Technologies for Future Challenges

THE ENERGY OF OMV

OMV Upstream

Moving more. Moving the future.
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Dear Reader,

I am proud to present this limited edition booklet showcasing the application of various technologies in OMV’s Upstream business.

OMV produces and markets oil & gas, innovative energy and high-end petrochemical solutions – in a responsible way. It is headquartered in Vienna and one of Austria’s largest listed industrial companies. In Upstream, OMV has a strong base in Romania and Austria and a balanced international portfolio, focusing on the core regions CEE, the North Sea, the Middle East & Africa and most recently Russia – along with selected development areas.

One of our unique selling points in OMV Upstream is the rapid prototyping of new technologies in our assets. We continuously strive for fast piloting and the implementation of new methods to maximize our success in extracting oil and gas. The driving forces behind our strategy are our cutting-edge in-house technologies coupled with access to well-maintained assets to pilot these technologies and foster rapid full field implementation worldwide.

Our mature assets in Romania and Austria are the major producers for OMV Upstream and hence the majority of our technology development initiatives are directed here. One focus of our efforts relates to artificial lift methods, which aim to increase the run time and thereby lower production costs and increase yields. Another focal point is the application of Enhanced Oil Recovery methods: One of the most promising is polymer injection, which changes flood patterns and so boosts recovery. The right selection of materials and minimizing corrosion is a third key area. Here we strive to extend the lifetime of our equipment and select materials with the best value/cost ratio for new projects.

I hope you enjoy reading about our technical capabilities, our achievements, and the challenges we have mastered in OMV Upstream.

Best regards & Glück Auf!

Johann Pleininger
OMV Executive Board Member
Responsible for Upstream
Mature Fields

- Improved Oil Recovery
- Enhanced Oil Recovery
- Managed Pressure and Underbalanced Drilling
- Artificial Lift
- Produced Water Handling
- Corrosion Control
- Lined Tubings
OMV operates multiple mature and super-mature fields in Austria and Romania. These are characterized by high water cuts and a long production history – well over half a century of oil production in the Matzen field, for example. Optimizing production from mature fields requires a thorough understanding of the reservoirs, quantitative risk assessment and methodologies to improve oil recovery – all areas in which OMV’s experts excel.

OMV is among the best in the world in terms of recovery factors for mature fields. Internationally, the ultimate recovery for crude is around 40% on average, while OMV has succeeded in extracting up to 60% of the crude oil available.

OMV addresses water injection challenges holistically including facility impact, injectivity, geomechanics and optimizing under uncertainty. Using this approach, it has been possible to increase the production rates of a super-mature field in Austria (16 Torton Horizon of the Matzen field) by 50% and to push ultimate recovery up to 60%, while keeping costs low.

OMV maximizes recovery without inflating costs.
High recovery factors of around 50% achieved
By optimizing reservoir management and localizing remaining oil, OMV has managed to increase production rates from (super) mature fields by 50%. The 16 Torton Horizon is a super-mature oil reservoir originally containing more than 550 mn bbl oil, which has been in production for more than 60 years. Here, tracer technology was applied to improve the understanding of the fields and waterflooding optimization strategies by rate management were successfully implemented.

Water flooding in the Matzen field
OMV uses modern stream-line simulation to optimize production from water-flooded fields. The example of the Matzen field shows that by modifying the streamlines of injector-producer pairs, it was possible to recover additional oil and to reduce the water cut. Streamline simulation facilitates the quantification of injector-producer connections and shows how the efficiency of water injection can be improved. No significant costs are involved; however, incremental oil can be accessed as flow paths are modified.

Technology implementation and results
► Streamline analysis of flood pattern
► Improved flood efficiency by shutting-in wells
► Around 10.5 kboe extra production achieved by redirecting streamlines (shut-in of one producer)

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<th>Matzen 8 Torton Horizon, Austria</th>
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<td>Average porosity:</td>
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OMV has developed cutting-edge capabilities to optimize Enhanced Oil Recovery (EOR) in mature reservoirs. One of the key technologies here involves injecting polymer to increase oil recovery by up to 15% and extend the life of the field. The same polymers which are used by OMV for EOR are utilized in the treatment of potable water.

