NORWEGIAN PETROLEUM DIRECTORATE

17.02.2021 | Report no. OD-02-22

Resource Accounts for the Norwegian continental shelf as per 31 December 2021

Organisational unit	Team
Technology, analysis and coexistence	Resource Accounts and Forecasts
Management involvement	
Technology, analysis and coexistence	
Quality assurance	
Resource Accounts and Forecasts, Exploration studies	
Comments	

Table of contents

1 Resource Accounts for the Norwegian continental shelf 2021

Primary trends:

- Increase in proven resources.
  - The proven resources have increased by 142 million standard cubic metres of oil equivalent (million scm oe) compared with last year's Accounts. 65 per cent of the increase is for gas.
- Good reserve growth, particularly for gas.
  - As regards gross reserves, there was an increase of 165 million scm oe this year, compared with the Accounts for 2020. The increase in 2021 can primarily be explained with the increased submission of plans for development and operation (PDOs) and extended operating periods for several fields.
- The estimate for overall undiscovered resources is nearly unchanged.
  - The NPD has increased the estimate for liquids resources in the Norwegian Sea and reduced the estimate for liquids and gas resources in the Barents Sea.

1.1 Oil and gas resources on the Norwegian continental shelf

Oil and gas resources are discovered, discoveries are developed as fields, if they are economically and technologically viable and the oil and gas is produced and sold. This results in dynamic resource accounts that change from year to year.

In the Resource Accounts as per 31 Dec. 2021 (Excel), the estimates for the overall resource volumes (including what has been sold and delivered) on the Norwegian shelf are

- 8,309 million scm oil
- 6,605 billion scm gas
- A total of 15,864 million scm oe
- This is an increase of 97 million scm oe compared with 2020

The total estimates for oil, liquids (oil, condensate and NGL), gas and overall petroleum products are shown in Table 1-1 along with changes from the Resource Accounts in 2020. The proven resources have increased by 142 million standard cubic metres of oil equivalent (million scm oe) compared with last year's Accounts. 65 per cent of the increase is for gas.

The volumes are listed in oil equivalent (1,000 scm gas = 1 scm oe)

Table 1-1 Expected values for petroleum resources as per 31 December 2021 with changes from 2020. (Liquids are oil, condensate and NGL)

Product	Oil million scm		Sum liquid million scm		Gas billion scm		Sum oil eq. million scm	
	Total	Change	Total	Change	Total	Change	Total	Change
Produced	4 631	102	5 218	123	2 798	116	**8 016**	240
Reserves	1 045	-80	1 204	-83	1 449	8	**2 653**	-74
Contingent resources in fields	377	31	423	42	316	-26	**739**	16
Contingent resources in discoveries	322	-27	359	-34	307	-6	**666**	-39
Total discovered resources	**6 374**	**26**	**7 203**	**49**	**4 870**	**93**	**12 074**	**142**
Remaining discovered resources	**1 743**	**-76**	**1 985**	**-74**	**2 072**	**-23**	**4 058**	**-98**
Undiscovered resources (open areas)	935	-5	1 025	-5	1 100	-40	**2 125**	-45
Total open areas	**7 309**	**21**	**8 228**	**44**	**5 970**	**53**	**14 199**	**97**
Undiscovered resources (unopen areas)	1 000	0	1 030	0	635	0	**1 665**	0
Total	**8 309**	**21**	**9 258**	**44**	**6 605**	**53**	**15 864**	**97**

In this table, the petroleum resources are split into resource categories, reserves, contingent resources and undiscovered resources; this is described in the Appendix.

The Norwegian Petroleum Directorate estimates undiscovered resources both in areas that are open for petroleum activities, as well as in areas that have not been opened. These estimates contain the volumes of petroleum that we estimate could be extracted from deposits that have yet to be proven through drilling.

The distribution of the remaining resource volumes into resource categories along with the volume sold and delivered as per 31 Dec. 2021 is shown in Figure 1-1. The middle of the columns shows the expected recoverable petroleum. Uncertainty in the overall estimates is illustrated with a low estimate on the left and a high estimate on the right in each column. The pie chart on the right shows that 50 per cent of the expected recoverable resources on the shelf have been produced, and that 24 per cent of the overall resources have yet to be discovered.

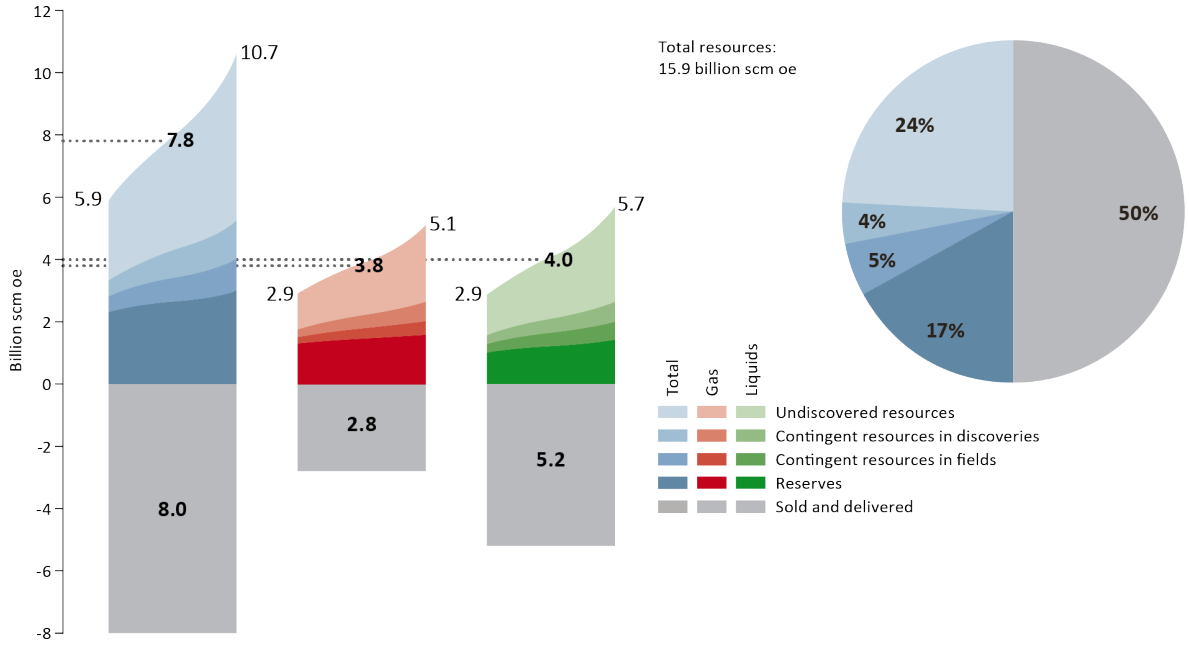

Figure 1-1 Petroleum resources and uncertainty in the estimates as per 31 Dec. 2021.

1.1.1 Resource development

Resource estimates change over time. New information and knowledge change the expected value and uncertainty associated with the overall resources. As resources are mapped, proven, matured and finally produced, their status changes. Figure 1.2 below shows the changes in the estimates for liquids and gas over the last ten years.

