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Wind-Powered CO_2 and water injection at NCS

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NORCE – Energy

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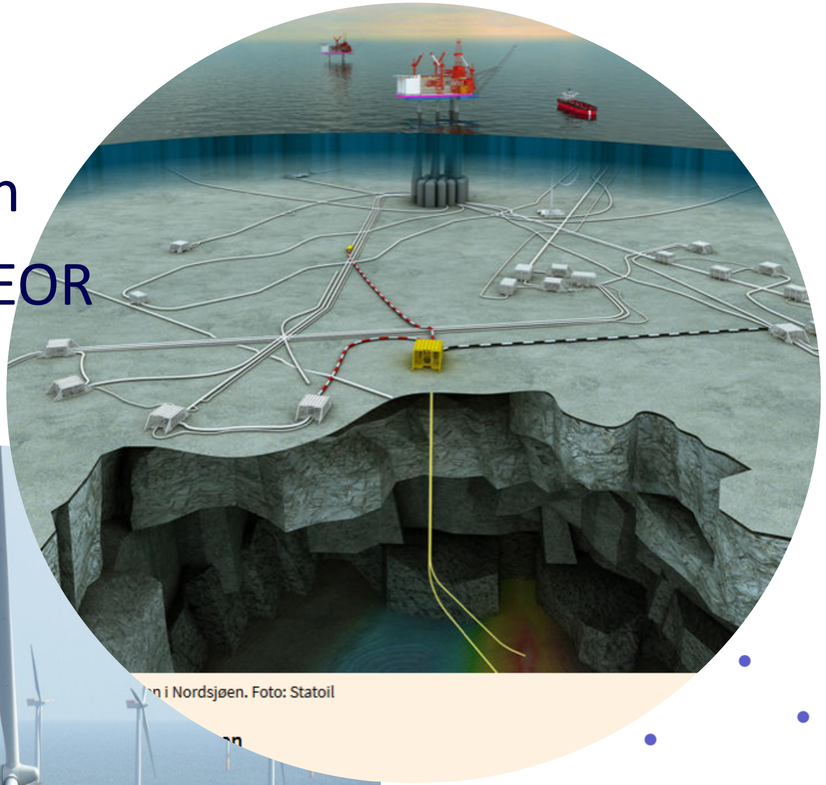
Content

- CO_2 Emission from oil and gas industry in Norway
- Use of wind power for combined water and CO_2 injection
- CO_2 dissolved in injection seawater for CO_2 storage and EOR



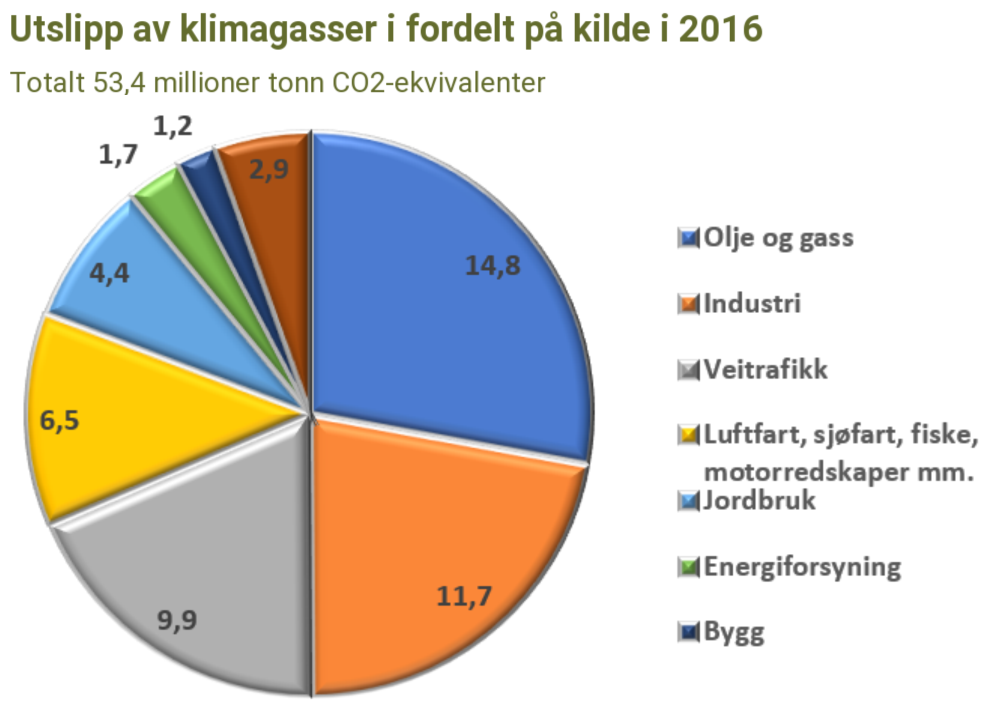
Courtesy photos from
- https://www.process-worldwide.com/statoil-invests-in-german-arkona-wind-farm-a-531022/

Equinor-plan: Hywind Tampen skal koste rett under fem milliarder

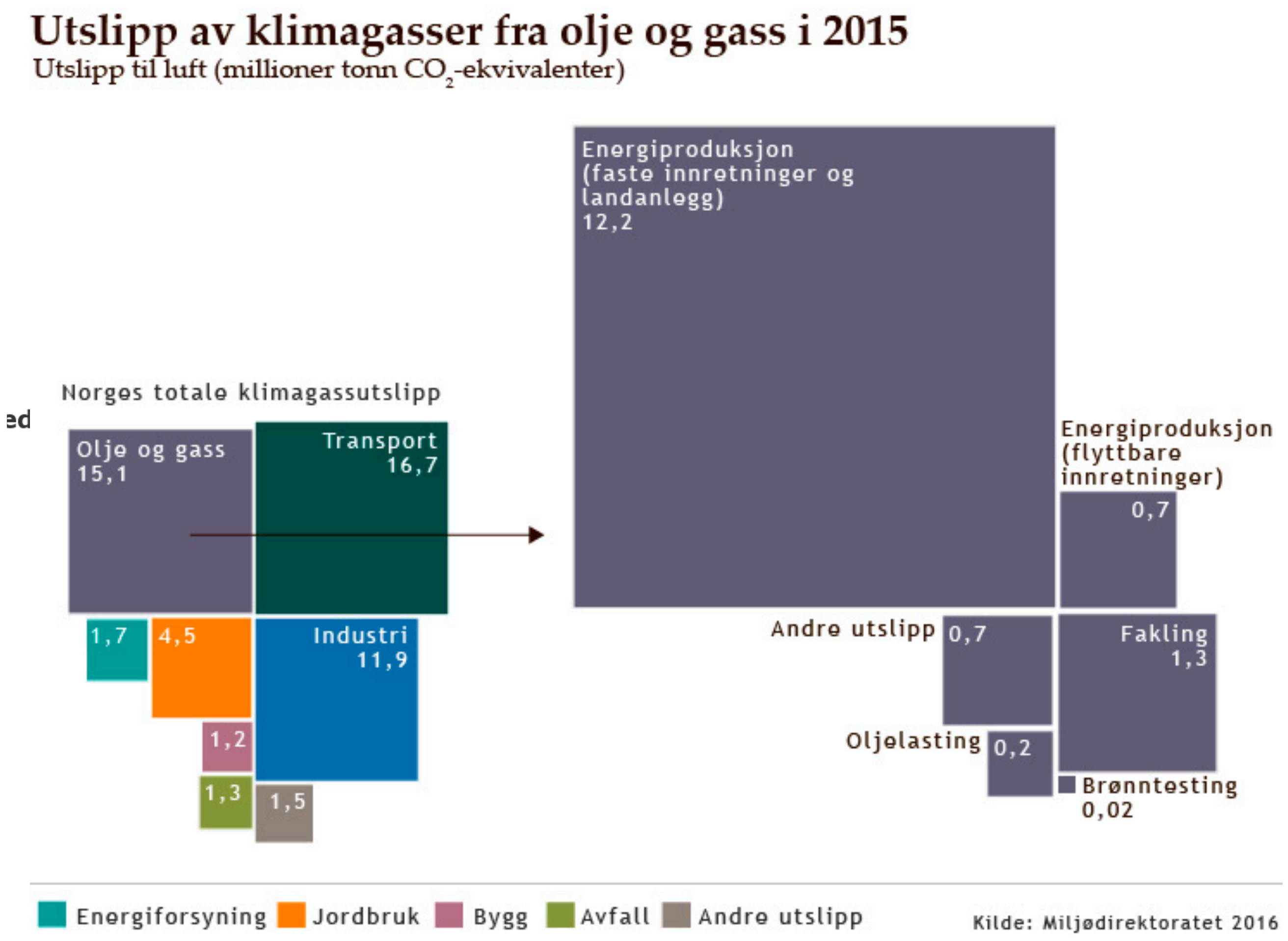
Equinor og partnerne har tatt en endelig beslutning om å bygge ut Norges første flytende havvindanlegg. Strømmen fra Hywind Tampen skal erstatte gasskraft på Snorre og Gullfaks.

