Profiting from reservoir surveillance, knowledge and control

It is estimated that, on average, across all the world's oil fields, less than 38% of the oil contained within a reservoir prior to development is actually recovered. Emerging reservoir imaging and management technologies have the potential to make recovery factors in excess of 50% possible in the future.

Operators developing today's deepwater oil fields are looking to new technology to provide solutions that address two key concerns:

- How to maximize the hydrocarbons extracted from their asset – increasing the reservoir recovery factor through efficient production.
- How to maximize daily production by ensuring continuous uptime of the production system – here, reliability is key.

As a leading supplier of complete production systems for the development of deepwater and subsea fields, ABB has built a reputation for ensuring high system reliability. Providing the technologies needed to achieve increased recovery factors is now a key strategic target for ABB's ongoing development of reservoir imaging and control systems.

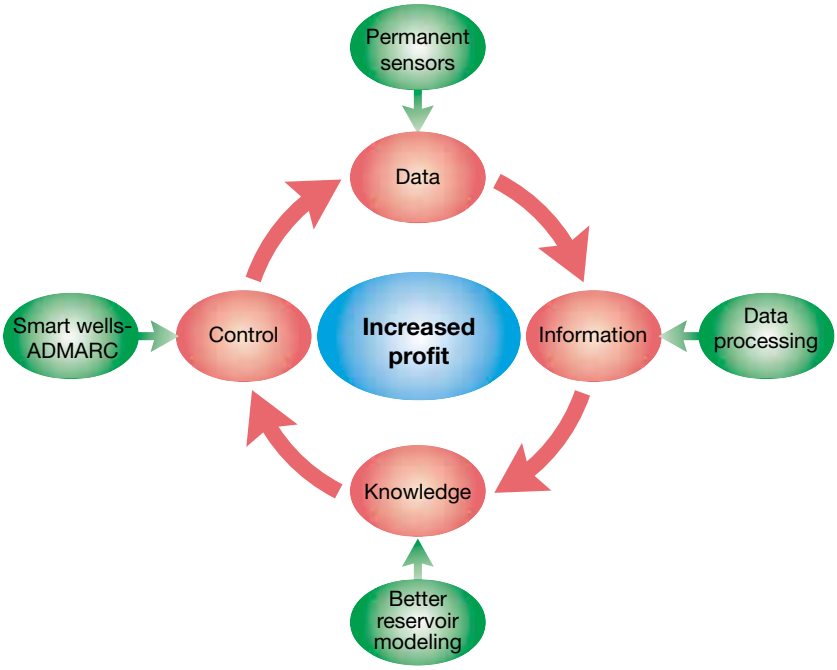
Giving oil recovery a boost

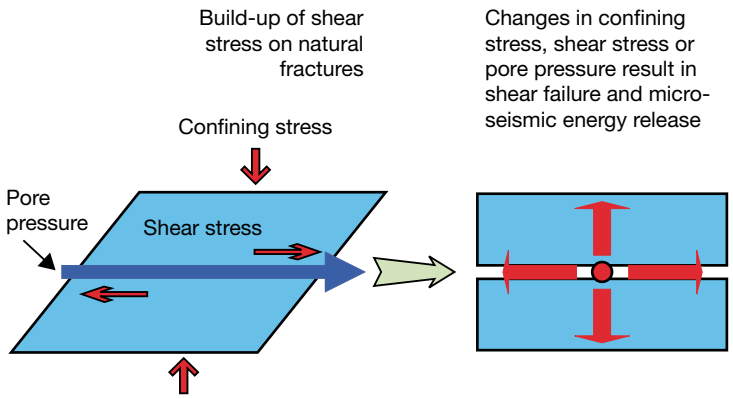
On average, across all the world's oil fields, less than 38% of the oil originally in place within a reservoir prior to development is estimated to be actually recovered. ABB believes that recovery factors in excess of 50% can be achieved, without drilling additional wells, through the application of emerging reservoir imaging and management technologies, and it is this market need that ABB is currently addressing. While the economics of individual fields varies widely, for a 'typical' subsea field an increase in recovery factor of this order of magnitude will generate additional profits for the asset owners in excess of US$100 million.

