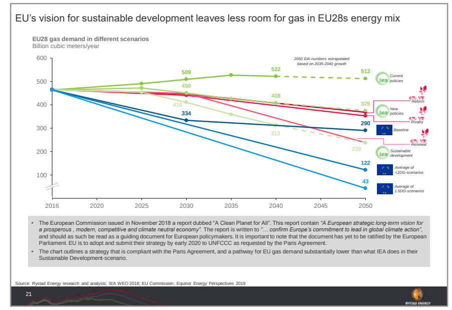
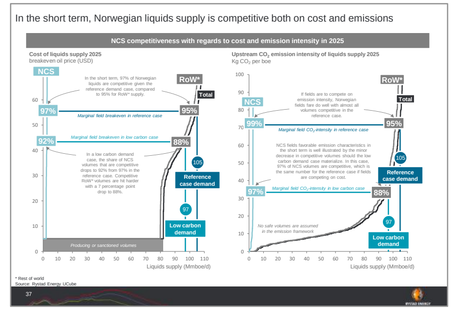
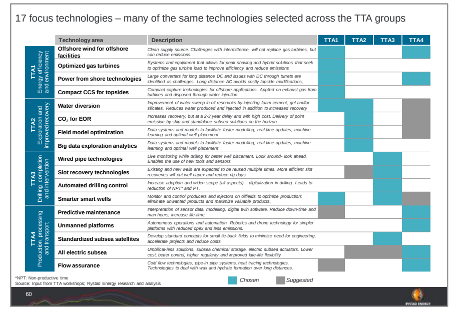
Technologies to improve NCS competitiveness – what's at stake?

OG21 Forum
Oslo
November

RYSTAD ENERGY

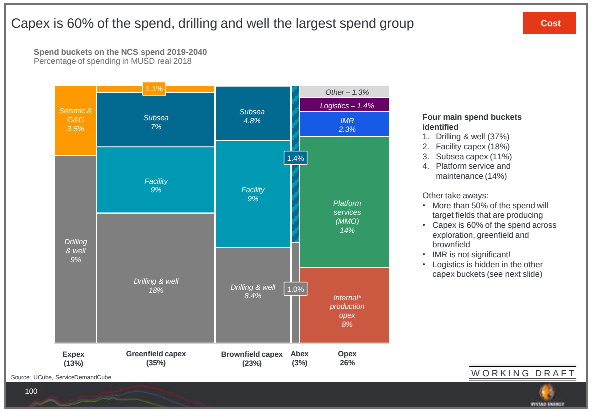
Rystad Energy report on technologies to improve NCS competitiveness – purpose and focus

Element	*Content*	*Key Exhibits*
A **Future oil/gas demand**	• *Demand projection research* • *Development of reference and low carbon cases*	
B **NCS competitive-ness**	• *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*	

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*
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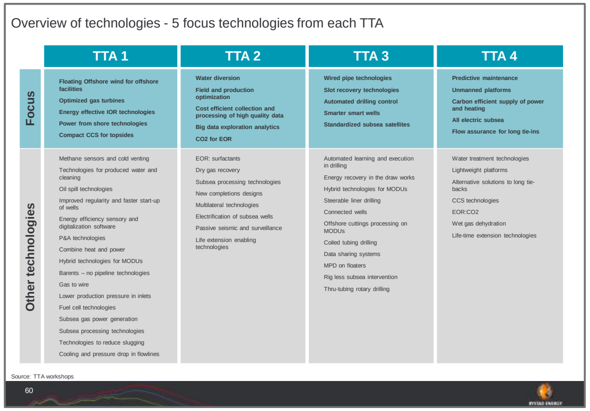
- *Provided input assumptions into the evaluation*



Evaluate focus technologies
Analyze effect of NCS in the period 2020-2050

- *Simplified business case evaluation of each technologies effect on the NCS in the period between 2020-2050.*
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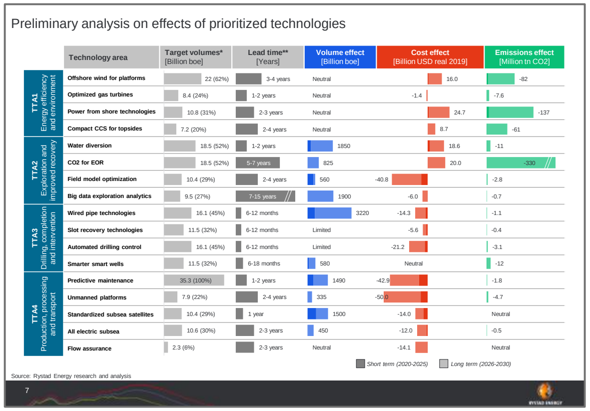