E24: https://e24.no/energi/i/2G4b0x/equinor-plan-hywind-tampen-skal-koste-rett-under-fem-milliarder
11. oktober 2019 07:08, Publisert 11. oktober 2019

CO_2 Emission in Norway and from Offshore Oil and Gas industry



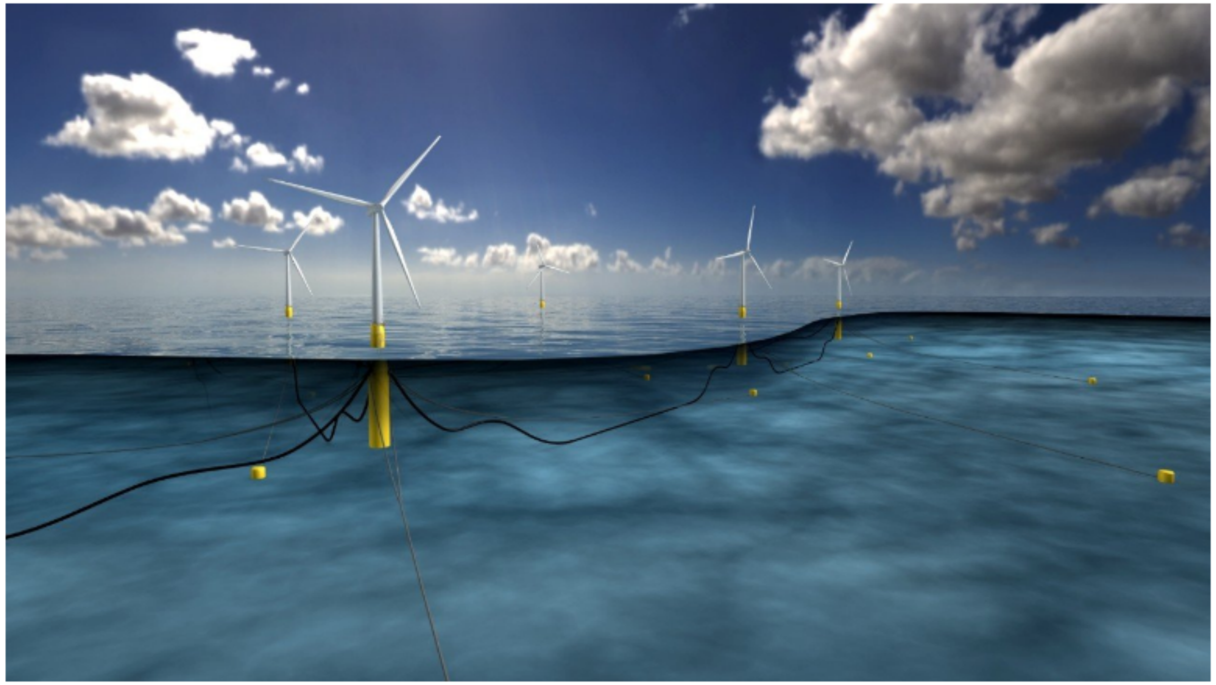
albyrå (SSB) Lisens: Norsk Lisens for Offentlige Data (NLOD)



EQUINOR - HYWIND

Statoil to build the world's first floating wind farm: Hywind Scotland

Not published



SYSLA | GRØNN

Anbefaler at Statoil får flytte Hywind til oljeplattformer

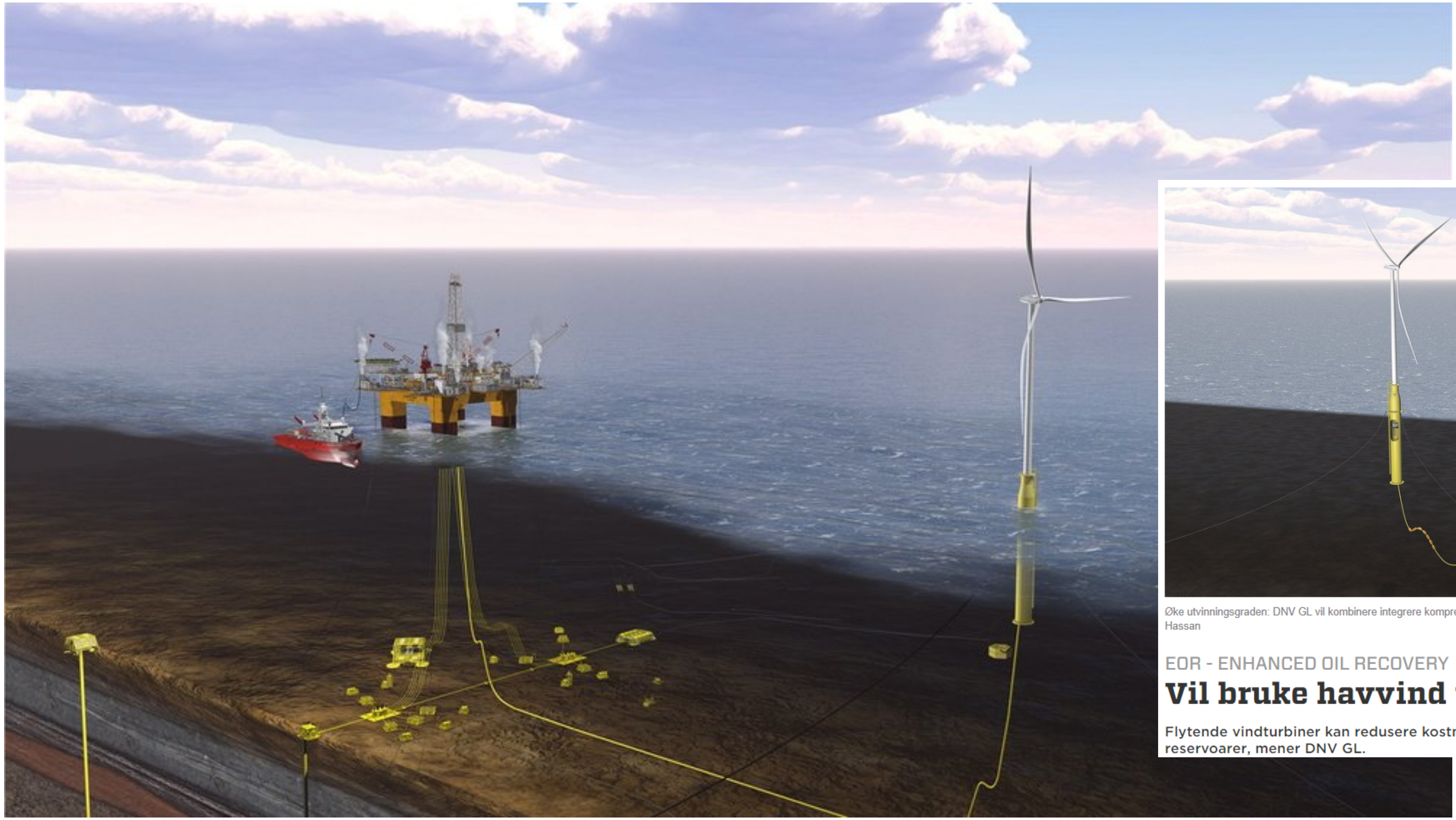
NVE støtter planene om å forsyne oljeplattformer med strøm fra havvind.

