

10. Present situation and real prospects of CCS in Slovakia and in the World

ĽUDOVÍT KUCHARIČ¹ and ĽUBOMÍR TUČEK²

¹State geological Institute of Dionyz Stur, Mlynská dolina 1, 817 04 Bratislava, Slovak Republic

²State geological Institute of Dionyz Stur, RC Košice, Jesenského 8, 040 01 Košice, Slovak Republic

In the present situation, despite the Slovak Act on CO₂ storage in force we do not expect specific activities in this issue in the near future. Some options might take shape in the case of getting funding for a pilot project. For this purpose, we have selected a number of structures - Láb, Marcelová, Stretava and Ptrukša, as well as Vysoká - Zwerndorf, where, however, the problem of joint ownership with the neighbouring states - Austria, has to be faced.

In terms of timeline the carbon dioxide storage is a long-term process as documented by the following picture.

- from a practical point of view, in relation to depleted hydrocarbon deposits there exist a possibility of some potential for CO₂ storage in Slovak conditions be-

cause still remains open an issue of additional exploitation of depleted gas deposits by Enhanced Gas Recovery methodology (EGS). This technology could be interesting in the future in Slovakia, particularly in relation to the aforementioned gas deposit Vysoká - Zwerndorf, where it remains unexploited "interesting volume" of methane.

- This issue is interesting in terms of the use of CO₂ as a cushion gas in the underground reservoirs of natural gas, because thank to its greater density it takes up less space than methane (CH₄/CO₂ ratio is 1:0.6), which provides undisputed benefits at an enlargement of the active volume capacity of planned reservoirs. However, the problem of the separation of two gases in the reservoir still remains open.

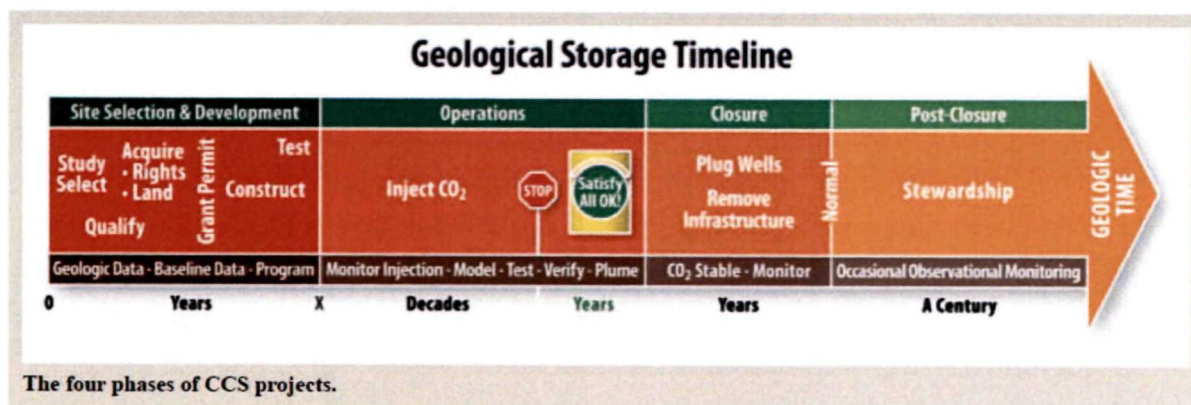


Fig. 10.1 Geological storage timeline (Source [www.CO₂Capture project.org](http://www.CO2Capture.project.org))

- Another problem is a very low price of the permits to emit (EUA), which are sensitive to the global economic situation. Even in the mid of 2011 these price levels amounted over 16 €/t, but under the influence of the economic crisis by May 2013 they got below the level of 3 €/t, which virtually eliminates at least approximate expert estimates for the costs associated with CO₂ storage. In this context, the financing or part-financing of a pilot project for the private sector, even if a theoretical profit considered, the sale of the extracted gas is very illusory. (According to theoretical calculations a price of 1 tonne of CO₂ storage should amount to 25-30 € - only operating costs). In this way, the CCS for business is actually non-attractive.
- The storage potential of 37.840 Mt was estimated in the area of the Danube Basin. Due to the fact that it is only a small aquifer deposits space, it can be expected that the quite optimistic storage potential will be reduced within further progress of work. However, this area is not negligible when considering the shift of CCS methodology into practice.
- At the pessimistic estimate the regional aquifers are set on 180,300 kt, in the optimistic estimate on 236,200 kt of stored CO₂. These numbers relative to the annual quota for Slovakia (NAPL - National Allocation Plan) of 40 Mt are not at all overwhelming.
- We pointed out prospective assessment of the hydrocarbons potential of the NE part of Slovakia (Rudinec,

Tab. 10.1 CCS projects in the world - presence and near future (according to Global CCS Institute)

