North Sea Transition Authority

TOPSIDES® UK 2022

Technology Priorities for Energy Security and Net Zero

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2nd November 2022

The Energy Trilemma

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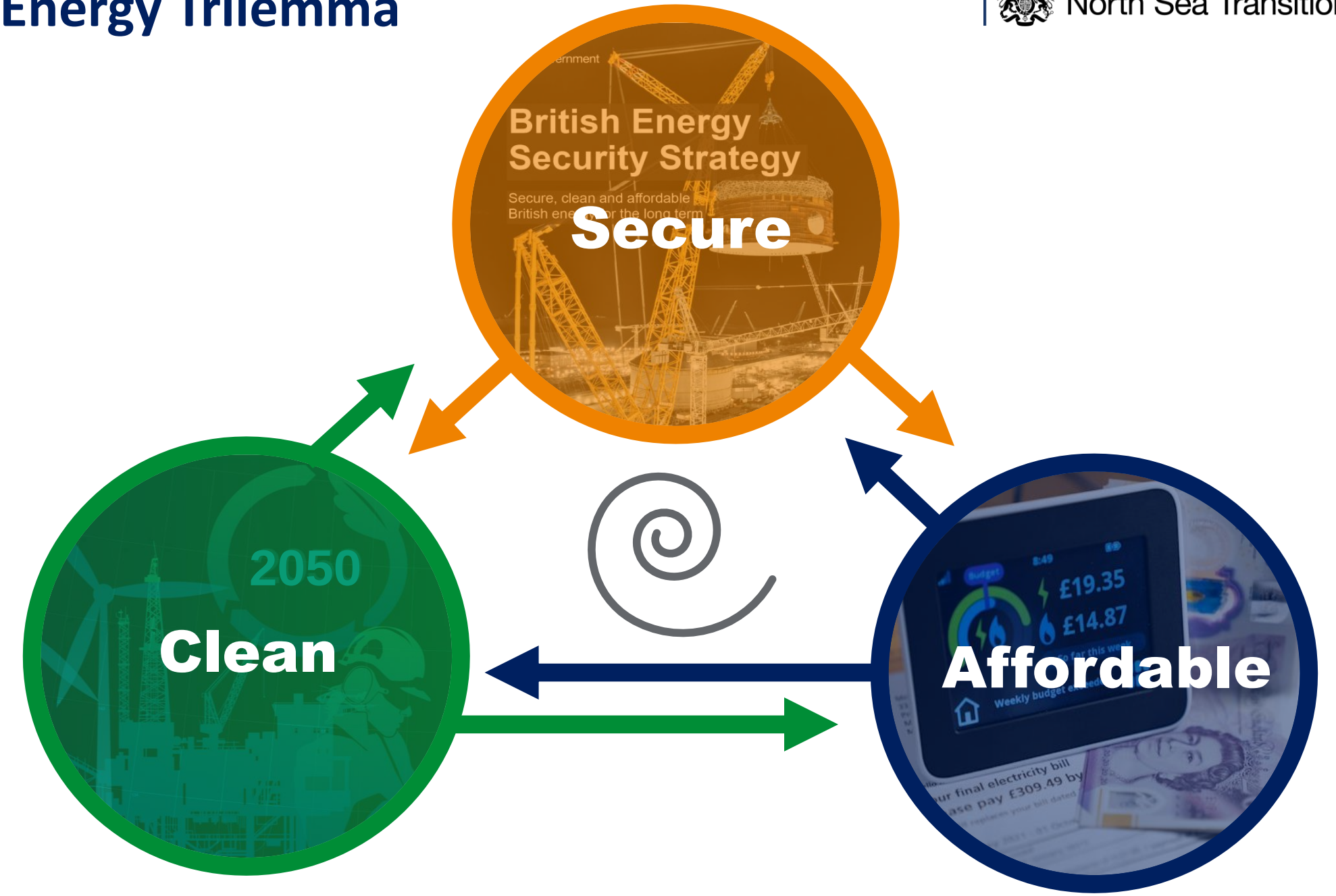

