WIN WIN

Wind-powered Water Injection – Offshore Wind supporting O&G operations

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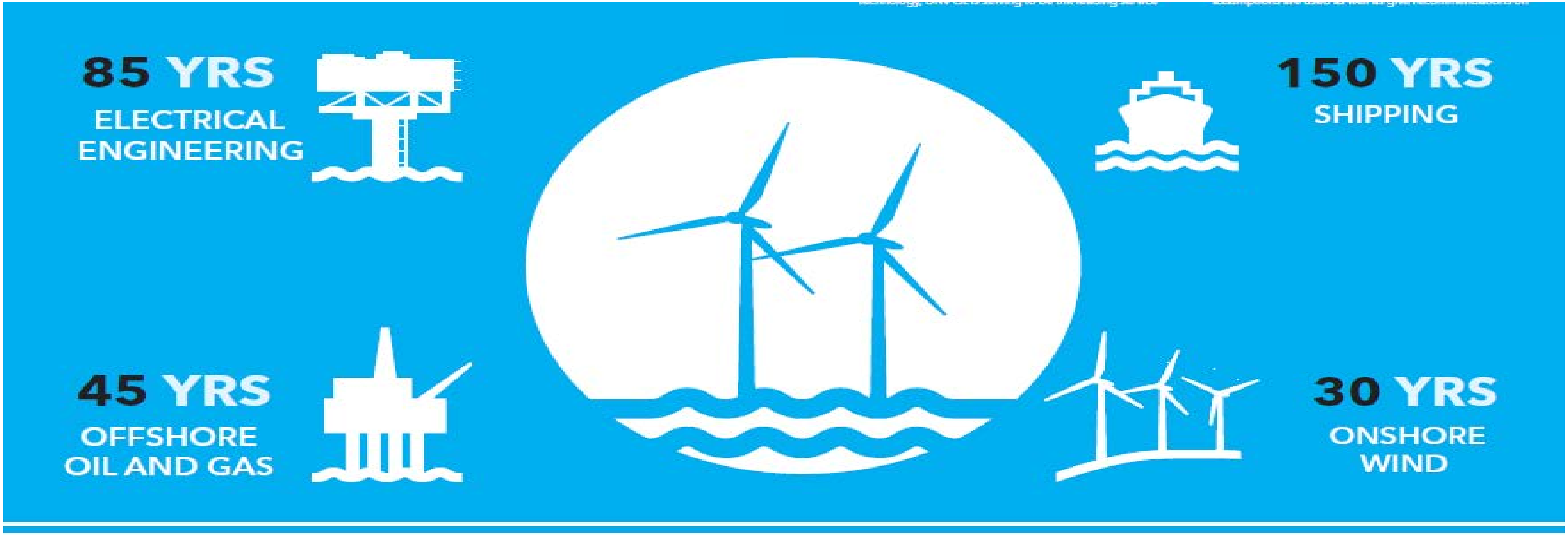
Presentation outline

- Leveraging on experience – Offshore wind industry
- Background to the WIN WIN JIP
- Brief introduction to Floating Wind
- The innovation project and it's different phases
- Summary and conclusions
- Q&A

Leveraging on experience – Offshore wind industry

DNV + GL + KEMA + Nobel Denton + Garrad Hassan = DNV GL Energy

The world's largest certification and advisory firm in renewable energy



Assessing a new concept for water injection, utilizing wind power

WIN WIN is a concept for a **new generation of oil recovery technology** currently being assessed. It comprises a **floating wind turbine** which supplies power to a **water injection process.** The concept is a fully stand-alone system that includes pumps and basic water treatment. Our ambition is that WIN WIN will **reduce costs, increase flexibility, and reduce emissions.**

