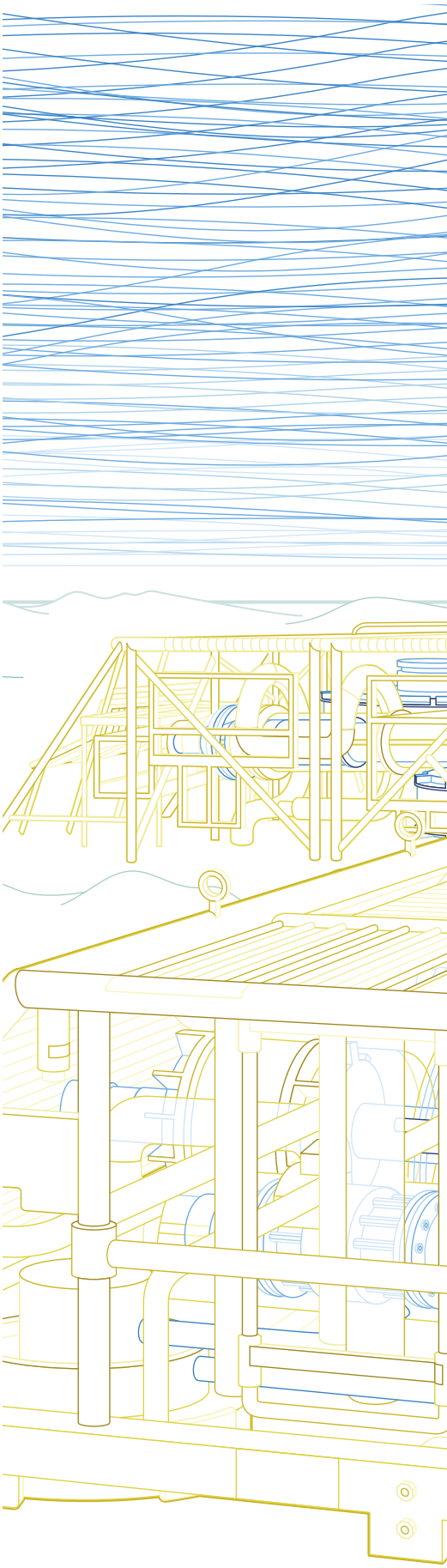
Oil and gas

The energy we love to hate

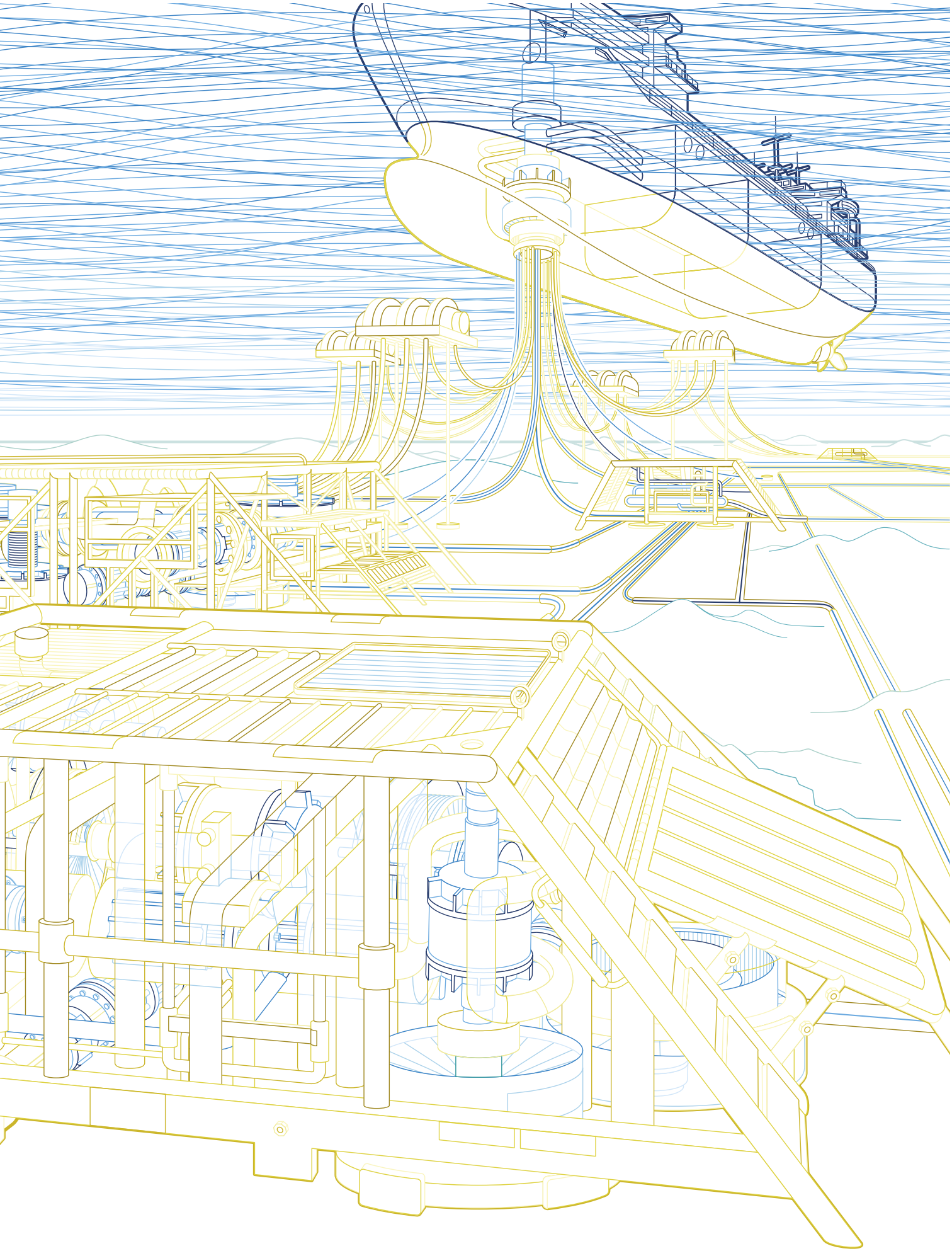


HÅVARD DEVOLD, SANDY TAYLOR – Oil and gas account for more than half of all primary energy consumed globally. Nevertheless, perceptions of the industry and its activities are mixed, with questions such as pollution, global warming and fluctuations in oil prices affecting people and the economy in numerous ways. The sheer volume of oil and gas consumed means that these fuels will continue to feed a large share of the world's hunger for energy for the foreseeable future. Assuring a reliable and dependable supply depends on the technologies used in their extraction. As ever-more challenging fields are commercialized, demands on technology are increasing to assure the economic, efficient and safe extraction of the fuel. ABB offers a