An outlook on the integration of North Sea energy systems

Erwin Niessen – EBN erwin.niessen@ebn.nl
Graciela Fernandez Betancor – NAM g.fernandez-betancor@shell.com
Joris Koornneef – TNO joris.koornneef@tno.nl

KIVI, Oil & Gas Technology – The Hague, June 5th, 2019

Koninklijk Instituut Van Ingenieurs

Afdeling Olie- en Gastechnologie

Lecture 'An outlook on the integration of North Sea energy systems'

The Netherlands' ambition is to transition from a fossil fuel dominated society to a new energy mix which is predominantly sustainable. However, this should be cost effective, have societal support, security of supply needs to be ensured and (in)dependence of foreign nations should be considered. Based on this the offshore wind energy has been very successful in delivering large and cost effective windfarms on the North Sea. The power of these windfarms is delivered to shore via high voltage cables which have no connection to the existing offshore gas infrastructure. With the increasing capacity of wind energy, transport and storage of energy might becoming an issue.

There is a large opportunity to (re-)use the existing gas infrastructure by connecting these to the windfarms. This will allow electrification of offshore platforms and thereby reduce offshore CO2 emissions. Several possibilities of electrification of offshore platforms are been studied and the most promising opportunities are currently in development. Turning these existing offshore gas platforms from gas driven into electrical driven, confronts the developers with many challenges.

In the future electrified platforms will in turn enable a more optimal use of the windfarms. In the future, the HV connection can also be used to minimize curtailments of windfarms due to strong winds by converting electricity to H2 (P2G) and spike the H2 in the gas pipelines and transported onshore. In addition, the connection can be used to provide the power required for CCS offshore.

During this lecture an overview of the current situation, opportunities, technical challenges and a glance of the future perspectives of the possibilities of offshore electrification will be presented. In a rather unique setup, the presentation will be done by representatives of three different stakeholders; each giving their own unique view of the main challenges ahead.

Speakers resume

Erwin Niessen graduated as mechanical engineering at the University of Eindhoven in 1997. Starting as a mechanical and process engineer at a Dutch EPC contractor, he had several roles in engineering, procurement, construction management and project management. In 2005 he joined Essent (later RWE) where he has led a mechanical department, led project teams and served operations with a team of technical and projects experts. In 2015, he joined EBN where he has a strong focus on innovations, cost optimisations, sustainability and collaboration. With his technical and managerial skills, together with his strong focus for collaboration, he leads various innovations and developments in the energy transition and system integration.

Graciela Fernandez Betancor is Concept Engineer at NAM. Graciela Studied Chemical Engineering at Imperial College London and joined Chevron in 2007 straight after graduation. Throughout her career she has had a numbers of roles in process engineering, operations support and Front-end engineering; which she focused on since she joined Shell in 2014. In the last two years she has been dedicated in realizing front end opportunities in the energy transition area with particular focus on Electrification of offshore assets and CCS in NL.

Joris Koornneef has a background in Science & Innovation Studies at Utrecht University. He is active in the field of zero emission power, or even carbon negative technologies, since 2005. He holds a PhD on the health, safety and environmental impacts of CCS. At ECN.TNO he currently supports the implementation and use of the subsurface within the energy transition towards a low carbon society. His focus areas are subsurface energy storage and energy transition opportunities in the North Sea. Joris is the scientific Lead of the North Sea Energy programme on offshore energy transition and system integration in the North Sea area.

Introduction

Offshore system integration by electrification

By Erwin Niessen (EBN)

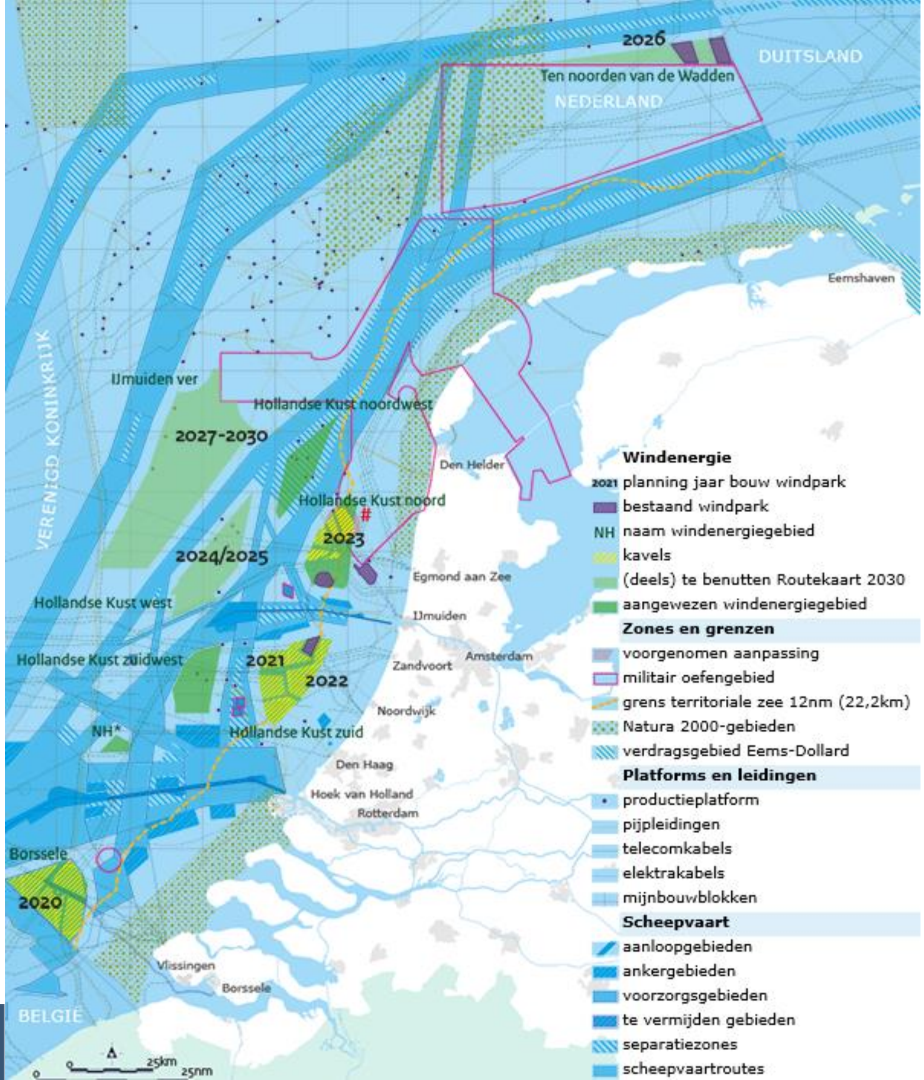
Electrification Lesson Learned

by Graciela Fernandez Betancor (NAM)

Future perspectives

By Joris Koornneef (TNO)

Source: https://www.noordzeeloket.nl/functies-gebruik/windenergie-zee/interactieve-kaart/