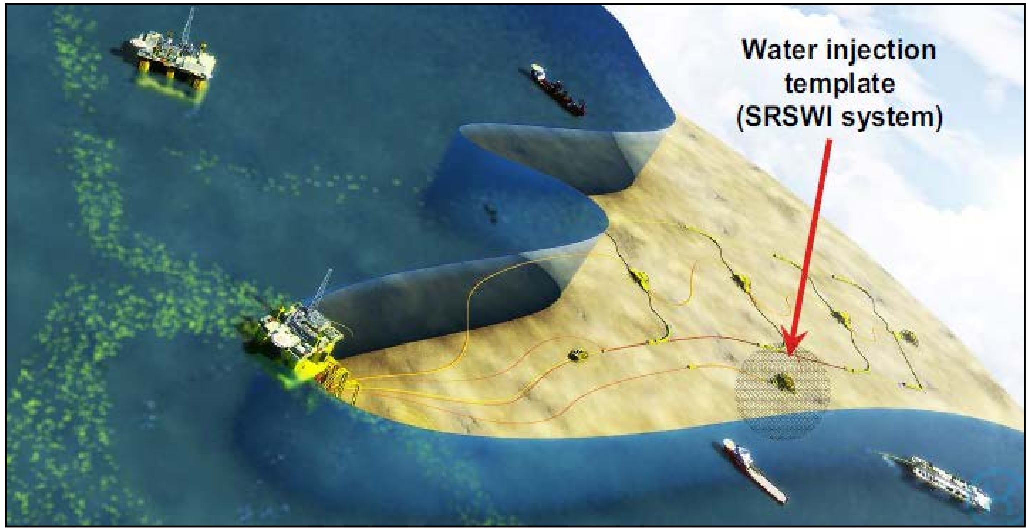
WIN WIN phase 1 main conclusions

1. Commercially competitive alternative in a range of cases
2. No technical showstoppers identified
3. Technically feasible

Background - Inspiration for the WIN WIN project

Successful operation and deveopments of floating wind technology

The development of EOR technology / Tyrihans Raw Seawater injection for EOR



Winter 2013/2014
Idea developed internally

April 2014
Concept first presented at OTC with call for a joint industry project

February 2015
Partnership formed and project started

May 2016
Project results presented at OTC

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Phase 2, pilot testing and commercial project

