Zero emissions platform

Cost of Transport
Large Scale and Post Demonstration

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panaware ab

European Technology Platform for Zero Emission Fossil Fuel Power Plants

Contents

Background –
ZEP & CCS Cost project

EU CCS Demonstration Programme

Zep
Zero emissions platform

Objective: Enable commercial availability of CCS

Three different challenges:

Capture Technology Down the Learning Curve

+

Minimize **Transport** Cost by Early Planning

€

+

Demonstrate Secure **Storage** for Public Perception

Why is the ZEP Cost Report unique?

- Publicly available cost data on CCS are scarce
- New, live, in-house data provided exclusively by ZEP member organizations
- Over 100 contributors and nearly 2 years of work…
- Complete CCS value chains; individual reports analyse costs for:
  - Capture
  - Transport
  - Storage
- Establishes reference point for costs of CCS, based on a "snapshot" in time (CAPEX referenced to Q2 2009)

Main Messages

CCS will be cost-competitive with other low-carbon power technologies

(Will be covered in the next presentation)

Transport Costs

Approach, Assumptions & Networks

Approaches to transport cost estimation

Bottom-up

- Detailed component cost built into dimensioning model for specific CCS cases
- Focusing on material costs, operating expenses
- Static, detailed view on cost

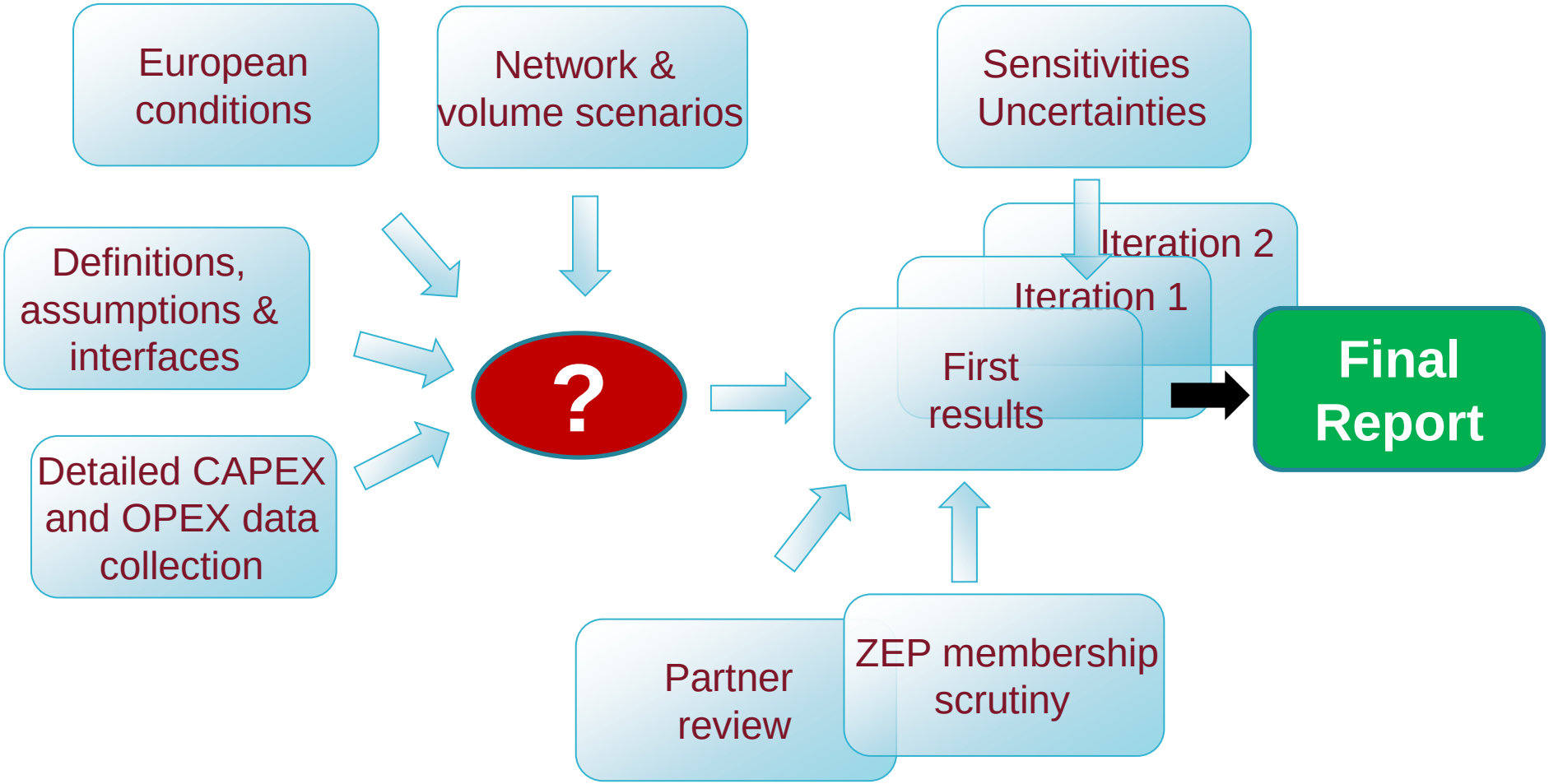
Top-down

- Analyzing ”the market”, potential capture projects coming on stream in a coordinated mode
- Based on phased-in volumes, approximating required, optimal transport capacities
- Focusing on total CAPEX
- Dynamic volume development view, extrapolations on cost

Integrated

- **Live, transport chain cost components, CAPEX and OPEX**
- **Simulated transport volume demands and network developments**
- **Integrating network scenarios and component costs**
- **Dynamic, generic view on cost and volume**