Roadmap to UK Net Zero

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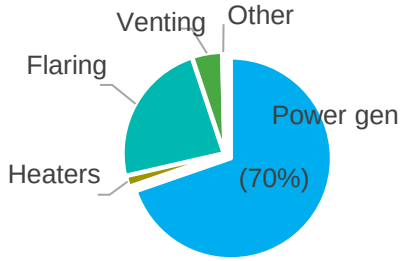
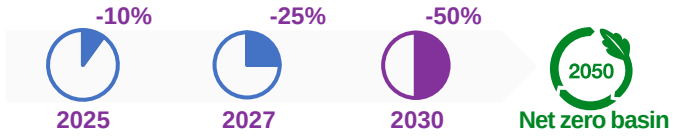
O&G offshore emissions reduction

14 MtCO2e in 2018 (base)



North Sea Transition Deal (2021)
- **emission reduction targets**



NSTA (2021) - Stewardship Expectation 11

NSTA (2021) - Flaring & Venting guidance

World Bank - Zero Routine Flaring by 2030

Offshore wind incl. electrification of O&G

Offshore Wind Sector Deal (2019)
- 30 GW by 2030

Prime Minister 10-point plan (2020)
- 40 GW by 2030

Scottish Government targets (2020 - 2022)
- 11 GW by 2030
- 27.6 GW ScotWind; ~18 GW floating
- ~5 GW INTOG

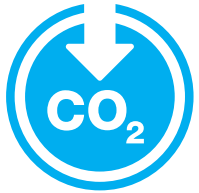
British Energy Security Strategy (2022)
- 50 GW by 2030
- Incl. up to 5 GW floating

Carbon Capture and Storage

North Sea Transition Deal (2021)
- 10 $MtCO_2$/yr of carbon capture by 2030
- At least 2 ‘track-1’ clusters approved by 2025
- >4 commercial scale projects 2030

UK Government CCUS Investor Roadmap (2022)
- 20–30 $MtCO_2$/yr of carbon capture by 2030

NSTA Carbon Storage Licence Round (2022)
- 26 applications received for all 13 areas offered



Low-carbon hydrogen

Prime Minister 10-point plan (2020)
- 5 GW by 2030

UK Hydrogen Strategy (2021)
- Blue and Green H2
- 1 GW by 2025
- 5 GW by 2030

British Energy Security Strategy (2022)
- 1 GW by 2025
- 10 GW by 2030 incl. 5GW from electrolysis

Delivering the NSTD: Emissions Reductions

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21% Reduction GHG emissions 2018-21

20% Reduction flaring 2020-21

1.2M Tonnes avoided since Jan 2021

Electrification crucial to meet NSTD targets

Supports floating wind, green H_2, CCS & regional schemes

NSTA expects targets to be met as absolute minimum

On track

Need industry to strive for 68%

2021

OGA Strategy

Net zero expectation

New fields

Flaring & venting

2025

2027

2030

2050

NSTD £16bn Deal – first of its kind from a G7 Country

Emission Reduction

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Energy Efficiency

- Power sharing across assets
- Variable speed drives
- eFuel switching
- Virtual emissions monitoring systems
- Compression re-wheels

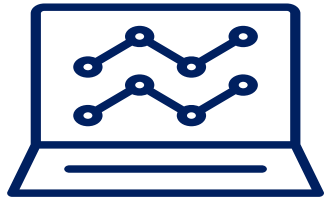
Flaring Reduction

- Flare gas recovery
- Vapour re-compression
- Plant performance optimisation
- Flare combustion efficiency

Venting & Fugitive Emissions

- Nitrogen for vessel blanketing
- Pipework condition monitoring
- Valve and joint remediation

Detection, Measuring & Monitoring



- Real time emissions monitoring using permanent on site detectors
- Methane and fugitive gas emissions quantification
- Satellite detection
- Drone hosted monitoring equipment