Asset Lifecycle Stage	Project Name	Description	State / District	Country	Volume CO ₂
Operate	Century Plant	Occidental Petroleum, in partnership with Sandridge Energy, is operating a gas processing plant in West Texas that at present can capture 5 Mtpa of carbon dioxide for use in enhanced oil recovery. Capture capacity will be increased to 8.5 Mtpa in 2012.	Texas	UNITED STATES	8.4 Mtpa*
Operate	Enid Fertilizer CO ₂ -EOR Project	Since 1982, the Enid Fertilizer plant has sent around 680,000 tonnes per annum of carbon dioxide to be used in enhanced oil recovery operations in Oklahoma.	Oklahoma	UNITED STATES	0.68 Mtpa
Operate	Great Plains Synfuel Plant and Weyburn-Midale Project	About 3 Mtpa of carbon dioxide is captured from the Great Plains Synfuel plant in North Dakota. Since 2000 the carbon dioxide has been transported by pipeline into Canada for enhanced oil recovery in the Weyburn Field, and since 2005 in Midale Field.	Saskatchewan	CANADA	3 Mtpa
Operate	In Salah CO ₂ Storage	In Salah is a fully operational CCS project in Algeria. Since 2004, around 1 million tonnes per annum of carbon dioxide are separated from produced gas, transported by pipeline and injected for storage in a deep saline formation.	Wilaya de Ouargla	ALGERIA	1 Mtpa
Operate	Shute Creek Gas Processing Facility	Around 7 million tonnes per annum of carbon dioxide are recovered from ExxonMobil's Shute Creek gas processing plant in Wyoming, and transported by pipeline to various oil fields for enhanced oil recovery. This project has been operational since 1986.	Wyoming	UNITED STATES	7 Mtpa
Operate	Sleipner CO ₂ Injection	Sleipner is the second largest gas development in the North Sea. Carbon dioxide is separated from produced gas at Sleipner T and reinjected into a deep saline formation above the hydrocarbon reservoir zone. This project has been in operation since 1996.	North Sea	NORWAY	1 Mtpa
Operate	Snohvit CO ₂ Injection	The Snohvit offshore gas field and related CCS activities have been in operation since 2007. Carbon dioxide separated from the gas produced at an onshore liquid natural gas plant is reinjected into a deep saline formation below the reservoir zones.	Barents Sea	NORWAY	0.7 Mtpa
Operate	Val Verde Natural Gas Plants	This operating enhanced oil recovery project uses carbon dioxide sourced from the Mitchell, Gray Ranch, Puckett, Pikes Peak and Terrell gas processing plants and transported via the Val Verde and CRC pipelines.	Texas	UNITED STATES	1.3 Mtpa
Execute	Air Products Steam Methane Reformer EOR Project	This project in construction will capture more than 1 million tonnes per year of carbon dioxide from two steam methane reformers to be transported via Denbury's Midwest pipeline to the Hastings and Oyster Bayou oil fields for enhanced oil recovery.	Texas	UNITED STATES	1 Mtpa
Execute	Alberta Carbon Trunk Line ("ACTL") with Agrium CO ₂ Stream	Agrium's fertiliser plant in Alberta is currently being retrofitted with a carbon dioxide capture unit. Around 585,000 tonnes per annum of carbon dioxide will be captured and transported via the Alberta Carbon Trunk Line (ACTL) for enhanced oil recovery.	Alberta	CANADA	Up to 0.59 Mtpa (initially 0.29 Mtpa)
Execute	Alberta Carbon Trunk Line ("ACTL") with North West Sturgeon Refinery CO ₂ Stream	Up to 1.2 million tonnes per annum of carbon dioxide will be captured at this new heavy oil upgrader in Alberta. In partnership with Enhance Energy, the carbon dioxide will be transported via the Alberta Carbon Trunk Line (ACTL) for enhanced oil recovery.	Alberta	CANADA	1.2 Mtpa
Execute	Boundary Dam Integrated Carbon Capture and Sequestration Demonstration Project	SaskPower is currently retrofitting a coal-based power generator with carbon capture technology near Estevan, Saskatchewan. When fully operational in 2014, this project will capture around 1 million tonnes per annum of carbon dioxide.	Saskatchewan	CANADA	1 Mtpa
Execute	Gorgon Carbon Dioxide Injection Project	This component of a larger gas production and LNG processing project will inject 3.4 to 4.1 million tonnes of carbon dioxide per annum into a deep geologic formation. Construction is under way after a final investment decision was made in September 2009.	Western Australia	AUSTRALIA	3.4 - 4.1Mtpa
Execute	Illinois Industrial Carbon Capture and Storage Project	The project will capture around 1 million tonnes per annum of carbon dioxide from ethanol production. Carbon dioxide will be stored approximately 2.1 km underground in the Mount Simon Sandstone, a deep saline formation.	Illinois	UNITED STATES	1 Mtpa
Execute	Kemper County IGCC Project	Mississippi Power (Southern Company) is constructing an air-blown 582 Mwe IGCC plant using a coal-based transport gasifier. Up to 3.5 million tonnes per annum of carbon dioxide will be captured at the plant and used for enhanced oil recovery.	Mississippi	UNITED STATES	3.5 Mtpa
Execute	Lost Cabin Gas Plant	This project will retrofit the Lost Cabin natural gas processing plant in Wyoming with CCS facilities, capturing around 1 million tonnes per annum of carbon dioxide to be used for enhanced oil recovery.	Wyoming	UNITED STATES	1 Mtpa
Execute	Quest	Quest will capture up to 1.2 million tonnes of carbon dioxide per annum from the Scotford upgrader, and transport it by pipeline for injection into a deep saline formation.	Alberta	CANADA	1.08 Mtpa
Define	Belchatów CCS	PGE EBSA intends to integrate a carbon capture plant into a new built 858 MW unit at the Belchatów Power Plant, capturing around 1.8 million tonnes per annum of carbon dioxide.	Łódź	POLAND	1.6 - 1.8 Mtpa
Define	Coffeyville Gasification Plant	CVR Energy is developing a new compression facility at its fertiliser plant in Kansas. The plant currently produces approximately 850,000 tonnes of carbon dioxide which will be transported to the mid-continental region for use in enhanced oil recovery.	Kansas	UNITED STATES	0.85 Mtpa
Define	Don Valley Power Project	Early in 2011, 2Co Energy acquired the Don Valley Power Project, a 650 MW IGCC facility in South Yorkshire. The project intends to capture around 4.8 million tonnes of carbon dioxide per annum for enhanced oil recovery or geological storage.	South Yorkshire	UNIT. KINGDOM	4.75 Mtpa
Define	ESI CCS Project	This project proposes to capture around 800,000 tonnes per annum of carbon dioxide from a steel plant in the Industrial City of Abu Dhabi by 2015. The project is being developed as part of the Abu Dhabi CCS Network (Masdar).	Abu Dhabi	UNITED ARAB EMIRATES	0.8 Mtpa
Define	Green Hydrogen	Air Liquide has built a new hydrogen plant in Rotterdam. The installation of a cryogenic purification unit at the plant, capturing up to 550,000 tonnes per annum of carbon dioxide, is under evaluation.	Zuid-Holland	NETHERLANDS	0.5 Mtpa
Define	Hydrogen Energy California Project (HECA)	SCS Energy has taken over the HECA project from Hydrogen Energy. The new design will be a 400 Mwe polygeneration plant capturing 3 million tonnes per annum of carbon dioxide for enhanced oil recovery and production of urea.	California	UNITED STATES	3 Mtpa