Source: Rystad Energy research and analysis

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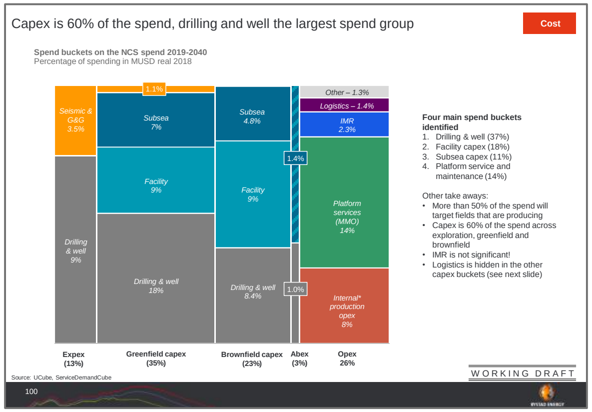

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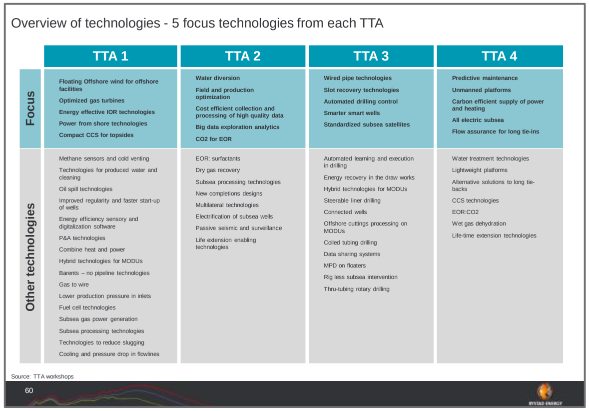

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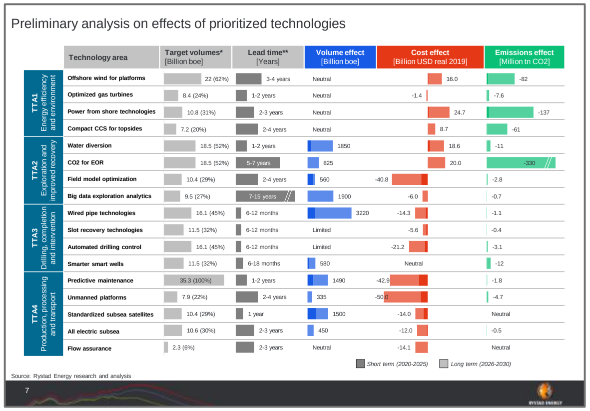