ZEP: The costs of CO_2 transport – method



Key Assumptions

General
- o exchange rates
- o project lifetime
- o cost of energy
- o interest rates
- o residual value
- o inflation
- o cost time stamp

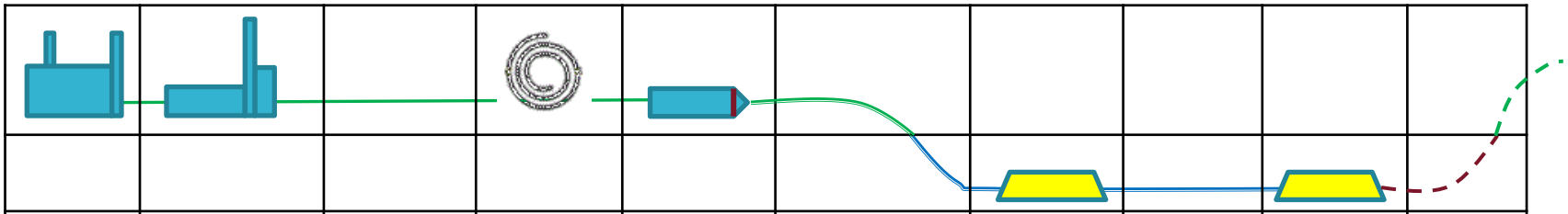
Common CCS
- o flow rates (volumes)
- o annual production profile
- o CO_2 purity
- o interface conditions
  - o inlet pressure/temperature
  - o outlet pressure/temperature
- o injection properties

Onshore pipeline
- o custom installations
- o flat topography, simple soil conditions
- o unobstructed right of way
- o pressures
  - o inlet 100 barg
  - o outlet 80 barg
  - o maximum design 100 barg
- o maximum CO_2 temperature 50°C
- o booster pumping >200 km's

Offshore pipeline
- o custom installations
- o 4 slot subsea template
- o control cable
- o pressures:
  - o inlet 100 barg
  - o outlet 60 barg
  - o maximum design 250 barg
  - o start 200 barg
- o environmental factors
- o market factors

Shipping
- o custom ship design maximum 40' m^3
- o buffer storage 0.8–1.0 * ship size
- o offshore terminal submerged turret
- o transport mode 7 bara & -55°C
- o discharge conditions
  - o pressure 60 barg
  - o temperature 0°C
- o direct injection
- o no offshore buffer storage
- o subsea template & control cable

Collection of Component Costs - Example

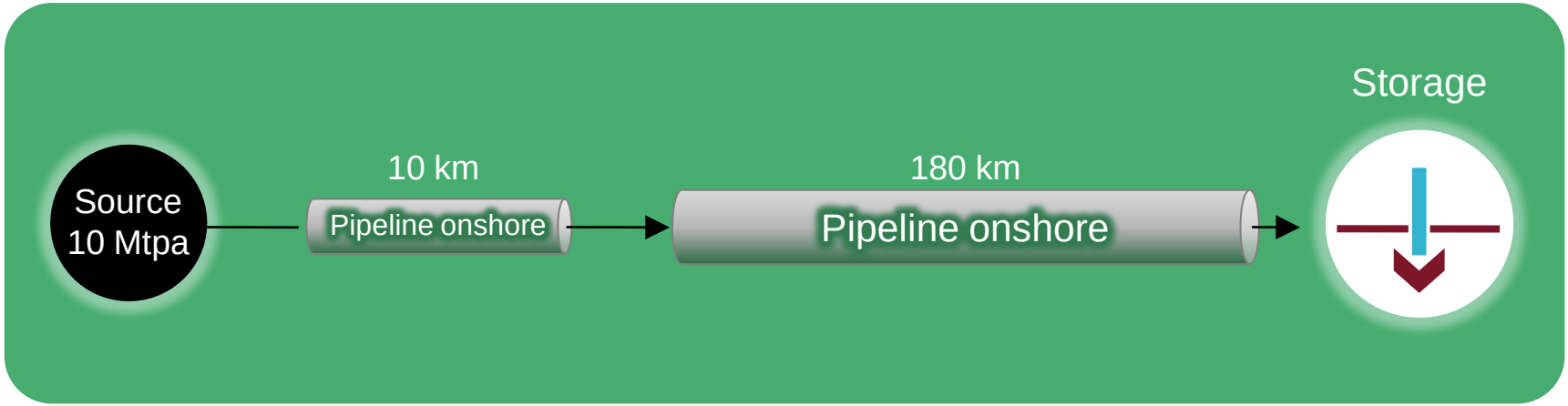


	Source	Capture/ Compression	Onshore pipeline	Pump	Launcher/ Landfall	Offshore Pipeline	Template Storage	Offshore Pipeline	Template Storage	Control Cable
Length			10 km			180 – 1 500 km		10 km		50 km
Pressure		110 barg	110→ 100 barg	100–> 200 barg	200 barg	200 → 60 barg	60 barg	60 barg	60 barg	
	A	B	C	D	E	F	G	H	I	J