The oil recovery factor is primarily governed by the natural drive energy existing within a reservoir. However, the efficiency with which the extraction process utilizes this energy has a major impact on the ultimate recovery from a field. Efficient utilization of the available drive energy to produce more oil is principally limited by insufficient and uncertain knowledge of the reservoir's structure, coupled with an operator's inability to alter the reservoir's depletion strategy once the wells are drilled. Current strategies for increasing recovery are to drill additional wells or to intervene and re-work existing wells – either of which often proves uneconomical in today's deepwater fields.

In short, what is needed to improve the recovery factor is:

- An improved understanding of how the reservoir is behaving based on real, measured data.
- The right information to be provided to the client at the right time.
- Knowledge of how the reservoir drainage strategy can be modified to maximize recovery, based on coupling the real-time information on reservoir behavior to reservoir simulators.
- A means to quickly modify the configuration of the wells through which the reservoir is being drained, based on intelligent well technology.





These elements form a closely linked reservoir management feedback loop – all of which ABB is targeting through its current technology R&D program.

IRViS (Integrated Reservoir Visualization Systems)

Today there is a widely accepted need for time-lapse reservoir monitoring, whereby conventional surface seismic surveys of the reservoir are repeated over the life of the field in an attempt to map the oil flow in the reservoir and identify bypassed oil zones. While the information provided by these surveys is valuable for efficient management of the reservoir, the high cost of acquiring the data results in only a few surveys being conducted over the life of today's best managed fields.

ABB believes that the next step-change in reservoir monitoring will be through the permanent installation of seismic sensors within the reservoir to provide continuous surveillance and to make use of naturally occurring seismic signals generated by the reservoir itself. This will enable operators to listen to the reservoir and detect the changes taking place!

Throughout the life of a reservoir, the hydrocarbon production process induces pressure changes within it which, in turn, affect the stresses experienced by the reservoir rock.

As a result, small faults and fractures which had existed within the reservoir before development began become reactivated and generate very small 'micro- earthquakes'.

These micro-earthquakes usually have a Richter magnitude of less than 0, and have been detected and located at distances of over one kilometer from the monitoring well in hydrocarbon reservoirs. By installing high-bandwidth seismic sensors within the reservoir, such micro-seismic events are ideal as a means of continuously monitoring the reservoir's behavior and tracking changes in production.

ABB has shown in oilfield trials that microseismic monitoring has the ability to;

- Provide real-time 3D monitoring of the reservoir structure and fluid pressure front movement.
- Identify geological faults in the reservoir that can result in parts of it not being drained, or faults that act as flow channels.
- Identify areas of reservoir compaction and potential wellbore instability.
- Provide high resolution time-lapse reservoir property images.