comprehensive portfolio of technologies and solutions ranging from integrated automation and electrical products and systems, instrumentation, analytics and telecommunication systems, engineering and service.

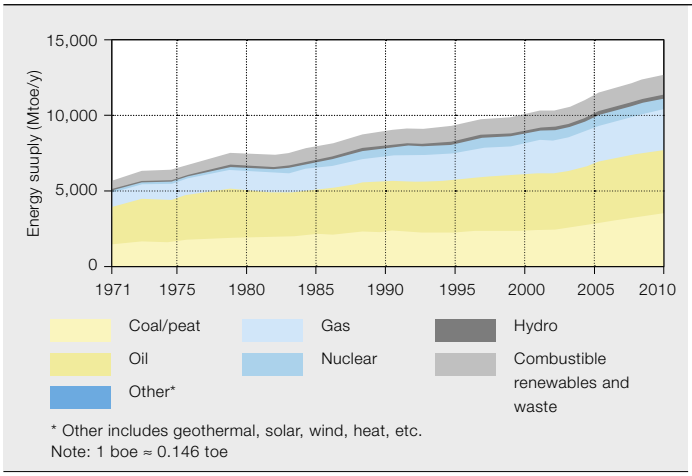
ABB has been a supplier of products and services to the global oil industry for more than 100 years. A significant shift occurred during the 1970s when, in the wake of the oil crisis and with oil becoming scarcer, new fields were being opened in more and more challenging locations, with technology progressing to meet the changing demands. During this decade, ABB started to provide microprocessor-based control systems, a technology that gradually began to replace mechanical and pneumatic hard-wired single-loop controls. The company also broadened its base technologically, adding further offerings for the sector.