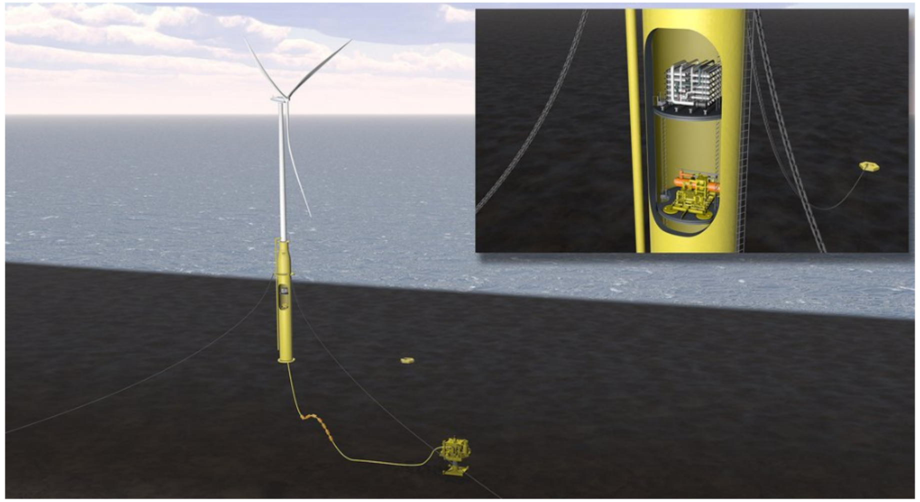
av **Martin Larsen Hirth**

Publisert 07.04.2016 15:16 / Oppdatert 10.04.2016 17:57

WIN WIN - WIND POWERED WATER INJECTION

DNV GL: Nå kan det lønne seg med flytende havvind til oljeplattformer





Øke utvinningsgraden: DNV GL vil kombinere integrere kompressor og vanninjeseringsutstyr inn i substrukturen til en flytende havvindturbin. Illustrasjon: Garrad Hassan

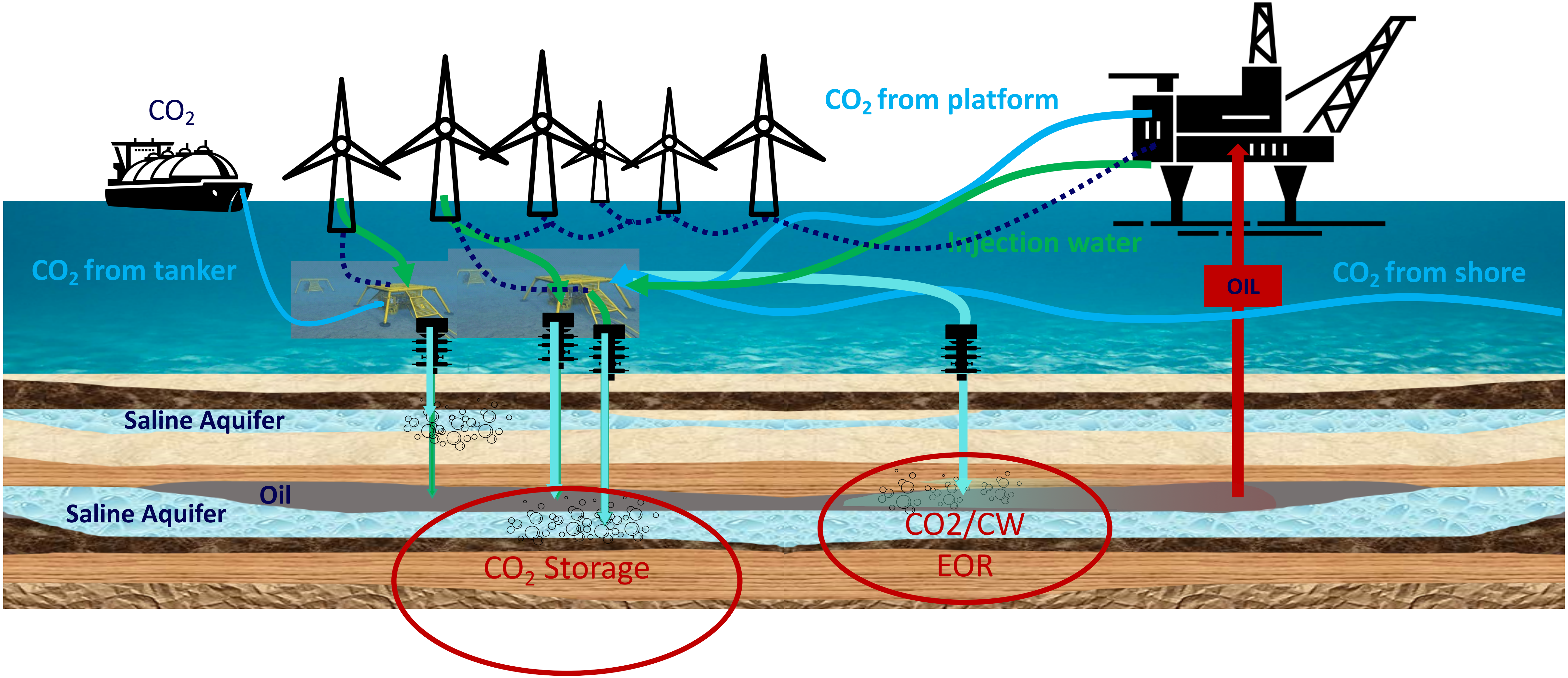
EOR - ENHANCED OIL RECOVERY

Vil bruke havvind til å øke oljeutvinningen

Flytende vindturbiner kan redusere kostnadene ved å øke oljeutvinningen i eldre og marginale reservoarer, mener DNV GL.