WIN WIN (Phase 1) – A joint industry project

DNV·GL

ExxonMobil

eni

Statoil

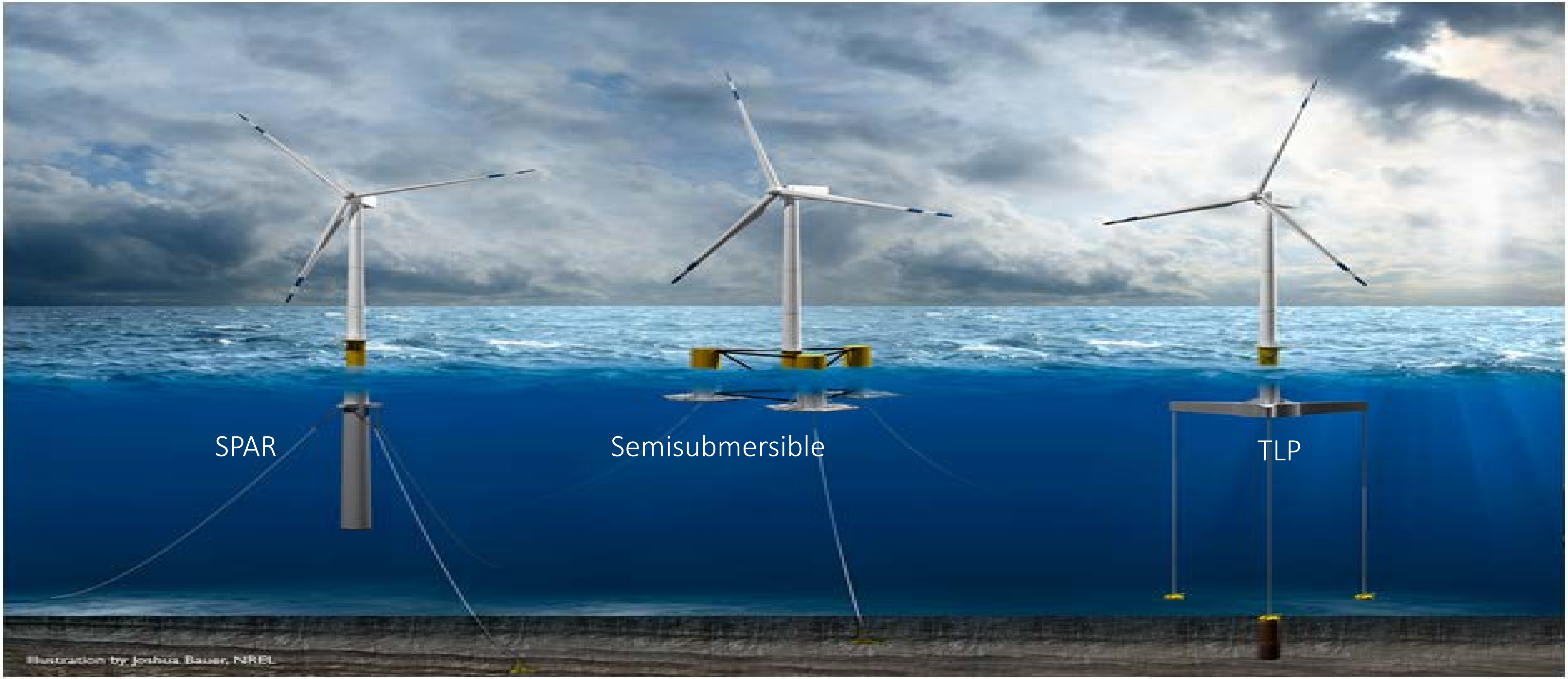
nexen
A CNOOC LIMITED COMPANY

VNG
Norge

CATAPULT
Offshore Renewable Energy

PG FLOW SOLUTIONS

Floating wind turbines – Three key philosophies



NREL

Key milestones for floating wind technology

- 2009: Hywind demo – 1st spar buoy
- 2011: WindFloat demo – 1st semi-sub
- 2012: Kabashima/Goto Spar – 1st concrete/steel

- 2012: VolturnUS – 1st concrete semi-sub
- 2013: Compact Semi – 1st of the Fukushima demonstration unit
- 2013: Fukushima floating substation – 1st floating substation

Use case and system specifications

Geographic location: *North Sea*

Water depth [m]: *200*

Distance from production host [km]: *30*

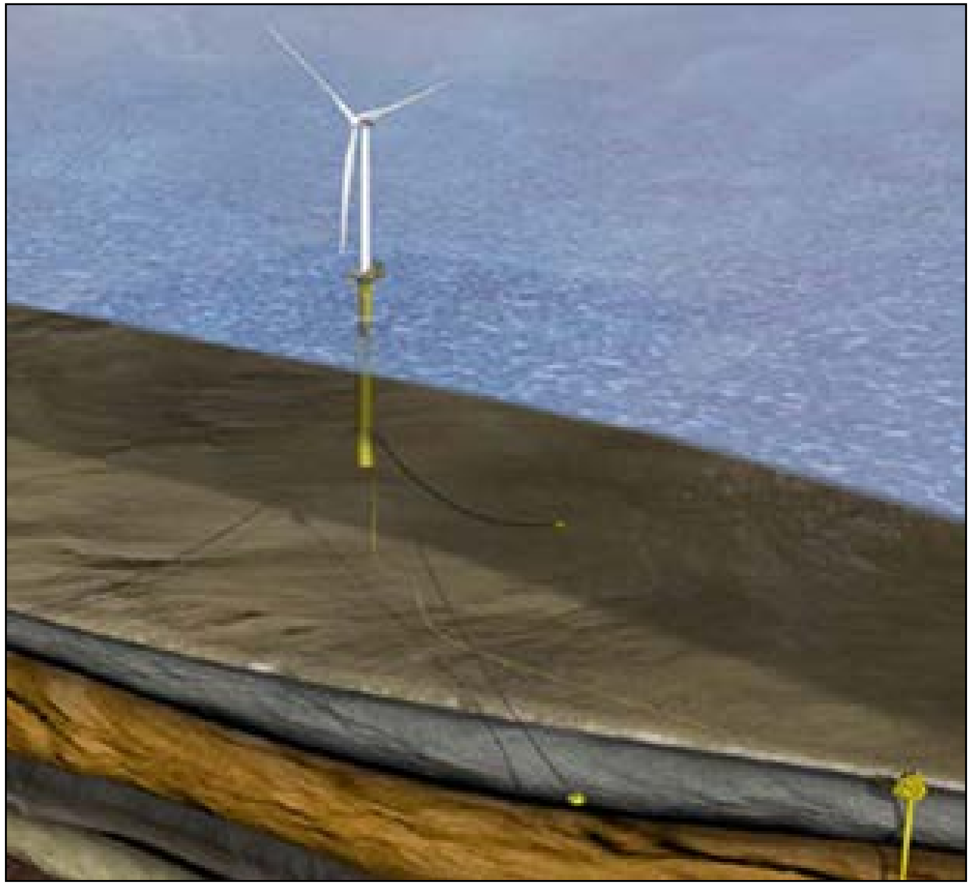
Reservoir conditions: *1 template, 2 injection wells, normal injectivity*

