PL 892 - Licence status report

Summary

The PL892 license (blocks 6508/08, 6508/11, 6508/12) is located on the Trøndelag Platform approximately 57 km east of the Heidrun field (Fig.1). The most relevant offset wells drilled on the Trøndelag Platform are 6507/6-3, 6508/5-1, 6507/12-2 and 6507/12-3 (Table 2 and Fig.2). The distance to these offset wells ranges from 30 to 50 km. Wells 6507/12-2 and 6507/12-3 are located at the edge of the Trøndelag Platform, close to the Bremstein Fault Complex.

The license was awarded 10.02.2017 with A/S Norske Shell as Operator, with an initial Data or Drop decision by 10.02.2019 and Drill or Drop decision by 10.02.2021. The initial phase expires 10.02.2026. Work commitments are fulfilled including G&G analysis, followed by two years with 3D seismic acquisition and G&G studies. Due to late incoming 3D seismic data, a one-year extension was approved in 2021. Current DoD decision gate expires 05.02.2022. Equinor acquired operatorship from Norske Shell 30.05.2021.

Many studies have been undertaken based on the new seismic survey PGS19002. A re-interpretation of the main horizons was carried out on the new 3D seismic, which significantly increased the prospect portfolio with several new closures. The largest are shown on Figure 1 and Table 3. All closures are associated with a very high charge risk, as modelling points towards shortage of expelled hydrocarbon volume within the assumed fetch area of the structures in the Halten Terrace. Further, the migration pathway from the fetch area into the structure (ca 77km, including the migration across the Bremstein Fault Complex) is also very challenging on updated structure maps.

Several structures were identified at the depth maps of the four stratigraphic levels Åre, Tilje, Ile, and Garn fms. Sandvær (the prospect was also named Minuett by A/S Norske Shell) is the largest closure in the license and has been the main prospect. Additional sub-salt structures were also mapped.

Based on the modelled maximum burial depth and reservoir parameters of the reservoir zones, AVO anomalies are expected to be seen on seismic data in case of HC presence (similar to either the Midgard field for oil or to the Draugen field for gas) in the structures. However, expected AVO anomalies have not been observed. An updated basin model clearly illustrates the main risk for the license: limited hydrocarbon availability and challenging long-distance migration.

