

Low-emission 2050 TG-workshops 3 and 11 June 2024

Summary note w/o appendices

Date: 14 June 2024



Overall summary: Near-term solutions will be important also in the longer run, but new technologies could make significant contributions to achieve near-zero emissions by 2050

From the long-list in the DNV-study in 2022, geothermal energy was the only additional technology identified as potentially important in a 2050-perspective

The Menti-polls confirmed traditional measures as important also towards 2050. In addition, geothermal and nuclear power were suggested as important 2050-opportunities

The break-out sessions provided additional insights: a holistic energy system approach as well as CO2 capture technologies and offset mechanisms, are important long-term measures

Long-list of decarbonisation measures

Replacing gas turbines through electrification

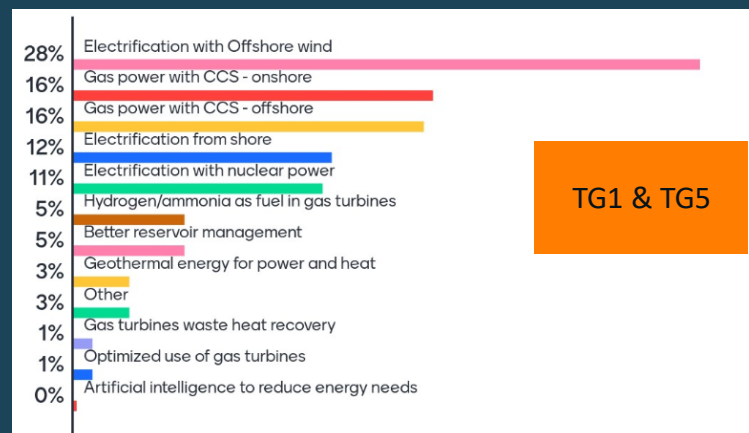
- Electrification: Power from shore (coordinated approach)
- Electrification: Power from shore (individual approach)
- Electrification: Local supply from offshore wind
- Gas-fired power hub with CCS

Reducing emissions from the gas turbines

- Compact topside CCS
- Hydrogen and hydrogen-derived fuels for power production
- Optimized gas turbines: Utilisation

Increasing the energy efficiency*

- Energy efficiency through reservoir management: Water management
- Energy efficiency through reservoir management: Artificial intelligence
- Energy efficiency through reservoir management: CO2-EOR
- Optimized gas turbines: Waste heat recovery
- Geothermal energy to reduce electrical power demand offshore**



- The 2030-measures are the most important also in the 2050-perspective, but with offshore wind and gas power w/CCS moving higher on the list. Better reservoir management is still a key technology. Nuclear power is a potential game changer, but associated with many challenges including regulations, safety and costs
- Data science methods, including AI, may reduce emissions when implemented efficiently in other tools, e.g. tools for better subsurface understanding. Data sharing and collaboration is important for efficiency and safety but introduces security concerns that must be managed
- Relatively little enthusiasm for using hydrogen/ammonia as fuel in gas turbines. TG1/TG5-workshop more optimistic than TG2/TG3/TG4-workshop. Several safety and working environment challenges need to be solved if this solution is further pursued
- Achieving near-zero emissions in 2050 will require a holistic approach to the whole energy system including gas, hydrogen, CCS and low-emission power
- Technologies which primary goal is to improve efficiency, are also important for reducing GHG emissions, e.g. drilling technologies that reduce time, and well completion and subsea separation technologies that reduce water lifted to topside
- When all power from offshore gas turbines has been replaced with low-emission sources, 15% of emissions still remain. These emissions must also be addressed to meet 2050-targets
- Several new technologies and offset mechanisms received attention, e.g.:
 - Direct air capture / direct ocean capture
 - Using heat pumps offshore
 - Direct exhaust treatment & injection