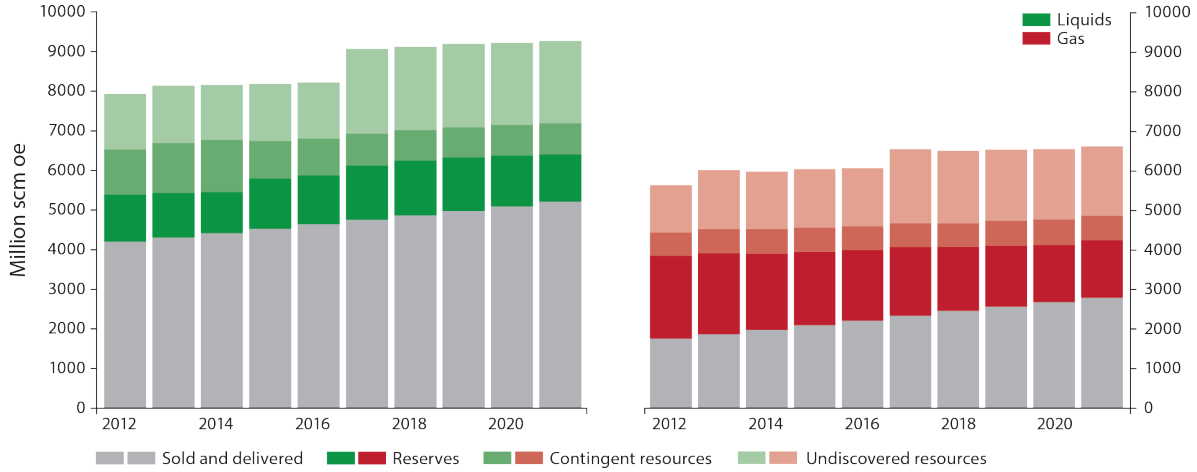

Figure 1-2 Development in expected value for liquids and gas resources over the last ten years. Liquids on the left and gas on the right.

The increase in undiscovered resources in 2017 is caused by including the resources in the Barents Sea North in the estimates. There has been a steady increase in both gross reserves and proven resources for liquids.

As regards gas, there has been a minor increase in gross reserves.

1.2 Oil and gas resources in Norwegian ocean areas

The three ocean areas the North Sea, Norwegian Sea and Barents Sea are different both as regards geology, resource base, maturity and scope of infrastructure and knowledge. An overview of the resources in the three ocean areas can be found here (Excel).

There has been petroleum activity in the North Sea since 1965. The Norwegian Sea and Barents Sea (areas north of the 62nd parallel) were opened for petroleum activities in 1980. The remaining resources and distribution between discovered and undiscovered resources in opened and unopened areas, respectively, therefore differ between the three ocean areas. The expected estimates can be found in Figure 1-3, which shows the distribution for oil and gas, respectively. The uncertainty in the volume estimates declines along with increasing maturity; read more in Chapter 3 about uncertainty in the undiscovered resources.

In the North Sea, the majority of oil and gas is defined as reserves, which means that they have approved plans for recovery. In the Barents Sea, the majority of oil and gas resources have the status of undiscovered. Vast areas in the Barents Sea have yet to be opened for petroleum activity, and this is where we find the greatest expected value for undiscovered resources.

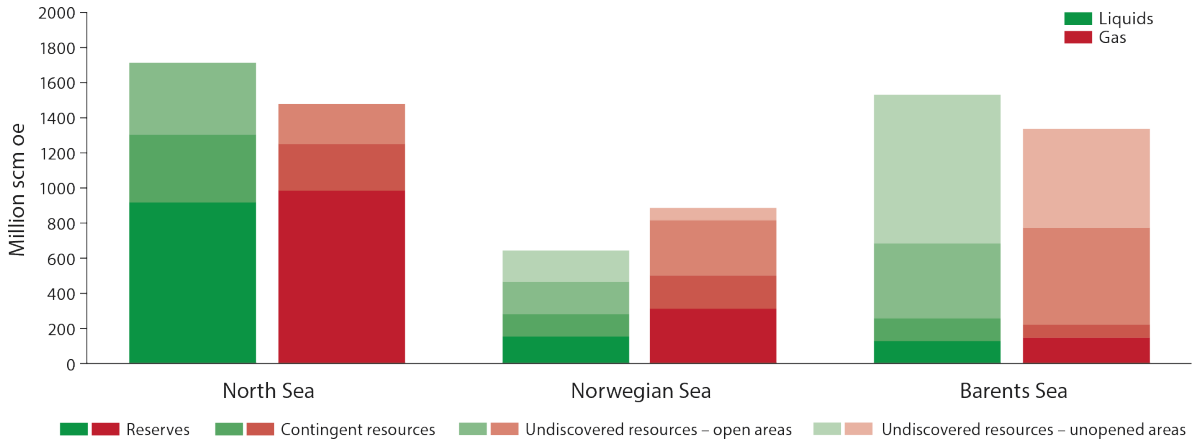

Figure 1-3 Distribution of remaining liquids and gas resources (expected values) distributed by ocean area and resource category. Liquids resources are shown in green and gas resources in red.

2 Discovered resources

2.1 Fields

The NPD's resource classification system defines oil and gas resources as reserves once the operator has submitted a plan for development and operation (PDO) or decided to implement a measure to optimise recovery that does not require a PDO. Discoveries are classified as fields once a development plan is approved. There are currently more than 100 fields in production, under development, or with plans for re-development.

The fields with the greatest remaining oil reserves as per 31 Dec. 2021 are Johan Sverdrup (346 million scm), Johan Castberg (90 million scm) and Snorre (74 million scm). The remaining gas reserves are greatest in Troll (685 billion scm), Snøhvit (148 billion scm) and Ormen Lange (105 billion scm).

2.1.1 Reserves

The overall remaining reserves total 1,045 million scm of oil and 1,449 billion scm of gas. This year's Resource Accounts show good growth in gas reserves, 125 billion scm. This is the highest reserve growth in gas since 2012. The growth in liquid reserves is lower, 40 million scm. The increase is mainly caused by the companies adopting and submitting more PDOs in 2021, and that the reserves increased on several fields, e.g. due to a longer expected operating period. Reserve estimates and production for each field can be found here (Excel).

In 2014, the Norwegian Petroleum Directorate established a goal for oil reserve growth of 1,200 million scm for the 2014-2023 period. This was done to ensure necessary focus on reserve growth, and to simultaneously follow up the development in a systematic manner.

The reserve growth for oil from 2013 to today is shown in Figure 2-1. The fields approved for development or in production on the Norwegian shelf in 2014 have seen a good reserve growth. By the end of 2021, they have already matured more than the objective set for 2023. In order to reach the goal, the resource estimates must increase over time. The discoveries with a development decision made during this period have seen a positive development since 2014.

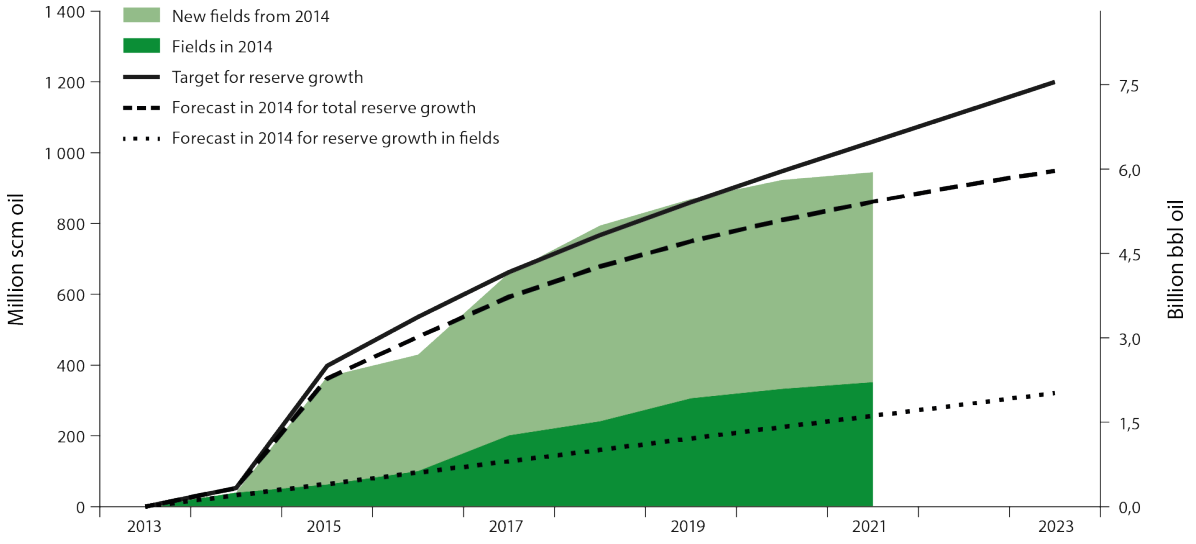

Figure 2-1 Growth in oil reserves from 2014 to 2021 compared with the NPD's forecast and goal from 2014. The growth is distributed between reserves from fields and from new discoveries that have come on stream.