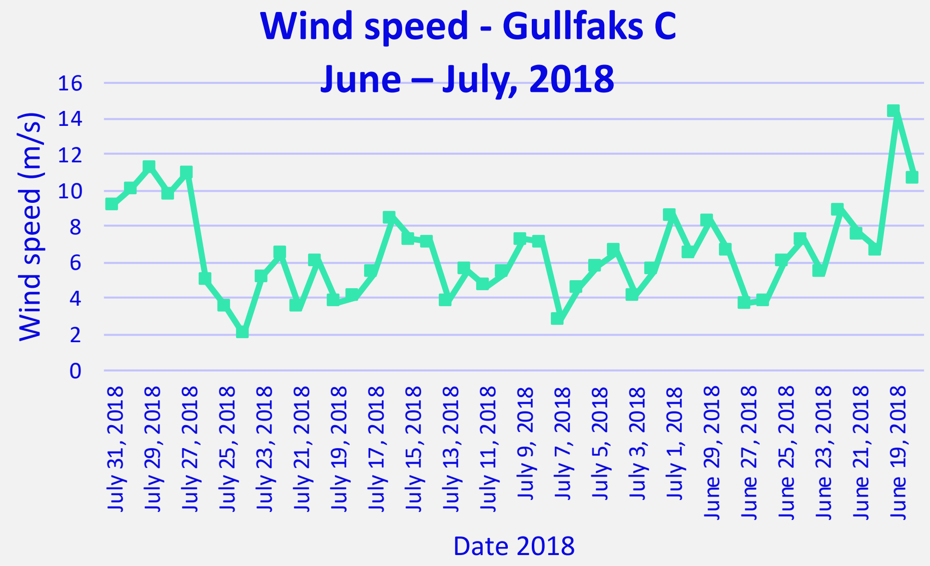
https://www.tu.no/artikler/vil-bruke-havvind-til-a-oke-oljeutvinningen/222467

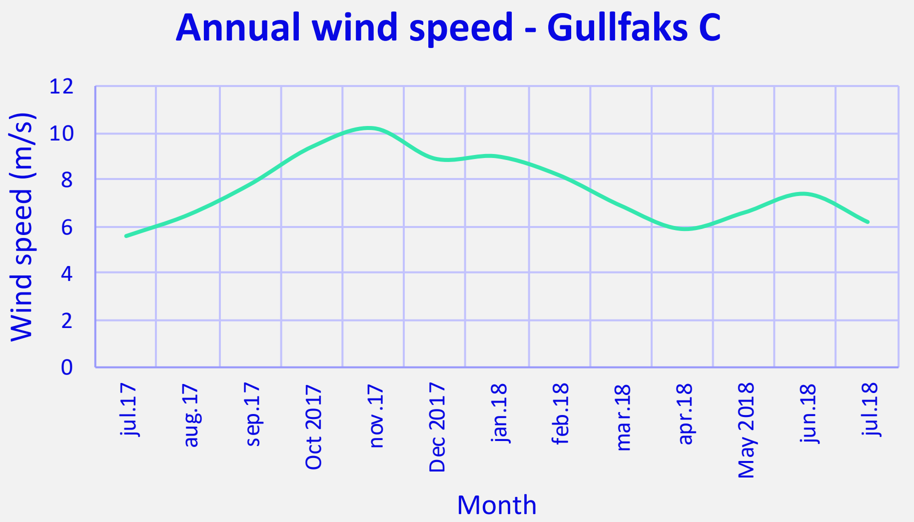
Combining water and CO_2 injection powered with offshore wind



Challenges and opportunities

- Wind power daily and seasonal variations
  - Regularity issues for injection / Well integrity (?)
  - Energy mix or storage (?)
  - Cyclic water and IOR (+)
- Combining CO_2 with seawater injection
  - CO_2 as carbonated water (CW) for EOR (+)
  - Reservoir rock interaction (?)