Asset Lifecycle Stage	Project Name	Operation Date	Facility Details	Capture Type	Transport Length	Transport Type	Storage Type	Project URL
Operate	Century Plant	2010	Natural Gas Processing	Pre-Combustion (Gas Processing)	256 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.oxy.com/
Operate	Enid Fertilizer CO ₂ -EOR Project	1982	Fertiliser Production	Pre-Combustion	225 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.kochfertilizer.com/
Operate	Great Plains Synfuel Plant and Weyburn-Midale Project	2000	Synthetic Natural Gas	Pre-Combustion	315 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.cenovus.com/
Operate	In Salah CO ₂ Storage	2004	Natural Gas Processing	Pre-Combustion (Gas Processing)	14 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.insalahco2.com/
Operate	Shute Creek Gas Processing Facility	1986	Natural Gas Processing	Pre-Combustion (Gas Processing)	190 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.exxonmobil.com
Operate	Sleipner CO ₂ Injection	1996	Natural Gas Processing	Pre-Combustion (Gas Processing)	0 km	Direct injection	Offshore Deep Saline Formations	http://www.statoil.com/en/
Operate	Snohvit CO ₂ Injection	2008	Natural Gas Processing	Pre-Combustion (Gas Processing)	152 km	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.statoil.com/en/
Operate	Val Verde Natural Gas Plants	1972	Natural Gas Processing	Pre-Combustion (Gas Processing)	132 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.exxonmobil.com/
Execute	Air Products Steam Methane Reformer EOR Project	2013	Hydrogen Production	Post-Combustion	101-150 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.airproducts.com/
Execute	Alberta Carbon Trunk Line ("ACTL") with Agrium CO ₂ Stream	2014	Fertiliser Production	Pre-Combustion	240 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.agrium.com/
Execute	Alberta Carbon Trunk Line ("ACTL") with North West Sturgeon Refinery CO ₂ Stream	2015	Oil Refining	Pre-Combustion	240 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.northwestupgrading.com/
Execute	Boundary Dam Integrated Carbon Capture and Sequestration Demonstration Project	2014	Power Generation	Post-Combustion	100 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.saskpower.com/
Execute	Gorgon Carbon Dioxide Injection Project	2015	Natural Gas Processing	Pre-Combustion (Gas Processing)	7 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.chevronaustralia.com/
Execute	Illinois Industrial Carbon Capture and Storage Project	2013	Chemical Production	Industrial Separation	1.6 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.adm.com/
Execute	Kemper County IGCC Project	2014	Power Generation	Pre-Combustion	75 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.mississippipower.com/
Execute	Lost Cabin Gas Plant	2013	Natural Gas Processing	Pre-Combustion (Gas Processing)	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.conocophillips.com/
Execute	Quest	2015	Hydrogen Production	Pre-Combustion	84 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.shell.ca/
Define	Belchatów CCS	2017	Power Generation	Post-Combustion	101-150 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.bot.pl/
Define	Coffeyville Gasification Plant	2013	Fertiliser Production	Pre-Combustion	112 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.cvenergy.com/
Define	Don Valley Power Project	2016	Power Generation	Pre-Combustion	425 km for EOR, 175km to alternative saline site	Onshore to offshore pipeline	Enhanced Oil Recovery	http://www.2coenergy.com/
Define	ESI CCS Project	2015	Iron and Steel Production	Industrial Separation	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.esi-steel.com/
Define	Green Hydrogen	2016	Hydrogen Production	Industrial Separation	26 km	Onshore to offshore pipeline	Offshore Depleted Oil and Gas Reservoirs	http://www.airliquide.com/
Define	Hydrogen Energy California Project (HECA)	2017	Power Generation	Pre-Combustion	6.4 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.hydrogenenergycalifornia.com/

