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National and Global Petroleum Assessment

Assessment of Continuous Oil and Gas Resources in the Lower Saxony Basin of Germany, 2020

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean resources of 321 million barrels of shale oil and 435 billion cubic feet of shale gas in the Lower Saxony Basin, Germany.

Introduction

The U.S. Geological Survey (USGS) quantitatively assessed the potential for technically recoverable continuous oil and gas resources in the Lower Saxony Basin of Germany (figs. 1 and 2). The Lower Saxony Basin is in the southern part of the USGS-defined Northwest German Basin Province. The Lower Saxony Basin evolved in the Mesozoic from an extensional regime into a large, east–west trending, complexly structured half graben situated between the Pompeckj terrane to the north and the Rhenish Massif and Lower Saxony Mountains to the south (Betz and others, 1987; Adriasola Muñoz and others, 2007; Bruns and others, 2013).

The organic-rich Early Jurassic Posidonia Shale was deposited across central Europe and is present throughout the Lower Saxony Basin, and the organic-rich Early Cretaceous Wealden Shale was deposited in the western half of the basin (Kockel and others, 1994; Stock and Littke, 2018). In the southern part of the basin, these source rocks were buried by several kilometers of Jurassic and Cretaceous sediments and were heated well into the thermal gas window, evidenced by vitrinite reflectance values of as much as 5 percent or more (Petmecky and others, 1999). In the shallower-buried northern margin of the basin and in the Gifhorn Trough, these source rocks are thermally immature to marginally mature (Schwarzkopf and Leythaeuser, 1988; Schwarzkopf, 1990). Compressional deformation associated with the Late Cretaceous Alpine orogeny inverted most extensional structures. The timing of deformation indicates that oil and gas within the reservoirs, or oil and gas retained within shales in the southern part of the Lower Saxony Basin, may have been lost during uplift and erosion of as much as seven kilometers of sediment. The source rocks in the northern margin of the basin and in the Gifhorn Trough largely reached thermal maturity for oil generation through Cenozoic burial, and oil generated during this time migrated into the Late Cretaceous structures created during the Alpine orogeny in the northern margin of the Lower Saxony Basin or into salt-affected structures in the Gifhorn Trough. Primary expulsion efficiencies of oil may be high from these fractured, organic-rich shales (Leythaeuser and others, 1988), possibly further reducing the retention of oil.

Compared to many of the viable shale oil or shale gas accumulations in the United States, the Posidonia and Wealden Shales in the Lower Saxony Basin are more structurally deformed and segmented, possibly reducing the amount of oil and gas retained within the shales and reducing the area within which these shales have retained oil or gas.

Total Petroleum Systems and Assessment Units

The USGS defined a Posidonia Shale Total Petroleum System (TPS) and three assessment units (AUs) within this system (fig. 1): the Lower Saxony Basin Posidonia Shale Oil AU, the Gifhorn Trough Posidonia Shale Oil AU, and the Lower Saxony Basin Posidonia Shale Gas AU. The USGS also defined a Wealden Shale TPS that includes the Lower Saxony Basin Wealden Shale Oil AU and the Lower Saxony Basin Wealden Shale Gas AU (fig. 2). The Early Jurassic Posidonia shale is a Type II marine organic-rich source rock with as much as 20 weight percent total organic carbon (TOC), hydrogen index (HI) values as high as 700 milligrams hydrocarbon per gram of total organic carbon (mg HC/g TOC), and an average thickness of 25 meters; shale thickness in the Gifhorn Trough is as much as 100 meters