Wind Power Growth and Electrification

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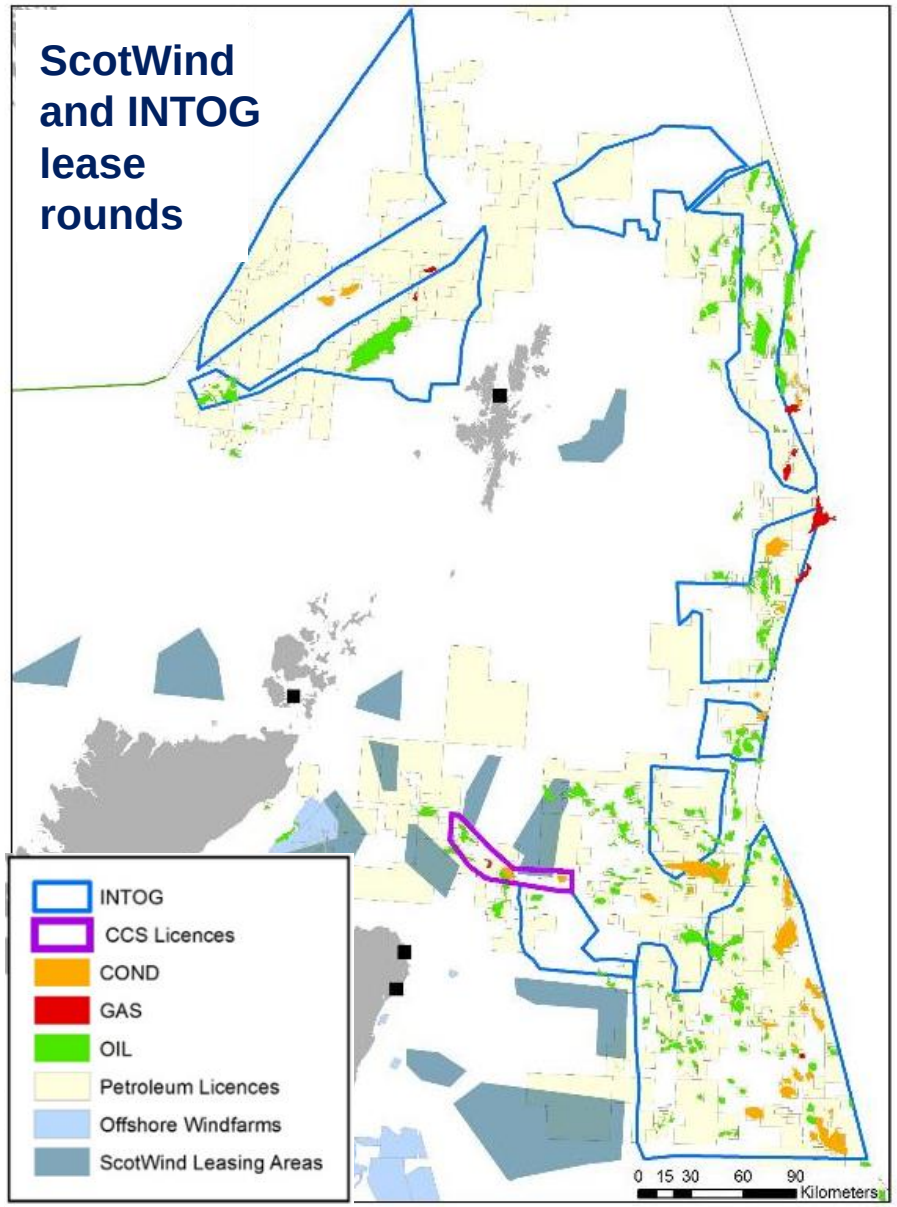
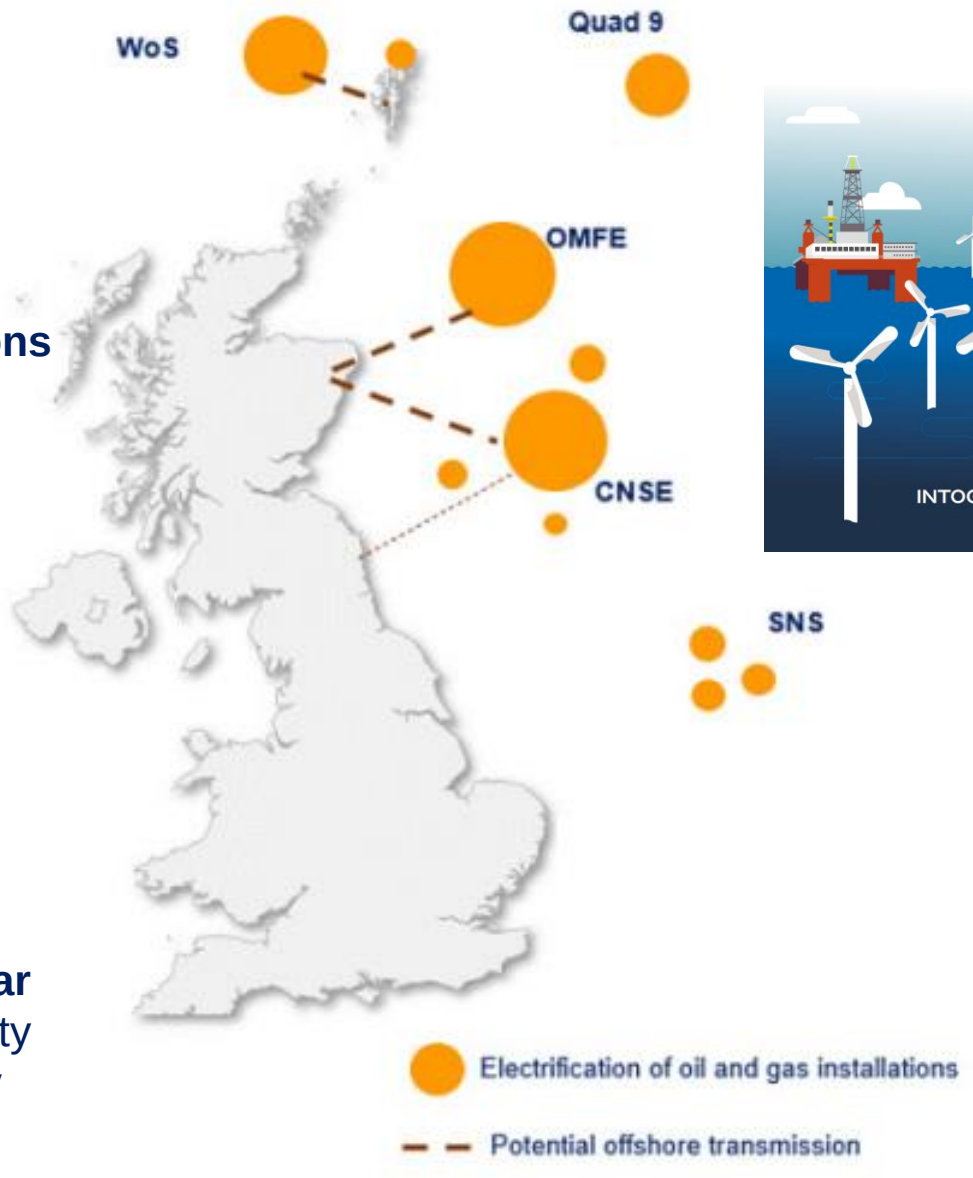


