COCATE

Large-scale CCS Transportation Infrastructure in Europe

Birmingham, March 2012

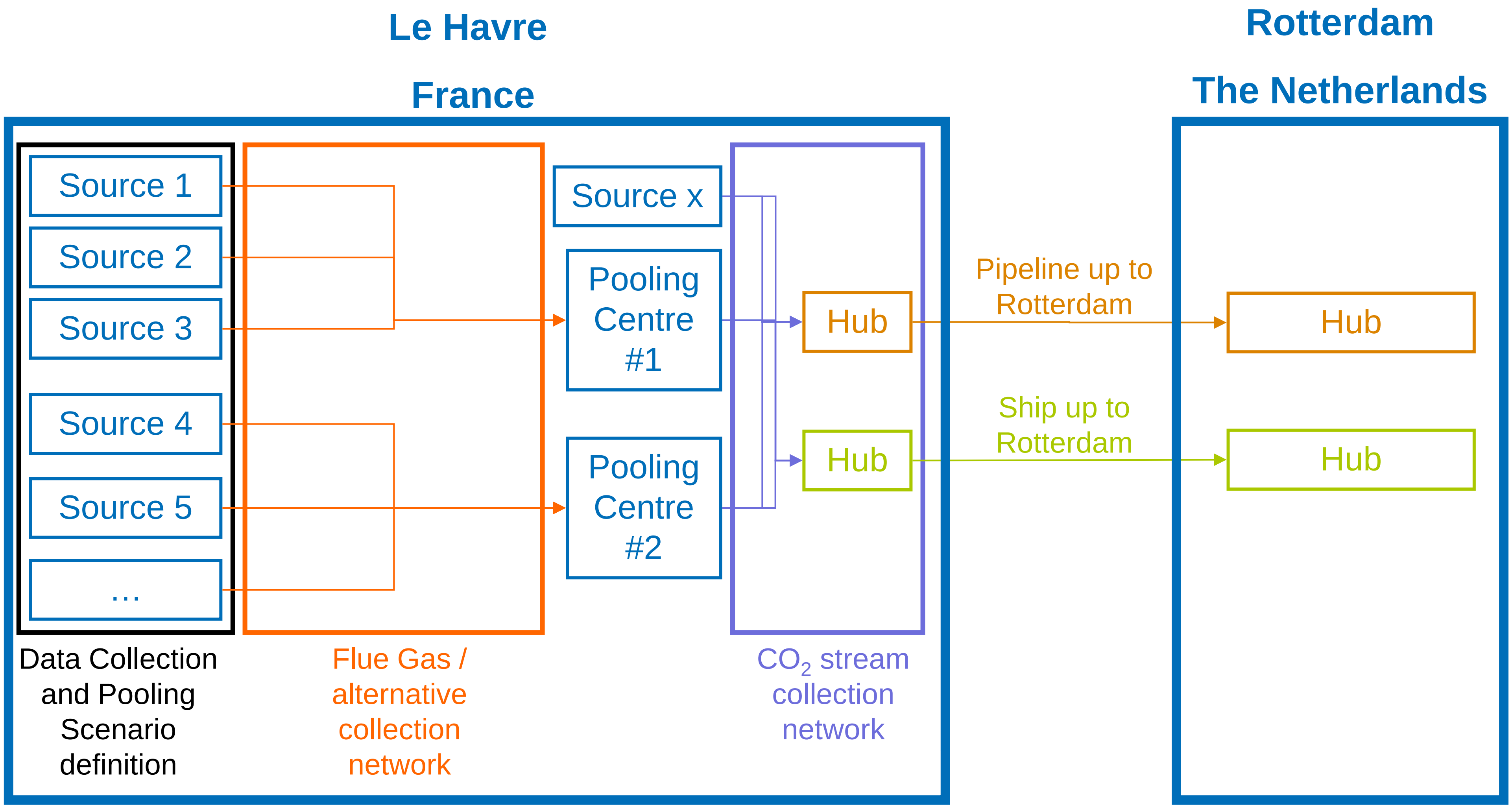
http://projet.ifpen.fr/Projet/cocate

Project description

- 1st January 2010 to 31th December 2012
- 9 partners: IFP Energies nouvelles, le Havre Développement, Geogreen, Accoat, Sintef-ER, DNV, TNO, Port of Rotterdam NV, SANERI
- 5 countries involved: France, Denmark, Norway, Netherlands, South Africa
- Research Project funded by the European Community under FP7 for a total operated budget 4,5 M € (EC contribution 3M €)

