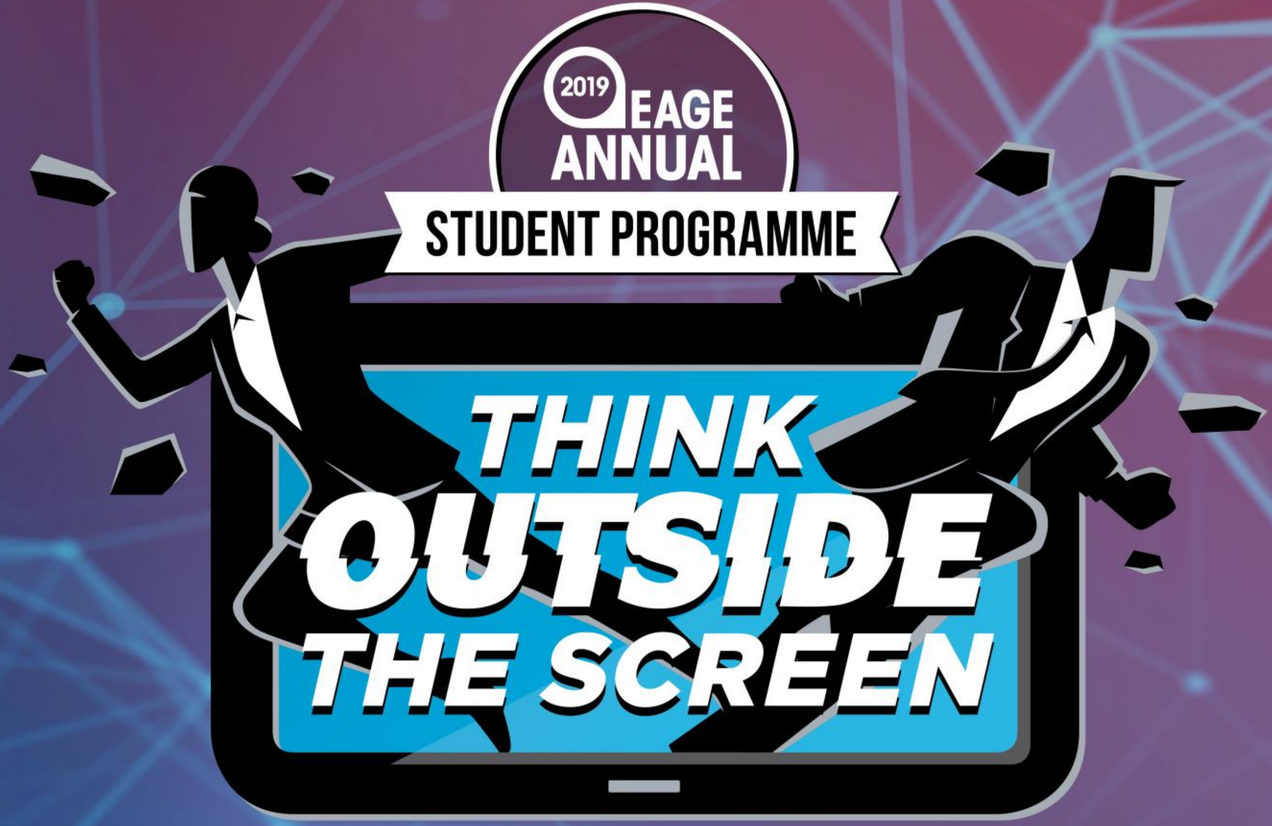
EAGE



Project Execution Plan for the Norne Oil Field

Presenters: Jennifer Lee, Ryan Taylor, Sarima Vahrenkamp

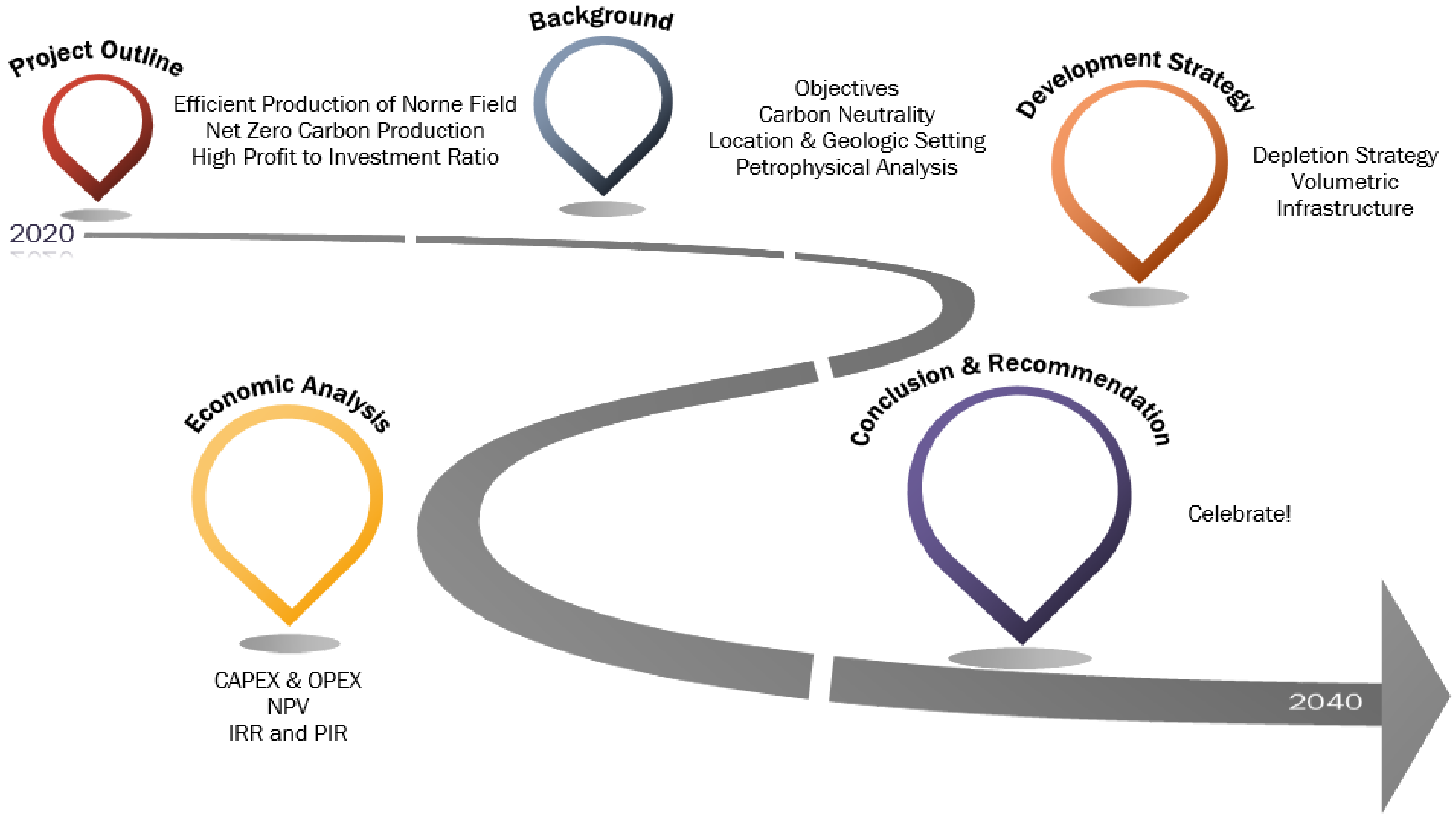
equinor TOTAL Schlumberger EAGE GREEN FUND

Executive Summary

- Located ~200km offshore in North Sea, water depth 380m
- Lower Jurassic Reservoir in horst block (2500m - 2700m below sea level)
- STOIIP ~1056 MBbls, GIIP ~408 BCF, EUR ~560 MBO with CO2 EOR
- Recommend Development with 16 producers and 14 injectors via FPSO
- CAPEX (USD) = $7.15 Billion, NPV10 (USD) = $ 6.94 Billion, DCFR ~30.5%

- Carbon neutrality achieved by CO2 EOR continued into CCS
- Simulated CO2 sequestered ~420 Mtonnes over 5 years
- Additional ~600 Mtonnes could be sequestered
- Recommend purchasing cement factory at Kjopsvik (~170M USD)
- CO2 transported via pipeline and compressed at well site (~2 Billion USD)
- Recommend considering using facility for commercial CCS