~10MtCO$_2$pa
O&G offshore **emissions** from power generation

~2.5 GW
O&G **power demand**

Windpower growth **near O&G areas,** opportunity to supply clean energy



Synergies realise net zero delivery and emission abatement at reduced Capex

Electrification & Floating Offshore Wind

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Platform design & modifications

Green field

- Design for electrification
- Substations, J-tubes, swivels
- Local renewables
- Power storage
- Process heating

Brown field

- Equipment integration
- Shutdown impact
- Footprint & weight

Offshore transmission & distribution

Transmission equipment

- Dynamic cables and swivels
- Subsea transformers, distribution and switch gear
- HVAC vs HVDC

Transmission installations and power hubs

- Fixed vs floating
- Integrated power hubs (built-in continuity vs power from shore)

Floating structures

Design for North Sea conditions and UK manufacturing capabilities

- Foundations
- Mooring systems
- Anchoring
- Use existing North Sea assets to accelerate deployment & development of FOW solutions

FOW system

Transmission & Storage

- 66 kV and 132 kV cables to reduce losses
- Dynamic high-voltage cables
- Integration with offshore hydrogen
- Subsea batteries, battery ships and hydrogen storage
- Floating substations with electrolysers and desalination

Electrification of oil & gas production can accelerate floating wind technology growth

