Norne Field Development: Fast Track From Discovery to Production

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Summary

The Norne field is one of the largest oil discoveries made on the Norwegian Continental Shelf during the last decade. The field will be developed by a monohull production ship connected to subsea wells. To improve project economics, a clear objective to reduce investment costs by 30% to 40% and to minimize time from discovery to production was established. To meet this objective, a new, more integrated approach to project management with parallel execution of activities; standardization; and close relations with contractors, license owners, and authorities was initiated. This paper reviews the reservoir development, the development concept, and the new approach to project management.

Introduction

The Norne field is 200 km offshore in Blocks 6608/10 and 6508/1 of the Norwegian Continental Shelf and is the northernmost field development in the North Sea. Water depth is 370 to 390 m. The field was discovered in Dec. 1991 with Well 6608/10-2 (**Fig. 1**). The discovery well contained a total hydrocarbon column of 135 m, a 110-m oil column with an overlying gas cap. An appraisal well, Well 6608/10-3, was drilled on the northern part of the structure in early 1993. This well confirmed the results from the discovery well and proved the extension of the field to the north. Well 6608/10-4 was drilled in a structure 2 to 3 km east of the Norne field in early 1994. This structure had a high potential, and the results from this well were important for optimum sizing of the process facility. However, only a minor oil accumulation was discovered.

To improve project economics and company performance, we established a clear objective to reduce investment costs by 30% to 40% compared with the 1993 levels in Norway and to minimize the time from discovery to production. The goal was to start production 5 to 6 years after the discovery.

Reservoir Development

The hydrocarbons in the Norne field are in sandstone formations of Lower and Middle Jurassic age, with in-place volumes estimated to be 160×10^6 std m^3 oil and 29×10^9 std m^3 gas (free and associated). The most likely recoverable oil reserves are estimated at 72×10^6 std m^3.

The Norne field is a part of a horst structure, with the top of the reservoir at 2525 m mean sea level (**Fig. 2**). The reservoir properties are generally good, but vary vertically from 100 to 2500 md in the various formations. Reservoir pressure is close to hydrostatic pressure, and reservoir temperature is approximately 100°C. The reservoir oil has a viscosity of 6×10^{-4} Pa·s, and the gas/oil ratio is 110 std m^3/std m^3.

The plan is to develop the field with 14 wells in the initial phase: seven horizontal oil producers, five water injectors, and two gas injectors. During production, reservoir pressure will be maintained at its initial level by reinjection of produced gas into the gas cap and injection of water into the aquifer. Predrilling of six wells is planned: five oil producers and one gas injector. Plateau production is expected to be reached a short time after production starts, and a plateau period of approximately 4 years is estimated. After 3 to 4 years of production, a second drilling phase is planned to prolong plateau production and to improve areal sweep.

Production wells are planned with horizontal sections in the range of 600 to 1200 m and are expected to have a production potential in excess of 6000 std m^3/d. The advantages of horizontal vs. conventional wells for the Norne field are (1) increased well production rates and thereby fewer wells, (2) delayed gas and water breakthrough, (3) accelerated production, (4) improved ultimate recovery, and (5) reduced cumulative water production (−50%). **Fig. 3** schematically illustrates the drainage strategy.

The injection water in the initial phase will be untreated seawater (no deoxygenation). As water production occurs, the injection water will be a mixture of untreated seawater and produced water. Special precautions have been taken to ensure corrosion control.

Development Concept

At an early stage during establishment of the development project, we concluded that the development concept should be a subsea development connected to a floating process facility. We evaluated several floating process facilities and decided that the ship-shaped production and storage vessel (PSV) provided the best technical and economical solution (**Fig. 4**). The PSV provides flexibility in payload increase, and the large deck area simplifies the design, fabrication, installation, and maintenance of the process facility.

The PSV is 260×41 m and will rotate around a 25-m-diameter turret anchored to the seabed with 12 lines. The turret is connected to the subsea templates by flexible flowlines. The wellstream will be transferred to the process facility through a swivel stack in the turret. Injection fluids will also pass through the swivel stack. The PSV is designed for a plateau oil production of 27 500 std m^3/d and will have a total oil-storage volume of 115 000 std m^3.

Five subsea templates will be located at the seabed, each with four well slots. Three templates are for production, one for water injection, and one for both water and gas injection. Two templates will be in the northern part and three in the southern part of the field.

Project Management

The project organization was established in Spring 1993. To achieve its objectives, a new approach to project management has been necessary. **Fig. 5** shows the important elements in the project management: an integrated asset team, parallel execution of activities, front-end loading and early freeze of engineering, cost reduction through standardization, closer contractor relations (active use of suppliers skills), and reduced documentation.

The Norne project organization was established as an integrated asset team with the total license responsibility, including development planning, construction, startup, and operation of the field.

