ECCO

Performing Case Studies with ECCOTool V1 Findings & Experiences

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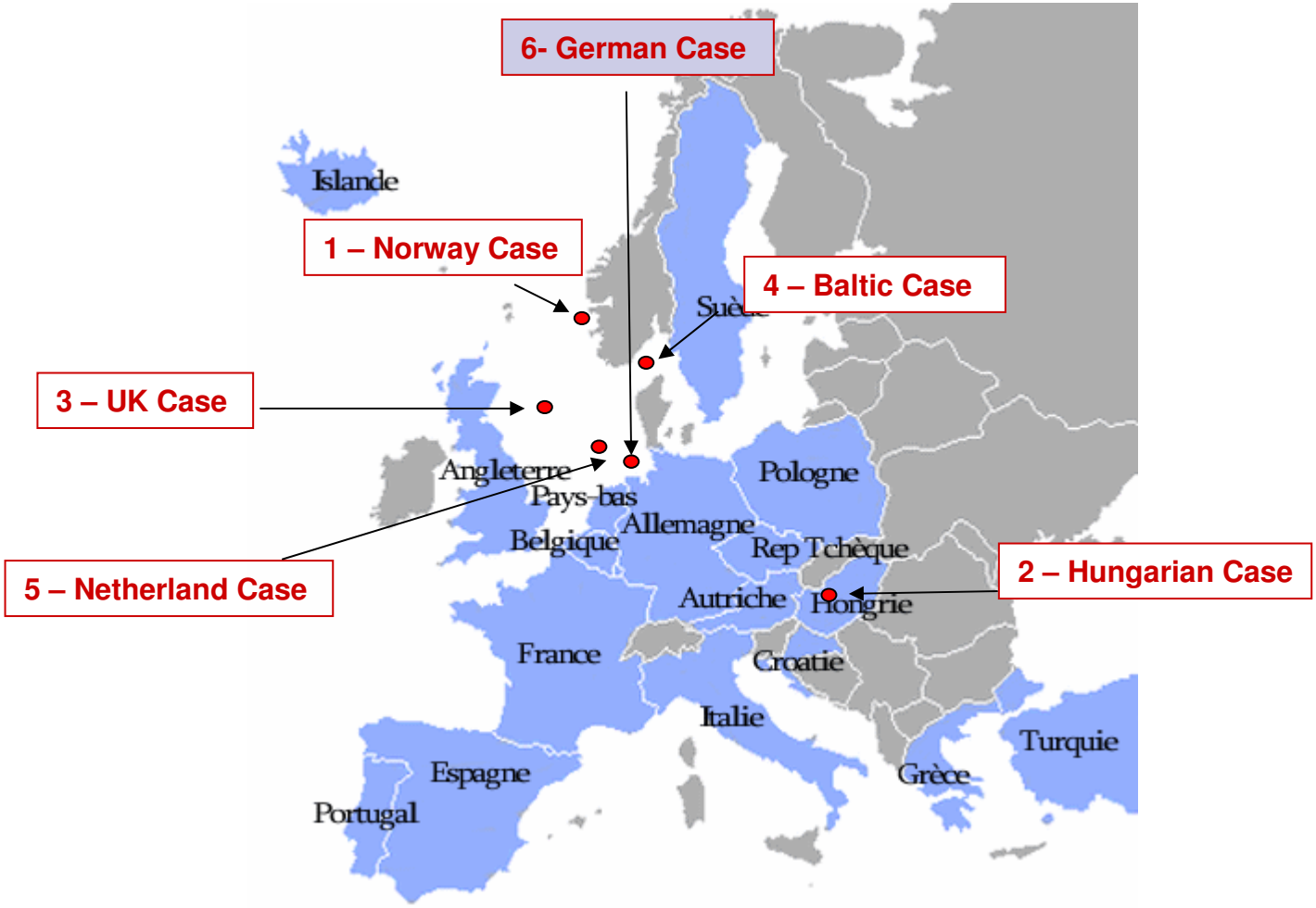
Structure of Presentation

- The Six Case Studies and their specificities
- Rules of case study implementation
- Features & Drawbacks of ECCOTool-V1
- Benefits of ECCOTool-V1

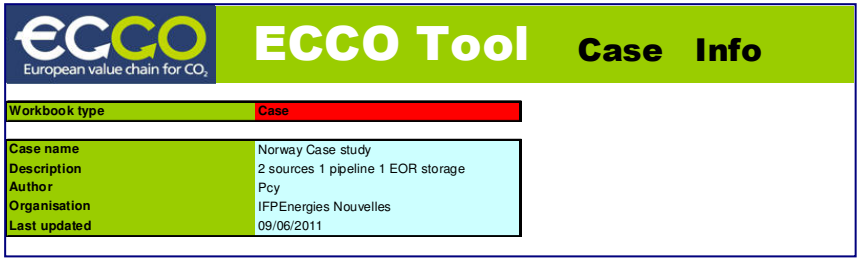
The Six Case Studies and their specificities



ECCOTool-V1
Input Data Required

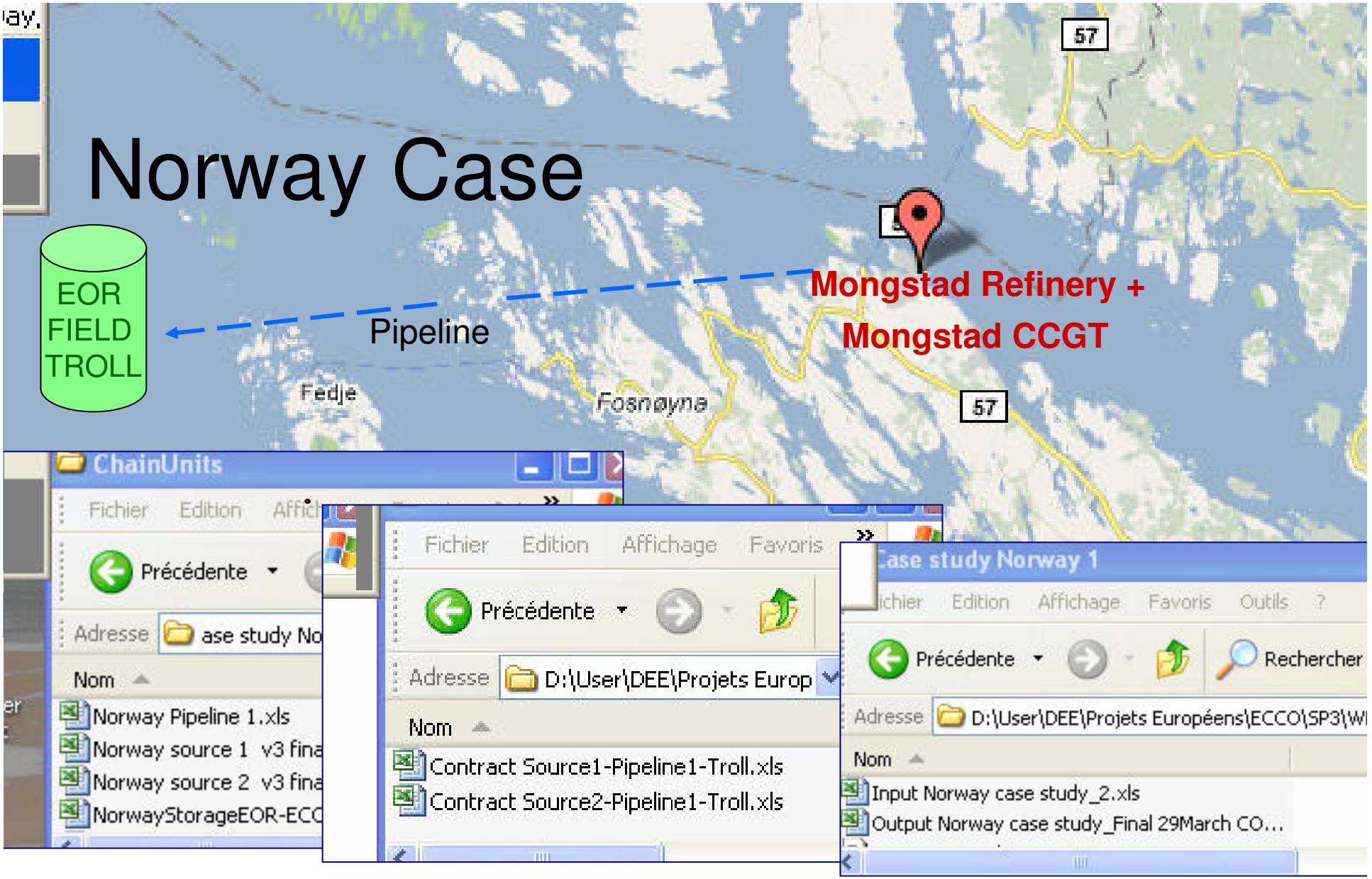
1. Unit Modules
   - Source Module
     - Power plant, refinery, cement...
   - Transport Modules
     - pipeline route
     - shipping route
   - Storage Modules
     - EOR
     - DGF/EGF
     - Aquifer

2. Contract files
   - for each actors
   - for each stream of CO2
   - to each storages



- input data file of the case
  - Economic scenario
  - CO2 transport price
  - Connection to unit files
  - Connection to contract files
  - Network grid implemented

Norway Case


EOR
FIELD
TROLL
Pipeline
Mongstad Refinery +
Mongstad CCGT
57
57
Fedje
Fosnøyne
ChainUnits
Fichier Edition
Précédente
Adresse
Nom
Norway Pipeline 1.xls
Norway source 1 v3 fina
Norway source 2 v3 fina
NorwayStorageEOR-ECC
Fichier Edition Affichage Favoris
Précédente
Adresse D:\User\DEE\Projets Europ
Nom
Contract Source1-Pipeline1-Troll.xls
Contract Source2-Pipeline1-Troll.xls
Case study Norway 1
Edition Affichage Favoris Outils
Précédente
Rechercher
Adresse D:\User\DEE\Projets Européens\ECCO\SP3\W
Nom
Input Norway case study_2.xls
Output Norway case study_Final 29March CO...