Target injection rate [bbl/d]: *44 000*

Maximum injection rate [bbl/day]: *81 000*

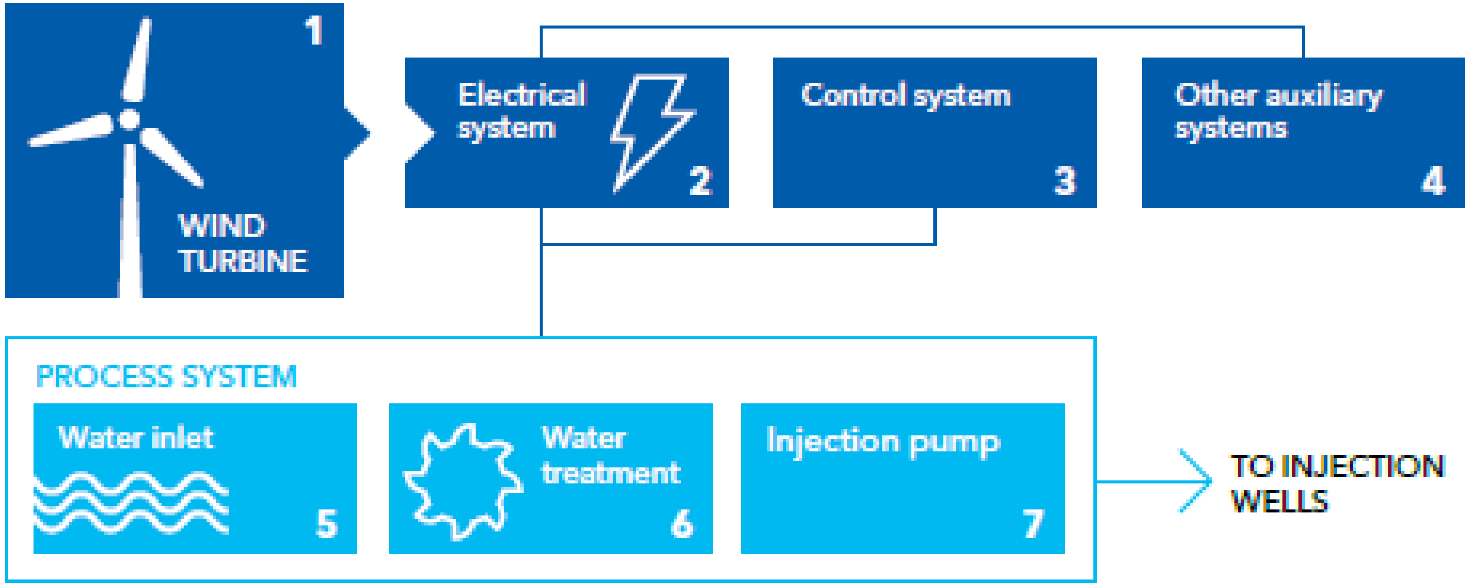
Maximum pump discharge pressure [bar]: *130*

Water treatment requirements: Water filtration / chemical injection



The system


Injection pump units x2
Shaft crane
Chemical injection
Filtration units x2
Wind turbine & tower
System package
Hydraulic power unit
Control container
Chemical storage
Drain drum and pump
Dump load unit
Offshore davit crane
Mechanical package
Laydown area
Exit ladder to boat landing
Boat landing


1
WIND TURBINE
Electrical system
2
Control system
3
Other auxiliary systems
4
PROCESS SYSTEM
Water inlet
5
Water treatment
6
Injection pump
7
TO INJECTION WELLS

The base case configuration and its functionality

1. A standard wind turbine is mounted to a floating foundation. This foundation also serves as a platform for the water injection system.

2. An electrical micro grid enables controlled start-up and shut-down of the system, and ensures that power demand matches power supply during operation. A battery bank ensures power to critical safety and communication functions during periods of no wind.

3. Communication with the host platform is enabled through satellite communication. A conventional control umbilical can also be used.

4. The system uses sea water, which is pumped topside using lift pumps.

5. The sea water is filtered down to 50 micron using a vertical disc filter with backwashing capability.

6. The water is treated with chemicals. Chemicals are stored on board in vessels, and refilled during other maintenance activities on the platform.