Asset Lifecycle Stage	Project Name	Description	State / District	Country	Volume CO ₂
Define	Hydrogen Power Abu Dhabi (HPAD)	This project will convert natural gas into hydrogen and carbon dioxide. The 380 MW hydrogen power plant will generate over 5 per cent of all Abu Dhabi's current power generation capacity. Captured carbon dioxide will be used for enhanced oil recovery.	Abu Dhabi	UNITED ARAB EMIRATES	1.7 Mtpa
Define	Lake Charles Gasification	Leucadia and Lake Charles Cogeneration plan to build a gasification plant to produce synthetic natural gas from petcoke. Around 4.5 million tonnes per annum of carbon dioxide will be captured at the plant and used for enhanced oil recovery.	Louisiana	UNITED STATES	4.5 Mtpa
Define	Medicine Bow Coal-to-Liquids Facility	Medicine Bow Fuel and Power propose to build a greenfield, coal-to-liquids facility that will produce up to 21,000 barrels of gasoline per day, and capture up to 3.6 million tonnes of carbon dioxide per annum for enhanced oil recovery.	Wyoming	UNITED STATES	3.6 Mtpa
Define	NRG Energy Parish CCS Project	NRG Energy proposes to capture more than 1.4 million tonnes per annum of carbon dioxide from its Parish coal-fired power plant in Fort Bend County, Texas, for use in enhanced oil recovery.	Texas	UNITED STATES	1.4 - 1.6 Mtpa
Define	OXYCFB 300 Compostilla Project	When operating at full scale, the Compostilla project would capture around 1.1 million tonnes per annum of carbon dioxide from a 300 Mwe oxyfuel power plant. The project's 30 MWth pilot started operating in December 2011.	Leon	SPAIN	1.1 Mtpa
Define	Porto Tolle	This project will capture around 1 million tonnes per annum of carbon dioxide from a new build coal-based power station using post-combustion capture. The carbon dioxide will be injected into a deep saline formation in the northern Adriatic Sea.	Veneto	ITALY	1 Mtpa
Define	Rotterdam Opslag en Afvang Demonstratieproject (ROAD)	E.ON and GdF Suez propose to capture around 1.1 million tonnes per annum of carbon dioxide from the flue gases of a new coal-based power plant that is currently being constructed within the industrial port of Rotterdam.	Zuid-Holland	NETHERLANDS	1 Mtpa
Define	Spectra Fort Nelson CCS Project	Carbon dioxide sourced at the Fort Nelson natural gas-processing plant will be injected into a nearby saline formation at a depth of approximately 2,200 metres. Injection rates will ramp up to 1.2 to 2 million tonnes per annum of carbon dioxide.	British Columbia	CANADA	2.2 Mtpa
Define	Swan Hills Synfuels A" In-Situ Coal Gasification/Power Generation Project"	This project intends to build a 300 MW combined cycle power plant, using syngas produced at an adjacent coal gasification unit. Around 1.4 million tonnes per annum of carbon dioxide will be captured for enhanced oil recovery.	Alberta	CANADA	1.2 - 1.4 Mtpa
Define	Taylorville Energy Center	The Taylorville Energy Center is a proposed 602 MW IGCC power plant located in Illinois. Around 3 million tonnes per annum of carbon dioxide will be captured at the plant and stored in onshore deep saline formations or used in enhanced oil recovery.	Illinois	UNITED STATES	1.92 Mtpa
Define	Tenaska Trailblazer Energy Center	Tenaska is developing a site near Sweetwater, Texas, to construct a supercritical pulverised coal-based power plant designed to capture up to 85-90 per cent of the carbon dioxide that would otherwise enter the atmosphere.	Texas	UNITED STATES	5.75 Mtpa
Define	Texas Clean Energy Project	Summit Power Group is developing a 400 MWe IGCC polygeneration plant capturing 2.5 million tonnes per annum of carbon dioxide to be used for enhanced oil recovery in the Permian Basin in West Texas.	Texas	UNITED STATES	2.5 Mtpa
Define	ULCOS - Blast Furnace	The project at a steel mill proposes to capture carbon dioxide from a coal and metallurgical coke facility for iron and steel production. The carbon dioxide would be transported by pipeline and stored in a deep saline formation.	Lorraine	FRANCE	0.7 Mtpa
Evaluate	Bow City Power Project	The Bow City Power Project is a proposed super critical 1,000 Mwe coal-based power plant in Alberta, incorporating post-combustion carbon capture and storage. Around 1 million tonnes per annum of carbon dioxide will be captured for enhanced oil recovery.	Alberta	CANADA	1 Mtpa
Evaluate	C.GEN North Killingholme Power Project	C.GEN is proposing a new IGCC plant in north Lincolnshire that would capture around 2.5 million tonnes per annum of carbon dioxide feeding into the National Grid transport and storage network. The project is part of the Yorkshire Forward initiative.	North Lincolnshire	UNITED KINGDOM	2.5 Mtpa
Evaluate	CarbonNet Project	The Victorian Government is developing this CCS hub project in the Australian state of Victoria. Carbon dioxide collected from various capture facilities would be stored in an offshore deep saline formation.	Victoria	AUSTRALIA	1 Mtpa
Evaluate	Cash Creek Generation	The ERORA Group proposes to build a hybrid IGCC project in Owensboro, Kentucky. It will produce about 565 MW as well as synthetic natural gas. The plant will capture about 2 million tonnes per annum of carbon dioxide for enhanced oil recovery.	Kentucky	UNITED STATES	2 Mtpa
Evaluate	Emirates Aluminium CCS Project	This project proposes to capture around 2 million tonnes per annum of carbon dioxide from two natural gas-based power plants by 2017. The project is being developed as part of the Abu Dhabi CCS Network (Masdar).	Abu Dhabi	UNITED ARAB EMIRATES	2 Mtpa
Evaluate	Full-scale CO ₂ Capture Mongstad (CCM)	StatoilHydro and the Norwegian government entered into an implementation agreement to develop carbon dioxide capture solutions at the Mongstad natural gas power plant, with a view to capture and store up to 1 million tonnes per annum of carbon dioxide.	Hordaland	NORWAY	1 Mtpa
Evaluate	FutureGen 2.0 Oxy-Combustion Large Scale Test	FutureGen 2.0 is an initiative to demonstrate state-of-the-art combined cycle turbine by repowering an existing 200 Mwe unit at Ameren's coal-based power plant in Meredosia, Illinois, with advanced oxy-combustion technology.	Illinois	UNITED STATES	1.3 Mtpa
Evaluate	Getica CCS Demonstration Project	Getica will capture around 1.5 million tonnes per annum of carbon dioxide from a lignite based power plant. The carbon dioxide captured at the plant will be stored in onshore deep saline formations.	Gorj County	ROMANIA	1.5 Mtpa
Evaluate	HuaNeng GreenGen IGCC Project	GreenGen Co. proposes to build a coal-based energy system that includes hydrogen production, electricity generation and carbon capture. The carbon dioxide captured at the site will be used for enhanced oil recovery.	Tianjin	CHINA	2 Mtpa
Evaluate	Indiana Gasification	This coal gasification plant project would include a methanation process to produce pipeline quality synthetic natural gas (SNG). The carbon dioxide captured at the plant would be used for enhanced oil recovery.	Indiana	UNITED STATES	4.5 Mtpa
Evaluate	Kentucky NewGas	This project is a new build mine to mouth coal to synthetic natural gas plant in Kentucky proposing to capture around 5 million tonnes per annum of carbon dioxide for enhanced oil recovery or for storage in a deep saline formation.	Kentucky	UNITED STATES	5 Mtpa