Source Module Data — Mongstad CCGT

Module Type
CCGT Post-CC

Source Type
Full Plant

Fuel Type	CV %
Low-Sulphur Coal	
High-Sulphur Coal	
Lignite	
Natural Gas	100%
Petcoke	
User-defined	

Operation
Baseload (24hrs)

Plant Parameters	Units	Values Default	Values User
Power Gross Capacity	MW	520	435
Power Net Output	MW	403	
Total CO2 Production	Mt/a	1,338	
CO2 Capture rate	%	90%	
CO2 Output Pressure	bar	100	
CO2 Output Temperature	?C	51	
Normal Availability	%	92,0%	
Net Elec Efficiency of plant	%	43,7%	
Employment FTE	No.	0	
Temp employment FTE	No.	0	

Derived Values	Units	Value
Captured CO2	Mt/a	1,204
Emitted CO2	Mt/a	0,134
Additional Compression	bar	0

Full Plant Costings	Units	Values (2010 basis) Default	Values (2010 basis) User
Fuel Handling / Utilities	€m	85	
Boiler / HRSG	€m	30	
Turbines & Generator	€m	51	
Flue Gas Cleansing	€m	169	
CO2 Removal & Compression	€m	66	
	€m	0	
	€m	0	
TOTAL Capex	€m	402	**402**
Fixed Opex	€m/a	5,7	
Variable Opex (excl fuel)	€m/GWh	0,0020	

Timing	Units	Default	User
Construction period	years	3	
Operation start year	year		2018
End Year	year		

Location (Deg 3dp)

GIS East	GIS North
5,00	60,83

Name of module

Mongstad CCGT

Escalation used	Index	NaturalGas

Operational Regime	Units	Default
Average Hours per day	hrs	24
Electricity Price factor		1,00

Indexation to be applied	Default	User
	RPI	
	RPI	
	RPI	

Norway Pipeline 1

from Mongstad

to Troll

Pipeline Type	
Mild steel	100%
Stainless steel	

Terrain	% of total length	
	Default	User
Onshore - Flat rural		
Onshore - Urban		
Onshore - Hills		
Onshore - Mountains		
Onshore - average	5%	
Offshore - Sandy seabed		
Offshore -Trenched		
Offshore - Difficult		
Offshore - Average	95%	
TOTAL	**100%**	**0%**

Crossings	Number	
	Default	User
Onshore - Road	0	
Onshore - Pipeline	0	
Onshore - Other	0	
Offshore - Pipeline	0	
Offshore - Other	0	

Remote Control	Number	
	Default	User
Umbilical	0	

Pipeline Parameters	Values		
	Units	Default	User
Design Maximum Pressure	bar	190	
Design Maximum Flow rate	Mt/a	5	3
Design Min Safe Output Pressure	bar	80	
Ambient Temperature	?C	4	
Leakage	%	0%	
Construction Employment FTE	No.	2	
Permanent Employment FTE	No.	0	

Derived Values	Units	Value	User
Pipeline length	km	78	
Pipeline Diameter	mm	305	
Pipeline wall thickness	mm	12	
Design Pressure Drop (Max)	bar	40	
Additional Compression	bar	0	

Warning - High Pressure Loss

Hoop Stress OK

Costings	Values (2010 basis)			Index		Cost summary
	Units	Default	User	Default	User	
Materials - steel pipe only	€m /km	0,04		RPI		Pipeline capital cost (base
Labour	€m /km	0,06		RPI		
Other costs for all pipelines	€m /km	0,05		RPI		Pipeline capital cost (scale
Offshore						
Platform tie in	€m	48,0		EAndPCosts		Opex cost fixed
Shallow Installation	€m /km	0,35		EAndPCosts		Opex cost variable
Heavy Lift	€m /km	0,02		EAndPCosts		
Dredging	€m /km	0,02		EAndPCosts		
Marine Survey	€m /km	0,02		EAndPCosts		
Transportation	€m /km	0,02		EAndPCosts		
Umbilicals	€m /km	0,06		EAndPCosts		
Trenching to beach	€m	22,0		EAndPCosts		
Materials - coating/concrete	€m /km	0,17		RPI		

Timing	Units	Default	User
Construction duration	years	3	
Operational	year		2018
Cease operations	year		

Pipeline Name
Norway Pipeline 1

Location points (Deg 2dp)	
Start module	
Mongstad	
5,00	60,83
End module	
Troll	
3,60	60,67

ECCOtool StorageEOR Scalar input variables

Royalty and fiscal parameters	Unit	Value
Royalty rate as fraction of HC sales		
Royalty tax deductible?		
Tax rate		
Tax depreciation method		
Tax number of depreciation years		

Prices and indices
CO2 quota charged model
Crude oil sales price (FOB) model
Crude oil sales price (FOB) - if consta
Gas sales (wellhead) price model
Gas sales (wellhead) price - if constar
Heating value gas: equiv scf gas/bbl o
Time delay of correlation
Capex cost index model
Opex cost index model

Business economic data
First year of time series input
Stop criterion: #yrs@NCF<0

Well and field related costs	Unit	Value

Subsurface	Unit	Value
conceptual sector	ST Mm3	600
)	rm3/STm3	1,4767
	rm3/sm3	0,0028
	rm3/STm3	1,0315
d high Rs values)	sm3/STm3	103
C and 317 bar/res m	t/rm3	0,67
nceptual model)	1	19,2%
tual model)	1	19,0%

	Unit	Value
	y	6
	well/y	4
	well/y	4
	slot/cluster	7
	well	1
	well	5
	well	10
	well	20
	cluster	1
	1	1
	t/d/well	1500
	sm3/d/well	1200

	Unit	Value
	1	90,0%
	1	16,7%
	1	5,0%
l gas	1	0,95

ECCOtool StorageEOR Tabular input variabl

This worksheet lists the reservoir performance of "typical" CO2-EOR reservoirs under various controllable and non-controlla

The reservoir's recovery mechanism is assumed to be steady-state injection/production of either CO2 or CO2&water. Hence, net Underground Withdrawal should be zero.

Input data are derived from reservoir simulation studies, with a characteristic trend for each reservoir-type / PDO combination. Later, a library of type curves will be made available. The user can then ea

Legend

	Input variable (deterministic)
	Output: calculated result

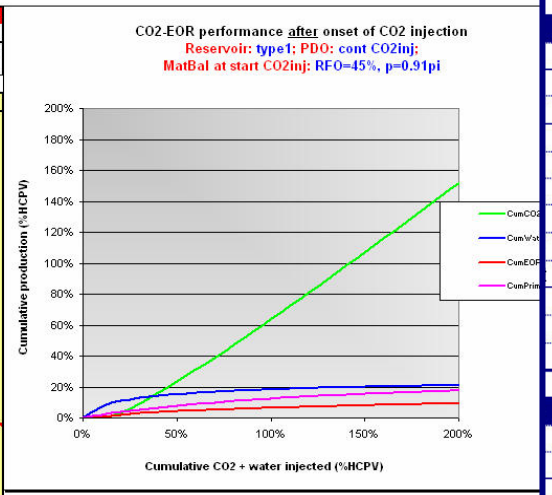
Conversion factors	
SG CO2 Normal [1 atm, 0 C] (kg/m3)	1,9768
SG CO2 Standard [1 atm, 15 C] (kg/m3)	1,8718

