the geological storage site are not at the same place, so there is a need for CO_2 to be transported by pipeline.

A long-term plan of the European Union (EU) is the construction of a CO_2 pipeline structure, similar to the one used in natural gas transportation. According to the plans, by 2050 this pipeline system will reach Hungary as well.

Important questions arise in connection with environmental protection when considering the construction and operation of the pipelines. The author attempts to summarise the issues to be considered.

1. The CCS chain

In 2009 the high rate of emission of CO_2 meant 29 billion tonnes. About half of this enormous amount consisted of emissions from thermal- and electric energy producers, the traffic sector and public consumption, and this is similar in the present as well. The two latter sectors are made up of numerous, even several millions of emitters, while power plants and other energy industry settlements have fewer source points. A significant part of the great amount of CO_2, produced at these resource points can be detached from flue gas by different types of technological methods. The "accessible" quantity of CO_2 was more than 1,300 million tonnes in the EU-27 and 15 million tonnes in Hungary in 2009 [1].

The first step of the technological chain at sites of energy producers and other energy industry actors is the separation of the nascent CO_2 from fuel gas. Among separation processes we differentiate pre-combustion, post-combustion and oxy-fuel technological separation.

Transportation is also an important task in the CO_2 chain, which can take place by an appropriate pipeline structure or by tanker. Specialists of the hydrocarbon industry have gained diverse experience in connection with this important task, since enhanced oil recovery (EOR) technologies. The first pipelines of the type were established in the 1970s in the USA; in Hungary a line to serve the oil production of Budafa was installed in 1972. The length of the CO_2 pipelines nowadays in the USA is nearly 6,000 km, while in Europe the total length is less than 500 km.

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The separated CO_2 can be stored underground in appropriate geological forms so as to decrease the emissions load of the energy industry. Different storage formations are: deep saline reservoirs, unrecoverable coal seams and depleted oil and gas fields.

2. The CO_2 pipeline system in the EU

On 11 March 2011 the European Commission released a communiqué titled "A roadmap for moving to a competitive low carbon economy in 2050" that marked out the path to an economy with lower CO_2 emissions. The EU considers present CCS technology as only a temporary solution, but considers it to be an important area that should be regulated and whose pilot projects should be financed, too [2].

Table I. Active CCS CO_2 pipelines in the EU [3]

Name	County	Amount of CO_2 (Mt/y)	Length (km)	Diameter (mm)	Pressure (bar)	Start of operation
Sleipner	Norway	1	160	n/a	n/a	1996
Snøhvit	Norway	0.7	153	200 (8")	100	2006
Lacq	France	0.06	27	n/a	n/a	2010

Three CCS projects are presently in operation in Europe (Table I), a Norwegian pipeline is under construction, and three projects (two Norwegian and one Dutch) were cancelled (due to the economic crisis, probably). Several projects across the continent are in the planning stages and several theoretical project locations are under consideration [1].

According to a study of JRC [4], the research institute of the European Commission, the EU will spend 25 billion Euros on the construction of a 2,005-km-long CO_2 pipeline until 2020 and by 2050 a so-called European CO_2 pipeline network is to be established, which means a pipeline of more than 20,000 km at a cost of 28.9 billion euro. The pipeline network to be built may be similar to the gas transportation network spanning the EU (Figure 1). Pipelines would connect source points of high emission to places of storage that are mostly within marine-located formations (e.g. distressed hydrocarbon fields).