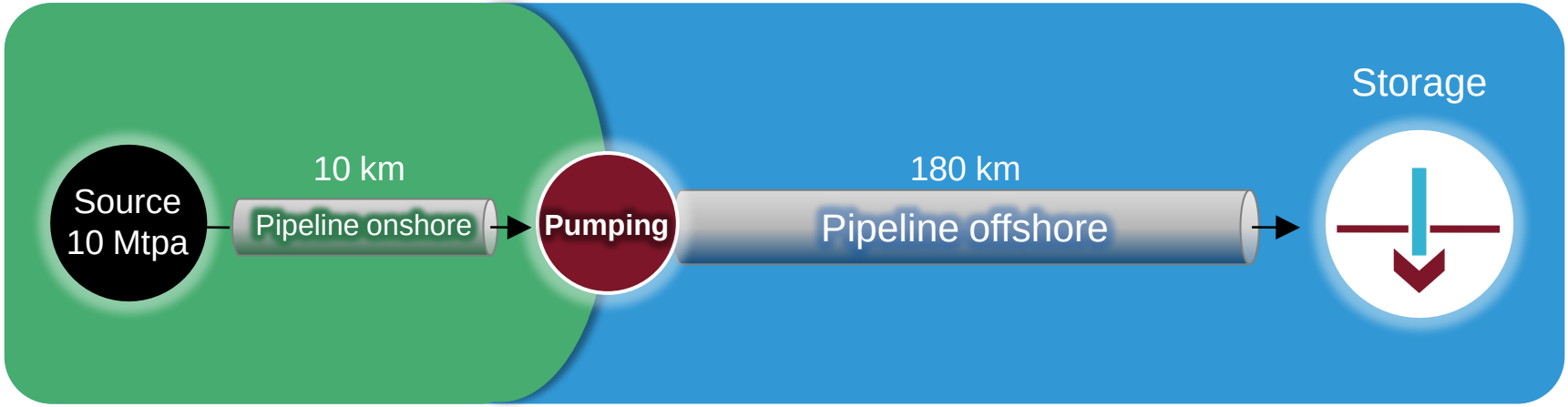
Battery limits and cost zones for offshore pipeline

CO_2 Transport from Point-to-Point ...