The figures below show the changes in reserves, including produced volumes during the 2012-2021 period. The production is replaced by reserve growth in the years where the columns exceed production, shown in the dotted lines. The last ten-year period has seen an increase in liquids reserves, while there has been a reduction for gas; see Figure 2-2.

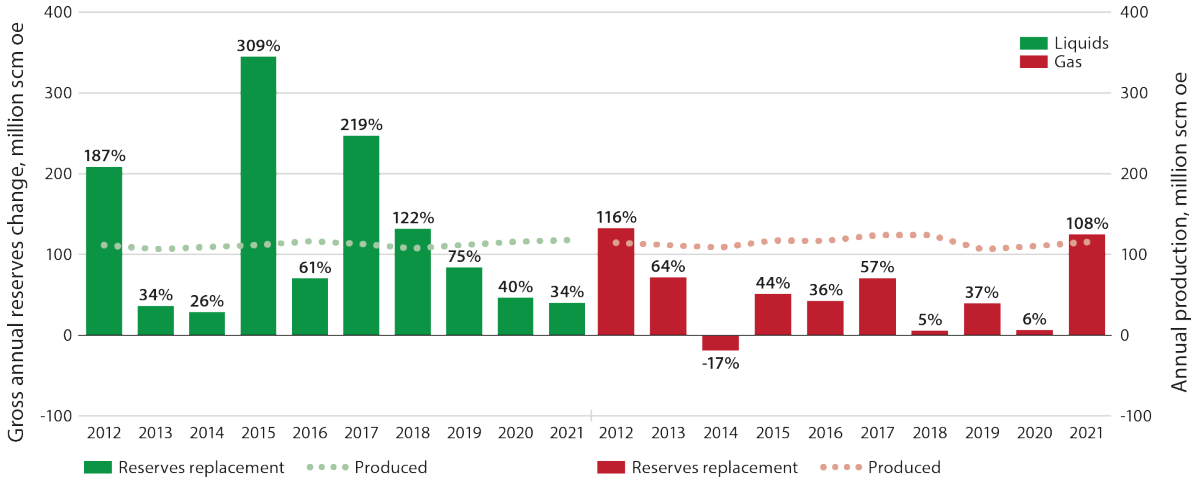

Figure 2-2 Reserve and production development for liquids and gas over the last ten-year period; the percentage shows annual reserve replacement

1,120 million scm of liquids has been produced since 2011, and the Accounts show that the remaining reserves are 117 million scm higher than in 2011. This means that the reserve replacement for liquids has exceeded 100 per cent over the last 10 years, while 34 per cent of the produced liquids reserves were replaced in 2021.

Gas production since 2011 totals 1,149 billion scm, and the Accounts show that the remaining reserves are 622 billion scm lower than in 2011. This yields a reserve replacement for gas of just under 50 per cent over the last 10 years, while more than 100 per cent of the produced gas reserves were replaced in 2021.

2.1.2 Contingent resources in fields

The expected value for contingent oil resources in fields is 377 million scm which is an increase of 31 million scm from 2020. The increase is caused by a project for late-phase production on Snorre.

For gas, the expectation is 316 billion scm, which is a reduction of 26 billion scm compared with 2020. This reduction is mainly caused by maturing resources into reserves and the submission of PDOs for e.g. Ormen Lange phase 3 and low-pressure production on Oseberg.

The Resource Accounts for 2021 include 184 specific, but not yet adopted, projects for improved oil and/or gas production and extended lifetime. Figure 2-3 shows these projects distributed by project type with associated resources shown in oe.

Projects to improve recovery are dominated by new wells, both in the number of projects (75) and volume (approx. 130 million scm oe). Other projects that could contribute considerably are further developments, particularly subsea developments with new templates tied into existing facilities, low-pressure and late-phase production. Fewer measures have been identified which utilise new injection or advanced methods.

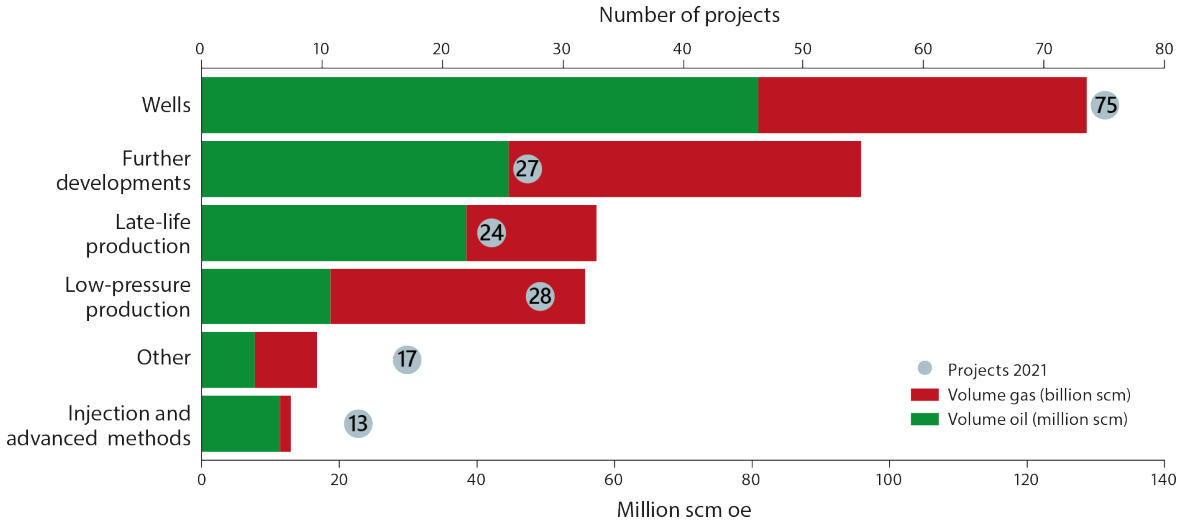

Figure 2-3 Specific projects for improved recovery from fields; number of projects and resources

2.1.3 Uncertainty - fields

The reserve estimates are based on thoroughly prepared plans. Nevertheless, there is uncertainty in the estimates, in the implementation of plans and whether everything will be produced. Despite the reserves being linked to production from existing fields, there is always uncertainty, because both the reservoir and technology can perform differently than expected. The range of uncertainty is shown in Figure 2-4.

