

Technologies to improve NCS competitiveness – what's at stake?



OG21 Forum
Oslo
November

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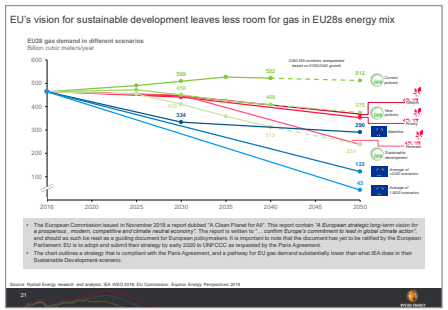
Element

Content

Key Exhibits

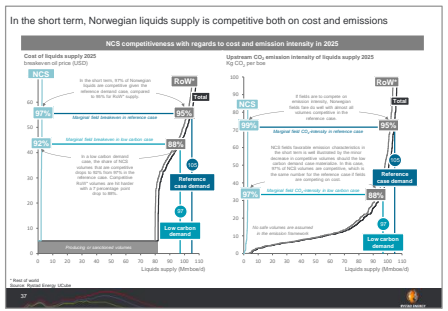
A Future oil/gas demand

- Demand projection research
- Development of reference and low carbon cases



B NCS competitiveness

- NCS's current competitive ability (break-even, lead time, carbon)
- Recent years' competitive improvement assessment
- Future competitive ability given oil/gas demand scenarios



C High impact technology areas assessment

Assessment of technology areas that address competitive ability on:

- Cost
- Volumes
- Carbon emissions

17 focus technologies – many of the same technologies selected across the TTA groups

Technology area	Description	TTA1	TTA2	TTA3	TTA4
Offshore wind for offshore	Deep water, harsh conditions, well cost, high gas prices, offshore wind				
Optimized gas turbines	System and equipment for power plants and hybrid systems, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Power from shore technologies	Large scale power plants for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Compact CCS for liquids	Large scale power plants for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Water desalination	Water desalination technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
CO2 for EOR	CO2 for EOR technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Field model optimization	Field model optimization technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Big data exploration analytics	Big data exploration analytics technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Wind pipe technologies	Wind pipe technologies for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Shut recovery technologies	Shut recovery technologies for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Automated drilling control	Automated drilling control technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Smarter smart wells	Smarter smart wells technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Predictive maintenance	Predictive maintenance technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Unmanned platforms	Unmanned platforms technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Standardized offshore satellites	Standardized offshore satellites technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
AI electric assets	AI electric assets technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				
Flow assurance	Flow assurance technology for power plants and power plants, that use a natural gas turbine, heat recovery, efficiency and other benefits				

Process of selecting and evaluating focus technologies to improve NCS competitiveness

Bucket analysis

Understand volume, cost and emission drivers on the NCS

- The outset for any technology evaluation is to find the application area. The larger the application area the larger potential of the technology
- Prepared for TTA workshops to aid the selection of focus technologies with high effect
- Investigated the largest buckets of volumes, spend and emissions on the NCS in a 2020-2050 timeframe.

Suggest focus technologies for evaluation

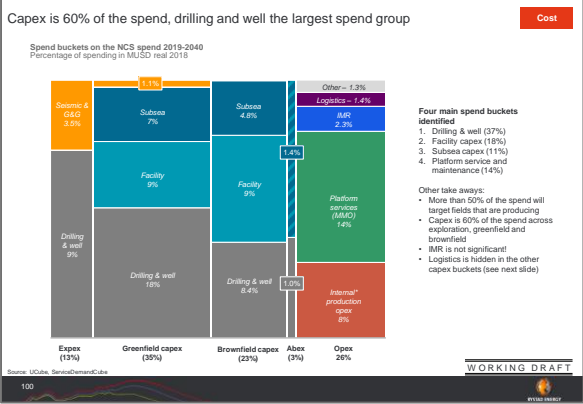
Four TTA workshops

- 4 half-day workshops held with each TTA group.
 - TTA 1: Energy efficiency and environment
 - TTA 2: Exploration and improved recovery
 - TTA 3: Drilling, completion and intervention
 - TTA4: Production, processing and transport
- Selected a set of focus technologies that could have large effect on improving NCS competitiveness
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Evaluate focus technologies

Analyze effect of NCS in the period 2020-2050

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 - Short term and long term effects evaluated for each technology.
- Additional interviews and workshops conducted to understand application potential of each technology.