In 1973 oil and gas production was 76 Mboe/d (million barrels of oil equivalent per day), about 20 percent of which was from offshore fields in relatively shallow waters.

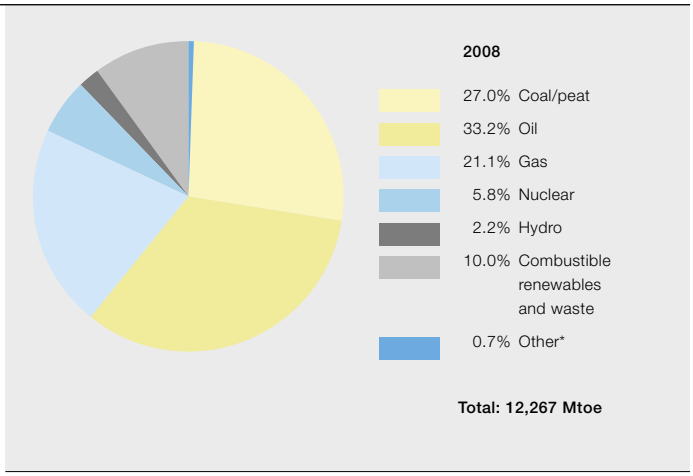
ABB soon established the rapidly growing offshore industry as its main market in the oil and gas sector, with many reference projects in the North Sea as well as huge offshore fields being developed in the Arabian Gulf. It was the age of large offshore field centers with gravity bases and fixed structure platforms. These were characterized by new requirements for fire and gas systems and by process control and integration across multiple



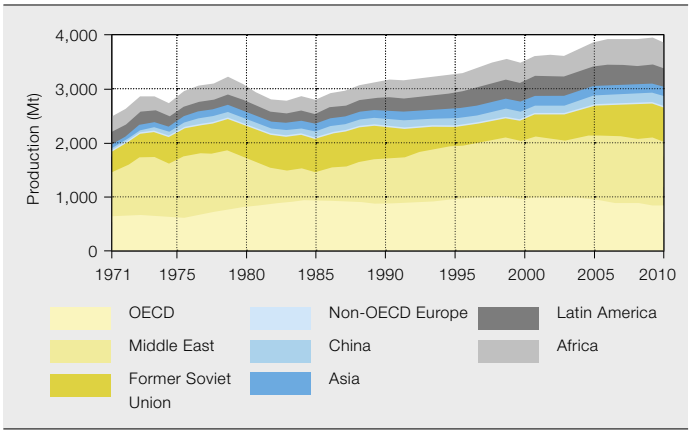
1 Evolution of the global primary energy supply



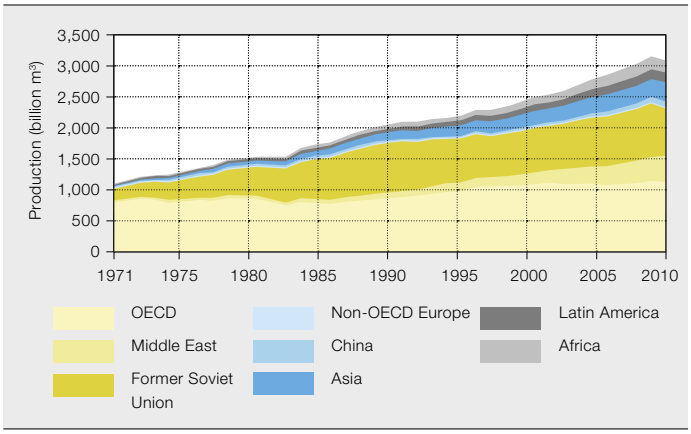
1a Evolution of world energy supply and mix



1b Oil and gas account for more than half the world's energy supply (2008 figures)