Table of contents

Contents

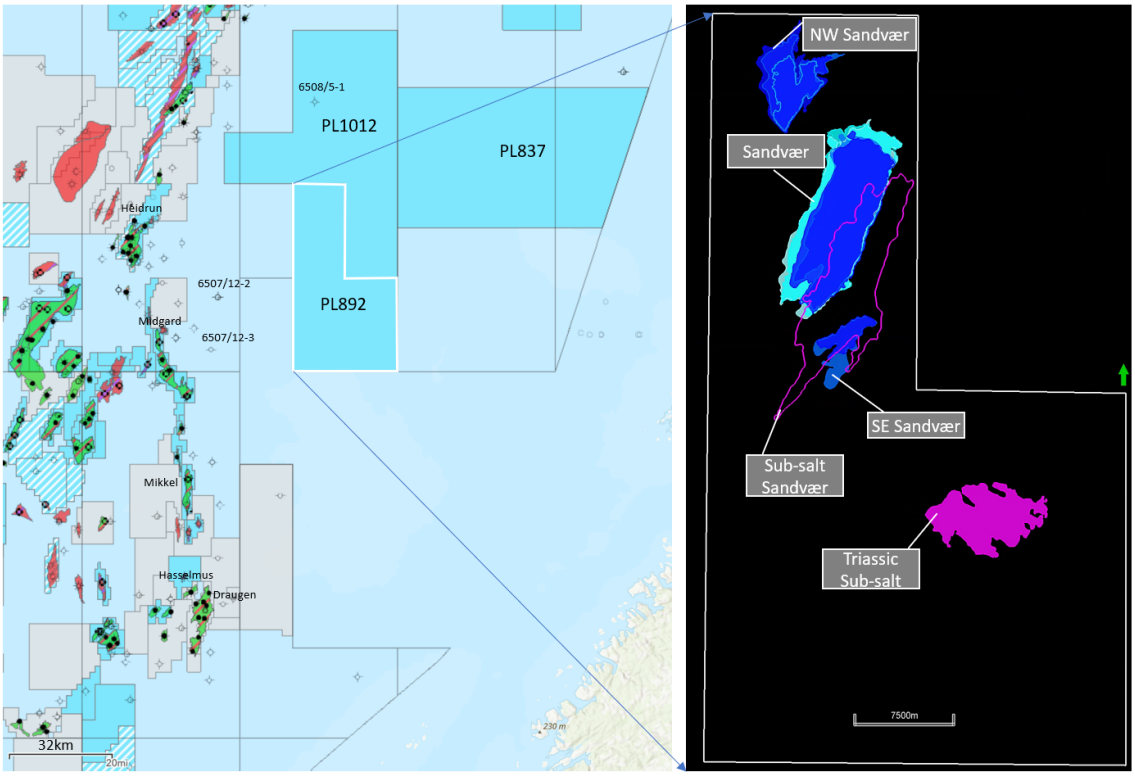

Figure 1: Area map with PL892 license outlined in white (left), prospects within the PL892 license (right).

1 Licence history

Licence: PL892

Awarded: 10.02.2017

License period: Expires 10.02.2022
Initial period: 9 years

License group: at the date of award:

AS Norske Shell	50%
Petoro AS	20%
Aker BP ASA	30%

Since 31.05.2021

Equinor	50 % (operator)
Aker BP	30%
Petoro	20%

License area: 1304.835km2

Work programme:

Reprocessing of 2D seismic	- Fulfilled
Acquire 2D seismic	- Fulfilled
Acquire new 3D seismic by 10.02.2019	- Fulfilled
Decision to Drill or Drop by 10.02.2022	

Meetings held:

31.01.2017	EC/MC meeting #1
02.11.2017	EC/MC meeting #2
31.05.2018	EC/MC meeting #3
07.11.2018	EC/MC meeting #4
28.11.2019	EC/MC meeting #5
18.11.2020	EC/MC meeting #6
11.11.2021	EC/MC meeting #7

Reason for relinquishment:

A tremendous amount of technical work has been carried out on the Trøndelag Platform in a larger area surrounding the PL892 licence. A complete re-mapping of the stratigraphy from Base Upper Permian until Seabed is carried out. Four source rocks have been included in the PSA model, and the maturity potential of the Trøndelag Platform has been modelled through time with several sensitivities applied, ranging from net erosion estimates to kinetic models. A large 3D seismic survey was acquired. None of the technical studies on any dataset have returned any signs of hydrocarbons within the PL892 license prospects.

2 Database overviews

It was initially proposed by the previous operator to include 10 wells into the common database, later an updated list was proposed and approved (fig.2 and table 2)