Outline



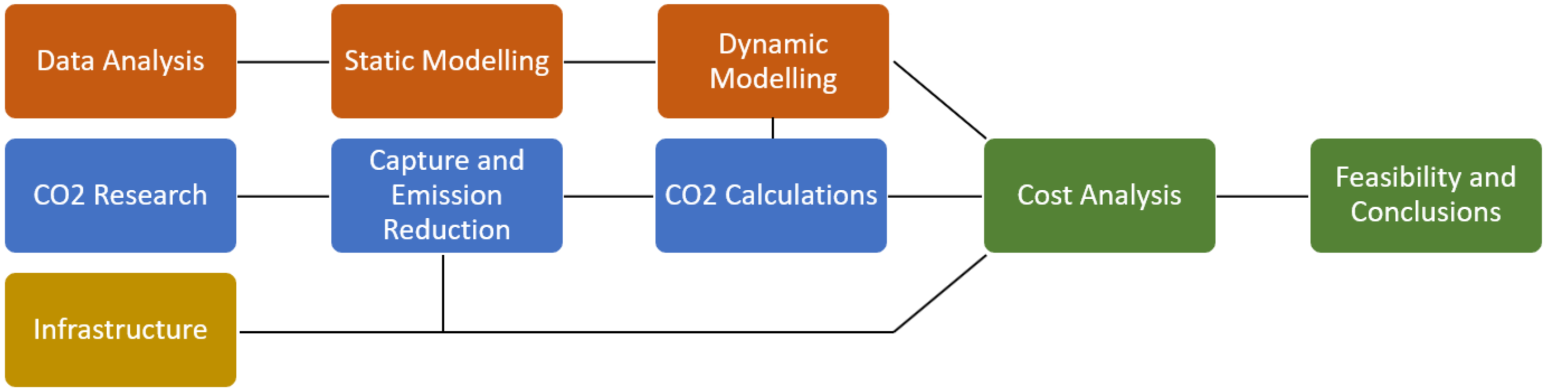
Project Outline
Efficient Production of Norne Field
Net Zero Carbon Production
High Profit to Investment Ratio
Background
Objectives
Carbon Neutrality
Location & Geologic Setting
Petrophysical Analysis
Development Strategy
Depletion Strategy
Volumetric
Infrastructure
Economic Analysis
CAPEX & OPEX
NPV
IRR and PIR
Conclusion & Recommendation
Celebrate!
2020
2040

Objectives

1) Maximize hydrocarbon production from the Norne Field

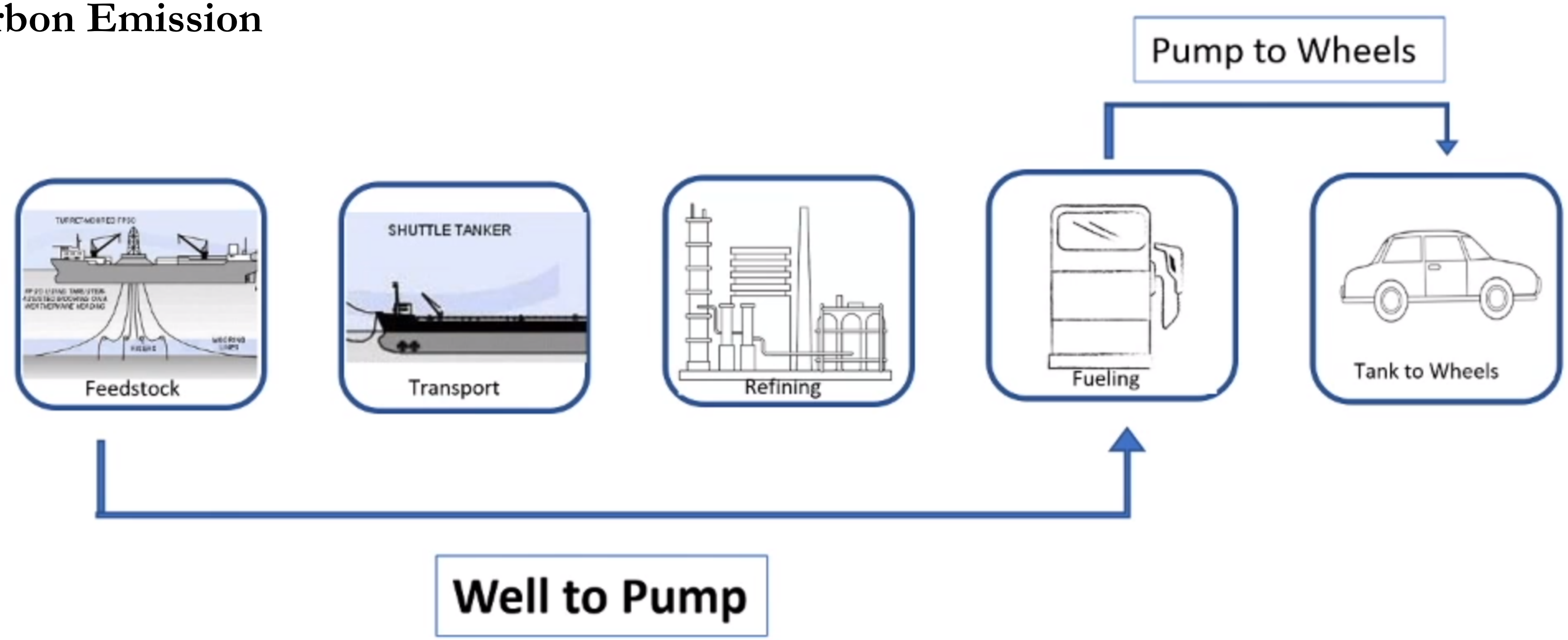
2) Achieve zero net emissions of CO2 during production and transport of hydrocarbons

3) Obtain a profitable production



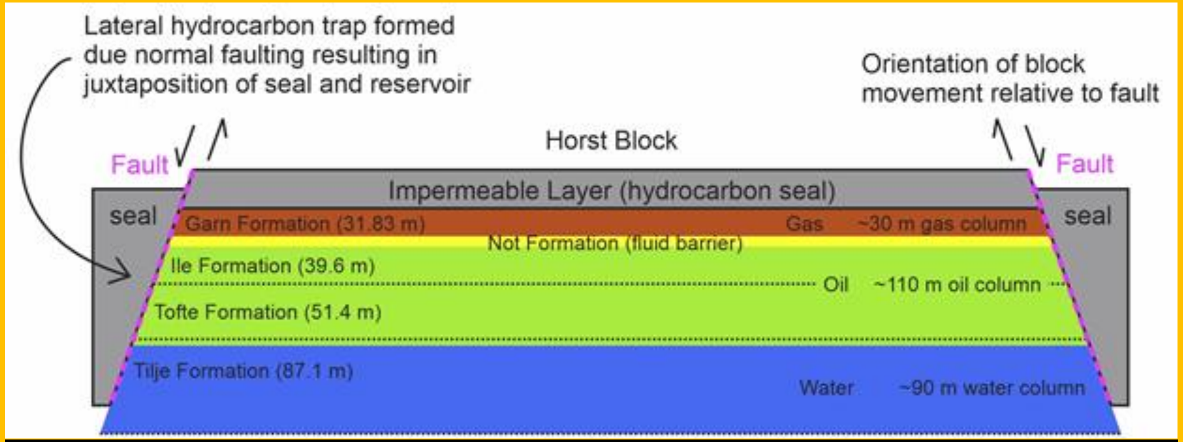
What is Carbon Neutrality?

