Sources of different country information on licensing and exploration history. The colour photo of the rig is the ConocoPhillips 44/23b-11 Kelvin platform drilling the development well in 2007, with the ConocoPhillips 44/19b-6 Harrison exploration well in the background. The black-and-white photo is of wooden drilling derricks in the Nienagen region of Germany during the 1930s. Photo of TGS Nopec Northern Explorer seismic acquisition vessel.
Chapter 14 Licensing and exploration history

1 Introduction

Exploration is intrinsically cyclical, responding to exploration success and commodity price and also reflecting geopolitical, economic and fiscal regulatory changes. This review of licensing and exploration history charts drilling and seismic trends, sets out country regulatory and fiscal frameworks and examines the success rate for discovering hydrocarbons in the SPF area.

Well statistics show that the exploration success ratio in the SPF area has been steadily climbing to about 50%. The most successful play prevalent in the Netherlands, but Cardenolites, Zeugodruses and Tournaissia plays also contribute to this exploration success (Chapters 13 & 15).

1.1 First onshore discoveries lead to licensing

Petroleum, in the form of oil, was first known in western Europe for many centuries at places such as Pellensmühle in the Rhein Valley and along the shores of Lake Neuchâtel, Switzerland, where Neolithic people are known to have used asphalt as an adhesive to attach horn or wooden handles to flint implements. Pits and simple drilling in 1854 are also thought to have used asphalt as an adhesive to attach horn or wooden handles to flint implements. Petroleum seeps along the southern coast of England in Dorset were first drilled in 1930. The discovery was in 1919 at the Dinantian Hardstoft well in the East Midlands (Chapter 6; Figure 6.1). The Zechstein dolomites at Ten Boer in 1956 was followed in 1959 by the discovery of fully gas-bearing 180 m of water-bearing Rotliegend sandstones (Section 6.2.1 in Chapter 7). A small gas discovery in 1944, oil was found in the Arnhem-01 well from an unknown reservoir. The Giethoorn well had reported oil, but subsequent drilling did not confirm the discovery. Exploration in Poland began in 1964, but it was not until 1964 that Pernian Zechstein gas was found that drilling that targeted a Triassic sandstone structures in the centre of the Free-Satlantic Montagne unpegged a 2D-analogise seismic data. The first oil was discovered in the same area in 1961 in the Bydgoszcz Main Dolomite (Chapter 8).

Figure 14.1 summarises the first play penetrations and first successes in each play for each country. Example 14.2, which depicted the licence areas on 1st January 1960, only shows licences in Belgium and the Netherlands as records of early onshore licensing are not available for Germany. There was no licensing in Poland until 1983.

1.2 Framework for offshore licensing leads to offshore discoveries

The Convention on the Continental Shelf adopted by the United Nations Law of the Sea Conference in 1958 provided for states to have the right to exploit the natural resources of their sector of the shelf to 200 miles. The Seabed-claims concept was a key resolution of the Convention, defined as the limit of a point equidistant from the nearest base line or from each State from which the width of the territorial sea was to be measured. It was left to individual States to regulate exploitation in their sector.

The Danish Government was the first to initiate licensing in its offshore area in 1962, awarding the whole continental shelf to 200 miles, which proved to be a dry hole with no Rotliegend reservoir. This was followed by more than 20 wells in the UK northern North Sea, where the first of many important gas discoveries was made at the West Sole field (Section 4.1.5 in Chapter 7). The first offshore gas discovery in the Netherlands was in 1964 when the Steenbergen-1 well found Rotliegend gas. This was first discovered in the S-UW well in 1968. The first well drilled in the German sector in 1964, well B1 in block B15, was abandoned after a gas showout. Wells drilled in the 1960s made some gas discoveries in the Pernian and Cardenolites plays, but none were economic due to the high nitrogen content and/or the amount of gas in place. The first gasfield (A6/B4) was discovered in 1974 but development did not start until 1999. Offshore exploration of the Polish Baltic Sea began in the late 1970s under the Petrolevan Company’s exclusive licence for exploration and exploitation. In 1981, oil was discovered in the B1-1/81 well, 80 km off the Rozewie Cape. In 1999, the Polish State Treaty became Petrobank’s only shareholder.

2 Legislation, licensing and fiscal regime

The regulation that governs licensing, the methodology for selecting blocks, criteria for awards and the chronology of licence rounds, differ for each country and have varied through time. Descriptions of these differing aspects and licensing history are therefore summarised individually.

In 1994, the EU established Directive 94/23/EC Conditions for Granting and Using Authorisations for the Prospect, Exploration and Production of Hydrocarbons/ defining the energy policy of the Community and the Member States. The Directive was intended to ensure greater integration of the internal energy market, free of barriers to trade, with a view to improving security of supply, reducing costs and improving economic competitiveness. Since 1994, Member States have followed this directive when issuing petroleum exploration covering factors that may (or may not) be taken into account when deciding whether or not to issue a licence and the minimum amount of public consultation. Poland has identified some areas that are not subject to the tender process.