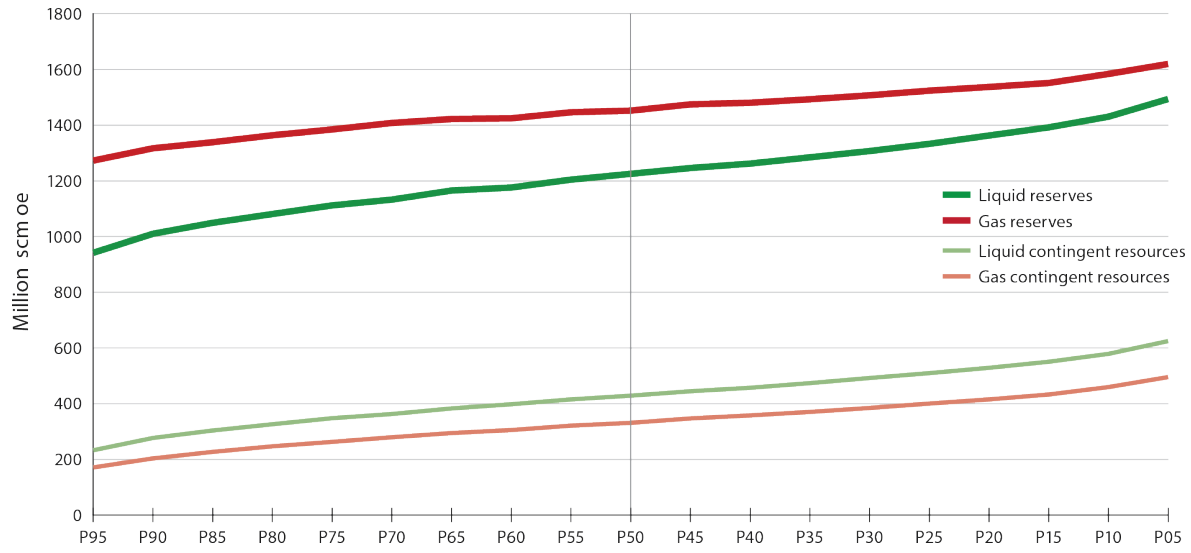

Figure 2-4 Uncertainty in reserves and contingent resources in fields for liquids and gas

The figure shows a probability distribution for the various volume estimates. The low end is the P95 estimate (95 per cent likelihood that the volume exceeds this value), and the high end is the P5 estimate (5 per cent likelihood that the volume exceeds this value).

2.2 Discoveries

Twenty discoveries were made in 2021, 18 of which in exploration wells and 2 in development wells with exploration targets. Thirteen of the discoveries were made in the North Sea, 4 in the Norwegian Sea and 3 in the Barents Sea.

On 1 January 2021, the discovery portfolio consisted of 95 discoveries. At the end of 2021, this number was 88, despite 20 new discoveries being made during the year; see Figure 2-5.

Assessments of whether discoveries will be profitable to develop will vary over time. Studies and measures could cause this status to change.

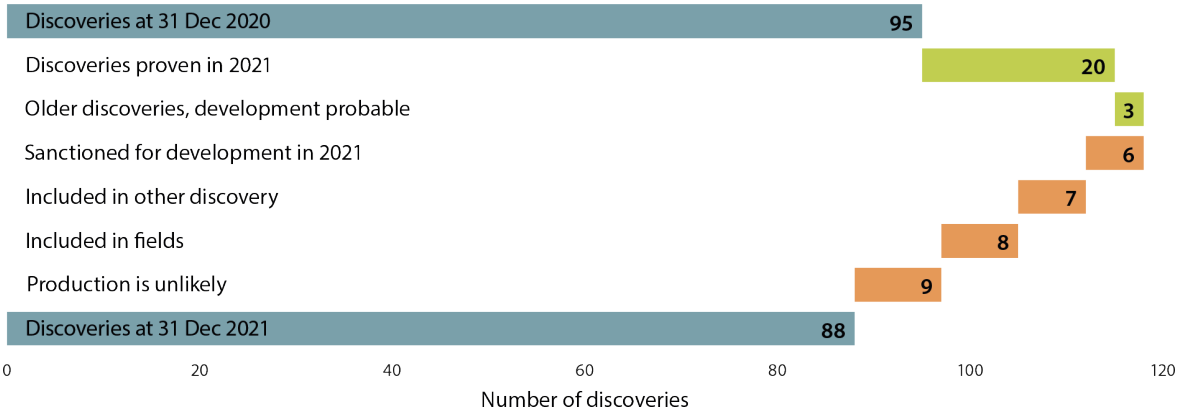

Figure 2-5 Overview of development in discovery portfolio through 2021. Categories in green show contributions to growth and categories in red show contributions to a reduction in the number of discoveries

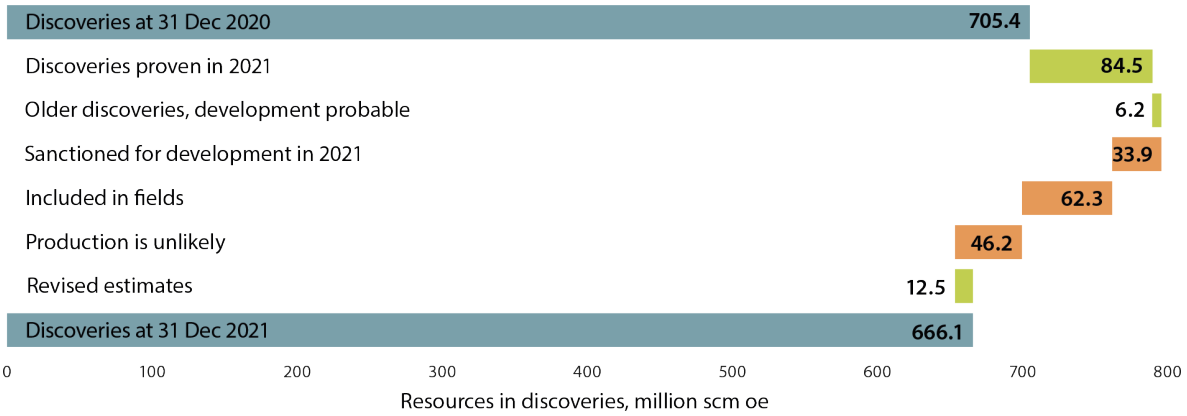

Figure 2-6 Overview of resource development in the discovery portfolio through 2021; categories in green show contributions to growth and categories in red show contributions to a reduction in resources awaiting a development decision

In addition to changes associated with new discoveries and new categorisation, the updates also cover updated estimates of what can be recovered from the various discoveries. This could be new studies of the subsurface, changes in concept for development solutions and conditions on the host installations. Of the 95 discoveries in the Accounts as per 31 Dec. 2020, 75 are also included in the 2021 Accounts. The estimate for recoverable resources in these discoveries has increased by 12.5 million scm oe.

2.2.1 Contingent resources in discoveries

There is a total of 359 million scm of liquids (oil, condensate and NGL) and 307 billion scm of gas in discoveries not yet developed, ref. Table 1-1. The total volume in discoveries has been reduced by 39 million scm oe compared with last year's Accounts. This reduction was mainly caused by resources maturing into reserves for several discoveries.

2.2.2 Many small and a few larger developments.

Figure 2-7 shows the discovery portfolio in the Resource Accounts by ocean area and size. A few major and several small discoveries were made in all areas, and the majority of discoveries are in the North Sea. The largest discovery is 7324/8-1 Wisting, which is located in the Barents Sea. In the Norwegian Sea, 6406/9-1 Linnorm is the largest, while 30/11-8 S Krafla is the largest in the North Sea.