1c Crude oil by region



1d Natural gas by region

Thanks to EOR (enhanced oil recovery), the recoverable reserves of many fields have more than doubled over the lifetime of the fields and are expected to rise further.

systems that had previously been standalone. Areas covered by this integration included safety, metering, process and supervisory systems. With a long history in the marine sector, it was natural for ABB to extend its scope for floating production as well as deepwater subsea. This field development concept gradually replaced many large fixed installations. Today offshore accounts for more than 40 percent of all oil and gas production, and new offshore capacity is coming from fields in water depths of more than 500 meters. Recently, the Chinook and Cascade field (offshore of Louisiana in the Gulf of Mexico) received a new FPSO (floating production storage and offloading vessel), the BW Offshore Pioneer, which sets a new record by working in more than 2,500 m of water. The vessel features automation and electrical systems from ABB.

Setting the stage for the years to come

Combustion of fossil fuels – coal, oil and gas – are generally accepted to be the direct cause of much of the measured and forecasted global warming. Fossil fuels accounts for 81.3 percent of all energy consumed → 1. Oil and gas make up 51 percent, with the balance coming from coal[1]. Despite these dire consequences, there is presently no practical source or carrier of energy that can replace oil and gas on a large scale in its application in transportation or as an industrial feedstock. Battery-powered electrical cars represent a promising potential with improving technology and range, but can currently only replace a few percentage points. Even if a revolutionary new source were to be identified, development of practical vehicles and distribution infrastructure would take well over a decade. Presently at 142 Mboe/d, combined oil and gas production is

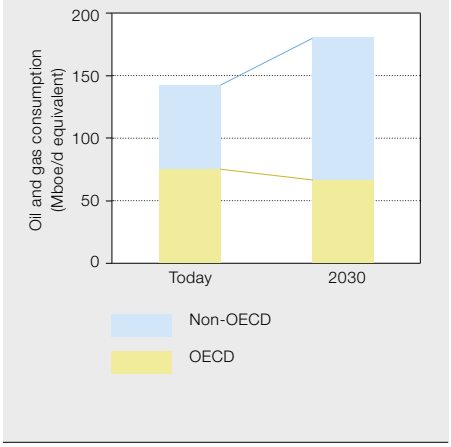
Footnote

1 IEA Key world energy statistics 2010 (www.iea.org)

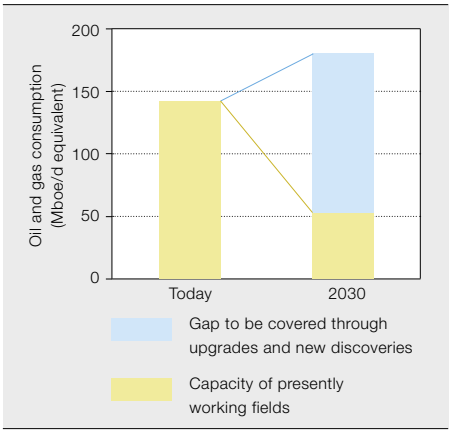
Title picture

An FPSO (floating production, storage and offloading vessel) is connected with a network of wellheads located on the sea bed.

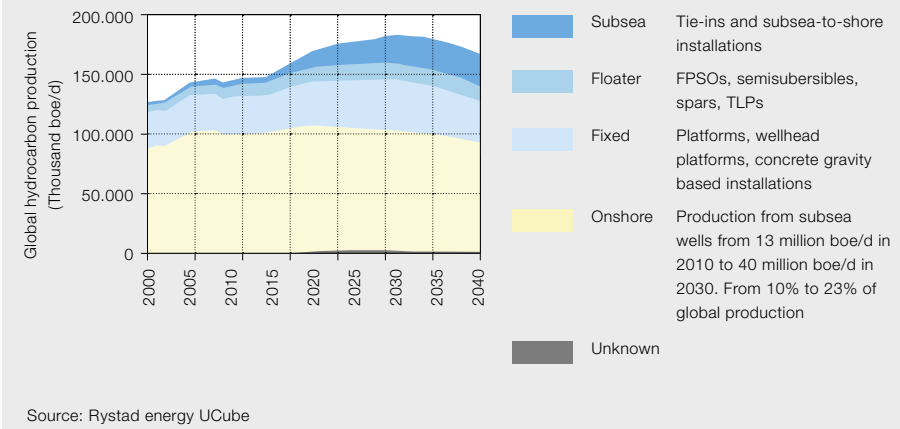
2 Making optimization and new discoveries match future demand is a major challenge