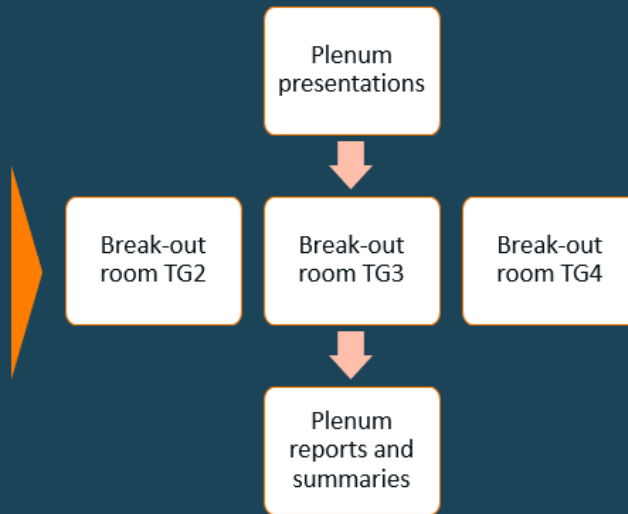
Summary from June 3 workshop TG2, TG3 and TG4



Summary – Workshop 3 June for TG2, TG3 and TG4

The 29 workshop participants were actively engaged through Menti polls and TG-specific break-out-sessions. This summary note includes a preliminary discussion of results from both

09:00 Welcome, plenum, Gunnar 5 minutes
09:05 Project purpose and objective, Gunnar, 10 minutes
09:15 Menti poll, All, 10 minutes
09:25 Presentation of pre-reads, Gunnar, 30 minutes
09:55 Transfer to break-out rooms, 5 minutes
10:00 Group work in Teams break-out rooms, 30 minutes, led by TG-leaders
10:30 Break, 15 minutes
10:45 Group work in Teams break-out rooms continues, 30 minutes
11:15 Back to plenum - TG-leaders report from break-out sessions, 3x8 minutes
11:40 Menti poll, All, 10 minutes
11:50 Next steps & closing remarks, Gunnar, 10 minutes
12:00 Adjourn



Main takes from TG-specific break-out sessions: 1

- Priorities from the DNV study in 2022 and the OG21 Strategy 2021 to reduce GHG emissions are, in general, still relevant
- Main opportunities lay within reservoir management and subsurface understanding. Data science methods, including AI, is an integral element to this
- Emission reductions also achieved through implementation of other technologies that lead to higher efficiency, faster drilling, and less use of power. In TG3, data science and collaboration are major components to achieve higher efficiency
- Within the TG4 domain, the effect of digital tools on reducing GHG emissions, was questioned

Main takes from Menti polls: 2

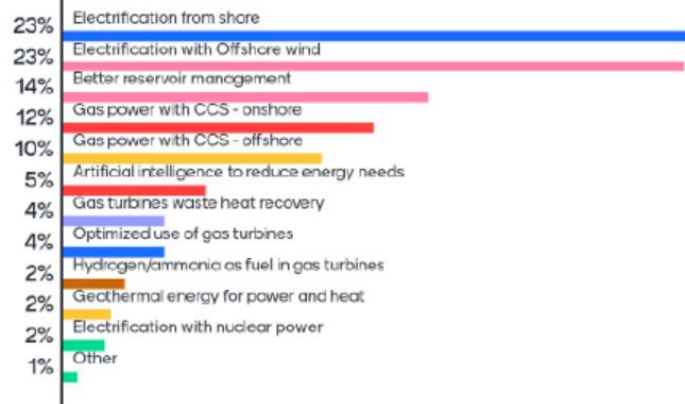
- In a 2030 perspective, power from shore is the most important solution, followed by offshore wind, water management, and gas power with CCS
- In the 2050 perspective, offshore wind is considered the most important solution. The “2030-solutions” are still considered to be among the most important, but in addition, geothermal energy and nuclear power are suggested to have substantial potential
- In a 2050-perspective, workshop participants believe also “other solutions” to become important. That includes elements such as: a holistic approach to the whole energy system including gas, H2, CCS and power, as well as direct exhaust treatment & injection, fusion energy and others