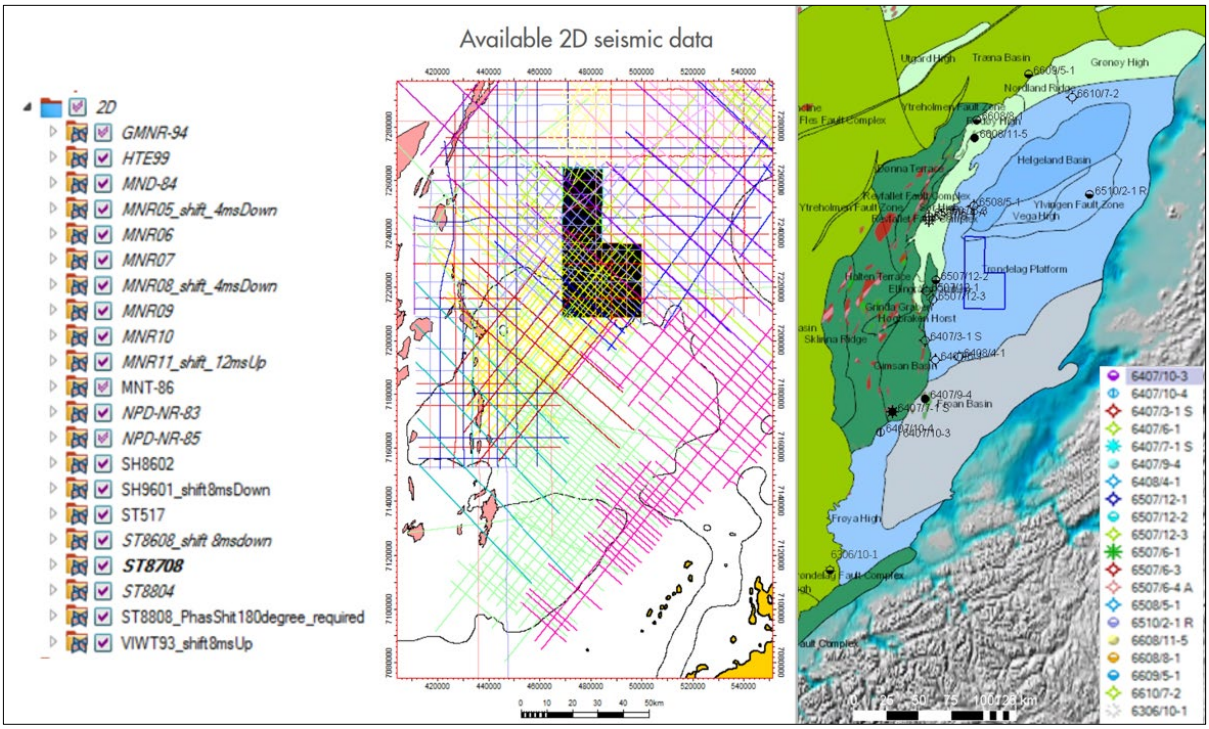

Fig.2 Common database: left – seismic; right – the wells

2.1 Seismic data

The seismic data that was utilized in the PL892 technical evaluations are shown in Table 1. The earlier evaluations were performed, using the 2d data surveys listed in Fig.2.

Table 1: Seismic data included in the PL892 common database

Survey	NPDID	TYPE	Quality
PGS19002 group license PL892 (the license area)	9000	3D	Good

2.2 Well data

All wells used in the PL892 exploration work are public available. The most relevant wells used for the licence exploration work are listed in Table 2. 6508/5-1, 6507/6-3, 6507/12-2, 6507/12-3 and 6510/2-1 are used for well ties.

Table 2: Wells included in the PL892 common database

Well	NPDID	Well	NPDID
6407/10-3	1927	6507/6-1	910
6407/10-4	7699	6507/6-3	5922
6407/3-1S	6582	6507/6-4 A	6753
6407/6-1	444	6508/5-1	1044
6407/7-1S	474	6510/2-1R	3263
6407/9-4	480	6608/11-5	5316
6408/4-1	1246	6608/8-1	2974
6507/12-1	202	6609/5-1	445
6507/12-2	437	6610/7-2	26
6507/12-3	485	6306/10-1	1551

3 Results of geological and geophysical studies

Work performed:

2017: Geological studies and analysis. All vintage 2D seismic data was time-shifted and aligned. New regional structure maps were generated. The Sandvær prospect (then called the Minuett prospect) definition was improved. A Petroleum Systems Analysis and Basin model (PSA model) was built for the Trøndelag Platform to improve predictions on the play models: (1) Lower-Middle Jurassic; (2) Triassic; (3) Permian.
Decision: acquire 3D seismic.

2018-2019: CSEM feasibility evaluation for Minuett/Sandvær prospect
2d seismic reprocessing
Hydrocarbon prediction modelling
Planning and acquisition of PGS19002 3D seismic survey.
Refinement of PSA model
Biostratigraphy study of the key wells
Seep&Sleek Hunting Desktop study
Wellties
Geochemical study

Results: CSEM survey is not recommended. High quality 3d might provide an uplift in the fluid interpretation of the prospect. 3D seismic acquired. Refined PSA model indicates severe difficulties with charge from fetch area

2020-2021: Fast-track preliminary interpretation of PGS19002 3D seismic data
Update of PSA model based on new structure maps from the 3D survey
Geological and geophysical studies and analysis based on PGS19002
Results: No DFI visible on fast-track data. Updated PSA model indicates severe difficulties with charge from fetch area

Update of the basin model: sensitivity on different source rocks, backstrip through time, maturation, expulsion and migration analyses were performed.