Onshore spine

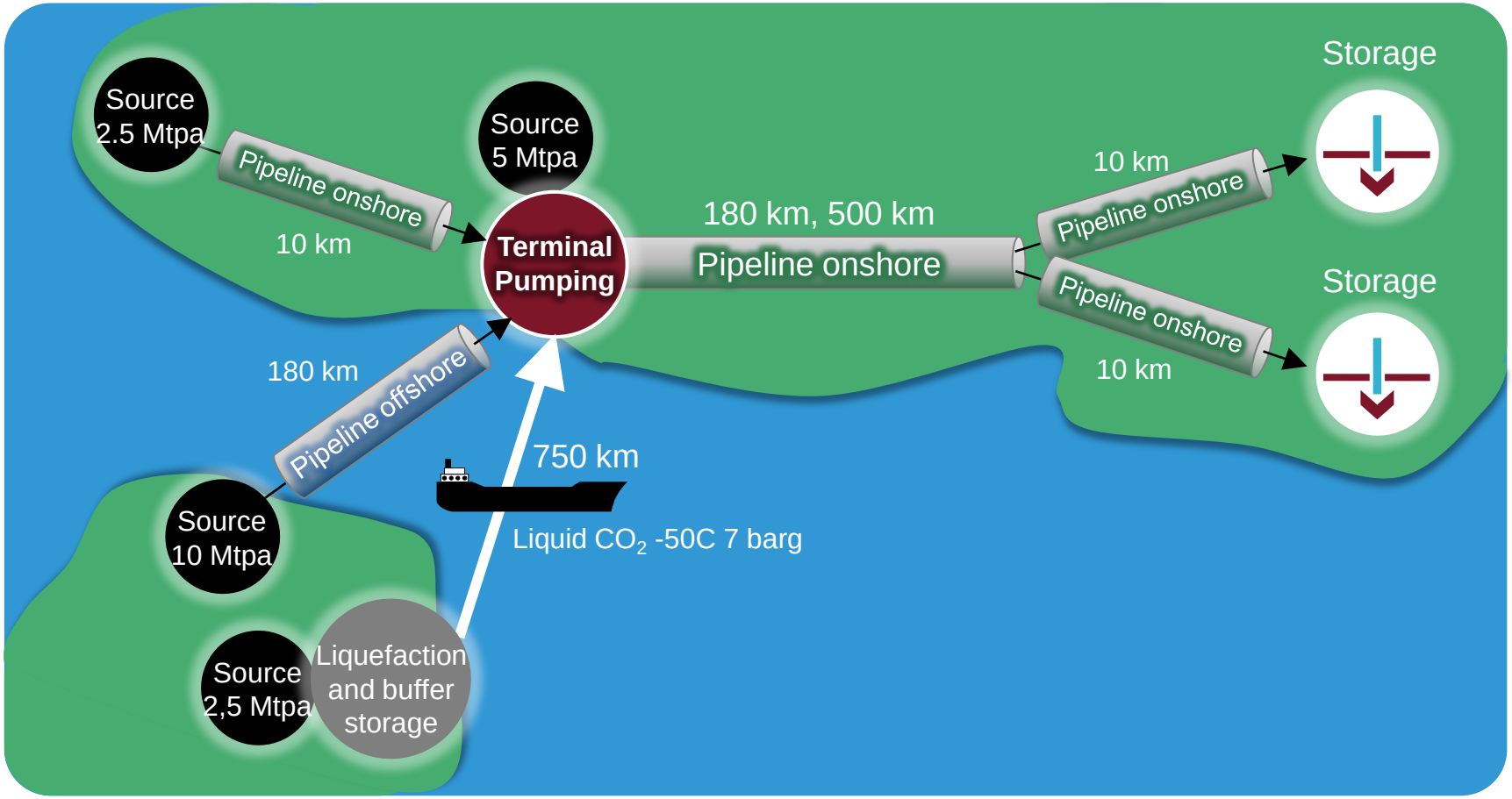


Offshore spine

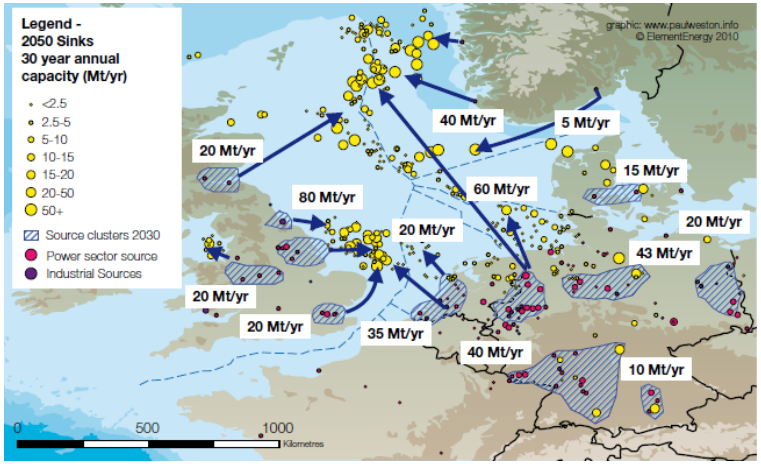


... to Complex Networks

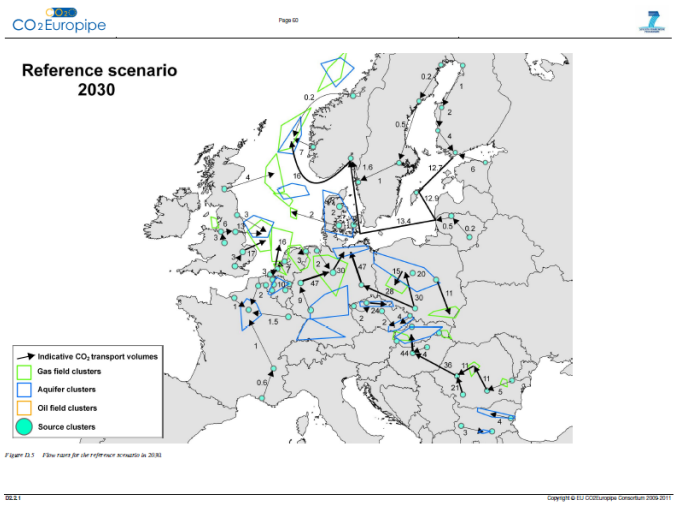
Complex networks with onshore pipeline spine of 180 km and 500 km



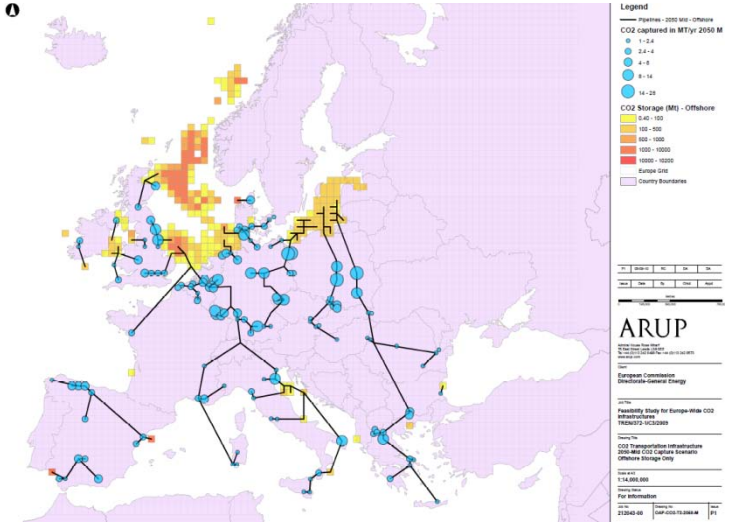
More robust scenarios built in other studies...



One North Sea study
"Very High scenario 2050"
May 2010



CO_2Europipe
Reference scenario 2030
September 2011



Feasibility Study for Europe-wide CO_2 Infrastructures
2050 Mid CO_2 Capture Scenario
October 2010

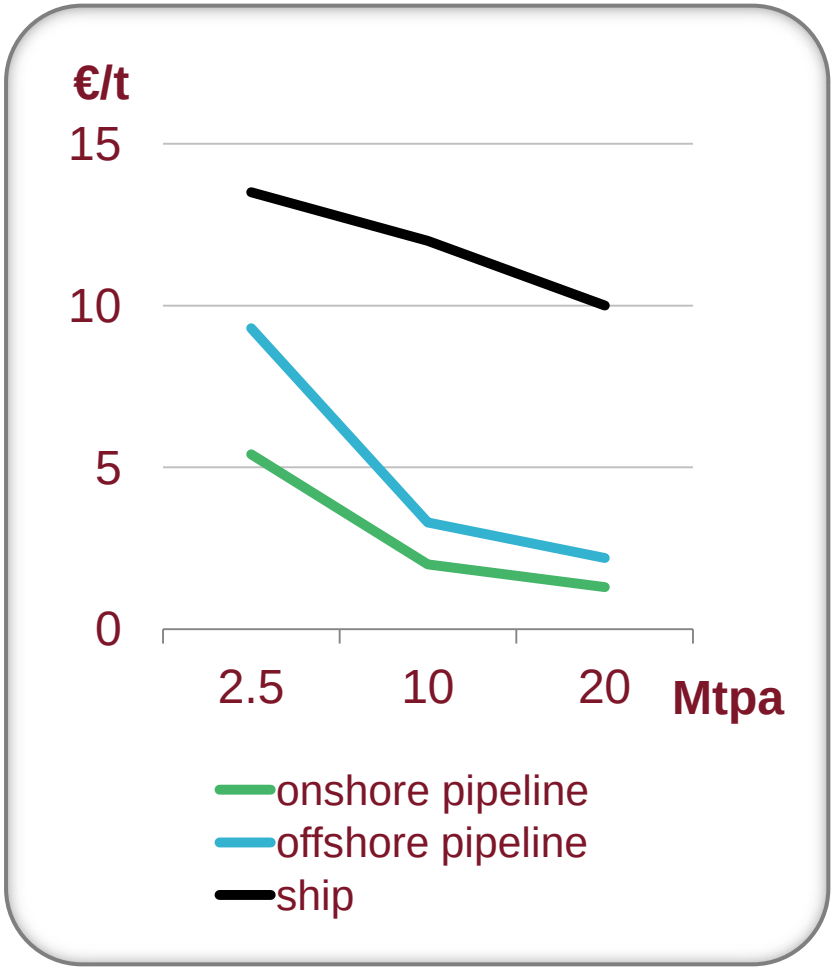
....but more detailed and reality based cost element analysis in ZEP