Overview of technologies - 5 focus technologies from each TTA

	TTA 1	TTA 2	TTA 3	TTA 4
Focus	Floating offshore wind for offshore facilities Optimized gas turbines Energy effective IOR technologies Power from shore technologies Compact CCS for liquids CO ₂ sequestration	Water desalination Field and production optimization Cost efficient collection and processing of high quality data Big data exploration analytics CO ₂ sequestration	Wind pipe technologies Slot recovery technologies Automated drilling control Smarter smart wells Standardized subsea satellites	Predictive maintenance Unmanned platforms Carbon efficient supply of power and heating All electric subsea Flow assurance for long lines
Other technologies	Mature services and cost saving facilities Technologies for produced water and cleaning Oil spill technologies Improved regulatory and faster start-up of wells Energy efficiency recovery and digitization software PMA technologies Corrosion heat and power Hybrid technologies for MDOUs Barrels - no pipeline technologies Gas to water Lower production pressure in wells Fuel cell technologies Subsea gas power generation Subsea processing technologies Technologies to reduce slugging Coding and pressure drop in flowlines	EOR surfactants Dry gas recovery Subsea processing technologies New completions designs Multistage technologies Simplification of access wells Passive seismic and surveillance Life extension enabling technologies	Automated steering and execution in drilling Energy recovery in the draw works Hybrid technologies for MDOUs Draggable liner drilling Connected wells Offshore cuttings processing on MDOUs Data sharing systems MRO on floats Rig less subsea intervention Thru-tubing rotary drilling	Water treatment technologies Lightweight platforms Alternative solutions to long facilities CCS technologies EOR-CO ₂ Water gas dehydration Live/semi subsea technologies

Source: TTA workshops

Preliminary analysis on effects of prioritized technologies

Technology area	Target volumes* (billion boe)	Lead time** (Years)	Volume effect (billion boe)	Cost effect (billion USD real 2019)	Emissions effect (billion t CO ₂ e)
TTA 1 Energy efficiency and environment					
Offshore wind for platforms	22 (62%)	3-4 years	Neutral	18.0	48
Optimized gas turbines	6.4 (24%)	1-2 years	Neutral	-1.4	-7.6
Power from shore technologies	10.8 (31%)	>3 years	Neutral	24.7	-137
Compact CCS for liquids	7.2 (20%)	2-4 years	Neutral	8.7	-61
TTA 2 Exploration and improved recovery					
Water diversion	18.5 (52%)	1-2 years	1800	18.6	-11
CO ₂ for EOR	18.5 (52%)	5-7 years	825	20.0	-246
Field model optimization	10.4 (29%)	2-4 years	100	-6.0	-2.8
Big data exploration analytics	9.5 (27%)	7-10 years	1900	-6.0	-2.7
TTA 3 Drilling, completion and intervention					
Wind pipe technologies	16.1 (45%)	6-12 months	3200	-14.3	-1.1
Slot recovery technologies	11.5 (32%)	6-12 months	Limited	-5.6	-0.4
Automated drilling control	16.1 (45%)	6-12 months	Limited	-21.2	-3.1
Smarter smart wells	11.5 (32%)	6-18 months	380	Neutral	-1.2
TTA 4 Production, processing and transport					
Predictive maintenance	36.3 (100%)	1-2 years	1400	-62.8	-1.8
Unmanned platforms	7.9 (22%)	2-4 years	325	-0.8	-4.7
Standardized subsea satellites	10.4 (29%)	1 year	1000	-14.0	Neutral
All electric subsea	10.6 (30%)	>3 years	400	-12.0	-0.5
Flow assurance	2.3 (6%)	>3 years	Neutral	-14.1	Neutral

Source: Rystad Energy research and analysis

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Process of selecting and evaluating focus technologies to improve NCS competitiveness