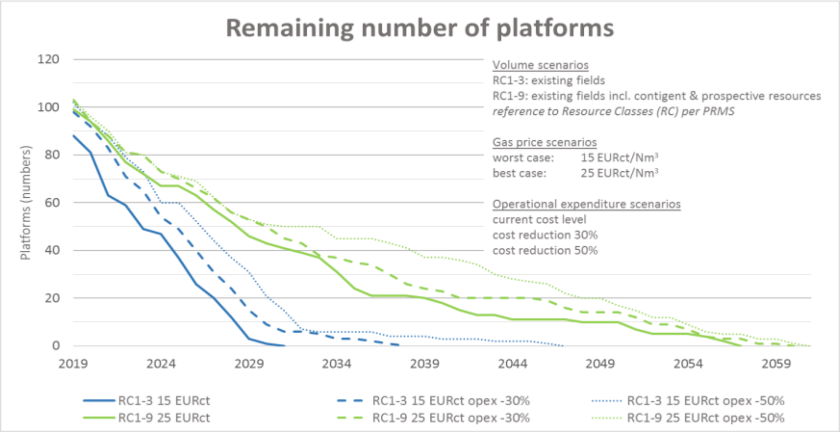


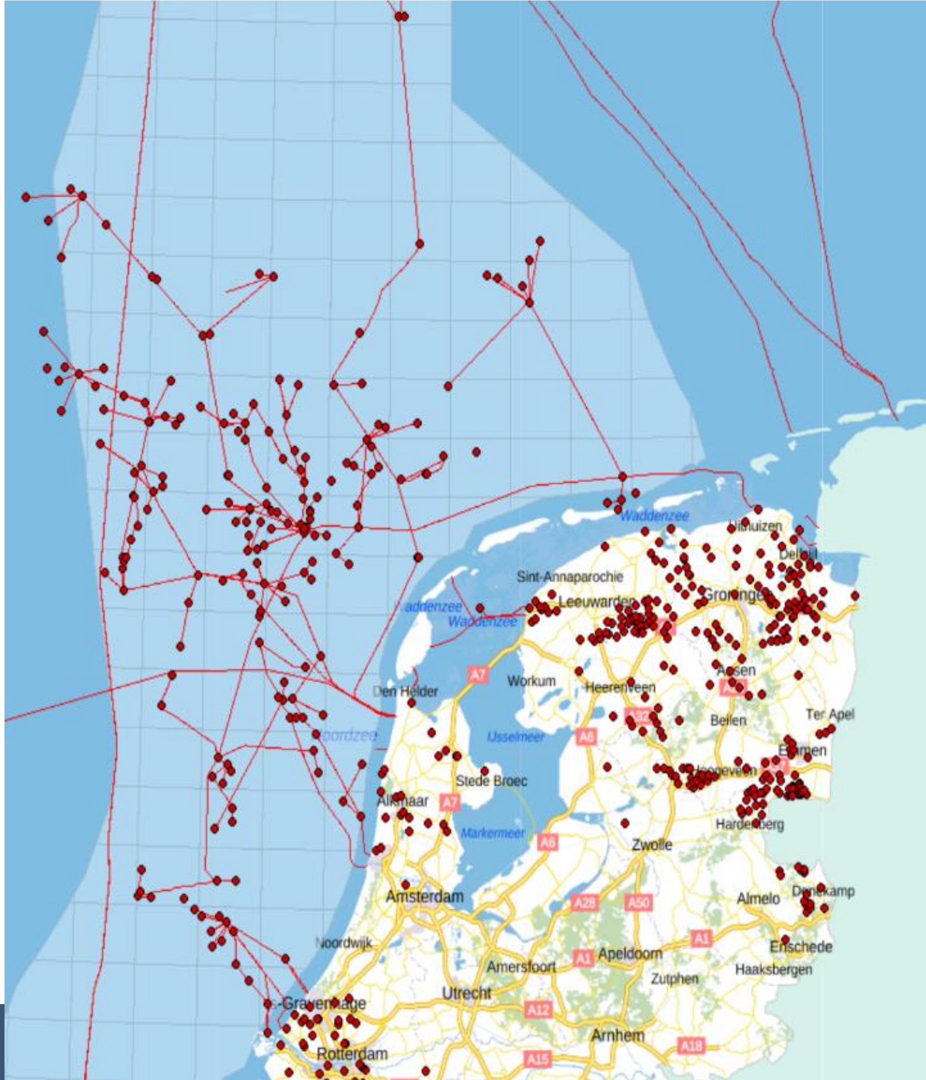
The Dutch national challenge

A change in the energy production, generation and consumption is necessary

Current situation: Offshore gas production

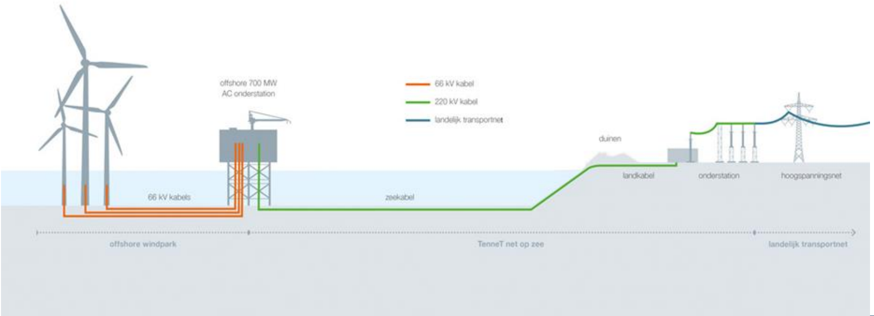
- A large gas infrastructure exists
- Gas production requires energy for gas treatment and compression
- Gas production is in decline
- Large energy consumers remain in operation for decades