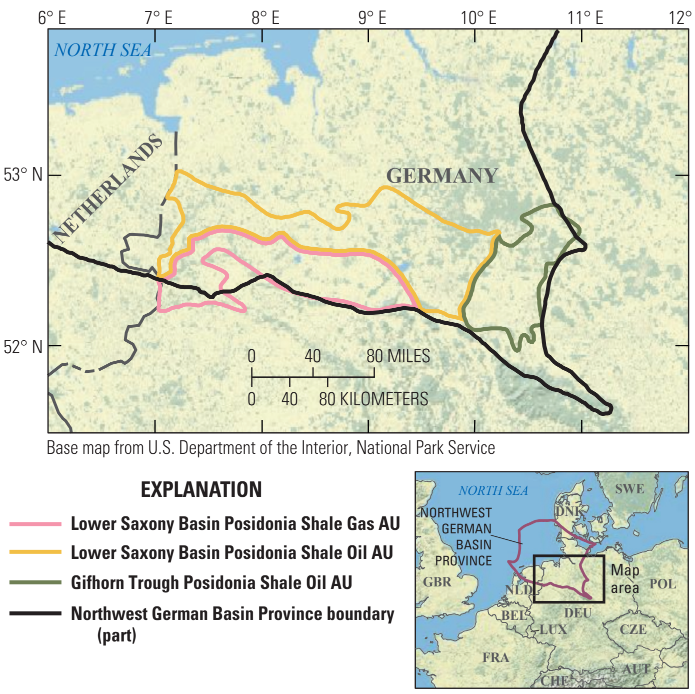

Figure 1. Map showing three continuous assessment units (AUs) in the Posidonia Shale defined within the Posidonia Total Petroleum System of the Lower Saxony Basin.

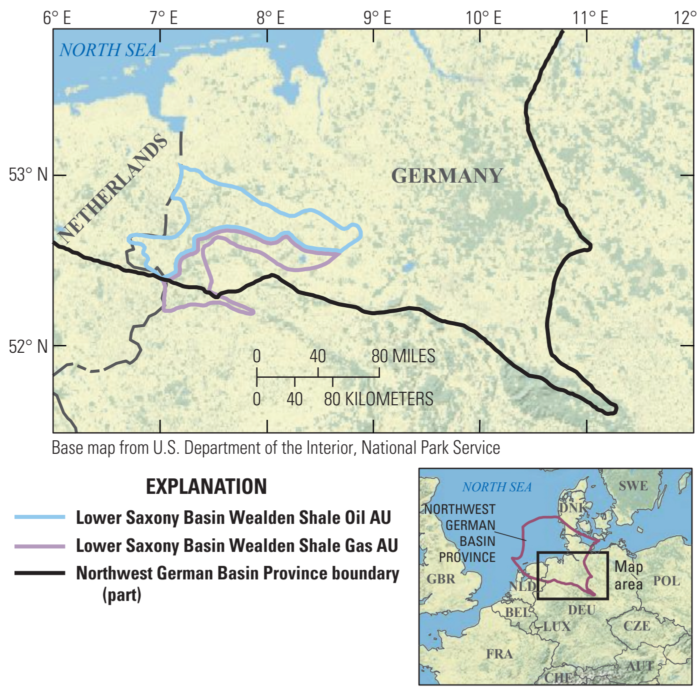

Figure 2. Map showing two continuous assessment units (AUs) of the Wealden Shale defined within the Wealden Total Petroleum System of the Lower Saxony Basin.

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(Schwarzkopf, 1990; Kockel and others, 1994; Adriasola Muñoz and others, 2007; Song and others, 2017; Fang and others, 2019). The Early Cretaceous Wealden Shale is generally interpreted as a lacustrine source rock with TOC values as much as 14 weight percent, HI values as much as 750 mg HC/g TOC, and an average thickness of 25 meters (Rippen and others, 2013). The Posidonia Shale is found throughout the Lower Saxony Basin, and the Wealden Shale is in the western part of the basin (Kockel and others, 1994). Assessment input data are summarized in table 1 and in Schenk (2022).

Undiscovered Resources Summary

The USGS quantitatively assessed continuous oil and gas resources in five geologically defined AUs (table 2). For technically recoverable continuous oil and gas resources, the mean totals are 321 million barrels of shale oil (MMBO) with an F95 to F5 fractile range from 75 to 696 MMBO, 435 billion cubic feet of gas (BCFG) with an F95 to F5 fractile range from 84 to 948 BCFG, and 2 million barrels of natural gas liquids (MMBNGL) with an F95 to F5 fractile range from 0 to 5 MMBNGL. Of the mean total shale gas of 435 BCFG, 353 BCFG, or about 81 percent of the mean total, is associated gas, leaving 82 BCFG as nonassociated shale gas.