Carbon Storage

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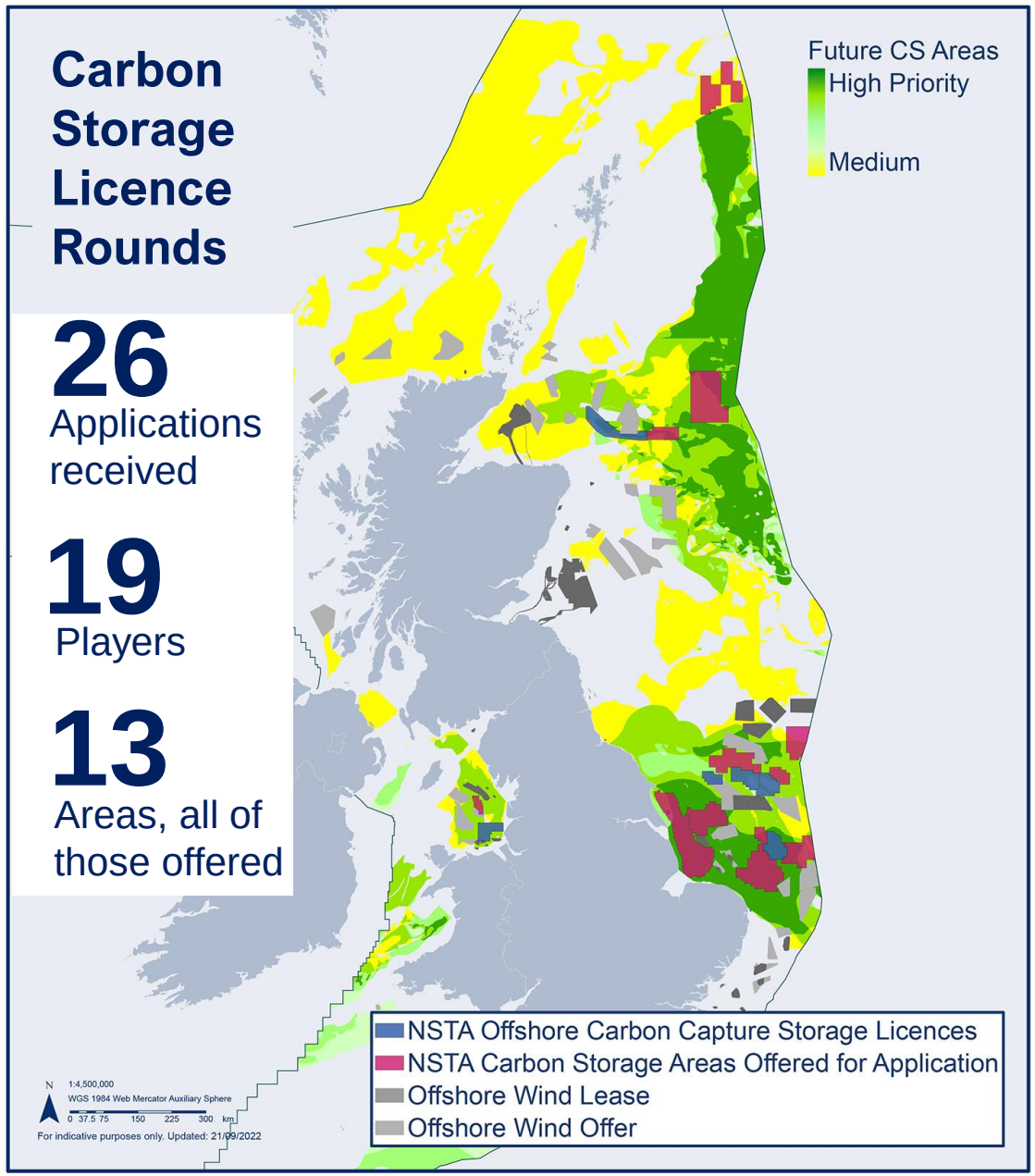
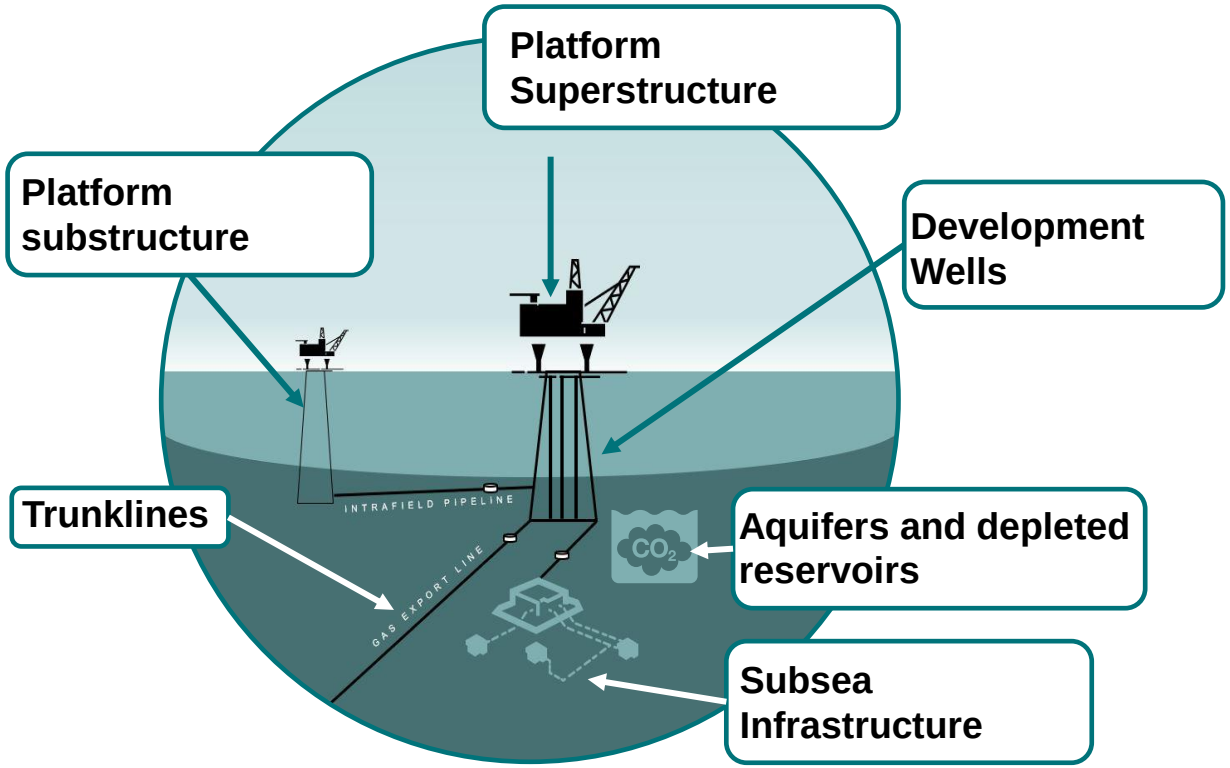


