Introduction

Finding substantial oil and gas volumes in the subsurface of the Dutch offshore has proven to be an increasing challenge in the last decade. Consequently, it becomes more important to use a structured and well-documented methodology to aid identification of the play risk associated with the various known hydrocarbon plays, even in a mature basin such as the Dutch offshore area. A Play Based Exploration (PBE) approach (e.g. Longley and Brown, 2015; Rose, 2017) has gained wider acceptance and importance with most of the currently active operators, as well as EBN (Dutch State-owned oil and gas company), making use of this approach in the exploration phase.

PBE is a well-known and widespread industry best-practice to document and evaluate knowledge of the subsurface and systematically determine the economic value of remaining reserves. This approach allows efficient screening of potential opportunities or pitfalls and provides steer towards an appropriate and focused work program. Besides stimulating efficiency, it provides a framework for securing technical quality of data and studies, with continuous benchmarking against pre-determined criteria. Managers in the industry can use the PBE results as a basis for improved high quality decision-making.

Oil and gas are important energy sources in the Netherlands and domestic gas will continue to play an important role in the energy transition. Therefore, EBN continues to support operators exploring for hydrocarbons. To make effective use of the subsurface in the near future, EBN’s ambition is to generate regional common risk segment (CRS) maps of the main plays in the Dutch subsurface and make them publicly and freely available to the industry. The CRS maps support operators in their exploration activities and provide additional reference for decision-making on identified opportunities.

Methodology for a PBE approach

The PBE process (as implemented by EBN) consists of multiple pre-determined steps and deliverables, and develops from a regional basin analysis (i.e. understanding of geology and basin fill in a regional tectonic context), towards a play and eventually lead/prospect focus (figure 1). In a mature basin like the Netherlands, the basin focus step (step 1) is generally well understood and effort is initially put into the play focus step (step 2). This paper will therefore elaborate on step 2 in the PBE process for the Chalk interval offshore the Netherlands.

EBN uses the Player Software (developed and owned by GIS-PAX) to systematically perform play analyses. Historical data is transformed into mappable information and provides an indication on the ‘chance of success’ of finding reservoir, seal, trap and source in a certain play and area. The power of the tool is that actions are well-structured in a pre-set manner and are easily repeatable and handed
over. In addition, dependencies can be assigned allowing to calculate Value Of Information (VOI) for those situations where part of a portfolio shares a common risk and a success can open up an entire new set of opportunities in the basin.

*Post-Drill Well Analysis*
An important part of the play evaluation is the post-drill well analysis (PDWA), which capitalises the value of the drilled well stock. The key to successful exploration is understanding why wells failed or were a success. Each analysed exploration well is assessed on ‘presence’ and ‘effectiveness’ for reservoir, seal, trap and charge. Combined results provide an overall PDWA classification for the analysed play. Selecting the ‘right’ wells is of high importance, whereas every well should play a part in constraining the extent of the proven play system. Therefore, initial focus should be on selecting key stratigraphic wells that hit multiple play targets, complemented with wells in the area of interest (AOI) and wells located at the ‘edge’ of your proven play areas (Longley and Brown, 2015).

*Common Risk Segment mapping*
Multiple CRS layers (e.g. reservoir presence, reservoir effectiveness, seal presence, charge and migration) can be constructed on the basis of seismic data, well data, GDE (Gross Depositional Environment) maps, study results, local knowledge, analogues, etc. Each of these CRS maps consists of a set of polygons, all assigned with a certain risk based on similar characteristics within that polygon (Longley and Brown, 2015). Polygon boundaries are preferably of a geological nature. After generating CRS maps for each play element, results are calibrated with the PDWA results and subsequently, the set of CRS maps is stacked to generate a composite CRS (CCRS) map. The CCRS map provides an overall ‘chance of success’ for the evaluated play interval.

In the play analysis phase, profound understanding of the petroleum system in the basin is of high importance. Therefore, EBN has commissioned IGI to perform a regional Petroleum System Analysis (PSA) of the entire Dutch offshore region. Main source rock intervals (Posidonia Shale Formation and Limburg Group) are modelled and results are common input for evaluation of Dutch oil and gas plays.

*A Chalk case study in the mid-Northern Dutch offshore*
The Upper Cretaceous Chalk play in the Norwegian, United Kingdom (UK) and Danish North Sea has proven itself successful with several major discoveries e.g. Ekofisk, Tor, Adda and Tyra. These successes are related to the main tectonic elements in the Central Graben, with further continuation of this structural setting into the southern North Sea region. The Netherlands currently has one producing Chalk oil field, the Hanze field. This field is located in block F02 and was discovered in 1996 (Hofmann et al., 2002). A number of other discoveries have been made in the past decade (e.g. Rembrandt, Vermeer, Snellius and Zulu North), but EBN holds the view that the Chalk play remains under-explored in the Dutch part of the North Sea.