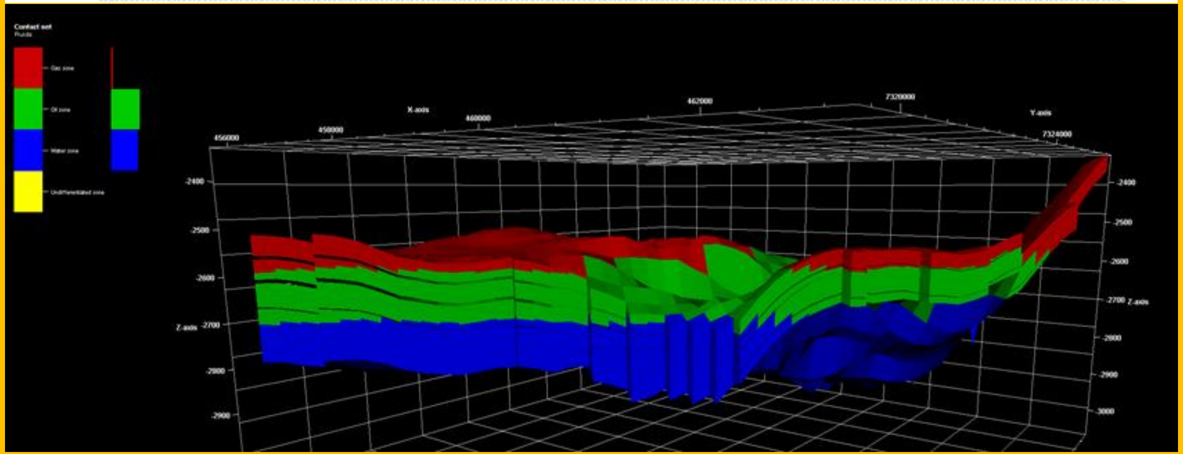
- **Well to Pump (What we will be doing)**
- **Pump to Wheels**
- **Zero Net Carbon Emission**



Background - Geologic Setting

- Lower and Middle Jurassic reservoirs
  - Properties populated from wells
- Low Relief Structure
- Hydrocarbons trapped in a horst structure
  - Structural framework from NTNU website
- Three-way structural fault closure and with a limited downdip aquifer
- Not Formation acts as a fluid barrier, separating oil bearing formations and the gas cap
- Also, barriers due to calcareous zones

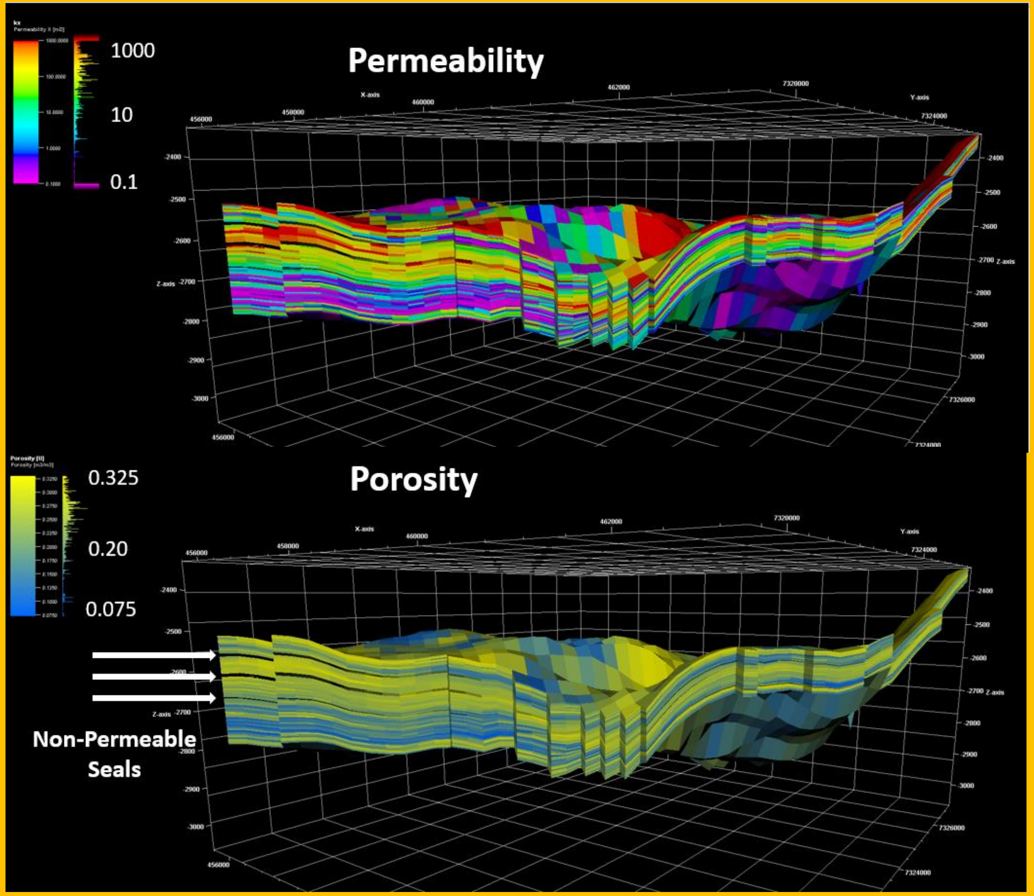




Petrophysical Analysis

Reservoir Properties:

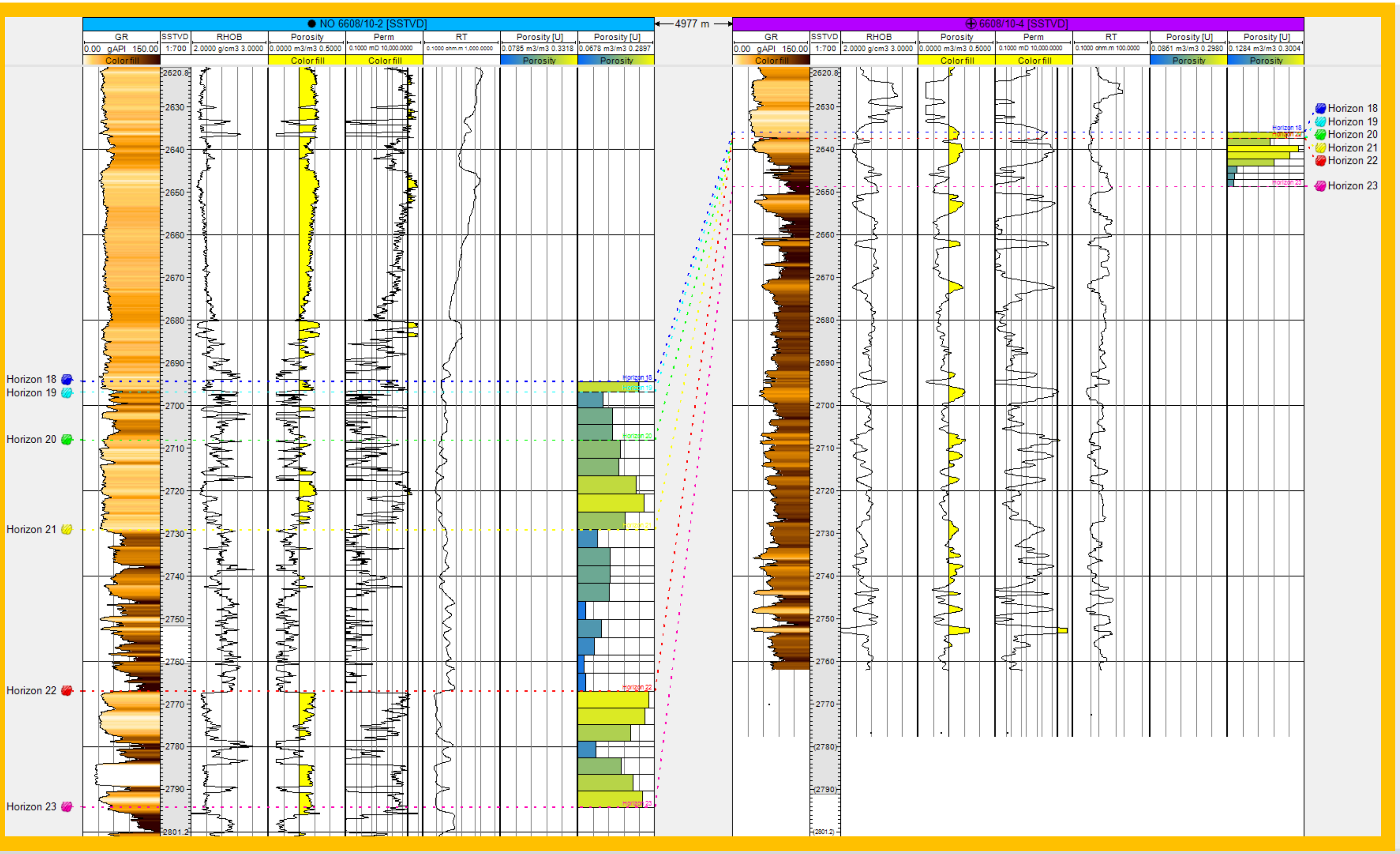
- Porosity ranging 7.5 - 32.5%, calculated from density logs
- Permeability ranging 0.1 - 1000 mD, calculated from porosities using K=pow(0.3516 + 21.69*Phi): (NTNU)
- Pressure of 273 bar and Temperature of 98 degrees Celsius at 2639m below sea level
- Oil Viscosity of 0.5 cP and Specific Gravity of 0.7
- Oil-Gas Ratio of 111 Sm^3/Sm^3