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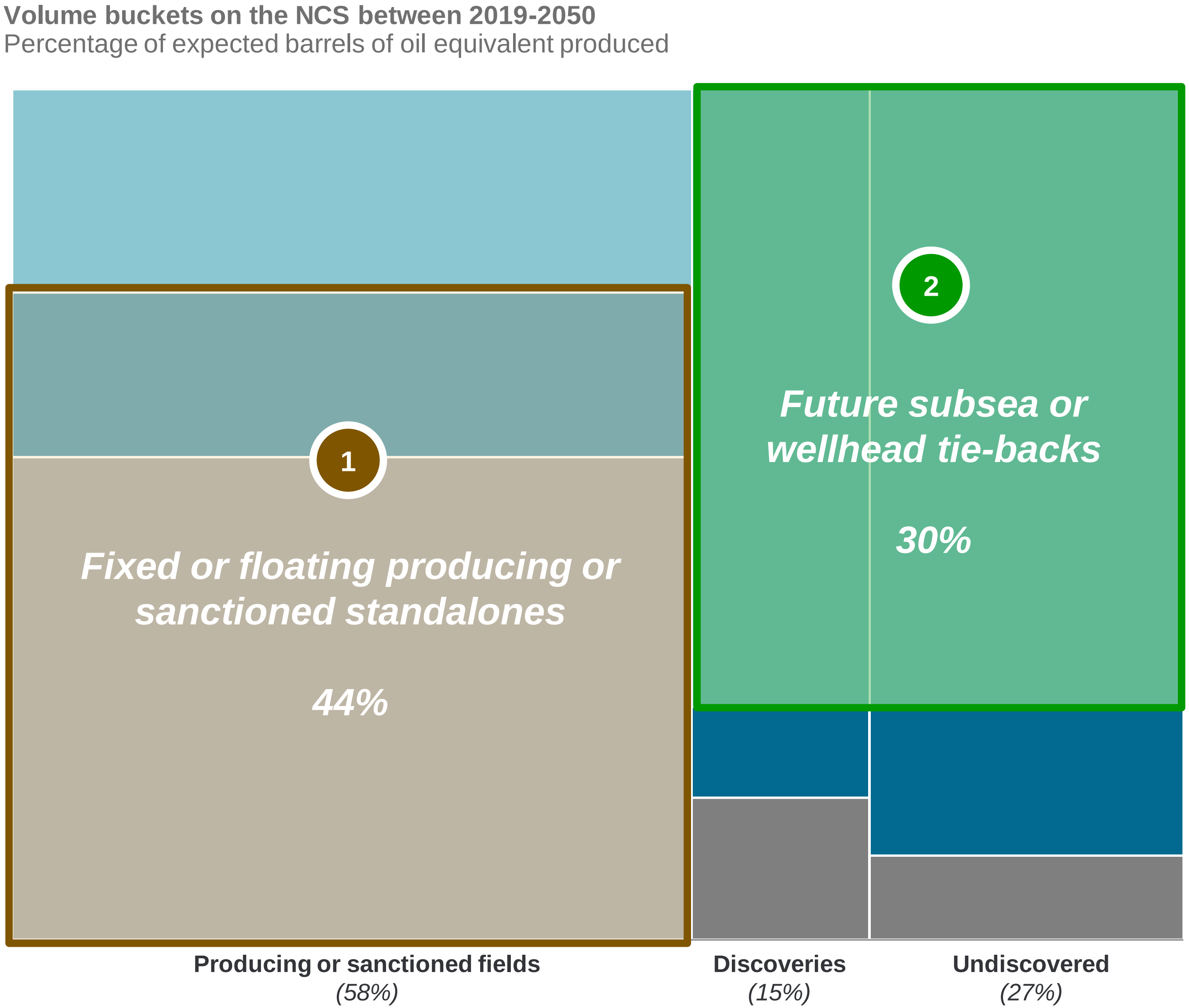
Current hubs and future tie-backs *are* the NCS; future infrastructure less important

Volumes



- 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 stand-alones 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

