# Collecting networks and export systems

## Lessons learnt from COCATE microeconomic study

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

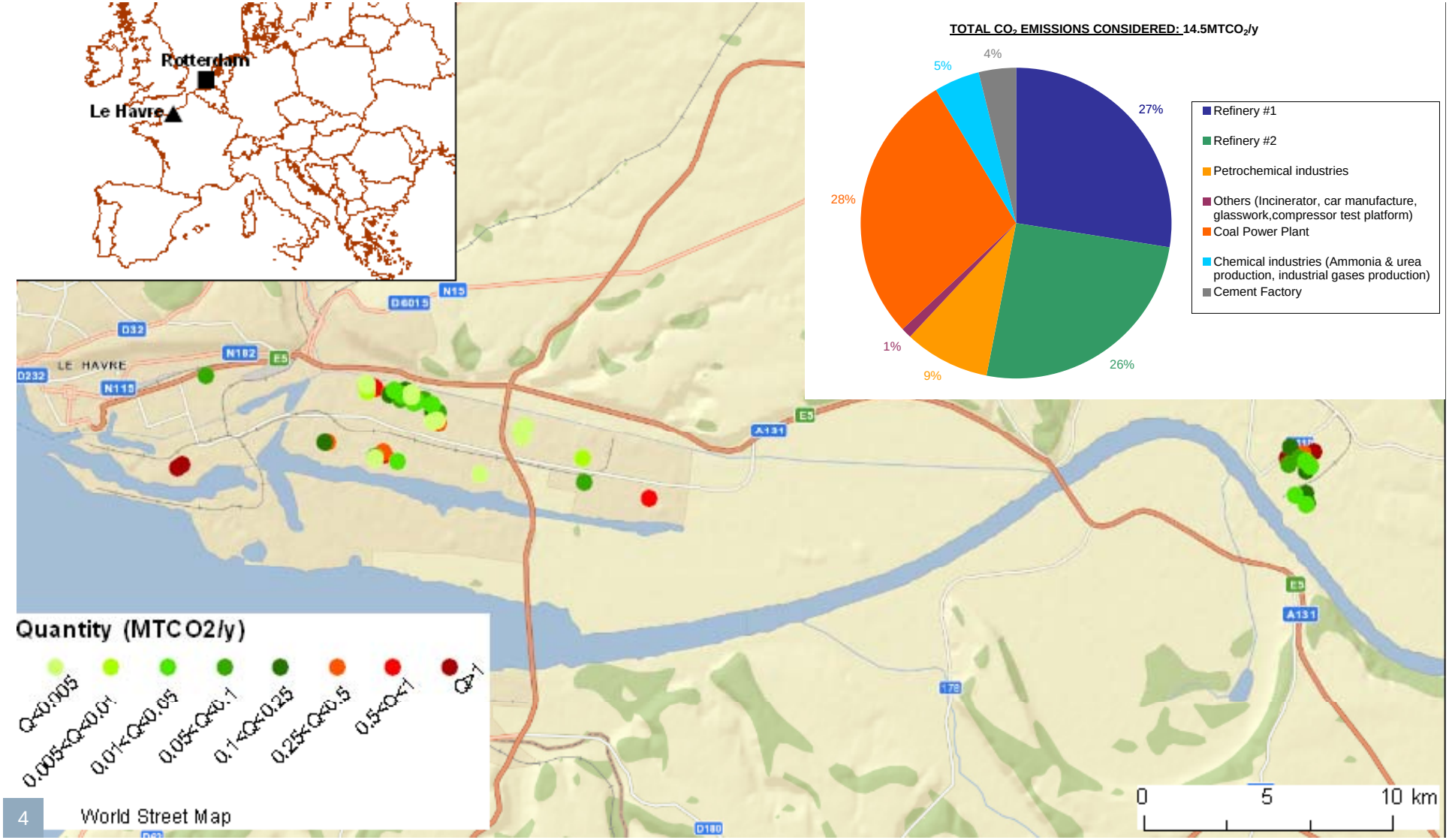
# Presentation outline

- COCATE WP4 Description
- Presentation of the area of interest
- Flue Gas collecting networks comparison
- $CO_2$ collecting networks comparison
- Export systems comparison
- Lessons learnt

