

Edison Norge AS

Expiry Report 2016





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1 Key License History

The Production License 616 was awarded on the 3rd February 2012 as result of the TFO2011 round. It covered the blocks 2/7, 2/10 and 2/11 of the southern North Sea for a total of 332,981 km². The area is part of a rich petroleum province containing major fields such as Valhall, Hod and Embla and has been subject to intense exploration activity for more than 40 years. The application comprised 3 play types, 2 prospects (located within Devonian limestone and Tor Fm.) and some leads located within the Upper Jurassic sandstone, Middle Devonian Limestone and Upper Paleozoic sandstone.

The PL616 was operated by Edison Norge AS and the licensees are reported in the Table 1.1.

Table 1.1 Licensees and interests in PL616

Licensees at award	Interest at award	Licensees at relinquishment	Interest at relinquishment
Edison International Norway Branch S.p.A. (Op.)	25 %	Edison Norge AS (Op.)	25 %
Norwegian Energy Company ASA	20 %	Aker BP ASA	20 %
Concedo ASA	20 %	Concedo ASA	20 %
North Energy ASA	20 %	North E&P AS	15 %
Skagen44 AS	15 %	Lime Petroleum Norway AS	15 %
-	-	Skagen44 AS	5 %

Upon the award the initial period extended until the 3rd of August 2019 (See Table 1.2).

Table 1.2 Work program for PL616

Work program task	Deadline	Results
Acquire new 3D seismic	03.08.2014	Fulfilled
Decision to drill an exploration well	03.08.2014	Drilled 2/11-11 well
Decision to concretize (BoK)	03.08.2016	Not continue
Decision to continue (BoV)	03.08.2018	-
Decision to submit a PDO	03.08.2019	-

A comprehensive work program has been conducted to mature the fully prospectivity of the license, in particular in the first phase on the “Haribo” prospect, in order to achieve a positive DoD decision.

The decision to drill the Haribo prospect was taken by the licensees on 16th May 2014. The objective of the well was to test the presence of hydrocarbons down-dip of the offset well 2/11-2 (Hod West discovery well). The main target was a stratigraphic-structural trap interpreted as a pinch-out of porous chalk inside the Thud/ Narve Fms. (Upper Cretaceous).

The well 2/11-11, spudded on 21st June 2015, subsequently showed that the prospect was dry and the reservoir properties were poorer than prognosed. The target formations were encountered as expected, but extremely tight.

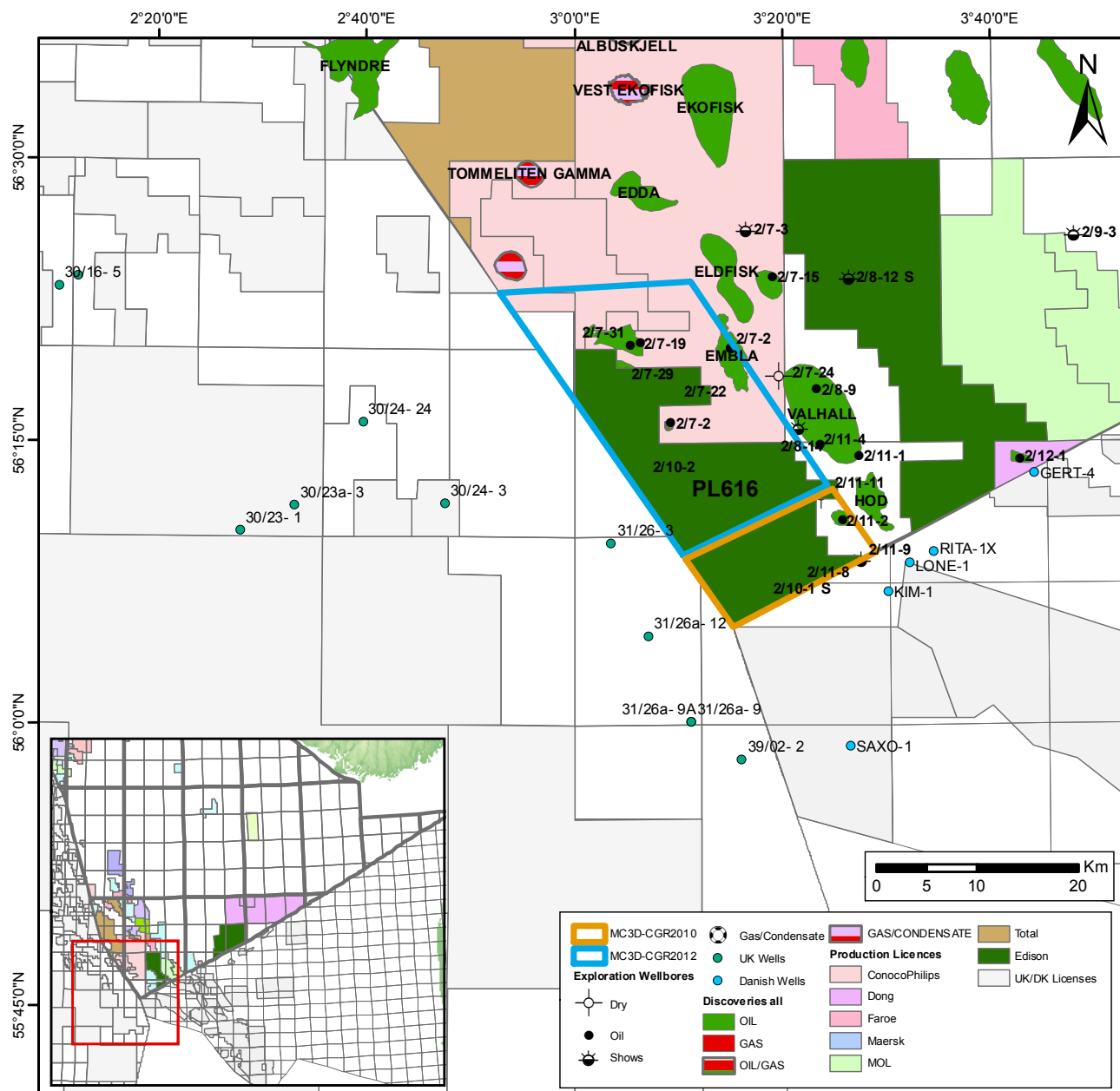
Following 2/11-11 drilling campaign, the JV continued maturing the Upper Jurassic play identifying the Nanna prospect (within the Eldfisk and Ula Fms. - Oxfordian/Kimmeridgian age sandstones) and deeper Paleozoic play potential, thanks to a new re-processed PSDM 3D seismic dataset.