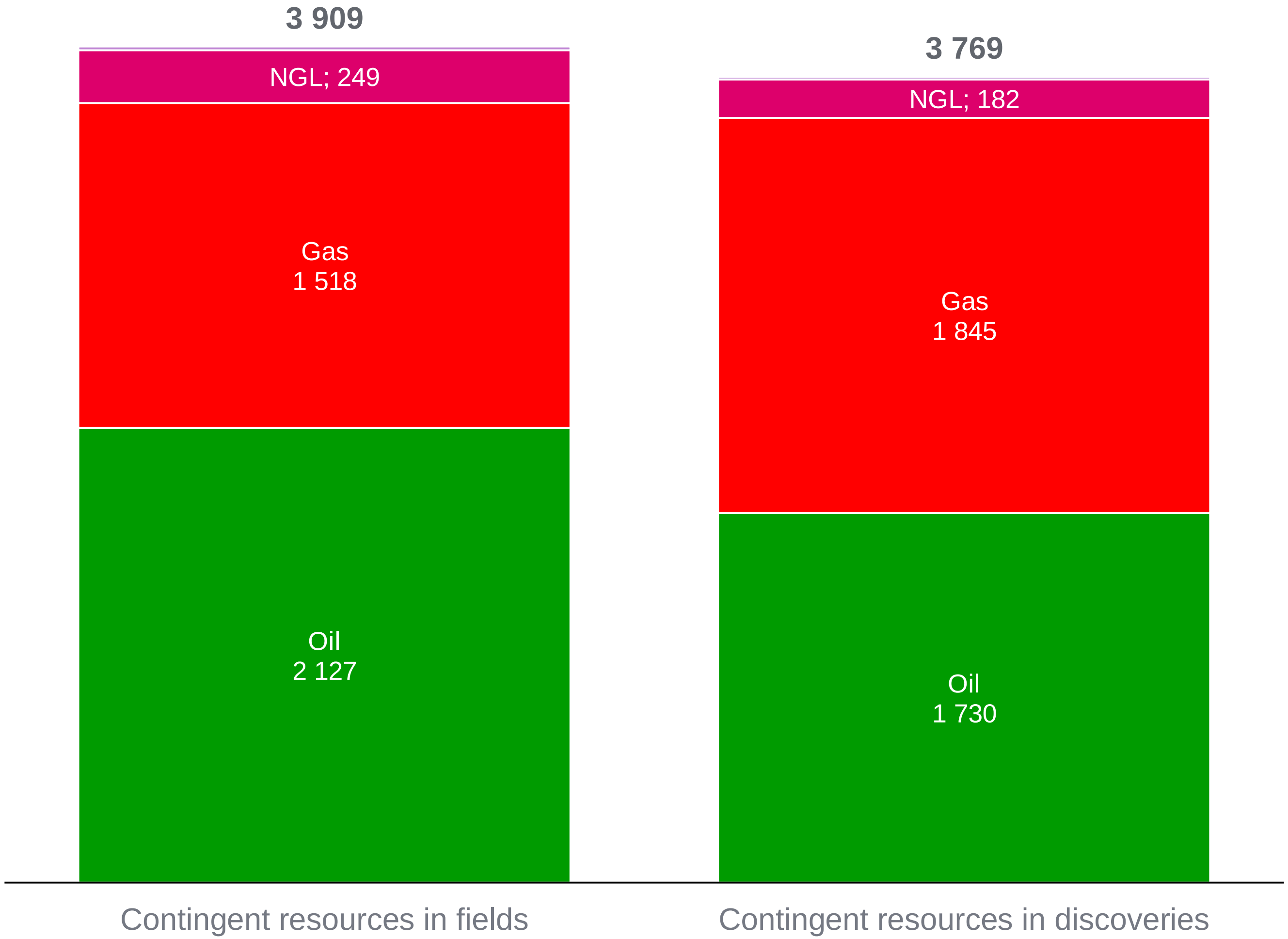
2 Future tie-backs

- 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



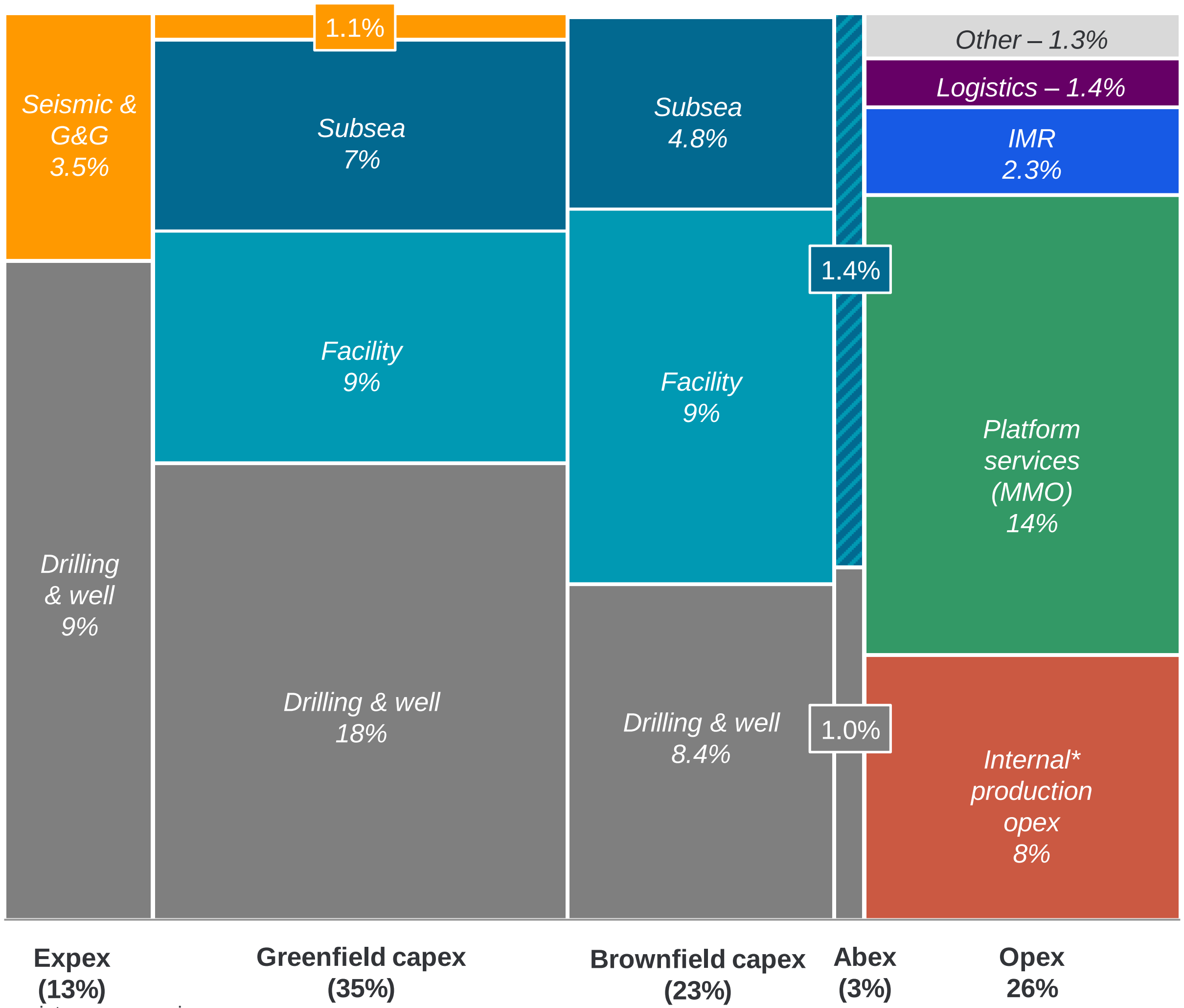
- The chart outlines NPDs accounts of contingent resources – resources that have been identified but are yet to be sanctioned
- Interestingly, current identified volume potential in fields is larger than in the combined portfolio of discoveries