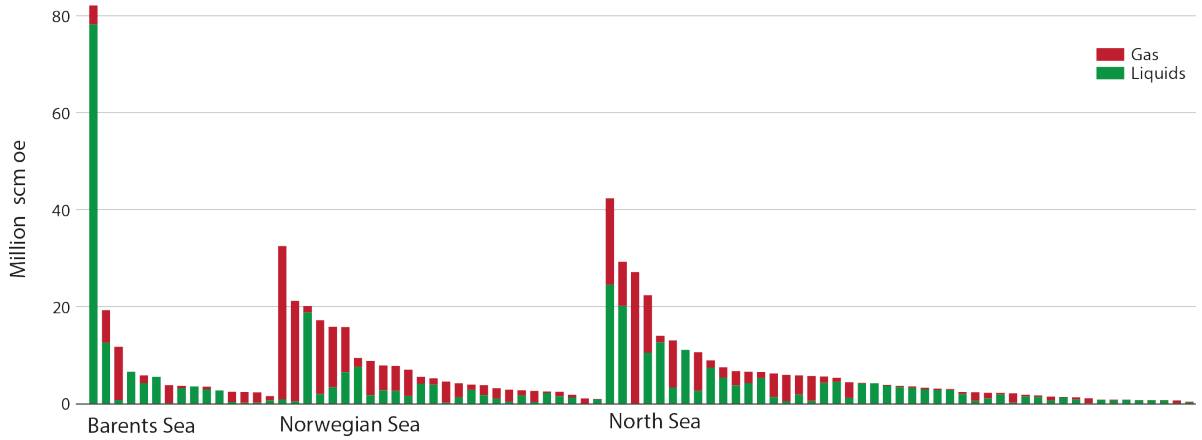

Figure 2-7 Discovery portfolio in the Resource Accounts

Both new and old facilities are important for the development of resources on the Norwegian shelf. A number of newer fields are tied into the existing infrastructure. As is evident from Figure 2-8, there are plans for several more tie-ins. New infrastructure is important for the development of resources in the area where it is established. This will allow for the tie-in of future discoveries, in addition to older discoveries that currently are not profitable for development.

A development with tie-in to existing fields or other major development projects is planned for 83 of the 88 discoveries in the figure. Several of the current discoveries are very likely to have joint solutions or be incorporated into fields before a development decision is made.

The most common development solution is subsea developments. This is the most likely concept for 64 of the discoveries. Another possible solution for smaller discoveries close enough to infrastructure is to use vacant well slots on existing fields. Such a solution has been reported for 18 discoveries.

The term production facilities is used here for platforms with separation and process equipment. Such facilities are the likely concept for five of the discoveries. They are used in areas which lack access to sufficient capacity in existing infrastructure or areas with vast distances. In order to invest in such facilities, the resource volumes must be relatively large, also through coordinated development of multiple smaller discoveries.

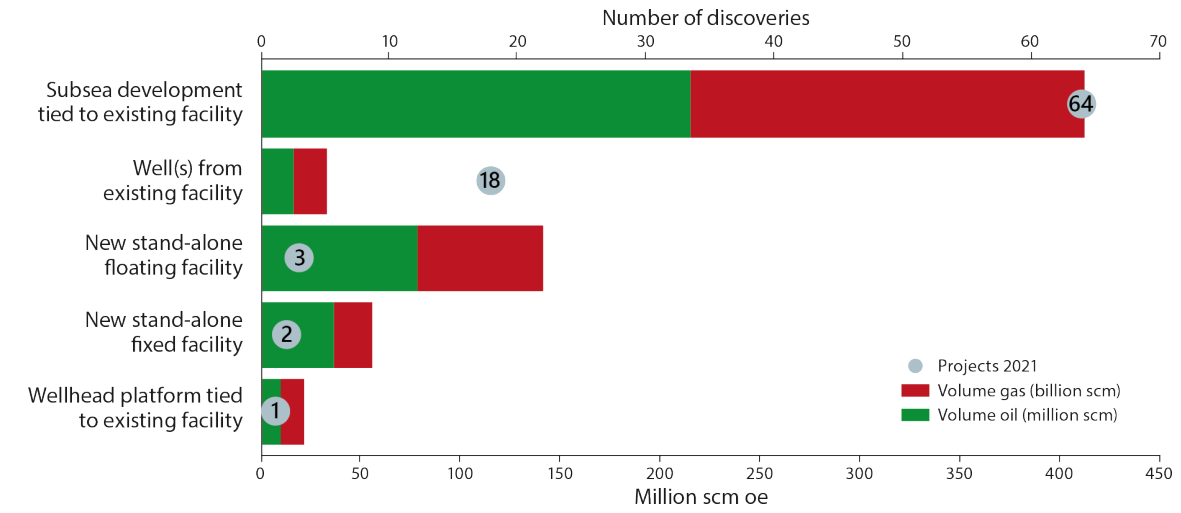

Figure 2-8 Likely development solutions for the 88 discoveries in this year's Resource Accounts, as well as overall resources per development solution

2.2.3 Uncertainty - discoveries

The range of uncertainty is shown in the figure below. The uncertainty is greater for resources in discoveries than in fields, since there is frequently less data available before a discovery is developed and becomes a field. There are many reasons for this, including less data on the size of the discovery and the possible technological solution.

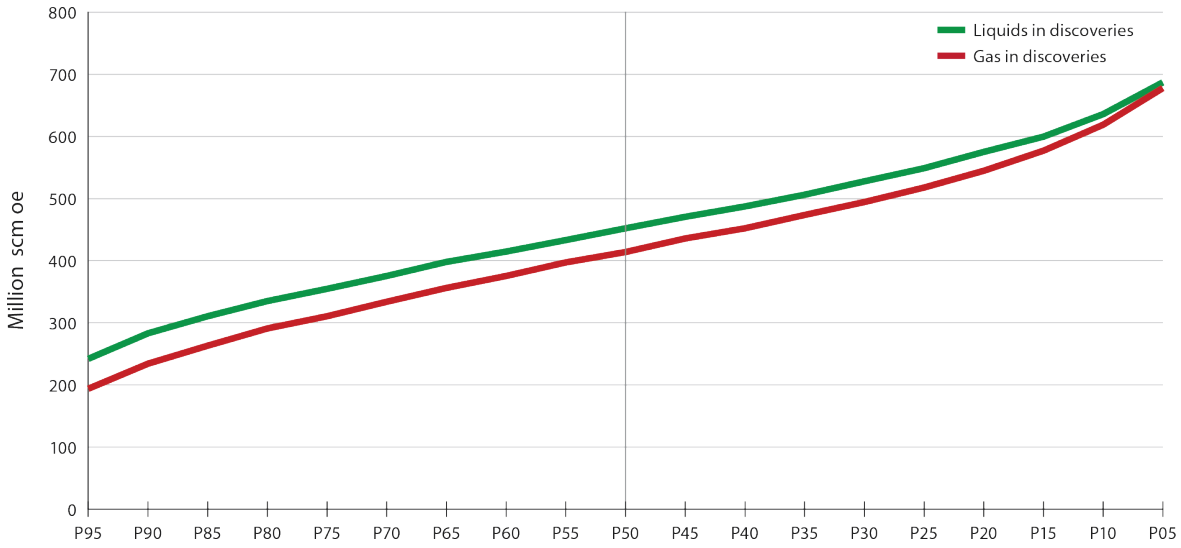

Figure 2-9 Uncertainty in resources in discoveries (liquids and gas)

2.2.4 Remaining proven resources

The figure below shows the change in remaining proven resources from 2020 to 2021. An increase in gross reserves and a minor increase in contingent resources in fields mean that the estimate for overall discovered resources has been reduced by just over 100 million scm oe, despite high production.