Considering the Nanna prospect uncertainties and the limited Paleozoic prospectivity in the license, the MC committee on 29th June 2016 did not support the Operator's recommendation to applying for an extension of the BoK decision in order to mature the Nanna drilling project. Consequently the majority voted to relinquish the license.

2 Database

2.1 Seismic Data

- MC3D-CGR2012/MC3D-CGR2010, 3D seismic dataset acquired in 2010/2012 by PGS and purchased by JV in 2012, to fulfil seismic commitments (Fig. 2.1).
- MC3D-CGR2012/MC3D-CGR2010 3D dataset reprocessed by ION GXT in 2014/2015.
- Additional 3D public seismic datasets: ST99M1-AREA1 (shot in 2000 for Statoil by WesternGeco) and SH933F0003 (1993, GEO PRAKLA for Shell) from UK CDA database.
- Additional 2D public datasets: AHN9002, ANO-8901, BPN8801, CAST-90, PC-88, PC86 and SG9107-2D.



2.2 Well Data

For well location please see Fig. 2.1.

- 2/11-11 new well drilled by the JV in PL616 license in 2015 on Haribo prospect
- Public Norwegian wells: 2/7-2, 2/7-9, 2/7-19, 2/7-20, 2/7-21, 2/7-22, 2/7-23s, 2/7-24, 2/7-26s, 2/7-29, 2/8-14, 2/10-1s, 2/10-2, 2/11-4, 2/11-8, 2/11-9.
- Danish wells purchased from GEUS: KIM-1, LONE-1, RITA-1x, GERT-4 and SAXO-1.
- UK wells (via CDA): UK 30d/16-5, UK 30/17a-1, UK 30/23-1, UK 30/23a-3, UK 30/24-3, UK 30/24-24, UK 31/26-03, UK 31/26a-12.

2.3 Special Studies

- **Geo-Structural studies** (Edison in-house): Study was aimed to reduce the uncertainties on the definition of the structural architecture, to provide a structurally sound template for the interpretation of deep areas with poor data quality, to improve the understanding of the timing of deformation and its implications on the effectiveness of the petroleum system, to try to further validate the interpreted fault geometries, linkage and segmentation pattern and finally to predict the sealing potential of faults which bounds the defined prospects.
- **Geological characterization study** (Edison in-house): a geological characterization study from seismic and well data was performed on both Cretaceous chalk and Jurassic sandstones main targets. The workflow adopted was taking care of seismic interval & seismic facies, flattened horizons & well correlations, thickness maps, seismic attributes and 3D seismic-geomorphological analysis of the main features. The goal for chalk target was to try to discriminate from primary pelagic chalk deposition and re-worked allochthonous chalk. For Jurassic a shallow marine fan-delta system has been outlined for Ula and Eldfisk sandstones in northern part of PL616 license.
- **Stratigraphic evaluation study** (RPS Ichron): the work was focused on the bio/litho-stratigraphic framework and zonation schemes on a dataset of approximately 40 wells in Feda Graben area. The goal was to obtain a local and consistent biostratigraphic and lithostratigraphic scheme applied to all wells in the license area.
- **Fairway mapping and Reservoir quality study** (RPS Ichron): the goal was to investigate the sedimentology and reservoir quality of both the Mesozoic and Palaeozoic intervals on a dataset of approximately 40 wells in Feda Graben area, following the stratigraphic study discussed above. The project was designed to provide a composite paleogeographic and depositional model for the area, along with reservoir quality indications for main targets.
- **Petrographic study for well 2/7-29** (RPS Ichron): the goal was to describe the sedimentological attributes of the cored interval in 2/7-29 well cores 1-5, with emphasis on the depositional processes recorded by sediments. In addition, was derived a likely depositional model for the cored interval based on facies observed and use core plug poroperm (CCA) data to investigate controls on reservoir quality.
- **Geochemistry & Basin Modelling study** (IGI): the focus of the study was to geochemically-constrain the source rock potential of Mesozoic and Palaeozoic sources within the PL616 area and surrounding area, to address the understanding of the petroleum system(s) and de-risk uncertainties related to both source rock presence and effectiveness.
- **Petrophysics and Pore Pressure study** (Edison in-house): petrophysical work was performed on the key wells in the area in order to investigate reservoir properties and parameters and main fluid contacts, in support of seismic interpretation and prospect assessment processes. A pore-pressure analysis study has been performed on few wells in the area, considering that a not negligible high-pressure (HP wells) is reported in the area below BCU level.