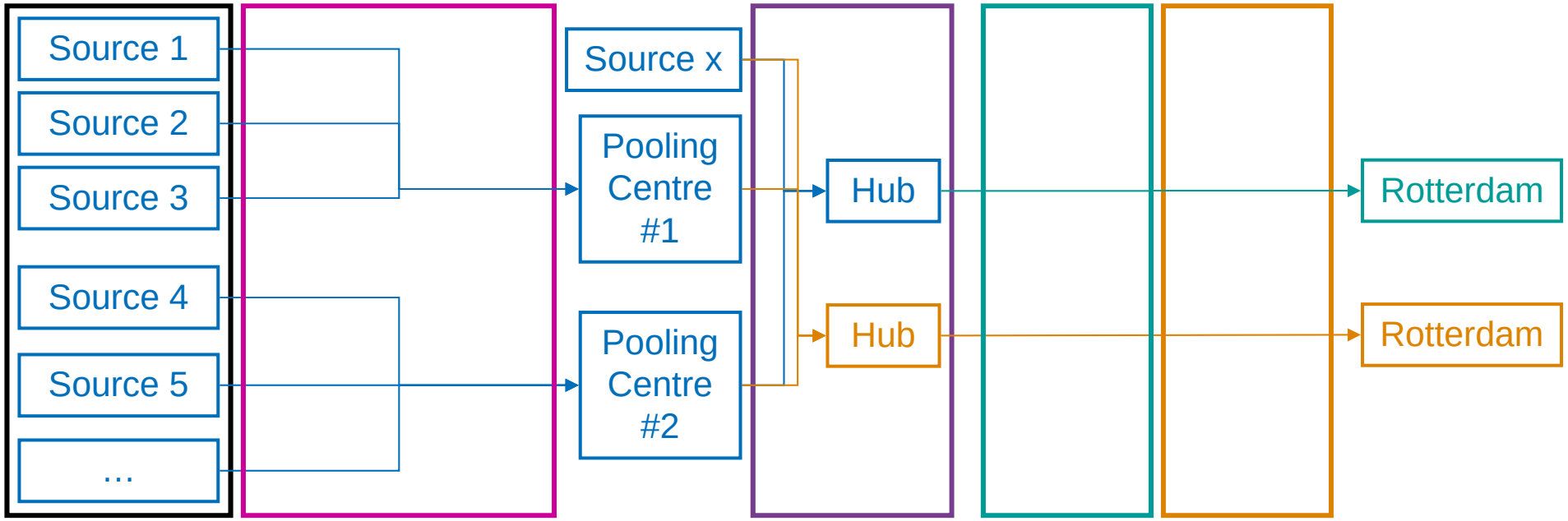
# Economic study

1. Micro-economic analysis: Identification of cost key drivers
   1. Collecting networks: Flue Gas and $CO_2$
   2. $CO_2$ Export Network: Shipping and pipeline alternatives, sequential vs Simultaneous Build Up
2. Macro-economic analysis: Investment strategy
   1. Identification of key-elements of an investment strategy for $CO_2$ transport business
   2. Investment options methodology analysis
3. Economic model and application to Le Havre case
   1. Economic $CO_2$ network optimisation model
   2. Application to Le Havre case

# Sources Considered



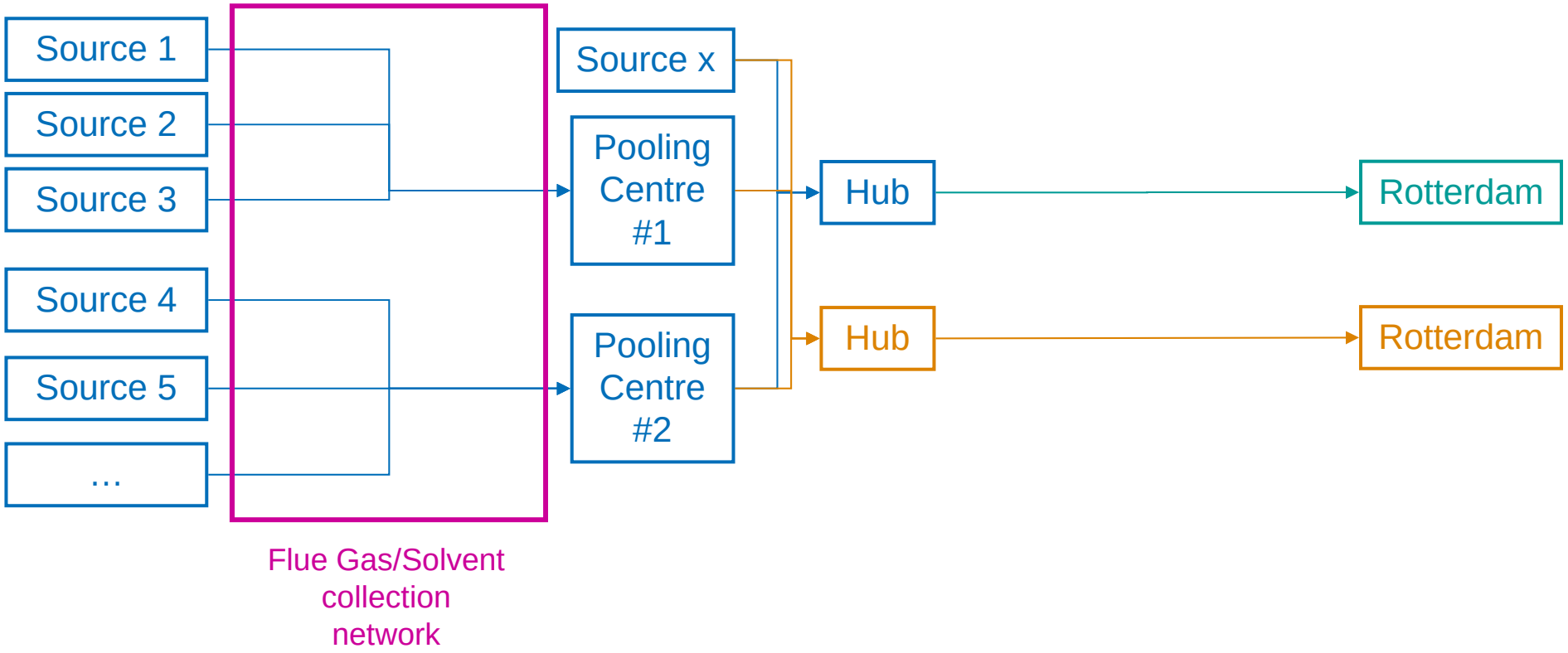
# Micro-economics in COCATE
# Studied systems



