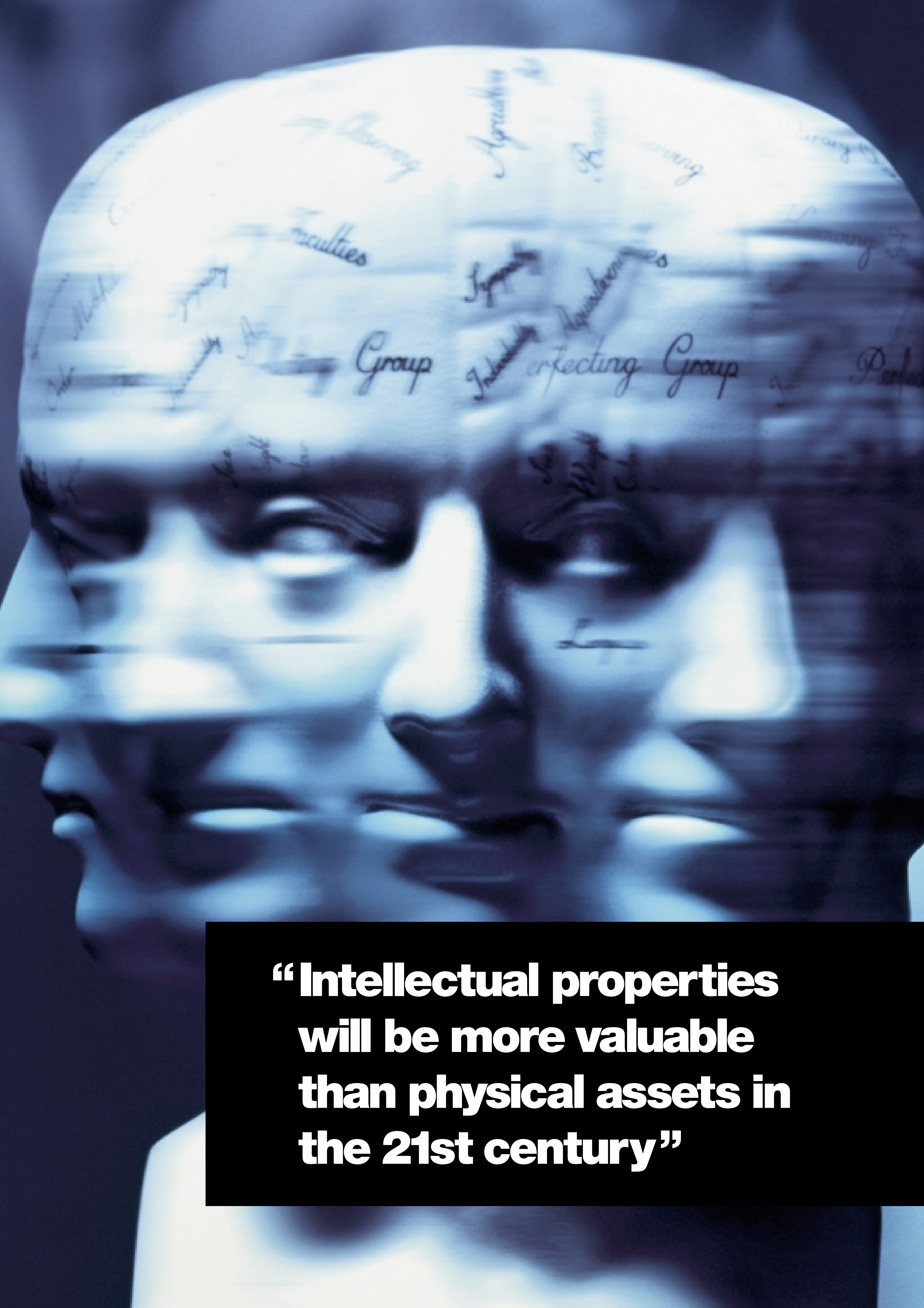

“Intellectual properties will be more valuable than physical assets in the 21st century”

Offshore technology at the threshold of a new era

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Two imperatives are defining the offshore development and production of oil and gas as we enter the new millennium: the need to narrow the cost gap between on- and offshore production, and the obligation to do everything that will minimize the sector's impact on the environment. Technology and know-how are not only at the highest level the industry has ever seen, they are advancing faster than ever before. The challenge is to put the new technology to use as effectively as possible. In many ways we have come to a crossroads; the opportunity is here – it is up to us to break with current industry trends and really shape our future.