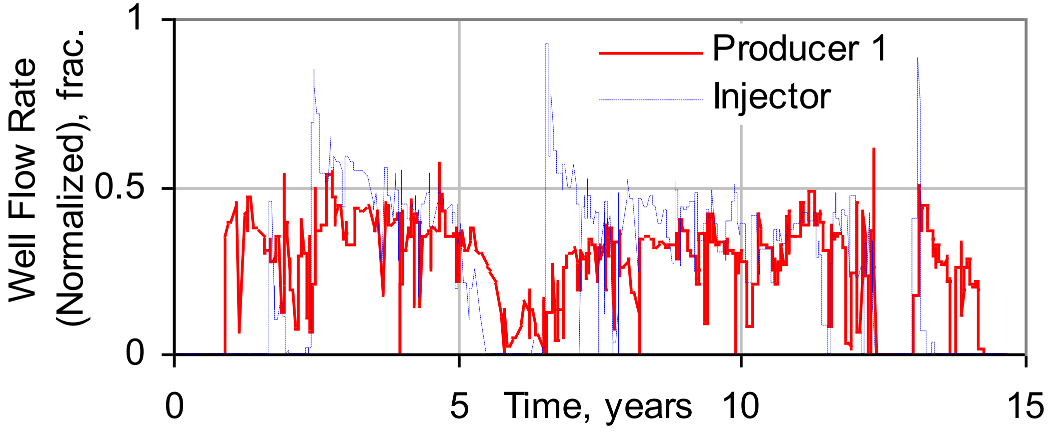




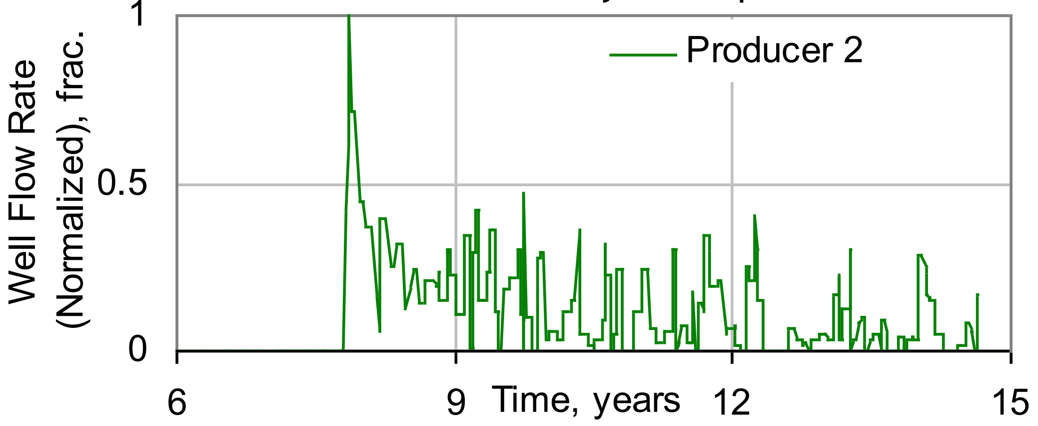
Data from Yr.no

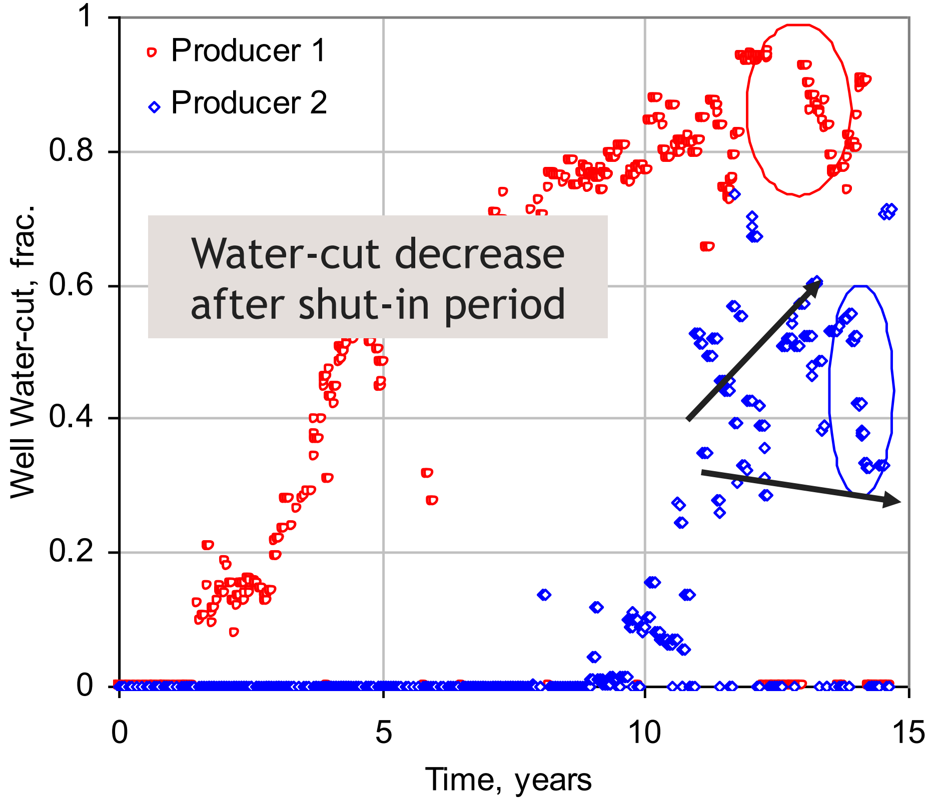
Cycles in well production / injection are often present in a field history

Producer 1 has Injector with cyclic rate



Producer 2 has intensive cycles in production rate

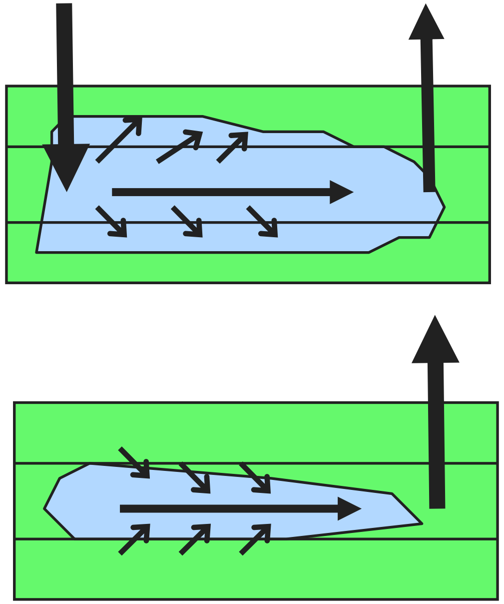




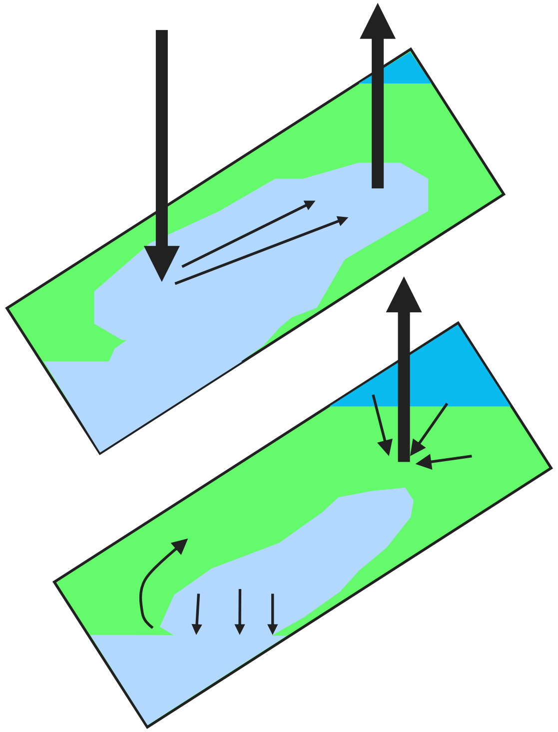
Reference: SPE 116873, A.A. Shchipanov (IRIS), L.M. Surguchev (IRIS), S.R. Jakobsen (StatoilHydro), presented at SPE Russian Oil & Gas Technical Conference and Exhibition, Moscow, 28–30 October 2008

Cyclic injection IOR – Main mechanisms

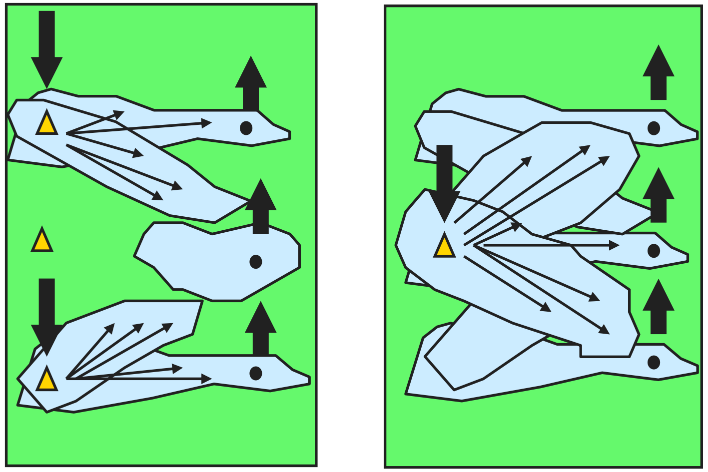
Expansion / compaction



Gravitational "siesta"