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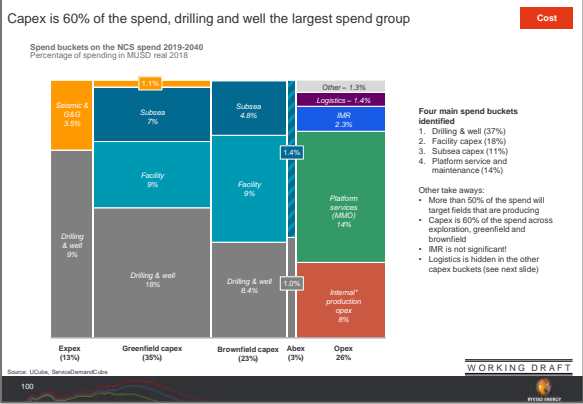
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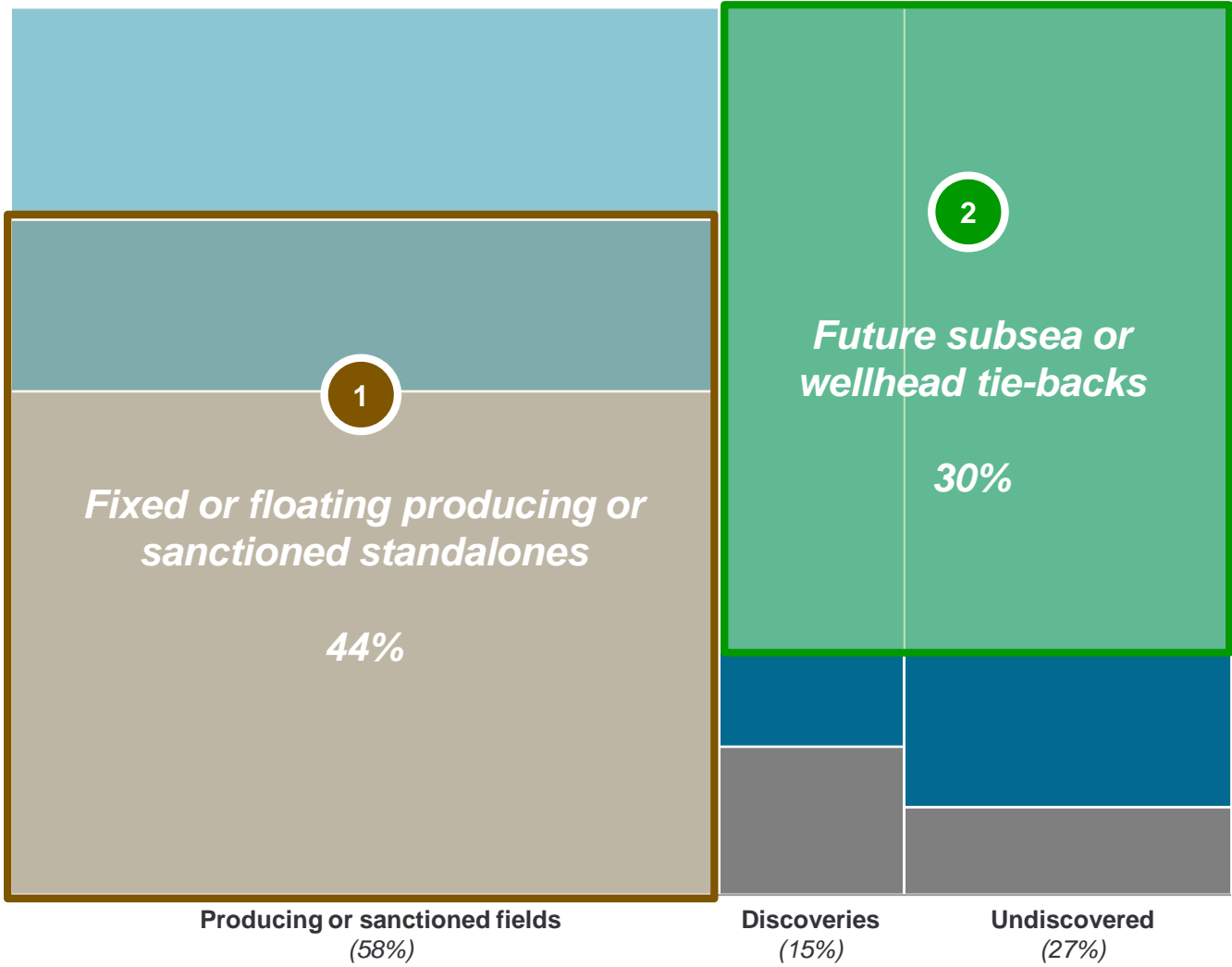
Source: Rystad Energy research and analysis