Petrophysics – Porosity Upscaling

Reservoir Properties:

- Porosity ranging 7.5 - 32.5%, calculated from density logs
- Permeability ranging 0.1 - 1000 mD, calculated from porosities using K=pow(0.3516 + 21.69*Phi): (NTNU)
- Data used to propagate porosity and permeability through the model



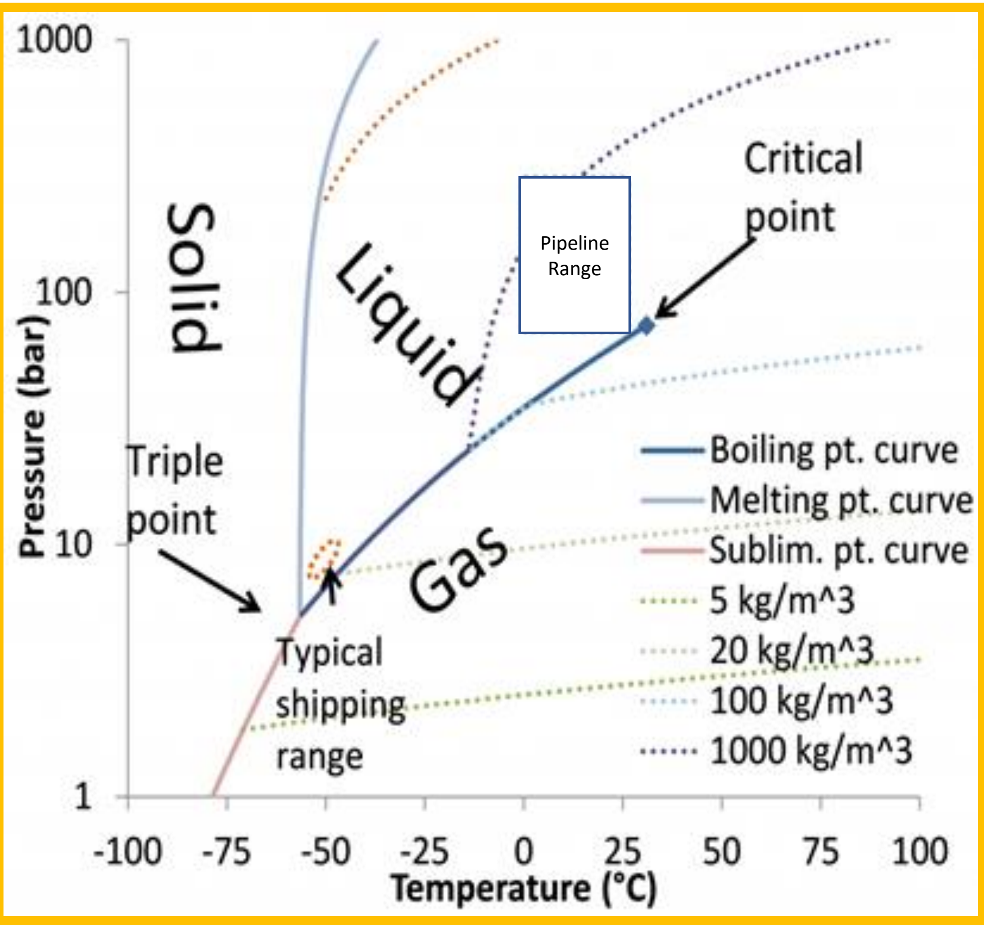
Properties of CO2

Super Critical Fluid state of CO2

- Density of Brine Water (approximately 0.615 g/cm3)
- Viscosity like Gas

CO2 EOR

- CO2 acts like a solvent
- Oil expands and flows easily to production wells



Development Strategy

Case 1

Carbon Credit Purchase (No EOR)

- Lower CAPEX
- Less CO_2 Emission
- Shorter Production Time
- Less Infrastructure
- Large Environmental Footprint
- Significantly lower EUR
- Lower Recovery Factor
- Lower Internal Rate of Return (IRR)

Case 2

Carbon Sequestration (CO_2 EOR)

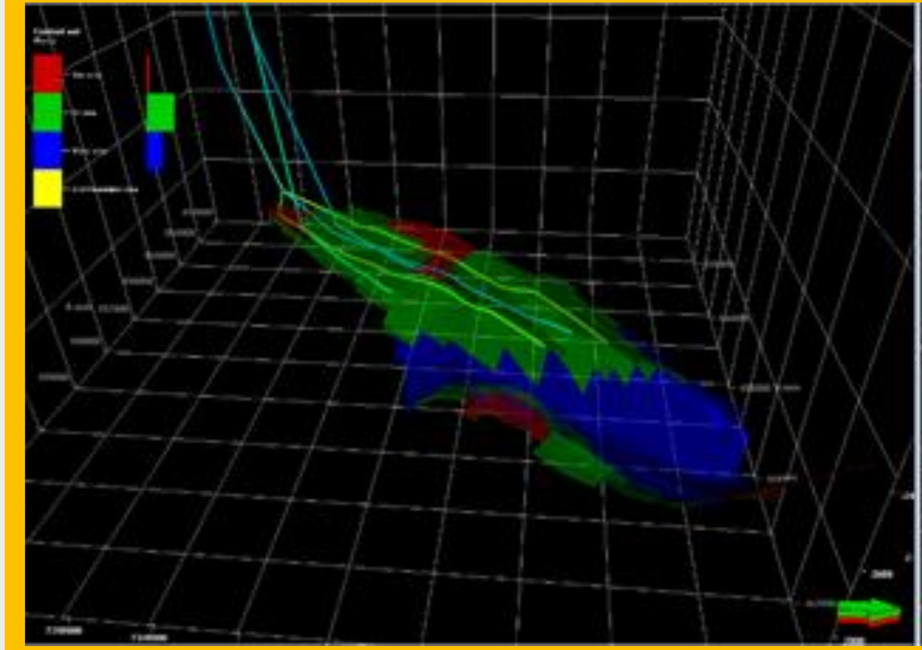
- Higher Recovery Factor
- Store higher volume of CO_2 vs CO_2 emitted
- Smaller Environmental Footprint
- Higher IRR
- Higher CAPEX
- Complexity of Infrastructure
- Need consistent source of CO_2

Well Placements in Tofte and Ile

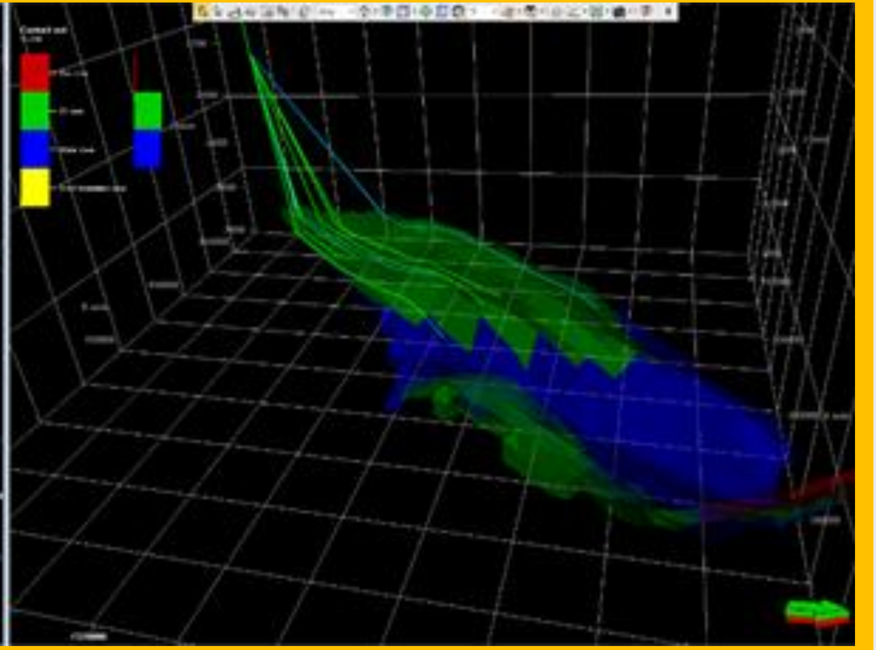
76% of Oil is in Ile and Tofte formations:

- Ile: 4 Producers, 4 Injectors
- Tofte: 5 producers, 4 Injectors

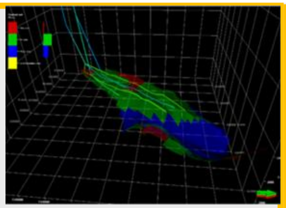
Ile



Tofte

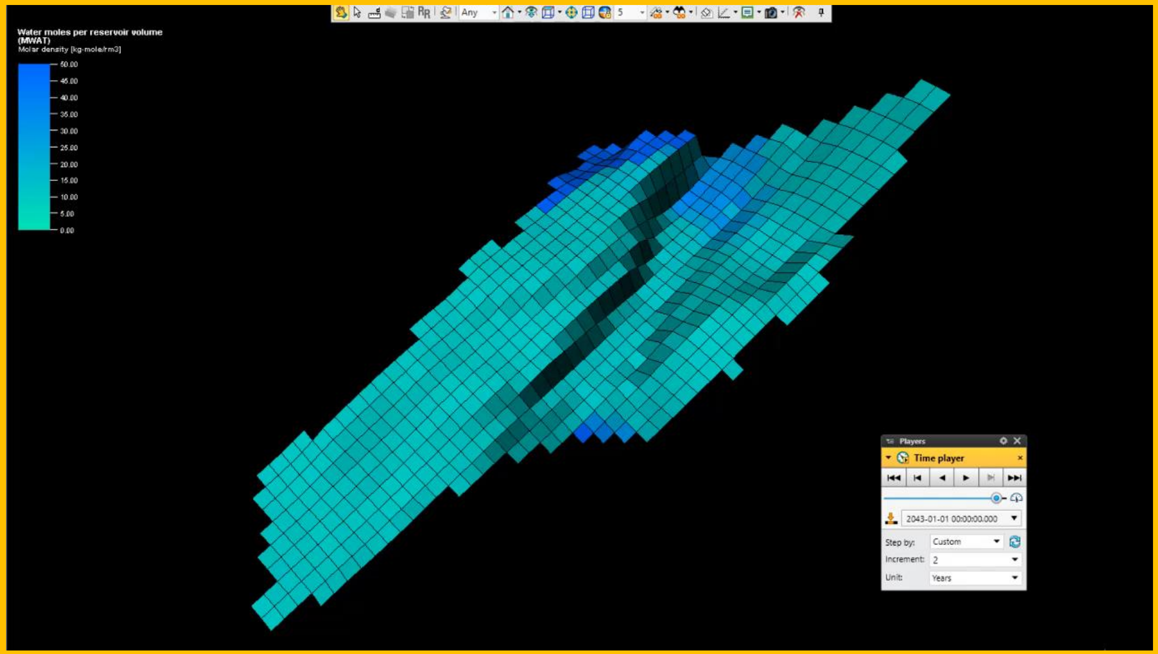


Simulation Video Tijle – Change in Sw (23yrs)

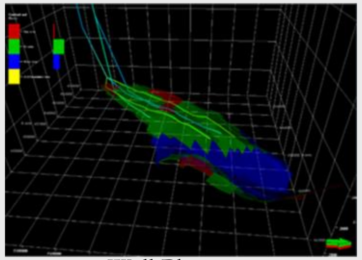

Well Placements

Water Saturation:

- No natural refilling aquifer
- Water mainly in the Tofte and Tilje formations (lower reservoir units)
- Pore space will not be recharged by water but rather by injected CO_2



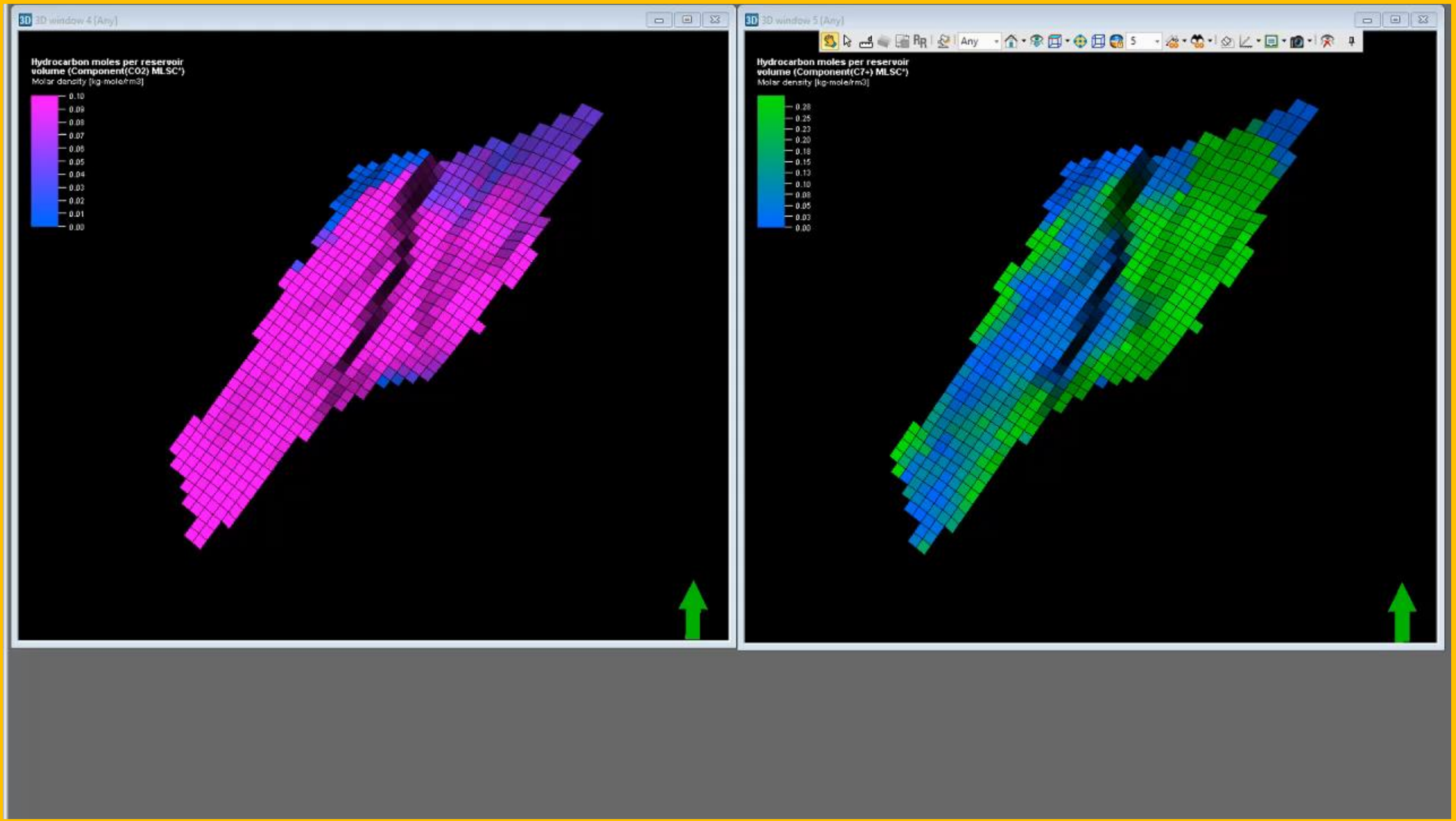
Simulation Video – Ile and Tofte Production



Well Placements

Simulations show CO2 depletion during production and CO2 saturation during post-production sequestration (Left).

The simulations show areas of residual oil within the reservoir after 20 years of production.