Asset Lifecycle Stage	Project Name	Operation Date	Facility Details	Capture Type	Transport Length	Transport Type	Storage Type	Project URL
Define	Hydrogen Power Abu Dhabi (HPAD)	2018	Power Generation	Pre-Combustion	201-250 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.hydrogenenergy.com/
Define	Lake Charles Gasification	2014	Synthetic Natural Gas	Pre-Combustion	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.leucadia.com/
Define	Medicine Bow Coal-to-Liquids Facility	2015	Coal-to-liquids (CTL)	Pre-Combustion	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.dkrwadvancedfuels.com/
Define	NRG Energy Parish CCS Project	2015	Power Generation	Post-Combustion	130 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.nrgenergy.com/
Define	OXYCFB 300 Compostilla Project	2015	Power Generation	Oxyfuel Combustion	120 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.compostillaproject.es/
Define	Porto Tolle	2015	Power Generation	Post-Combustion	101-150 km	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.zeportotolle.com/
Define	Rotterdam Opslag en Afvang Demonstratieproject (ROAD)	2015	Power Generation	Post-Combustion	26 km	Onshore to offshore pipeline	Offshore Depleted Oil and Gas Reservoirs	http://www.road2020.nl/en
Define	Spectra Fort Nelson CCS Project	2016	Natural Gas Processing	Pre-Combustion (Gas Processing)	35 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.spectraenergy.com/
Define	Swan Hills Synfuels A" In-Situ Coal Gasification/Power Generation Project"	2015	Synthetic Natural Gas	Pre-Combustion	51 – 100 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.swanhills-synfuels.com/
Define	Taylorville Energy Center	2017	Power Generation	Pre-Combustion	8 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.cleancoalillinois.com/
Define	Tenaska Trailblazer Energy Center	Not specified	Power Generation	Post-Combustion	201-250 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.tenaskatrailblazer.com/
Define	Texas Clean Energy Project	2015	Power Generation	Pre-Combustion	≤50 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://texascleanenergyproject.com/
Define	ULCOS - Blast Furnace	2016	Iron and Steel Production	Industrial Separation	51-100 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.ulcos.org/en/
Evaluate	Bow City Power Project	2018	Power Generation	Post-Combustion	≤50 km	Onshore to onshore pipeline	Enhanced Oil Recovery	www.bowcitypower.ca
Evaluate	C.GEN North Killingholme Power Project	2015	Power Generation	Pre-Combustion	151-200 km	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.cgenpower.com/
Evaluate	CarbonNet Project	2018	Power Generation	Not Decided	51-100 km	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.invest.vic.gov.au/
Evaluate	Cash Creek Generation	2015	Power Generation	Pre-Combustion	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.erora.com/
Evaluate	Emirates Aluminium CCS Project	2018	Power Generation	Post-Combustion	351-400 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.tapco.ae/
Evaluate	Full-scale CO ₂ Capture Mongstad (CCM)	2020	Power Generation	Post-Combustion	Not decided	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.statoil.com/en/
Evaluate	FutureGen 2.0 Oxy-Combustion Large Scale Test	2016	Power Generation	Oxyfuel Combustion	≤50 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.futuregenalliance.org/
Evaluate	Getica CCS Demonstration Project	2015	Power Generation	Post-Combustion	40 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.ispe.ro/en/
Evaluate	HuaNeng GreenGen IGCC Project	2020	Power Generation	Pre-Combustion	151-200 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.chng.com.cn/eng/
Evaluate	Indiana Gasification	2015	Synthetic Natural Gas	Pre-Combustion	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.leucadia.com/
Evaluate	Kentucky NewGas	2018	Synthetic Natural Gas	Pre-Combustion	Not specified	Onshore to onshore pipeline	Various Storage Options Being Considered	www.kentuckynewgas.com