- **Rock Physics and Seismic Inversion studies** (Edison in-house): rock physics modelling (RPM) followed by Seismic Inversion was performed on the 3D dataset in order to estimate AI, SI and VpVs. The inverted parameters have been consequently transformed to reservoir parameters. In the Cretaceous chalk the possible presence of high porous chalk bodies has been highlighted. Relative acoustic impedance volume (RAI) showed for Haribo prospect the strongest anomaly within PL616 area. For Jurassic target, however, the results are not encouraging due to high noise level in VpVs for depth often exceeding 5000 m.
- **Low Frequency study** (JV study): a low frequency ISA (Instantaneous Spectral Analysis) study has been tested on the license by partner Skagen44 on Top Ekofisk Cretaceous chalk level. The low frequency anomalies (frequencies domain 4,8-7,2 Hz) are often a good indicator for permeability. The study shows good correlation with the Haribo anomaly outlined by Seismic inversion study.

After the G&G assessment of the license prospectivity and a review of the interpretation, it was decided to focus the efforts on the Haribo prospect located within the Hod Fm. in the south eastern part of the license (Fig. 3.2). The Haribo prospect was located on the eastern side of the inverted Skrubbe fault complex on the Lindesnes Ridge structural high, defined by a mixed component stratigraphic-structural trap and interpreted as a pinch-out of porous chalk encased in lower porosity chalk inside the Upper Cretaceous Hod Fm. (Thud-Narve Fms.), down-flank of Hod West field.