Mid 2020s

- 2 ‘track-1’ clusters approved by 2025
- First injection at minimum 2 pilots

2030

- At least 4 commercial scale projects
- 20–30 $MtCO_2$/yr of carbon capture by 2030



Carbon Capture & Storage

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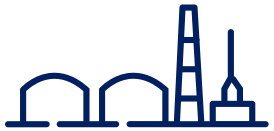
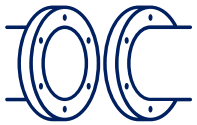
Capture



Capture methods

- More efficient amine blends
- CO_2 adsorbents
  - Temperature swing
  - Vacuum swing
  - Pressure swing
- Alternatives
  - Advanced calciner
  - Allam cycle: CO_2 vs steam

CO_2 Flow Assurance & Transportation



Flow & energy

- Power requirements
- Unsteady state constraints
- Composition impact

Compression & liquefaction

- Supersonic CO_2 compressors
- Improved compression, cooling and liquefaction to reduce Opex for ship transport in liquid phase

Wells & storage

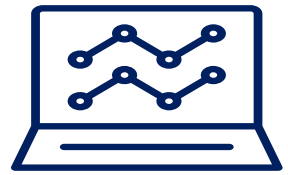
Well design

- CO_2 compatible completions
- Decom provision

Store size & suitability

- Injection modelling
- Improved seismic to accelerate pre-FID
- Store characteristics

Measurement, Monitoring & Verification



Fiscal & allocation CO_2 metering

- Multiple producers / hubs / multiple stores

Subsurface tracking

- Consistency with modelling
- Imaging of CO_2 migration
- Seismic monitoring
- Autonomous monitoring