Reservoir and concept evaluations were run in parallel. The concept evaluation started with preliminary design data that were updated as the reservoir work proceeded. Parallel execution of activities made it possible to freeze the selected concept a short time after drilling the third well (Well 6608/10-4).

Use of standard solutions and equipment has been an important element in reducing costs. Using an "off-the-shelf" type subsea template (previously used for two other field developments) reduced costs by 40% to 50%. Involvement of personnel with operational experience in the concept-definition phase was important to design a simple, robust, and easy-to-operate facility by use of proven technology and standard solutions.

Major engineering contractors and suppliers were identified and involved at an early stage so that their skills could be used in the concept definition. Integrated teams (operator and engineering contractors) have been established, and economic incentives have been incorporated in the contracts.

Formal documentation of the work performed in the early project phase was minimized to speed up the process. An open and constructive dialogue with engineering contractors, license owners, and authorities has made it possible to make decisions and to proceed with a minimum of formal reports.

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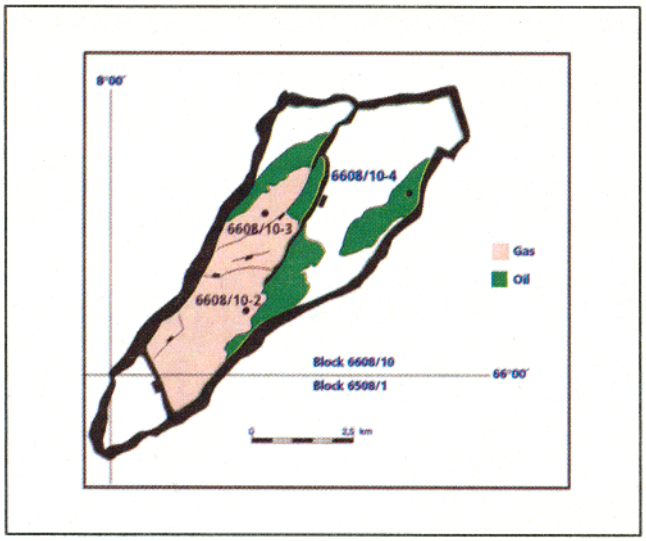

Fig. 1—Location of exploration wells.

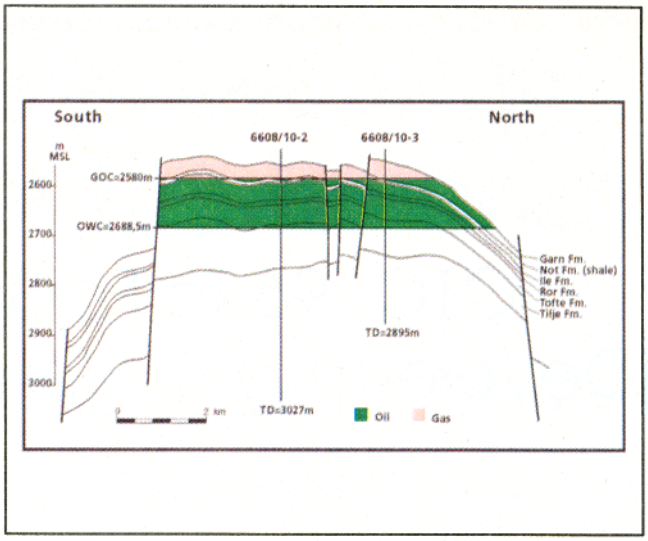

Fig. 2—South-north cross section.

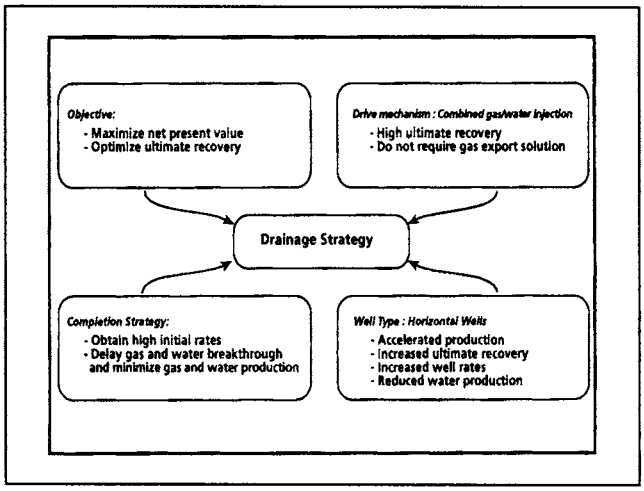

Fig. 3—Drainage strategy.