2a Non-OECD versus OECD demand



2b Present fields versus required optimization and new discoveries



Source: Rystad energy UCube

2c Production by source

almost double what it was in 1973. Despite progress in energy efficiency and the introduction of renewable sources such as biofuel, it is likely to grow further, reaching 180 Mboe/d by 2030. In a few years, non-OECD consumption will surpass that of the OECD, and is predicted to grow by 120 percent by 2030. It will by then be double that of the OECD. The latter will fall slowly by about 12 percent over the same period due to increasing energy efficiency and limited population growth → 2a.

A typical field's production increases steeply to a maximum (the plateau) and then slowly drops off (the tail end). The world average production of oilfields in this phase declines at about six percent annually – if no upgrades take place. This means that in 2030, the gap between new demand and remaining tail capacity will be 70 percent of total consumption. This capacity must come from fields upgraded or developed between now and then, or from new unconventional sources. The gap is only slightly smaller than today's total production, placing high demands on exploration and production technology → 2b.

Different from the easy oil of yesterday, a significant fraction of this oil and gas must come from fields characterized by such adjectives as arctic, deepwater, cold, heavy, high in water content, high sulfur content, to name but a few. In addition, improved oil recovery (IOR) technologies can be used on existing reservoirs to extract additional oil that would otherwise not be extracted. In most cases, IOR features flow assist (eg, pumping), heating, processing, water treatment, software models and similar technologies. IOR works: Whereas a recovery rate of 20 to 30 percent was considered acceptable half a century ago, many fields are now targeting 50 percent, with best practice surpassing 70 percent. For many fields, this means that recoverable reserves have more than doubled over their lifetime, and still continue to rise as even more sophisticated enhanced oil recovery (EOR) technologies are developed as a combination of 3-D and 4-D seismic modeling, fracturing and stimulation of the reservoir, advanced modeling and other technologies.

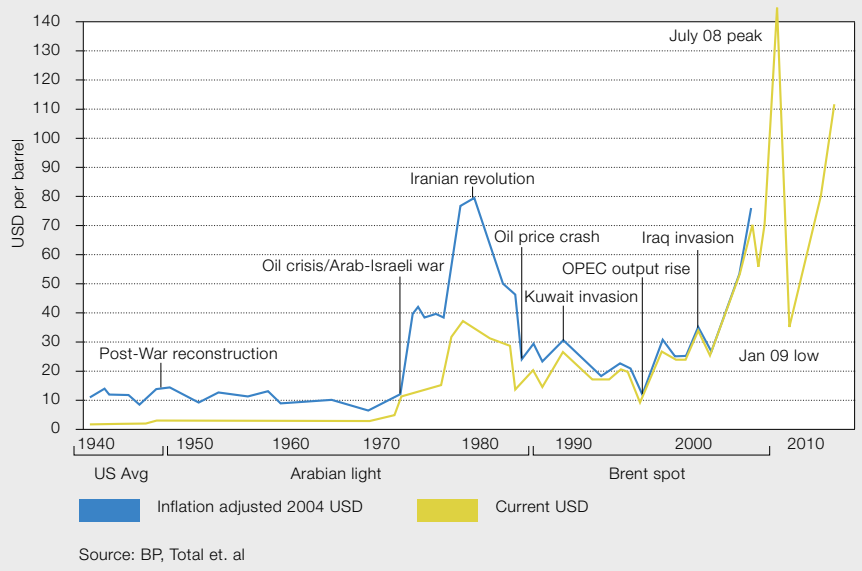
Fracturing and stimulation are technologies that open up channels in the reservoir rock to increase hydrocarbon flow out of the porous structure. Fracturing is achieved by applying high pressure (hydraulic fracturing), explosive shocks (explosive fracturing), chemicals (eg, acid fracturing) and other technologies as well as other solutions to prevent the channels from closing (eg, proppants) and the loss of permeability.