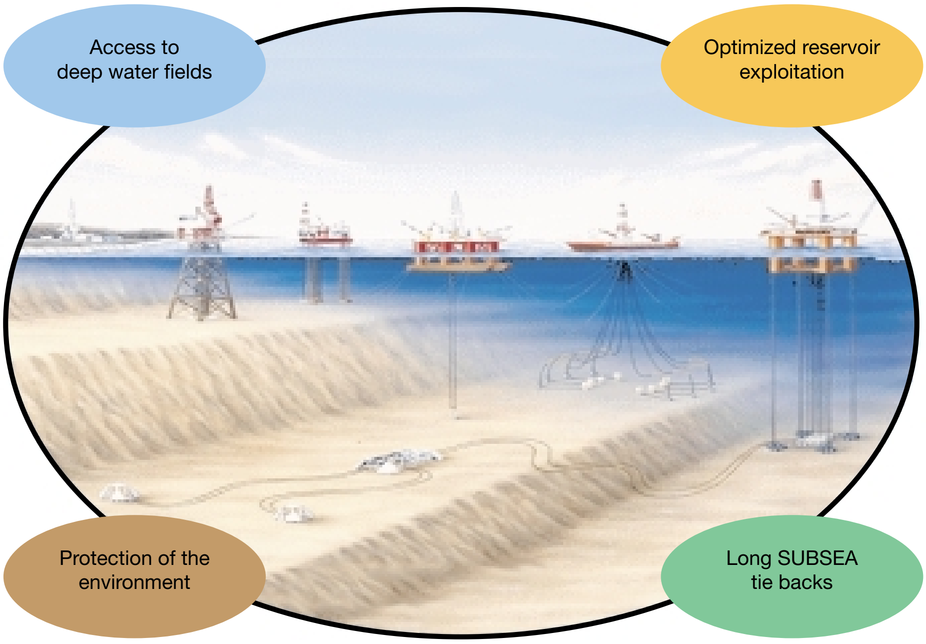
The winners will be those who are able to look ahead and be pro-active – shaping their future as they create new markets and new business trends. Investing in and making use of human capital and intellectual property will be decisive for future success. The most important competitive advantages will be knowledge, technology, and our ability to utilize these assets in the best possible way.

The challenges of 2005

Today's offshore oil and gas comes largely from fields planned and developed as part of a scenario defined by high prices and relatively shallow waters, not more than 500 meters deep.

As recent trends, and especially the fluctuations in the price of oil have shown, the industry has to be prepared in the future for unstable markets, more complex reservoirs, a move from deep to ultra-deep waters, and small, marginal fields.

Since offshore oil has to compete with onshore oil in the marketplace, we need to narrow the cost gap and



1 Challenges of the immediate future include narrowing the cost gap between onshore and offshore oil and reducing the environmental impact of offshore production

lessen the impact offshore production has on the environment 1. In other words:

- We need safe and cost-effective access to the deep-water fields.
- We must significantly improve total hydrocarbon recovery and recovery rates.
- We must substantially reduce investment levels and operating costs. Here, long subsea tiebacks are very promising solutions.

In mature areas we can meet these challenges by utilizing existing infrastructure much more efficiently than today. Developing technology for remotely controlled subsea production and the long-distance transportation of wellstream fluids will enable us to connect distant finds to existing infrastructure or even directly to shore 2.

At the same time, production rates from subsea wells will be increased to the level for onshore wells; even better, total recovery from the field will be substantially improved.

Emerging technologies will change our future

Technologies for increased recovery are probably the most important in terms of how they will make offshore production more competitive.

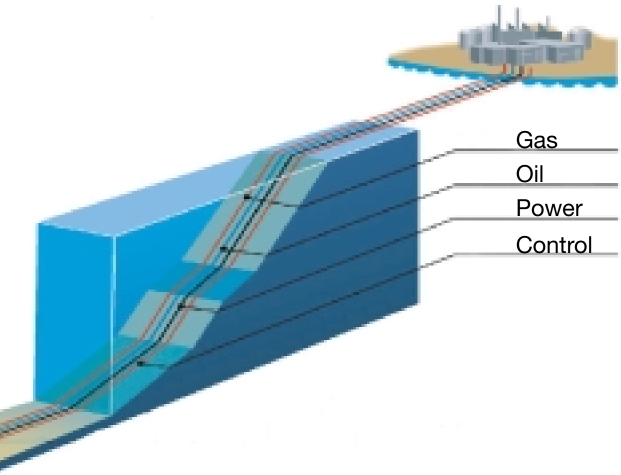
One reason for the lower recovery from a subsea well is the cost of well intervention. Reducing this cost through permanently installed instrumentation and control systems and by using lighter and cheaper vessels and equipment is therefore a must.