For More Information

Assessment results are also available at the USGS Energy Resources Program website at https://www.usgs.gov/mission-areas/energy-and-minerals.

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Table 1. Key input data for five continuous assessment units (AUs) in the Lower Saxony Basin of Germany.

[Well drainage area, success ratio, and estimated ultimate recovery are defined partly using U.S. shale-oil and shale-gas analogs. The average EUR input is the minimum, median, maximum, and calculated mean. Shading indicates not applicable. AU, assessment unit; %, percent; EUR, estimated ultimate recovery (per well); MMBO, million barrels of oil; BCFG, billion cubic feet of gas]

Assessment input data—Continuous AUs	Lower Saxony Basin Posidonia Shale Oil AU				Gifhorn Trough Posidonia Shale Oil AU			
	Minimum	Mode	Maximum	Calculated mean	Minimum	Mode	Maximum	Calculated mean
Potential productive area of AU (acres)	1,000	865,500	1,731,000	865,833	1,000	387,000	773,000	387,000
Average drainage area of wells (acres)	60	100	140	100	60	100	140	100
Success ratio (%)	10	30	60	33.3	10	40	80	43.3
Average EUR (MMBO)	0.01	0.04	0.1	0.043	0.02	0.08	0.15	0.083
AU probability	1.0				1.0			
Assessment input data—Continuous AUs	**Lower Saxony Basin Posidonia Shale Gas AU**				**Lower Saxony Basin Wealdon Shale Oil AU**			
	Minimum	**Mode**	**Maximum**	**Calculated mean**	**Minimum**	**Mode**	**Maximum**	**Calculated mean**
Potential productive area of AU (acres)	1,000	546,500	1,093,000	546,833	1,000	402,500	805,000	402,833
Average drainage area of wells (acres)	80	120	160	120	60	100	140	100
Success ratio (%)	5	20	35	20	10	30	60	33.3
Average EUR (BCFG, gas; MMBO, oil)	0.04	0.07	0.1	0.071	0.01	0.04	0.1	0.043
AU probability	0.9				1.0			
Assessment input data—Conventional AUs	**Lower Saxony Basin Wealden Shale Gas AU**							
	Minimum	**Mode**	**Maximum**	**Calculated mean**				
Potential production area of AU (acres)	1,000	212,500	425,000	212,833				
Average drainage area of wells (acres)	80	120	160	120				
Success ratio (%)	5	20	35	20				
Average EUR (MMBO)	0.04	0.07	0.1	0.071				
AU probability	0.9							

Table 2. Results for five continuous assessment units (AUs) in the Lower Saxony Basin of Germany.

[Results shown are fully risked estimates. F95 represents a 95-percent chance of at least the amount tabulated; other fractiles are defined similarly. Shading indicates not applicable. MMBO, million barrels of oil; BCFG, billion cubic feet of gas; NGL, natural gas liquids; MMBNGL, million barrels of natural gas liquids]

Total petroleum systems and assessment units (AUs)	AU probability	Accumulation type	Total undiscovered resources											
			Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
			F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Lower Saxony Basin Posidonia Shale Total Petroleum System														
Lower Saxony Basin Posidonia Shale Oil AU	1.0	Oil	29	108	272	124	32	119	299	136	0	1	2	1
Gifhorn Trough Posidonia Shale Oil AU	1.0	Oil	33	125	299	140	37	138	329	154	0	1	2	1
Lower Saxony Basin Posidonia Shale Gas AU	0.9	Gas					0	55	130	59	0	0	0	0
Lower Saxony Basin Wealden Shale Total Petroleum System														
Lower Saxony Basin Wealden Shale Oil AU	1.0	Oil	13	50	125	57	15	55	139	63	0	0	1	0
Lower Saxony Basin Wealden Shale Gas AU	0.9	Gas					0	22	51	23	0	0	0	0
Total undiscovered conventional resources			**75**	**283**	**696**	**321**	**84**	**389**	**948**	**435**	**0**	**2**	**5**	**2**

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