Asset Lifecycle Stage	Project Name	Description	State / District	Country	Volume CO ₂
Evaluate	Korea-CCS 1	This project proposes to capture around 1 million tonnes of carbon dioxide per annum from an integrated circulating fluidized bed combustion (CFBC) power plant for storage in deep saline formations.	Not Decided	KOREA	1 Mtpa
Evaluate	Mississippi Gasification (Leucadia)	Leucadia Energy and Mississippi Gasification propose to capture around 4 million tonnes per annum of carbon dioxide from a petcoke gasification plant in Moss Point, Mississippi. The carbon dioxide will be used for enhanced oil recovery.	Mississippi	UNITED STATES	4 Mtpa
Evaluate	Peterhead Gas CCS Project	Around 1 million tonnes per annum of carbon dioxide will be captured by Peterhead Power Station, one of Scotland's largest plants. The carbon dioxide is likely to be transported offshore and stored in depleting gas fields in the North Sea.	Aberdeenshire	UNIT. KINGDOM	0.97 Mtpa
Evaluate	Quintana South Heart Project	A 175 MW IGCC electric power generating facility in southwest North Dakota. The facility will convert lignite into hydrogen and power, capturing up to 2.1 million tonnes per annum of carbon dioxide for enhanced oil recovery.	North Dakota	UNITED STATES	2.1 Mtpa
Evaluate	Riley Ridge Gas Plant	Denbury Resources proposes to retrofit a natural gas processing plant under construction in Wyoming to capture around 2.5 million tonnes per annum of carbon dioxide for enhanced oil recovery.	Wyoming	UNITED STATES	2.5 Mtpa
Evaluate	Sinopec Shengli Oil Field EOR Project	Around 1 million tonnes per annum of carbon dioxide will be captured from an existing power plant in Shandong and used for enhanced oil recovery.	Shandong	CHINA	1 Mtpa
Evaluate	South West CO ₂ Geosequestration Hub (formerly Collier-South West Hub)	This project proposes to develop a transport and storage hub collecting carbon dioxide captured from various facilities in Western Australia. The project aims to store more than 2 million tonnes per annum of carbon dioxide in deep saline formations.	W. Australia	AUSTRALIA	2-3 Mtpa
Evaluate	Southland Coal to Fertiliser Project	Solid Energy and Ravensdown are jointly developing a coal to fertiliser plant capturing around 1.2 million tonnes per annum of carbon dioxide for storage in a deep saline formation. The plant is projected to begin operations in 2018.	Southland	NEW ZEALAND	1 Mtpa
Evaluate	Surat Basin CCS Project (formerly Wandoan)	Around 1 million tonnes per annum of carbon dioxide would be captured from this 250 MWe power plant in Central Queensland, and stored in deep non-potable aquifers.	Queensland	AUSTRALIA	1 Mtpa
Evaluate	Teesside Low Carbon (formerly Eston Grange CCS Plant)	Progressive Energy proposes to develop a new IGCC power plant with pre-combustion carbon capture at 400MWe on a snfield site in Teesside. This project is part of the North East CCS Cluster initiative.	North East England	UNIT. KINGDOM	2.5 Mtpa
Evaluate	White Rose CCS Project (formerly UK Oxy CCS Demonstration)	Alstom UK, Drax Power and National Grid are jointly developing a new 426 MW oxy-fired plant in North Yorkshire which would capture around 2 million tonnes per annum of carbon dioxide. The project is part of the Humber CCS Cluster.	N. Yorkshire	UNIT. KINGDOM	2 Mtpa
Identify	Shenhua / Dow Chemicals Coal to Chemicals Plant Project (Yulin)	This project developed by Dow Chemical proposes to build a coal to chemicals production plant capturing 2-3 million tonnes of carbon dioxide per annum for use in enhanced oil recovery.	Shaanxi	CHINA	2-3 Mtpa
Identify	Captain Clean Energy Project (formerly Caledonia Clean Energy Project)	Summit Energy proposes to replicate its Texas Clean Energy Project concept at this new build plant in Scotland. Carbon dioxide captured at the plant would be stored or used for enhanced oil recovery in the North Sea.	Scotland	UNIT. KINGDOM	Not specified
Identify	Daqing Carbon Dioxide Capture and Storage Project	This project proposes to capture more than 1 million tonnes per annum of carbon dioxide from a new coal-fired power plant near Daqing City.	Heilongjiang	CHINA	1 Mtpa
Identify	Dongguan Taiyangzhou IGCC with CCS Project	Dongguan Taiyangzhou Power Corporation intends to construct an 800 MW IGCC plant capturing up to 1 million tonnes of carbon dioxide per annum to be stored in depleted oil and gas reservoirs.	Guangdong	CHINA	1 Mtpa
Identify	Dongying Carbon Dioxide Capture and Storage Project	The China Datang Group is developing a new power generation project with CCS, with a planned capture capacity of around 1 million tonnes per annum of carbon dioxide, which will then be used for enhanced oil recovery.	Shandong	CHINA	1 Mtpa
Identify	Industrikraft Møre AS Norway	The proposed Sargas Stargate 250 Gasfired Powerplant in Norway would capture more than 1.4 million tonnes per annum of carbon dioxide. The project could be operational in 2016.	Møre og Romsdal	NORWAY	1.4-1.6 Mtpa
Identify	Jilin Oil Field EOR Project (Phase 2)	More than 800,000 tonnes per annum of carbon dioxide from a natural gas processing plant are planned to be injected into the Jilin oil field for enhanced oil recovery by 2015.	Jilin	CHINA	0.8-1 Mtpa
Identify	Korea-CCS 2	This project proposes to capture 1 million tonnes of carbon dioxide per annum from an oxyfuel or IGCC power plant. The carbon dioxide captured at the plant would be shipped for injection into a deep saline formation.	Not Decided	KOREA	1 Mtpa
Identify	Lianyungang IGCC with CCS Project	This project will consist of a 1200 MW IGCC power plant and 2 x 1300 MW supercritical power plant capturing up to 1 million tonnes of carbon dioxide per annum. Synthetic natural gas and chemicals will be co-produced at this plant.	Jiangsu	CHINA	1 Mtpa
Identify	Maritsa Thermal Power Plant CCS Project	This project proposes to capture 2.5 million tonnes per annum of carbon dioxide from an existing lignite-based thermal power plant in Bulgaria. The plant belongs to the Maritsa Iztoch Complex, which is the largest energy complex in South Eastern Europe.	Stara Zagora	BULGARIA	2.5 Mtpa
Identify	Sargas Green Power Plant Malta	Sargas AS proposes to build a new power plant in Malta that would capture around 1.2 million tonnes per annum of carbon dioxide. The project could be operational in 2017.	Delimara	MALTA	1.2 Mtpa
Identify	Shanxi International Energy Group CCUS project	This project will involve the construction of a new, super-critical coal-fired power plant with oxyfuel combustion capturing more than 2 to 3 million tonnes per annum of carbon dioxide.	Shanxi	CHINA	2-3 Mtpa
Identify	Shen Hua Ningxia Coal to Liquid Plant Project	Shenhua Group proposes to build a new coal-to-liquids plant that would capture around 2 million tonnes per annum of carbon dioxide. Possible storage options are currently under evaluation.	Ningxia	CHINA	2 Mtpa
Identify	Shenhua Ordos CTL Project	This project intends to capture around 1 million tonnes of carbon dioxide per annum from an existing coal-to-liquids facility by 2020. It is the second phase of the operating pilot-scale Ordos Shenhua DCL plant CCS Project.	Inner Mongolia	CHINA	1 Mtpa