Power and automation play a key role in realizing the IOR/EOR potential as well as extracting from the more complex deep and cold newly discovered fields. One example is the deepwater type of oilfield with relatively shallow reservoirs found in Angola which generally requires subsea multiphase pumping.

As the oil price continues to rise beyond 100 $/bl (April 2011) → 3, and gas prices recover in the longer term, focus is again returning to unconventional resources. There is a boom in unconventional gas (shale gas, coal bed methane) and also oil/tar sands. These sources are not only more difficult to produce from but also require more energy, which in turn implies more corresponding emissions, both directly and indirectly eg, from produced water. Therefore, future production must be done with an increased focus on such topics as emissions,

Presently at 142 Mboe/d, combined oil and gas production is almost double what it was in 1973, and is likely to rise further, reaching 180 Mboe/d by 2030.

3 Evolution of oil price



Source: BP, Total et. al

As reservoirs get colder, deeper and more geographically distant, the energy needed to extract has increased, and with it the importance of energy efficiency.

discharges, accidental spills and leakages as well as industrial accidents. As a result, relative capital expenditure (CapEx) will triple over the next decades, and suppliers will be required to supply new technology at acceptable cost → 4.

Subsea and FPSOs

The early 1990s saw the end of the large gravity base (GBS) installations, culminating with the Troll A platform at 656,000 metric tons, standing 472 meters tall in 369 m of water → 5 (there are taller structures in the Gulf of Mexico, but not as massive). GBSs are still preferred in some shallow to medium depth arctic areas such as in Canada (eg, Hebron field), Kara Sea and Sakhalin island in Russia due to sea ice and iceberg problems. However, both the cost level and the fact that almost all new discoveries made since then have been made in more than 500 meters of water depth, have led to a gradual change of concept. Subsea production systems in which the wellhead was placed on the sea bottom, later also with part of the processing systems replaced so called “dry trees” sitting above water on structures or vessels, and floating production facilities are being increasingly used instead of fixed platforms. The most popular form is the FPSO (floating production storage and offloading vessel), often based on a tanker hull with oil and gas processing equipment placed on the deck. One factor supporting this is the availability of used tanker hulls that are reaching the end of their life certification for open sea transport, but can still provide 10 or more years in stationary use. As ABB was already a major player in the marine market, the company was able to gain a leading position in this sector, supplying installations for more than 50 FPSOs. Because these facilities are generally of modular design, they also provided ABB with an opportunity to expand electrical module activities to large eHouses for FPSOs (as described in the article on Electrical Houses on page 29 of this *ABB Review*). Also, FPSO projects are generally implemented quickly and with a desire to minimize interfaces and achieve higher standardization on board. This favors ABB’s integrated electrical, instrument and telecom (EIT) focus, in which all wired and wireless systems (including electrical) on board are handled by a single integrated concept. This not only reduces operational cost but has also been proven to enable 15 to 20 percent lower overall CapEx for EIT systems and system engineering, as well as reducing delivery time by several months.

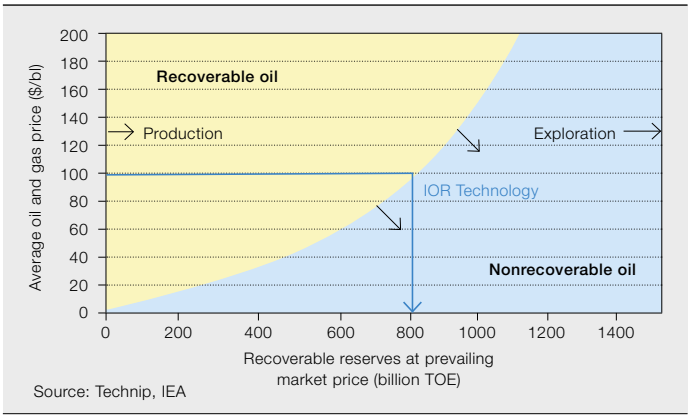
Initially, subsea installations were clusters of four to six wells tied back to an FPSO over a distance of less than a few kilometers. Over the years, subsea structures have developed into full subsea production systems in their own right, with large “offsets”, often in the range of tens of kilometers between satellite subsea systems. The most recent trend is to remove all surface facilities and tie the subsea production system directly back to shore. This often means pipeline, power and communication distances of 100 kilometers or more under water.