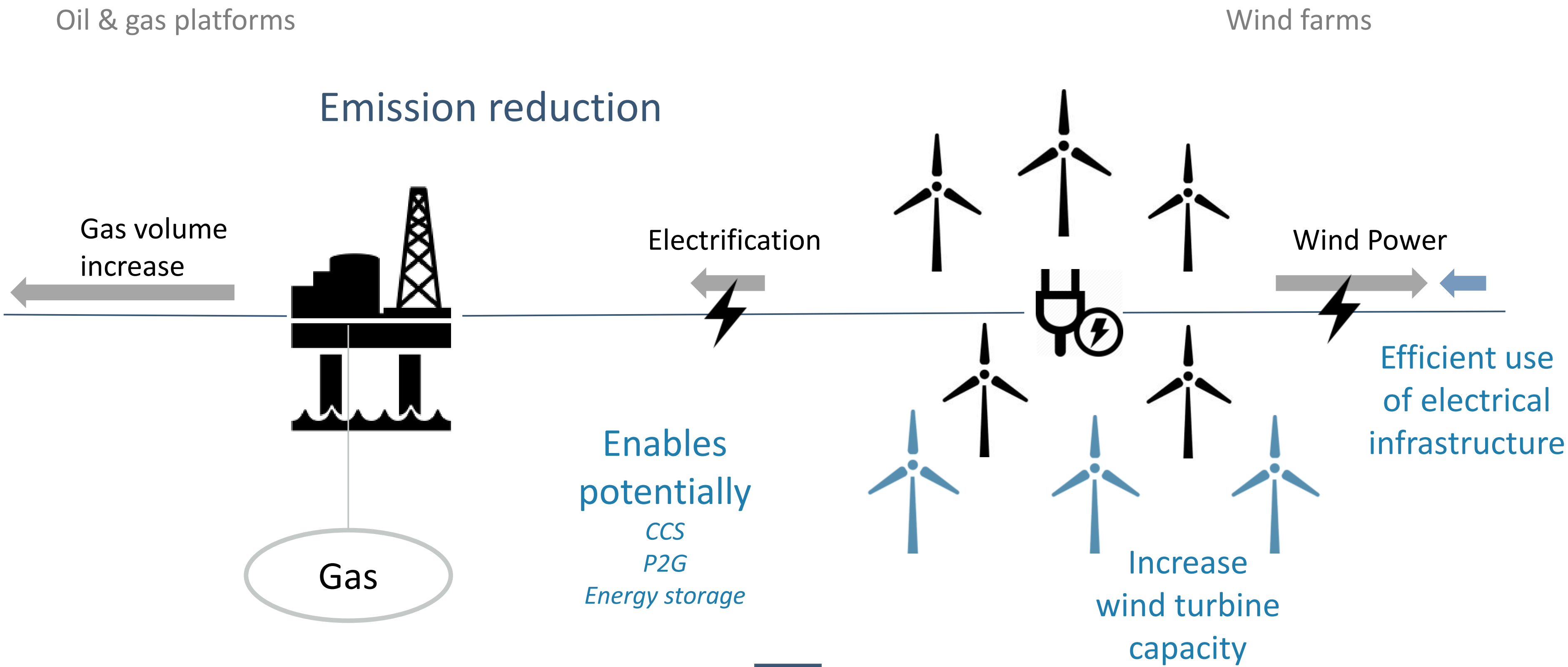


New developments: Offshore wind farms

- Wind farm areas are under development
- A large wind farm capacity has to be installed by 2030 (11.5 GW)
- An extension of the electricity grid is to be developed
- A new energy infrastructure arises



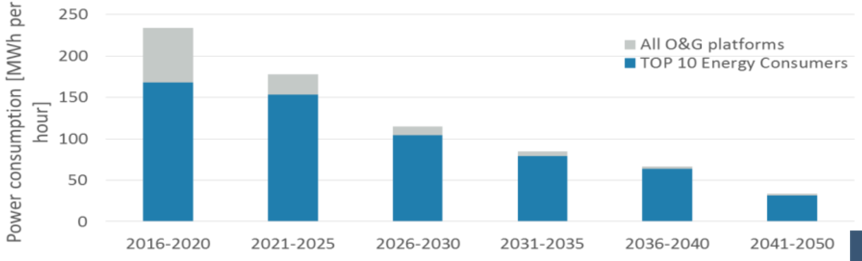
The opportunities for offshore electrification

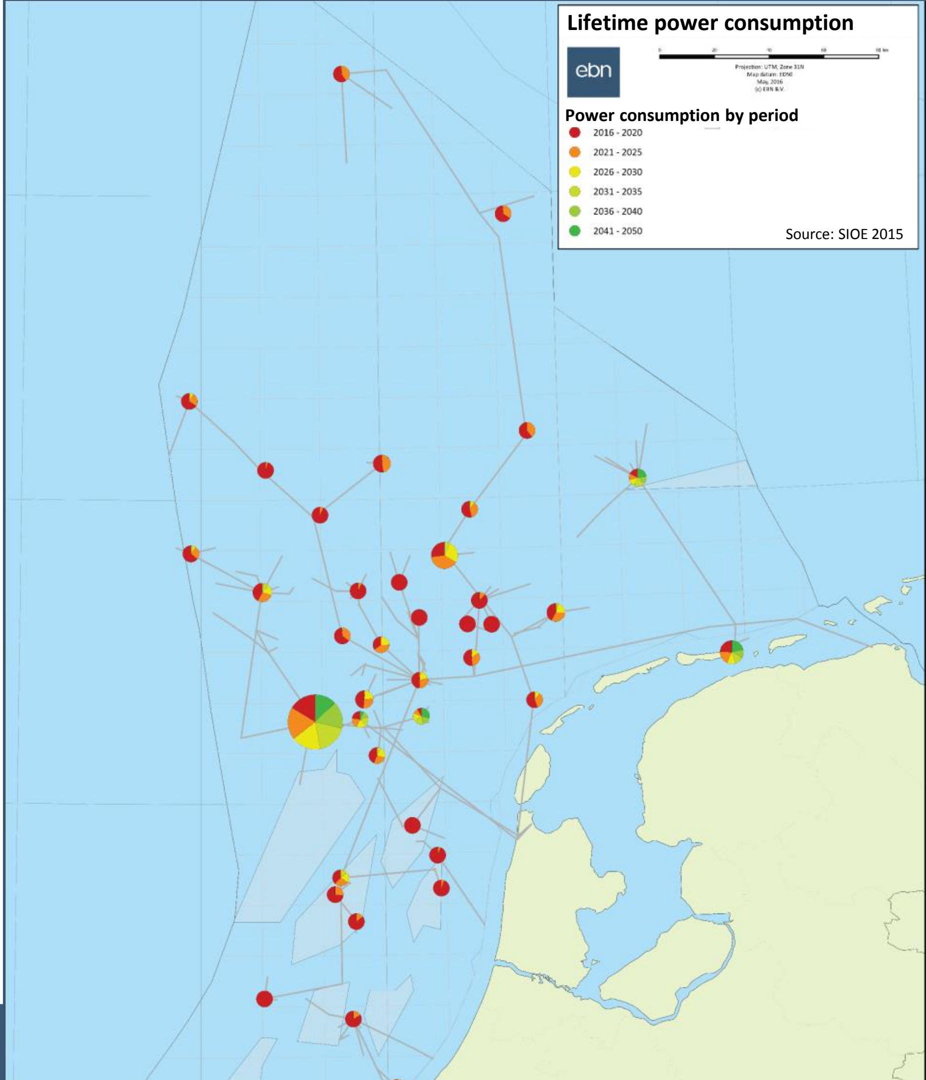


Next developments: System integrations

- The energy consumption on a hub platform is dominated by the gas compression
- The installed power generation on a hub platform is 15 to 35 MW
- But, the window of opportunity for electrification is narrowing

Power consumption forecast of offshore platforms on the DCS
(source: SIOE, 2015)