The IT revolution will also change the oil & gas business in other ways. New field developments will start from a reservoir model, based on which the best development plan will be chosen from a life-cycle perspective. During operation, a complete model will be available, with the reservoir, wellstream flow, process performance and all the other parameters needed to optimize operation of the field. This model will learn and improve itself over the field's lifetime. Permanent and reliable monitoring and data communication systems will provide the basis for this.

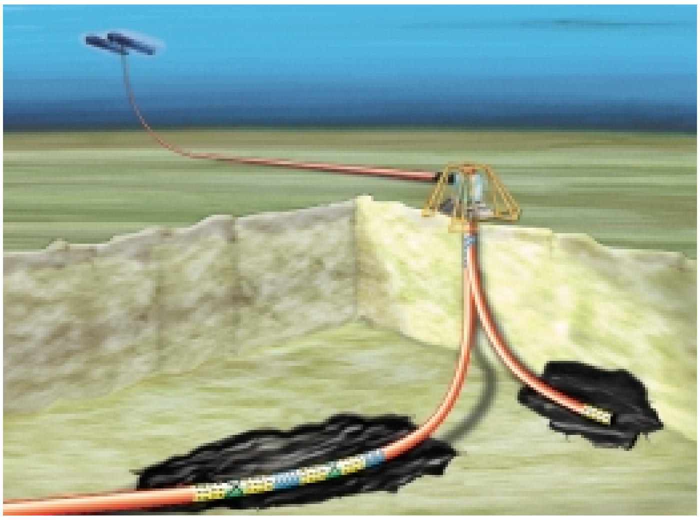
Advanced automation of the oil & gas fields will lead to higher and more stable production from each well, as well as more oil earlier.

A good basis for production optimization is intelligent well technology, in which a smart well system monitors all the key production parameters and can use downhole chokes to remotely control the wellstream from different zones in a multilateral well 3. Several zones can then produce simultaneously, while zones that produce too much water, etc, can be shut down when required. Potential improvements in oil recovery from subsea wells from today's average of 30 to 35% to a level of 50 to 60% are quite realistic.

The cost of exploration must come down. This will happen through better seismic methods for gathering data, improved



2 Technology is being developed which will allow distant finds to be connected to existing infrastructure or even directly to shore.



3 Smart well technology at work in different zones of a multilateral well

methods for data interpretation, and better presentation of the models through the use of CAVE technology. In some areas we will see more slim-hole finder wells drilled by cheaper rigs with light equipment, and we shall also see exploration wells drilled with the intention of converting them later to production wells.

The major improvement, however, will be in reservoir production monitoring. This will take several forms:

- 4C/4D seismic, which considers the development over time and uses shear waves to detect oil/water interfaces.
- Measurements while drilling, aimed at positioning the production wells more accurately.
- Permanent micro-seismic monitoring by listening to continuous micro earthquakes 4. This will allow us to squeeze even more out of the reservoir.

Substantial savings can also be achieved by eliminating new floaters or platforms, which brings us to the challenge of long-distance wellstream transportation. To meet this challenge, we are developing new technologies that address:

- Flow assurance
- Subsea electrical power distribution
- Subsea and downhole processing
- Subsea rotating machinery

Making such developments a reality depends to some extent on the industry shedding its tendency towards conservatism. Before considering some examples of the latter two issues, let's look first at flow assurance and subsea electric power distribution.

Flow assurance technology aims at:

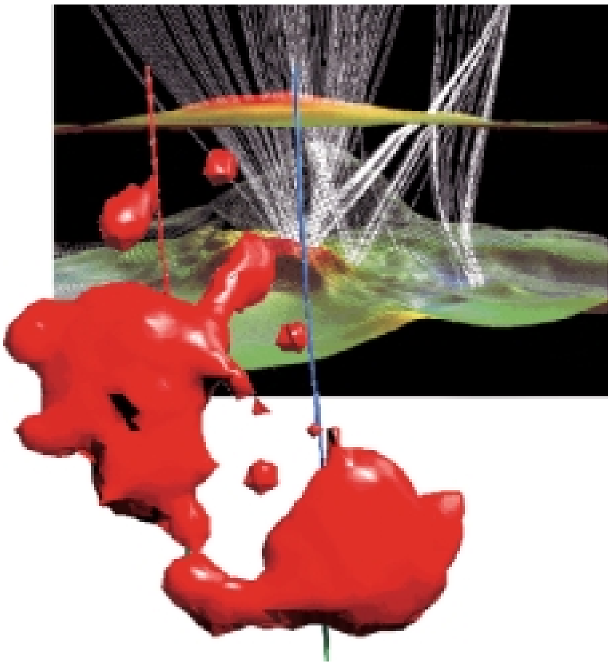
- Avoiding/managing wax, hydrate and other depositions
- Optimizing flowing conditions
- Minimizing flow back-pressure
- Minimizing system downtime

This could be summed up by: *'More oil, cheaper and faster'*.

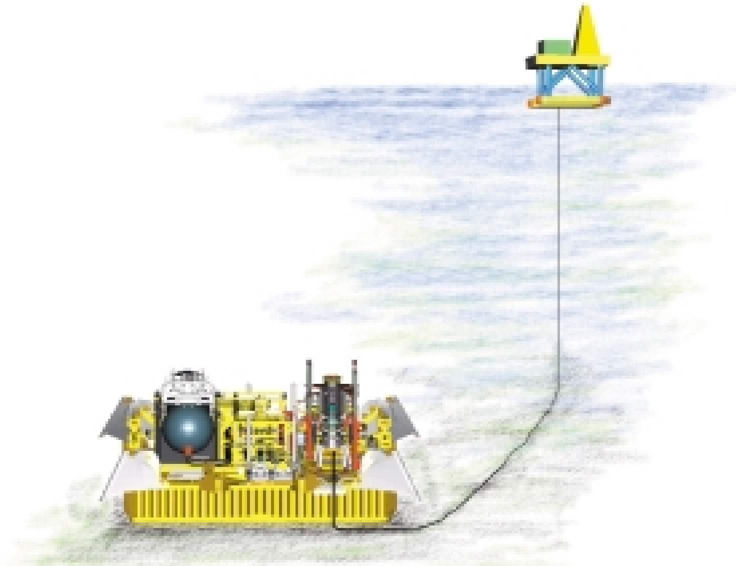
The subsea transmission and distribution of electric power between offshore sites and between offshore and onshore is basic to the realization of 'zero surface facilities', and also a prerequisite for any reduction in offshore power consumption, and hence pollution 5.

Subsea, the power is primarily intended for rotating machinery, but will also be used for heating and separation.

"Having the ability to minimize pollution and mitigate the consequences will be a condition for sustainable exploitation of oil and gas in the future."



4 Reservoir image produced by micro-seismic monitoring



5 The SEPDIS™ system is designed to reliably distribute electrical energy in a subsea environment.

Topside, an offshore power grid will help to drastically reduce the need to have a gas turbine on every installation and also enable electric energy to be imported from and exported to shore.

New-generation HV direct-current technology, known by the name of HVDC Light, makes this economically viable.

By the year 2005, the industry will be able to supply electric power to water depths of 2000 m and more over distances that cover most new finds. With HVDC Light installed, distance is not a problem.

We have already mentioned that subsea solutions can be considered viable for all water depths, but for many fields dry trees will continue to be the solution of choice. Whether wet or dry trees are preferred will depend on the reservoir itself and on the experience of the operator.

Although ship-shaped FPSOs may still rule the waves for wet-tree solutions, there is definitely room for improvement and for new thinking. This is true of both the hull shapes and risers.

For dry-tree solutions there are several new hull forms now being launched on the market. The market's need for a portfolio of floaters suitable for dry trees in deep water is therefore also evident. This portfolio will also include solutions for storage. To keep costs at the necessary low level, we shall see standardized solutions for given weather conditions, water depths and payload requirements 6.

The major challenges in deepwater drilling are related to the water column, pressure and reservoir. The depths in themselves demand long risers, introducing heavy loads and making large, expensive equipment necessary. Each drilling operation is also time-consuming and expensive. At the reservoir end, the mud pressure inside a very long riser may fracture and ruin the well.

New drilling methods are under development that will overcome these deepwater challenges. An example is so-called dual-density drilling, in which the reservoir pressure is balanced by a seabed-based mud pump rather than the mud column in the riser. Some companies are also considering placing a complete remotely operated drilling rig on the seabed.