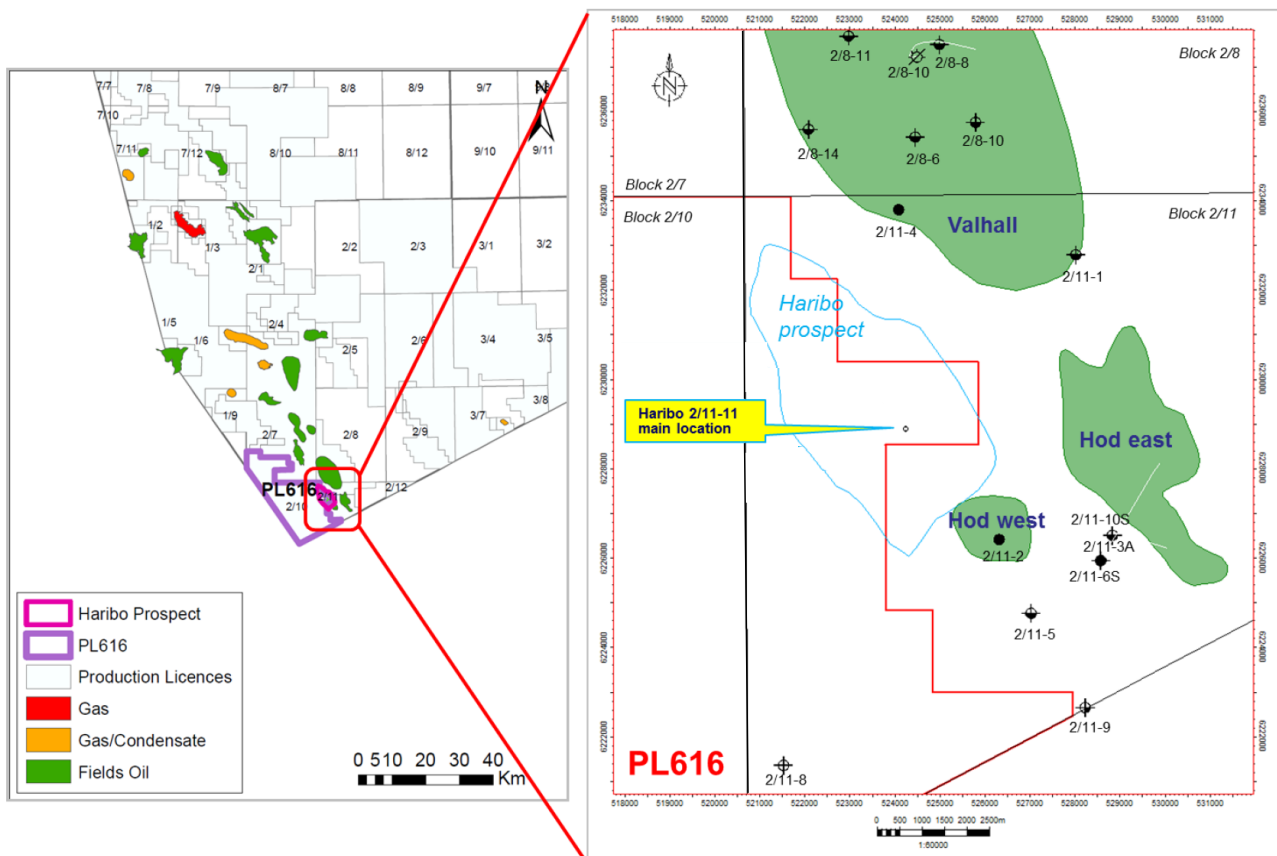


Fig. 3.2 Location of the Haribo well (2/11-11)

In addition to a detailed seismic interpretation and mapping of the key horizons, comprehensive studies were performed to understand the prospectivity of the license. Detailed geo-structural study was performed to reduce the uncertainty on the definition of the structural architecture, provide a structurally sound template for the interpretation of deep areas of poorer seismic quality, improve the understanding of the timing of deformation and its implications on the effectiveness of the petroleum system.

A combined litho-stratigraphic and chrono-stratigraphic study was performed over 40 wells in the area, in order to have a homogeneous and consistent well database, supporting the seismic interpretation, helping in preparing well correlations and facies analysis prediction for main stratigraphic intervals.

In order to understand better both the chalk reservoir intervals and of the Jurassic ones, a detailed geological characterization study was performed. For the chalk section, the main goal was to understand the depositional mechanism, blank deposition and/or sediment gravity flows. The result of the study indicated that for the Narve and Thud Fms. a pelagic chalk deposition occurred, although complicated by the growing of the Hod west structure inversion.

For Jurassic target, the geological depositional model build was expecting to have Eldfisk Fm. sandstones of Kimmeridgian age compatible with shallow-marine fan-delta system and deeper Ula Fm. sandstones of Oxfordian age interpreted to be in a shoreface – coast foreshore depositional environment.

A total of 21 wells were included in the petrophysical study (13 wells were located in Norway, 6 in the UK and 2 in Denmark) for both chalk intervals as well as Jurassic/Triassic targets.

Rock physics studies were performed in two steps (prior to the 2014-2015 reprocessing). First rock physics modelling was performed to determine the effect of reservoir property variations (F, lithology, fluid type) on acoustic parameters. In the feasibility study, seismic conditions were simulated for acoustic and elastic properties in order to identify potential lithology separation, porosity estimation and fluid-type recognition through seismic inversion. The study performed highlighted the presence of an anomaly on the RAI cube associated with a porosity interval within the Hod Fm. down-dip of Hod west field (Haribo prospect).

Even if the area is a prolific HC province, a geochemical and basin modelling study was performed for de-risking migration path and charging mechanisms. The source rock study concluded that Upper Jurassic and Permian shales have the highest average organic content, oil-prone kerogen and potential yield. Middle Jurassic coals have very good source potential but are locally variable in their distribution. Triassic, Lower Jurassic and Cretaceous shales have comparably low source potential and should not be considered regional sources. The Upper Jurassic Mandal Fm. has excellent organic content (5-9% TOC) as well as highly oil-prone Type I/II kerogen and is oil-mature throughout most of the PL616 area. A geochemical appraisal of Q2 oils indicates that a Paleozoic clastic interval is likely to have co-sourced most oils along with an Upper Jurassic source.

Oil and gas expulsion is likely to have occurred recently throughout the study area from both an Upper Jurassic and Paleozoic source. Upper Jurassic shales may have contributed up to 70 mmbbls/km² of oil & 12 bcf/km² of gas while Paleozoic source(s) may have contributed 22 mmbbls/km² of oil & 55 bcf/km² of gas if present. All known fields and discoveries can be charged by the Mandal Fm. oil and gas expulsion alone, but additional charge from a Paleozoic source is also likely, correlating favourably to the mixed-source oil geochemistry.