Objectives

Design, Network Management, Risks, Economics
From a case study to a generic strategy of deployment



Work Programme

WP2: Collecting network and export line lifetime

Task 2.1 Thermodynamics and corrosion
Task 2.2 Network Management

WP1: Global Capture to Storage Transport Network

Task 1.1 Definition of a network from sources to sinks
Task 1.2 Strategy for deployment

WP3: Safety of global capture to storage network

Task 3.1 Development of a Safety Management Toolkit
Task 3.2 Risk assessment collecting network
Task 3.3 Export systems
Task 3.4 Risk assessment of integrated CCS chains

WP4: Economic Study

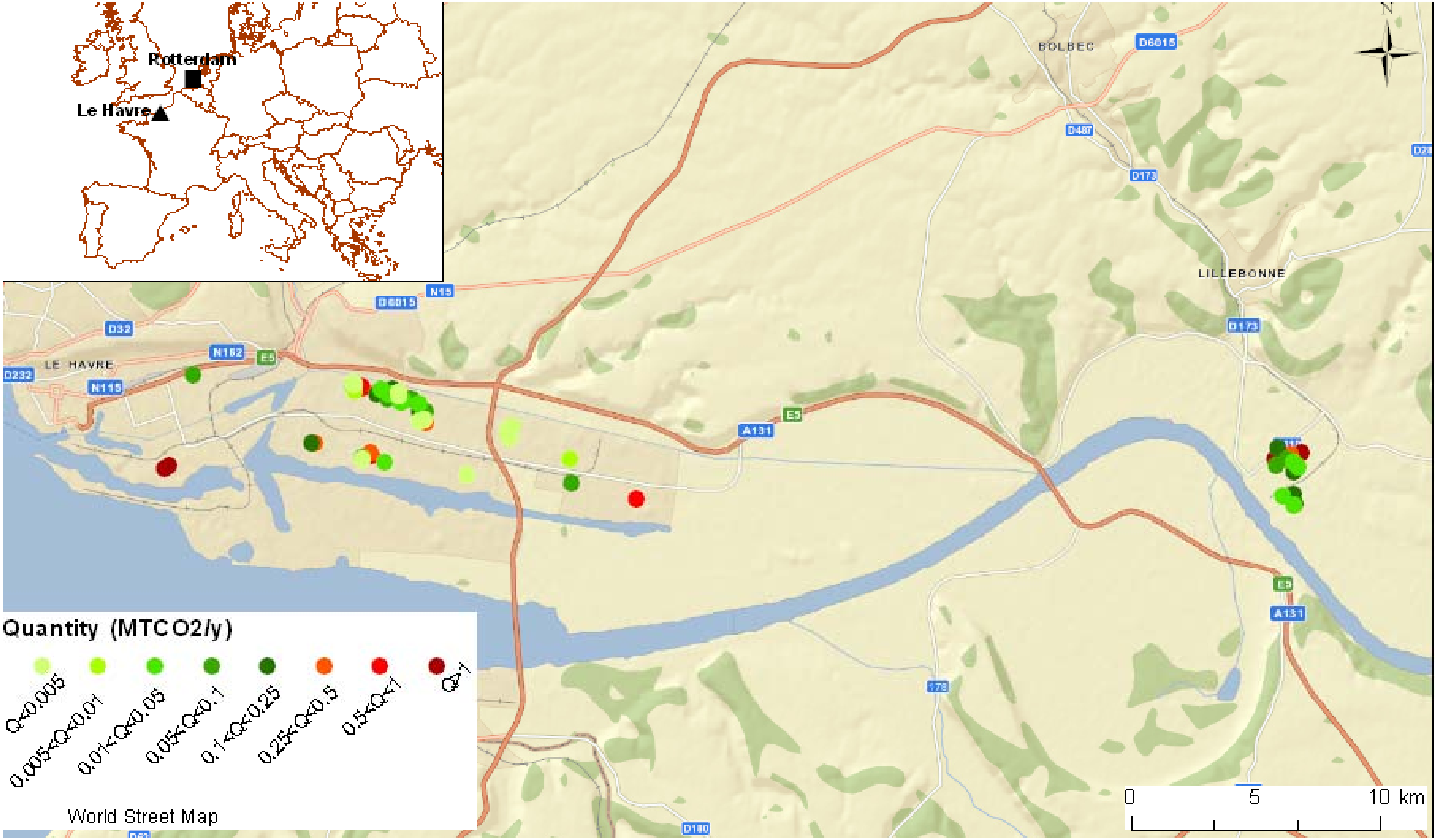
Task 4.1 Micro-economic analysis: identification of cost key drivers
Task 4.2 Macro-economic analysis: investment strategy
Task 4.3 Economic model and application to Le Havre case