decline per step
0,95

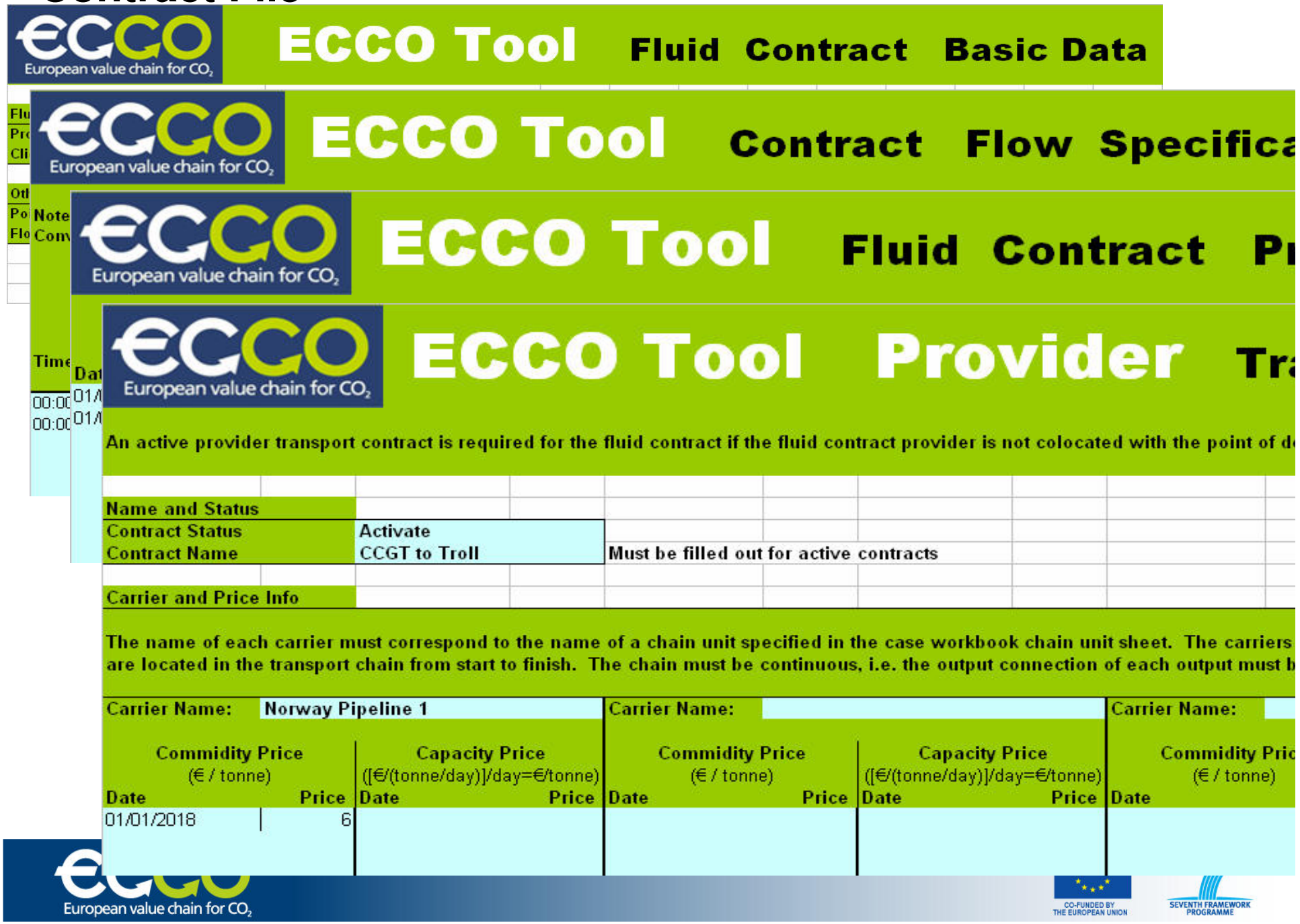
Characteristic CO2-EOR behaviour See comment

for ResType1@PDO1 | MBcond1 at start CO2inj

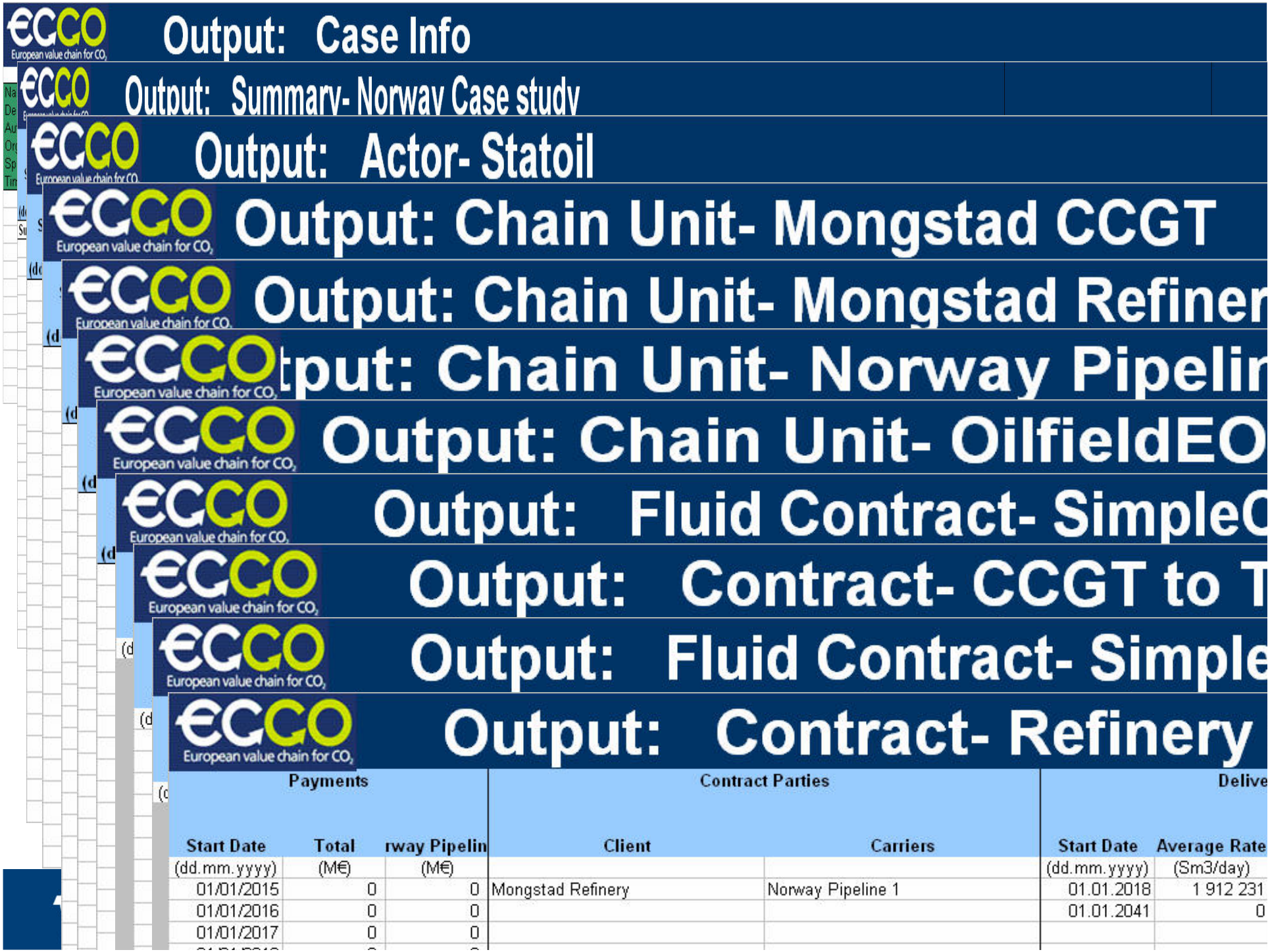
CumCO2Inj	CumWatInj	CumCO2 + WatInj	CumPrimOR	CumEOR	CumWatProd	CumCO2Prod
(HCPV)	(HCPV)	(HCPV)	(HCPV)	(HCPV)	(HCPV)	(HCPV)
0,0%	0,0%	0,0%	0,00%	0,00%	0,00%	0,00%
5,0%	0,0%	5,0%	1,12%	0,00%	3,83%	0,03%
10,0%	0,0%	10,0%	2,13%	0,40%	7,42%	0,09%
15,0%	0,0%	15,0%	3,04%	1,38%	9,62%	1,16%
20,0%	0,0%	20,0%	3,87%	2,20%	11,04%	3,39%
25,0%	0,0%	25,0%	4,63%	2,78%	12,11%	6,21%
30,0%	0,0%	30,0%	5,34%	3,20%	12,96%	9,38%
35,0%	0,0%	35,0%	6,01%	3,54%	13,67%	12,77%
40,0%	0,0%	40,0%	6,64%	3,83%	14,29%	16,31%
45,0%	0,0%	45,0%	7,24%	4,10%	14,85%	19,93%
50,0%	0,0%	50,0%	7,81%	4,35%	15,35%	23,61%
55,0%	0,0%	55,0%	8,37%	4,60%	15,80%	27,35%
60,0%	0,0%	60,0%	8,90%	4,83%	16,20%	31,15%
65,0%	0,0%	65,0%	9,41%	5,06%	16,56%	35,01%
70,0%	0,0%	70,0%	9,91%	5,29%	16,89%	38,94%
75,0%	0,0%	75,0%	10,38%	5,51%	17,19%	42,92%
80,0%	0,0%	80,0%	10,84%	5,72%	17,47%	46,97%
85,0%	0,0%	85,0%	11,27%	5,93%	17,74%	51,05%
90,0%	0,0%	90,0%	11,68%	6,13%	17,99%	55,17%
95,0%	0,0%	95,0%	12,08%	6,32%	18,23%	59,32%
100,0%	0,0%	100,0%	12,46%	6,51%	18,46%	63,50%
105,0%	0,0%	105,0%	12,82%	6,69%	18,67%	67,71%
110,0%	0,0%	110,0%	13,16%	6,87%	18,87%	71,95%
115,0%	0,0%	115,0%	13,49%	7,04%	19,05%	76,23%
120,0%	0,0%	120,0%	13,81%	7,21%	19,22%	80,55%
125,0%	0,0%	125,0%	14,12%	7,37%	19,38%	84,88%
130,0%	0,0%	130,0%	14,41%	7,53%	19,53%	89,24%
135,0%	0,0%	135,0%	14,69%	7,69%	19,67%	93,63%
140,0%	0,0%	140,0%	14,96%	7,84%	19,80%	98,03%
145,0%	0,0%	145,0%	15,23%	7,99%	19,93%	102,46%
150,0%	0,0%	150,0%	15,48%	8,14%	20,06%	106,90%
155,0%	0,0%	155,0%	15,73%	8,28%	20,18%	111,35%
160,0%	0,0%	160,0%	15,96%	8,42%	20,30%	115,83%
165,0%	0,0%	165,0%	16,19%	8,55%	20,42%	120,33%
170,0%	0,0%	170,0%	16,42%	8,68%	20,53%	124,84%
175,0%	0,0%	175,0%	16,63%	8,81%	20,64%	129,37%
180,0%	0,0%	180,0%	16,84%	8,94%	20,74%	133,92%
185,0%	0,0%	185,0%	17,04%	9,06%	20,84%	138,49%
190,0%	0,0%	190,0%	17,24%	9,18%	20,94%	143,07%
194,9%	0,0%	195,0%	17,54%	9,34%	21,10%	147,31%
199,9%	0,0%	200,0%	17,77%	9,48%	21,21%	151,79%