Even in tropical regions, the water temperature at depths of more than 2,000 meters are close to freezing. Since lighter hydrocarbons such as propane and butane can freeze around these temperatures under high pressure, additives are often required to prevent the freezing of flowlines should production slow down and the wellflow temperature no longer be able to heat the flowlines sufficiently. In other fields the production is heavy crude (below 20 API [2]) where the viscos-

Footnote

2 API (American Petroleum Institute) gravity is a measure of the gravity or density of a fluid. API 10 is equivalent to water, with higher numbers being less dense (float on waters) and lower numbers denser (sink below water).

4 IOR can increase recoverable reserves



Source: Technip, IEA

5 The Troll A platform weighs 656,000 metric tons and stands 472 meters tall in 369 m of water

ity can become too high due to cooling from the surrounding seawater. Also long distances, high risers from the seabed and other effects necessitate flowline heating, downhole pumps and other multiphase flow-assist devices such as pumps or compressors. These all require large amounts of electrical energy and accurate control. However, transferring energy over such distances with acceptable losses is itself a challenge. ABB has been able to design systems optimizing offset distance to power. It is likely that this trend will continue, particularly for arctic and environmentally sensitive areas where offsets of up to 500 km have been envisioned.

IOR/EOR

By the end of the 1990s, the most important factors that differentiated control-system products started to evolve away from basic functionality (such as operating systems, screen resolution and clock frequency) to oil and gas oriented applications and emerging technologies such as fieldbus and IOR solutions. It is not commonly known that the oil price fell as low as 8.70 $/bl and many technology conferences in the second half of the 1990s had as a main theme technology optimized for an oil price of 10 $. Focus was on reducing the cost of developing new oilfields by leveraging engineering efficiency, standardization and simplification, but also achieving cost reductions by getting more out of the existing reservoirs. ABB first established IOR technologies under the heading “Enhanced Oil Production” in 1997. Throughout the last decade, this portfolio evolved into today’s “Integrated Operations” portfolio and is tailored to increase throughput, decrease energy consumption and decrease the cost of operation by advanced use of available data, such as real-time process data and asset condition monitoring.

The integrated operations business has evolved into a collaborative environment between the local facilities, centrally located operations centres and expert resources both within the oil company and with key providers of products and services.

Electrification and energy efficiency

With the development of deeper and more difficult reservoirs, focus shifted to energy efficiency. As reservoirs get colder, deeper and geographically distant, the energy needed to lift the oil up from the well, pump oil or compress gas into pipelines or convert gas to LNG has dramatically increased the specific power rating of energy from some 200 kW per 1,000 barrels per day in a typical offshore facility in the 1980s to 1 MW or more in some installations today. Unconventional resources can require considerably more than even that, with up to one barrel of energy consumed for every five barrels shipped.

Extraction of oil and gas is an energy consuming process, and on the average, 11 percent of what comes out of the well is consumed before the gas or crude oil can be sold. The primary use is heating, pumping, compression and associated treatment processes, and often this energy is generated locally by relatively low-efficiency thermal generation equipment. Efficiency ranges of 20 to 40 percent are most common with a reasonable average around 25 percent. Many case studies have demonstrated that significant savings can be made by utilizing variable speed drives both for smaller loads such as pumps as well as for driving large compressors, pipelines and loading pumps. In the latter case they can even replace gas turbines in direct drive arrangements, delivering substantial savings not only in emissions and fuel (in the order of 40–70 percent) but also in reliability, uptime and maintenance costs. ABB is a leader in this technology with installations in compressor stations, LNG Plants, NGL facilities (natural gas liquids) and gas treatment plants.

Even in tropical regions, the water temperatures at depths of more than 2,000 meters are so low that many hydrocarbons freeze.