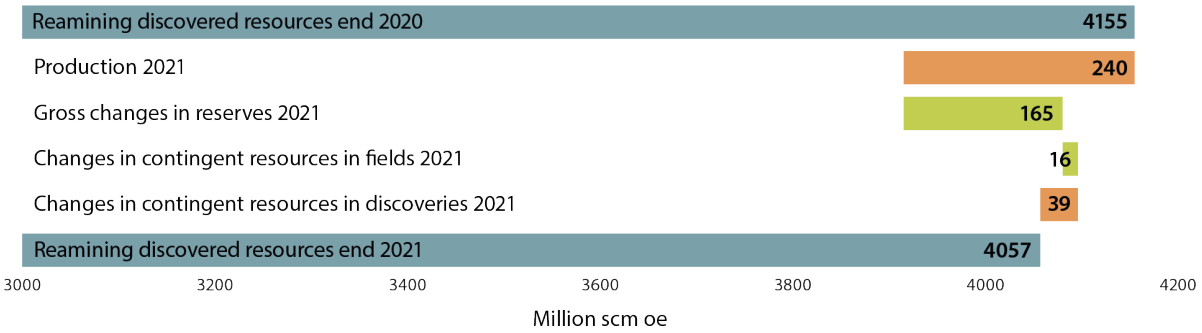

Figure 2-10 Overview of the change in proven resources from 2020 to 2021

3 Undiscovered resources

Undiscovered resources are volumes of petroleum that we project could be recovered from deposits not yet proven through drilling. The estimates of undiscovered resources in opened areas are updated every two years with an assessment of recent years' exploration results, new mapping and new documentation. The analyses were last updated in autumn 2021.

In interim years, the estimates are adjusted based on the last year's drilling activity. The estimates for the ocean areas of Lofoten, Vesterålen and Senja, as well as the Barents Sea North and the ocean area around Jan Mayen have not been updated and therefore remain unchanged since the previous Resource Accounts.

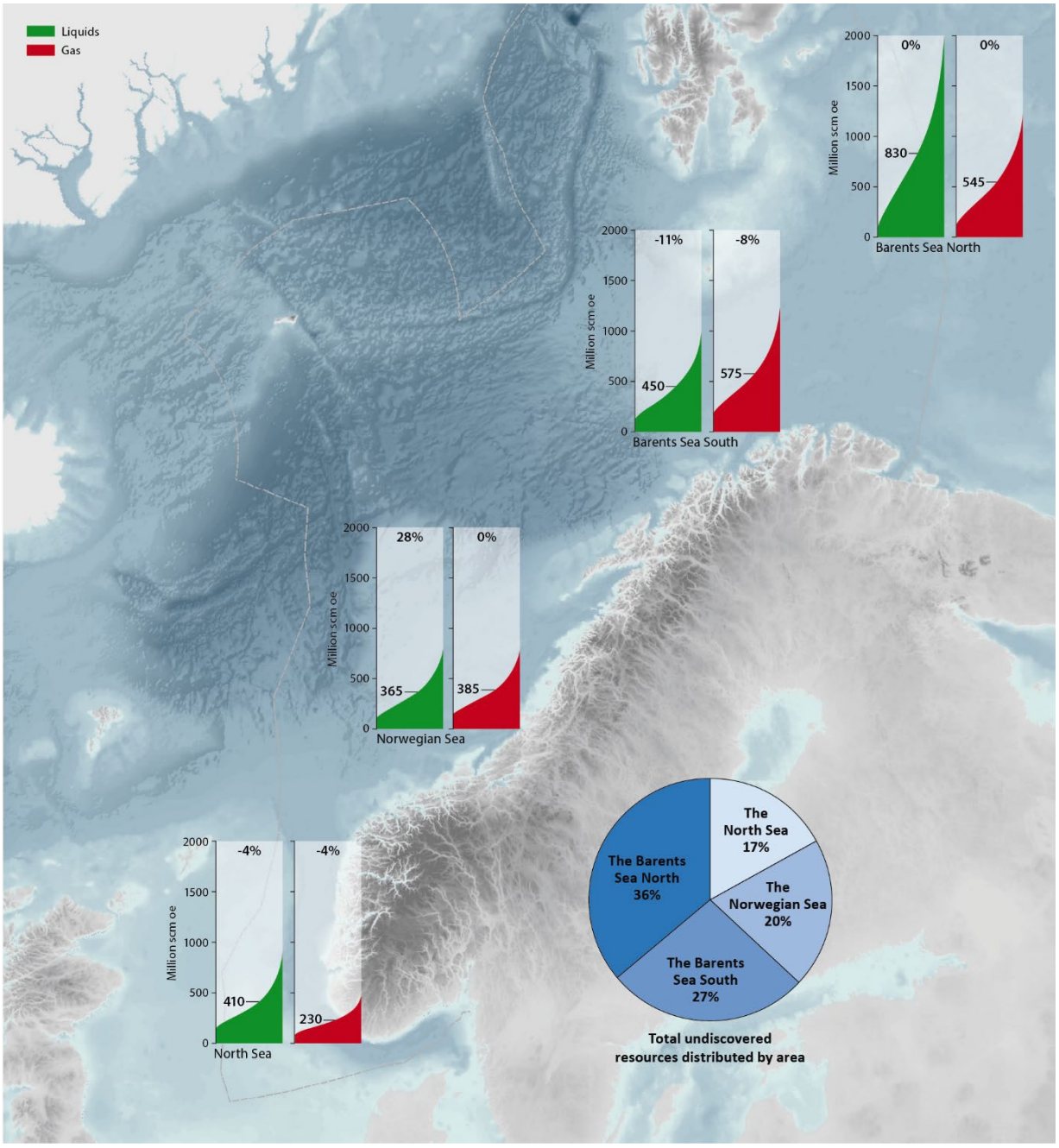

Figure 3-1 Distribution of undiscovered liquids and gas in the various ocean areas with range of uncertainty.

The pie chart in Figure 3-1 shows the percentage distribution between overall undiscovered resources in each ocean area. More than 60 per cent of the undiscovered resources are located in the Barents Sea. In the Barents Sea North, we expect there to be twice the volume of undiscovered liquids compared with the other ocean areas. But this is also where the uncertainty is greatest, which is reflected in the considerable range between the high and low estimate. The potential for gas on the Norwegian shelf is also greatest in the Barents Sea. It is distributed fairly equally between south and north.

There are nevertheless considerable undiscovered resources in the North Sea and Norwegian Sea as well. In the North Sea, we expect liquids to account for the largest share, while there is an equal distribution between undiscovered liquids and gas in the Norwegian Sea. The range of uncertainty shown in Figure 3-1 is from P95 to P05 in the estimated probability distribution for the resource outcome. The figures are listed in Table 3-1. The percentages shown for each range of uncertainty reflect the change in expectation from the previous year.

Table 3-1 Undiscovered resources per ocean area with range of uncertainty

	Liquids Million scm			Gas Billion scm			Sum oil eqvivalents Million scm		
Ocean areas	**P95**	**Mean**	**P05**	**P95**	**Mean**	**P05**	**P95**	**Mean**	**P05**
North Sea	185	410	710	110	230	380	360	640	990
Norwegian Sea	140	365	660	180	385	655	335	750	1 295
- Barents Sea South	*170*	*450*	*815*	*230*	*575*	*1 015*	*410*	*1 025*	*1 810*
- Barents Sea North	*185*	*830*	*1 600*	*175*	*545*	*1 020*	*400*	*1 375*	*2 550*
Barents Sea	545	1 280	2 155	580	1 120	1 770	1 180	2 400	3 865
Total, NCS	**1 200**	**2 055**	**3 025**	**1 100**	**1 735**	**2 465**	**2 400**	**3 790**	**5 385**

3.1 Undiscovered resources in opened and unopened areas

The NPD expects the undiscovered resources to make up 24 per cent of the overall resources on the Norwegian shelf. 56 per cent of this is in opened areas. 26 per cent of these resources are in the Barents Sea, 13 per cent in the Norwegian Sea and 17 per cent in the North Sea, as shown in Figure 3-2.