Contract File




ECCO Tool Case Info
ECCO Tool Case Basic Data
ECCO Tool Chain Unit Data Files
ECCO Tool Contract Data Fil
ECCO Tool Ac
ECCO Tool Ownership of Chai
ECCO Tool Case Conn
ECCO Tool Case Net
European value chain for CO2
Fill in "Connections" and "Ownership of Chain Units" sheets first!
Chain Unit Name: name as specified in workbook defining the Chain Unit
In/Out: This field is only relevant for transport units
Chain Unit Name
In/Out
Connection Name
Comments/Description
Mongstad CCGT
In/Out
PowerPlant
Mongstad Refinery
In/Out
PowerPlant
Norway Pipeline 1
In
PowerPlant
Norway Pipeline 1
Out
Storage
OilfieldEOR
In/Out
Storage



Payments			Contract Parties		Delive	
Start Date	Total	rway Pipelin	Client	Carriers	Start Date	Average Rate
(dd.mm.yyyy)	(M€)	(M€)			(dd.mm.yyyy)	(Sm3/day)
01/01/2015	0	0	Mongstad Refinery	Norway Pipeline 1	01.01.2018	1 912 231
01/01/2016	0	0			01.01.2041	0
01/01/2017	0	0				

Norway Case

Sources	Unit	Source 1 CCGT Post-CC	Source 2 Refinery Post-CC
Source Type		Full Plant	Add-on Capture Only
Fuel Type	CV%	Natural Gas 100%	Natural Gas 100%
Derived Values -Captured CO2 -Emitted CO2	Mt/a Mt/a	1.204 0.134	1.308 0.231
Full Plant Costings (values 2010 basis) -Capex -Fixed Opex -Variable Opex (excl fuel)	€m €m/a	402 5.7 0.0020 €m/GWh	462 37.0 5.0000 €m/Mt

Pipeline	Unit	Pipeline 1
Terrain onshore/offshore -Onshore average -Offshore average	% of total length	5 95
Pipeline Parameters -Design Max Pressure -Design Max Flow rate	 bar Mt/a	190 3
Derived Values -Pipeline length -Pipeline diameter -Design Pressure Drop (max)	 km mm bar	 78 305 40

Contracts	SimpleContract	SimpleContract2
Provider Client, point of delivery Total flow -tonne/day -Start Date -End Date	Mongstad CCGT OilfieldEOR 3296.4 2018 2040	Mongstad Refinery OilfieldEOR 3581.1 2018 2040

EOR	Unit	
Subsurface -STOIIP of North Sea (*) -Density CO2 at reservoir conditions (@101°C and 317 bar/res m3) -Average porosity (*) -Average Swi (*)	 ST M/m3 t/m3 1 1	 600 0.67 19.2% 19.0%

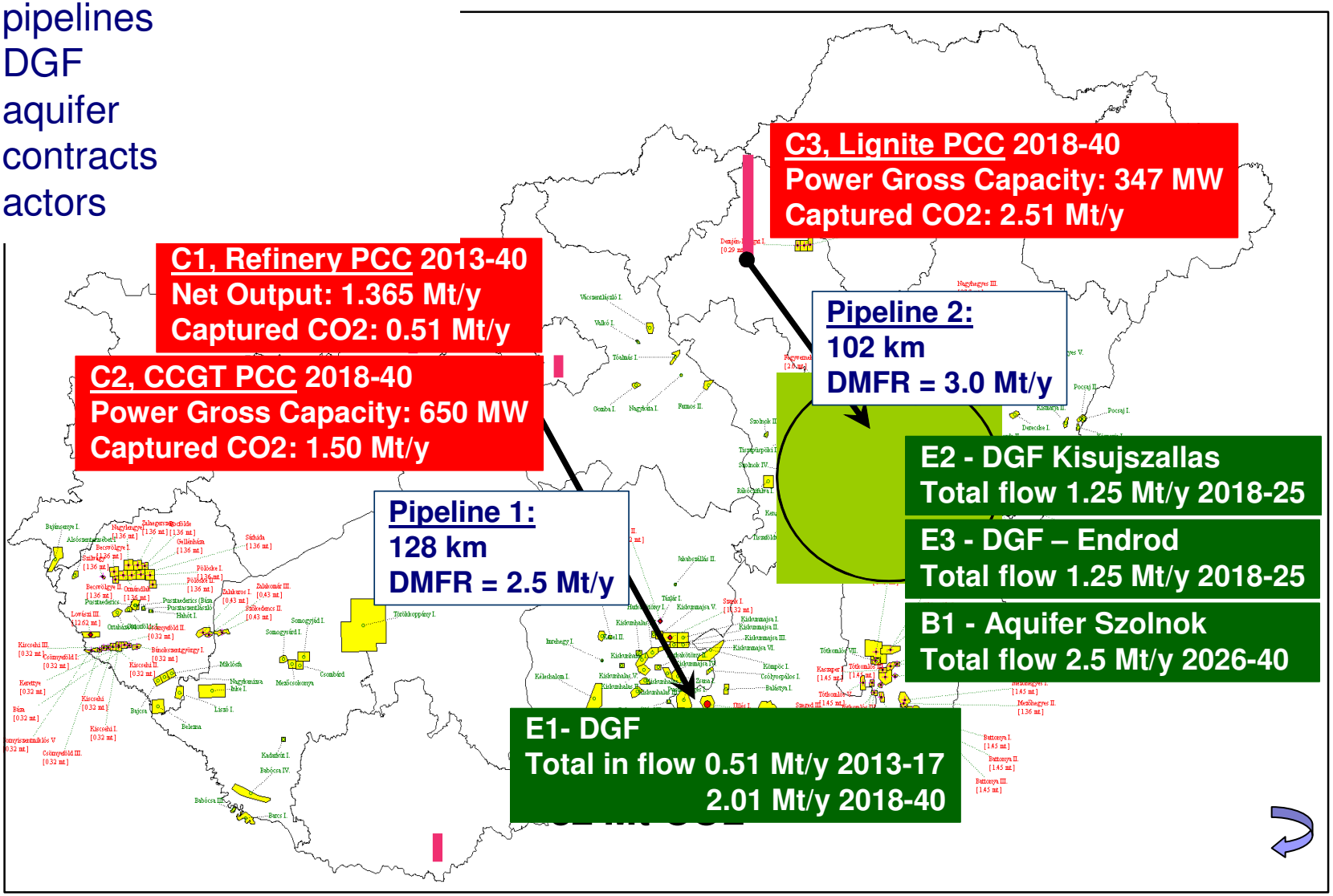
CO-FUNDED BY THE EUROPEAN UNION
SEVENTH FRAMEWORK PROGRAMME

Norway Case

Norway	Source 1 CCGT Post-CC Full Plant	Source 2 Refinery Post-CC	Global Norwegian case
Captured CO2 - Mt/a	1.204	1.308	
years	22	22	
CO2 captured 2018-40 - Mt	**27.7**	**30.1**	**57.8**
Emitted CO2 – Mt/a	0.134	1.308	
CO2 emitted 2018-40 - Mt	**3.1**	**5.3**	**8.4**

Hungary Case:

3 sources
2 pipelines
3 DGF
1 aquifer
5 contracts
2 actors



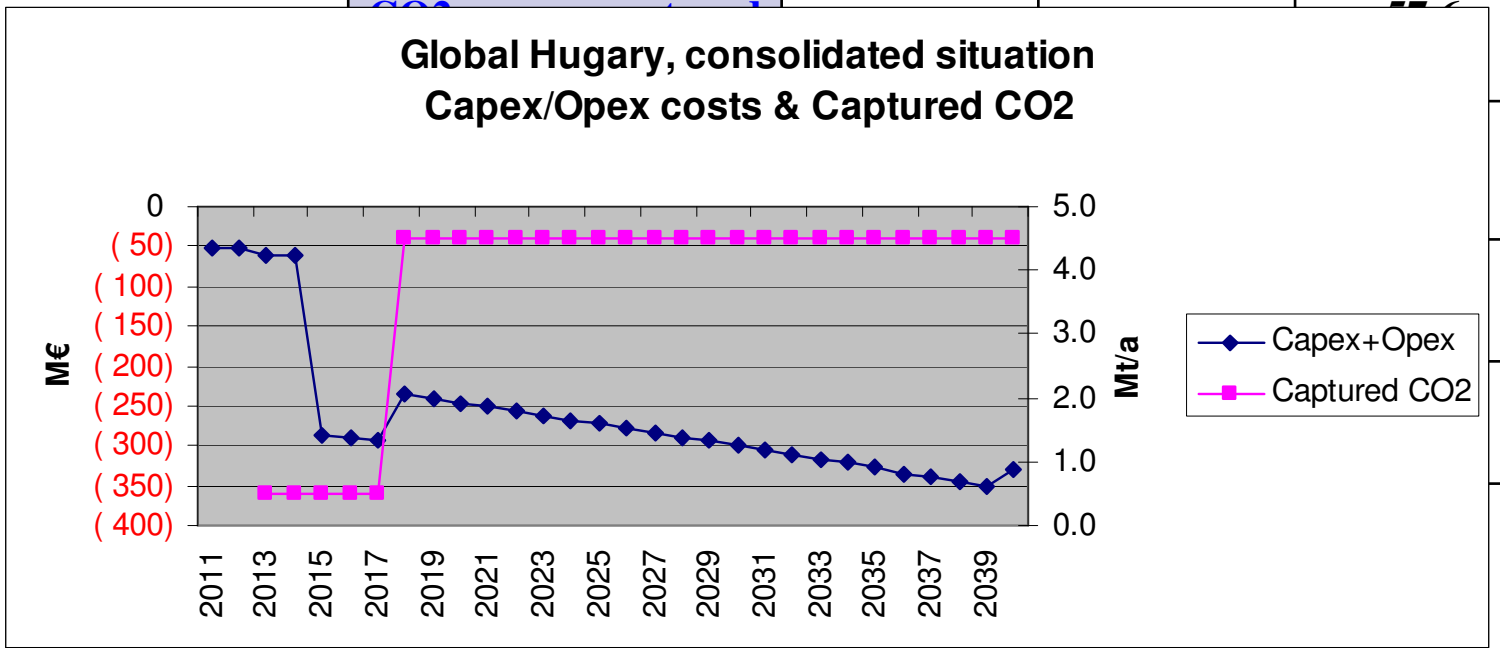
Hungary Case

Sources	Unit	Source 1 Refinery Post-CC	Source 2 CCGT Post-CC	Source 3 Lignite Post-CC
Source Type		Add-on Capture Only	Add-on Capture Only	Add-on Capture Only
Fuel Type	CV %	Natural Gas 100%	Natural Gas 100%	Lignite 100%
Plant Parameters -Net Output -Power Gross capacity -CO2 Capture rate	 Mt/a MW %	1.365 60	650 75	347 85
Derived Values -Captured CO2 -Emitted CO2	Mt/a Mt/a	0.51 0.34		

Pipelines	Unit	Pipeline 1	Pipeline 2
Terrain on-shore -Flat rural -Urban -Hills	 % of total length	 80 20 5	 85 5 5
Pipeline Parameters -Design Max Pressure -Design Max Flow rate	 bar Mt/a	 100 2.5	 120 3
Derived Values -Pipeline length -Pipeline diameter -Design Pressure Drop	 km mm bar	 128 457 10	 102 457 8

Hungary Case

	Source 1 Refinery Post-CC	Source 2 CCGT Post-CC	Source 3 Lignite Post-CC	Global Hungary case
Captured CO2 - Mt/a	0.514	1.499	2.506	
years	27	22	22	
				106
				31.3
				74