- Pipeline data from both existing CO_2 pipelines and….
- … in comparison with hydrocarbon networks
- Data from current (2010) demonstrator projects
- Detailed interface definitions with Capture and Storage experts
- Shipping data from live projects and LPG tonnage
- Process (compression, regas and liquefaction) from vendors and projects

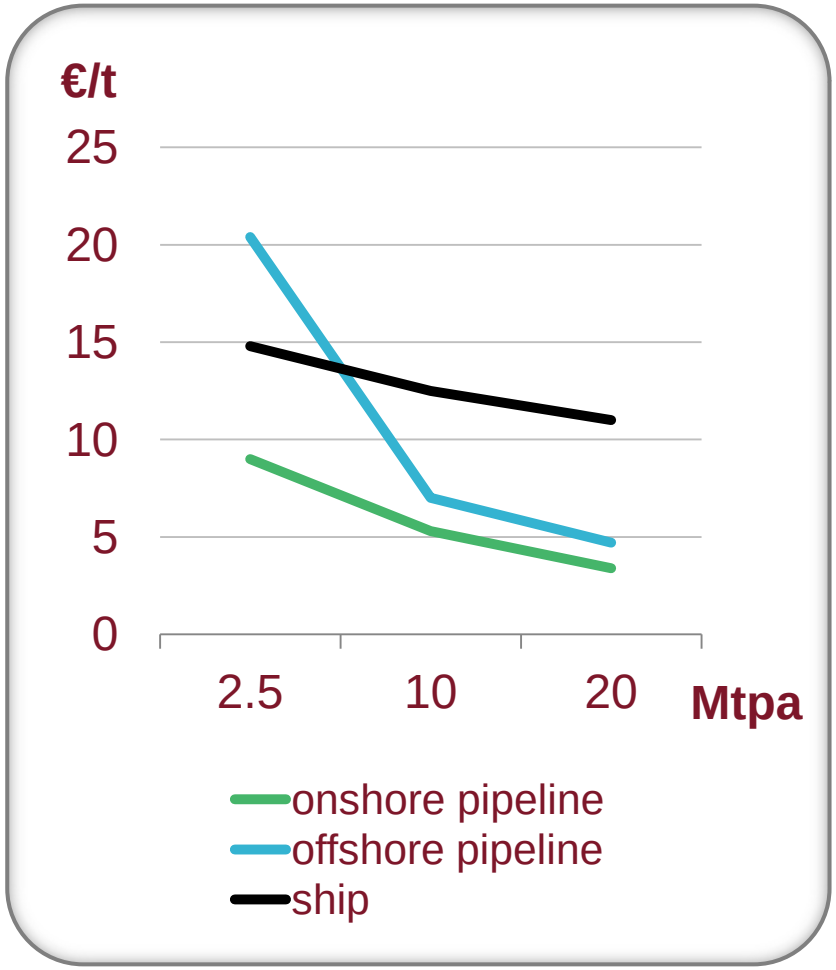
Cost Predictions

Scale effects are real (total cost €/t)