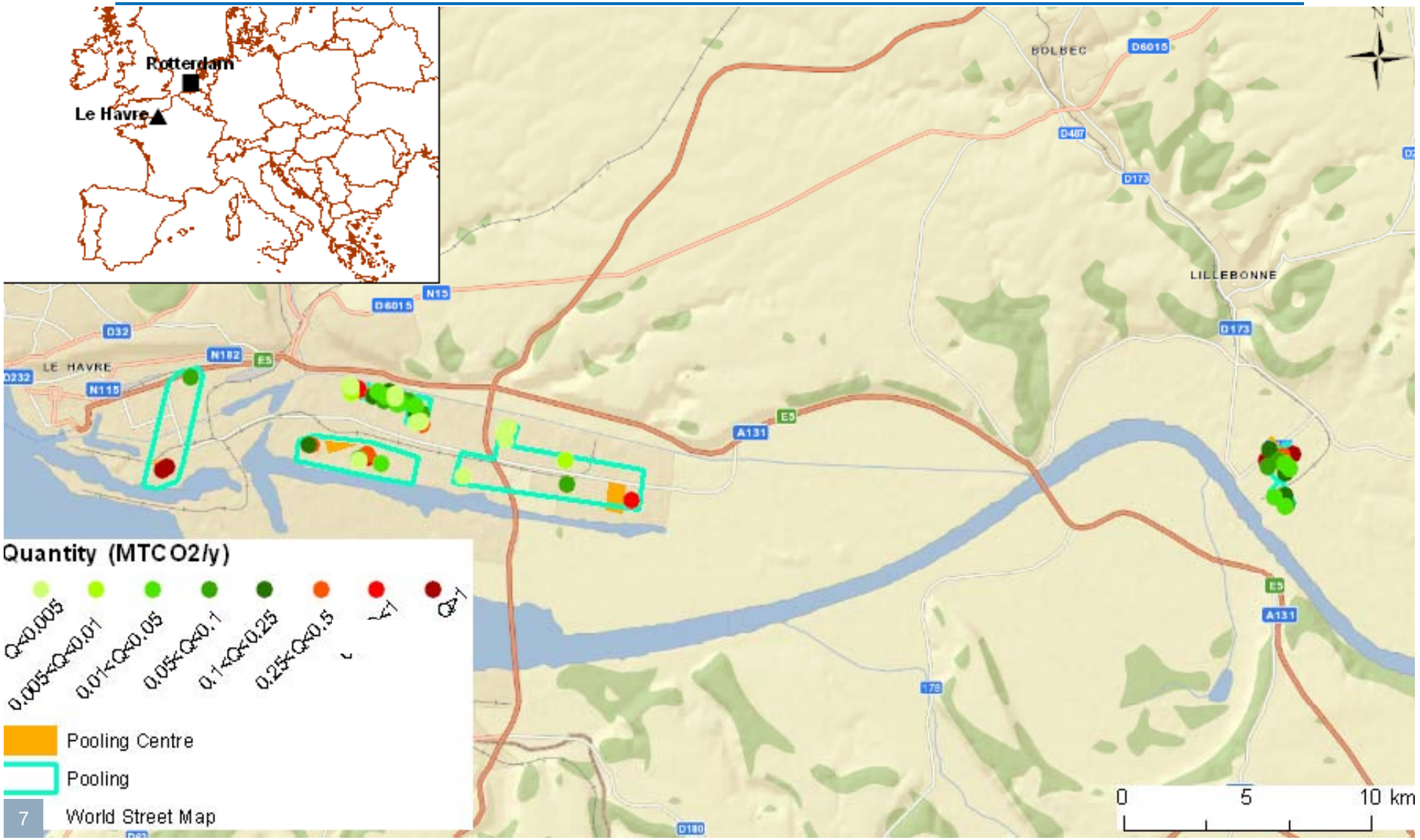

Different implementation strategies

1. Over designs
2. Simultaneous implementation
3. Sequential implementation

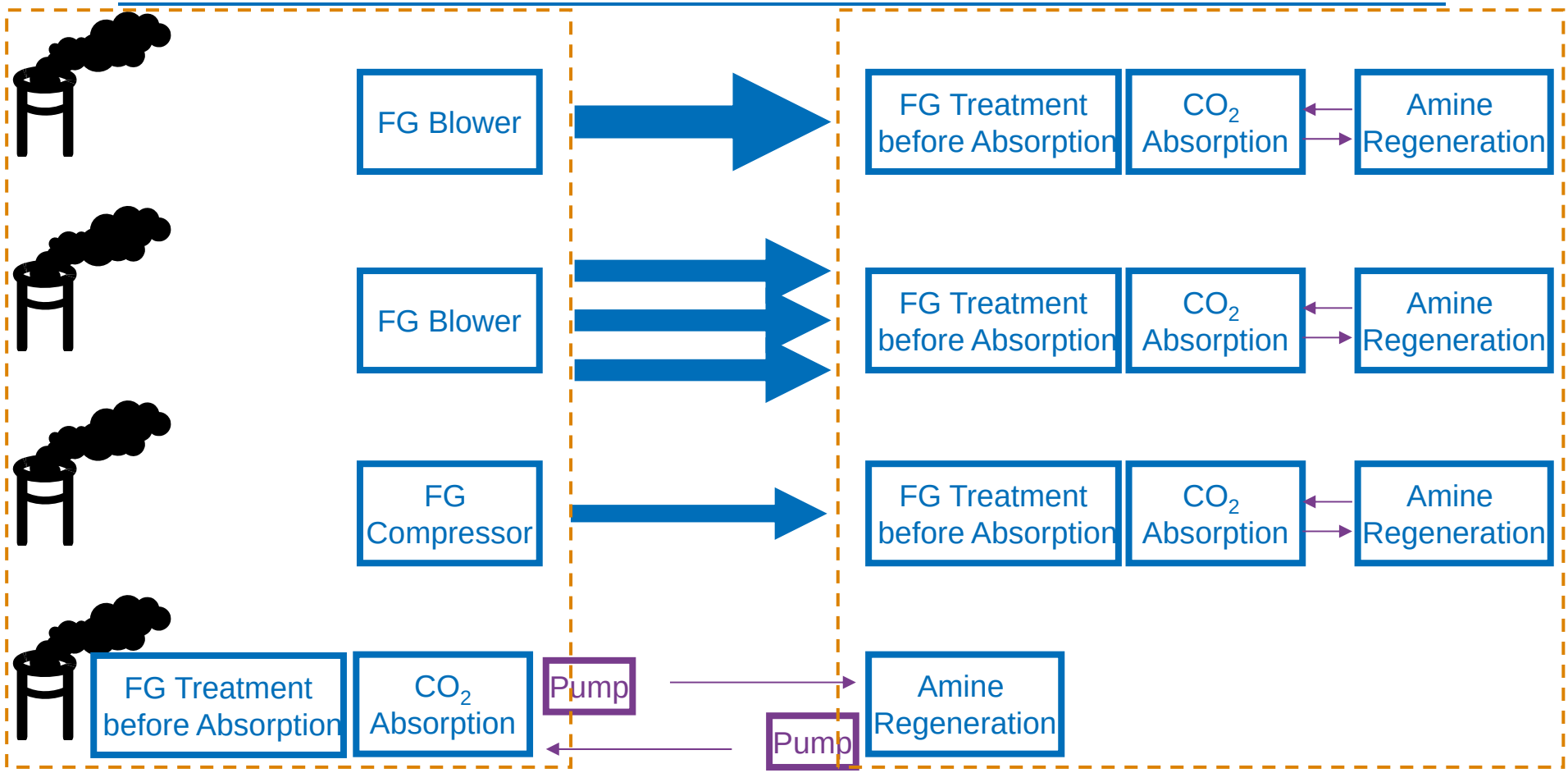
# Flue gas/solvent collection networks



# Pooling Centres studied



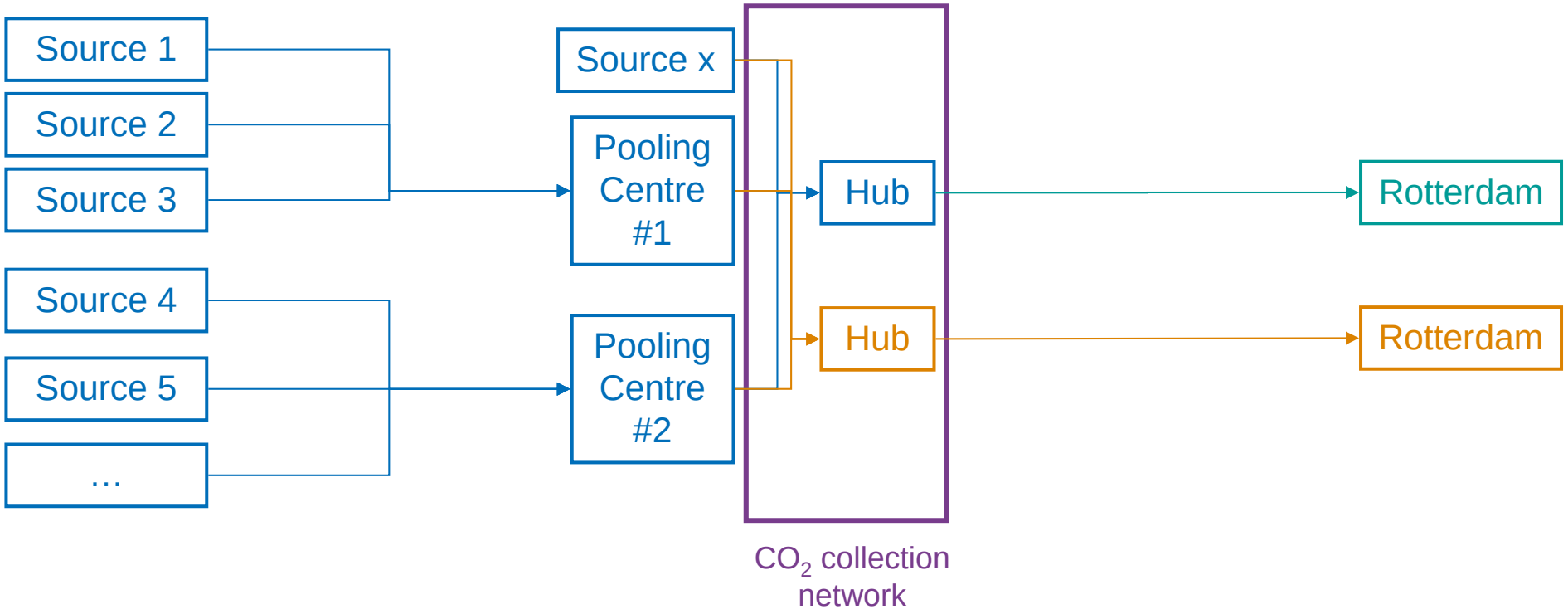
# Flue gas/solvent collection networks
# Options compared



# Flue gas/Solvent collection networks Main Conclusions

- Pooling flue gases may be an interesting strategy
  - either to increase the $CO_2$ volume to capture
  - or to increase the CO2 content in the flue gas.
- The interest of pooling will highly depend on the capture cost considered and thus on the capture process selected
- For a given concentration,
  - as soon as the yearly emissions are bigger than 500kt$CO_2$ a stand alone capture unit is more competitive than pooling it to any other source.
  - as soon as the individual yearly emissions are smaller than 500kt$CO_2$ for several emissions points, transporting the flue gases even in stainless steel pipelines is better than a stand alone capture unit per emission point.
- For pooling huge sources and/or low $CO_2$ concentrated ones,
  - pooling amine instead of flue gas seems to be a better economic choice.
  - This result which was found on a specific case (3 huge sources close to each other and one low concentrated source) should be verified for other cases (outside COCATE project) with different distances.