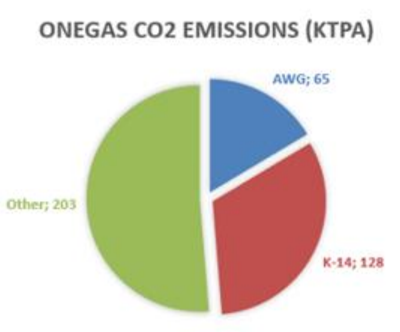


Electrification Lesson Learned

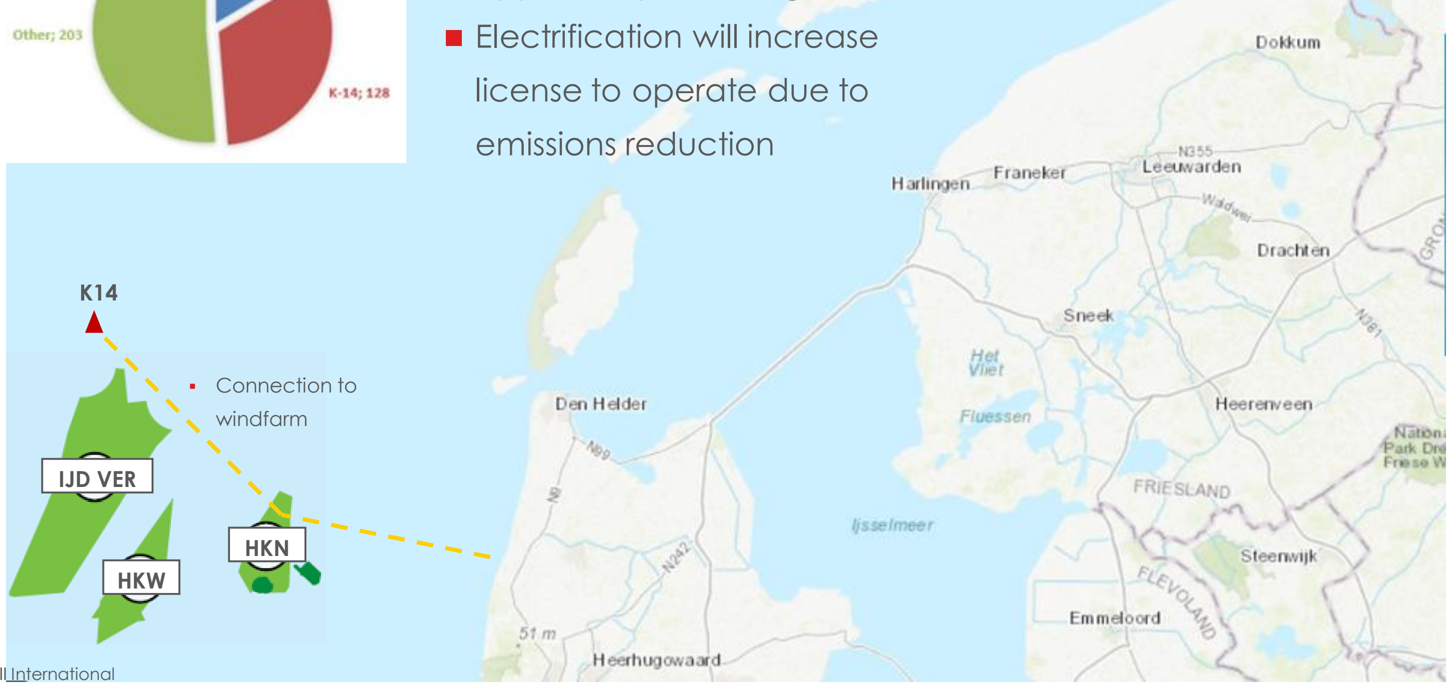
March 2019

Graciela Fernandez
Concept Engineer

AWG vs K14 Electrification: Same Goal, Different Challenges

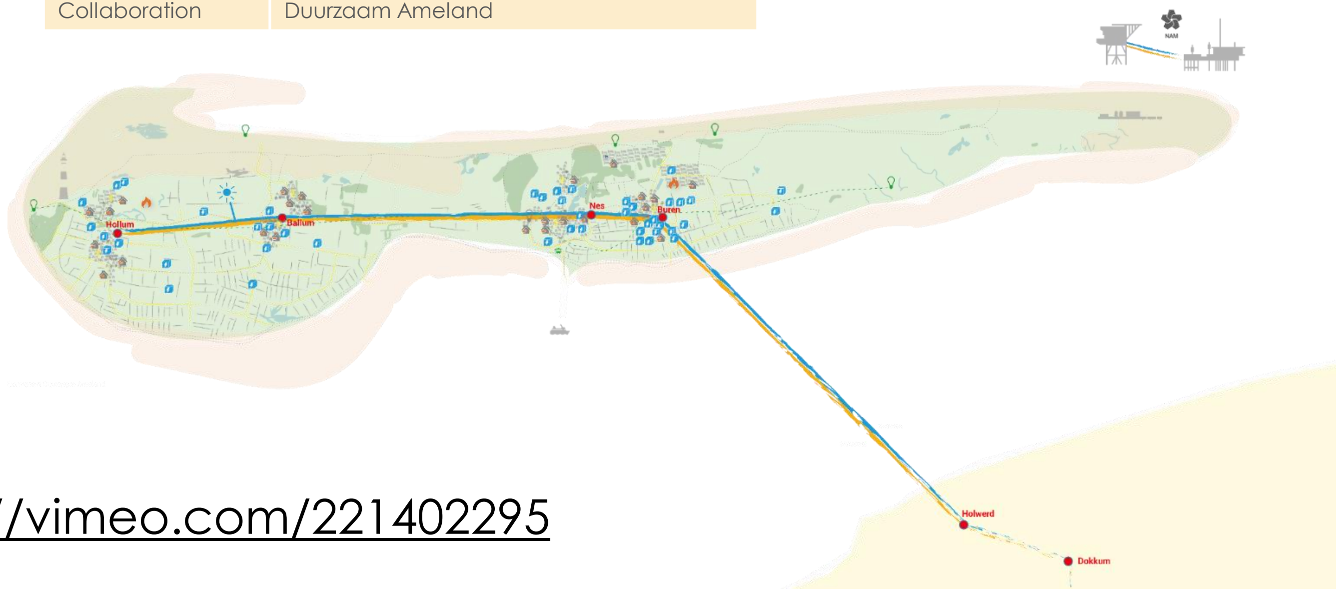


- Electrification constitutes the largest CO_2 abatement opportunity for ONEgas
- Electrification will increase license to operate due to emissions reduction



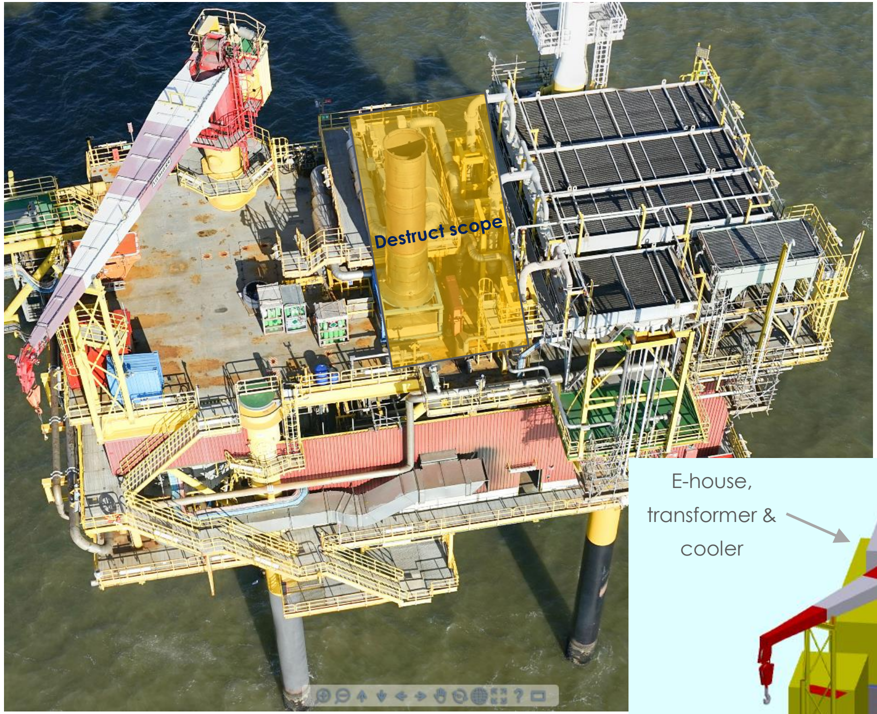
AWG Electrification Overview

Project Indicator	Status
Project Status	Starting Basic Design Engineering
Onstream Date	2022
CO_2 Savings	62 kton/yr
Connection	20kV 4km, Direct to Grid
Collaboration	Duurzaam Ameland