Chapter 14 Licensing and exploration history

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Bibliographic reference
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Figure 14.2a  Licensed acreage at 1 January 1960. Note that records of early onshore licensing are not available for Germany and there was no licensing in Poland before 1993.

Figure 14.2b  Licensed acreage at 1 January 1970. Note that records of early onshore licensing are not available for Germany and there was no licensing in Poland before 1993.

Figure 14.2c  Licensed acreage at 1 January 1980. Note that there was no licensing in Poland before 1993.

Figure 14.2d  Licensed acreage at 1 January 1985. Note that there was no licensing in Poland before 1993.
Chapter 14 — Licensing and exploration history

Figure 14.2e  Licensed acreage at 1 January 1990. Note that there was no licensing in Poland before 1993.

Figure 14.2f  Licensed acreage at 1 January 1995.

Figure 14.2g  Licensed acreage at 1 January 2000.

Figure 14.2h  Licensed acreage at 1 January 2005.
Chapter 14 — Licensing and exploratory history

2.2 UK legislation

The Petroleum (Production) Act 1974 (now consolidated in the Petroleum Act 1998) vested ownership in the Licence of petroleum (oil and gas) within the UK and its territorial sea. It also gave the Government powers to grant licences to explore for and exploit these resources.

Before 1996, the Department of Trade and Industry (DTI) issued a sequence of separate licences for each stage of an onshore field’s life: an Exploration Licence, an Appraisal Licence, a Development Licence and a Production Licence. Petroleum Exploration and Development Licences (PEDLs) were introduced at the 8th Licensing Round to reduce the bureaucratic burden of issuing a series of licences.

For the offshore UK Continental Shelf (UKCS), the DECC issues a Production Licence that permits the holder to search, drill for and extract (‘search, bore for, and get’) any petroleum found in a specified area. In recent years, licences have been issued with variations of the ‘Traditional’ Production Licence: the ‘Promote’ Licence, the ‘Frontier’ Licence (but not in the SPBA area) and licences specially drafted to cover the redevelopment of a demised field. Production Licences have usually been awarded through licensing Rounds and their duration has varied from round to round. Recently, licences wishing to progress developments have been able to apply for specific blocks ‘Out-of-Round’.

The Exploration Licence allows exploration work (including the acquisition of seismic data), other than deeper (greater than 350 m) drilling, in all areas of the UKCS that are not covered by a Production Licence. Exploration Licences may be obtained at any time and are valid for 3 years.

2.2.2 UK licence offers and criteria for awards

The first UK Licence Round took place in 1964 when a large part of the UK within the SPB area was licensed. More than 50 of those first 342 licences awarded are still extant, and no subsequent round has seen such a large number of licences awarded (Figure 14.5). Table 14.1 lists offshore licensing rounds 1964 to 2005.

![Figure 14.3](image)

Figure 14.3: Licensed acreage at 1 January 2006. Note no licence awards in Belgium, Germany and Poland.

![Figure 14.4](image)

Figure 14.4: Licence award chronology.
A number of changes were introduced in the period 2002-2005 in response to the significant sustained interest in developing North Sea fields, and in a boost to exploration and appraisal activity.

A number of changes were introduced in the period 2002-2005 in response to the significant sustained interest in developing North Sea fields, and in a boost to exploration and appraisal activity.

Supplementary charge

Supplementary charge is an additional charge of 20% (30% prior to 1 January 2006) on a company’s ring-fence profits excluding finance costs. The supplementary charge was introduced on 1st April 2002.

Petroleum Revenue Tax (PRT)

Petroleum Revenue Tax (PRT) is a special tax on oil and gas production from the UK and Ireland (see above). It is a field-based tax charged on profits arising from individual oilfields. PRT is deductible as an expense against Corporation Tax and the supplementary charge. From 1st January 2006, the marginal tax rate on new fields is 50% whereas the marginal tax rate on fields paying PRT is 75%.

A Ring Fence Expenditure Supplement (RFES) assists companies that do not have taxable income for Corporation Tax or the supplementary charge against which to set their exploration, appraisal and development costs and capital allowances. The RFES increases the value of unused expenditure normally forward from one period to the next by a compounded 6% per year for a maximum of 11 years. It applies to all considered expenditure from 1st January 2004. The State does not participate in exploration or development in the UK.