Comparison of tectonic similarity between the Danish and Dutch sector indicates that it is likely that more Chalk traps can be identified in the Dutch Central Graben (DCG) area. Therefore, EBN identified the need to study the Chalk play in this part of the North Sea. PBE provides the necessary framework to focus Chalk exploration by performing PDWA and integrated CRS mapping. This paper presents the CRS mapping process of the Chalk oil play in the mid-Northern Dutch offshore. Input for each play element CRS map is discussed in the following section together with assumptions made.

*Reservoir Presence*
Sediments of the Ekofisk, Ommelanden and Texel Formations (CEKEK, CKGR and CKTX) are all considered potential reservoir for the Chalk play. However, reservoir rock characteristics are highly variable throughout the Chalk Group and only limited information is available on porosity and permeability distribution. Well calibrated regional horizon interpretations by TNO, the Dutch Geological Survey, provide the main input for the reservoir presence CRS map. Although the generated CRS map for the Chalk case study is only an indication for potential reservoir presence, reservoir effectiveness is a necessary consideration in the following prospect focus step (step 3) of the PBE process.
Seal Presence
Presence and thickness of the Landen Clay Formation (NLLFC) and other potential sealing clays in the Lower and Middle North Sea Group are approximations of the sealing capacity for the Chalk play. Similar to reservoir presence, well calibrated regional horizon interpretations provide the main input.

Charge and Migration
Input for the charge and migration CRS map is the Posidonia oil expulsion map as generated in the PSA study (Gardiner et al., 2019). The expulsion map takes presence and maturity of the source rock into account, as well as the timing of hydrocarbon generation. ‘Buffer zones’ have been added to incorporate the possibility of lateral migration. Although this is a generic approach, it is applicable as an approximation of the ‘chance of success’ for hydrocarbon charge and migration in the Chalk play. However, a more detailed evaluation of charge and migration pathways will be required in the prospect focus step (step 3) of the PBE process.

Each of the discussed play elements is risked based on a ‘split risking’ approach, which takes separate account of ‘shared play risk’ and ‘non-shared prospect risk’. This method provides direct linkage between prospects and plays and highlights dependencies (Longley and Brown, 2015). Multiplication of both risks gives an ‘overall play risk’ per play element. Stacking of the risked play element CRS maps finally results in one composite CRS (CCRS) map, which highlights the overall ‘chance of success’ for the evaluated play. Results for the CCRS of the Chalk oil play are presented in figure 2.

![Figure 2 CCRS map created by multiplication of Chalk oil play CRS maps for reservoir presence, seal presence and charge and migration. Map colours show the ‘chance of success’ for the Chalk oil play and plotted in dark green are the 5 known Chalk discoveries in this region of the Dutch offshore.](image)

Apparent from this CCRS map is that the DCG region should be the main focus of Chalk exploration for oil. This is not surprising, as currently known Chalk oil discoveries are exclusively located in the Graben. An extraction of the overall CCRS map allows evaluation of the main risk factor, highlighting the weakest element inside a polygon (figure 3). It is clear that outside the DCG, charge and migration provide the main risk factor due to the limited extent of the Posidonia Shale Formation. However, inside the DCG, the limited extent of the reservoir facies presents the main risk. Seal presence is not considered a main risk factor, whereas effective seals are considered present in almost the entire AOI.

Besides the oil play evaluation, EBN also determined the play risk for the Chalk gas play in the mid-Northern Dutch offshore, based on gas expulsion from Westphalian source rocks. The main risk for this play is partial seal failure due to the presence of hydrostatic overpressures in the Chalk Group. An economic discovery would require a certain gas column height, for which seal strength support is not sufficient as a consequence of failure due to overpressures. However, some areas do show potential for gas fill, whereas a combined gas/oil discovery could also be a possibility in some regions.
Conclusions

A Play Based Exploration (PBE) approach provides the basis for a well-structured, easily repeatable and ever-greened play evaluation, based on the understanding of the regional geology and tectonic context of the basin. Besides under-pinning efficient screening of potential opportunities, it captures the availability and technical quality of data and exploration studies. In a slightly modified form, this approach is also applicable for the growing geothermal industry.

The Chalk case study presented here demonstrates that historical subsurface data can easily be transformed into mappable information and an approximation of the overall play ‘chance of success’. Resulting products provide a solid basis for supporting decision-making in the exploration phase. As oil and gas will likely continue to play an important role in the Dutch energy system, EBN will continue supporting operators in their activities. In this regard, in a similar manner to this case study, EBN will perform play evaluations of the main hydrocarbon plays in the Netherlands during the coming year with results being made available to the public free of charge.

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References