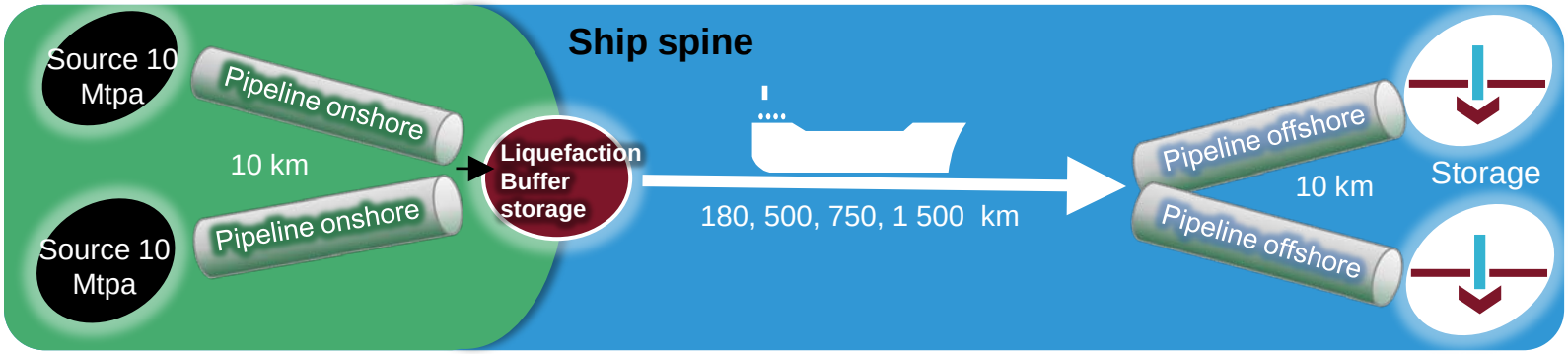
Point-to-Point **180 km**

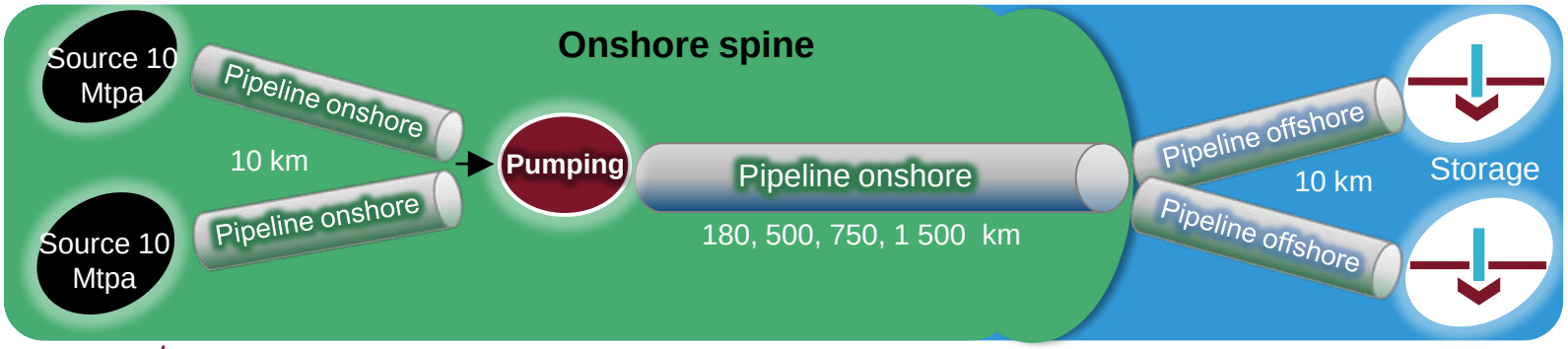


Point-to-Point **500 km**

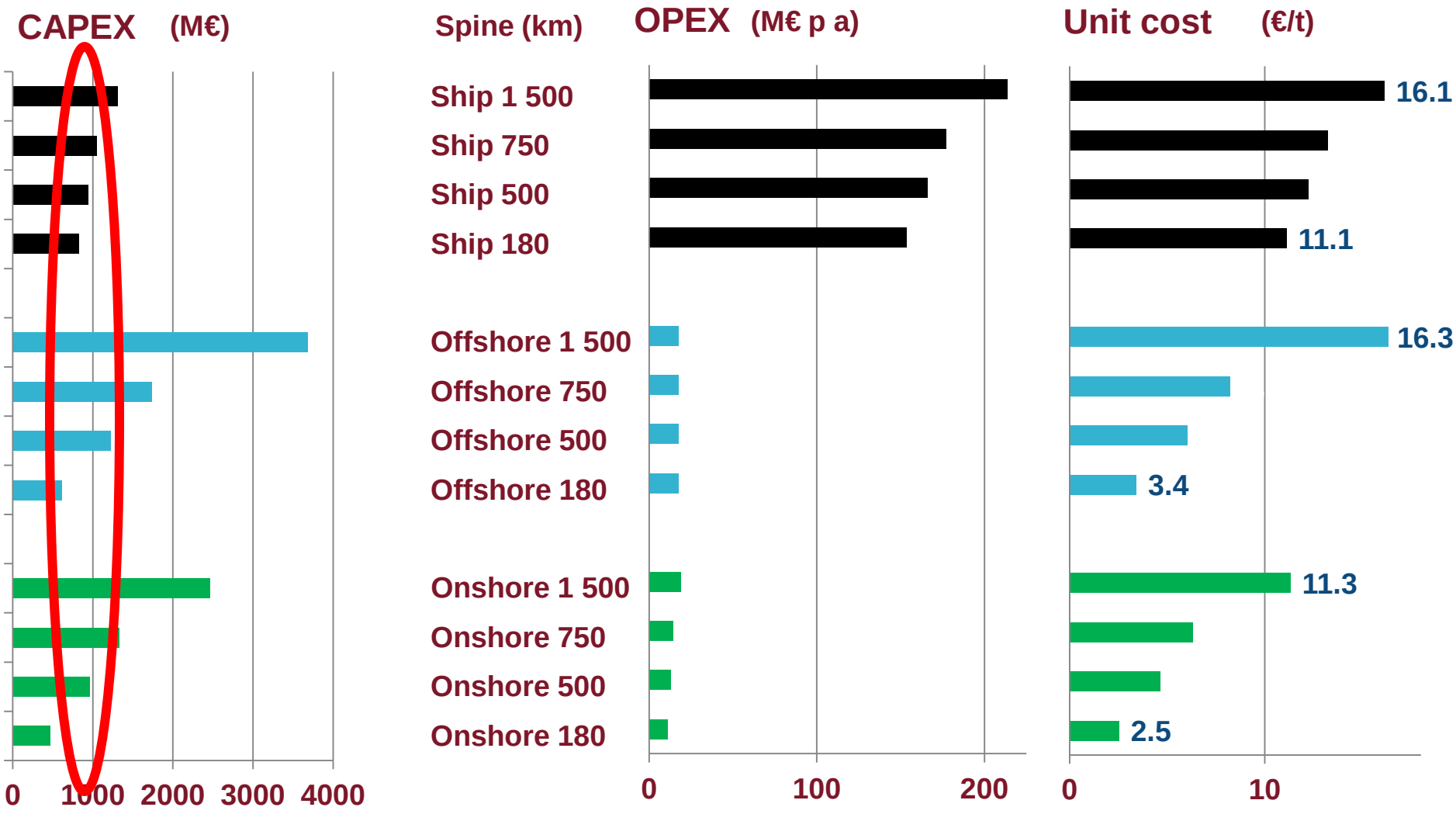


Selected Networks:
20 Mtpa, 2 sources, 2 offshore storages



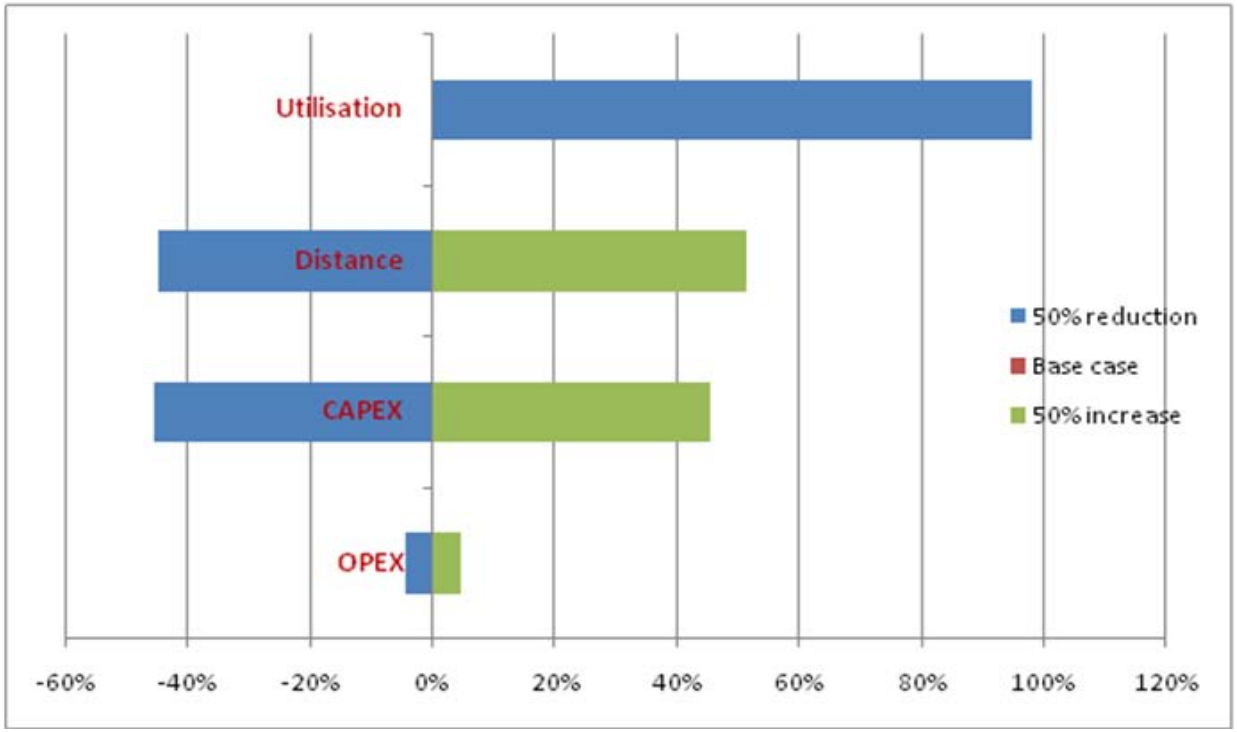


Network costs:
20 Mtpa, 2 sources, 2 offshore storages



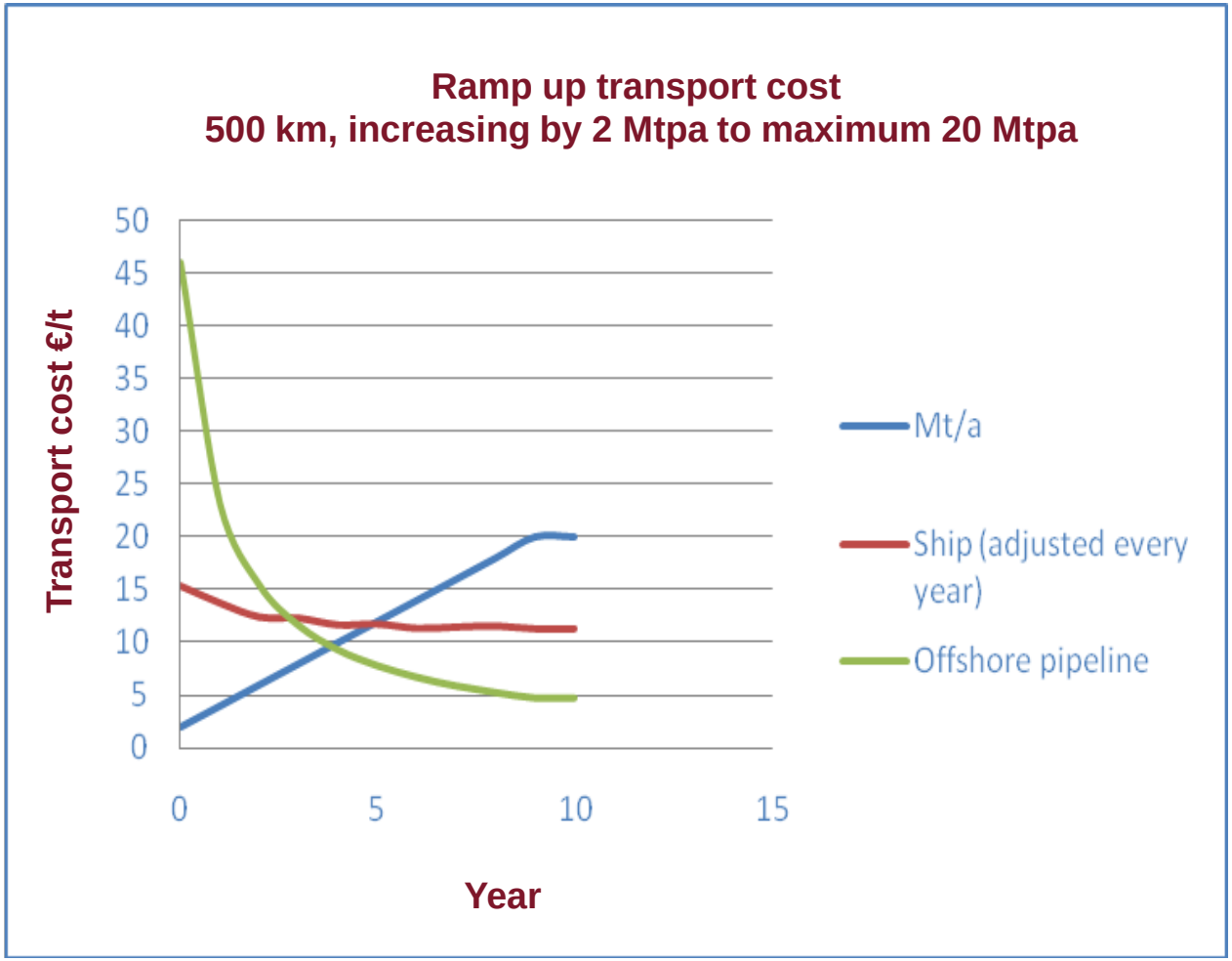
Pipeline sensitivities

Pipeline
% changes in cost per ton



Sensitivities for offshore pipeline 10 Mtpa and 500 km

Volume Ramp-up Sensitivity



Conclusions