4 Prospect Update

Haribo prospect (well 2/11-11)

The Haribo prospect was located on the eastern side of the inverted Skrubbe fault complex on the Lindesnes Ridge structural high, defined by a mixed component stratigraphic-structural trap and interpreted as a pinch-out of porous chalk encased in lower porosity chalk inside the Upper Cretaceous Hod Fm. (Thud-Narve Fms.), down-flank of Hod West field. The area has infrastructures and given a discovery, a fast track tie in to the Valhall production facility was considered as an option (Fig. 3.2).

The work program had successfully de-risked the prospect, identified on the new seismic inversion cubes performed by Edison and also outlined by the G&G studies. The expected main HC phase was oil with associated gas and the estimated recoverable resources were 25,3 MSm³OE (mean case). Haribo COS (chance of success) was 25%, with the reservoir presence / effectiveness and trapping mechanism / lateral seal as main risk. Based on these assumptions, Edison recommended the MC committee on 16.05.2014 to support a drilling decision on the Haribo prospect. This was approved by the licensees. (Fig. 4.1 and Fig. 4.2)

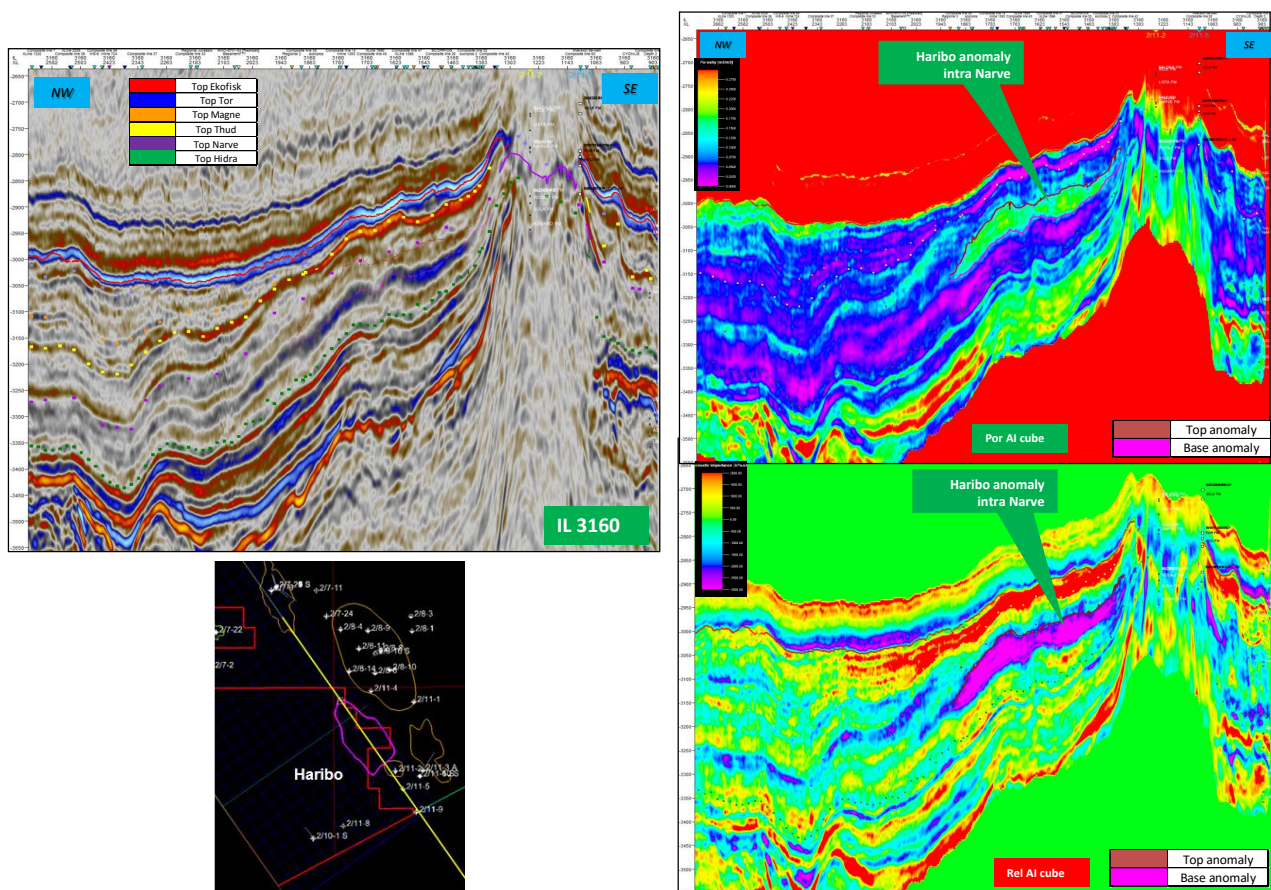


Fig. 4.1 Overview of the Haribo prospect (pre-drill) on Seismic, Por AI cube and Rel AI cube.