2.2 Legislation, licensing and fiscal regime in Belgium


2.2.1 Belgian legislation and licensing

Exploration and exploitation in Belgium was regulated by the Royal Decree No. 83 of 1919 “relating to the search and the exploitation of bituminous rocks, oil and gas” and modified by the Decree of the Report in 1946. As a result of the change to a Federal State, the regions of Flanders, Wallonia and Brussels-Capital took control of the original Decree of the Flemish Government, dated 21st July 1972, “regulating the form and the methods of the examination of the requests for obtaining a licence for the prospecting and the exploitation of oil and gas” and modified by the Council of Government. The Royal Decree of 1959 remains the constitutional base for the Belgian offshore sector.

2.2.2 Belgian fiscal regime

No fiscal regime has been established to date as there has been no oil or gas production in Belgium, apart from some coal-seam gas and attempts to extract oil from bituminous shale in the Jura of the Paris Basin. Since 2003, approved field development plans (Winningplan) have been required in mining activities. Since 2003, approved field development plans (Winningplan) have been required in mining activities.

2.3 Legislation, licensing and fiscal regime in the Netherlands

Further information is available from the NL Mijn en Gas Portal www.alg.nl.

2.3.1 Dutch legislation and licensing

The history of Dutch mining legislation started with the founding of the Kingdom of the Netherlands in 1815. The Dutch Mining Act of 21st April 1818 was brought under Dutch legislation. This French act was called ‘Loi concernant les Mines, les Minières et les Carrières’ (Bulletin des Lois, no. 285) was already in use in the parts of the Netherlands that belonged to France. In the Mine Act of 1903 there were some applications on the art of 1583. In 1919, both Mine Acts were used for the production of salt and, after 1948, for hydrocarbons. These acts could only be used in case of activities on land, such as the Groningen concessions of 1913 concerning the Dutch Scheltewij of gasfield. As the mining industry became interested in activities offshore in the North Sea, a special act, The Continental Shelf Mining Act 1965, was introduced in 1945 to cover that specific case. This mining act was more modern than the older acts and envisaged a much more commercial setting for mining activities offshore. The Mining Act of 1965 provided for the establishment of a Mining Advisory Council (Article 105, third paragraph of the permit that has been requested. The council meets every 2 to 3 months.

In accordance with the provisions in Article 17 of the Mining Act, the Minister of Economic Affairs must issue a decision on the application for an Exploration Licence no later than 6 months after the permit for submitting counter-applications has ended. If the Minister extends the decision-making period once or twice, but no longer than 6 months. The decision to issue the exploration permit is announced in the Staatscourant, the Dutch Government Gazette (Article 15 of the Mining Act). Interested parties have 15 weeks from the date of publication in the Staatscourant to make written objections. Once the 13 weeks have passed, the Minister shall notify the interested parties that the objections have been considered and that no permit for exploration has been granted.

Production Licences

For the holder of an Exploration Licence, the procedure for applying for a Production Licence is outlined in Chapter 2 of the Mining Act (Articles 14-17, in particular) and Chapter 1 of the Mining Regulations. Further information is available from the NL Mijn en Gas Portal www.alg.nl.

An application for a Production Licence for an open area can be submitted to the Ministry of Economic Affairs. These Licence applications are decided on after a licensing procedure; all kinds of Production Licences; one made for the holder of the exploration licence and the other in the case of an open area.

Exploration Licences

An application for exploring an Exploration Licence is outlined in Chapter 2 of the Mining Act (Articles 14-17) and detailed in Chapter 1 of the Mining Regulations, Section 1.3 and Appendices 2-4 of the Mining Regulations contain a summary of the information that must be provided with a licence application.

Application for an Exploration Licence for an open area can be submitted to the Ministry of Economic Affairs. These Licence applications are decided on after a licensing procedure; all kinds of Production Licences; one made for the holder of the exploration licence and the other in the case of an open area.

Further information is available from the NL Mijn en Gas Portal www.alg.nl.

Table 14.2 Dutch licensing rounds.

<table>
<thead>
<tr>
<th>Round</th>
<th>Year</th>
<th>Licence duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>1960</td>
<td>5 + 4</td>
</tr>
<tr>
<td>1964</td>
<td>1968</td>
<td>10 + 5</td>
</tr>
<tr>
<td>1968</td>
<td>1972</td>
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<td>1980</td>
<td>1982</td>
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<td>g</td>
<td>1986</td>
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<td>1990</td>
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</tr>
<tr>
<td>g</td>
<td>2022</td>
<td>6 + 6</td>
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</table>

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An application for a Production Licence for an open area can be submitted to the Ministry of Economic Affairs. These Licence applications are decided on after a licensing procedure; all kinds of Production Licences; one made for the holder of the exploration licence and the other in the case of an open area.
The Severance Tax only applies to onshore licences. It is a fee on the turnover generated by a Production Licence holder. The rates vary according to the duration of the permit: 1 to 6 calendar years = €209 per km²; 7 to 9 calendar years = €168 per km²; 9 or more calendar years = €128 per km².