WP5: Management

WP6: Dissemination

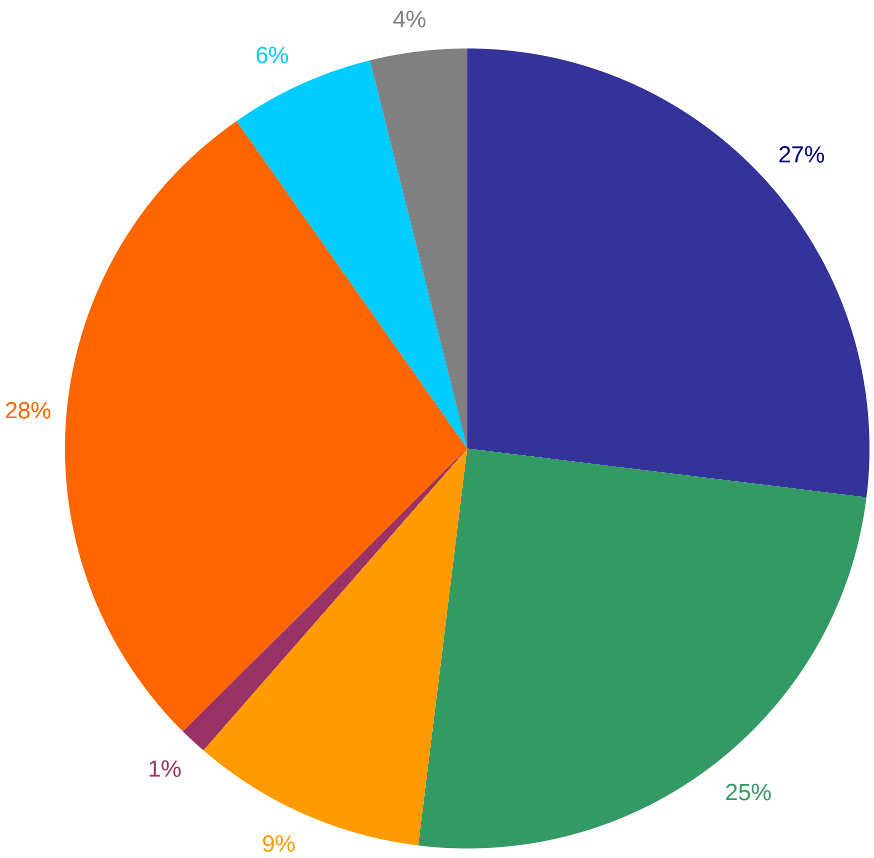
Inputs

Sources Considered



Inputs
Data Collection and Pooling Scenario Definition

CO_2 Breakdown of emissions in Le Havre and Port Jérôme areas - 2009



85 point sources

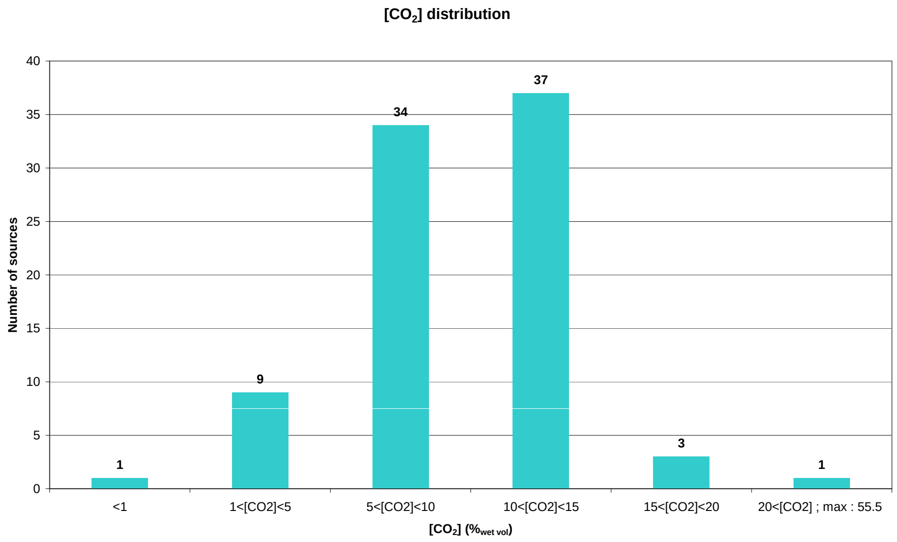
Post Combustion

14.5Mt$_{CO2}$/Year emitted

- Refinery #1
- Refinery #2
- Petrochemical industries
- Others (Incinerator, car manufacture, glasswork,compressor test platform)
- Coal Power Plant
- Chemical industries (Ammonia & urea production, industrial gases production)
- Cement Factory