Main takes from TG2/TG3/TG4 Menti polls, 3 June

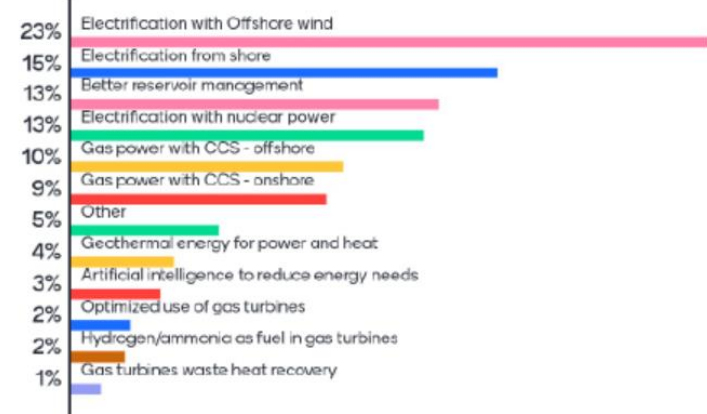
Results from the 2022 DNV study on most important technologies in a 2030 perspective, were confirmed: power from shore, offshore wind, reservoir management, and gas power with CCS

In a 2050-perspective, many of the same technologies were thought to be important, with offshore wind as the most important. Nuclear power and “other” technologies came high on the list as potential measures

2a) What are the most important measures to reach near-zero emissions by 2030? (allocate 100%-points)



2b) What are the most important measures to reach near-zero emissions by 2050? (allocate 100%-points)



“Other” suggestions shown below

2c) Which other options do we have to reduce emissions to near-zero by 2050? (provide answer and give up to 3 votes to others' answers)

Demand destruction	Keeper Wells	Fusion Energy	Direct exhaust treatment and injection
Supply destruction	Reuse of facilities and equipment	Closer cooperation between all operators and other stakeholders to standardize solutions and reduce carbon footprint.	Subsea gas to power (including subsea CCS)

2c) Which other options do we have to reduce emissions to near-zero by 2050? (provide answer and give up to 3 votes to others' answers)

Retrofit old wells	flexible energy demand	More efficient drilling operations	Focus on an integrated energy system including gas, H2, CCS & power
CCS in depleted reservoirs and reuse Wells for CCS	Repair, recycle, on demand	Cooperation across licensees, operations	Repair instead of replace

2c) Which other options do we have to reduce emissions to near-zero by 2050? (provide answer and give up to 3 votes to others' answers)

Power Market with efficient regulations of price from non-regulating sources	Energy efficiency per boe produced	Ccs for retrofitting old installations
--	------------------------------------	--

Main takes from TG2/TG3/TG4 break-out sessions 3 June

Main takes from the TG2 session

- Two technology priorities are still the most important to cut GHG emissions:
 - **Water management**
 - **Subsurface understanding and models**
- Need to see more progress on both R&D and implementation of prioritized technologies
- Large opportunities in AI/ML controlled field management. Requires:
 - Better collaboration: Potential in utilizing Subsurface/WellOps together, reservoir/geoscience
 - Good automation / data management needs to be in place

Main takes from the TG3 session

- Most TG3 technology priorities in the OG21 strategy still relevant to reduce GHG emissions
- The priorities have aggregated effects on **reducing GHG emissions** mainly **through improved efficiency and reduced drilling time**
- Similarly, efficiency gains and thus GHG emission reductions can be obtained through **improved collaboration** on data sharing, btw. disciplines, and btw. licenses
- Some themes that could help reduce GHG emissions, attracted extra attention in the workshop:
 - “Keeper wells”: Exploration wells that become production wells
 - Electric X-mas trees and BOPs to avoid hydraulic leakages which often lead to downtime
 - Standardization of wells
 - Rigless P&A

Main takes from the TG4 session

- The prioritization in the OG21 Strategy on **“Unmanned facilities and subsea tie-backs** includes technologies that are still relevant for **reducing GHG emissions**, among the most important are subsea water management, subsea intervention and subsea all-electric. Subsea processing is generally considered more energy effective than topside
- **Collaboration** is important: Need holistic R&D involving subsurface, drilling&well, SURF and topside facilities to achieve step change in subsea solutions
- The workshop participants **do not share** the view expressed in the OG21 Strategy from 2021 that “Digital tools for improved maintenance and improved efficiency” have a high potential for reducing GHG emissions. There will be some impact, but the major effects of these tools are on other parameters such as HSE and costs