Asset Lifecycle Stage	Project Name	Operation Date	Facility Details	Capture Type	Transport Length	Transport Type	Storage Type	Project URL
Evaluate	Korea-CCS 1	2017	Power Generation	Post-Combustion	251-300 km	Ship/Tanker	Offshore Deep Saline Formations	http://www.kepco.co.kr/eng/
Evaluate	Mississippi Gasification (Leucadia)	2015	Synthetic Natural Gas	Pre-Combustion	176 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.denbury.com/
Evaluate	Peterhead Gas CCS Project	2017	Power Generation	Post-Combustion	102 km	Onshore to offshore pipeline	Offshore Depleted Oil and Gas Reservoirs	http://www.sse.com/
Evaluate	Quintana South Heart Project	2017	Power Generation	Pre-Combustion	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.greatnorpowers.com/
Evaluate	Riley Ridge Gas Plant	2015	Natural Gas Processing	Pre-Combustion (Gas Processing)	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.denbury.com/
Evaluate	Sinopec Shengli Oil Field EOR Project	2017	Power Generation	Post-Combustion	51-100 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://english.sinopec.com/
Evaluate	South West CO ₂ Geosequestration Hub (formerly Collie-South West Hub)	2017	Fertiliser Production	Pre-Combustion	51-100 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.dmp.wa.gov.au/
Evaluate	Southland Coal to Fertiliser Project	2018	Fertiliser Production	Pre-Combustion	51-100 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.coalnz.com/
Evaluate	Surat Basin CCS Project (formerly Wandoan)	2020	Power Generation	Post-Combustion	151-200 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.wandoanpower.com.au
Evaluate	Teesside Low Carbon (formerly Eston Grange CCS Plant)	2016	Power Generation	Pre-Combustion	225 km	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.estongrange.co.uk/
Evaluate	White Rose CCS Project (formerly UK Oxy CCS Demonstration)	2016	Power Generation	Oxyfuel Combustion	Not specified	Onshore to offshore pipeline	Offshore Deep Saline Formations	http://www.whiteroseccs.co.uk/
Identify	Shenhua / Dow Chemicals Coal to Chemicals Plant Project (Yulin)	Not specified	Chemical Production	Industrial Separation	≤50 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.dow.com/
Identify	Captain Clean Energy Project (formerly Caledonia Clean Energy Project)	2018	Power Generation	Pre-Combustion	Not specified	Onshore to offshore pipeline	Enhanced Oil Recovery	http://www.summitpower.com/
Identify	Daqing Carbon Dioxide Capture and Storage Project	Not specified	Power Generation	Oxyfuel Combustion	Not specified	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.china-cdt.com/en/index.html
Identify	Dongguan Taiyangzhou IGCC with CCS Project	Not specified	Power Generation	Pre-Combustion	101-150 km	Onshore to onshore pipeline	Onshore Depleted Oil and Gas Reservoirs	http://www.dgpowerfuel.com/english/
Identify	Dongying Carbon Dioxide Capture and Storage Project	Not specified	Power Generation	Not Decided	≤50 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.china-cdt.com/en/index.html
Identify	Industrikraft Møre AS Norway	2016	Power Generation	Post-Combustion	Not specified	Combination (pipeline and shipping)	Not specified	http://sargasnearzero.com/
Identify	Jilin Oil Field EOR Project (Phase 2)	2015	Natural Gas Processing	Pre-Combustion (Gas Processing)	151-200 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://www.petrochina.com.cn/Ptr/
Identify	Korea-CCS 2	2019	Power Generation	Not Decided	251-300 km	Ship/Tanker	Offshore Deep Saline Formations	http://www.kepco.co.kr/eng/
Identify	Lianyungang IGCC with CCS Project	Not specified	Power Generation	Pre-Combustion	201-250 km	Onshore to onshore pipeline	Enhanced Oil Recovery	http://english.cas.cn/
Identify	Maritsa Thermal Power Plant CCS Project	2020	Power Generation	Post-Combustion	Not specified	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.bgenh.com/en/
Identify	Sargas Green Power Plant Malta	2017	Power Generation	Post-Combustion	351-400 km	Ship/Tanker	Enhanced Oil Recovery	http://sargasnearzero.com/
Identify	Shanxi International Energy Group CCUS project	Not specified	Power Generation	Oxyfuel Combustion	Not specified	Not Specified	Various Storage Options Being Considered	http://en.sxginy.com/Singlelist.aspx?tp=cominfo&catalogID=8
Identify	Shen Hua Ningxia Coal to Liquid Plant Project	Not specified	Coal-to-liquids (CTL)	Industrial Separation	201-250 km	Onshore to onshore pipeline	Various Storage Options Being Considered	http://www.cscic.com.cn/ens/index.shtml
Identify	Shenhua Ordos CTL Project	2020	Coal-to-liquids (CTL)	Industrial Separation	201-250 km	Onshore to onshore pipeline	Onshore Deep Saline Formations	http://www.shenhuaigroup.com.cn/english/