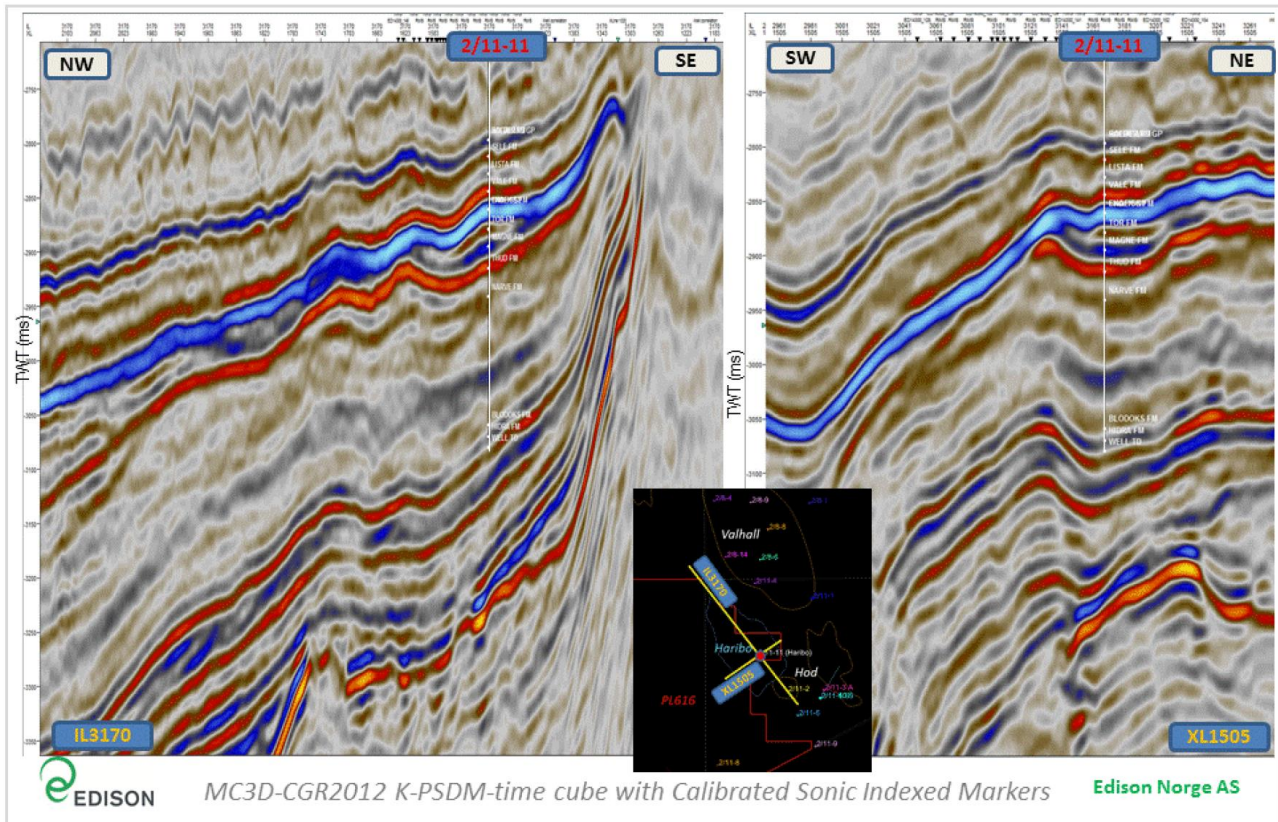


Fig. 4.2 IL3170 vs. XL1505 seismic profiles across Haribo well location

The well 2/11-11 was spudded on 21st June 2015, with the Transocean Searcher and successfully reached TD at 3410m MDKB (-3387,9m TVDSS, 15m into the Hidra Fm.) on 17th July 2015, in agreement with the well program. Thud and Narve Fms. were encountered at 3035m MDKB (-3012,9m TVDSS) and 3060m MDKB (-3037,9m TVDSS), respectively 7,9 m higher and 24,0 m deeper than prognosis. Chalk interval was founded extremely tight with no visual porosity. No significant hydrocarbon shows were evidenced, neither gas shows nor fluorescence. No conventional core were cut. Petrophysics interpretation results gave a value between 25% and 33% of porosity for the upper half of the Ekofisk Fm. and a maximum of 25% for the top of Tor Fm.. Except these layers, no significant porosity development were observed in the Shetland Gp. Chalk interval. An intensive logging programme was performed, including an extra MSCT run, collecting 31 samples cut from Ekofisk to Narve Fms.. Formation pressure measurements were attempted with MDT XL probe and Saturn probe, but all were unsuccessful (tight or supercharged). The well was permanently plugged and abandoned and the rig was released on 1st August 2015.