The principles of polymer injection Enhanced Oil Recovery (EOR) can increase production and decrease the amount of produced water from mature fields. Oil recovery from medium-viscous fields is low due to the poor ability of water to displace oil. Polymer flooding aims to increase the water viscosity to improve the displacement of oil by polymer-augmented water. The injection of polymer can change flood patterns, boosting recovery markedly. However, such projects require careful expenditure controls due to the high costs of the chemicals needed.

OMV is conducting a polymer injection pilot program to accelerate the deployment of the technology. Owing to the promising results, an extension of the pilot is currently and a sector roll-out is being investigated.
Polymer injection pilot in the Matzen field
A field trial is underway at the 8 Torton Horizon of the Matzen reservoir in Austria with the goal of proving the technology at reservoir scale, whereby a polymer unit was built and polymer injected into two wells. Polymers have increased the viscosity of the injected water leading to improved sweep efficiency. In addition, in heterogeneous reservoirs, polymers are effectively diverting flow from high permeability streak to lower permeability areas.

Cutting-edge technologies for the separation of polymer/water/oil are being tested and numerous uncertainties regarding polymer injection projects have already been resolved. The results of the pilot show that incremental oil is produced. Furthermore, parameters important for polymer injection (injctivity, polymer adsorption, polymer degradation) have been determined.

The two diagrams show the response of two production wells (S66 and S95) first with water and then with polymer injection. Water injection led to an increase in the oil/water ratio (i.e. higher oil production) and polymer injection resulted in a continuous higher oil/water ratio compared with a base case of no polymer injection. The pilot proved that substantial incremental oil can be mobilized by polymer injection. For well S66, about 4,400 m³ incremental oil was produced by polymer injection while for well S95, 3,200 m³ incremental oil was produced. Owing to the success of the polymer pilot, an extension of the pilot is currently underway with horizontal wells. In addition, a roll-out of polymer injection for a larger area is envisaged commencing in 2019.
OMV is highly successful at maximizing production from existing reservoirs, whereby heavy oil production poses special challenges owing to the high viscosity of the oil. OMV operates the world’s longest lasting in-situ combustion project, allowing recovery factors of over 60%.

Overcoming the challenges of heavy oil
Heavy oil is characterized by high viscosities, similar to honey. Decreasing the oil viscosity results in higher oil production rates and dramatically increases the recovery factor. The oil viscosity can be decreased by the injection of heat, but this heat needs to be transferred to the reservoir in a cost-effective manner.

The most efficient method of providing heat to the reservoir is in-situ combustion. In-situ combustion leads to in-situ heat generation in the reservoir. This means that no heat is lost in the injection wells. An in-situ steam drive is generated, heating the oil effectively and providing a displacement mechanism. OMV Petrom is the operator of the world’s longest lasting in-situ combustion project and new well and line drive configurations have led to a boost in oil production.
Heavy Oil Recovery in the Suplac oil field

Heavy oil production suffers from low recovery factors and low production rates. The reason is the high viscosity of the oil. In the case of the Suplac field, the in-situ oil viscosity is about 2,300 cP. Owing to the high viscosity (water has a viscosity of about 0.8 cP at these conditions), the flow resistance is high and therefore the oil production rates are low.

One method to improve heavy oil recovery is to provide heat to the reservoir. In the Suplac field, heat is provided by applying in-situ combustion. There are only a few known examples of successful in-situ combustion projects worldwide. In Suplac, the recovery factor has already reached more than 50%. The picture shows the top structure of the Suplac field. The top structure is in the south and the original oil/water contact in the north. A combustion front propagated through the reservoir from south to north effectively heats the oil and results in high oil recovery. The red line indicates the current location of the combustion front. Ahead of the front, oil production is accelerated by applying cyclic steam stimulation; the combustion front leads to additional heating of the reservoir and ultra-high recovery factors.

Technology

- Cyclic steam injection, down dip of combustion front
- In-situ combustion in a linear drive configuration
- 50 years of production
- Current production ~ 8,000 boe/d
- 55% recovery factor to date

Overview

- The world’s longest lasting in-situ combustion project
- OMV implemented steam injection and in-situ combustion
- New well configurations have led to a boost in oil production
- Current recovery factors are already > 55% of the oil in place
- Recovery factors above 60% can be achieved
- Cost efficient heating of reservoir

Suplac oil field, Romania

- Reservoir: Pannonian
- Average porosity: 32%
- Average permeability: 2,000 mD
- Oil gravity: 16°API
- Oil viscosity at 25°C: 2,300 cP
- Current avg. res. pressure: 7 bar
Managed Pressure (MPD) and Underbalanced Drilling (UBD) systems have enabled OMV to successfully overcome drilling challenges in Yemen and the company achieved best-in-class through applying this technology in the Kurdistan Region of Iraq.

