INTRODUCING THE LIQUID LOGISTIC SHIPPING CONCEPT

The objective pursued by these companies in their collaborative action is to jointly contribute to the RCI target setting regarding CO_2emissions reduction.

Rotterdam Climate Initiative objectives

The Rotterdam Climate Initiative is founded by the Port of Rotterdam, the companies in the industrial port district, the municipality and the environmental protection agency Rijnmond. RCI intends to achieve 50% reduction in CO_2 emissions by 2025 as compared to the level in 1990. The following measures are envisaged:

- energy efficiency measures;
- use of low-temperature industrial heat;
- large-scale use of biomass;
- CO_2 capture, transport, reuse and storage (CCS).

From Figure 2 it can be seen that CCS will be responsible for more than 50 % of the total reduction target that has been set by RCI.

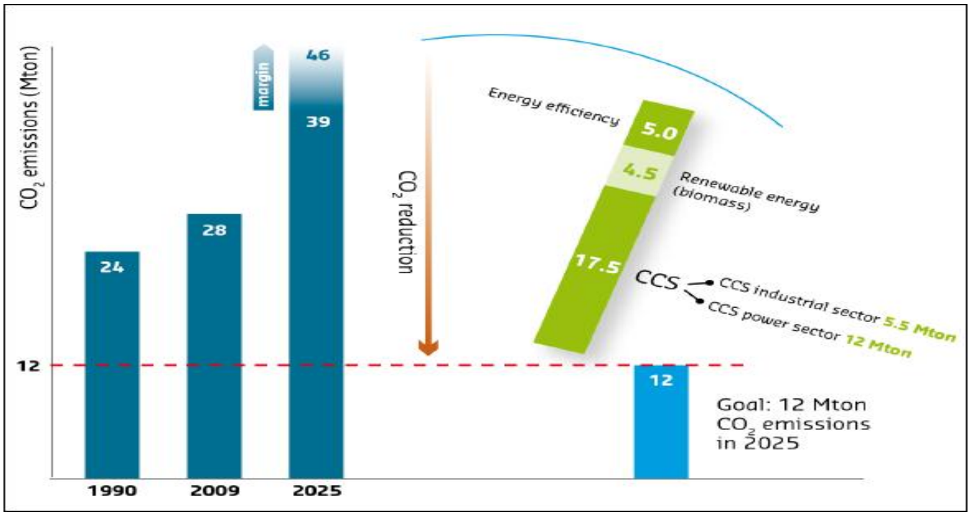

Figure 2: Schematic indicating how CCS will contribute to Rotterdam's emission reduction target

Vopak and Anthony Veder have received funding from the Global CCS Institute (GCCSI) to study the LLSC.

The Global Carbon Capture and Storage Institute (Global CCS Institute) is an initiative aimed at accelerating the worldwide commercial deployment of at-scale CCS, whereby CO_2 is captured, transported and then injected deep underground for secure, long-term storage.

- The Global CCS Institute has international support, with more than 30 national governments and over 130 leading corporations, non-government bodies and research organizations signed on as Members or Collaborating Participants;

- Announced by the Australian Government in September 2008, the Global CCS Institute was formally launched in April 2009 and became an independent legal entity in July 2009.

Vopak and Anthony Veder are developing a CO_2 LLSC that will provide emitters a complete logistical transportation solution for their captured CO_2 from their site to an offshore storage location.

The objective of this study is to develop a LLSC for a robust, reliable and safe CO_2 transport system, with minimum costs for the entire CO_2 transport system (from capture flange to storage well). The knowledge and expertise from project partners, vendors, consultants, designers and other third parties will be gathered and combined into the LLSC.

The LLSC will take the captured CO_2 from the emitter to an intermediate storage site (i.e. Port of Rotterdam) via either barges (in liquefied phase) or pipeline (gaseous phase). From this intermediate storage location (CO_2 Hub) the liquid CO_2 is shipped by a seagoing vessel to the offshore reservoirs for permanent storage, where the ship will discharge on a standalone basis via an offshore infrastructure (e.g. turret, submersed flexible hoses or loading tower) that links the vessel to the subsea completion/template or infrastructure. In addition compressed CO_2 is transferred from this CO_2 Hub to the storage sites by means of offshore pipelines. The CO_2 Hub will combine and link pipeline systems and barging/shipping routes, and will include functions like intermediate liquid storage, liquefaction of CO_2 and vaporization of liquid CO_2. The concept will provide maximum flexibility and reliability to both emitters and storage locations, eventually leading to reduced cost of Carbon Capture and Storage (CCS). A schematic of the flexible chain is shown in Figure 3.