* per annum

- 1989) as confirmed by Zboj borehole results. We have contributed to these results not only by CCS input, but also further added value has been achieved in the potential importance of this site with Au-Ag base metal ore mineralization, as well as the extension of its potential into geothermal research, as one of the renewable energy sector. The study of appropriate structures is an undeniable benefit to further identification or forecasting of other raw materials, suitable for the needs of the economy.
- Similarly, open remains the issue of the marketable J - Br waters of an enclosed structure Marcelová, while carbon dioxide could serve as a mean for their pushing out on the surface.
- The most important outcome of the benefits of technological and geological research is finding and proof of gaseous carbon dioxide storage using geological materials from different localities of Slovakia in laboratory conditions, whereas the CO₂ is permanently and stably bound in new products, in which the newly formed carbonates (mainly hydromagnesite, calcite and aragonite) thermodynamically stabilize carbon dioxide prior to permanent storage.
- According to the results obtained by carbonatization the most promising material for mineral sequestration of CO₂ is serpentine rock containing about 37% of MgO component, bound mainly to serpentine minerals - chrysotile, lizardite and antigorite, or the olivine minerals - forsterite and fayalite, or it can be a rock containing wollastonite.
- The lowest costs according purpose-made feasibility study of the CO₂ capture and storage using the mineral sequestration were achieved using olivine as an input geological material - 54 US\$/t CO₂, 64 US\$/t CO₂ using wollastonite and 78 US\$/t CO₂ using serpentine (O'Connor, 2005, and Gerdemann, 2007).
- According to our findings to capture one tonne of carbon dioxide an average of 2.6 tonnes of amorphous serpentine rock is needed; the average cost of this quantity will be 616 €/2.6 tonnes of rock.
- One tonne of carbon dioxide binds to 1.92 tonnes of MgCO₃ (formation of fine-grained newly precipitated magnesium carbonate), which value as a potential white inorganic filler in the case of CaCO₃ compensation may be at least around 390 €/t (price of untreated precipitated calcium carbonate).
- The next key fact is that due to the carbonatization of investigated materials (in high-pressure reactor) the

hazardous waste turns to other waste in terms of waste classification.

The aim of the analysis was to contribute to the debate on the high costs incurred in the mineral sequestration. These are undisputable, but it is possible to reduce them by the price of the final carbonatization product, which might find its use in the industry. At present, it is difficult to quantify the ecological aspects of this way of storage.

It should be noted that often used cliché about the costs of the hydrodynamic storage regime, moving in the range of 30-40 €/t of CO₂, represents only the net operating costs, without giving the costs of the investment, which is a bit misleading. The investment costs for the transport facilities are extremely high - approximately 1.1 million €/km of pipeline (Hendriks et al., 2004) and represent a significant increase in the cost item and we still do not include the cost of sequestration technology.

Ultimately, the use of the results of CO₂ sequestration by carbonatization research in a laboratory-scale in a high-pressure reactor can contribute in the near future to reduce the amount of CO₂ emitted into the atmosphere and also to reduce and change the properties of the stored quantities of waste material, thereby significantly contributing to the protection of the environment as a whole. The technology can be a good complement to hydrodynamic technology and a way how to get secondary sources of minerals (quartz, magnesite, iron, nickel ...).

To illustrate the overall situation in the world, we present a summary Table of the sources of Global Institute (Australia), which summarizes all the CCS activities already underway, or planned in the next future. In spite of limitations generated by the economic crisis it is clear that the issue is hot. The Table describes in a comprehensive manner the operated or planned repositories. In addition to the geographical location it presents a process and method of CO₂ capture. It is obvious that meanwhile 8 storage objects at industrial scale are being operated. Annual volume fluctuates around 1 Mt store. Clearly dominating factor is the connection of storage with EOR (Enhanced Oil Recovery) - additional exploitation of already depleted oil deposits, because the economic benefits of the obtained residual reserves reduce significantly the financial costs of the CCS technology. Lengths of pipelines from the source are certainly interesting as well as a distance of emissions source to the repository. We leave a more detailed analysis of the Table on the reader, who can get additional info by visiting the respective website.