The principles of MPD and UBD
The use of traditional drilling fluids can present problems when drilling low-pressure or high-permeable formations such as depleted reservoirs or faults. MPD or UBD can be used to reduce bottom hole pressure variations during the drilling process and can minimize drilling problems such as losses and wellbore stability. MPD is a process used to more precisely control the pressure profile throughout the wellbore, and bottom hole pressure is slightly above or equal to the reservoir pore pressure. UBD is achieved when the pressure exerted on the well is less than or equal to that of the reservoir.

These methods reduce common issues such as lost circulation, differential sticking, minimal drilling rates and formations damage. MPD technology was used in Kurdistan to drill heavy fractured formation to mitigate losses and drill sour reservoirs safely. UBD has been employed in Yemen to reduce formation damage while drilling fractured basement reservoirs.
Managed pressure drilling in the Bina Bawi field

Managed pressure drilling has proven successful in the Bina Bawi field in Kurdistan. The technology was used to reduce the heavy losses and, consequently, severe drilling problems on the wells. Technology facilitated lower mudweight to enable drilling through highly fractured formations. The sharp fall in losses through the application of MPD enabled OMV to become the best-in-class in the region.

Technology benefits

- Reduces risk to personnel and the environment from well-control incidents
- Enables higher rate of penetration
- Reduces non-productive drilling time
- Enhances recovery (by reducing formation damage)

Cost vs. depth graph showing comparison between OMV wells with MPD system (green lines) and a competitor’s wells without MPD system (red and yellow lines) in the same field

Cost (USD)

- OMV-Bina Bawi 6
- OMV-Bina Bawi 4
- OMV-Bina Bawi 5
- OMV-Mala Omar 1
- Company-Rovi2
- Company-Sarta2

Managed Pressure and Underbalanced Drilling

Bina Bawi, Kurdistan Region of Iraq

Number of wells: 6
Time: 2013/2014
Formation: Highly fractured carbonate
Close cooperation between OMV experts and external research institutes has yielded impressive results in artificial lift methods including measurable reductions in power consumption, CO₂ and downtime.

Artificial lift refers to the use of artificial means to increase the flow of liquids from a production well – either to accelerate production or to maintain production due to depleted reservoirs in mature fields. In 2016 nearly 7,000 wells were equipped with artificial lift systems (ALS) in OMV globally. The reliable application of artificial lift methods for fully designed lifetimes, even under changing environments (e.g., gas-oil-ratio, water cut increase, formation damage...), faces manifold challenges. Therefore it is essential to achieve maximum possible run times (low wear, can handle gassy and sandy conditions), high flexibility in lifting capacity (fit for a high range of productivity indices) and high (energy) efficiency (lowest possible production costs).

**Optimization initiatives underway in 2016**
- Romania MTBF (Mean time between failure) 700 for 4,418 Sucker Rod Pump (SRP) wells
- Austria MTBF 2000+ for ~ 500 SRP wells
- Establish a centralized artificial lift performance surveillance system in OMV
- Austria energy efficiency field test with potential of 15–30% energy savings ~ 1,500 t CO₂ reduction
- OMV funded (sucker rod / PCP) pump test stand at the Mining University of Leoben
- Development of a new insert sucker rod pump type (SRABS)
- Investigation on automated pattern recognition tools for failure prediction based on artificial lift system data
Potential benefits
An increase in run life of 10% only will result in:

- ~9% cost savings per year (incl. deferments)
- ~9% fewer well interventions, which will reduce HSSE risk
- ~9% more rig capacity

Austria performance enhancements
Increase in MTBF by 13.6% resulted in:

- EUR 2.8 mn cost savings (normalized) per year
- 39 fewer well interventions per year
- >1,800 rig-hours spare capacity with existing rig stock

Romania performance enhancements
- 2004: ~8,000 wells, MTBF of 36 days resulting in 150,000 well interventions
- 2015: 4,418 SRP wells (6,158 total), MTBF of 540 days resulting in 4,887 interventions (due to well failures)

Effective field and asset life cycle management as well as the usage of new applicable technologies are key factors for performance improvement.