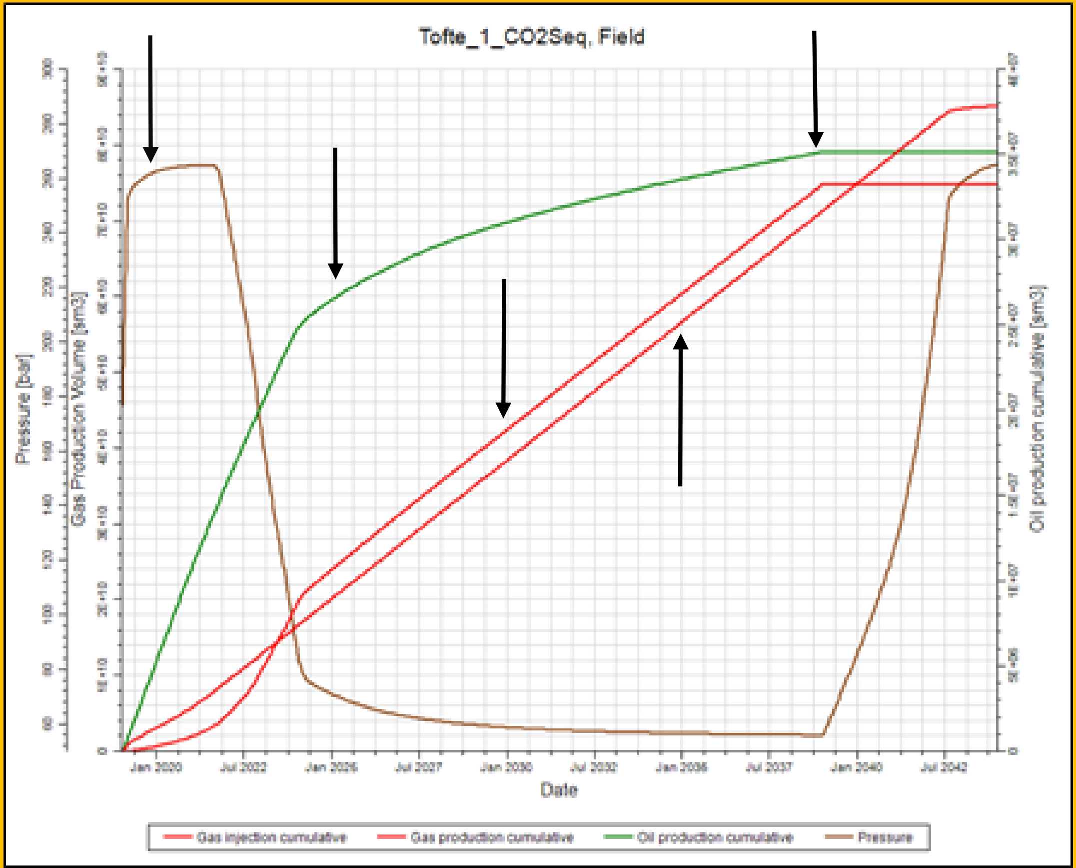
Production, Injection, and Pressure

Depletion:

- Simulated production over 18 years
- CO_2 is used to create a miscible flood

Sequestration:

- Production halted
- CO_2 injection continued for and additional 5 years



Volume Summary

Formation	STOIIP [MBO]	STOIIP [*10^6 sm3]	EUR [*10^6 sm3]	RF	GIIP [*10^6 sm3]	GIIP [BcF]	HCPV [*10^6 10^6 rms]
Garn	169.83	27	5.4	20%	10550	372.56	33
Ile	352.24	56	36.4	65%	867	30.62	67
Tofte	434.01	69	41.5	60%	0	0.00	83
Tilje	100.64	12	4.41	37%	0	4.91	14
Total	1,056.72	164	87.71	53%	11,556	408.09	197

53% Recovery Factor
EUR 559.68 MBO
EUR 87.71 *10^6 sm3

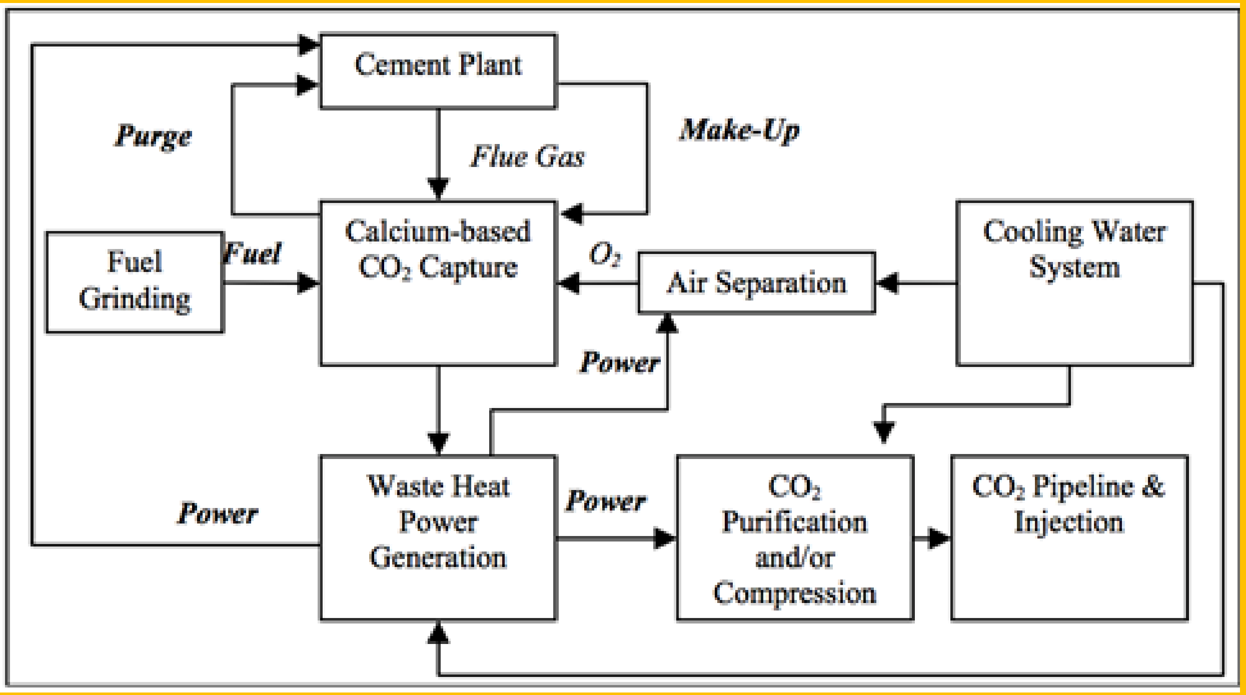
Emission Reduction Strategies

Carbon Sequestration:

- Provides the most reduction but also highest cost
- CO2 Sources:
  - Recycling from reservoir
  - Cement plant
  - Garbage burning
  - Fertilizer (purest form of CO2 to capture)

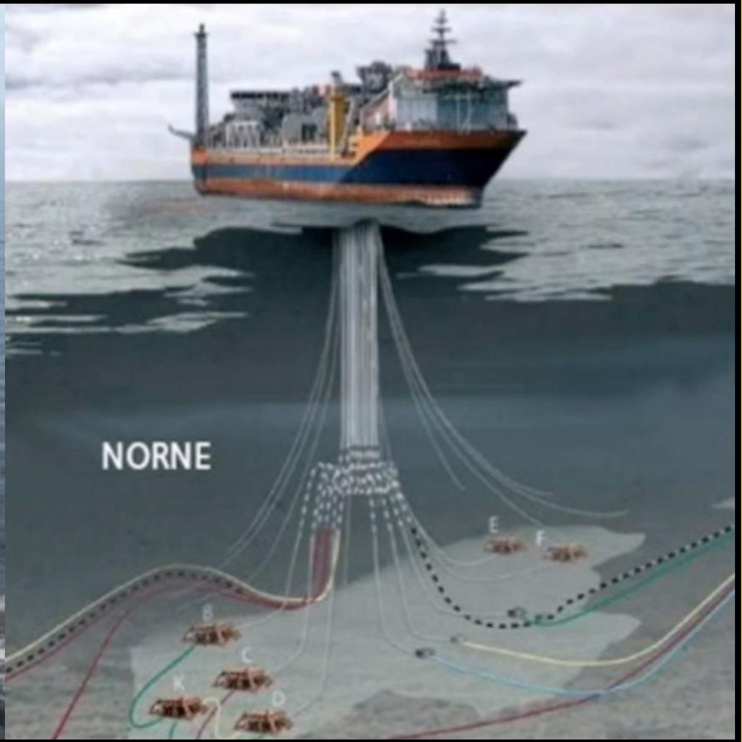
Other Reduction Strategies:

- Alternative power during production
  - Tidal Energy
  - Platform Wind Turbines
- Reforestation projects