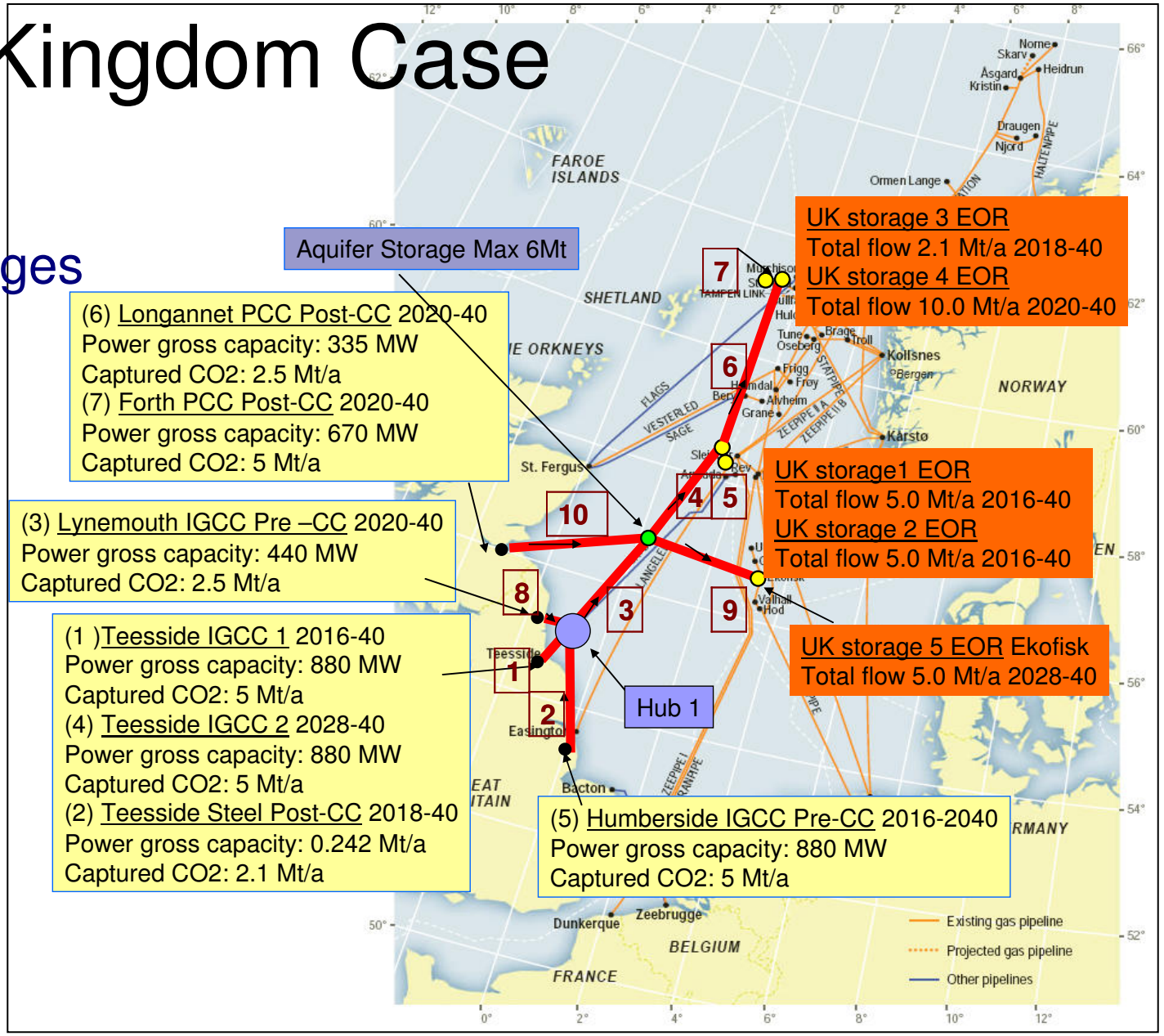


Capex+Opex : 7859 M€ , 2011-40

Hungary case study annual average captured cost indicator : 74 €/tCO2

United Kingdom Case

7 sources
10 pipelines
5 EOR Storages
1 aquifer
7 contracts
9 actors

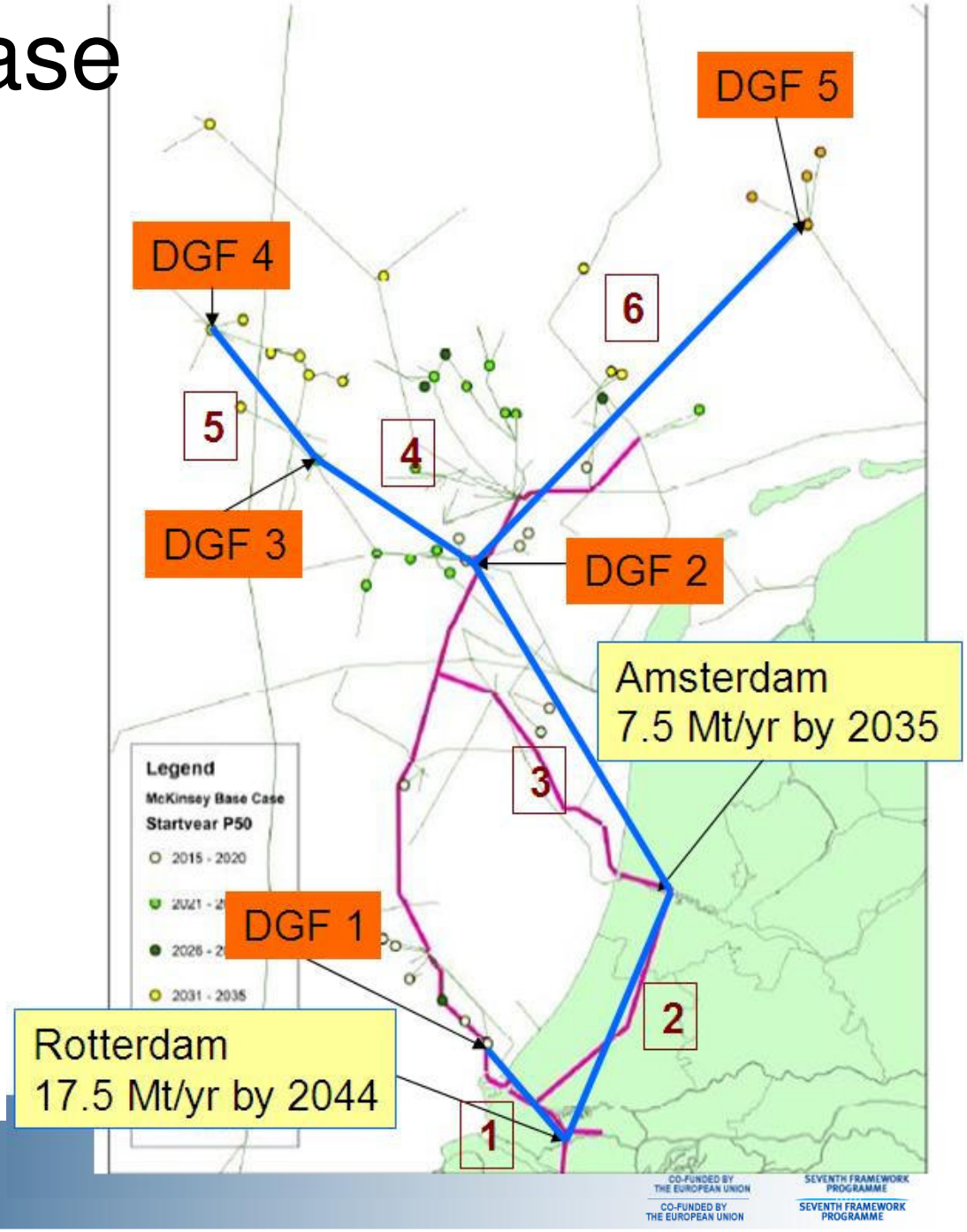


United Kingdom Case

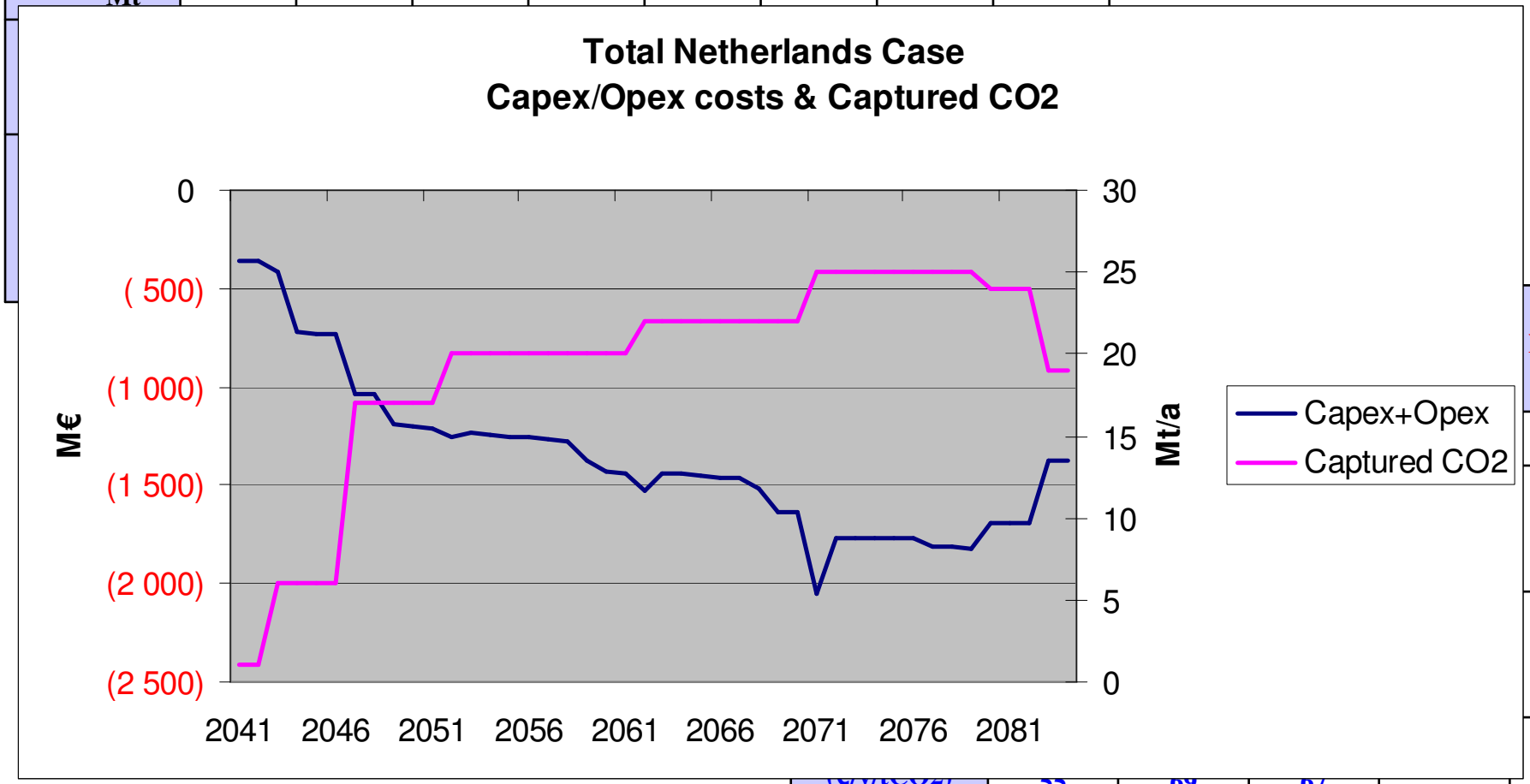
	Teesside IGCC1 Pre-CC Full Plant	Steel Teesside Post-CC	Lynemouth IGCC1 Pre-CC Full Plant	Teesside IGCC2 Pre-CC Full Plant	Humberside IGCC1 Pre-CC Full Plant	Longannet PCC	Forth PCC	**Global**
Captured CO2 - Mt/a	5.007	2.067	2.504	5.007	4.988	2.487	4.975	
years	25	23	21	13	25	21	21	**25**
CO2 captured 2016-40 - Mt	125.2	47.5	52.6	65.1	124.7	52.2	104.5	**571.8**
Emitted CO2 – Mt/a	0.556	0.365	0.278	0.556	0.554	0.276	0.276	
CO2 emitted 2016-40 - Mt	13.9	8.4	5.8	7.2	13.9	5.8	5.8	**60.8**

Netherlands Case

12 sources
6 pipelines
5 DGF
15 contracts
2 actors



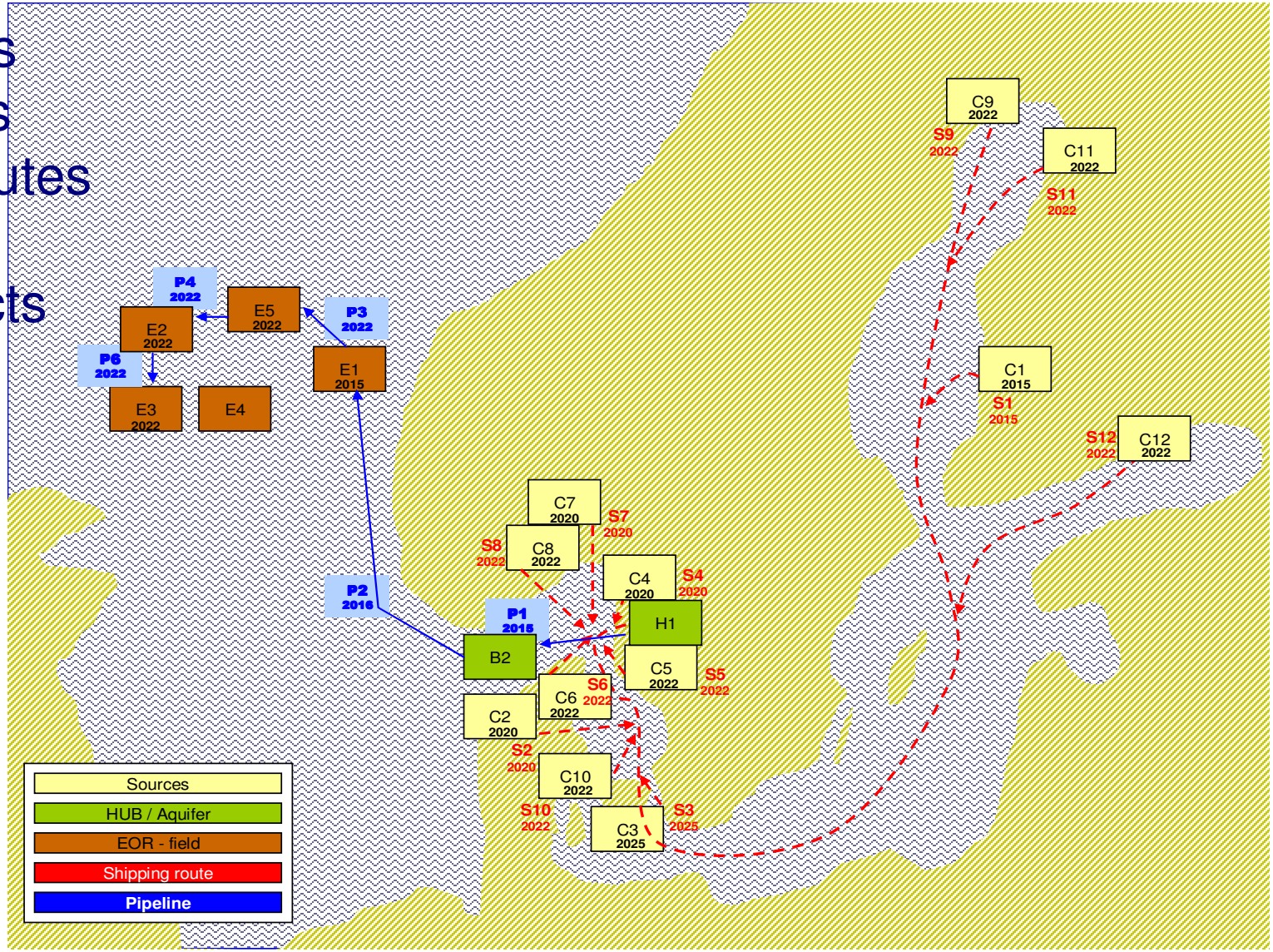
Netherlands case (1/2)	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Source 7	Source 8
years	40	40	40	40	40	40	40	40
CO2 captured - Mt	39	40	40	60	60	80	80	80