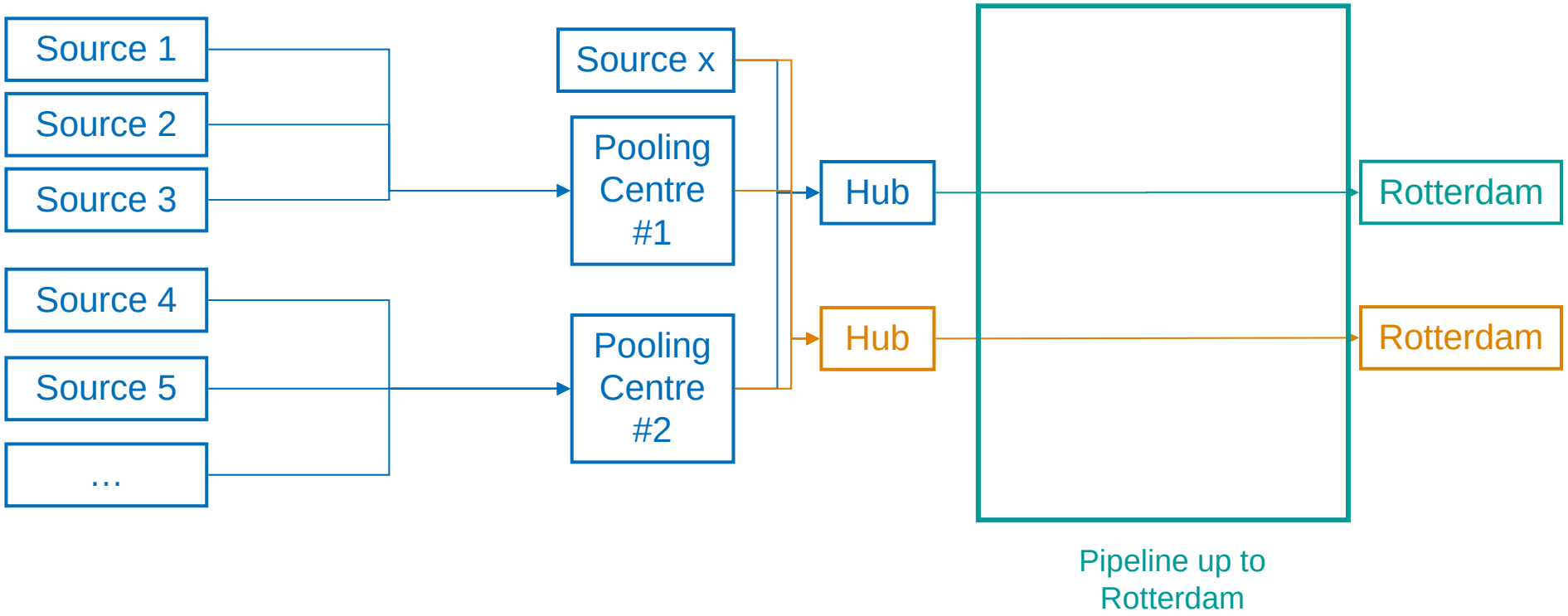
# $CO_2$ collection networks



# $CO_2$ collection networks Main conclusions

- Minimize the low pressure transport
  - Dense and Liquid transport best options from an economic standpoint (costs driven by electricity consumption)
  - If there is enough space at the pooling centres' level, conditioning before transport should happen at this place and not at the hub level
- Common hub
  - $CO_2$ transported in dense phase
  - At the hub level
    - Either liquefied by expansion
    - Or, pumped for pipeline transport
  - More expensive than ammonia cycles but flexibility when mixed export systems are used
- Applicability to generic cases: benchmark of options should be re-evaluated (other distances and mapping)

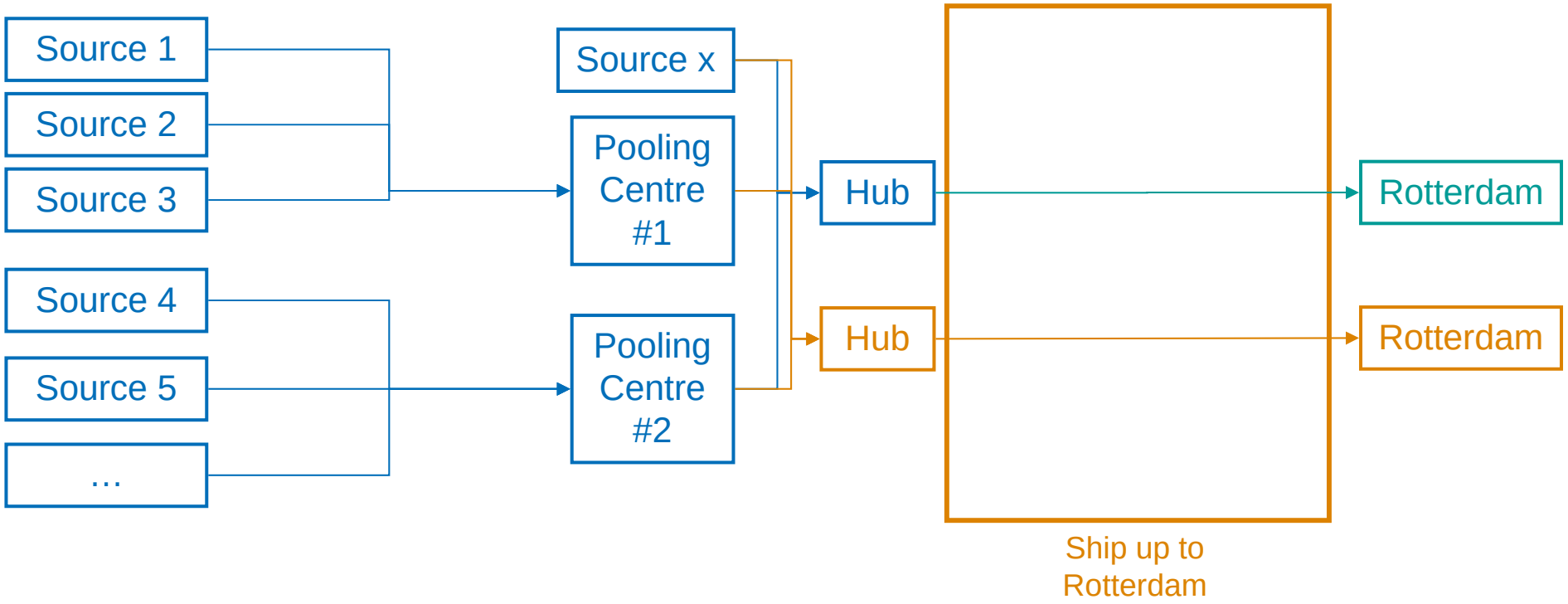
# $CO_2$ export systems
# On/offshore pipelines