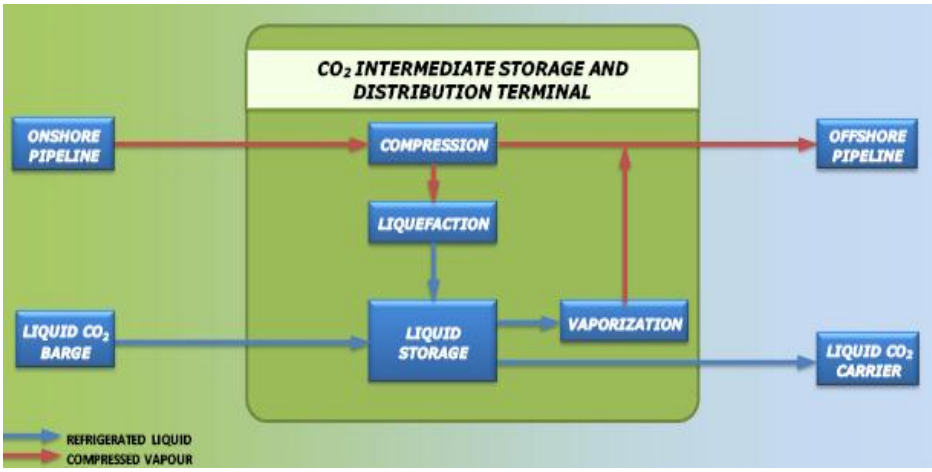

Figure 3: Liquid Logistics Shipping Concept

By nature the CO_2 logistical transportation chain under consideration is of a very large scale and should have a minimum environmental impact given the role CCS should have on the global climate change counter effort.

Given its large scale it will resemble the oil and gas logistics chain which utilizes intermediate storage, pipelines and ships. As such Vopak and Anthony Veder (and other parties) joined forces to create a flexible and reliable CO_2 logistical transportation chain. Vopak being world leader in the liquid bulk logistics industry (80 terminals in 31 countries) it is considered to be uniquely positioned to provide services in this respect together with Anthony Veder's (integrated ship owner) decade long expertise in shipping CO_2.

Using their experience in the logistics field, Vopak and Anthony Veder developed the LLSC and joined forces with Gasunie (Dutch national gas grid operator) and Air Liquide (gas processing service provider) to set up the joined venture CINTRA (Carbon In Transport) to offer a one-stop shop for the LLSC's envisaged customers. This concept comprises of a CO_2 terminal which is capable of gathering CO_2 from multiple sources upon which it is distributed via multiple transportation modalities to various sinks. The concept anticipates the use of offshore sinks because of public posture and land permitting issues.

LLSC objectives

The LLSC goals are as follows:

- Creating transportation economies of scale by combining multiple sources and sinks;

- Enhancing reliability in a cost effective manner by creating a source/sink network which allows parties to act as each other's backup CO_2 disposal route, thus creating CO_2 routing flexibility;
- Accommodating cost effective organic growth of the logistic chain by expanding existing terminals, adding terminal tanks, vessels and pipelines and swapping vessel service between different CO_2trades when volumes become significant enough for pipelines;
- Creating a reliable CO_2 source for industrial purposes such as EOR - facilitating as such an economic incentive for CCS.

To achieve these goals the LLSC has the following functionality:

- Accommodating an expanding group of emitters and storage providers;
- Connecting an onshore pipeline collection grid and offshore discharge route(s) to the various sinks (shipping and pipeline);
- Accommodating the unloading of barges coming from inland and the loading of ships going to offshore sinks;
- Linking the pipeline and barge/ship system by providing CO_2 vaporization/liquefaction and intermediate CO_2 storage services at the hub.

In this concept the pipeline system and barge/ship transportation system are considered complementary since eventual weaknesses/downtimes of one of the transportation modalities are counterbalanced by the other in terms of transportation capacity, permit application approval procedures, flexibility of deployability and economies of scale. A CO_2 flow that joins the hub system initially via the piped route may switch to the other when the economics call for this. Furthermore, the usage of a vessel will allow serving several storage sites creating a higher reliability and the option to use also smaller storage locations. As such not only storage in depleted gas fields become viable but above all the usage of captured CO_2 for EOR purposes given the shorter time frames that come forward with this tertiary form of EOR.