Downstream

The refining business is constantly affected by crude-oil market fluctuations, high cost of energy, environmental regulations, and consumer needs. These factors all contribute to very tight margins. During such times, the need for innovative “value-added” applications increases greatly, as refiners seek to squeeze as much product out of a barrel of crude oil as possible, whilst optimizing energy costs, meeting environmental regulations and supplying the market with products to the required specification (Euro III and IV gasoline, and ultra-low sulfur diesel).

ABB's "Integrated Operations" portfolio is tailored to increase throughput while decreasing energy consumption and operating costs.

Despite discovery and production becoming more complex, there is still enough conventional and unconventional hydrocarbon in the ground to last mankind through the next century.

ABB has many years of experience in refining with its instrumentation, analytics, control and safety system product ranges. The company is well established in the market and provides a stable platform for advanced applications such as:

1 Early fault detection and diagnosis, which provides early detection of potential events, reducing / preventing unplanned outages.
2 multi-vaiable advanced process control, which optimizes production.
3 energy management, which optimizes the use and thus cost to run a refinery.

ABB continuously develops its own core solutions in electrification, control, safety systems and instrumentation.

4 Asset management to monitor integrity of the plant assets.
5 A full compliment of consultancy services, ensuring full plant safety assured solutions.

ABB's recent major successes have come as a result of the upgrade and enhancement of the oil movements, storage and blending solution (RBC/ABC, regulatory blend control, advanced blend control). In 2010 ABB successfully implemented and commissioned blending solutions which significantly improved refiners' margins.

EPC (engineering, procurement and construction)

ABB has many years of experience in the main contracting business, both in construction activities and as main contractor for large oil and gas projects. In the early 2000s, ABB reinforced its offering to the oil and gas segment with a dedicated EPC centre of excellence based in Italy, inheriting the long tradition and know-how of a former Italian contractor.

ABB recognized emerging requirements of industry and expanded its large systems capabilities with multi-discipline project execution, integrating EPC capability with its traditional electrical and automation project execution capabilities. ABB provides complete turnkey solutions (both onshore and offshore) for oil and gas applications in the upstream and midstream fields, including: gas/oil separation plants, gas treatment plants, gas/water injection plants, compressor and pumping stations, terminals, compact power plants, and water treatment. These activities contribute to ABB's significant oil and gas business. At present, few players in the market can boast such a capacity to offer world-class products, advanced integrated systems and proven EPC capabilities.

One example of the extent of these activities is presented in an article featuring the challenges of the El Merk project, currently underway in Algeria (see page 20).

And beyond ...

ABB meets the future challenges of oil and gas in two ways: Firstly, the company continuously develops its own core solutions in electrification, control, safety systems and instrumentation. Secondly, it has over the years been a partner for strategic customers and demonstrated the capability to develop unique enabling

ABB provides complete turnkey solutions (both onshore and offshore.)

technologies such as subsea electrification, power from shore and integrated operations. These solutions would not have been possible without risk sharing, financing and real proof of concept/field trials. In particular, projects on the Norwegian continental shelf and the long term commitment of companies such as Conoco Phillips, Shell, BP and Statoil to joint research and development projects with ABB and others in what has been referred to as “Laboratory North Sea”.

Also partnerships and research and development agreements with such companies as Sonatrach, Dow, and Petrobras continue to enrich ABB’s technology. The next step is increased focus on such partnerships in the Middle East, especially in Saudi Arabia, Qatar and UAE that would focus on sustainable and efficient solutions with particular relevance to this region. These projects will include themes such as IOR, water and water management and unmanned remote inspection and intervention. The article “Remote inspection and intervention on page 50“ focuses on one of these technologies.

Despite discovery and production becoming more complex, there is still enough conventional and unconventional hydrocarbon in the ground to last mankind through the next century. Reducing the environmental footprint will be the greater challenge than getting enough product. In an energy-hungry world where per capita energy consumption is almost synonymous with wealth, there still seems to be little choice despite how much we love to hate our dependence on oil and gas.

For more information on ABB’s oil and gas offering, please visit www.abb.com/oilandgas.

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