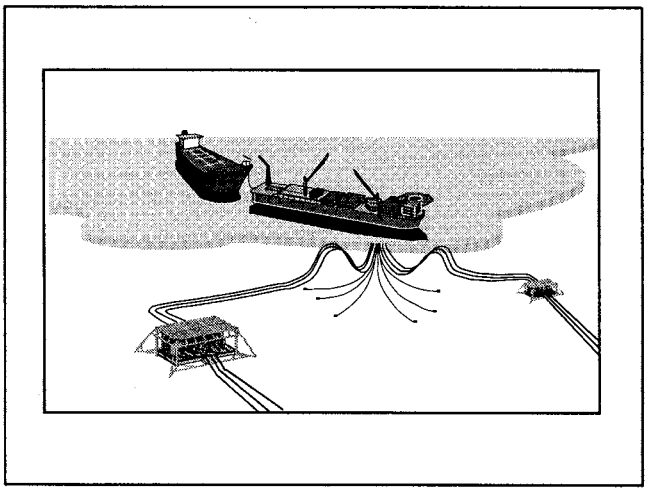

Fig. 4—Development concept.

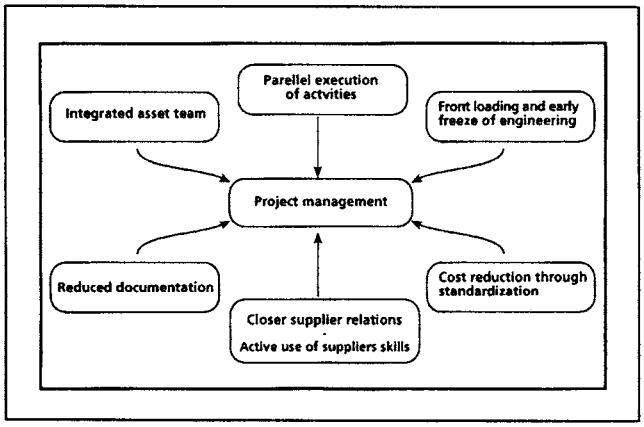

Fig. 5—A new approach to project management.

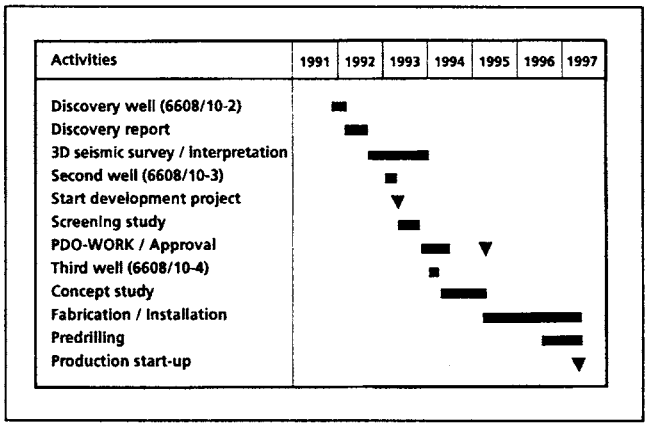

Fig. 6—Time schedule for Norne development project.

The plan for development and operation was issued to the authorities in Sept. 1994,[1] and government approval was granted in March 1995. Production start is targeted for the first quarter of 1997 (**Fig. 6**). **Table 1** compares some key figures from Norne and two recent field developments on the Norwegian Continental Shelf.[2]

Conclusions

So far, the Norne field development is considered a successful project with regard to time and cost reductions. The time from discovery until production starts will be approximately 5 years. The total investment including drilling of wells is estimated at 7.45 billion NOK,* with potential for further reductions.

*Exchange rate: US$1.00 = 7 NOK.

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NORNE FIELD DEVELOPMENT

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TABLE 1—COMPARISON OF RECENT FIELD DEVELOPMENTS

	Field		
	Field A	Field B	Norne
Development concept	Concrete monotower	Tension-leg platform	Production ship
Water depth, m	250	350	380
Oil reserves, 10^6 std m^3	94	133	72
Number of wells	12	16**	14
Process capacity, std m^3/d	25 000	35 000	27 500
Discovery to production, years	9	10	5
Development time, years*	5	4.5	2
Investment cost, billions of 1994 NOK	14.7	≈26	7.45

*Time from government approval to start of production.
**Sixteen predrilled wells are included in the investment cost. Total number of wells will be approximately 50.

Acknowledgment

We thank the Norne license owners (Norsk Hydro Produksjon a.s, Saga Petroleum a.s, Enterprise Oil Norge Ltd., and Norsk Agip A/S) for their constructive cooperation in this fast-track project.

References

1. "PL 128 Norne, Plan for Development and Operation," Statoil, Stavanger (June 1994).
2. "Faktaheftet-Norsk Petroleumsvirksomhet," Nærings og energidepartementet (Jan. 1995).

SI Metric Conversion Factors

bbl × 1.589 873	E−01 = m^3
cp × 1.0*	E−03 = Pa·s
ft × 3.048*	E−01 = m
ft^3 × 2.831 685	E−02 = m^3
md × 9.869 233	E−04 = μm^2
mile × 1.609 344*	E+00 = km

*Conversion factor is exact.

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