Triassic prospectivity study

Gas chimney cubes were produced and analized.

Evaluation of additional Lower-Middle Jurassic and Cretaceous prospectivity within the license. AVO and attribute analysis on final dataset. Updated Sandvær prospect evaluation.

Results: Final data did not provide any new information compared with fast-track data.
Decision: relinquish the license

3D seismic interpretation

A substantial work program was conducted with respect to 3D seismic interpretation and following AVO and rock physics analysis, attribute analysis, chimney cube analysis and Source Rock from Seismic analysis. The conclusion of the seismic interpretation efforts on the PGS19002 survey data are mainly the following:

(1) Confirmation of shallow marine environments and thus reservoir presence further east and south that earlier known
(2) Higher confidence in continuous permeable pathways from the kitchen to the prospect area
(3) No signs of hydrocarbons in the AVO cubes
(4) No gas chimneys, except for a weak possible indication within PL892
(5) No clear and confident signs of locally present Permian or Triassic mature source rocks in the seismic.

The conclusion of the seismic interpretation work is that there are no signs of locally matured hydrocarbons within PL892, and there are no signs of hydrocarbons migrating into the license from the Halten Terrace. Although signs of shallow gas are noticed both on the near to ultrafar stacks and the AVO cubes.

4 Prospect update report

Sandvær Prospect

The PGS19002 survey seismic data were interpreted, and the structural surfaces and the attribute maps were made within PL892. Depth conversion is a key uncertainty for the depth structural surfaces and associated prospect assessment. PSDM stacking velocities have been used for the depth conversion model.

There are a few depth closures identified on the depth converted structural maps of the several stratigraphic levels within the license area. The Sandvær prospect, being the largest structure within the license, is located on the Trøndelag Platform, approximately 60 km to the northeast from the Midgard field in the Norwegian Sea, Halten Terrace.

Trap definition:

The Sandvær prospect is a rotated fault block and consists of the stacked 3-way closures against the normal fault, striking from the north-northeast to the south-southwest (Fig. 3). The Garn, Ile and Tilje Formations

sandstones (Fig.4 and Fig.5) are considered to represent the Sandvær prospect; in addition, there are closures in the Åre (fig.6, middle and right) and pre-salt levels identified. Top and lateral seals are both Upper and Middle Jurassic shalestones (concept sketch, Fig 5). The HC distribution columns were chosen to have a logarithmic like geometry in order to reflect the HC charge limitations due to the long distance migration from the source rock, located within Halten Terrace.