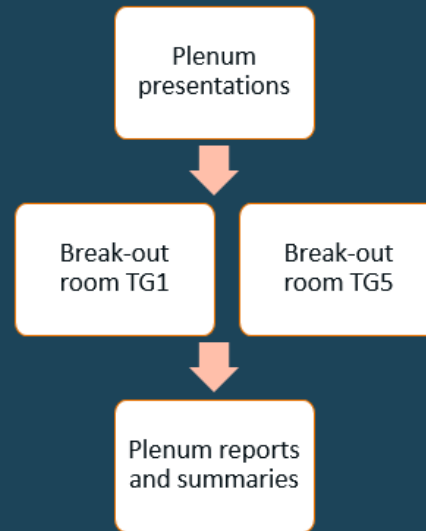
Summary from June 11 workshop TG1 and TG5



Summary – Workshop 11 June for TG1 and TG5

The 17 workshop participants were actively engaged through Menti polls and TG-specific break-out-sessions. This summary note includes a preliminary discussion of results from both

- 09:00 Welcome, plenum, Gunnar 5 minutes
- 09:05 Project purpose and objective, Gunnar, 10 minutes
- 09:15 Menti poll, All, 10 minutes
- 09:25 Presentation of pre-reads, Gunnar, 30 minutes
- 09:55 Transfer to break-out rooms, 5 minutes
- 10:00 Group work in Teams break-out rooms, 30 minutes, led by TG-leaders
- 10:30 Break, 15 minutes
- 10:45 Group work in Teams break-out rooms continues, 30 minutes
- 11:15 Back to plenum - TG-leaders report from break-out sessions, 2x10 minutes
- 11:40 Menti poll, All, 10 minutes
- 11:50 Next steps & closing remarks, Gunnar, 10 minutes
- 12:00 Adjourn



Main takes from TG-specific break-out sessions:

- Priorities from the DNV study in 2022 and the OG21 Strategy 2021 to reduce GHG emissions are, in general, still relevant. The geopolitical, societal and energy transition context has changed, and both short and long-term priorities need to align with the new realities and expectations
- New technologies such as all-electric subsea, ammonia as fuel, nuclear power, and big data and AI, introduce new safety and environmental risks that must be understood and managed
- Data science methods, including AI, do not alone reduce GHG emissions, but may contribute to reductions when used together with other tools/knowledge.
- Managing safety, security and environmental risks may require optimization of conflicting interests, e.g. GHG reducing measures may increase health risks, sharing data to improve safety may increase security risks
- New technologies with significant potential include: DAC/DOC/nature based solutions, nuclear/fusion, and onshore gas power w/CCS

Main takes from Menti polls:

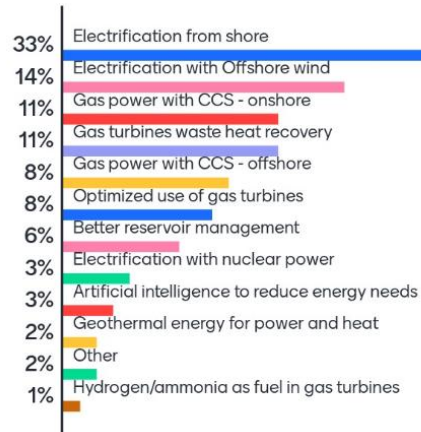
- In a 2030 perspective, power from shore is the most important solution, followed by offshore wind, gas power w/CCS, and optimized use of gas turbines
- In the 2050 perspective, offshore wind is considered the most important solution. The “2030-solutions” are still considered to be among the most important, but in addition, nuclear, hydrogen/ammonia as fuel, and reservoir management are suggested to have substantial potential
- In a 2050-perspective when emissions need to be near-zero, workshop participants draw attention to the need for also reducing emissions not coming from gas turbines
- A suggestion for the petroleum industry to contribute to “demand destruction” got support from several other attendees