Environmental issues

7 shows the typical sources of negative environmental impact emanating from an offshore field. Having the ability to minimize this pollution and mitigate the consequences will be a condition for sustainable exploitation of oil & gas in the future.

One of these sources is highlighted by the constructed satellite picture of our world in 8. We expect to see a lot of lights in the eastern US, Japan and Central Europe, where there are huge urban agglomerations, but the frightening thing is that the lights in Africa, Siberia and the Middle East are not the result of electric lighting – they are caused by flaring of gas. This is one of the largest sources of CO_2 emissions around, and definitely an area where even just a moderate investment would help the environment a lot.

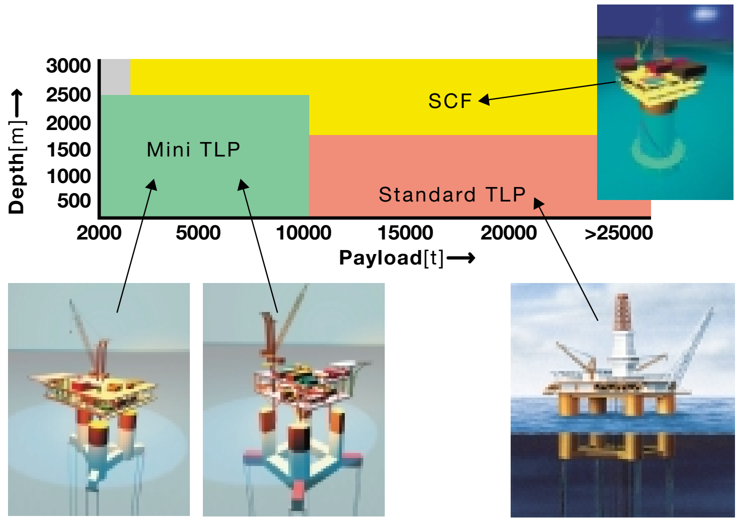
The management of CO_2 coming from offshore oil & gas production includes three important attack strategies:

- Improved combustion systems for gas turbines and combined cycle plants. Combined cycle with air is the commercial standard today, and the replacement of air by oxygen or hydrogen will need further development.
- Separation and removal of the CO_2 before or, in most technologies, after combustion. Membranes for separation are currently available on a laboratory scale, other separation methods being available but not

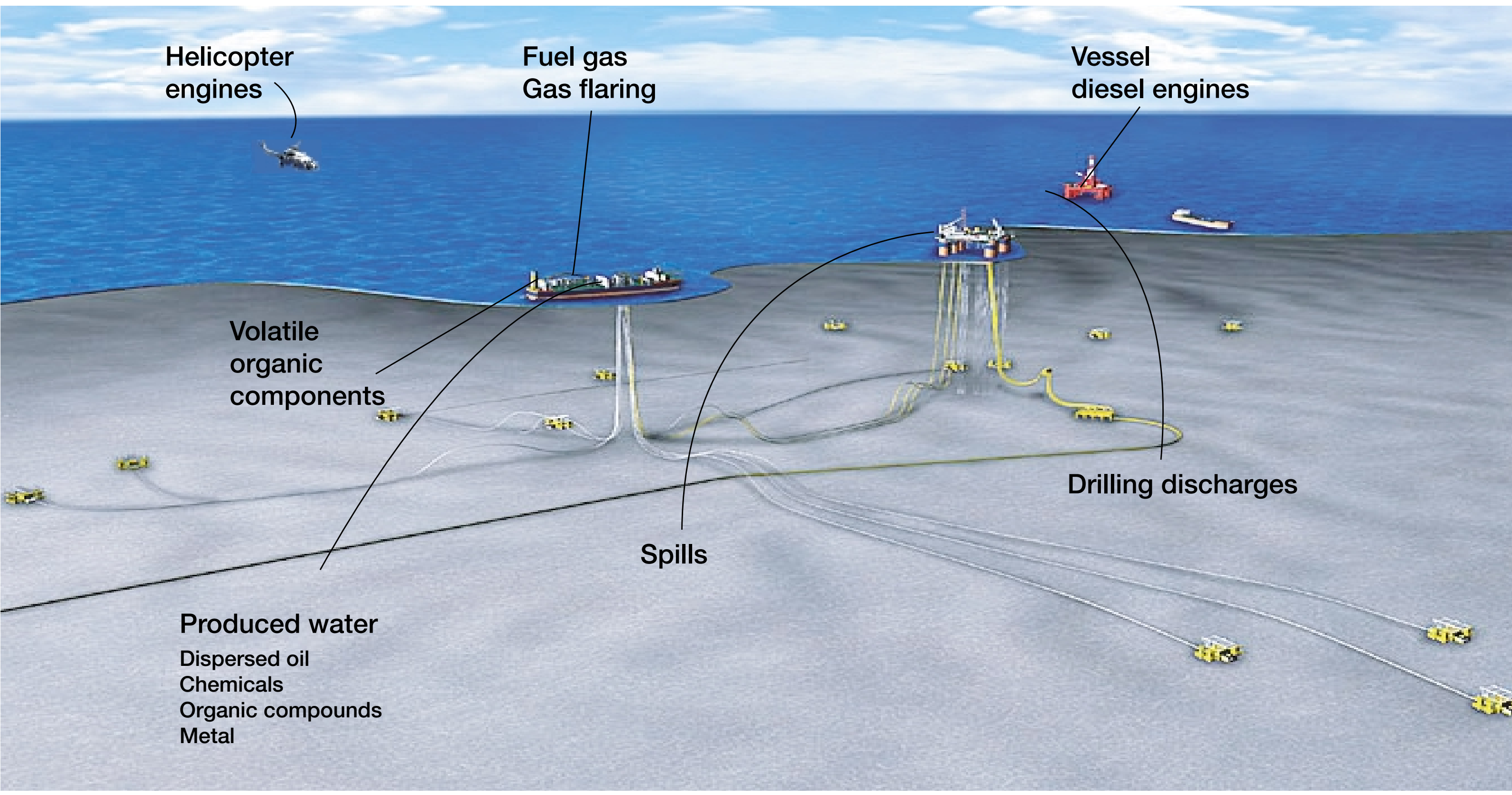
6 ABB's portfolio of floaters for deep water