7. Water is injected into the reservoir by injection pumps.

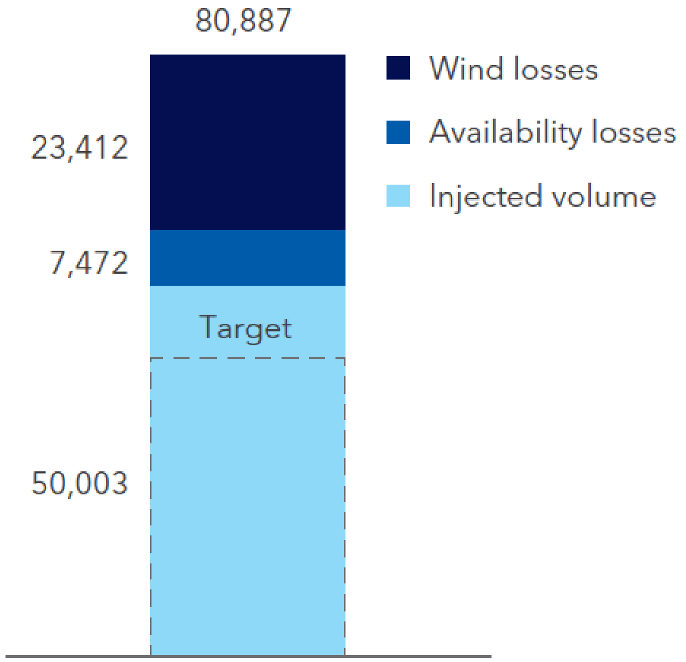
Performance of WIN WIN

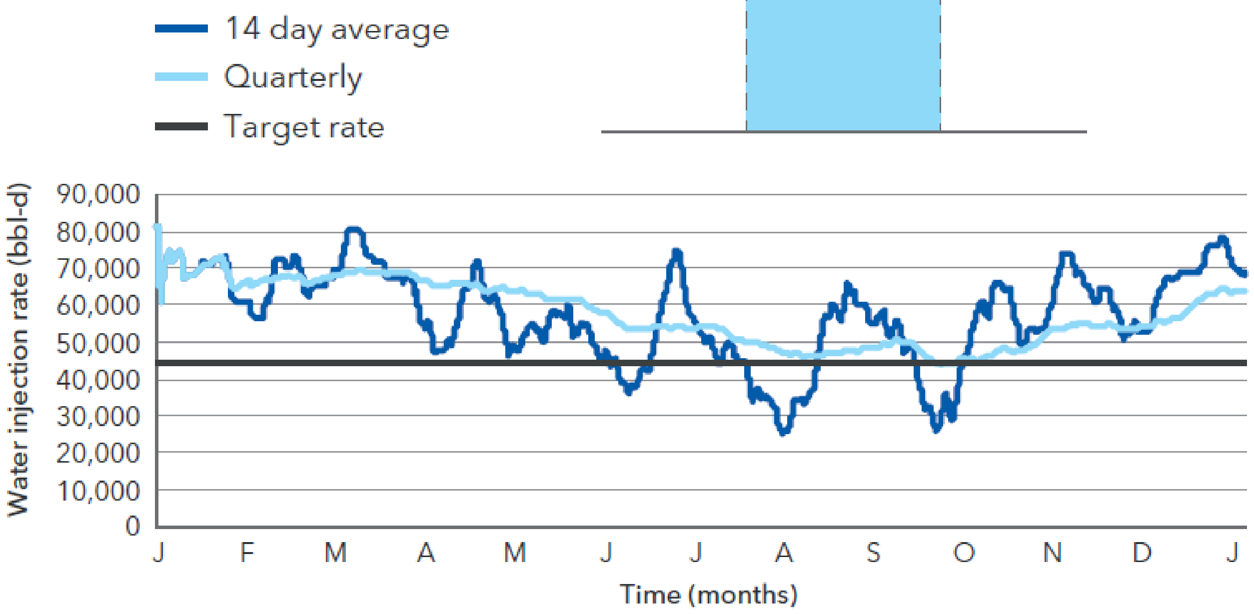
- The WIN WIN concept has shown that it can meet the demands in relation to set requirements

- Key performance issues addressed in the project include delivering required injection volumes, understanding overall availability as well as investigating start-stop cycles and downtime.