Since the Act of 1932 on Exploration and Production of Resources in the subsoil of the Kingdom of Denmark, the EBN has participated automatically if a licensee carries out such further exploration. A Production Licence (in which EBN usually participates) allows further exploration in the licence area. If EBN has not participated in the exploration preceding the Production Licence, the agreement states that EBN pays the licensee 40% of the costs incurred in discovery of the hydrocarbons, their further exploration and the further investments for mining activity referred to in the reimbursement agreement.

Example: If 3 billion (3 × 10⁸) m³ gas is produced, the percentage in Severance Tax owed is:

- 0-200 0%
- 200-600 1%
- 600-1200 3%
- 1200-2000 4%
- 2000-5200 5%
- 5200-12000 6%
- 12000-25000 7%
- 25000 and over 8%

The Severance Tax rate is increased by 15% if the average cost for crude oil imported into the Netherlands in a year rises above €45 per barrel. 

The main reasons for tax and fee exemptions are:
- An exploration production licence to explore and produce for a specified period of time. It is a concession agreement which allows the holder to carry out exploration and production activities without paying any fees or taxes.
- A licence to carry out specified activities, such as drilling for oil and gas, is granted by the Danish Energy Agency and is subject to the approval of the Minister.
- A licence to carry out specified activities, such as drilling for oil and gas, is granted by the Danish Energy Agency and is subject to the approval of the Minister.

The Severance Tax is calculated by multiplying the gross revenue generated by the production licence by the Severance Tax rate. The formula for calculating the Severance Tax is:

\[ \text{Severance Tax} = \text{Gross Revenue} \times \text{Severance Tax Rate} \]

The Severance Tax rate is increased by 15% if the average cost for crude oil imported into the Netherlands in a year rises above €45 per barrel.

2.4.4 Danish State participation

Whereas in the earlier licensing rounds State participation was carried, a fully paying State interest of 20% has been applied in all licences granted in the 4th and later rounds.

State participation has been exercised by the national oil company (DONG) in licences granted between 1994 and 2004. Following the Danish Parliament’s decision to privatise DONG in 2004, State participation was reorganized in 2005 when the Danish North Sea Fund (Nordsøfonden) was set up to take up responsibility for the State’s 20% participation in future hydrocarbon licences. The Nordsøfonden will also be responsible for the State participation in DUC from 2012. The Nordsøfonden is independent and will define costs and receive income from the new licence. The Danish North Sea Partner (Nordsøenheden), an entity under the Ministry of Transport and Energy, was also set up in 2005 to administer the Nordsøfonden.

2.5 Legislation, licensing and fiscal regime in Germany

The legislation, licensing and fiscal regime in Germany are the responsibility of the local State Authority for Mining of the Federal States. Further information about the regimes within the SPBA can be found on the following websites:

- www.montanabt.mer.de for Nordrhein-Westfalen.
- www.smb.mv.lm.de for Sachsen.
- www.smb.lf-tb.bayern.de/ for Bayern.
- www.mine-natur.sachsen.de for Sachsen-Anhalt.
- www.wirtschaftsausschuss.de for Thüringen.

2.5.1 German legislation and licensing

There is a long tradition in Germany concerning the right to explore and produce minerals. The oldest known legal basis can be found in the so-called ‘Bachdorfer Konvention’ from Emperor Friedrich Barbarossa dating from 1158. During the next 700 years, the mining rights were held by the local sovereign. A new Mining Law was issued in 1900 when licences for important minerals (such as coal or potash) could only be issued by the State. Depreciation commences when the assets come into active use. The base VAT rate of 19% is charged on all sales, but reduced rates of VAT (7% and 3%) are imposed on sales of some products and services. There is a State participation in exploration or development onshore in Poland, but the Baltic Sea area is held by Pobaltic, whose only shareholder is the Polish State Treasury.

2.5.2 German fiscal regime and taxation

2.6 Polish fiscal regime and taxation

Poland levies a fee on hydrocarbon production based on a percentage of the recoverable reserves multiplied by the unit price of the mineral and by the average utilisation factor, with the fee ranging from 0.1% to 2%. Royalties are also levied based on multiplication of the Royalty rate and the amount of product exported in the period under consideration in most cases (1 year) for example, 5.0 PLN/1000 m³ at market activity. The Concession is in 1.0 PLN/1000 m³ of natural gas; 0.5 PLN/m³ net of royalty.