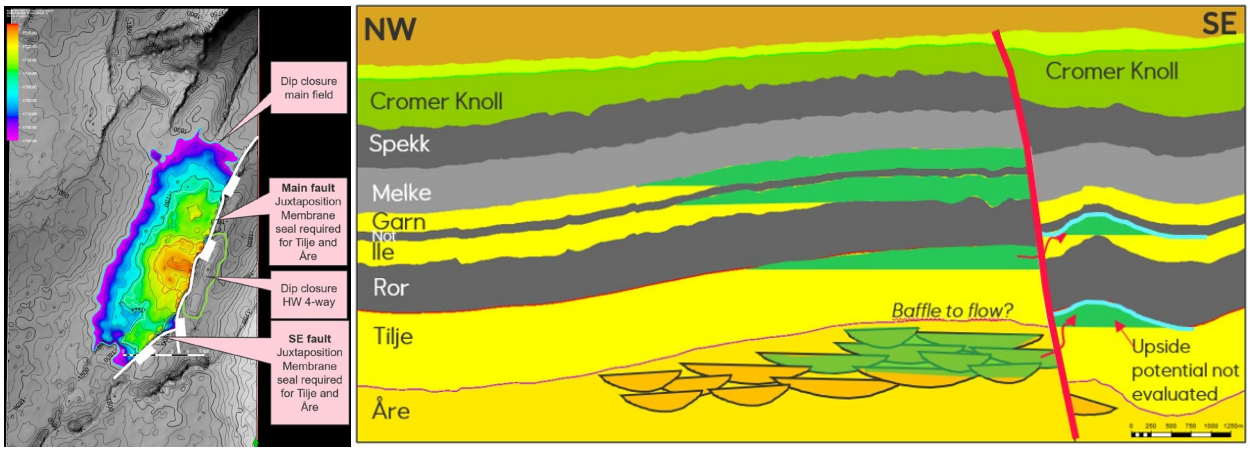

Fig. 3. *The Sandvær prospect: a structural map to the left – main prospect elements of the trap concept; the concept sketch to the right – inline exctracted from a 3D structural model across apex.*

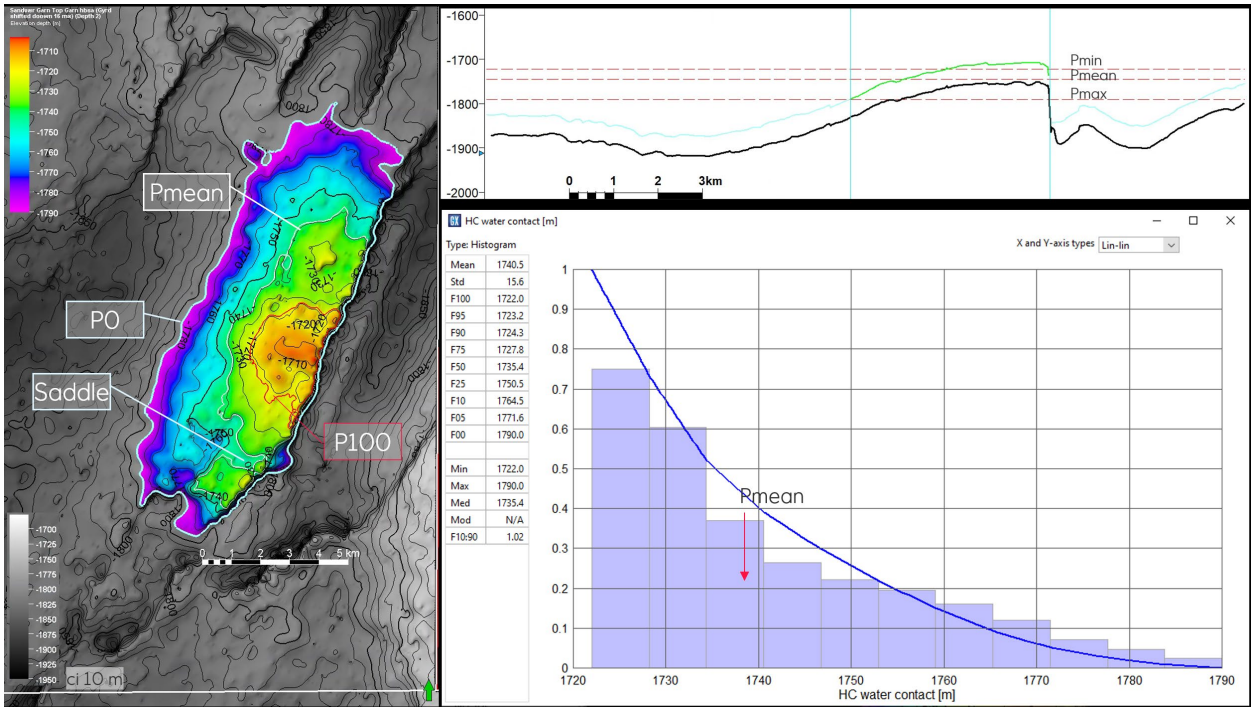

Fig. 4. The top Garn reservoir: left – the structural depth map with the contacts; upper right – a section with the contacts in depth; lower right – HC contact distribution for the Garn segment.