Main takes from Menti polls TG1/TG5, 11 June

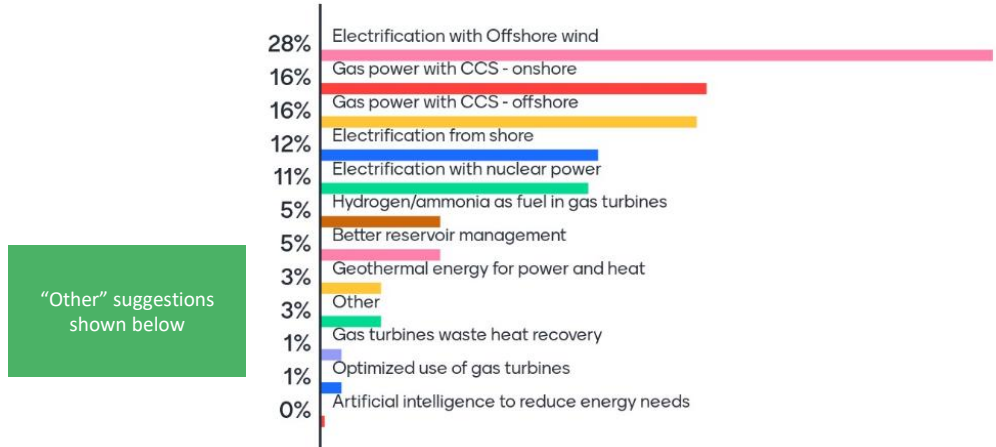
Results from the 2022 DNV study on most important technologies in a 2030 perspective, mainly confirmed: power from shore, offshore wind, and gas power with CCS. Optimization of gas turbines high on the list. Reservoir management lower on the list than in TG2/TG3/TG4-workshop 3 June

In a 2050-perspective, many of the same technologies were thought to be important, with offshore wind as the most important. Nuclear power high on the list. Some support for hydrogen/ammonia as fuel. Other emissions than gas turbine emissions also need to be reduced to achieve near-zero

2a) What are the most important measures to reach 2030 goals? (allocate 100%-points)



2b) What are the most important measures to reach near-zero emissions by 2050? (allocate 100%-points)



2c) Which other options do we have to reduce emissions to near-zero by 2050? (provide answer and give up to 3 votes to others' answers)

When all gas turbine emissions are taken care of there are still emission sources to be addressed (flaring, engines on drilling rigs etc) 7 Popular	Heat pump 6	Fusion technology 5	Increased effort on energy efficiency for the offshore operations. 5
The ambitions in fossil extractions affect the planners on the user-side. As such, a massive scale-up of oil&gas affects the investments of renewable solutions on the consumer side. 5	Demand destruction/actively by o&g 4	Consolidated CO2 infrastructure, planning and operation 2	New Processes for H2 Generation - higher efficiencies 1

2c) Which other options do we have to reduce emissions to near-zero by 2050? (provide answer and give up to 3 votes to others' answers)

The oil and gas industries have an extremely important role to compensate for the remaining emissions. Approx same scale as of today (on Gt handling each year). 1	Direct co2 capture
--	--------------------