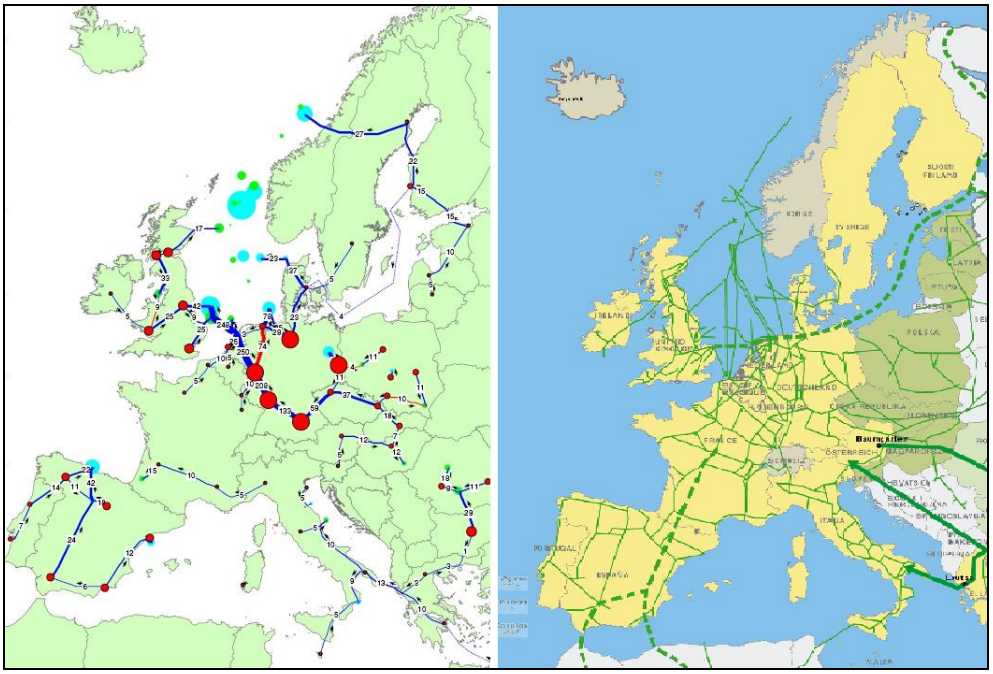

Figure 1. The planned CO_2 network system by 2050 [5] and the natural gas network system in 2010[8]

3. Environmental effects of CO_2

Naturally, environmental effects of the transported material, and the protection of the pipeline's environment are notable points of view when considering the establishment and operation of CO_2 pipeline as an element of CCS technology.

3.1 Characteristics of CO_2 [5]

CO_2 is a languid type of gas, which exists in the air at a low proportion (at 0.039% static pressure), is non-combustible, and is heavier than the air (1.98 kg/m$^{3)}$. It can be easily liquefied (at room temperature, at a 35 bar load), but strongly evaporates at normal static pressure, while detracting heat from its environment. At this point a solid snow-like material arises, the so-called dry ice (often used as cryogenic media).

CO_2 forms a light acid with water – carbonic acid – so it weakly dissolves in water.

3.2 Effects on the human body [5]

Naturally existing CO_2 in the air does not have any effect on human health, but if the cubic capacity percent of CO_2 in the air is 5%, it can cause dizziness, headache and nausea. In high concentration it attacks the respiratory centre and affects the metabolic process of

the blood. At an increasing concentration of CO_2, the oxygen concentration of the air drops and at a 16% oxygen proportion asphyxia can occur.

3.3. Effects on the eco-system

CO_2 pipelines functioning nowadays go through areas of low population density, so the CO_2 that blows out from the pipe affects mainly the flora and fauna. Above the necessary concentration, CO_2 can be dangerous to plants, but in some cases it can act positively, up to 20-30%.

When CO_2 gets into groundwater there is an acid reaction and in some disadvantageous cases it releases chemical elements from rocks, so it can change the composition of groundwater and the stability of rocks.

It can also happen that marine pipelines malfunction and the filtering gas mixes with marine water. An acid reaction occurs here as well, with the degree of the negative effects strongly depending on the pH value. The creatures most seriously affected are those which are immovable and cannot leave the area polluted by CO_2.

4. Construction, operation and environmental protection of pipelines

Specialists of the hydrocarbon industry have gained diverse experiences in connection with this important task, since EOR technologies apply CO_2 in rock-oil exploitation, and pipelines are used for transported to the site of exploitation.

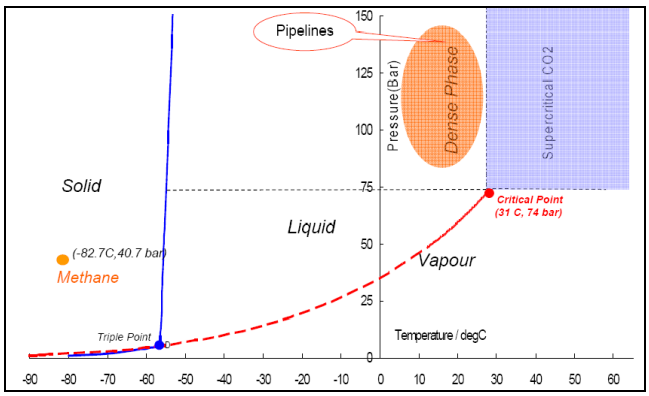

Figure 2. Properties of CO_2 [6]

The path of the pipelines should be carefully chosen considering the right of way (ROW). It is important to take into account that CO_2 is denser than air, so when lying down the pipeline path, it is necessary to consider the possibility of an accidental outflow that could be dangerous to the environment.