- Moreover, non-sanctioned liquids resources in existing 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

Cost

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:

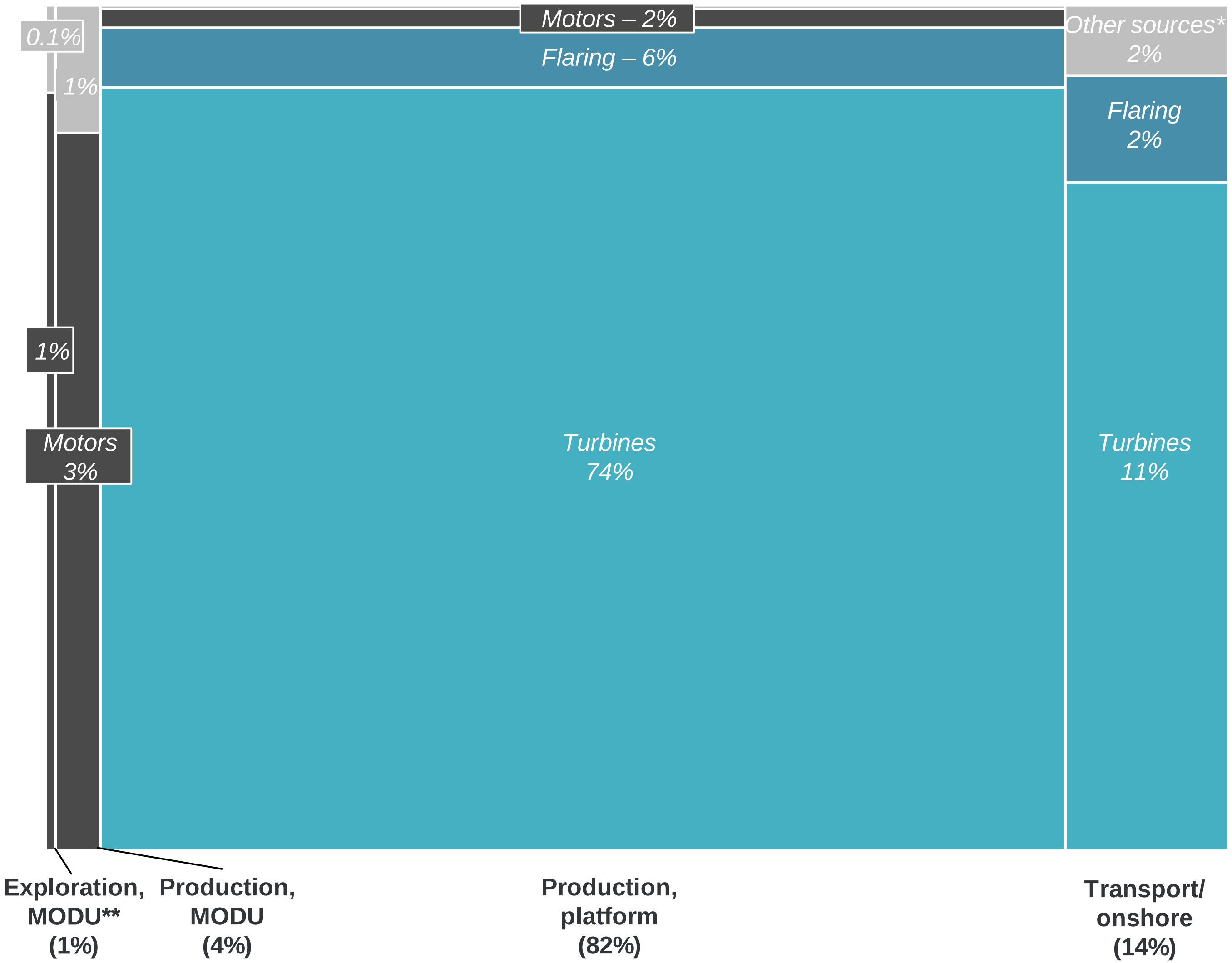
- More than 50% of the spend will target fields that are producing
- Capex is 60% of the spend across exploration, greenfield and brownfield
- IMR* is not significant
- Logistics is hidden in the other capex buckets (see next slide)