Hub location

The Rotterdam area and the German Ruhr area both concern a huge concentration of large stationary CO_2 sources. Secondly the North Sea contains a large number of (near) empty oil and gas field which may act as a sink for this potentially captured CO_2 as can be seen in Figure 4. The relatively short distance between the German Ruhr area and the North Sea with Rotterdam right in the middle makes the LLSC a perfect match for this part of the world. In addition most stationary sources require significant amounts of cooling water and are therefore located near the shore line or inland water ways. The fact that the largest rivers of North West Europe flow into sea at Rotterdam makes this location also extremely suitable for barging.

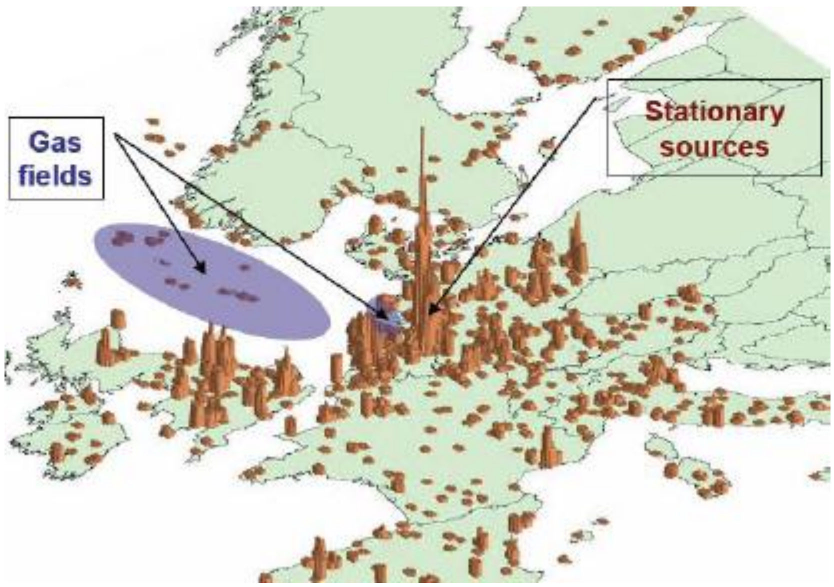

Figure 4: Locations of CO_2 emitters and (near) empty oil and gas fields

This Knowledge Sharing Report contains a SHE (Safety/Health/Environment) study on the complete chain from emitter up to and including the offshore unloading system. SHE aspects of the complete chain will be investigated and if needed possible measures to reduce the risks will be provided. The objective of the safety study is to provide CINTRA and the public with an understanding of the possible hazardous consequences and risks posed by the different CO_2 activities of the LLSC to the surrounding areas. The report consists of a safety study/QRA (Quantitative Risk Assessment) performed by DNV [1] and important dynamic behavior issues (waterhammer, reliability, metallurgic behavior etc.) throughout the complete chain. The QRA results of the identified consequences and risks are compared with the applicable Dutch risk criteria and, where needed, recommendations are made for possible mitigation measure to reduce the risks.

A quantitative risk assessment, as mandatory within the EU, starts from normal operating conditions and then looks at the various what-if scenario's. This implies that the input of the QRA is based on a proper design: the right control and safeguarding systems are assumed to be in place. Their failure on demand is then modeled with the QRA. The engineering company needs to perform a HAZOP: a hazard and operability analysis. This analysis is also based on a "chance times effect" methodology and is used to define the required Safety Integrity Level (SIL) of the various systems. This HAZOP is to be performed on the system's Piping & Instrumentation Diagrams (P&ID's), which are not available at the time of writing. Any outcome of the dynamic behavior study (which at that stage will consists of dynamic simulations if deemed necessary) shall then be taken into account. Subsequently the Notified Body (NoBo) needs to approve this HAZOP, together with the systems hydro test certificates, pipe material certificates, vendor data books etc.

Source: http://hub.globalccsinstitute.com/publications/co2-liquid-logistics-shipping-concept-llsc-safety-health-and-environment-she-report/2