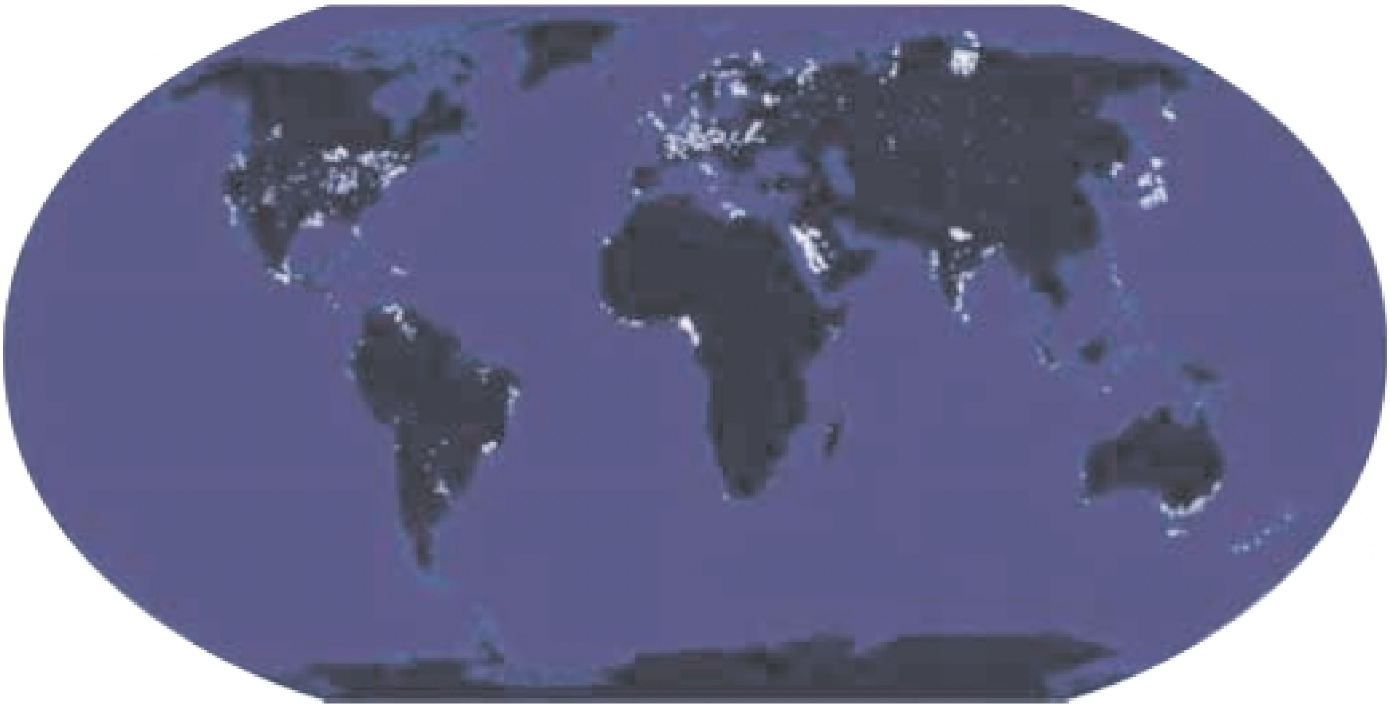
SCF *Single column floaters*

TLP *Tension leg platform*



7 Sources of pollution from an offshore field





8 Constructed satellite image of the world at night. The lights in Africa, Siberia and the Middle East are caused by flaring of gas.

economically viable. A breakthrough can be expected here within three to five years.

- Disposal or deposition of the CO_2. Several methods are feasible, but uncertainties exist with regard to the long-term effects and stability.

Stranded gas and the deposition of associated gas is a major problem in the development of marginal fields away from existing infrastructure. Flaring is not ecologically acceptable, transportation may be too expensive, and re-injection may not always be viable.

The capability exists for converting gas into transportable liquid, but in large, world-scale plants. When we are able to build conversion plants which are small, lightweight and financially viable in a 20 USD/barrel scenario, a lot of marginal fields will suddenly become economically sound. However, this is not likely to happen within a five-year timeframe. As the gas reserves are much larger than the oil reserves, we shall also see more gas being used as fuel for chemicals and for power production. World-scale gas-to-liquid plants have the potential to become a major new industry.