TOTAL CO_2 EMISSIONS CONSIDERED: 14.5MTCO2/y

Inputs
Distribution of CO_2 concentrations in flue gases



Most of the concentrations are ranging from 5 to 15 % which is the typical concentration coming from combustion processes

- T from 70 to 470°C
  - Most of the temperature from 100 to 250°C
- P from below 1 atm (cement factory) to 1.1 bara
- H_2O from 5 to 30%

Some data are not measured thus not available: particles size and nature, pH

- Impurities
  - O_2
    - ~50% of the streams have composition from 0 to 5%
    - ~50% of the streams have composition from 5 to 10%
  - NOx from 0.0001 to 0.04%
  - SOx from 0.001 to 0.6%
  - CO from 0.0002 to 0.4%
  - Other possible components: VOC, N_2O, CH_4, HF, HCl, Ar, Heavy Metals.
  - Particulate matters from 0 to 200mg/Nm^3

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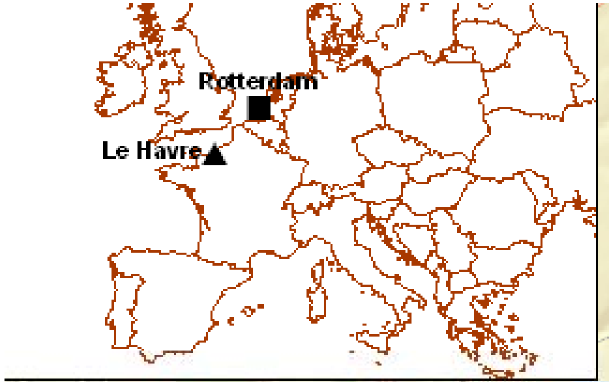
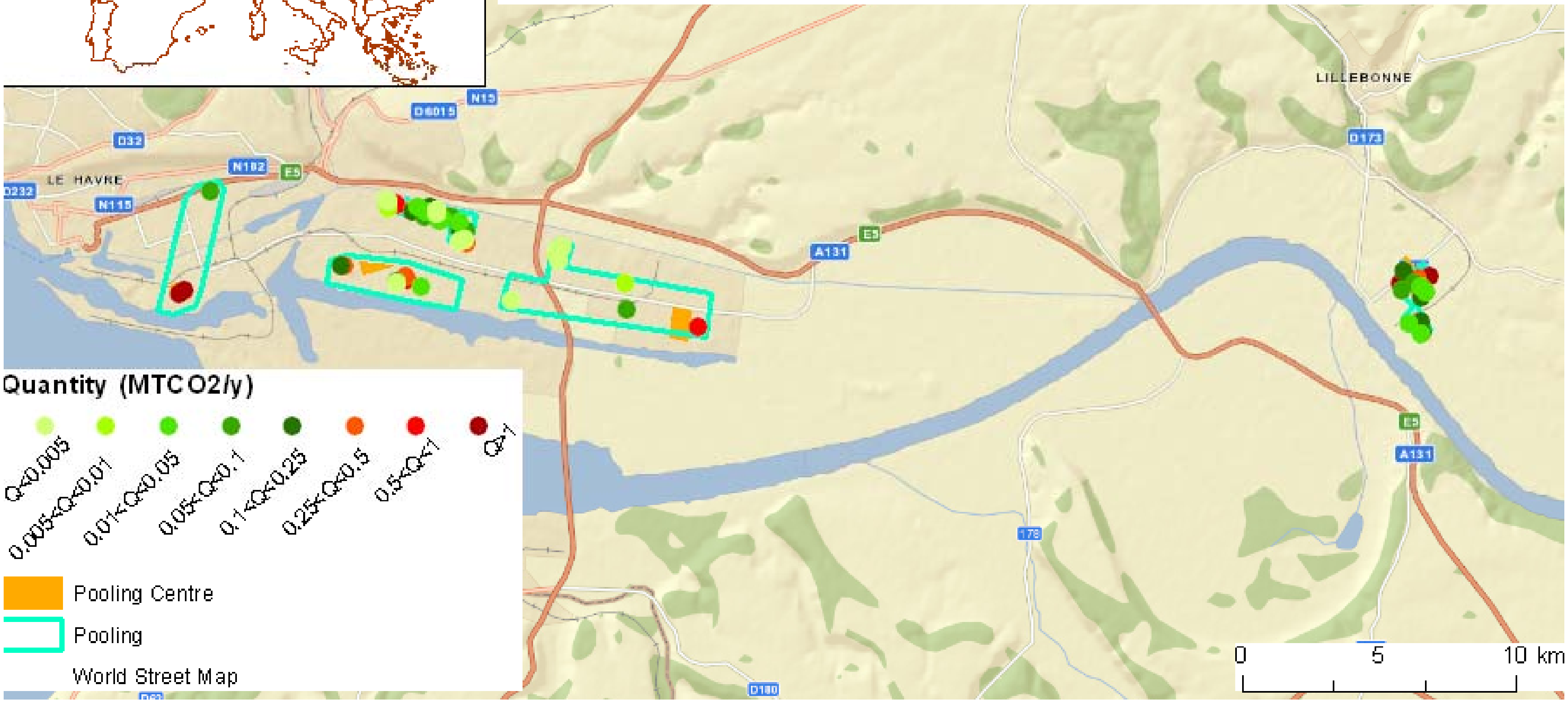
Pooling centres studied