2.6.1 Polish legislation and licensing

Poland’s Ministry of the Environment grants authorisation for prospecting and exploration of hydrocarbons. Until license 1984, no maps were published in the Official Journal of the European Union (OJEU), and valuable information was available from the Department of Geological and Geological Concessions website, setting concession areas which are the result of obligatory tender and areas where concessions are granted without the tender process. The obligatory tender areas are subject to the procedure provided for in Article 12(1) of Directive 94/22/EC, whereas a competitive bidding process is established in the non-obligatory tender areas. The Ministry has also identified areas where mining is granted on a permanent basis with regard to authorizations for prospecting and exploration of hydrocarbons, according to Article 13(1) of Directive 94/22/EC.

Concessions are granted for areas with a total maximum acreage of 1200 km². The concession fee is based on the amount of acreage in the concession and type of mineral. For oil and gas exploration, the concession fee is 200 PLN/km²/year. In addition, a Mining Fee is paid as a result of mining activity concerning hydrocarbons. The fee is individually negotiable for every licensee, but for exploration it is ≤ 200 PLN/km²/year.

2.6.2 Polish fiscal regime and taxation

3 History of seismic surveying

Figure 14.5 shows the amounts of 2D- and 3D-seismic data acquired annually in each country versus the oil price since 1960. The advent of digital seismic-data recording in 1985 is reflected in the increase in seismic acquisition, peaking in the 1980s following the oil-price rise, and waning in the late 1980s to levels comparable to the seismic acquisition. Breakthroughs in 3D-seismic imaging and migration technology have been critical to the success of many Permian and Carboniferous plays.
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Figure 14.6a  2D-seismic data acquired before 1970.

Figure 14.6b  2D-seismic data acquired between 1970-1979.

Figure 14.6c  2D-seismic data acquired between 1980-1989.

Figure 14.6d  2D-seismic data acquired between 1990-1999.
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Figure 14.6e    2D-seismic data acquired between 2000-2006.

Figure 14.7b    3D-seismic data coverage, 1990-1999. Figure 14.7c    3D-seismic data coverage, 2000-2006.

Figure 14.7a    3D-seismic data coverage, 1970-1989.
3.2 3D-seismic data

Maps of 3D-seismic data by decade (1970-2000) in the SPBA area are shown on Figure 14.7a (where data are available). The first 3D-seismic survey in the SPBA area was acquired in 1976 in the Dutch North Sea sector in Quadrant L, followed by Belgium’s first 3D-seismic survey offshore northern Belgium in 1978 (Figure 14.7a). It was not until 1983 that 3D-seismic data were acquired in Danish North Sea waters in Quadrant N6, followed by the UK Safe P1 3D-seismic survey in 1984 and ‘Wandelburg Field’ in onshore Germany in 1985.

In the 1980s, 3D-seismic data were generally considered to be a field-delineation/development tool, with large surveys only acquired in the Netherlands and no acquisition in Belgium or Poland. That approach was expanded in the 1990s by larger surveys that created overlapping ‘target’ of surveys in the UK and until now them not previously covered in the Netherlands. In Germany, the Lower Saxony Basin was covered by large 3D-seismic surveys, and the Danish Central Graben was subject to widespread 3D-seismic data acquisition. Poland’s first 3D-seismic data were not acquired until 1993 when the World Bank funded purchase of 3D-seismic equipment and training, which were first used to delineate the Rozansko field.

Since 2000, 3D-data acquisition has been more limited, generally utilizing gaps in coverage except for two large-scale surveys in German North Sea waters, and surveys of increasing wood extent acquired in Poland. Some new 3D-seismic data have been acquired in areas previously surveyed with new acquisition parameters.

A change in investment frameworks from acquisition to recompressing efforts has been seen in the last 10 years, with seismic contractors merging overlapping surveys pre-stack and then re-migrating the data with a variety of time- and depth-migration techniques with even more complicated algorithms to more accurately image horizons underlying structural complexity and lateral velocity variations. Seismic inversion, amplitude analysis and AVO (amplitude variation with offset) processing have been increasingly utilised in field development and to reduce risk on exploration prospects.

4 Exploration and drilling history

About 17 000 wells have been drilled in the German part of the SPB area, of which more than 6000 are exploration wells, mostly in the Mesozoic Lower Saxony Basin. There are more wells in Germany than in any other country in the SPB area, more than four times more than in Poland (1588 exploration, appraisal and development wells since 1980, which includes wells drilled for salt, copper, and lignite (brown coal) or the Netherlands (4079) and five times more than the number of wells drilled in UK part of the SPB area (1200). 149 exploration and appraisal wells were drilled in the Danish part of the SPB area, but sidetracks are not counted as separate wells. Only seven exploration wells have been drilled in Belgium. However, these numbers can be somewhat misleading as much of the early onshore drilling was very closely spaced and shallow.

4.1 Exploration

The number of exploration wells drilled since 1980 is plotted by year in Figure 14.6a, which shows the limited exploration drilling before World War II, except in Germany, where the ‘Reichsbaggerprogramm’, Government aid to encourage oil exploration started in 1984. Exploration drilling in Germany started to decline in the 1980s as the oil plays became mature, despite new exploration drilling for gas.