# $CO_2$ export systems
# Export Pipeline Le Havre Rotterdam
# Main Conclusions

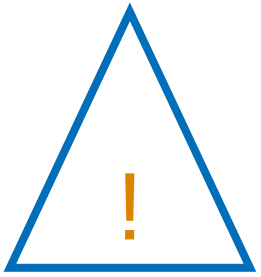

- Onshore transport
  - For our specific case (France, low electricity price), whatever the flow rate, the cost optimized options are with small diameters and 1 pumping station every 100-150km
    - Small diameter option allows having smaller upfront investment
    - From a risk standpoint, pumping stations =sectioning, containment in case of $CO_2$ leak
- Offshore transport
  - Offshore pipeline is 30% more expensive than onshore pipeline (Laying and material)
  - Offshore pipeline may be interesting
    - if the pipeline goes directly from Le Havre to an offshore storage site without passing by Rotterdam
    - if social acceptance or risk is an issue

# $CO_2$ export systems
# Ships



# $CO_2$ export systems
## Ship Export Le Havre Rotterdam
## Main Conclusions

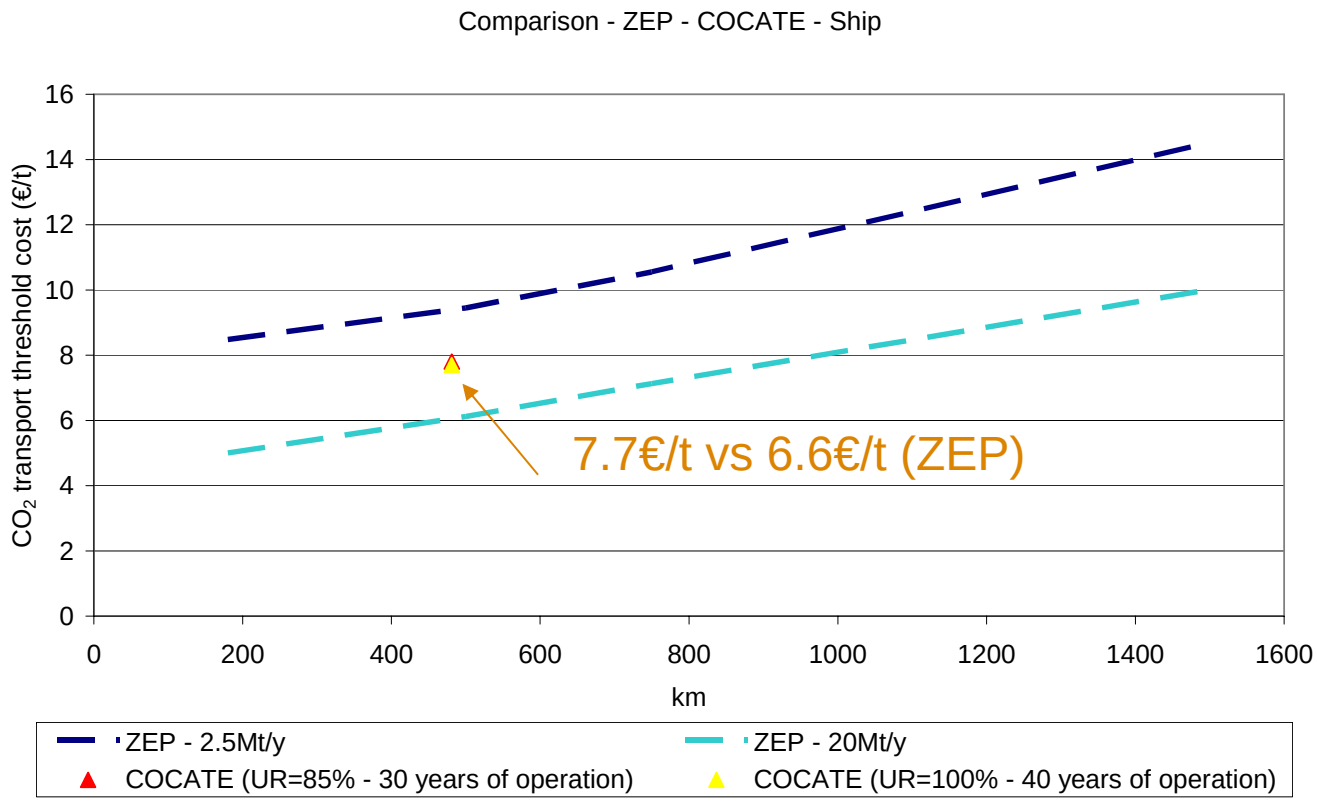
- Costs independent of the ship sizes (20,000 to 40,000$m^3$) but depend on the utilization rate