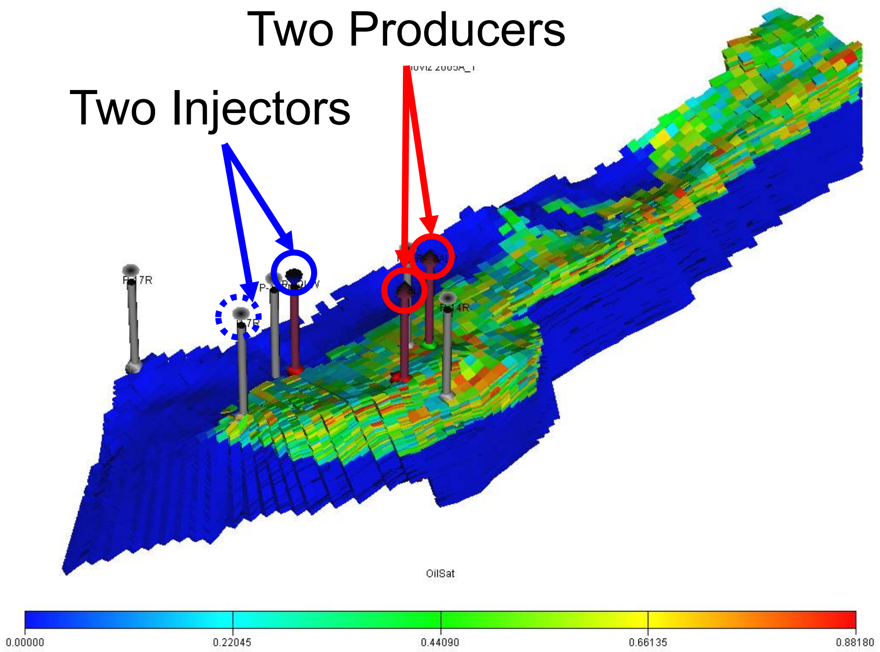


Alternating waterflood patterns



Reference: SPE 116873, A.A. Shchipanov (IRIS), L.M. Surguchev (IRIS), S.R. Jakobsen (StatoilHydro), presented at SPE Russian Oil & Gas Technical Conference and Exhibition, Moscow, 28–30 October 2008

Effect of cyclic water injection



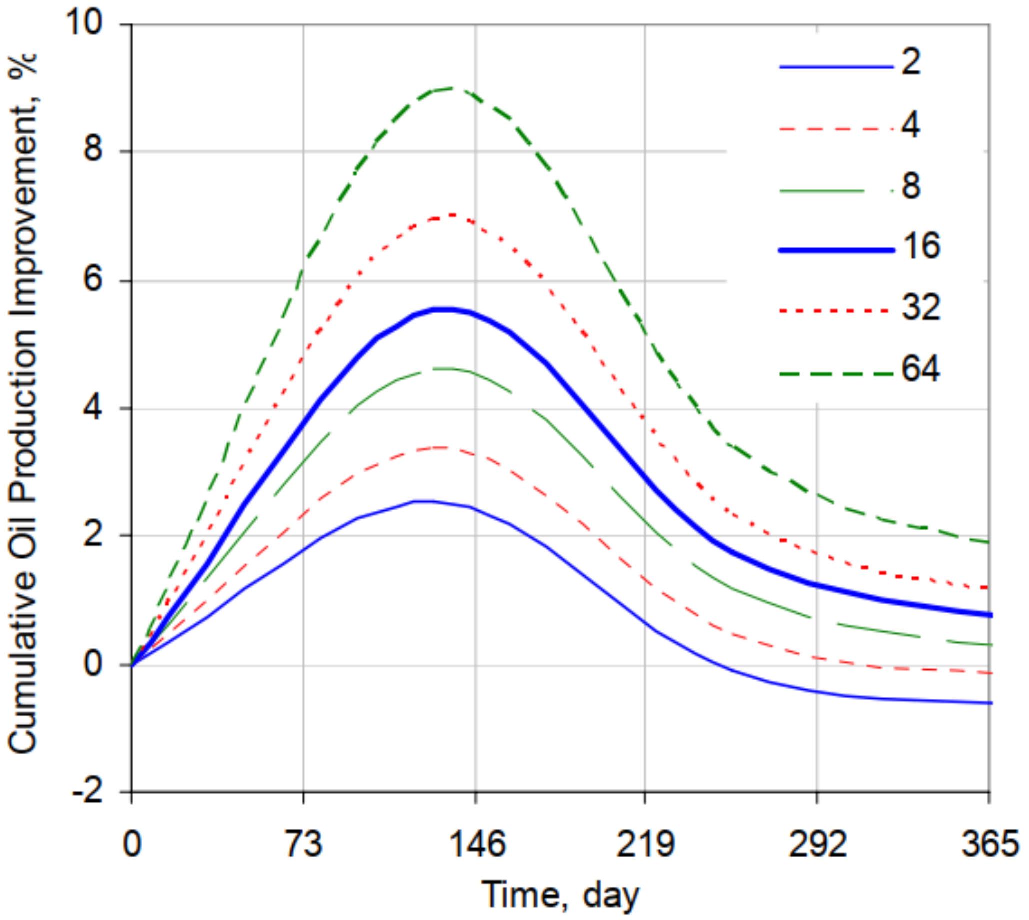


Fig. 18: Cyclic production at different cycles. Index: half-cycle length, days.

Reference: SPE 116873, A.A. Shchipanov (IRIS), L.M. Surguchev (IRIS), S.R. Jakobsen (StatoilHydro), presented at SPE Russian Oil & Gas Technical Conference and Exhibition, Moscow, 28–30 October 2008

6-field case: How much CO_2 can be blended in the injected seawater*

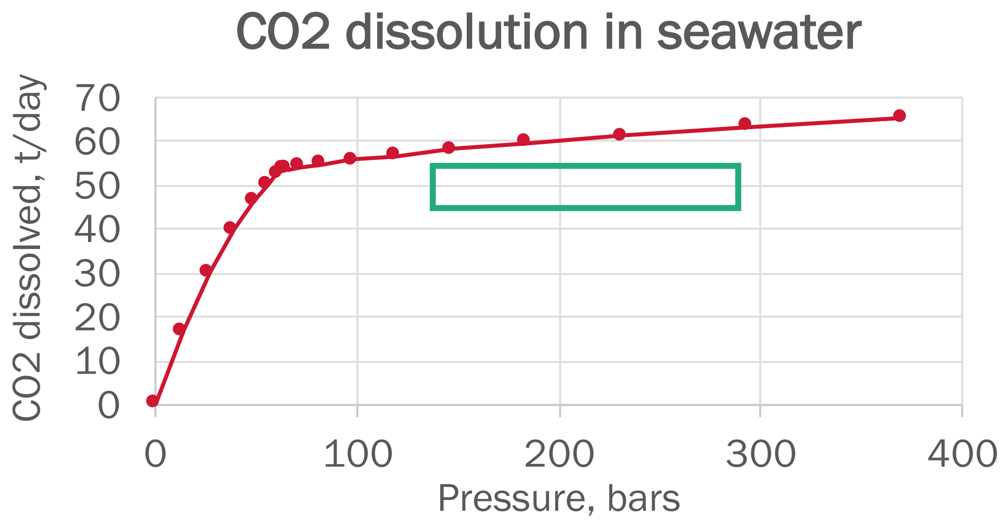
- Total CO_2 emission is about 1.5 Mt per year
- Total amount of injected water is ~ 66 MSM3 per year
- Total amount of CO2 in saturated seawater at 70 - 150 bar:

  $\Rightarrow$ ~ 50-60 t/1000 SM3 water

  $\Rightarrow$ ~ 3.3 – 4.0 Mt / year CO_2 can be blended to injection water

  $\Rightarrow$ ~ 1/3 water injectors needed to carry all CO_2 to reservoir

*) Estimated from 2014 data from NPD fact data.