9 SUBSIS™, the world's first subsea separation and injection system, being prepared for the Troll Pilot project in the North Sea

Coal-fired power plants will be phased out and replaced by modern, gas-fired, combined-cycle facilities, thus benefiting the environment.

The intermediate solution

The future we have talked about is already here. In the following real-world example, it is shown how new satellite fields can be tied into existing floating production systems without major rework of the topside facilities.

The field in question is in the British sector of the North Sea, and the traditional solution in such a case would require three new flowlines and major modification of the floater.

The alternative solution utilizes subsea separation and water re-injection technology qualified as part of the Troll Pilot project[1] 9. Besides needing only two new flowlines and very limited modifications topside 10, it will also result in higher production rates and earlier peak production. The major benefits are:

- One 10" production flowline instead of two.
- Significantly fewer modifications to the floater.
- No need to dock the floater.
- Earlier production start and peak production.
- Increased total production.

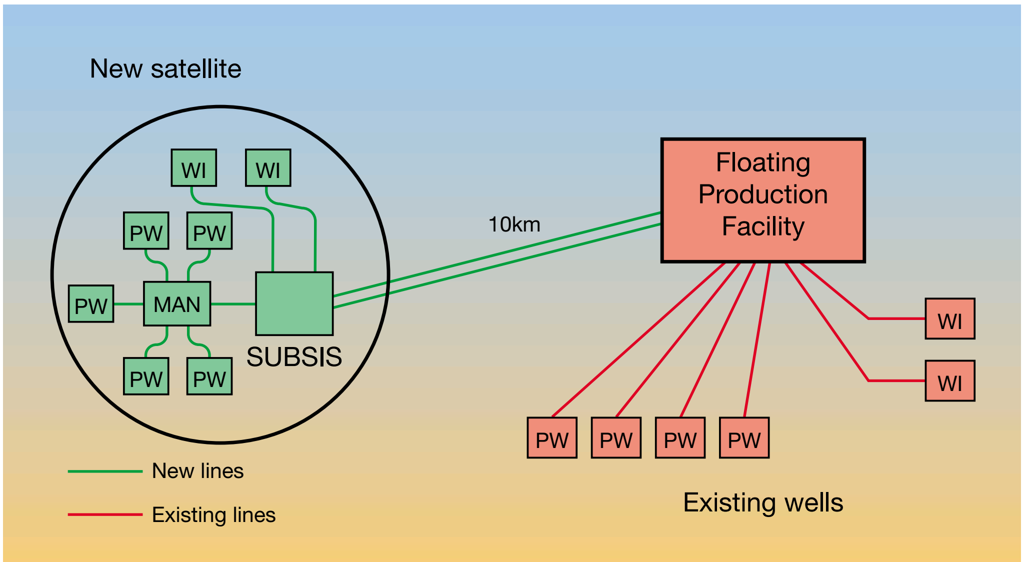
In sum, this can lead to the net present value of the investment being improved by more than 60%.