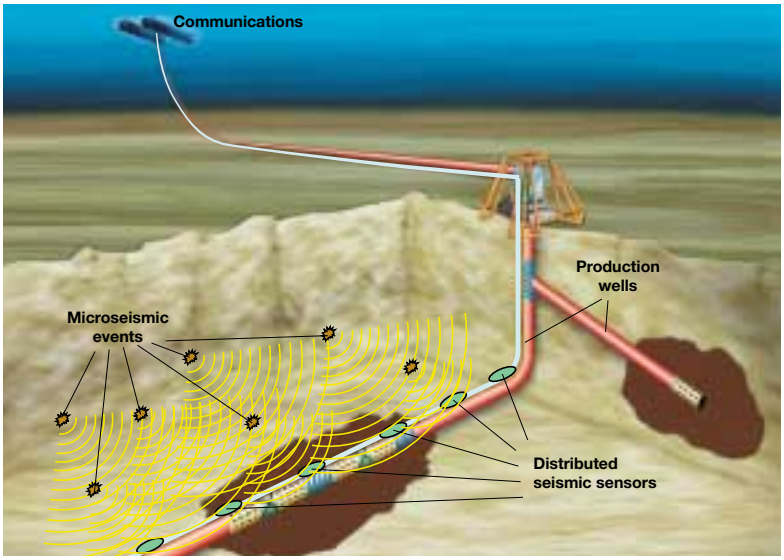


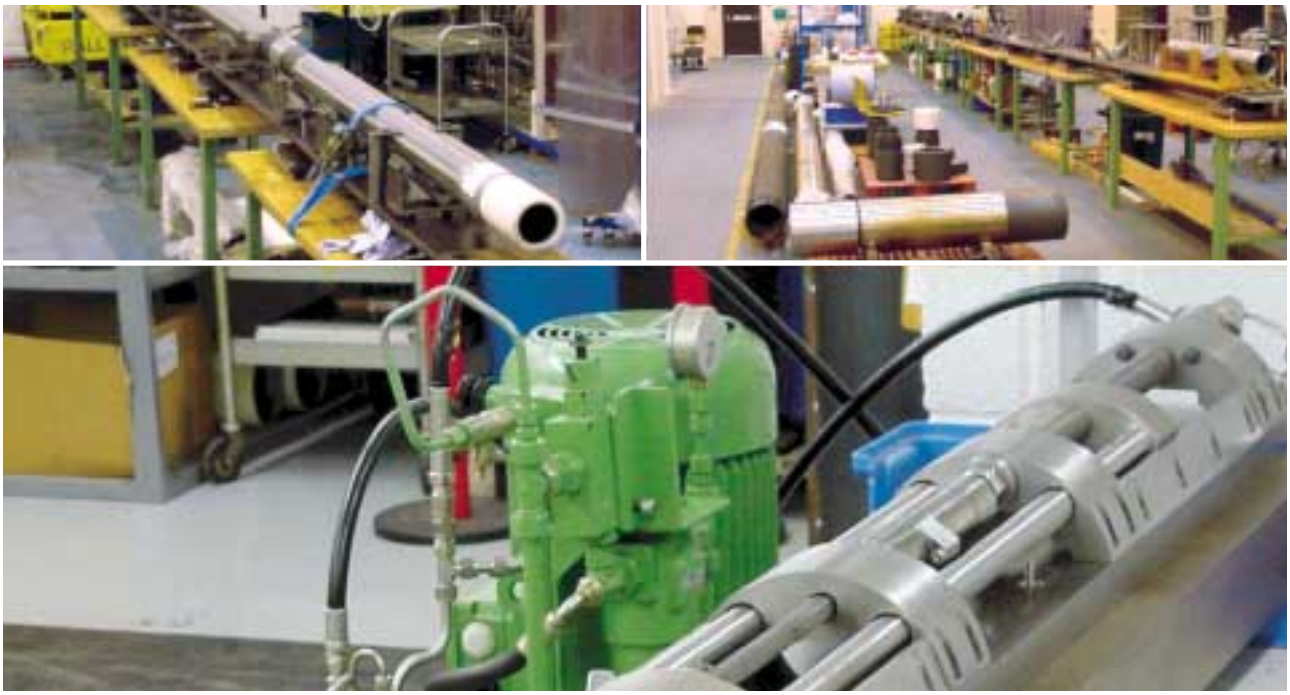
ABB is now moving forward with larger-scale field trials of reservoir imaging technology and the development of efficient methods of deploying permanent seismic sensors into the harsh downhole environment.

Intelligent wells for remote control

While IRViS aims to provide field operators with improved real-time knowledge of how their asset is performing, they also require a means to remotely change how a given well acts to further drain the reservoir. This control can be most efficiently provided by means of remotely operated flow control devices deployed within the production well itself. ABB has developed a high-performance smart well system known as ADMARC (Advanced Downhole Monitoring and Reservoir Control) [1] which delivers highly reliable downhole flow control valves, sensors and a control system together with the ability to integrate tomorrow's advanced sensing systems. Development of this new product continues with a production prototype which is currently under test.

Reference

[1] **R. Phillips, J. G. Hoseth**: Getting more from the reservoir. ABB Review 2/2000, 43-48.



ADMARC system under test