Reservoirs
The prospect comprises stacked reservoir zones: Garn, Ile, Tilje. The probability of the reservoir presence is high, based on area knowledge and reference wells, and also supported by PGS19002 3D seismic, where geomorphological geometries, attributed to sand-rich strand-plain deposits for Garn and channels for Tilje Fm, are identified. A low risk related to the minimum average net thickness and minimum porosity is included.

Seal
Claystones of Ror, Not and Melke Fms are serving as seals for all three segments and are regionally known as presenting high quality sealing capacity. For the Garn and Ile Fms reservoirs the juxtaposition of the reservoirs are against the sealing Melke Fm claystones.

Source presence and maturity
The Upper Jurassic Spekk Fm matured at the Halten Terrace might potentially be the source for the PL892 area. The detailed work on available charge volumes from the fetch area at the eastern edge of the Haltern Terrace along the Bremstein Fault system demonstrated insufficient expelled volumes available to reach the prospect. The Åre coals within the Trøndelag Platform are immature.

Hydrocarbon migration
Migration is the highest risk for all prospects within PL892. The long-distance migration route (70-80km) is required to fill the prospect. The migration route is complex, following a route from the basin, through the Bremstein Fault Complex and up to and across the platform where Sandvær is at the end of a fill-spill route. The Draugen and Hasselmus discoveries have proven two entry points for migration through the Bremstein Fault Complex up onto the Trøndelag platform, but these discoveries are located close to the fault complex and further to the south from the Sandvær location. Due to the structural setting, with gentle and varying tilt over time, the migration to Sandvær is present in some vintages of the structural depth maps, and not in other vintages. Interpretation has changed somewhat through time.
The low migration efficiency and uncertainties in timing of migration might potentially influence the amount of HC available to the trap, and the HC water contact distributions are modelled to reflect the high probability of underfilling. The minimum column is set to obtain a calibrated minimum volume.

HC Phase
The HC-phase is believed to be oil, with the rationale that a gas-oil-contact would be visible on seismic at these depths. The analogue is the oil-producing Draugen Field and is used as a fluid property analogue for the lighter oil end of the ranges. The expected reservoir temperature is 66-82°C, and hence there is a risk of biodegradation, which is included in the fluid property ranges using the Linerle discovery as analogue.

DFI assessment
There are no observed AVO or other DFI responses on the PGS19002 dataset for Sandvær. With the good reservoir properties and shallow burial, a DFI response is expected for hydrocarbons. Therefore, a significant DFI downgrade is applied. Garn Fm. is the uppermost reservoir and in combination with the reservoir parameters it is more likely to observe DFI with the presence of hydrocarbons in Garn than in Ile which is thinner and in Tilje with lower net to gross and porosity. Hence, Garn has the strongest downgrade.