Key success criteria
- Detailed failure and root cause analysis to focus on the important issues only.
- Holistic team approach (all shareholders and stakeholders involved)
- Improving documentation, database and communication procedures

Results
- Project “SCOPE” is coordinating a huge variety of small projects – from improving processes and procedures within the different stakeholders, implementing new data sets in the artificial lift and well production database, implementing new material specifications, and developing optimized Basis of Design (BoD) for SRP bottom hole assemblies based on specific well environments.

- Project “MTBF 2000+” showed successful results within the first year, raising the MTBF from 1,291 days (2015) to the current 1,457 days in Austria

- A new and unique measurement methodology for nondestructive material tests of sucker rods including detecting deposit corrosion under rod protectors is currently under development

HolloRod technology in Romania

Technology implementation
- HolloRod technology (hollow rods) allows the injection through the hollow rod string of chemical substances and inhibitors that modify the properties of paraffin crystals and reduce wax deposits on the surface of production equipment.

Results
- After two months of testing, the paraffin deposits were down to 5 kg per 100 m of string
- 50% increase in efficiency of the dewaxing process
- Decrease of up to 60% in the number of interventions due to paraffin deposits
- Significant reduction in operating costs
Having operated mature fields in Austria for more than five decades, OMV is well aware of the importance of produced water handling. Its experience in this area has facilitated a tremendous increase in the economic lifetime of mature fields.

Maintaining pressure, displacing oil and stabilizing production

When operating mature oil fields, formation water is produced together with crude oil, meaning that it has to be separated and treated for re-injection or disposal. Water cut usually increases with the age of the field and in Austria the average has reached more than 90%.

Water is separated from crude in gathering stations and then collected in a central water treatment plant. Here it is processed for reinjection, whereby the intended future use determines the water quality needed. If the water will be used for water flooding operations, good water quality is important to ensure injectivity and minimize the risk of reservoir damage. Water used for EOR projects may need additional purification.

OMV has longstanding experience in produced water handling and re-injection, with its first water treatment plant operating successfully since 1961 and a new, cutting-edge facility that started in 2015.
**Water handling in the Matzen field**

The old water treatment plant (open aerobic system) was operating for more than 50 years and has undergone capacity upgrades from the original 1.5 million m³ per year to around 10 million m³ per year until operation was stopped in mid-2016. The water, produced from various reservoirs, is commingled, treated and pumped to 75 injectors via a 100 km long pipe system.

The treatment capacity of the central new water treatment plant is over 10 million m³ per year. The main reservoirs are water flooded mainly by peripheral injection patterns. Due to water injection, the reservoir pressure is maintained and oil is displaced to the production wells, resulting in stabilized production and improved oil recovery.

The water quality requirements are dependent on the field and application. The majority of the water is injected to relatively sensitive sandstones, which require good water quality. Therefore, the water quality requirements for injection water are relatively strict, e.g. with a maximum residual oil below 2 ppm.

**Results**

- Cost-efficient water treatment
- High and stable water quality for reinjection
- A closed system ensures that the CO₂ footprint is reduced by 70%

**Injection water quality criteria, Austria**

- Residual oil: < 2 ppm
- Suspended solids: (≥ 3 µm) ≤ 1 mg/l

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**Water treatment in Matzen, Austria**

- Total volume: 12 mn m³/year
- Water cut: > 90%
- Number of injectors: 75
- Length of pipe system: 100 km

**New water treatment plant**

**Technology implementation**

- The plant is fully automated, thereby maximizing plant safety
- Nitrogen blanketing enables an anaerobic process
- Uses state-of-the-art technology:
  - Parallel plate separator
  - Dissolved gas flotation
  - Nutshell filtration

**Results**

- Cost-efficient water treatment
- High and stable water quality for reinjection
- A closed system ensures that the CO₂ footprint is reduced by 70%
OMV possesses decades of experience in the corrosion control of mature fields and very corrosive environments. A corrosion control program and the careful selection of materials lead to optimized equipment performance and maximum service life.