- For the use case considered and others, WIN WIN exceeds target injection rates over time.

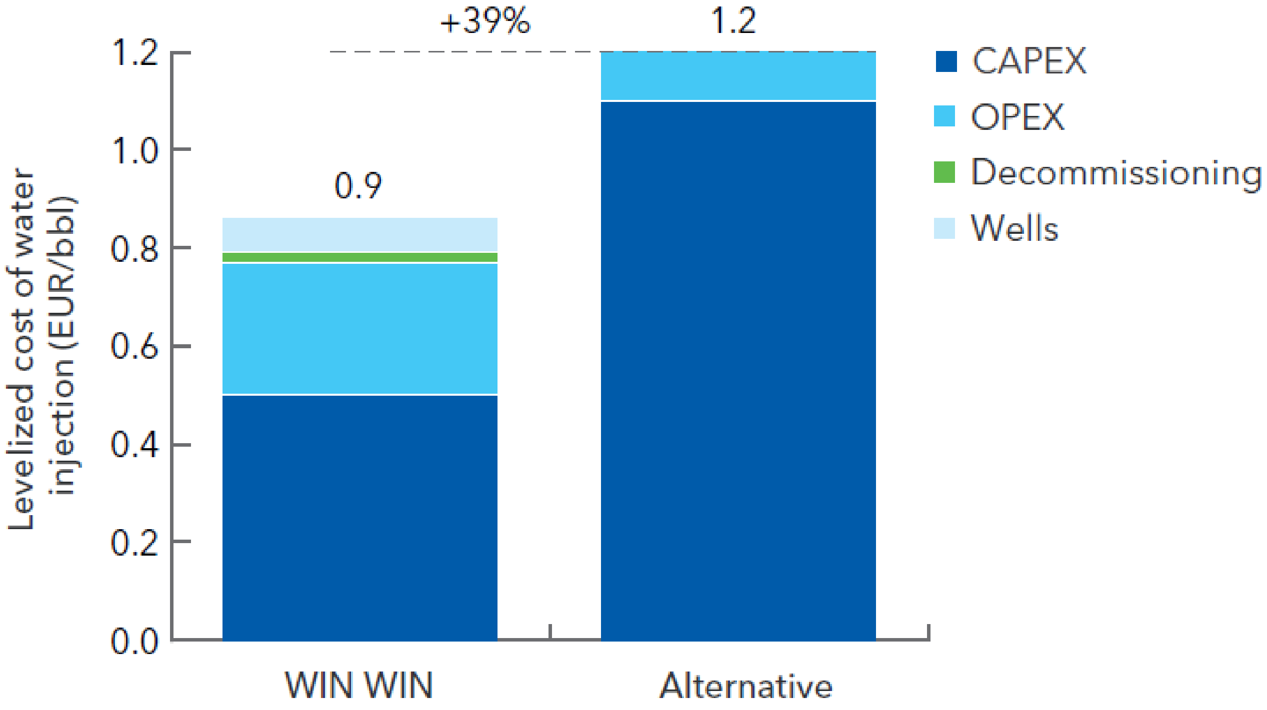
- Injection volumes over time have been simulated based on realistic wind-data for the use case, showing that volumes exceed target rate, despite some periods of low wind.





WIN WIN is cost competitive for suitable fields

- The use case costs have been compared with a conventional alternative where water injection is accomplished with a flowline from the host.
- While WIN WIN has higher operational expenditures compared to a conventional alternative, the significantly lower capital expenditure means that it comes out comparable in 20 year life-cycle comparison.
- WIN WIN is therefore a commercially competitive alternative in a range of cases, and especially when host platform capacity is limited or injection wells are located far away.



* Only includes difference in well cost, full well cost not included

Develop the WIN WIN concept along four pathways Validate, Innovate, Reccomend and Explore

WIN WIN Phase 2 –Work Packages (WP)

A. Validate		B. Innovate		C. Recommend	D. Explore
A.1	A.2	B.3	B.4	C.5	D.6
Electrical system validation	Detailed assessment of pump type, performance and reliability	Detailed technology assessment of water treatment systems	Identify and assess opportunities to improve reliability and reduce OPEX	Development of guideline for design and operation of WIN WIN	Identify other applications where wind power could prove a cost-effective solution for the oil and gas industry

Thank you

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