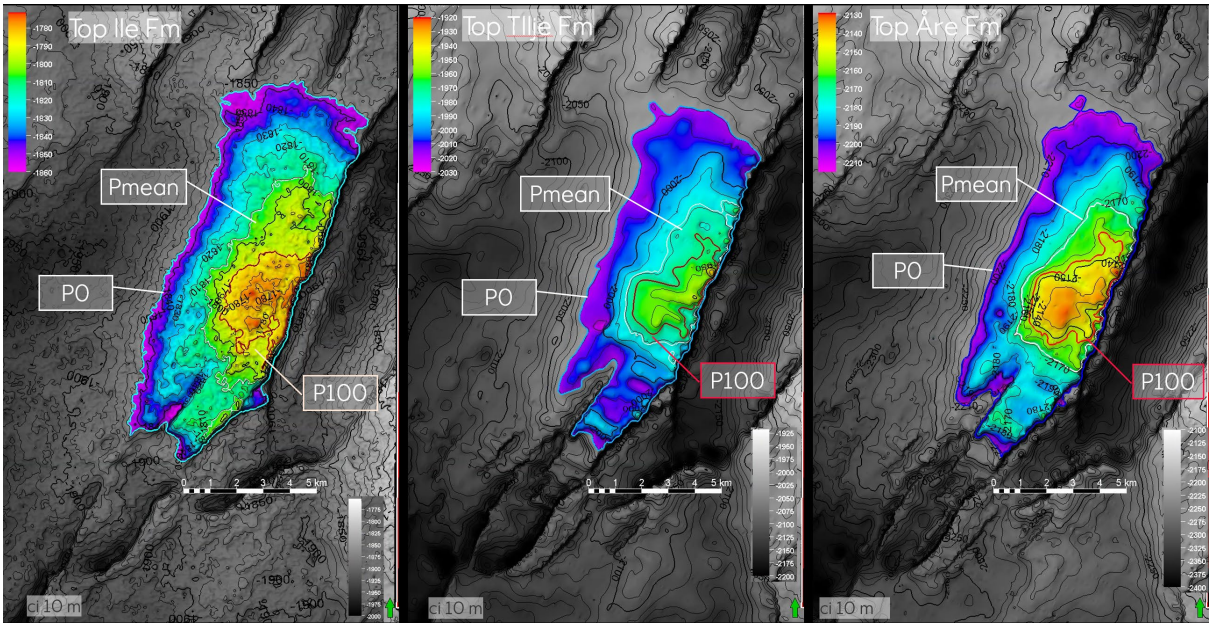

Fig. 5. The Sandvær prospect: depth maps with the P100-Pmean-P0 contacts for Ile, Tilje and Åre Fms

Prospect	Recoverable resources (MSm3)			Recoverable resources (mmboe)			Pg /Pg main phase /After DFI modification
	P90	mean	P10	P90	mean	P10	(%)
Sandvær aggregated (3 segments	2.4	27.3	77.5	15.12	171.99	488.25	12
Sandvær Garn	3.1	33	93.2	19.53	207.9	587.16	10/10/5.3
Sandværr Ile	2.5	25.6	71.2	15.75	161.28	448.56	6.3/6.3/4.3
Sandvær Tilje	1.4	10.2	27.2	8.82	64.26	171.36	4.8/4.8/3.3

Table 3: Sandvær prospect resource potential

Additional prospectivity

There are the structures on the Åre and the sub-salt levels identified under the Sandvær prospect with the lower confidence, and other prospects within the PL892 license (for location fig.1). List of the prospects with the estimated volumes and probabilities (if DFI applied, then Pg after DFI is included) is shown below (Table.4)

Prospect	Recoverable resources (MSm3)			Recoverable resources (mmboe)			Pg /Pg main phase
	P90	mean	P10	P90	mean	P10	(%)
Sandvær Åre (additional)	1.5	6.7	15.9	9.45	42.21	100.17	2/2
Sandvær pre-salt (additional)	1.7	9.7	24	10.71	61.11	151.2	7/7
NW Sandvær Aggregated (3 segm	0.8	2.6	5.1	5.04	16.38	32.13	12
NW Sandvær Garn	1.1	2.4	4.2	6.93	15.12	26.46	5.3/5.3
NW Sandvær Ile	0.6	1.7	3.7	3.78	10.71	23.31	4.3/4.3
NW Sandvær Tilje	1.3	3.3	7.1	8.19	20.79	44.73	3.3/3.3
NW Sandvær Åre (additional)	1.9	4.2	8.1	11.97	26.46	51.03	2/2
SE Sandvær Aggregated	1	2.6	4.7	6.3	16.38	29.61	5
SE Sandvær Tilje	1.7	3.1	5	10.71	19.53	31.5	3.3/3.3
SE Sandvær Åre	0.8	1.4	2.2	5.04	8.82	13.86	2/2
Triassic pre-salt	1.5	2.3	3.4	9.45	14.49	21.42	7/7

Table 4: Additional resource potential of PL892 matured during the license period