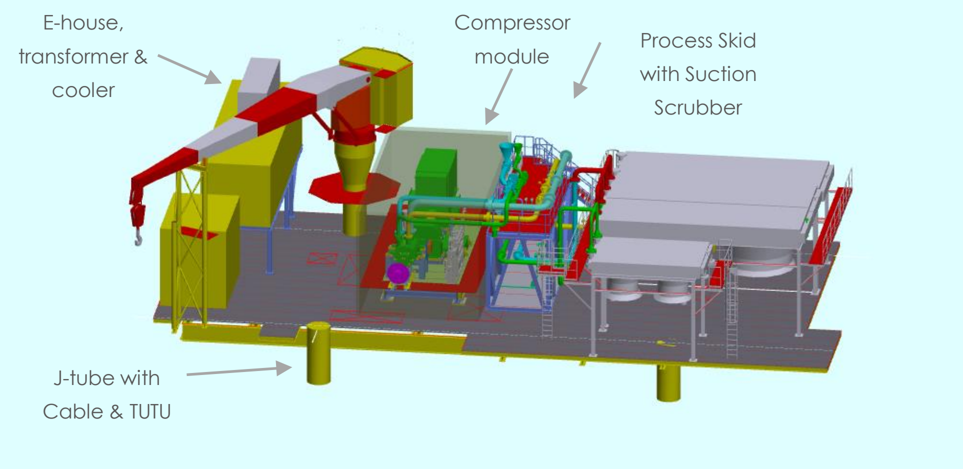


https://vimeo.com/221402295

AWG Offshore Electrification Scope

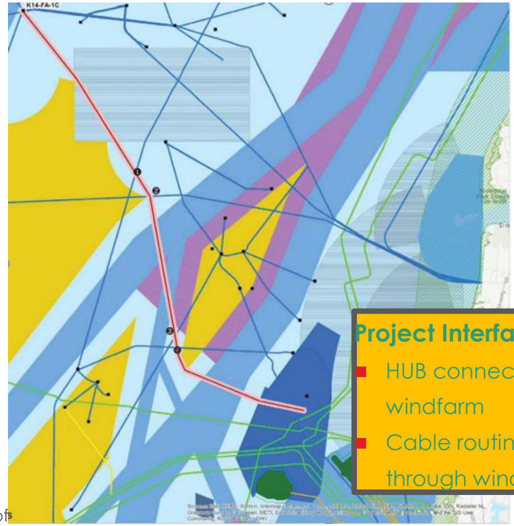


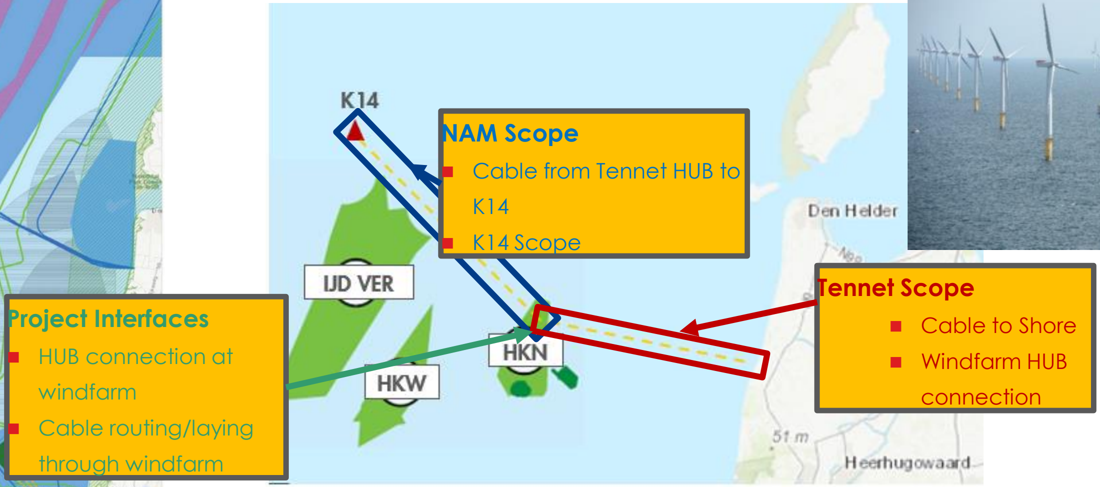
- New 6 MW E-compressor, 2 stage
- New Suction Scrubber
- New E-house, transformer and trafo cooler
- Re-use existing interstage coolers and suction scrubber
- AWG Brownfield Tie-ins
- Decommission Eductor and Exhaust
- New Cable from AME-1
- AME-1 Substation & Brownfield Mods
- New utilities for compressor: N2 seal purge and instrument air purge for EXP-motor
- HLV required to support execution

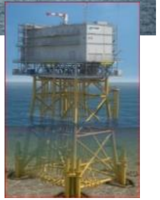


K14 Collaboration Overview

- In 2018 a joint project team was established to further progress the opportunity.
  - NAM Operator of JDA Assets. Responsible for Cable from Windfarm to K14 and offshore K14 scope.
  - EBN Their role is to enable through expertise, participation & influence, strong support to make the Energy Transition happen, particularly in liasing with EZK
  - TenneT Responsible for connecting new offshore windparks to the national grid. TenneT will provide a connection at their HUB in the windfarm. The windfarm development is not TenneTs responsibility, this will be tendered by EZK (owner will be known in 2020)



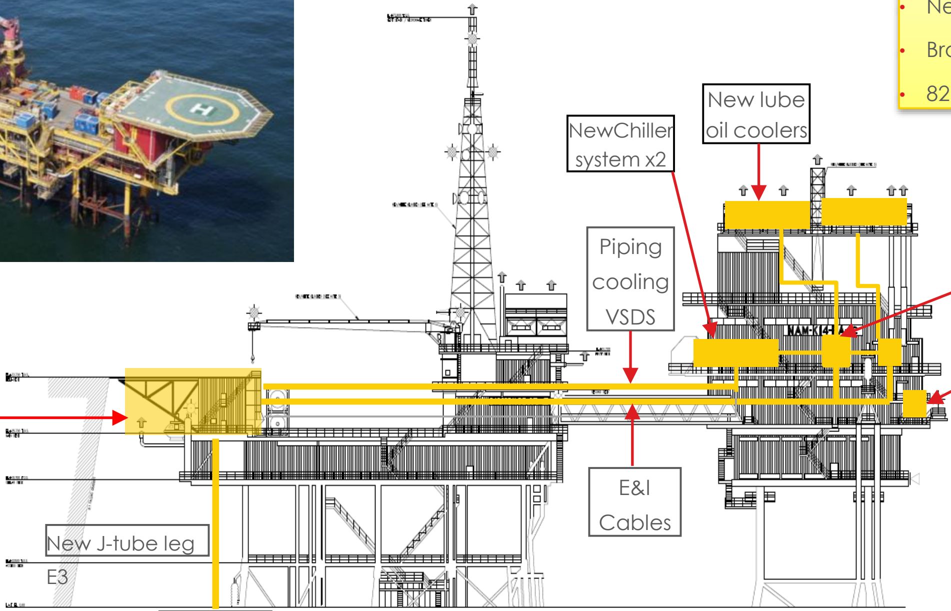




K14 Offshore Electrification Scope

Scope Overview K14

- Replace 2x Gas driven compressor engines with 30 MW electrical motors
- New e-module with switchgear for e-motors
- New supporting utilities for e-equipment
- Brownfield tie-ins
- 82km, 66kV cable and J-tube.