Adding up, for Europe, we speak BIG numbers...

Infrastructure investment required is massive, yet overall numbers remain the results of highly approximate extrapolations, only, so <u>no</u> <u>guarantees</u> issued on this

report	*year*	*CAPEX (b€)*
Arup/EUC	2010	7 – 20
ZEP	2011	40 - 50
CO_2 Europipe	2011	50 - 80

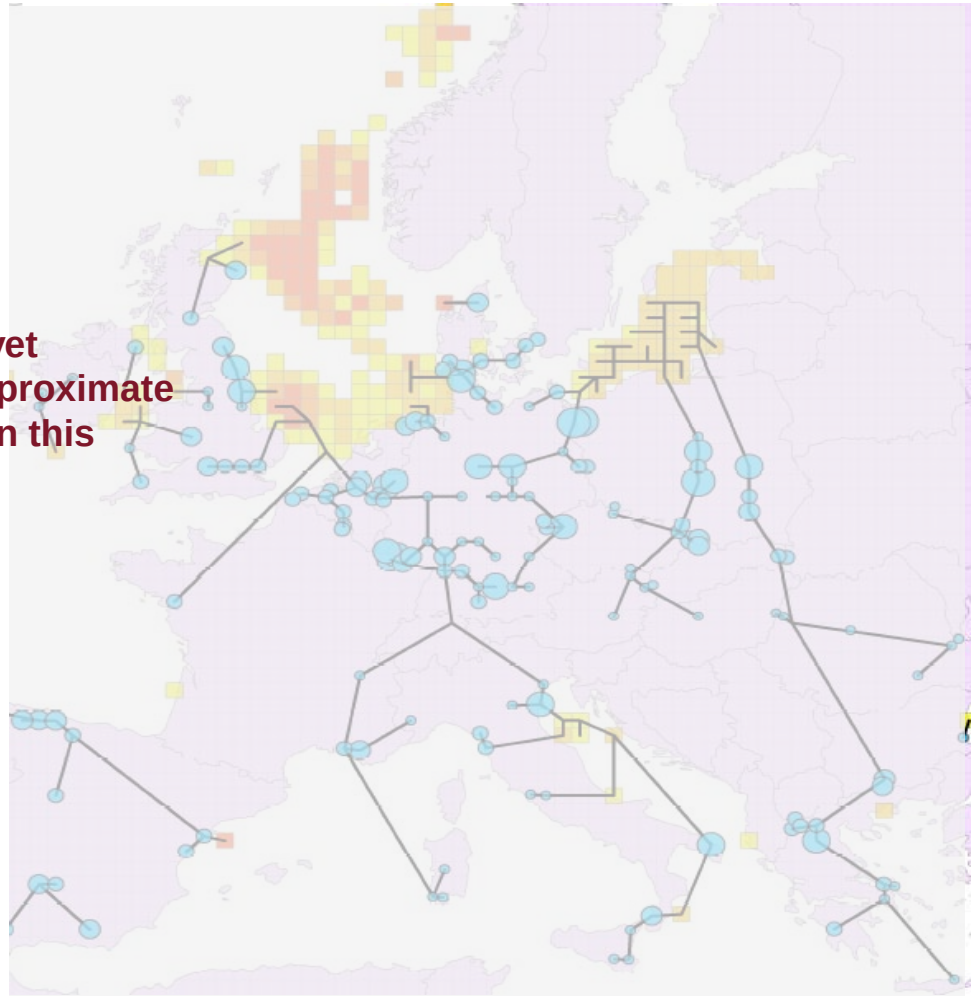


Illustration: Arup, EUC, DG ENER, Infrastructure study Oct 2010; High Scenario 2050

Key Conclusions

Early strategic planning of large-scale CO_2 transport infrastructure is vital to reduce costs

- Capital expenditure appears prohibitive and provides high risk – combining pipelines and ships can reduce risk
- Clustering plants to a transport network can achieve significant economies of scale – in both transport and storage
- Large-scale CCS requires the development of a transport system equivalent to the current hydrocarbon transport infrastructure
- Greatly reduced long-term costs can be ensured with early strategic planning

Acknowledgements – Working Group Participants

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