Leakage detection

- Injection & legacy wells

Develop & deploy technology to reduce CCS costs towards/below carbon price

Hydrogen Ramp-up

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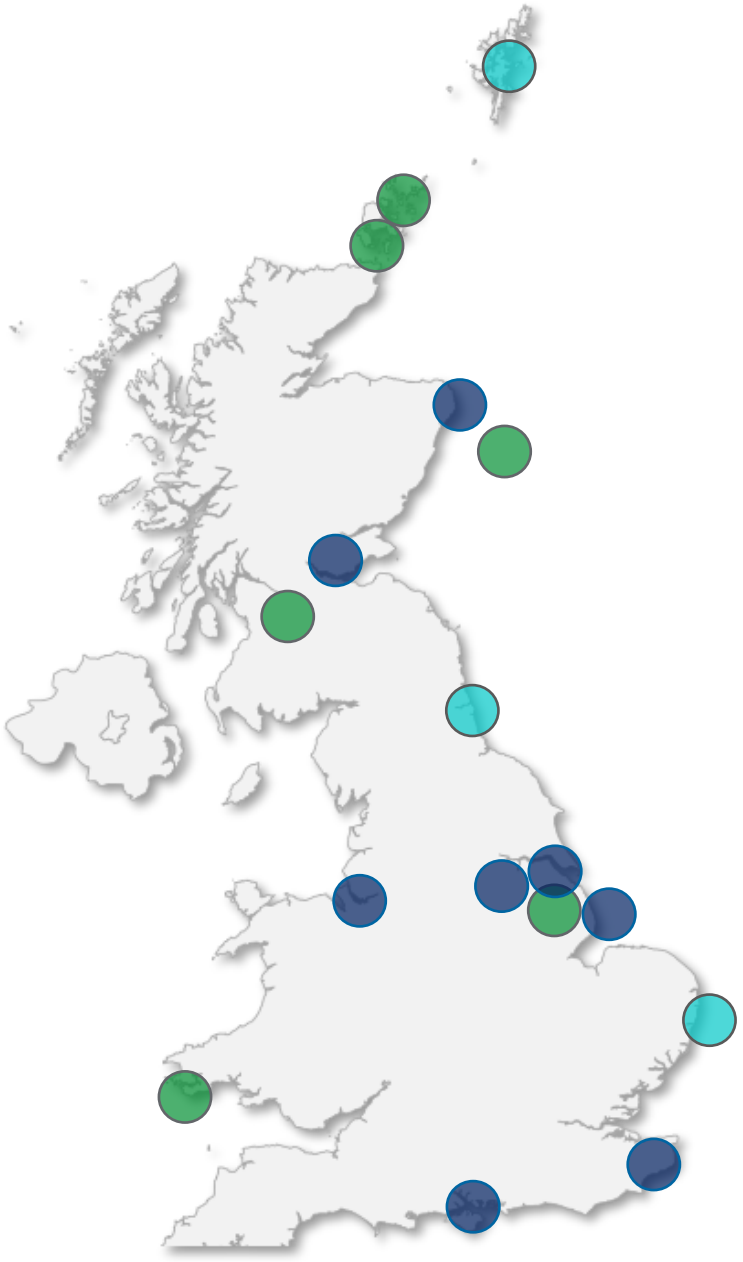
UK Hydrogen Production Potential

- Blue H_2
- Green H_2
- Both



Projects announced

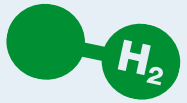
Blue H_2 potential capacity
~12GW

Green H_2 potential capacity
~2GW

Enablers

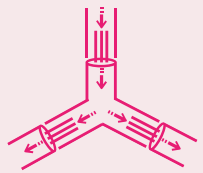
Low-carbon H_2 production

Blue H_2 : Industrial clusters & CCUS, natural gas feedstock



Green H_2 : Coastal locations, offshore renewable electricity generation capacity & water supply

H_2 infrastructure



Pipelines & network integration (with CO_2 / CH_4) inc. blending

Production ‘hubs’

H_2 storage

Balancing demand and supply, underground / surface, offshore / onshore

UK Government targets: 10GW low-carbon H_2 capacity by 2030, of which at least 5GW is Green H_2

Blue Hydrogen

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Reformers

ATR / SMR / POX – established

- >90% Opex
- >80% of Opex is feed gas
- Process integration / heat recovery / district heating
- Improved catalysts
- Higher CO_2 capture rates
- Scaling of production
- Optimise ASU & use green electricity

Pyrolysis

Next-generation CH_4 pyrolysis

- Solid carbon by-product offers high capture potential but needs market outlet / disposal
- Needs low-cost, high-performance materials
- Efficiency to be improved
- Currently TRL 6
- Test and demonstration centres needed