The dry-well analysis showed that the well objectives were fulfilled in terms of HSE, geological and geophysical objectives, data collection and commercial objectives. A post-well seismic inversion was carried out to better understand the elastic-reservoir properties that highlighted Haribo prospect. The original inversion correctly predicted AI and porosity in five key wells used as an input (2/7-2, 2/7-22, 2/7-31, 2/7-19, 2/11-9), whilst too high AI dynamic range and porosity values were predicted at Haribo 2/11-11 well. The post-well inversion showed more accurate results for Haribo, except for the upper Narve interval, where similarly to original results porosity remained over-estimated. Moreover it pointed out the relevance of using long wavelets, in order to properly capture low frequency part of the seismic spectrum. This fact was not indicated by any of the other five wells, used in the original inversion study.

In particular Haribo 2/11-11 well response is anomalous in comparison to 5 wells used in the original inversion study by:

- Higher porosity of Narve Fm in 2/11-11 Haribo well than in the other 5 wells.
- Lower Density and Vp in Narve Fm. than in the other 5 wells, which therefore outlined the presence of AI anomaly.

The updated inversion did not reduce the anomalous porosity of targeted chalk interval, but extended the porous interval up to the top Narve Fm..

Remaining prospectivity evaluation:

Following the Haribo prospect drilling results, the exploration focus was addressed to the evaluation of the remaining licenses prospectivity and particularly of the Upper Jurassic “Nanna” prospect, located in the northern part of the license, to the W/NW of four discovery wells («Ebba» 2/7-31 & 2/7-19 and 2/7-29 & 2/7-22 discoveries), where HC was proven in the same stratigraphic intervals (Fig. 4.3).