North Sea Energy

offshore system integration

Future perspectives

Joris Koornneef (ECN.TNO)

Research program aimed at research & development of opportunities for system integration by integrating offshore wind and gas

Strategic Spatial Planning

Scenario development for spatial synergies now and in the future

Society & Governance

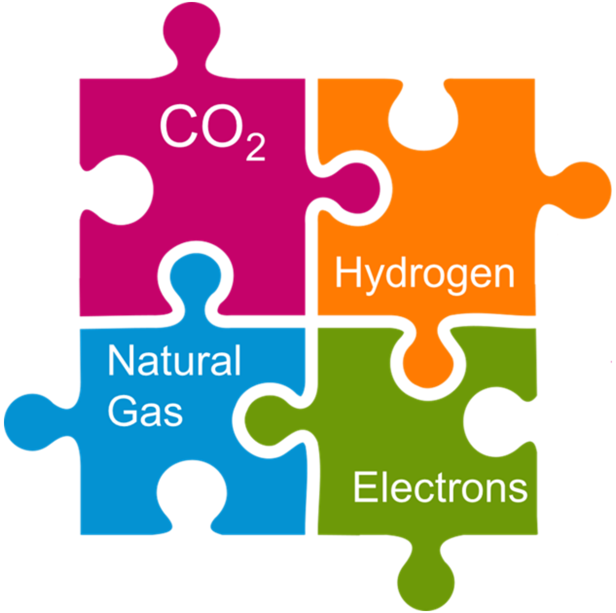
Human Capital, Public Engagement and Regulations

Physical Networks

Techno-economic evaluation of various system integration options

HSE

Health and Safety, Emissions and Environment



North Sea Energy offshore system integration

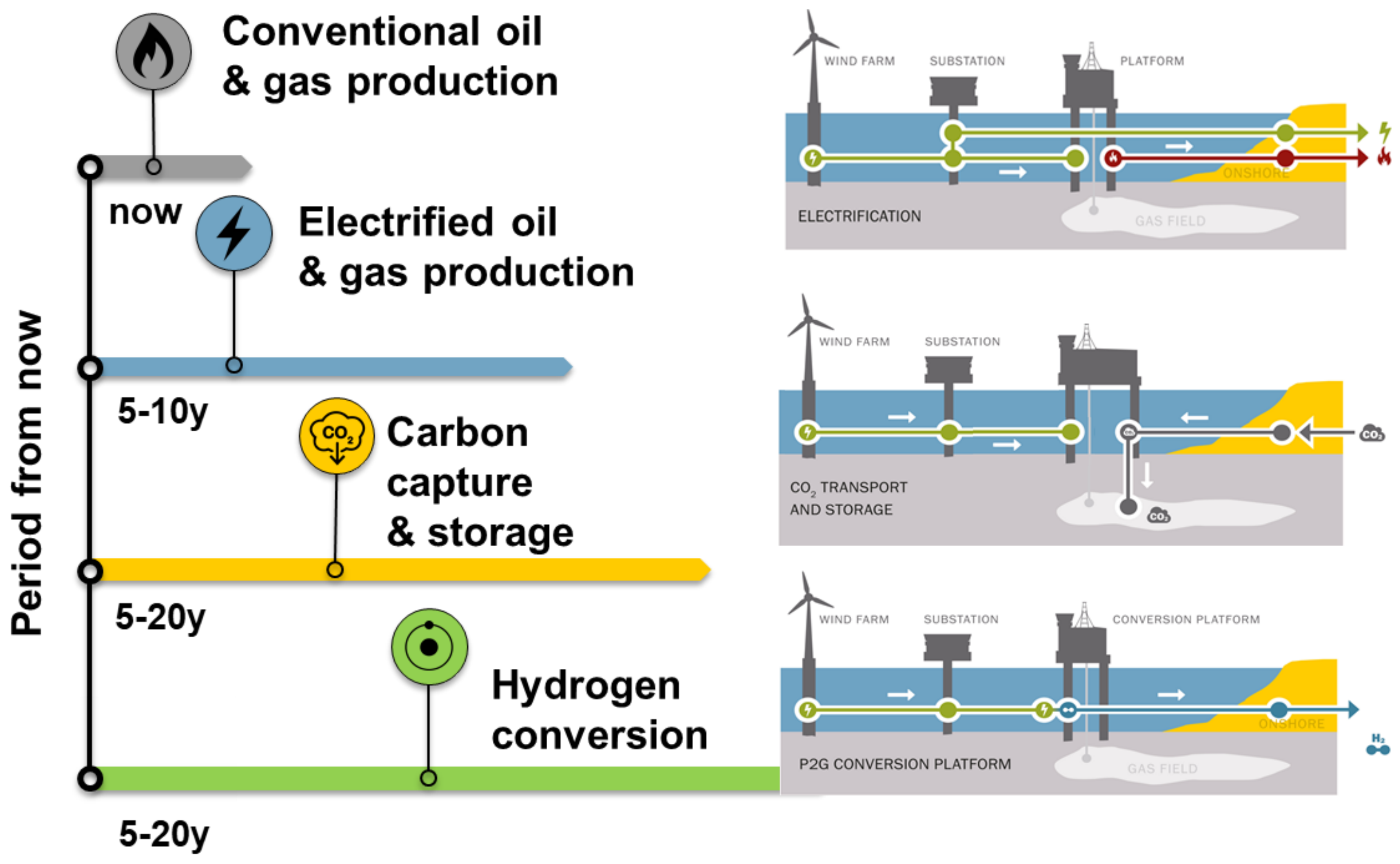
In collaboration with:

TNO
New Energy Coalition
university of groningen
Hanzehogeschool Groningen University of Applied Sciences
NEN
dana PETROLEUM
Van Oord Marine ingenuity
ORANJE-NASSAU ENERGIE
BILFINGER TEBODIN
gasunie
NAM
ebn
TOTAL
DEME Dredging, Environmental & Marine Engineering
Boskalis
XKP
Oil & Gas Authority
NEPTUNE ENERGY
Royal HaskoningDHV Enhancing Society Together
GasTerra
Hint
YOKOGAWA

System integration options

Development of large-scale offshore wind can be integrated with offshore gas infrastructure along the following main options:

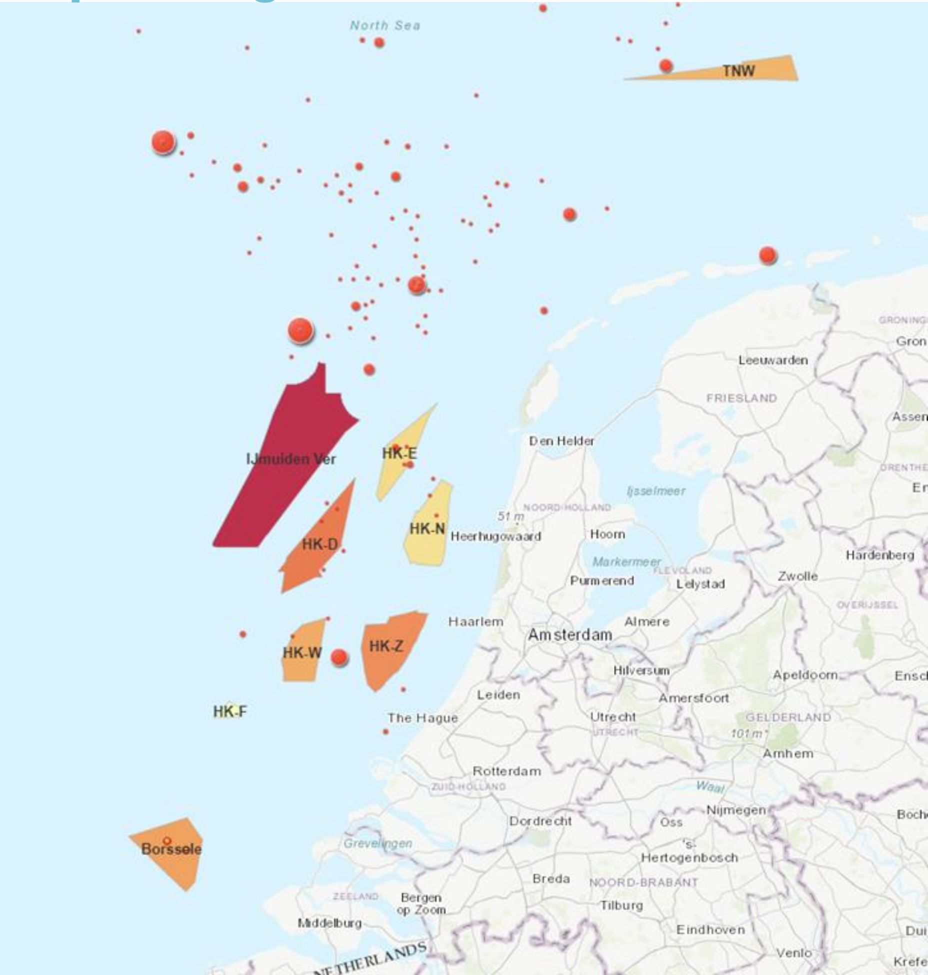
- **Electrification of offshore gas platforms**
- **Power to Gas**
- **Carbon Capture and Storage (CCS)**
- **Gas to Wire**
- **Energy storage**



North Sea Energy
offshore system integration

Work in progress: Strategic offshore power grid

- Shared power grid to electrify low hanging offshore fruit
- Costs & Value for oil and gas operators
- Costs & Value from power grid & wind perspective
- Costs & Value Netherlands



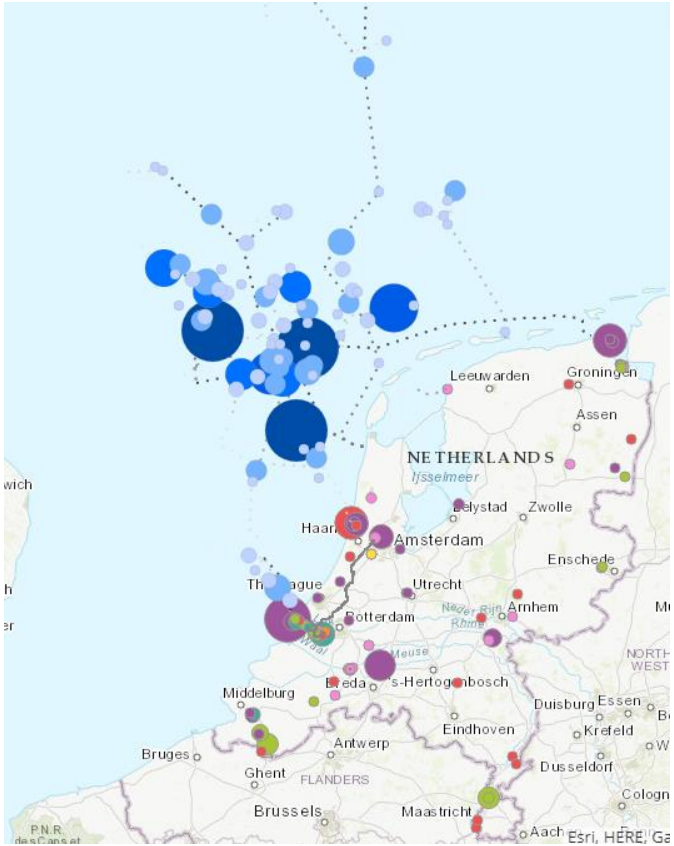
North Sea offshore system integration Energy

Trends: Carbon Capture and Storage

Coalition agreement (PBL update): implementing carbon capture and storage (CCS) with up to 7 Mt of CO2 storage per year by 2030

In the scenarios by PBL CCS is estimated to considerably grow towards

- 2050 → 45 MtCO2/yr.



North Sea energy Atlas http://www.north-sea-energy.eu/atlas.html

North Sea Energy offshore system integration

Current CCS activities in the Netherlands

- Rotterdam harbour: Porthos consortium
  - Target ~5 Mtpa by 2030; to grow beyond 2030
- Steel plant (TATA Steel)
  - HIsarna process: pilot – demo – plant
  - 0.1 – 0.5 – 2-3 Mtpa
- Waste processing
  - Capture projects (CCU) starting or ongoing
- 3Dproject France: 8 Mtpa

Market incentive needed

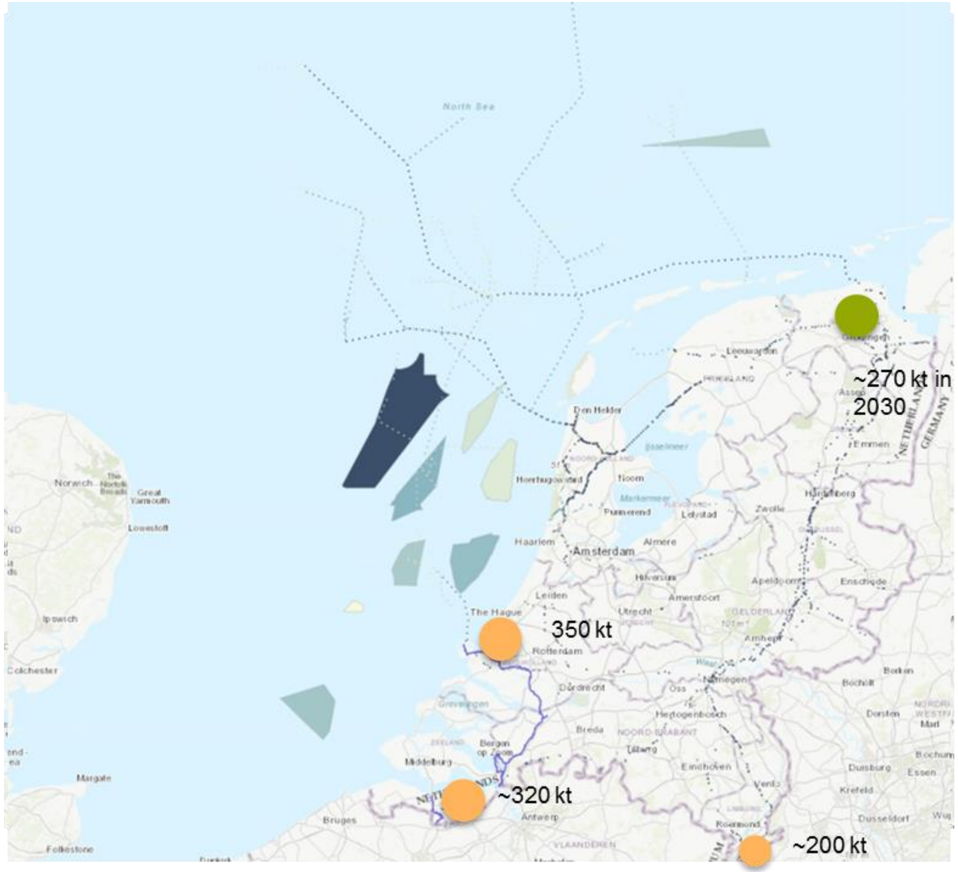
Transport and storage of CO_2 in NL, 2017