**Fuel 30% of the total cost**

**Harbour fees 30% of the total cost**

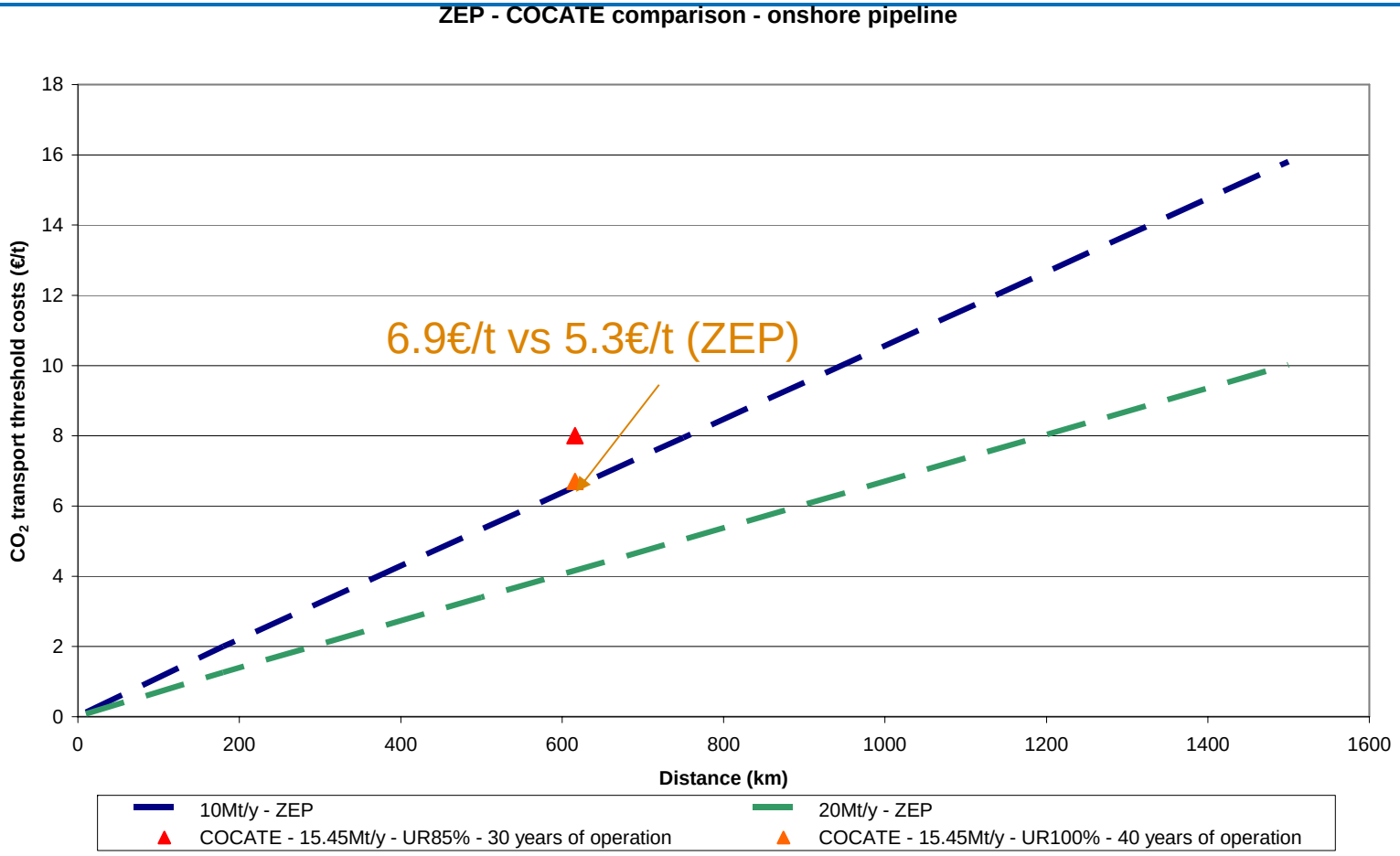
# $CO_2$ export systems
# Comparison with ZEP costs - Ship




**COCATE:** low sulphur fuel, such as distillate fuels, in 2020 -1,100 USD per ton
Outlet = inlet of an offshore pipeline - 200bar