Geological events and linked oil-price increase in the 1980s spurred increased exploration activity (Figure 14.6b). In the UK and Netherlands, but peak activity lagged by 5 years. The drop in exploration drilling in the UK after 1992 may have been the response to the removal of PRT relief for exploration wells that was announced after the 4th Round (see above). The oil price seen in 1999 were followed by a lower rate of exploration within only 2 years. Exploration has not seen a dramatic increase in the SPF area since the upturn in price after 2000.

Figure 14.6 shows all exploration drilling in the SPF area (all Polish wells are shown because they can not be differentiated into exploration, appraisal or development), reflecting the productive gas and oil trends. The bottom-hole stratigraphy of the wells is depicted on Figure 14.7a showing all exploration drilling in the SPB area (all Polish wells are shown because they can not be differentiated into exploration, appraisal or development), reflecting the productive gas and oil trends.

An exception to the cluster of wells that terminated in Cretaceous or Jurassic strata lies in the Danish Central Graben, and a significant number wells terminated at the same stratigraphic levels across central Netherlands and Germany, extending into northern Germany. In Poland, the three provinces, Pomo-Sudeot, Przeworsko and Czarnow (Figure 14.11) are easily distinguished, with wells mostly terminating at Retliziec, Zachowic and pre-Danian levels respectively. The north-west-south-east oriented Jurassic play trend can also be seen crossing central Poland.

The pattern of target horizons for these exploration wells (Figure 14.11) is markedly different to the distribution of bottom-hole stratigraphy (Figure 14.10). The Retliziec and Carboniferous trends in the UK, with intersected Triassic Bunter target horizons, are easily identified with the Retliziec play trend forming a lobe, north-west-south-east-oriented axes across the southern and central parts of the Southern North Sea Basin, and with the Carboniferous trend lying across the northern part of the basin. The UK Triassic play trend also lies nearly across the northern part of the basin, but there have been a number of wells with Titantic targets across the southern and central parts of the UK Southern North Sea Basin. In the UK onshore, the southern England Jurassic and East Midlands Carboniferous play trends are easily distinguished.

The Retliziec play extends across most of the Netherlands offshore sector. Few wells appear to have targeted the Carboniferous in the sector, but note that there are many Dutch offshore wells for which the target stratigraphy is unknown. The Danish Central Graben trend is shown by a linear cluster of wells with Cretaceous and Jurassic targets. In Belgium, the pre-Danian and Carboniferous plays lie in the west and north-east of the onshore area respectively.

In Germany, different trends evolve one another, although the Carboniferous/Zechstein and Retliziec trends can be differentiated across central/northern Germany; with the Cretaceous/Zechstein play trend continuing to the south of the Retliziec play trend. Within the narrow confines of the German offshore waters in the Ostea Rough Basin, bounded on the east by an inheritance called the Weda High, in which the Ad So field is located with gas accumulations in a complex setting of reservoirs consisting of Jurassic sandstones and carbonates, Zechstein carbonates, Retliziec clastics and volatiles. Wells targeting Jurassic and Cretaceous strata south of the Retliziec fairway reflect the oil plays of the Mesozoic Lower Saxony Basin. The cluster close to the western border of the SPF is related to the Zechstein play of the Thuringian Basin. Unfortunately, the target horizon of most of the west German wells is not available (including most of the Thuringian Basin wells).
no information is available with respect to play target for the Polish wells; however, drilling falls into three main exploration provinces; the Fore-Sudetic Monocline (Zechstein play), Pomeranian (Zechstein play) and Cambrian (Cambrian Main Dolomite play).

Figures 14.12a–e examine exploration drilling through time from pre-1970 and in subsequent decades. Figures 14.13a–e highlight the results of these wells. All Polish wells are shown as exploration wells because they can not be differentiated into exploration, appraisal or development.

The maps of wells drilled before 1970 (Figures 14.12a and 14.12b) and exploration drilling histograms (Figures 14.12a and 14.12b) do not include wells drilled in Poland before 1960. This shallow drilling was carried out by the Petroleum Exploration Company (PEC), a special institution organized after World War II for planning, preparation and running of exploration projects in an attempt to isolate salt diapirs, which were analogous to the diapirs developed in Germany. Drill locations were selected using gravimetric and magnetometric surveys, followed by analogue seismic-reflection and refraction surveys in the 1950s. Exploration wells were located more conventionally in the 1960s, as early seismic data were replaced by analogue seismic and then by digital seismic recording in the 1970s.