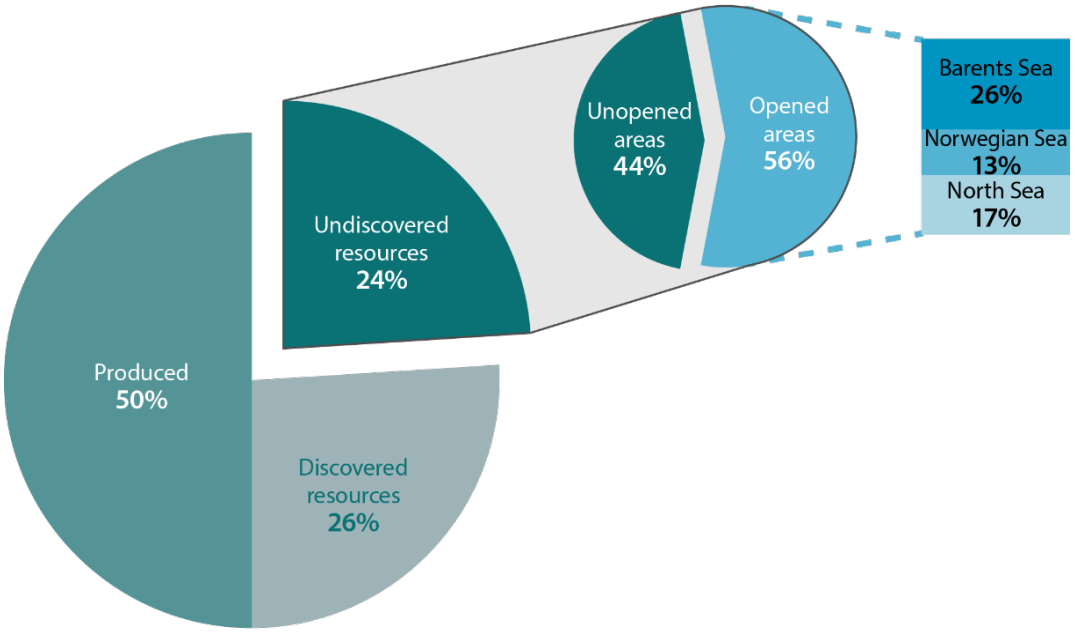

Figure 3-2 Distribution of undiscovered resources between opened and unopened areas.

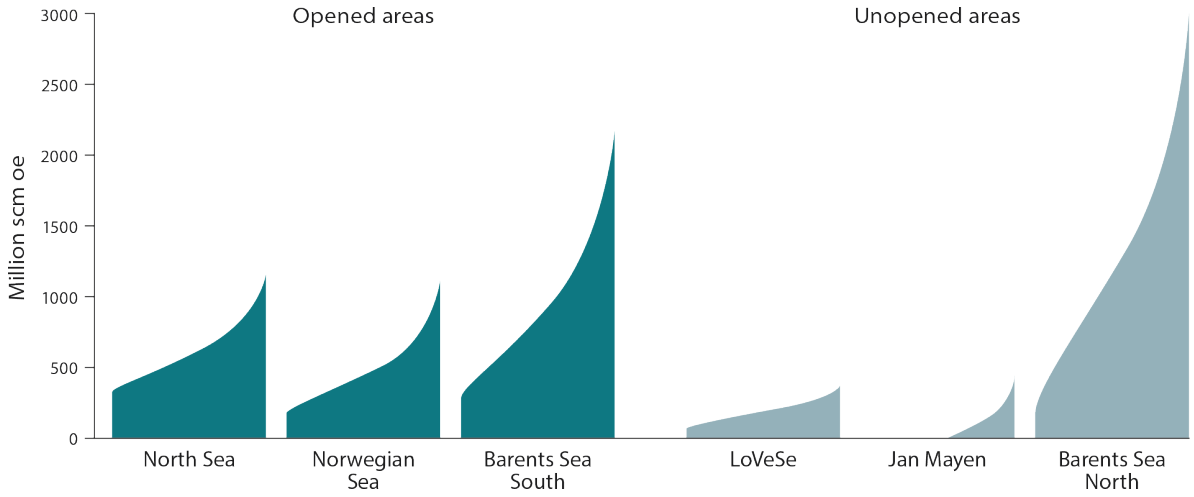

Figure 3-3 Undiscovered resources in opened and unopened areas with range of uncertainty. LoVeSe is an abbreviation for the areas of Lofoten, Vesterålen and Senja.

Despite the somewhat greater resource potential in the opened areas, the upside is greatest in the unopened part of the Barents Sea (Barents Sea North). But this is also where the uncertainty is the greatest, as shown in Figure 3-3. The resources in LoVeSe are distributed between the Norwegian Sea and the Barents Sea South.

Table 3-2 Undiscovered resources per ocean area, in opened and unopened areas.

	All areas			Opened areas			Unopened areas		
Ocean areas	Liquids Million scm	Gas GSm³	Sum oe Million scm	Liquids Million scm	Gas Billion scm	Sum oe Million scm	Liquids Million scm	Gas Billion scm	Sum oe Million scm
North Sea	410	230	640	410	230	640			
Norwegian Sea	365	385	750	185	315	500	180	70	250
- Barents Sea South	*450*	*575*	*1 025*	*430*	*555*	*985*	*20*	*20*	*40*
- Barents Sea North	*830*	*545*	*1 375*				*830*	*545*	*1 375*
Barents Sea	1 280	1 120	2 400	430	555	985	850	565	1 415
Total, NCS	**2 055**	**1 735**	**3 790**	**1 025**	**1 100**	**2 125**	**1 030**	**635**	**1 665**

3.2 Undiscovered resources in Norwegian ocean areas

The North Sea

The estimate for the undiscovered resources in the North Sea is 640 million scm of recoverable oe This is distributed between 410 million scm of oil and condensate (liquids) and 230 billion scm of gas. This is a reduction of four per cent from the previous year for both liquids and gas resources. This reduction is smaller than the resource volumes proven through exploration since the last estimate, which in real terms means that the estimate for remaining prospectivity is more positive than in the previous estimate.

Even in a mature area such as the North Sea, there is still significant uncertainty in the estimates for undiscovered resources, as illustrated in Figure 3-1. The figure shows a probability distribution where the low end is the P95 estimate (95 per cent likelihood that undiscovered resources exceed this value) and the high end is the P05 estimate (5 per cent likelihood that undiscovered resources

exceed this value). These figures indicate the expected value in the distribution. This is normally somewhat higher than the P50 value.

Even if one cannot rule out that larger discoveries could be made in the North Sea, we expect that most discoveries will be relatively small. The average discovery size in the North Sea over the last five years is 3.6 million scm of recoverable oe.

The Norwegian Sea
The estimate for undiscovered resources in the Norwegian Sea is 750 million scm of recoverable oe. This is distributed between 365 million scm of oil and condensate and 385 billion scm of gas. This is an increase from the previous year of 13 per cent and 22 per cent for liquids resources and 5 per cent for gas resources, respectively. The increase is linked to plays in the Early Cretaceous and Late Triassic to Middle Jurassic in the more mature areas in the Norwegian Sea and reflects the successful exploration in this area in recent years. The average discovery size in the Norwegian Sea has increased over the last five years and is now 6.2 million scm of recoverable oe. The resource estimates for the Norwegian Sea also include the unchanged resource volumes in the unopened areas outside Lofoten and Vesterålen, as well as in the ocean area around Jan Mayen. These constitute about 33 per cent of the overall estimate.