5 Technical evaluation

The technical-economical valuation for the Sandvær prospect was performed on an oil case for three segments in Garn, Ile and Tilje Fms late 2021. The prospect is situated 57 km east of Heidrun in an area without any other existing infrastructure close by. The shallowest reservoir depth (Garn Fm) is at 1790 m TVDMSL, the expected reservoir temperature is ~65 ^{0}C. The development solution on Sandvær consists of either a stand-alone case for discoveries above 20 MSm3 o.e. recoverable, or a tie-back to Heidrun for discoveries between 10-20 MSm3 o.e. recoverable (Fig.6). Due to the water depth of 320 meters, the stand-alone solution is a FPSO concept. The mean case consists of 11 producers drilled from three 4-slot templates, 5 single slot templates for water injection, and a gas injector for gas reinjection. Pressure support is given by the water injection, and gas lift is included for all producers. The recoverable volume used for the case in the decision tree is 66,5 MSm3 o.e. with a recovery factor of 41%. A sensitivity with an UPP solution is included. This shows a better economy but cannot be chosen as base-case due to the required large technological step-out from existing UPP experience we have in Equinor. Assumed start-up is in 2032. For the stand-alone options, power from shore is assumed, which means a power cable of approximately 120 km from shore.

For the tie-back solution to Heidrun, the average recoverable volume is 14,8 MSm3 o.e. with a recovery factor of 35%. To reach this recovery factor, 3 producers from one 4-slots template are assumed needed, and 2 water injectors. The oil will be sent in a 57 km long heated and insulated pipeline to the Heidrun structure, with pressure support from a subsea booster pump. With the current profile, with start-up in 2029, all oil will be produced before the end of lifetime for Heidrun in 2045. Water injection capacity may be a challenge in the start. But this is dependent on the other projects that may tie-in to Heidrun at the same time.

Nevertheless, Equinor didn't find to get enough value due to very low probability of success.

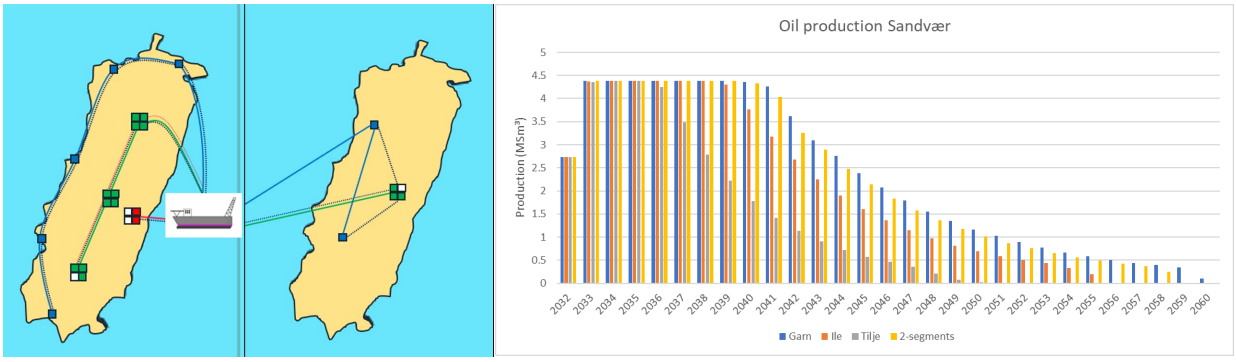

Fig. 6. Left: concept/development solution – Stand-alone FPSO, middle – Tie-back to Heidrun; right – Oil production plot.

6 Conclusion

The main plays for consideration within the PL892 license have been the Lower and Middle Jurassic. Several robust structures have been identified on the seismic data. The multiple level Sandvær prospect was put forward as the largest and main structure within the license. A thorough evaluation of the Sandvær prospect has been carried out, including acquiring modern 3D broadband seismic data, conditioning of the seismic dataset, AVO and attribute analyses. Integration of all these data brought the prospect forward as the best opportunity within the license that can test the Jurassic plays on the Trøndelag platform within the PL892 license, with testing the concept of the hydrocarbon migration from the Halten Terrace, through the Bremstein Fault Complex. This long-distance migration has been clearly identified as the main risk.

The Sandvær prospect was however seen as a too high risk opportunity to bring forward as a drill candidate by the PL892 license partners, and therefore the PL892 must be dropped.