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Current hubs and future tie-backs *are* the NCS; future infrastructure less important

Volume buckets on the NCS between 2019-2050
Percentage of expected barrels of oil equivalent produced



- The chart outlines production volumes on the NCS in the period 2019-2050 in terms of current status of the source field and facility type of that field
- Fields that are yet to be sanctioned are expected to rely heavily on tie-back solutions, whereas currently producing fields (mostly in the North Sea) have been developed as standalones with fixed or floating production facility
- As a result, we define two important buckets of future production volumes:

1 Producing and sanctioned standalones

- These volumes are already sanctioned as standalone developments with dedicated processing facilities

2 Future tie-backs

- Volumes from fields expected to be developed as subsea/wellhead tie-backs

Source: Rystad Energy UCube

Upside in existing rivals potential in discoveries underlining the importance of our hubs

NPD contingent resources as of 31 December 2017
 Million boe



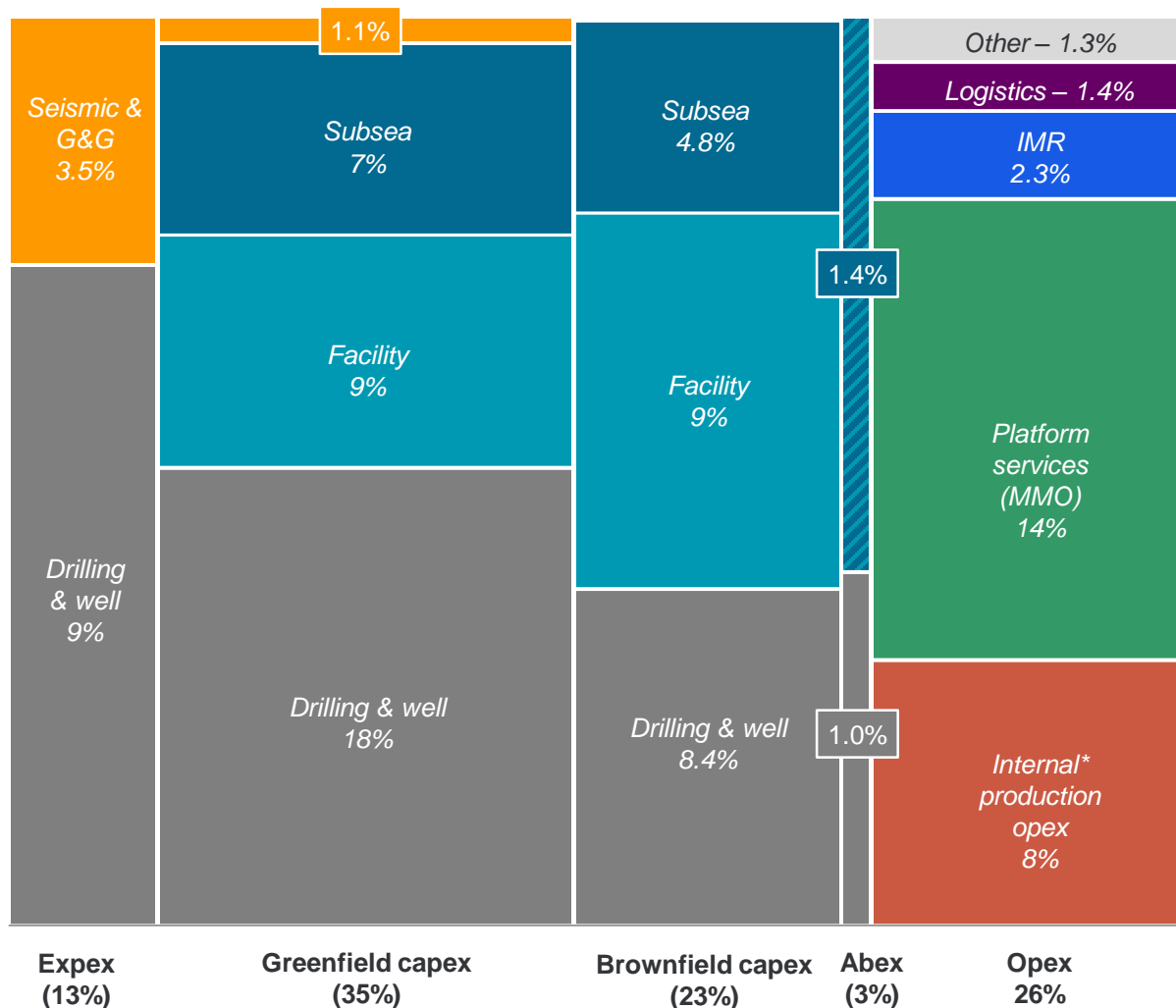
- The chart outlines NPDs accounts of contingent resources – resources that have been identified but are yet to be sanctioned
- Interestingly, current identified volume potential in fields is larger than in the combined portfolio of discoveries
- Moreover, non-sanctioned liquids resources in existing fields account for 31% of total contingent resources
- Thus, technology increasing oil recovery in existing fields (where infrastructure is already in place) will have a large impact.