Activity in Poland was maintained at a high level from 1964 to 1974 when exploration, appraisal and development drilling was focused on the Polish Trough, the Fore-Sudetic Monocline and a scatter of wells along the Baltic Sea coast. Exploration drilling has been in decline since 1966. However, POGG, the only Polish oil and gas exploration and production company working onshore, was started in 1982 and there has been recent licensing by multinational oil companies.

Pre-1970 UK exploration drilling reflects the early onshore activity, when drilling in the East Midlands, southern England and the Cleveland Basin was fostered by the need for wartime production, and tax breaks for indigenous oil in 1953–1961. After 1965, the peak on Figure 14.4b reflects new offshore exploration wells resulting from the large number of blocks awarded in the 1st Round. Most of the large Rotliegend fields were discovered on these 1st Round licences drilled between 1965 and 1975 (Figures 14.17). There were a number of unsuccessful Mid North Sea High wells drilled before 1970 and the area has only recently seen renewed interest. A second phase of UK exploration followed the price rise in the early 1980s when most of the Carboniferous fields were discovered. The drop in the oil price in 1988 was followed by a decline in exploration drilling to a minimum level in 2000, which has only slightly improved despite the trend of oil-price variation since 1998.

Belgium’s first exploration wells were drilled in the 1970s, stimulated by discoveries in Germany. A prolific drilled in 1962 on the Recht Bank in the Lower Carboniferous (Rotliegend) stimulated extensive limestone of the Campus Basin resulted in the development of the site for gas storage after 1970.

Pre-1970 exploration in the Netherlands was almost entirely onshore, extending the 1959 Groningen discovery and chasing the same Rotliegend gas play. The Dutch part of the continental shelf was opened up in this search in 1968. The drilling rate shows a trend very similar to the UK sector, driven by increasing oil prices (and linked gas prices) peaking in the mid-1980s. In the 1980s, the drilling rate gradually decreased to a low level in about 2000 following decreasing oil prices and also reflecting more focused and efficient exploration because of the availability of the then-modern 3D seismic data on an exploration scale. Since 2000, the offshore drilling rate has been maintained at a level of about two wells/year; however, onshore drilling has further decreased to only a few wells per year. This can be partly explained by the more mature stage of exploration onshore compared to the larger, more prospective offshore areas, but also because environmental constraints have become very severe; permission to drill may take several years in some locations. Recently, after a process of some 15 years, new gas production has started from under the Wadden Sea, a protected tidal-flat area. It remains uncertain if further exploration in or near environmental sensitive areas will be feasible in the Netherlands.

Pre-1970 exploration-drilling in Denmark began in the mid-1930s with the drilling of two wells on the Jylland peninsula for oil and gas in general. No further wells were drilled until 1969 when a number of onshore wells were drilled targeting various plays. No hydrocarbons were discovered during this period. With the award of the Sole Concession in 1962, exploration in Denmark also moved offshore and the first oil discovery in Denmark, and in the North Sea, was made in 1965. The majority of the later wells have focused on the offshore areas and most have targeted the chalk play. With the gradual relinquishment of the Sole Concession areas and the introduction of licensing rounds at the beginning of the 1980s, exploration drilling peaked in the mid-1980s. The drilling rate has subsequently levelled out at two to four exploratory wells per year, approximately half of which have been drilled in the SPB area.

4.2 Appraisal and development drilling

The trends in exploration drilling (Figures 14.14a and 14.15b) are largely reflected in appraisal and development drilling (Figures 14.14b and 14.15b), where times of heightened exploration activity are associated with increased appraisal and development drilling. However, this can be misleading, because many early discoveries in the North Sea are only marginally economic now that gas prices have increased since 1998, and recent development drilling has delineated these older discoveries. Figure 14.16a shows that almost half of the UK ‘Significant Discoveries’ (where the well was deemed capable of testing more than 1000 bscf/day or 15 Mcf/d) and field discovery wells in the SPB area were licensed in the 2nd Round, although some of these discoveries are only now being developed.

4.3 Success rates by country and by play

A very simple success rate can be calculated by dividing the number of discoveries in a year by the number of exploration wells drilled in the same year (more is introduced by wells that started in one calendar year and finished in the next). Figure 14.17a–e chart exploration drilling versus the exploration success rate. These success rates show a large degree of scatter on a year-by-year basis and lump together different discovery sizes, from sub-economic finds to giant fields. Note that the UK discoveries comprise only the ‘Significant Discoveries’ published in the ‘Brown Book’. Figure 14.18a–e chart the exploration success rates in individual plays for each country and Figures 14.18a–e show in which age play their success rates are found (except for Poland, where all discoveries are shown in every age play).