Carbonated water (CW) in Water injectors

- Volume and cost estimate (400 NOK/t CO_2 tax on NCS)

	1 well			2 wells			3 wells		
	5000 Sm3/d			10000 Sm3/d			15000 Sm3/d		
	Water injected	2 % CO2 dissolved	5 % CO2 dissolved	Water injected	2 % CO2 dissolved	5 % CO2 dissolved	Water injected	2 % CO2 dissolved	5 % CO2 dissolved
Month	SM3	tonn	tonn	SM3	tonn	tonn	SM3	tonn	tonn
1	150 000	3 000	7 500,00	300 000	6 000	15 000	450 000	9 000	22 500
2	300 000	6 000	15 000,00	600 000	12 000	30 000	900 000	18 000	45 000
3	450 000	9 000	22 500,00	900 000	18 000	45 000	1 350 000	27 000	67 500
4	600 000	12 000	30 000,00	1 200 000	24 000	60 000	1 800 000	36 000	90 000
5	750 000	15 000	37 500,00	1 500 000	30 000	75 000	2 250 000	45 000	112 500
6	900 000	18 000	45 000,00	1 800 000	36 000	90 000	2 700 000	54 000	135 000
7	1 050 000	21 000	52 500,00	2 100 000	42 000	105 000	3 150 000	63 000	157 500
8	1 200 000	24 000	60 000,00	2 400 000	48 000	120 000	3 600 000	72 000	180 000
9	1 350 000	27 000	67 500,00	2 700 000	54 000	135 000	4 050 000	81 000	202 500
10	1 500 000	30 000	75 000,00	3 000 000	60 000	150 000	4 500 000	90 000	225 000
11	1 650 000	33 000	82 500,00	3 300 000	66 000	165 000	4 950 000	99 000	247 500
12	1 800 000	36 000	90 000,00	3 600 000	72 000	180 000	5 400 000	108 000	270 000
Annual CO2 Tax (MNOK)		**14,40**	**36,00**		**28,80**	**72,00**		**43,20**	**108,00**

Carbonated water may enhance oil recovery (EOR)

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SPE-175159-MS

A Thorough Investigation of Mechanisms of Enhanced Oil Recovery by Carbonated Water Injection

Mehran Sohrabi, Alireza Emadi, Seyed Amir Farzaneh, and Shaun Ireland, Centre for Enhanced Oil Recovery and CO2 Solutions, Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK

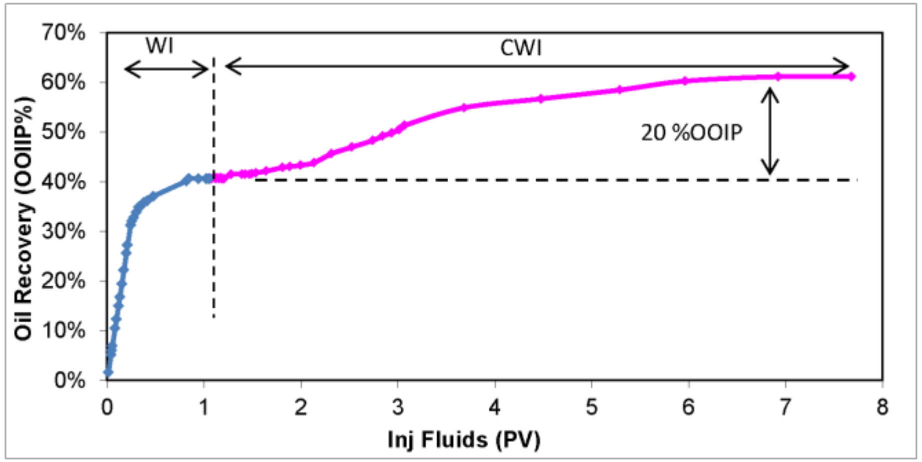


Figure 29—Oil recovery profile during secondary WI and subsequent tertiary CWI, Test 6.

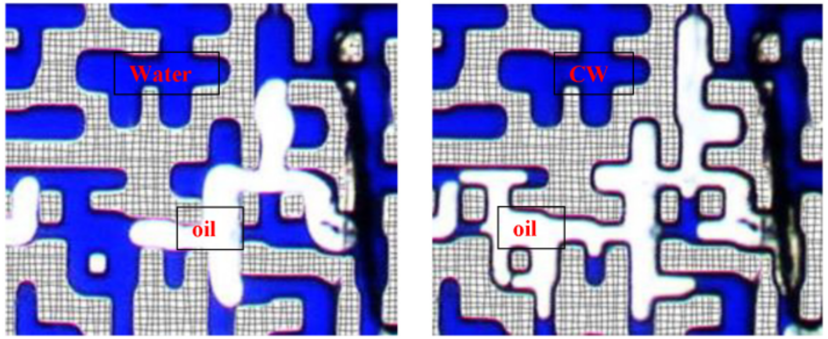


Figure 3—Comparison of the volume of an oil ganglion (white area) before (left) and after CWI (right). Image analysis has shown that a massive 105% oil swelling took place.

SLIMAIA

IFP Energies nouvelles

The National IOR Centre of Norway

University of Stavanger

IRIS

IFE

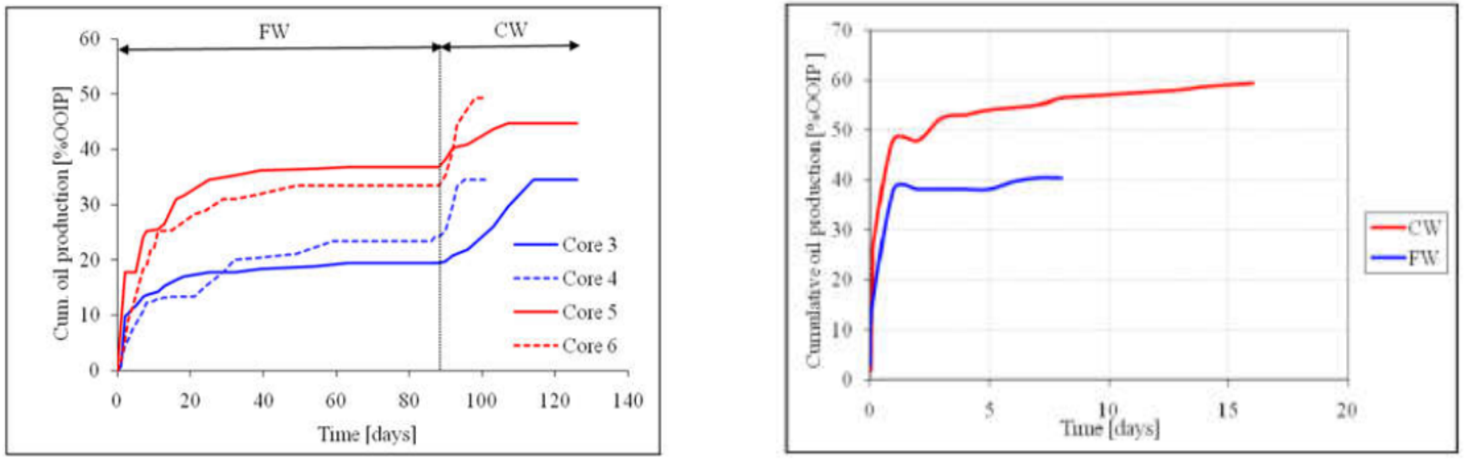
IMPROVED OIL RECOVERY AND CO_2-STORAGE BY CARBONATED WATER INJECTION

Ingebret Fjelde[abc], Samuel Erzuah[ab] & Aruoture V. Omekeh[ac]
a -The National IOR Centre of Norway, b - University of Stavanger (UiS) &
c - International Research Institute of Stavanger (IRIS)