Source: NPD Resource Report 2018

Capex is 60% of the spend, drilling and well the largest individual spend group

Spend buckets on the NCS spend 2019-2040

Percentage of spending in MUSD real 2018



Four main spend buckets identified

1. Drilling & well (37%)
2. Facility capex (18%)
3. Subsea capex (11%)
4. Platform service and maintenance (14%)

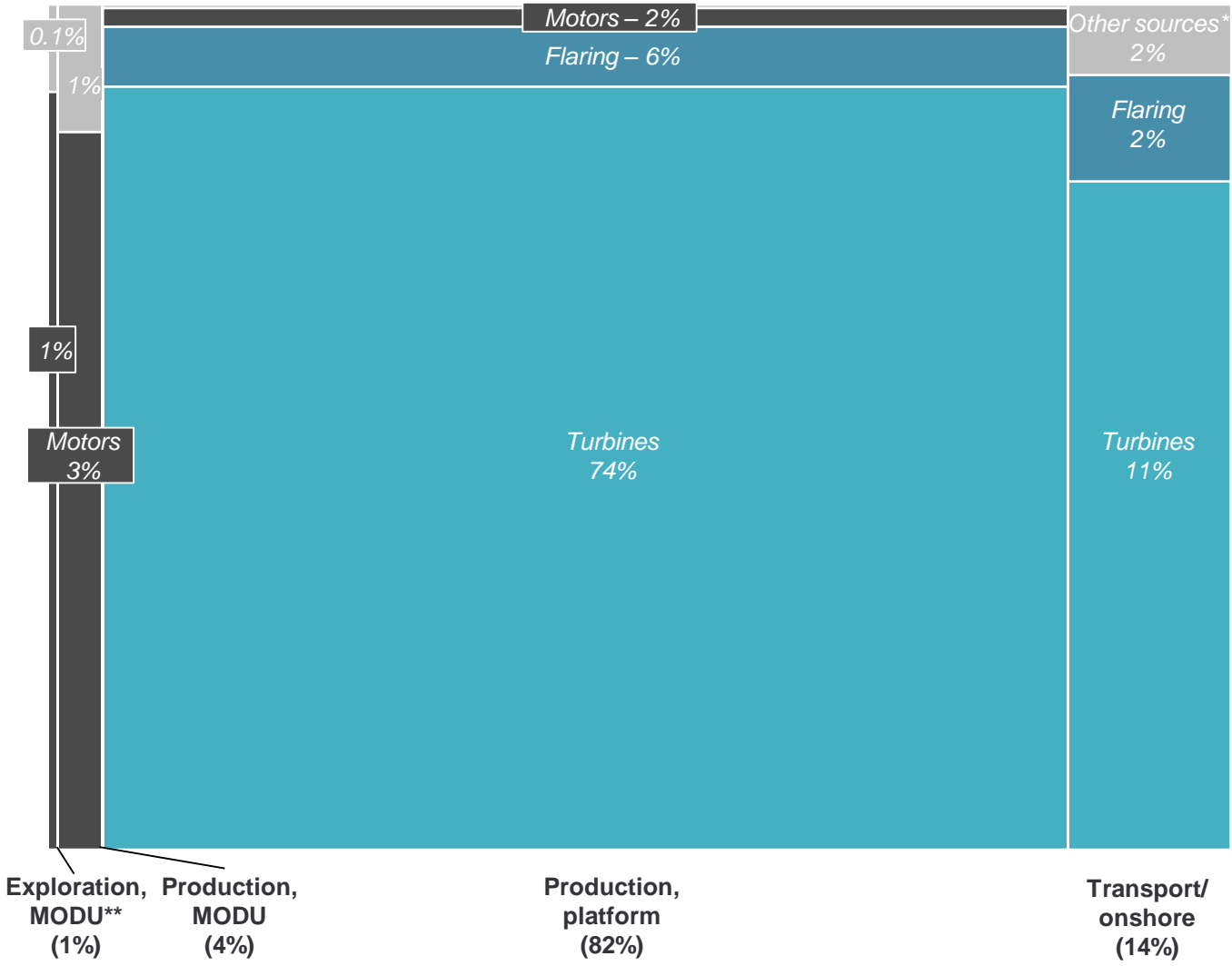
Other takeaways:

- More than 50% of the spend will target fields that are producing
- Capex is 60% of the spend across exploration, greenfield and brownfield
- IMR* is not significant
- Logistics is hidden in the other capex buckets (see next slide)

*IMR: inspection maintenance repair
Source: UCube, ServiceDemandCube

Fuel combustion in gas turbines constitutes 85% of upstream CO₂

Upstream and midstream CO₂ emissions from the NCS in 2017, by emission source and activity
 [% of the total 13.2 Mt CO₂ emitted]



- The chart outlines CO₂ emissions from the NCS in 2017 in terms of activity and the emission source.
- Activity is defined as in which stage the emissions took place: Either exploration drilling from a drilling unit, in the production stage of a specific field – either from a drilling unit or a platform, or during transport/onshore. The latter bucket is due to NOROG including some onshore activity (e.g. Melkøya) and transport from onshore facilities (e.g. Kårstø) in their upstream reporting, although this is usually considered as part of midstream activities.
- Emission sources are split by four: Turbines, flaring, motors and other sources such as boilers and well testing.
- Platforms on producing fields are by far the largest emitters, and turbines made up 74% of the CO₂ emitted from platforms on the NCS in 2017.

*E.g. boilers, well testing, minor leakages** MODU: Mobile drilling units
 Source: Norsk Olje and Gass; NPD; Rystad Energy research and analysis

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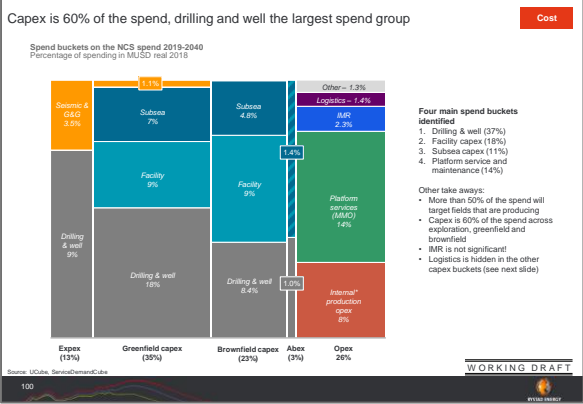
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Source: TTA workshops

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Source: Rystad Energy research and analysis

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TTA1 Energy efficiency and environment	Offshore wind for offshore facilities	Chosen			Chosen
	Optimized gas turbines	Chosen			
	Power from shore technologies	Chosen			Chosen
	Compact CCS for topsides	Chosen			
TTA2 Exploration and improved recovery	Water diversion	Chosen	Chosen		Suggested
	CO ₂ for EOR		Chosen		
	Field model optimization		Chosen		Suggested
	Big data exploration analytics		Chosen		
TTA3 Drilling, completion and intervention	Wired pipe technologies			Chosen	
	Slot recovery technologies		Suggested	Chosen	
	Automated drilling control			Chosen	
	Smarter smart wells	Chosen		Chosen	Suggested
TTA4 Production, processing and transport	Predictive maintenance	Suggested			Chosen
	Unmanned platforms				Chosen
	Standardized subsea satellites			Chosen	
	All electric subsea		Suggested	Suggested	Chosen
	Flow assurance	Suggested			Chosen

*NPT: Non-productive time
 Source: Input from TTA workshops; Rystad Energy research and analysis