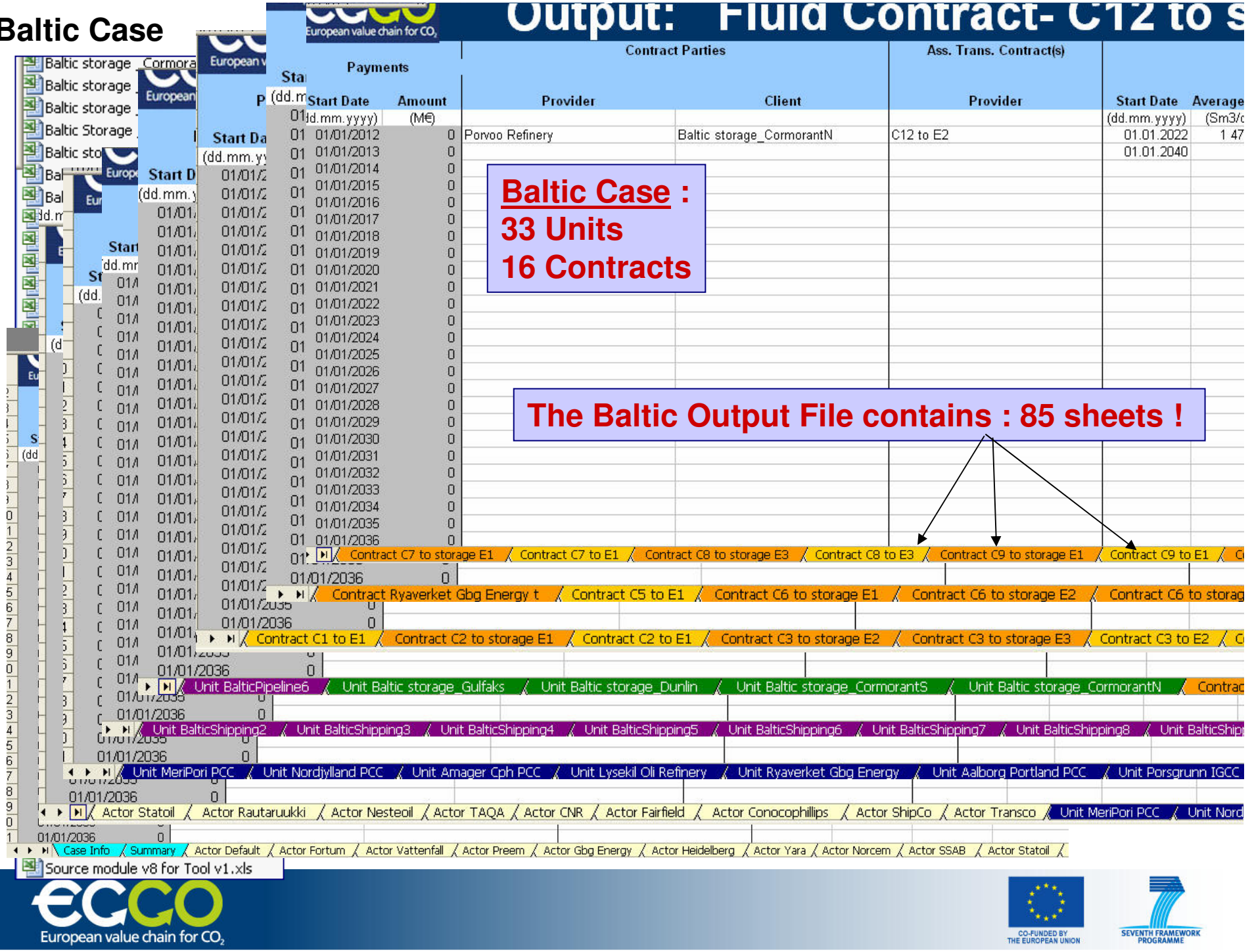
Global NL case
71
1027
13
75

Baltic Case

12 sources
5 pipelines
12 ship routes
5 EOR
16 contracts
15 actors

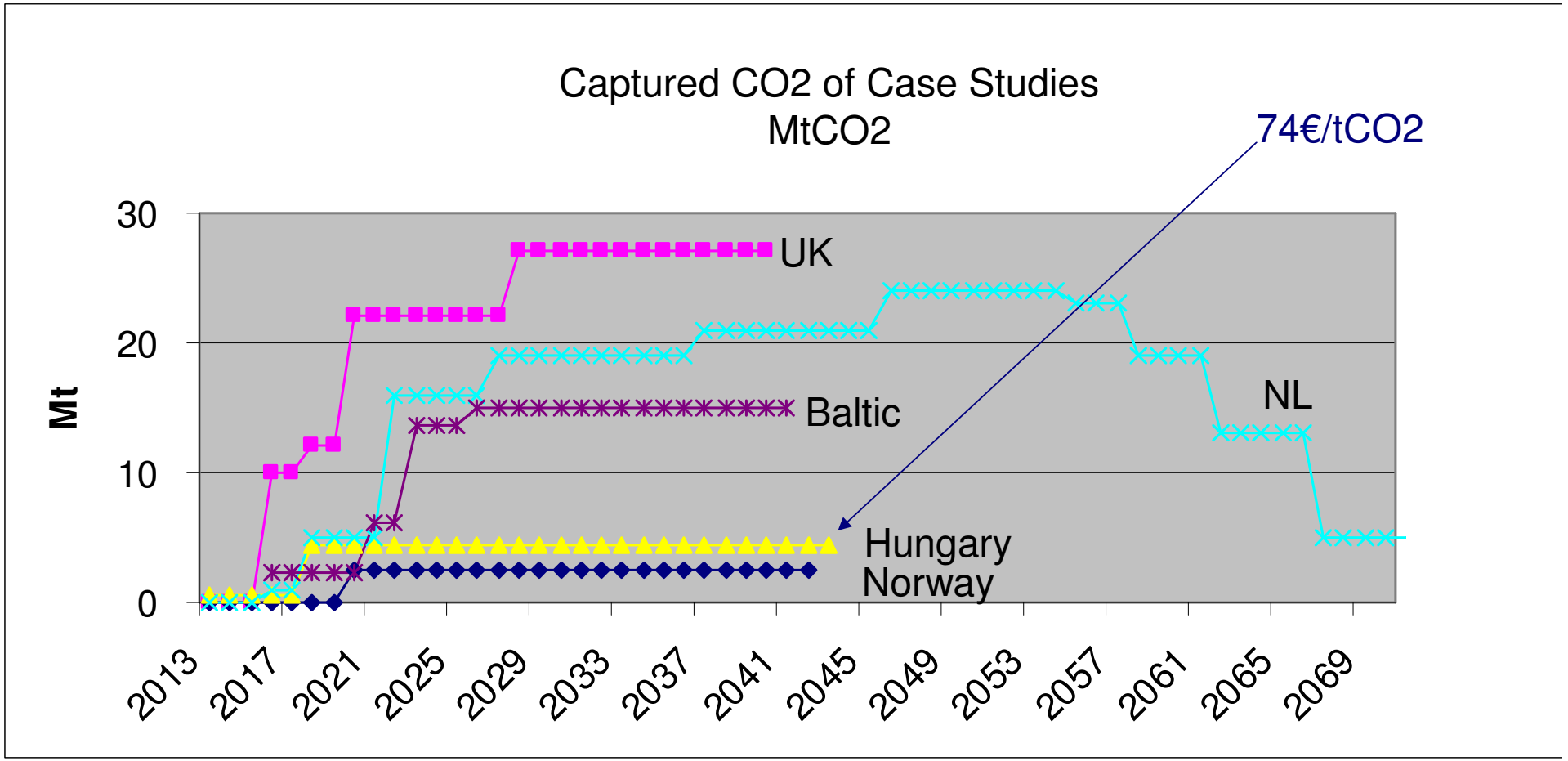


Baltic Case


Output: Fluid Contract- C12 to s
Contract Parties
Ass. Trans. Contract(s)
Payments
Start Date
Amount
Provider
Client
Provider
Start Date
Average
(dd.mm.yyyy)
(M€)
(dd.mm.yyyy)
(Sm3/
Porvoo Refinery
Baltic storage_CormorantN
C12 to E2
01.01.2022
1 47
01.01.2040
Baltic Case :
33 Units
16 Contracts
The Baltic Output File contains : 85 sheets !
Contract C7 to storage E1
Contract C7 to E1
Contract C8 to storage E3
Contract C8 to E3
Contract C9 to storage E1
Contract C9 to E1
Contract Ryaverket Gbg Energy t
Contract C5 to E1
Contract C6 to storage E1
Contract C6 to storage E2
Contract C6 to storag
Contract C1 to E1
Contract C2 to storage E1
Contract C2 to E1
Contract C3 to storage E2
Contract C3 to storage E3
Contract C3 to E2
Unit BalticPipeline6
Unit Baltic storage_Gulfaks
Unit Baltic storage_Dunlin
Unit Baltic storage_CormorantS
Unit Baltic storage_CormorantN
Unit BalticShipping2
Unit BalticShipping3
Unit BalticShipping4
Unit BalticShipping5
Unit BalticShipping6
Unit BalticShipping7
Unit BalticShipping8
Unit MeriPori PCC
Unit Nordjylland PCC
Unit Amager Cph PCC
Unit Lysekil Oli Refinery
Unit Ryaverket Gbg Energy
Unit Aalborg Portland PCC
Unit Porsgrunn IGCC
Actor Statoil
Actor Rautaruukki
Actor Nesteoil
Actor TAQA
Actor CNR
Actor Fairfield
Actor Conocophillips
Actor ShipCo
Actor Transco
Case Info
Summary
Actor Default
Actor Fortum
Actor Vattenfall
Actor Preem
Actor Gbg Energy
Actor Heidelberg
Actor Yara
Actor Norcem
Actor SSAB
Actor Statoil
Source module v8 for Tool v1.xls