RESULTS

SPONTANEOUS IMBIBITION

❖ **CW resulted in higher spontaneous imbibition than FW due to alteration to more water-wet.**



Spontaneous imbibition experiments (Fjelde et al., 2011)

CO_2 in injection water (Carbonated Water) has lower risk for CO_2 back production

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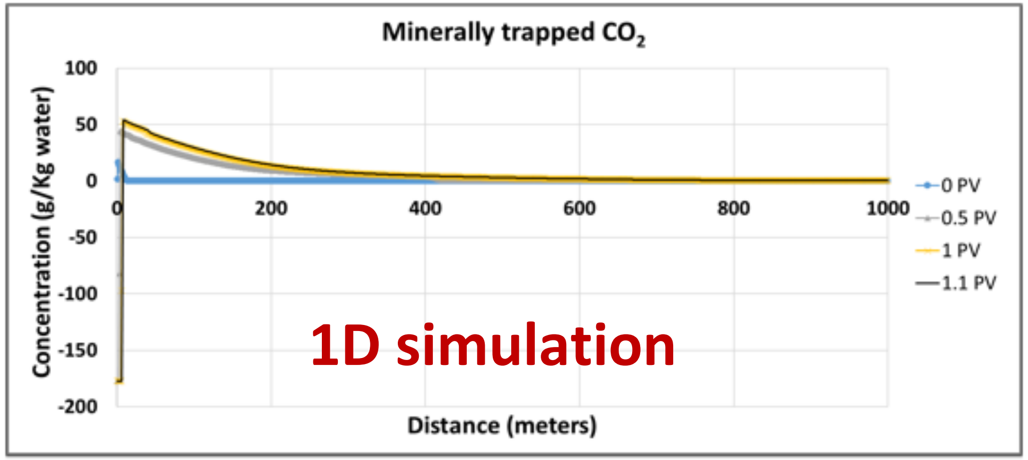
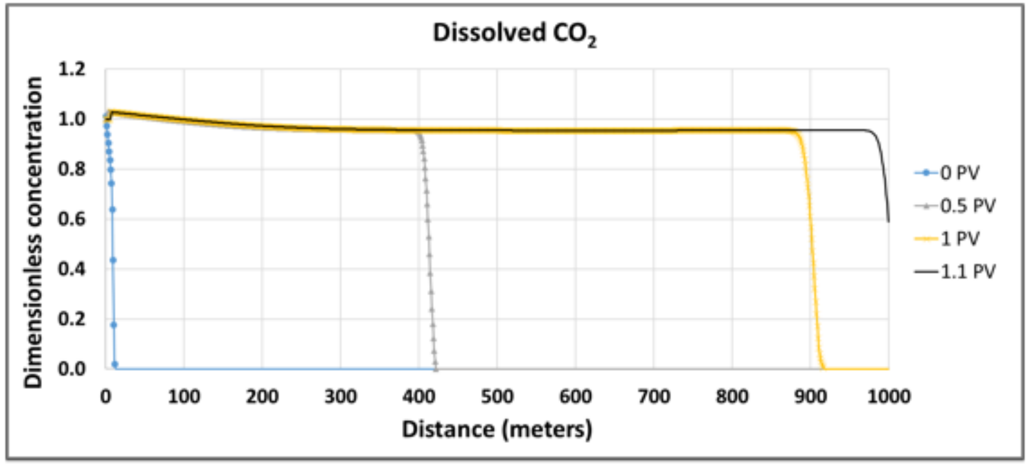


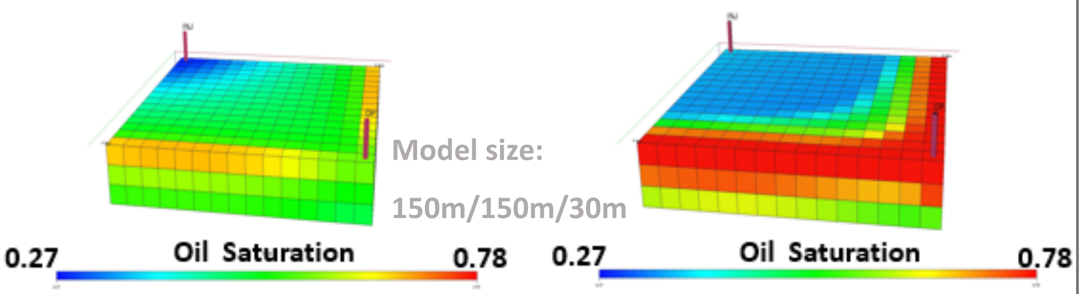
Most of minerally CO_2-trapping close to injector after 1 pore volume (PV) (9 years)

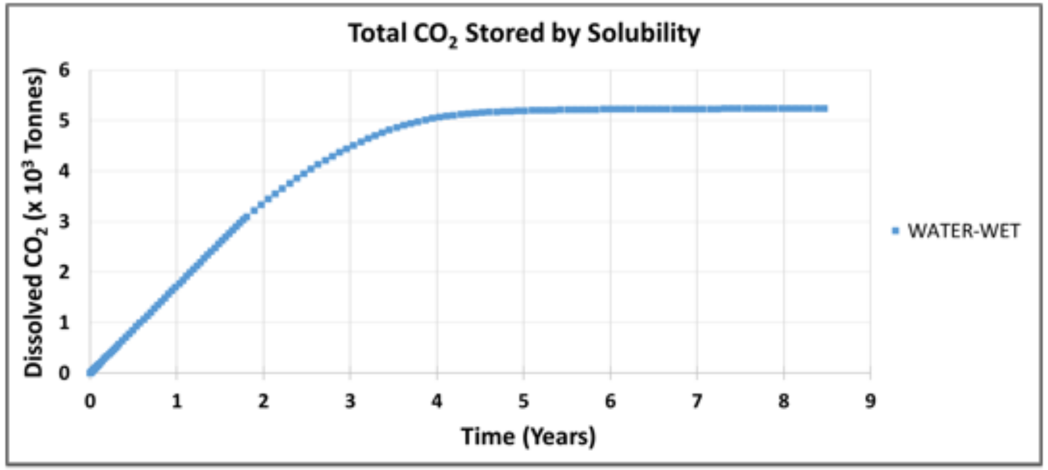


Retardation in CO_2-front as a result of mineral trapping of CO_2. It takes approx. 1.1PV for CO_2 front to reach the injector

2D simulation

Oil distribution in reservoir (after 570 days)





Amount of CO_2 stored in the reservoir by dissolution in water only

Summary

- Using wind power for water and CO_2 injection is feasible even with daily and seasonal variation
- Combining CO_2 storage with seawater injection could be an attractive solution for CO_2 emission reduction on NCS
- More R&D
  - Energy sources and storage for stand-alone injection optimization
  - Cost effective blending of CO_2 into injection seawater
  - Understanding well integrity due to frequent injection rate variation and geochemical reaction with carbonated water
  - Accelerated CO2 dissolution by convectional mixing
  - Simulation tools to quantify the CO_2 storage efficiency and CO_2-EOR potential

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Thanks for listening!