Trends: Hydrogen

- Current demand 0.8 million ton hydrogen
  - Ammonia
  - Refineries

- Future sector growth expected in:
  - Industry
  - Mobility
  - Electricity

Theoretical demand potential 14 Mt H_2



North Sea energy Atlas http://www.north-sea-energy.eu
Contouren van een Routekaart Waterstof 2018
NIB De Groene Waterstofeconomie in NoordNederland 2017

North Sea Energy offshore system integration

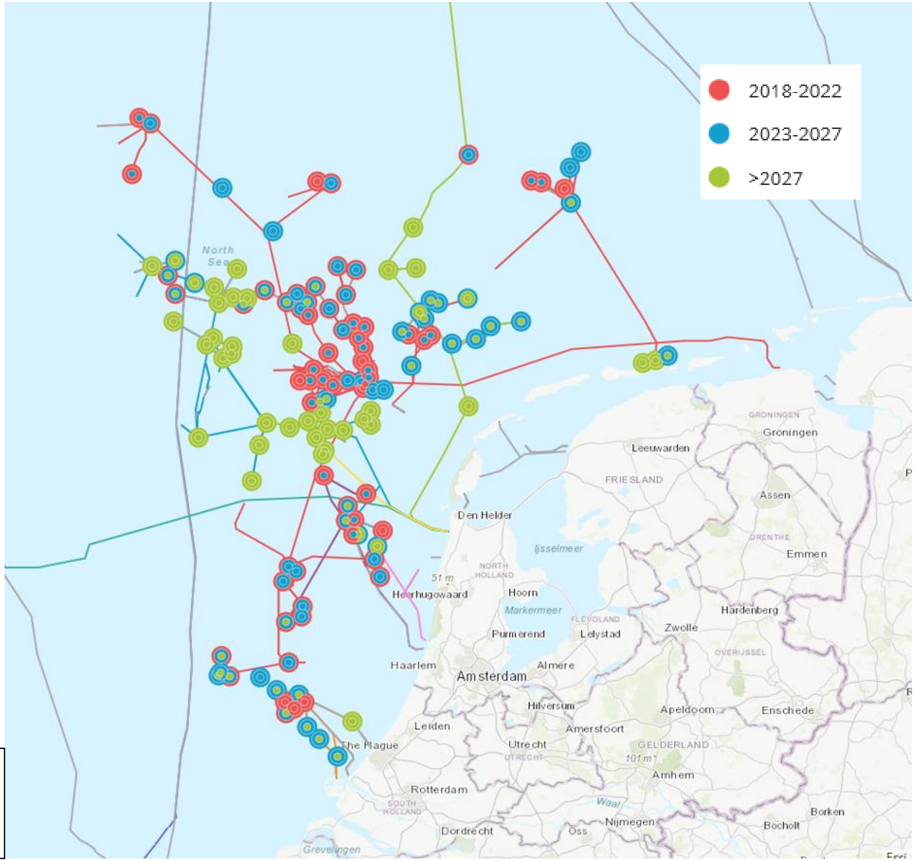
Power to hydrogen: Advantages, but not the holy grail!

- Decoupling of supply and demand for energy
- reduces congestion problems
- H2 can be transported and stored in large amounts; re-use gas infrastructure
- Hydrogen can be used as a green gas for sectors that cannot completely be electrified (e.g. industry, transport)
- Current hydrogen supply can become green
- Hydrogen may be used as green feedstock

- Requires space offshore / onshore
- Competition with other flexibility options
- Not competitive with grey/blue hydrogen
- Admixing or pure transport: technical and legal challenges
- Volume market for green hydrogen

Challenges: availability of infrastructure

1. Timing of build up of wind
2. Timing of cessation of production Oil and Gas
3. Size & weight constraints H2 production on platform
4. Synergy and conflict with CCS



Cessation of Production: fast, most likely & slow scenario

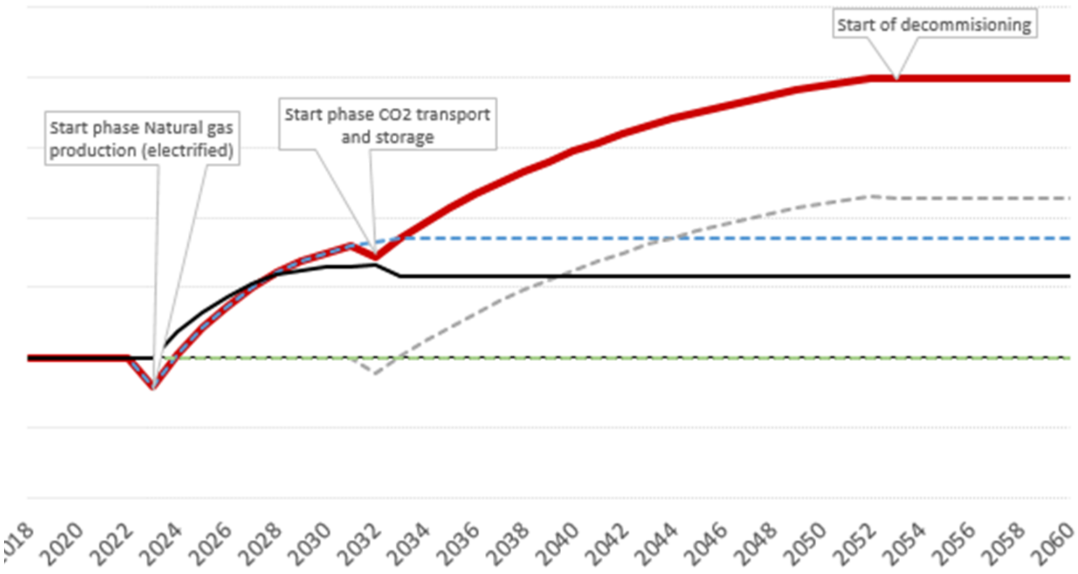
https://www.north-sea-energy.eu/atlas.html

Source: Nexstep 2018

North Sea Energy offshore system integration

Techno-economics of hybrid options

- Platform electrification is a stepping stone for offshore Carbon Capture and Storage and Power-to-hydrogen
- Enhancing circularity of offshore assets improves the business case
  - Pipeline, platform, wells, reservoirs
- Space, timing and coordination are key pre-requisites to save costs

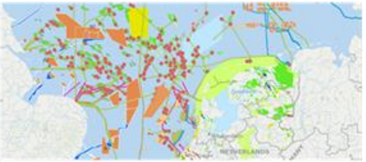


North Sea Energy
offshore system integration

Barriers → Actions for the short term

Future planning
- Timing is critical
- Develop common vision and action plan for offshore system integration (gas, H_2, wind, CO_2)

Business case
- Market incentive to stimulate investments in offshore system integration



Strategic Spatial Planning

Scenario development for spatial synergies now and in the future

Society & Governance

Human Capital, Public Engagement and Regulations

Physical Networks

Techno-economic evaluation of various system integration options

HSE

Health and Safety, Emissions and Environment

Regulatory framework:
- provides insufficient guidance on re-use and repurpose
- blocks offshore system integration
- no clear guidance on the market regimes for new infrastructure connections

Techno - economics
- Weight and size on platform for large scale H_2
- Case specific timing and technical re-use of infrastructure double check

Ecology and environment
- Synergies and trade-offs, but no showstoppers

North Sea Energy offshore system integration

https://www.north-sea-energy.eu/