*IMR: inspection maintenance repair
Source: UCube, ServiceDemandCube

Fuel combustion in gas turbines constitutes 85% of upstream CO_2

Emissions

Upstream and midstream CO_2 emissions from the NCS in 2017, by emission source and activity
[% of the total 13.2 Mt CO_2 emitted]



- The chart outlines CO_2 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 CO_2 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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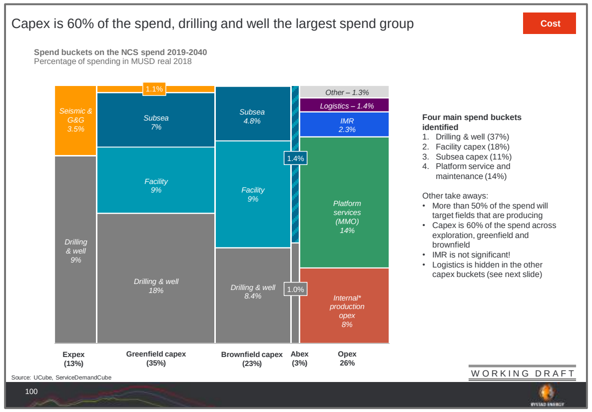

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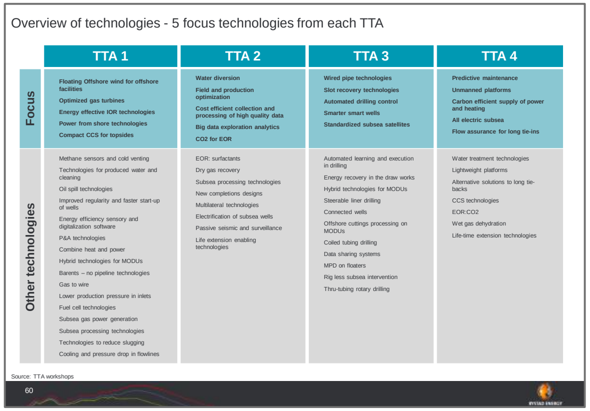