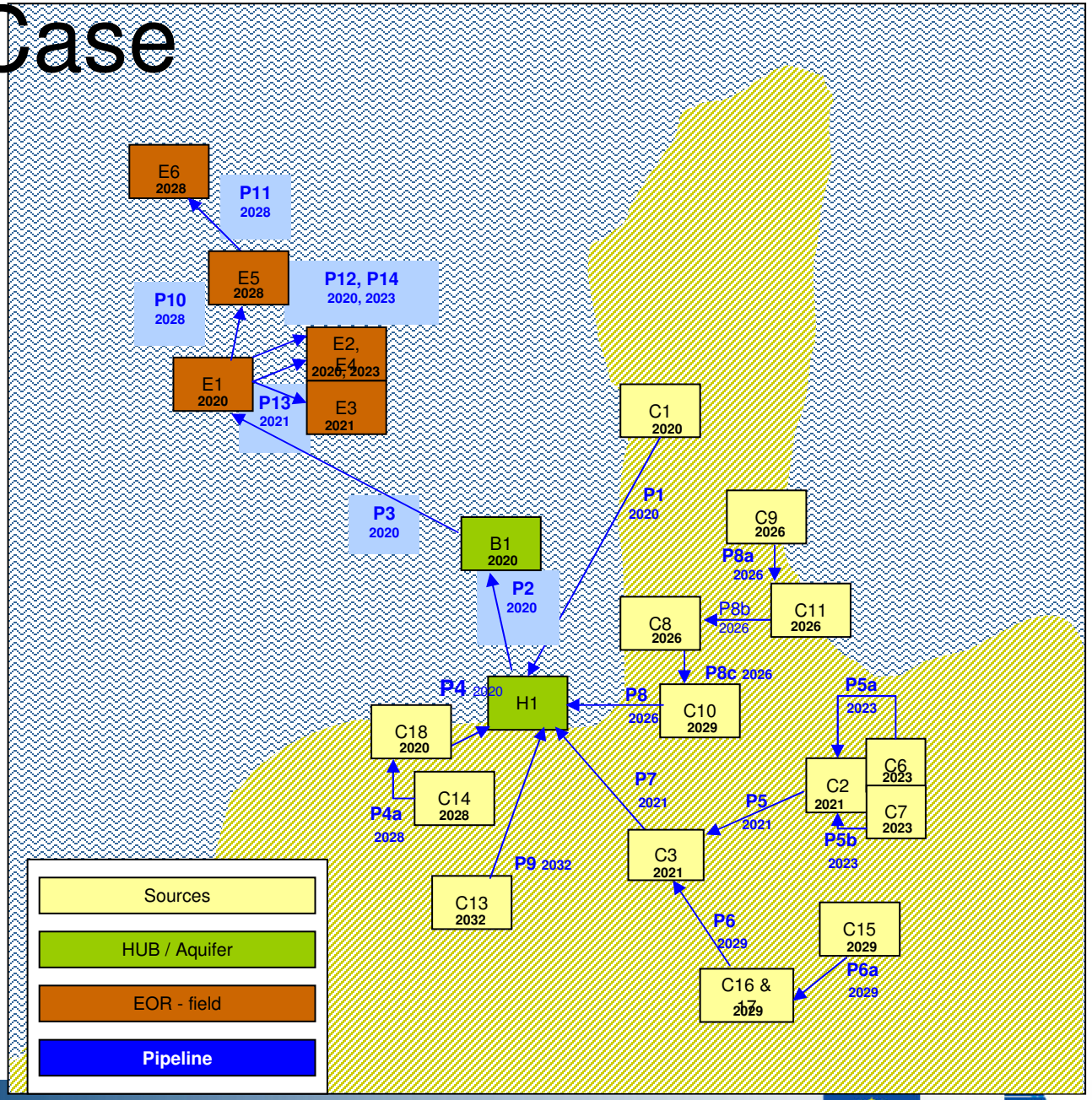
Baltic case (1/2)	Source 1 Coal PF Sub-C Post-CC Full Plant	Source 2 Coal PF Sub-C Post-CC	Source 3 Coal PF Sub-C Post-CC	Source 4 Refinery (H2) Post-CC Full Plant	Source 5 CCGT Post-CC	Source 6 Cement Post-CC	Source 7 IGCC Pre-CC Full Plant	Source 8 Cement Post-CC Full Plant
years	28	20	15	18	18	18	20	18
CO2 captured - Mt	**60.56**	**39.4**	**21.7**	**31.1**	**11.2**	**23.6**	**15.6**	**19.8**
CO2 emitted - Mt	74	4.4	2.4	4.2	1.2	4.18	1.7	3.5

Baltic case (2/2)	Source 9 Steel Post-CC Full Plant	Source 10 Refinery Post-CC Full Plant	Source 11 Steel Post-CC Full Plant	Source 12 Refinery Post-CC Full Plant	Global Baltic case
years	18	18	18	18	**28**
CO2 captured - Mt	**22.7**	**14.6**	**32.1**	**26.2**	**318.6**
CO2 emitted - Mt	**4**	**2.6**	**5.7**	**4.6**	**112.5**


Captured CO2 of Case Studies
MtCO2
74€/tCO2
Mt
30
20
10
0
UK
Baltic
NL
Hungary
Norway
2013
2017
2021
2025
2029
2033
2037
2041
2045
2049
2053
2057
2061
2065
2069

German Case

14 sources
21 pipelines
6 EOR
1 aquifer
18 contracts
18 actors



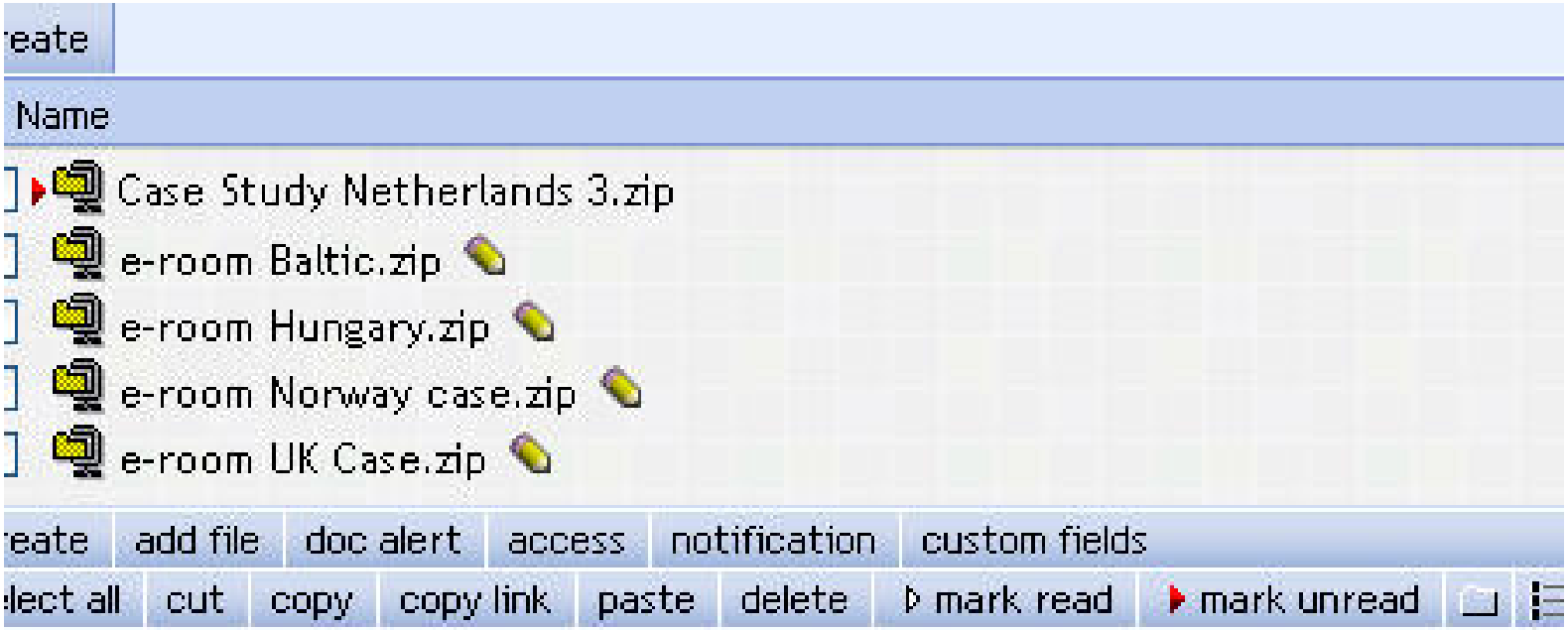
chain methodology and tool development

tudies VERSION 1 ECCOTool

inal version Case Studies VERSION 1 ECCOTool edit

older created by Paula Coussy on 3 mars 11

this folder the final version of the outputs with the version 1 of the ECCOTool



Features and Drawbacks of ECCOTool V1 – Input Data

- required to deal with multiple workbooks to build a case,
- same information (GIS positions, names) have to be filled in different workbooks for the same case,
- problematic definition of nodes in infrastructure,
- Contracts could be rationalized or included in the input file to have a much more friendly interface and easier contracts.
- Storage module :
  - probably the module which requires the most technical skill.
- lack of transparency for users of the economic scenario data used

Features and Drawbacks of ECCOTool V1- Output data

- bugs and result inconsistencies,
- Results output are insufficient. The user need to have much more detailed outputs per case studies. They should allow user to analyze case study
- lack of graphical presentation of the economics of the case,

Benefits of ECCOTool V1

- economic evaluation of :
  - the all chain of CCS, per actors, per units,
  - lots of intermediate values : DCF,energy consumption...
- the output file contains all the information of the case study
- easy to duplicate one module to another
- easy to copy the case and duplicate sensitivities
- A prototype working