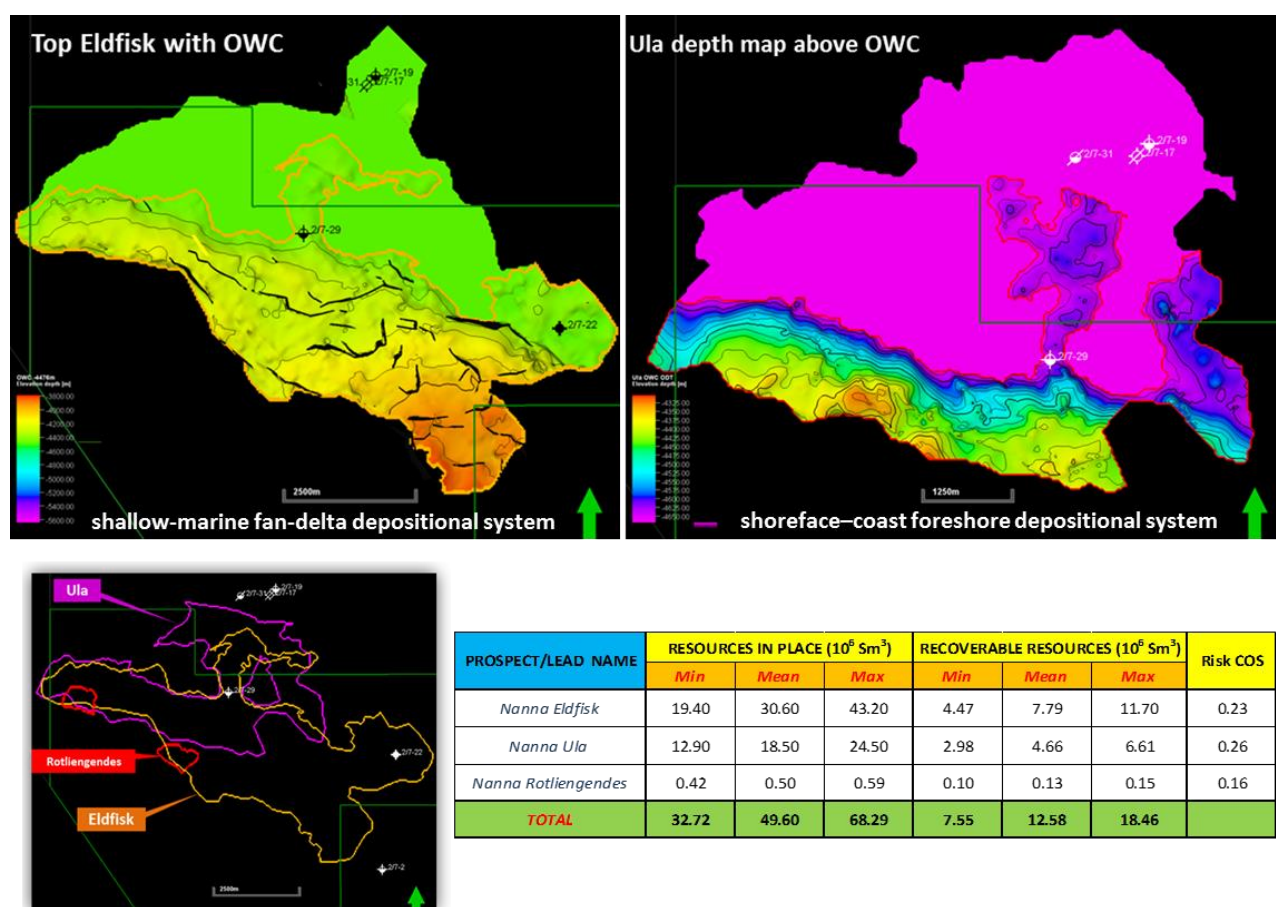


Fig. 4.3 Prospect outline and volumetrics summary for the Nanna prospect

Nanna prospect consists of a combined structural and stratigraphic controlled trap on an anticline structure, with the main reservoirs in the Jurassic Kimmeridgian/Oxfordian age sandstones, belonging to Ula and Eldfisk Fms. (Tyne Gp.), down to secondary potential Permian Rotliengendes Gp. sandstones target. The maturation of that prospect started with a PSDM reprocessing of the MC3D-CGR2012 dataset carried out in 2015. The reprocessing was able to improve the lateral positioning, continuity and focusing of the target events and faults below BCU and particularly over the Nanna high structure (Fig. 4.4). In addition a refinement of the structural framework was performed, followed by a detailed seismic interpretation and an updated basin modelling study (Fig. 4.5).

linked to the poor imaging below BCU, affect the net GRV and potential reservoir correlations among the faulted blocks. Moreover, due to high-pressure regime expected in the prospect, the risk of trap breaching is still high, although the sealing capacity study pointed out that a large HC column could be hold.

Upon these considerations, Nanna prospect assessment has defined potential resources in the mean case equal to 7,8 MSm³OE for Eldfisk segment and 4,7 MSm³OE for Ula target, with negligible contribution in term of potential volume for the Permian Rotliegendes reservoir or deeper Devonian targets. Oil with associated gas is the most likely expected HC phase for the both targets in HP environmental condition, but gas & condensate fluids phase cannot be ruled out. The Geological Chance of Success is respectively 23% and 26% for Eldfisk and Ula targets and the main risks are associated with reservoir presence and trap effectiveness.

At present stage, Edison considers the Jurassic prospectivity the most relevant play to be pursued in PL616 license.

The residual Palaeozoic potential in the license is limited in the Grensen Nose area and in the southern sector, where Devonian “Skagastølen” lead, identified as main target in the submitted APA 2011 application, has been re-mapped but its main culmination is outside PL616 license. Going into the deep southernmost Ål Basin, the mapping and faults architecture confidence is poorer because the low S/N ratio. Moreover, the Jurassic sequences are eroded in this area, excluding than any possible HC plays aggregation.

Edison quality assurance process has confirmed and supported the technical and economical view on the license prospectivity, concluding that, apart for the Jurassic play in Nanna prospect, the residual block potential is very limited and can be disregarded.

5 Technological Evaluation

The area is characterized by a widespread presence in infrastructures and given a discovery, a fast track tie-in into already existing facility was considered as the best option. In particular the possible Nanna prospect development scenario (Eldfisk target case only) considered a subsea tie-back to Eldfisk field (approximately 25 km).

The well stream was supposed to be transported in a new 12" pipeline to the Eldfisk wellhead platform and further transported to Ekofisk for separation into stable oil and gas. The oil will be exported to Teeside through the Norpipe oil pipeline and the gas to Emden through the Norpipe gas pipeline.

Four producers and two water injection wells are required for P50 case with one 6-slots template in order to recover the final resources of 55 MBOE for Eldfisk target over 16 years.

All wells were supposed to be drilled before production start, due to high pressure (HP-HT) in the reservoir.

The Ekofisk facilities should have sufficient liquid, gas and water injection capacity to meet the requirements from the prospect. As an alternative, the Valhall field may be used for the tie-in to a mother platform.

6 Conclusion

Since awarding in 2012, Edison, on behalf of PL616 JV, performed a very detailed and comprehensive seismic interpretation and G&G studies analysis. The conclusion of these activities, led to highlighting the chalk potential of Haribo prospect and to finally maturing a drilling recommendation at drill or drop gate in 2014. Well 2/11-11 was drilled in 2015 but proved to be dry with poorer reservoir properties than expected.

After disappointing Haribo results, PL616 JV focused the attention on the maturation for the Jurassic geological play, identifying the Nanna prospect (Kimmeridgian and Oxfordian sandstones) as the best candidate for a potential second drilling project in PL616. Moreover the residual Palaeozoic potential in the license (following the original “Skagastølen” lead, identified in APA 2011 application) is evaluated very negligible in terms of resources, excluding any possible HC plays aggregation

Considering the Nanna prospect uncertainties related to the sandstones presence and trap efficiency, some further possible de-risking actions (i.e. new 3D seismic acquisition with high-res grav-mag dataset) have been outlined, but would have required an additional work programme not compatible with the license time-frame (BoK 3rd August 2016).

The final license assessment has been presented to the MC committee on 29th June 2016, with a recommendation to apply for an extension of the BoK, but the partners did not support the recommendation and voted to relinquish the license.