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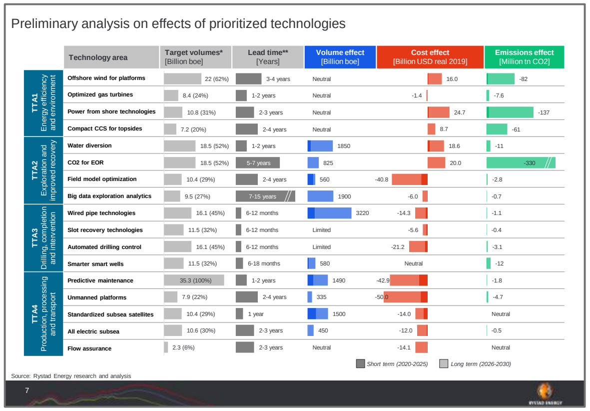

Source: Rystad Energy research and analysis

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

	Technology area	TTA1	TTA2	TTA3	TTA4
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		Suggested
	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

Chosen *Suggested*

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

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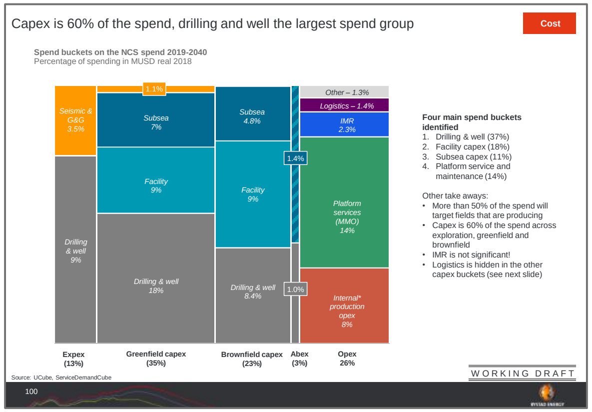

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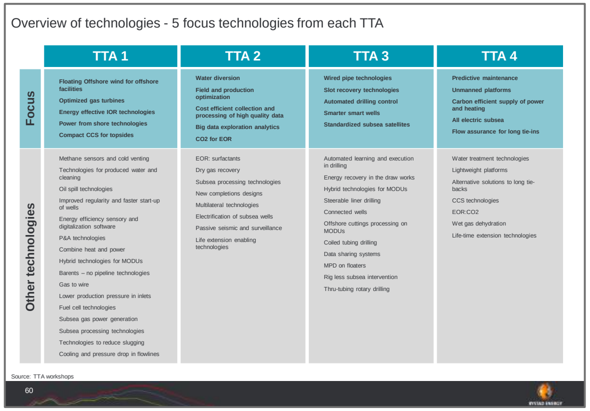

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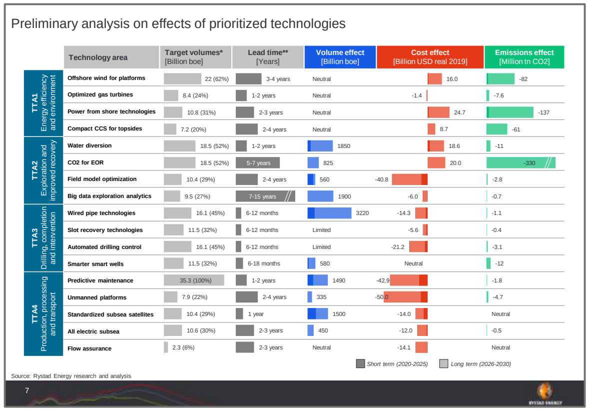

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Analysis on effects of the selected focus technologies

	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)*

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CO_2 for EOR holds the potential to cut 330 megatons of CO_2 to 2050 – six times Norway's total emissions in 2018

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Wired pipe may yield volumes equal to one Johan Sverdrup

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Better field models can help us save half a Sverdrup in cost (while yielding a Castberg)

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Technologies may yield four Sverdrups...

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...while saving one National Budget...

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	Smarter smart wells	11.5 (32%)	6-18 mon			-12
TTA4 Production, processing and transport	**Predictive maintenance**	35.3 (100%)	1-2 year			-1.8
	Unmanned platforms	7.9 (22%)	2-4			-4.7
	Standardized subsea satellites	10.4 (29%)	1 year			Neutral
	All electric subsea	10.6 (30%)	2-3 y			-0.5
	Flow assurance	2.3 (6%)	2-3 y			Neutral

...and 12 years worth of Norwegian CO_2 emissions

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

Source: Rystad Energy research and analysis