The Barents Sea
The estimate for undiscovered resources in the Barents Sea is 2,400 million scm of recoverable oe. This is distributed between 1,280 million scm of oil and condensate and 1,120 billion scm of gas. This is a reduction of 4 per cent from the previous year for both liquids and gas resources. The entire reduction is associated with the Barents Sea South, where the reduction is 11 per cent for liquids and 8 per cent for gas. This reduction is largely linked to plays in the Triassic in the eastern parts of the area. Recent years' exploration results in the Barents Sea have been disappointing, with an average discovery size of 3.9 million scm of recoverable oe. This is the primary reason for the reduction. In the previous five-year period, the corresponding figure was 10.6 million scm of oe.

In the Barents Sea, 59 per cent of the resources are located in areas that have not been opened for petroleum activities, primarily in the Barents Sea North. This is the area with the greatest likelihood of making major new discoveries on the Norwegian shelf. There are considerable uncertainties associated with the estimates in these areas. The NPD is currently engaged in a geological mapping of the Barents Sea North based on new data collected since the previous mapping in 2016. The resource estimates for this area will be updated over the course of 2022.

4 Production

A total of 8,000 million scm of oil equivalent (oe) has been sold from Norwegian fields. The annual values for oil and gas are shown in Figure 4-1. Measured in oe, more gas than oil has been sold over the last ten years.
During the 1985–2010 period, the production of oil was significantly higher than that of gas.

At year-end, 94 fields had the status “in production” on the Norwegian shelf. Production started on five fields in 2021; Duva, Martin Linge, Solveig, Yme and Ærfugl Nord. No fields were shut down in 2021.

It is presumed that 88 discoveries will come on stream. The overall resource estimate for these is 666 million scm of oe., distributed between 54 per cent liquids and 46 per cent gas.

Oil production is presumed to reach a new peak around 2024-2025 of approx. 2 million barrels per day. This is more than 60 per cent of the level in the year 2000. Gas sales have been at a relatively high level over the last ten years and are expected to remain at this level leading up to 2026.

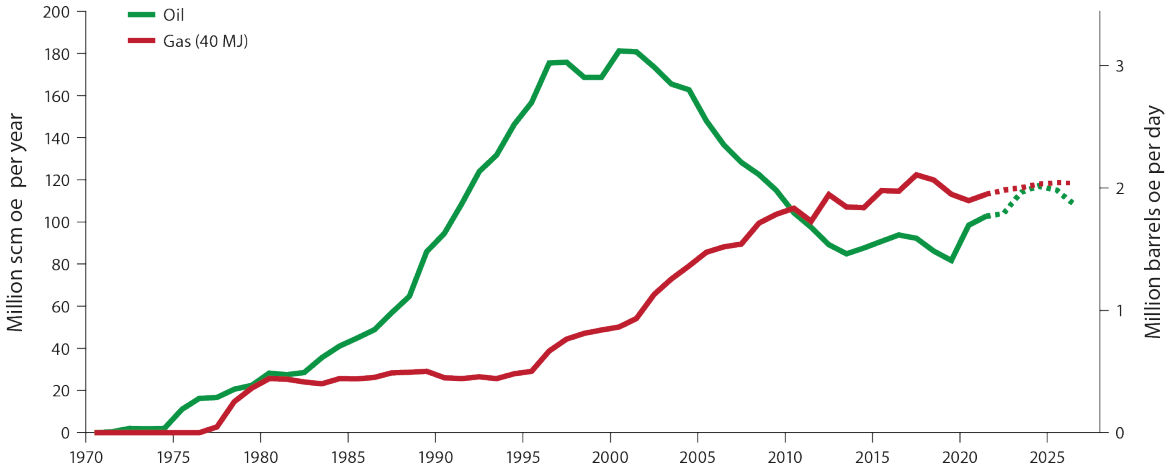

Figure 4-1 Historical sales of oil and gas with forecast (dotted lines) leading up to 2026

Without new fields or major investments in existing fields, production from the Norwegian shelf will decline. As a result of high development activity in recent years, we expect production to increase moving forward. Over the short term, the fields that come on stream will offset lower production from ageing fields. The production level is uncertain over the longer term. This will depend, among other things, on which measures are implemented on the fields, which discoveries are approved for development, and when they come on stream. New discoveries, their size and how and when they are developed, will also affect the production level over the longer term.

Historical total production and a forecast leading up to 2031, distributed by maturity of resources, is shown in Figure 4-2.

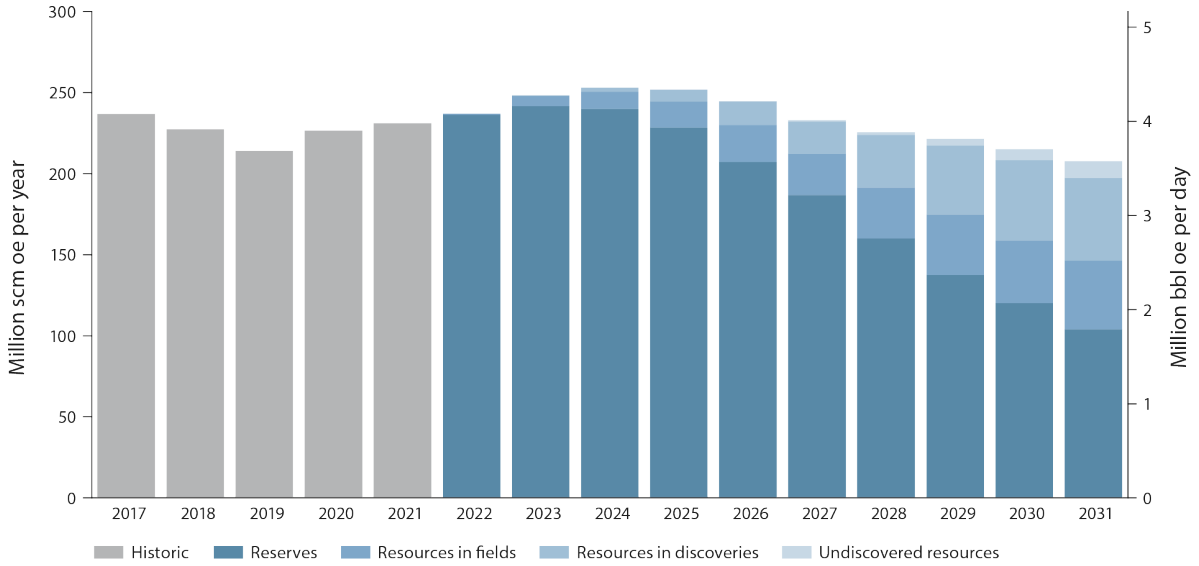

Figure 4-2 Historical total production and forecast distributed by maturity of resources

5 Appendix

Conversion factors and designations:
https://www.npd.no/en/about-us/information-services/conversion-table/

The NPD's resource classification and definitions:
https://www.npd.no/globalassets/1-npd/regelverk/forskrifter/en/classification-of-petroleum-resources.pdf

Resource categories:

- ✓ Resources is a general term for all oil and gas that can be recovered.
- ✓ Resources are classified according to maturity, which measures how far along they are in the planning phase leading to production.
- ✓ Reserves are recoverable petroleum volumes not yet produced, but which have been approved for production.
- ✓ The primary classifications are reserves, contingent resources and undiscovered resources.

Plays and method for calculating undiscovered petroleum resources:
https://www.npd.no/en/facts/geology/plays/