CCS Integration

Co-locate green & blue H_2

- Capture and use O_2 from electrolysis to reduce ASU Capex & Opex (for ATR & POX)
- Enable steam generation optimisation and heat recovery across plants

Next 10 years to enable H_2 economy, followed by 20 more years as renewables ramp up

Green Hydrogen

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Electrolysis

- New membranes, catalysts and electrodes to reduce costs, increase efficiency & improve resistance to impurities
- High-pressure & higher temperature systems
- Modularised electrolyser design
- Marinisation of components to work offshore

Desalination

- Desalination is a modest cost driver in electrolysis costs, but….
- Minimise desalination plant offshore footprint & weight for offshore substructures
- Direct seawater electrolysis avoids desalination, reduces Capex and Opex

Transportation

- Develop larger, more compact compressors with greater efficiency
  - Blade design
  - Monitoring & control
- Flow metering and leakage detection optimised for H_2
- Retrofit pipelines with new materials for H_2 service
- Raise electrolyser output gas pressure

Storage

- Short term, to supply:
  - H_2 compatible gen sets
  - Fuel cells
- Seasonal
  - Geological formations
  - Depleted O&G fields
  - Salt caverns
- High energy density
  - Compressed; liquified; LOHCs
  - Small green NH_3 plants offshore

Co-locate green hydrogen & wind resources to minimise grid reliance & accelerate scale-up of the industry

What next?

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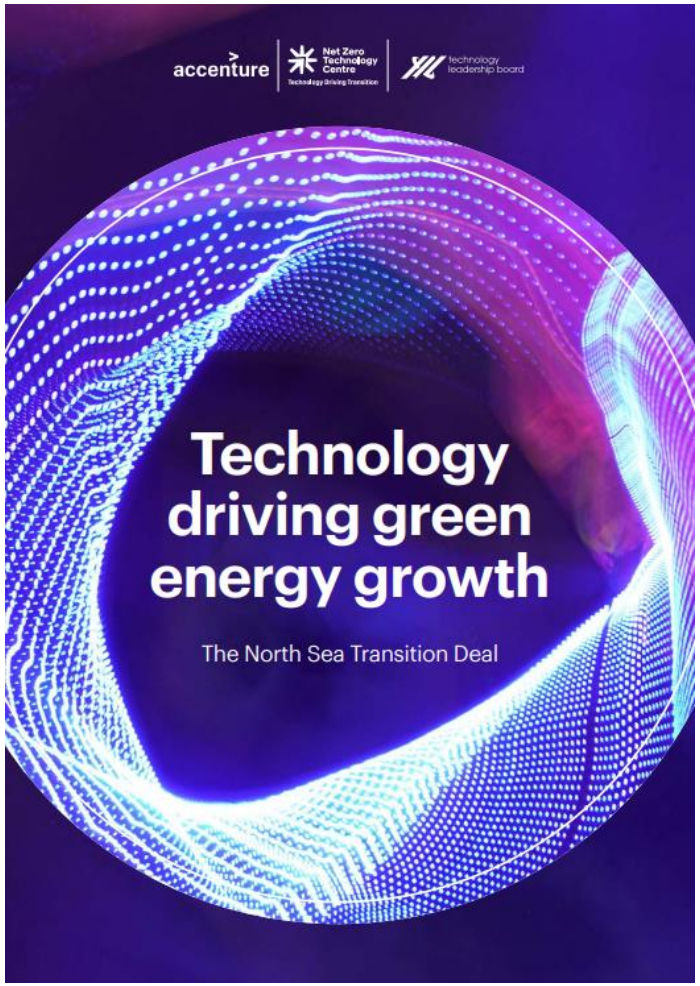
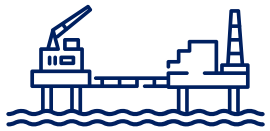
More details on net zero technology priorities in the report on www.netzerotc.com and www.the-tlb.com



Actions

- Keep abreast of the fast moving technology landscape
- Identify what you and your company need or could deliver
- Prepare technology plans to meet energy security and Net Zero challenges
- Support the UK's innovative supply chain:
  - To deliver a better, faster, more sustainable energy transition
  - To grow its size, capacity and capability in the many breakthrough technology areas mentioned today
- And remember, it is you people in this room who have the expertise and the energy to make the difference.

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Thank you