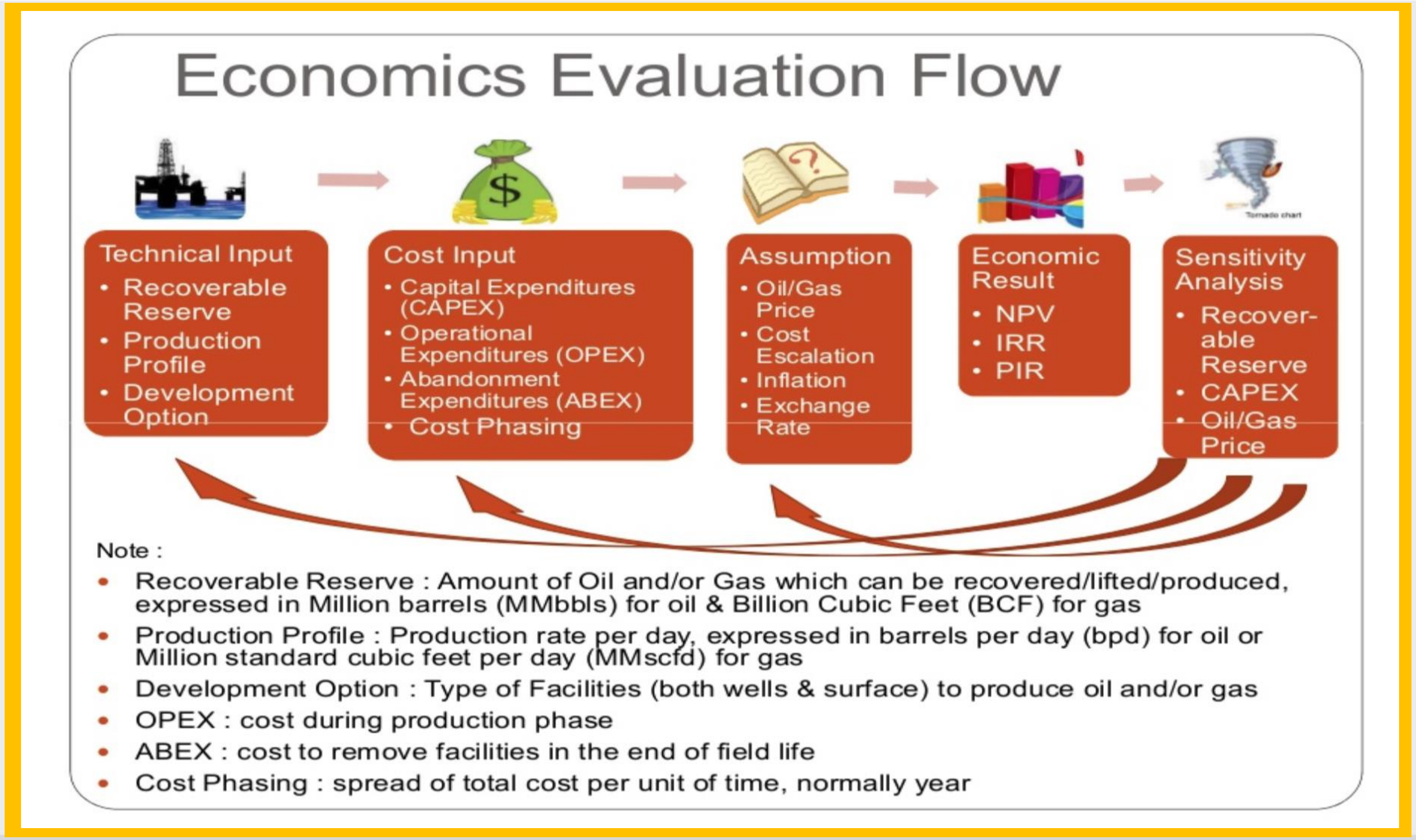


Project Infrastructure

- Floating Production Storage and Offloading System (FPSO)
- Subsea Production System
- Teekay E-Shuttle Tanker for oil Transportation
- Source of CO_2: Cement Plant



Economic Analysis



Economic Analysis

- **Capital Expenditure (CAPEX): $7.15 Billion USD**
- **Net Present Value at 10% Discount Rate (NPV10): $6.94 Billion USD after 20 years of Production**
- **Internal Rate of Return (IRR): 30.53%**
- **NB: Well Costs are Front Loaded**

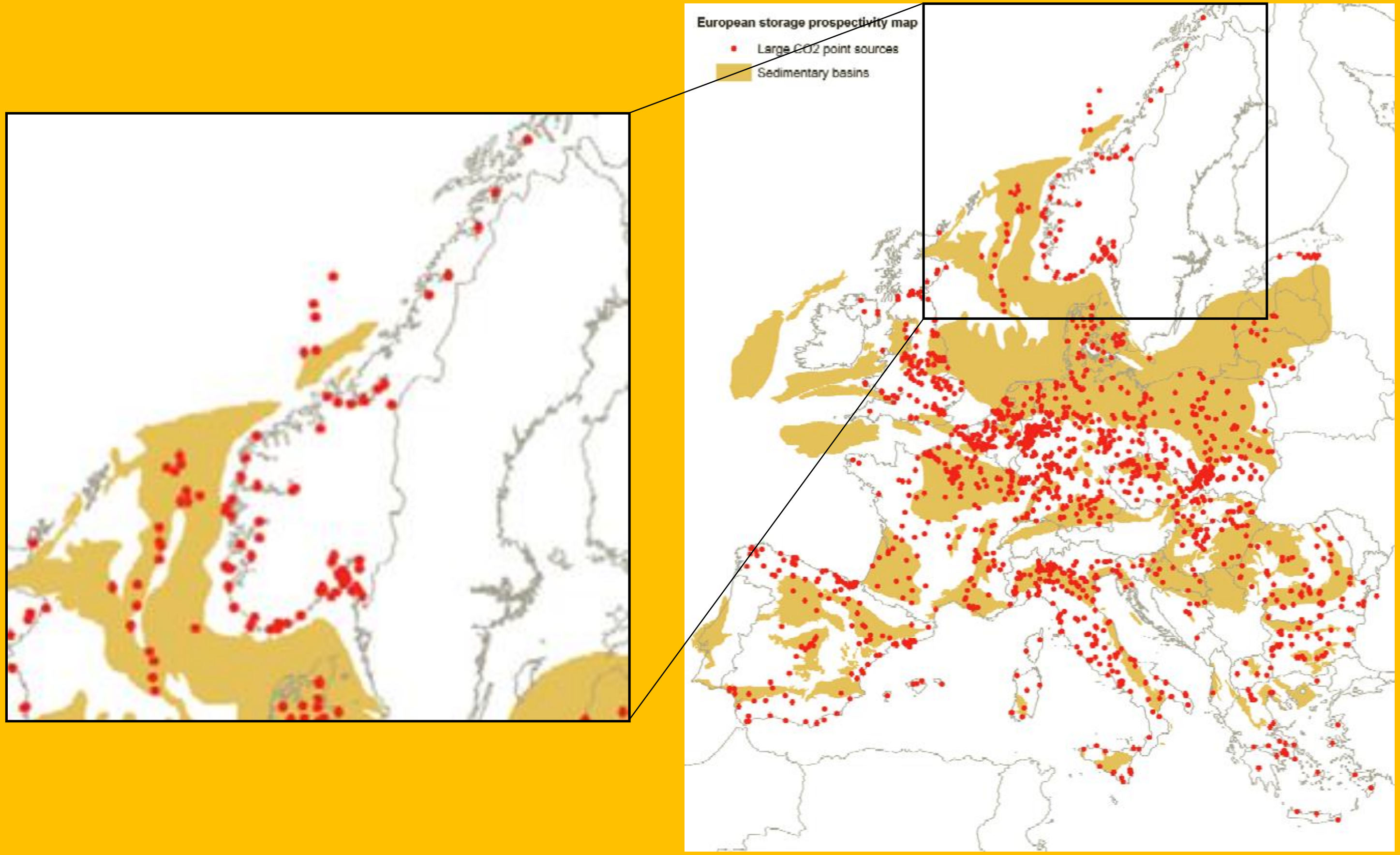
		2020	2021	2022	2023	2024	2025	2036	2037	2038	2039	2040
Year		0	1	2	3	4	5	16	17	18	19	20
Oil production - av. daily prod bbls/day		0	50	100	200	200	175	25	25	25	10	10
Oil production in year- MBO (millions barrels)		0	18.25	36.5	70	70	63.875	9.125	9.125	9.125	3.65	3.65
Cumulative oil prod- MBO		0	18.25	54.75	124.75	194.75	258.625	470.325	479.45	488.575	492.225	495.875
To scale up muliply by:	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Oil prod MBO / year			21.9	43.8	84.0	84.0	76.7	11.0	11.0	11.0	4.4	4.4
CO2 m tonnes- full cycle at 0.4 tonne /bbl	0.7		15.3	30.7	58.8	58.8	53.7	7.7	7.7	7.7	3.1	3.1
Cum Oil Prod- MBO			21.9	65.7	149.7	233.7	310.4	564.4	575.3	586.3	590.7	595.1
Oil Price $/bbl	70	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Oil Revenue $m			1533.0	3066.0	5880.0	5880.0	5365.5	766.5	766.5	766.5	306.6	306.6
Gas production av. daily- mmcfpd			30.000	40.000	45.000	50.000	50.000	35.000	30.000	30.000	25.000	20.000
Gas production in year- BCF			10.950	14.600	16.425	18.250	18.250	12.775	10.950	10.950	9.125	7.300
Cum gas BCF			10.950	25.550	41.975	60.225	78.475	224.475	235.425	246.375	255.500	262.800
Gas revenue $m, at $x per mcf	10		109.500	146.000	164.250	182.500	182.500	127.750	109.500	109.500	91.250	73.000
CO2 m tonnes- at 53000 tonnes / BCF	0.053		0.6	0.8	0.9	1.0	1.0	0.7	0.6	0.6	0.5	0.4
Gross Revenue $m (million)			1642.5	3212.0	6044.3	6062.5	5548.0	894.3	876.0	876.0	397.9	379.6
Cum Gross Revenue $m			1642.5	4854.5	10898.8	16961.3	22509.3	41752.1	42628.1	43504.1	43901.9	44281.5
Capex: FPSO $m		-750										
Capex: 30 Wells Estimate 100 $m each		-3000										
Capex: Subsea completions $m		-1000										
Capex: Pipelines		-200										
Capex: Carbon Compression		-2000										
Capex: Cement Plant		-200										
Opex: tanker costs $m			-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
Opex: running FPSO $m	30		-30	-30	-30	-30	-30	-30	-30	-30	-30	-30
Opex:												
Opex:												
Cost of CO2 onshore $ per tonne	20		-307	-613	-1176	-1176	-1073	-153	-153	-153	-61	-61
			-12	-15	-17	-19	-19	-14	-12	-12	-10	-8
Decommisioning fund $m			-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Net Cash Flow each year $m BTAX		$ (7,150.00)	$ 1,279.29	$ 2,538.32	$ 4,805.84	$ 4,822.16	$ 4,410.56	$ 682.41	$ 666.09	$ 666.09	$ 281.86	$ 265.54
Cum net cash flow		$ (7,150.00)	$ (5,870.71)	$(3,332.38)	$ 1,473.46	$ 6,295.61	$10,706.17	$25,742.65	$26,408.74	$27,074.83	$27,356.69	$27,622.23
Tax 30% after payout	0.3	0.0	0.0	0.0	-1441.8	-1446.6	-1323.2	-204.7	-199.8	-199.8	-84.6	-79.7
Tax2												
Tax3												
Net Cash Flow each year ATAX		-7150.0	1279.3	2538.3	3364.1	3375.5	3087.4	477.7	466.3	466.3	197.3	185.9
NPV $m at 10% discount rate (XL function)	0.1		-5442.7	-3535.7	-1237.9	858.0	2600.7	6723.2	6807.1	6883.3	6912.7	6937.8
IRR (DCFR) (Excel Function)			-82.11%	-31%	0%	15%	23%	30.47%	30.50%	30.51%	30.52%	30.53%