**ZEP:** marine diesel oil with a price of 514 USD per ton
Outlet = injection at 60bar

# $CO_2$ export systems
# Comparison with ZEP costs - Pipeline

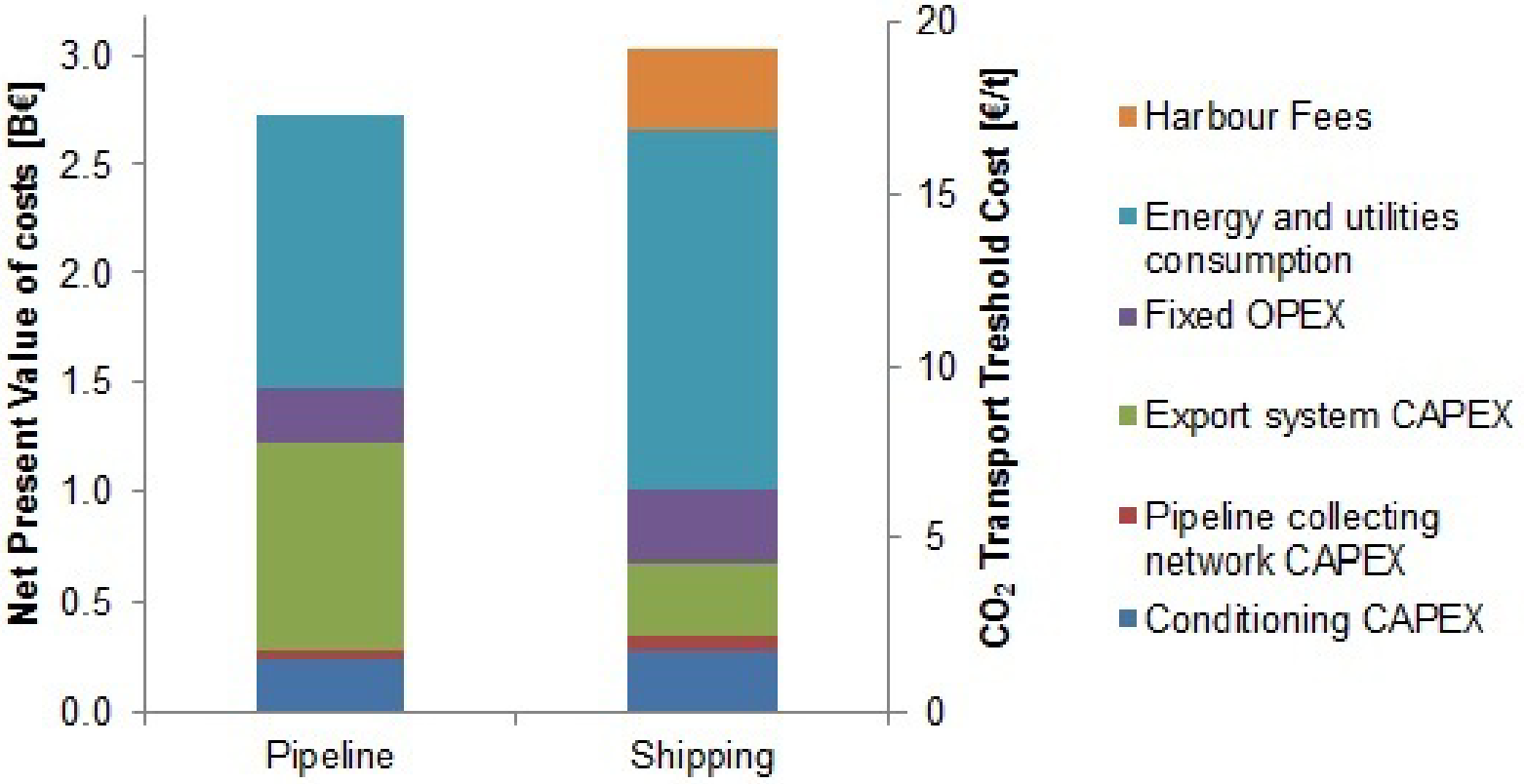



**COCATE:laying coefficient=1.4**

**Safety Class D – more steel**

**ZEP:** **flat topography – no special crossing**

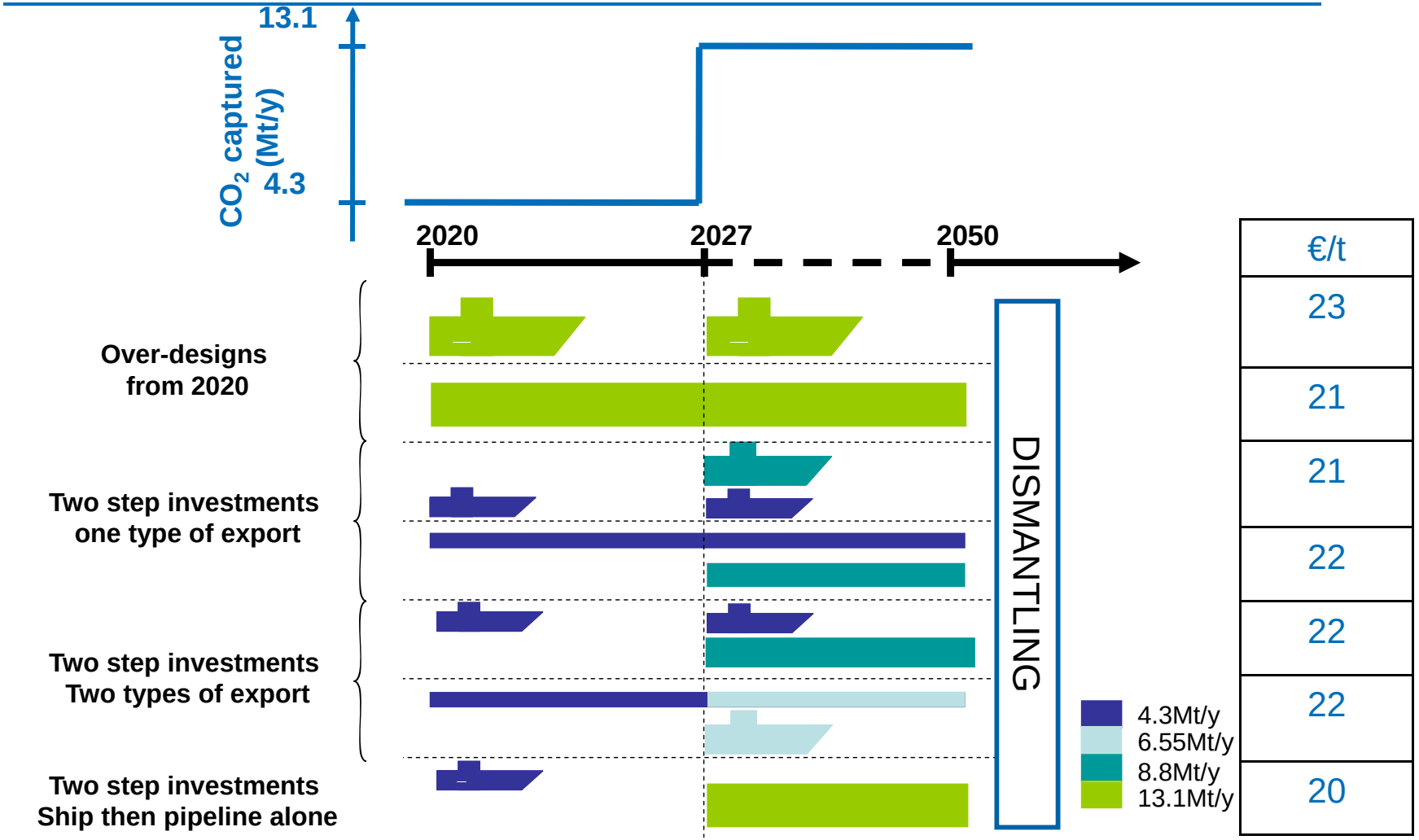
# $CO_2$ export systems
# From pooling centres in Le Havre to Rotterdam




**$CO_2$ emissions from collecting 13.1Mt$CO_2$/y, conditioning, and exporting them to Rotterdam (depending on the source of energy (Coal power plant with/without $CO_2$ capture)):**

- **Pipeline: 0.2 – 1.1Mt$CO_2$/y**
- **Ship: 0.3 – 1.3Mt$CO_2$/y**

# Implementation strategies




**1 step deployment – pipeline: cheapest option (17€/t)**

# Micro-economics in COCATE
# Lessons learnt

- Flue gas collection network
  - Pool if $CO_2$ volume smaller than 500kt/y
  - Option: transport capture solvent instead of flue gas
- $CO_2$ collection network
  - Minimize low pressure transport
  - Envisage a common hub if mixed export systems (ship and pipeline)
- Onshore pipeline
  - cost optimized options: small diameters and 1 pumping station every 100-150km
- Offshore pipeline
  - 30% more expensive than onshore pipeline
- Ship
  - Ship size does not matter in terms of cost if utilization rate is maximized
  - Fuel and Harbour fees account for 60% of the total cost
- Comparison
  - Onshore pipeline less expensive but big upfront investment
  - Costs comparable to ZEP ones (slightly higher for pipeline but more accurate assumptions)

# THANKS FOR YOUR ATTENTION

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