■ Chosen
 ■ Suggested

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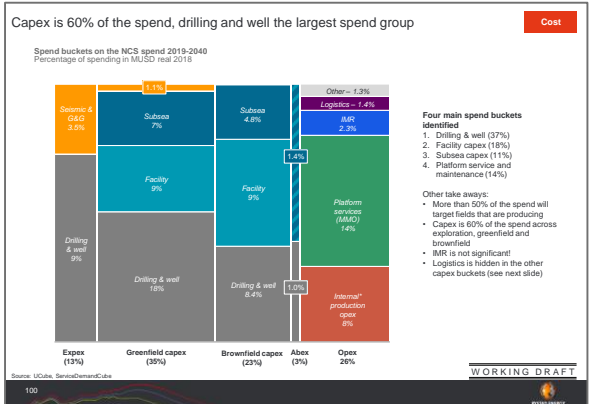
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Analysis on effects of the selected focus technologies

	Technology area	Target volumes [Billion boe]	Lead time [Years]	Volume effect [Million boe]	Cost effect [Billion USD real 2019]	Emissions effect [Million tn CO ₂]
TTA1 Energy efficiency and environment	Offshore wind for offshore facilities	22 (62%)	3-4 years	Neutral	16.0	-82
	Optimized gas turbines	8.4 (24%)	1-2 years	Neutral	-1.4	-7.6
	Power from shore technologies	10.8 (31%)	2-3 years	Neutral	24.7	-137
	Compact CCS for topsides	7.2 (20%)	2-4 years	Neutral	3.5	-61
TTA2 Exploration and improved recovery	Water diversion	18.5 (52%)	1-2 years	1850	18.6	-11
	CO ₂ for EOR	18.5 (52%)	5-7 years	825	20.0	-330
	Field model optimization	10.4 (29%)	2-4 years	560	-40.8	-2.8
	Big data exploration analytics	9.5 (27%)	7-15 years	1900	-6.0	-0.7
TTA3 Drilling, completion and intervention	Wired pipe technologies	16.1 (45%)	6-12 months	3220	-14.3	-1.1
	Slot recovery technologies	11.5 (32%)	6-12 months	Limited	-5.6	-0.4
	Automated drilling control	16.1 (45%)	6-12 months	Limited	-21.2	-3.1
	Smarter smart wells	11.5 (32%)	6-18 months	580	Neutral	-12
TTA4 Production, processing and transport	Predictive maintenance	35.3 (100%)	1-2 years	1490	-42.9	-1.8
	Unmanned platforms	7.9 (22%)	2-4 years	335	-50.0	-4.7
	Standardized subsea satellites	10.4 (29%)	1 year	1500	-14.0	Neutral
	All electric subsea	10.6 (30%)	2-3 years	450	-12.0	-0.5
	Flow assurance	2.3 (6%)	2-3 years	Neutral	-14.1	Neutral

Short term (2020-2025)
 Long term (2025-2050)

Source: Rystad Energy research and analysis

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<p>CO₂ for EOR holds the potential to cut 330 megatons of CO₂ to 2050 – six times Norway’s total emissions in 2018</p>						
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<h2 style="margin: 0;">Wired pipe may yield volumes equal to one Johan Sverdrup</h2>						
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Short term (2020-2025)
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Analysis on effects of the selected focus technologies

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TTA1 Energy efficiency and environment	<h2 style="text-align: center; background-color: #e67e22; color: white; padding: 20px;">Better field models can help us save half a Sverdrup in cost (while yielding a Castberg)</h2>					
TTA2 Exploration and improved recovery	Field model optimization	10.4 (29%)	2-4 years	560	-40.8	-2.8
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Analysis on effects of the selected focus technologies

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	All electric			450	-12.0	-0.5
	Flow assu			Neutral	-14.1	Neutral

Technologies may yield four Sverdrups...

■ Short term (2020-2025) ■ Long term (2025-2050)

Source: Rystad Energy research and analysis

Analysis on effects of the selected focus technologies

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	Flow assurance				-14.1	Neutral

...while saving one National Budget...

■ Short term (2020-2025) ■ Long term (2025-2050)

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...and 12 years worth of Norwegian CO₂ emissions

Short term (2020-2025)
 Long term (2025-2050)

Source: Rystad Energy research and analysis