Potential CO2 Capture Areas

The identification of storage potential:

This begins with:

- Identifying sedimentary basins suitable for geologic storage of CO2
- Identifying point sources of CO2 in the regional areas of the North Sea



Comparative Projects

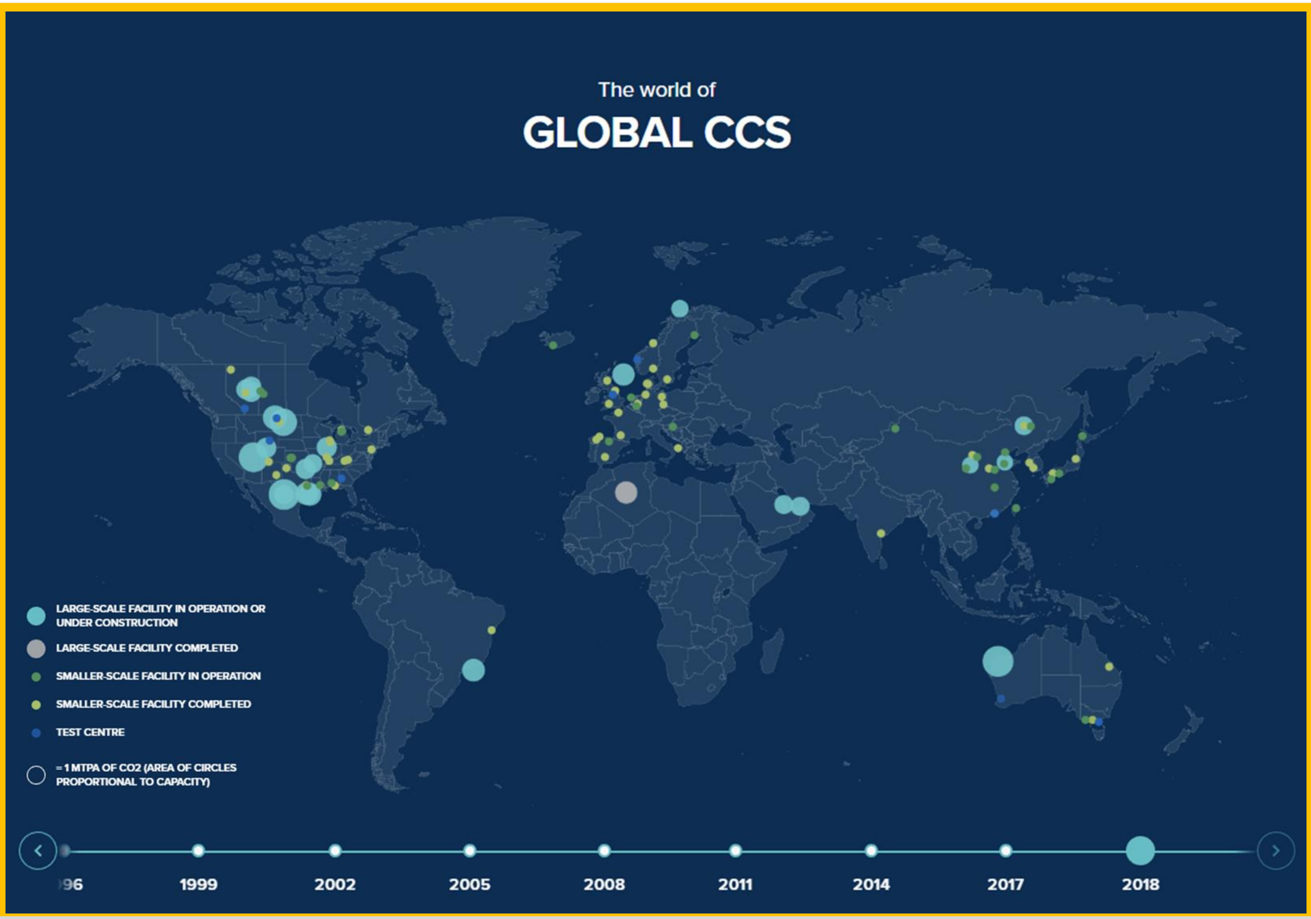
There are only a few active sequestration projects active in the world

Snohvit, Norway:

- ~0.7 Mtonnes CO_2 per year

Alberta Carbon Trunk Pipeline Project, Alberta Canada (world's largest):

- ~14.6 Mtonnes CO_2 per year (max capacity)



Assumptions and Exclusions

Exclusions:

- **Excluded segment G, contained less than 5% of oil in the field**
- **Garn and Tilje Simulations for purposes of presentation**

Assumptions:

- **70$/bbl and 70$/tonne of CO_2**
- **Faults are sealing and not migratory paths**

Conclusions and Recommendations

- Norne Field Production using Carbon EOR
- EUR 560 MBO with CO2 EOR and 216 BCF of gas
- Sequester ~420 Mtonnes over 5 years, with additional voidage for ~600 Mtonnes of CO2
- Purchase Cement Factory at Kjopsvik (~170M USD) for source of CO2
- CAPEX (USD) = $7.15 Billion, NPV10 (USD) = $6.94 Billion, DCFR ~30.5%
- Utilize facility for commercial CCS after oil and gas production
- Ongoing well monitoring and 4D seismic monitoring after completion

Questions & Answers