In pipelines, which can run several hundreds of kilometres (the longest one in the USA is 800 km) CO_2 should be at a high pressure – more than 100 bars – so as not to let its liquid aggregate rise to a temperature of more than 31°C (see Figure 2).

Due to the applied high pressure it is very important to keep the area safe. The security area can extend from 10 m up to even 24 m in Hungary [7].

Before implementing a project an environmental impact study is carried out to investigate the environmental effects of the construction and operation of the pipeline.

Pipeline construction can have effects on:

- *The cleanness of air*: pipelines are constructed fractionally, so effects do not occur organically in the pathway. During the laying of the barrel and the extrusion, CO_2 pollution can be notable. Earth moving equipment and the exhaust fumes of transporters vehicles can temporarily increase dust and air pollution (CO, NO_x, etc.) at the construction site.
- *The soil, groundwater, subterranean water*: earth moving equipment should be in impeccable condition and well-serviced, and during their operation it is necessary to ensure that no fuel or dangerous chemicals contact the soil and surface water. The extent of accidental pollution should be immediately limited.
- *Flora and Fauna*: strict care should be taken of species living in the vicinity of the construction area, especially those under protection. For example a temporary restriction can be applied for the nesting period of a protected bird species.
- *Noise pollution:* during the operation of the transporters and the earth moving equipment it can temporarily occur.
- *Managing Waste:* waste produced should be taken away.

According to the categorisation above, effects during operation can be:

The cleanness of air: the appropriate operation of the pipelines does not inferewith air quality, except for emissions from the compressors. Typically, , the quantity of CO_2 emitted in the air when pipeline damage occurs is not significant if pipeline monitoring is constant and block values are applied.

- *The soil, groundwater, subterranean water*: when the pipeline is operating appropriately it does not have any negative effect. When it is damaged, the emitted CO_2 can change the pH value of the soil and can make it acid. Also, heat reduction can cause freezing.
- *Flora and Fauna*: operation does not have any danger if the path is well-cleaned.
- *Noise pollution:* During the operation only the noise caused by the compressors can result in this pollution.
- *Managing Waste:* no waste is produced during operation, but waste from maintenance (e.g. oily rags, waste oil, etc.) should be taken away, and communal waste should be managed by the general regulations.

4. Conclusions

One of the main goals of the EU is the creation of an economy with lower CO_2 emissions, by which climate change and global warming can hopefully be significantly decreased, even if it cannot be turned back. CCS technology, which is at an initial status for the present, can serve this aim. Only a few projects operate presently in Europe but the EU plans to finance more for the collection of experience.

There have been several pieces of information collected about CO_2 transportation, the middle element of the technological chain, thanks to application of EOR technology, and to continuous build-up and development of the natural gas pipeline network that has been taking place for decades.

The environmental regulations of planned European CO_2 pipeline network would be based on these experiences, according to the previously described effects.

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References

[1] Database of European Environmental Agency
http://www.eea.europa.eu/data-and-maps (2012. 07.20.)
[2] European Commission. A Roadmap for moving to a competitive low carbon economy in 2050 COM (2011) 112
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF (2012.01.31.)
[3] Bellona Environmental CCS Team: A világ CCS projektjei, 2011. november
http://bellona.org/ccs/uploads/media/CCS_projects_Nov2011.xlsx (2012.03.04.)
[4] Morbee, J., Serpa, J., Tzimas, E. (2010): The evolution of the extent and then investment requirements of a trans-European CO_2 transport network. JRC Scientific and Technical Reports
http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/15100/1/ldna24565enn.pdf (2012.02.03.)
[5] Berecz E.: Kémia műszakiaknak, Tankönykiadó, Budapest, 1991. pp. 393-394
[6] Seevam, P.J.: Transporting the Next Generation CO_2 for Carbon, Capture and Storage, Proceedings of IPC2008 International Pipeline Conference, Calgary, 2009
[7] 79/2005. (X.11) GKM rendelet, a szénhidrogén szállítóvezetékek biztonsági követelményeiről és a Szénhidrogén Szállítóvezetékek Biztonsági Szabályzata közzétételéről