Next step – the complete solution

By 2005 it will also be possible to have an offshore field producing directly to shore without platforms or floaters at a cost of around US$6-10 per barrel. However, before this can become reality pilot test sites will be needed in order to qualify the equipment. This is probably the single most important factor in achieving the goal of direct production to shore.

By utilizing all of these emerging technologies, it will be possible to remotely operate fields located more than 200 km

[1] *Troll Pilot is a joint venture project being implemented by Norsk Hydro and ABB.*

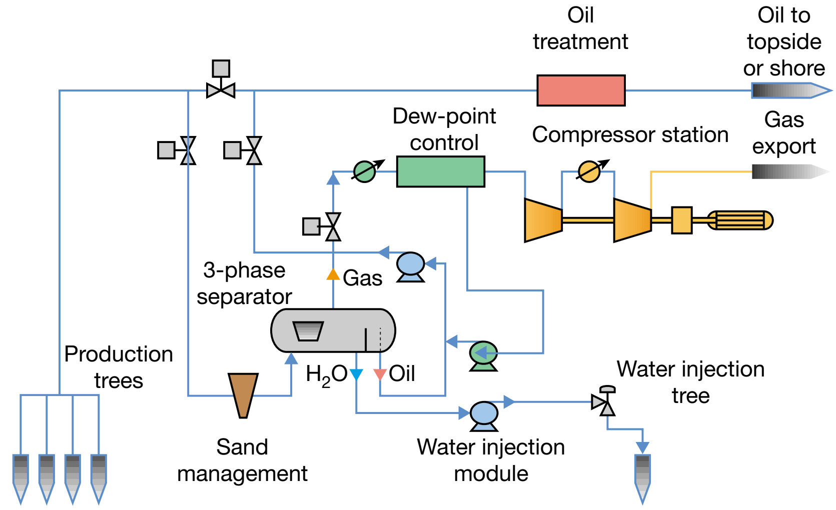


10 Floating production system combined with seabed processing

PW *Production wells*

MAN *Manifold*

WI *Water injection*



11 Subsea processing – the complete solution

from the shore or from existing infrastructure. And it will be possible to operate them as efficiently as onshore wells. What is more, the environmental impact and risk to personnel will be drastically reduced. The main advantage of such a solution is that the water does not need to be transported to the platform and back again for re-injection. Fewer flowlines are needed, back-pressure is lower, oil recovery is increased, less energy is consumed, and the hydrate problem is smaller, which reduces the amount of chemicals needed.

Once the SUBSIS/Troll Pilot technology is being fully utilized, the next step will be to include facilities for subsea compression and re-injection of the wet gas, either separately or mixed with water 11 . Boosting will also be used to transport the oil over longer distances. Gas re-injection serves two purposes:

- It solves the stranded-gas problem and allows early production start-up without gas export facilities.
- By maintaining an acceptable reservoir pressure, it allows better exploitation of the oil.

For larger fields, or fields in which the gas production is at too high a level for re-injection, there will be a need for subsea compression of larger quantities of gas for export over longer distances. Remotely operated gas-lift facilities could also be added.

Looking forward to 2005

Where, in the light of all these developments, will the industry stand in five years? Some predictions are in order:

- Investment costs will be reduced by 30-50% due to utilization of the existing infrastructure, reduced demand for new platforms, plus some processing being done subsea prior to transportation to shore for final processing.
- Fewer people and simpler systems offshore will lower the operating costs and improve safety. Here we see a potential saving of 30-60%.
- Intelligent wells, subsea processing and lightweight well intervention will dramatically increase the oil recovery rate for a subsea well to as much as 60%.
- Production boosting will yield more oil earlier.
- Standardized subsea building blocks, less complex floaters and use of existing infrastructure will reduce the development time by 30-50%.
- A potential reduction in environmental impact of more than 50% is feasible.

All of this is possible technologically, but it requires industry and the oil companies to cooperate and work towards common goals. This premise will guide our technology development over the coming years, and yield for our customers the competitive advantages required for future market success.

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