Pooling flue gases may be an interesting strategy

1. **either to increase the CO_2 volume to capture**
2. **or to increase the CO_2 content in the flue gas**

The interest of pooling will highly depend on the capture cost considered and thus on the capture process selected



Assumptions
Flue gas collecting network

- Flue gases are sent as they are at the bottom of the stack into the flue gas collecting network
- Design made for the peak flowrate
- They are just boosted at the level of CO_2 sources
- The pipeline diameter cannot exceed 80”
  - Maximal value available in the API 5L standards
- Minimal thickness of the pipeline is calculated
  - Maximal Allowable Operating Pressure
  - Corrosion allowance
- Change in elevation taken into account;
- Heat transfer
  - with air when pipelines are aerial
  - with ground if buried

Impacts on design
Potential issues - transport of FG at low pressure

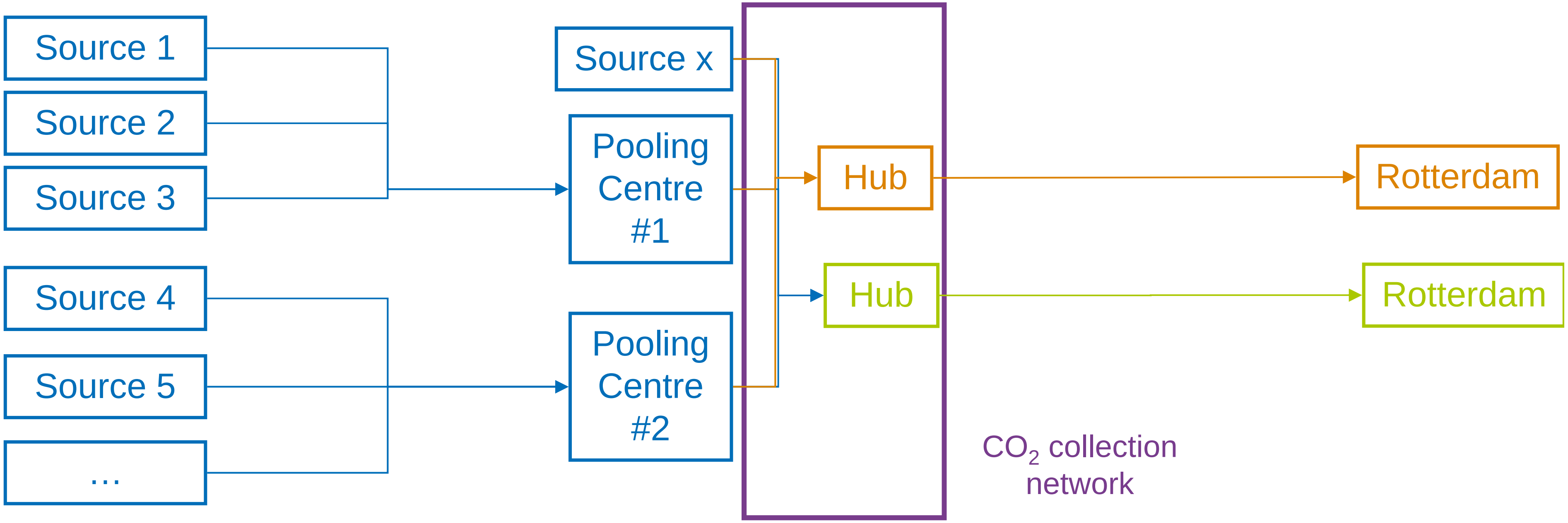
Major problems identified in the network are:

- Excessive velocities (NORSOK standards 60m/s – noise and vibration)
  - ⇒ large pressure drops
  - ⇒ excessive power requirements
  - ⇒ large erosion rates
- Large amount of particulate matter (Uncertainty: type of PM)
  - ⇒ large erosion rate
  - ⇒ integrity issue with blowers
  - ⇒ large amounts of solids
- Corrosion
  - ⇒ large corrosion rates for Carbon steel
  - ⇒ uncertainties (to be confirmed by experiments)

⇒ ALTERNATIVES TO THE TRANSPORT OF FLUE GASES AT LOW PRESSURE WERE PROPOSED

TO BE COMPARED FROM RISK, NETWORK MANAGEMENT AND ECONOMIC PERSPECTIVES

CO_2 collection networks

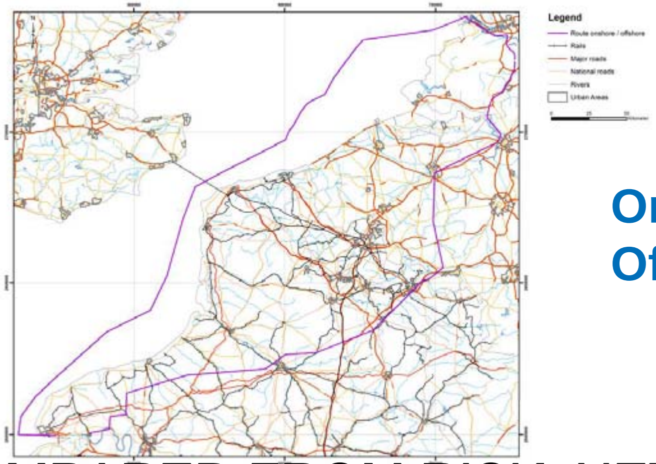


- Ship Hub (CO2 at -50°C/6.5bar)
  - Liquefaction required
- Pipeline Hub (CO2 at 20°C/150bar)
  - Compression required
- Designs performed:
  - Compression/liquefaction at the pooling centres level or at the hub level

TO BE COMPARED FROM RISK, NETWORK MANAGEMENT AND ECONOMIC PERSPECTIVES

CO_2 export systems
On/offshore pipelines

- Pipeline routing
  - Avoiding populated or protected zones, minimizing length
- Pipeline design
  - Dense transport (>80bar) – peak flowrate
  - 99.9% CO_2 (Impurities 500ppm H_20, H_2, N_2, O_2, NO, CO)
  - Onshore: P_{in}= 150bar, some pumping stations present along the way
  - Offshore: P_{in}= 200bar, no pumping station (prohibitive costs)



Onshore route: 616km
Offshore route: 505km

TO BE COMPARED FROM RISK, NETWORK MANAGEMENT AND ECONOMIC PERSPECTIVES

Ship Export of CO_2 from Le Havre to Rotterdam

- Send continuously the CO_2 coming from the ship to an offshore pipeline (200 bar) - Shipping schedules defined
- Assumptions
  - 3 ship sizes studied: 20,000 - 30,000 – 40,000m^3 (-50.3°C, 6.5bar)
  - 16.5 knots, 260 nautical miles
  - Water reduced to 50ppm
- Estimation of
  - temporary storage
  - number of ships
  - fuel consumption
- 60 hour cycle
  - mooring, loading, departure, journey
  - mooring, unloading, departure, journey

TO BE COMPARED FROM RISK, NETWORK MANAGEMENT AND ECONOMIC PERSPECTIVES

Work Performed

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Future steps

- Results from corrosion and coatings experiments
- Risk assessments for the collection networks and the export systems
- Building of an economic tool to select the optimized export system between several sources and several sinks
- Strategy of deployment for Le Havre case
- Applicability to other industrial basins
- Workshop in South Africa
  - November, 7th to 9th

THANKS FOR YOUR ATTENTION

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