Main takes from TG1/TG5 break-out sessions

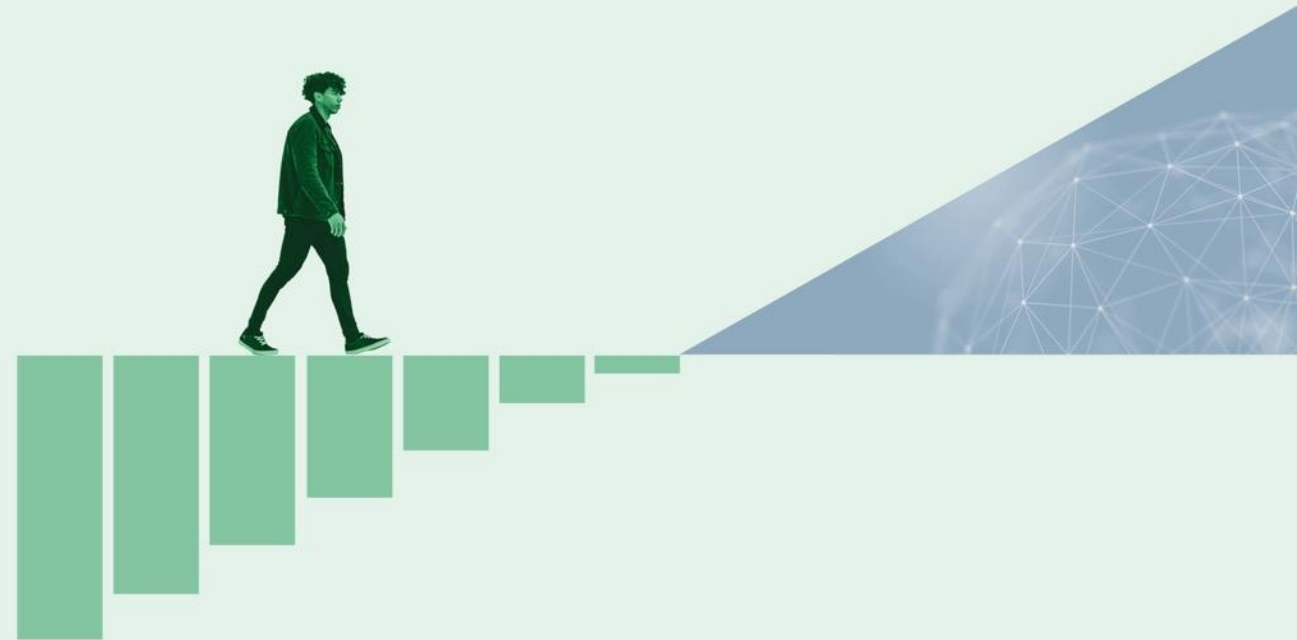
Main takes from the TG1 session

- The TG1 prioritized technologies in the OG21 Strategy are still relevant, but the social context has changed. NCS measures need to align with the need to reduce global emissions, and reflect society expectations
- There are challenges and opportunities linked to both electrification and alternative fuels, such as wind, hydrogen, and direct capture and storage. Challenges include technical difficulties, public perception, and value chain implications.
- Potential technologies for GHG reduction: More attention to heating and cooling needs, DAC/DOC/nature based solutions, onshore gas power generation with CCS, and nuclear/fusion..
- It is questionable whether ML and AI are not the main solution, but they can play a role in tackling complexity, combining sources, operation planning, and safety. Rather than only focusing on AI, we need to leverage the full digital toolkit.
- It is important with holistic thinking and integrated solutions for achieving GHG reduction goals. We need to think in terms of value chain, parallel contributions, and combined resources. There is a need for standardization and cost-price-value analysis.

Main takes from the TG5 session

- The TG5 priorities in the OG21 Strategy were mainly confirmed. Uncertainty and risks have increased both due to geopolitical unrest and use of new technologies
- Geopolitical unrest create new safety and security challenges which require increased attention
- New technologies such as all-electric subsea, ammonia as fuel, nuclear power, and big data and AI, introduce new hazards and risks that must be understood and managed
- Managing safety, security and environmental risks may require optimization of conflicting interests, e.g. GHG reducing measures may increase health risks, sharing data to improve safety may increase security risks
- Managing safety, working environment and security requires collaboration across disciplines
- Traditional safety and working environment hazards like benzene exposure, need continued attention whilst managing risks of new technologies

Appendices with all TG- notes and Menti-polls available on request



The background of the image is a photograph of ocean waves. The water is a deep, dark blue, and the waves are breaking, creating white foam and spray. The perspective is from a slightly elevated position, looking down at the water. The overall tone is somewhat desaturated, giving it a professional and serene feel.

OG21