For the UK, Figure 14.17a shows a generally increasing trend in exploration success rate from about 20% in the 1960s and 1970s, to about 5% in the 1980s and 1990s. After the number of wells drilled fell dramatically in 1992, the success rate began to climb to about 45% following the rise in oil price. In recent years, the success rate has been improving in the SPB area, although exploration–well drilling in 2005, the last year included in the data presented in this chapter, yielded a disappointing number of ‘Significant Discoveries’. Figure 14.18a shows that the Rotliegend is the most drilled play in the SPB area with a 42% chance of finding a ‘Significant Discovery’. Rotliegend wells comprise 71% of the Significant Discoveries, followed by the Carboniferous with 18% (Figure 14.19a).
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Figure 14.12a  Exploration wells drilled pre-1970. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.12b  Exploration wells drilled between 1970-1979. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.12c  Exploration wells drilled between 1980-1989. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.12d  Exploration wells drilled between 1990-1999. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.
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Figure 14.12a: Exploration wells drilled between 2000-2006. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.13a: Exploration wells drilled pre-1970 showing results. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.13b: Exploration wells drilled between 1970-79 showing results. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.13c: Exploration wells drilled between 1980-89 showing results. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.

Figure 14.13d: Exploration wells drilled between 1990-99 showing results. Note all Polish wells are shown as exploration/appraisal/development can not be differentiated.
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The Dutch exploration success rate (Figure 14.17b) also shows an inverse relationship; when fewer wells were drilled after 1992, they were more successful, and an overall increasing success rate trend that topped 75% in 2005. The Rotliegend has the highest number of play penetrations with an average 42% success, but Triassic, Cretaceous and unknown age plays have been drilled (Figure 14.18b). There is a diverse age of successful wells in the Netherlands and the Rotliegend comprises only 18% of the discoveries (Figure 14.19b). The 1968 area includes only the northern part of the Danish exploration area. Since the discovery of the Halflin (Section 4.2 in Chapter 11) and Sif fields in 1998, newer discoveries have been made north of the S7A, which explains the apparent recent decline in success. The Cretaceous is the most successful play, with a 50% success rate, followed closely by Jurassic plays with a 50% success rate and some Zechstein and Triassic plays with lower success rates (Figure 14.18b). Looking at the number of wells drilled in each play, Cretaceous wells comprise 60% of the discoveries, followed by Jurassic successes comprising 35% (Figure 14.19b). The exploration success rates in Germany (Figure 14.17c) have shown a steady increase since the application of modern geoscience; most of the wells drilled before 1970 had low (<10%) success rates. A success rate up to about 50% was achieved as drilling continued in the mature basin in the mid-1990s. The play-penetration data are not complete for the German wells, so most of the wells are noted as ‘unknown’ on Figure 14.18b, but by excluding those wells on Figure 14.19b the diverse age of successful wells in Germany can be seen.

Exploration drilling can not be differentiated from appraisal or development drilling in Poland, but Figure 14.27a shows the poor success rate of early drilling before the advent of modern exploration technology in the 1970s and an increasing success rate through time. Figure 14.18b shows that the Free-Sudetic Monline petroleum province is the most drilled with a greater than 50% success rate. Wells in this province make up 40% of the successful wells, excluding the 712 wells with unknown result (Figure 14.19b). An analysis of the number of exploration-well penetrations into each of the three stratigraphic plays, and whether or not the wells were successful in finding hydrocarbons, is shown in Figure 14.20, which shows that the Rotliegend is the most successful play and demonstrates the poor success rates of early German drilling, which pre-dated modern seismic acquisition and imaging technology.

4.4 Factors that influence drilling investment and success

The amount of exploration has fluctuated in response to many factors, both globally (e.g. oil price, perceived prospectivity in other international basins) and locally (e.g. prospectivity, regulatory and tax changes) influenced. Together these components interact to produce a complex response to market conditions including the access to acreage in licence rounds and commercial deals, changes in the tax and fiscal regime, the availability and cost of drilling rigs, commercial barriers and entrants, the availability of infrastructure, State participation, perceived technical risk and reward and, more recently, environmental considerations.

Exploration drilling in Germany and oil drilling in Poland is largely decoupled from oil prices and reflects the trend of gradual decline in activity since 1990 (Figure 14.28b). Exploration activity in the UK, the Netherlands and Denmark is more closely related to oil price. It is interesting to note that the oil price
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The increase in 1979-80 was reflected by a gradual increase in exploration drilling that peaked in about 1990 fuelled by exploration success, but it was constrained by relatively conservative price forecasts predicted by the industry. However, in contrast to the drop response to oil-price rise, the oil-price deep in 1988 was soon followed the next year by a drop in exploration drilling from which the industry has yet to recover, despite the dramatic increase in oil price seen in recent years. The worldwide demand for drilling rigs and development hardware, increased environmental requirements, and the shortage of experienced geoscientists and engineers, has made the SPBA area an expensive place to operate (particularly offshore), although new large discoveries are still being made.