Low corrosion rates are a key requirement for the safe and reliable operation of mature fields.

Based on extensive R&D, the following measures have been applied:

- Careful selection of carbon steel and/or corrosion resistant alloys for critical parts based on relevant standards and in-house specifications
- Thorough laboratory-based selection of appropriate corrosion inhibitors for carbon steel equipment and optimization of the corrosion inhibitor treatment in the field
- Corrosion monitoring in order to assure that the corrosion rates comply to OMV thresholds of ≤ 0.050 mm/year for oil field applications and ≤ 0.005 mm/year for gas field applications

The successful implementation of corrosion control programs for mature oil and gas fields has led to optimized equipment performance and extended service life to a maximum. Even in highly corrosive environments, OMV’s corrosion rates for carbon steel equipment are as low as some thousandths of a millimeter per year compared to several mm/year in the untreated case.
Corrosion control in the Matzen oil field
Technology implementation
- Corrosion control of carbon steel equipment by selection of an appropriate corrosion inhibitor followed by an inhibitor optimization program
- Establishment of in-house specifications for subsurface equipment (tubings, sucker rods, rod guides and couplings, sucker rod pumps)
- Use of lined tubings in sucker rod and PCP wells

Results
- Mean Time Between Failures (MTBF) of the sucker rod wells currently exceeds three years compared to the competitors’ average of one year
- Yearly cost savings due to reduction in well interventions and deferred production
- Reduction of well interventions from 780 in 1988 to 180 in 2016

Corrosion control in the Schönkirchen Tief sour gas field
In this sour gas field the corrosion inhibitor is squeezed into the formation twice a year, providing corrosion protection for subsurface and surface carbon steel equipment; a corrosion monitoring program is also in place. This has enhanced the reliability of operations of a mature sour gas field containing 12% CO₂ and 2% H₂S and led to negligible corrosion rates of approximately 0.005 mm/year at the wellhead.

Generally OMV is aiming to inject corrosion inhibitors already downhole in order to protect as much equipment as possible.

Matzen field, Austria
- Production start: 1949
- Number of sucker rod wells: 500
- MTBF: 1,457 days

Schönkirchen Tief sour gas field, Austria
- Production start: 1967
- Well depth: up to 6,000 m
- Downhole temperature: 175°C
- Initial pressure: 590 bar
- Gas contains: 2% H₂S, 12% CO₂
The research and development team at OMV focuses on innovations that add value to the business. A good example is the polymer lining for tubings – developed in-house and patented by OMV and Borealis in 16 countries.

A smart solution for corrosion and abrasion problems
Early tubing failures are one of the main reasons for unexpected and cost-intensive workovers of artificial lifted oil wells. In many cases the actual cause of tubing failure is a synergistic effect of both the rods wearing on the tubing wall (abrasion) coupled with an electrochemical attack (corrosion). Whereas corrosion can be reduced successfully by measures such as the use of corrosion inhibitors, the combination of corrosion and abrasion may lead to tubing wear resulting in tubing leaks. The OMV solution? Lined tubings.

Lined tubings are tubings where cross-linked polyethylene pipes are inserted in order to prevent the tubing from abrasion and corrosion. Lined tubings are utilized for oil wells operated with sucker rod pumps and progressive cavity pumps, as well as in water injection wells.

This technology was developed in-house in order to further increase the MTBF (mean time between failures) of sucker rod pumped and PCP wells (patent approval in 16 countries including Europe, Asia, GCC and USA).

Further lifetime extension through polymer lining of tubing (patented by OMV)
Development of lined tubings
➤ Tribological and immersion tests of 19 different polyolefinic materials in the laboratory under subsurface conditions in order to identify the best material
➤ Successful field application in more than 500 wells in Romania and more than 20 wells in Austria
➤ Proven savings of > EUR 5 mn for two oil fields (total of 40 wells in Romania)

Lined tubing benefits
➤ Potential savings of EUR 50k/well/year
➤ Reduction in deferred production
➤ Cutting costs for production & well intervention by reduced mechanical friction (electrical power savings approx. 15%)
Complex Developments

- Sour Field Development & Operation
- Extended Reach Drilling
- Harsh Environment Drilling
- Casing while Drilling
- High Pressure Stimulation
- Materials Selection
- TECH Center & Lab
OMV has successfully managed sour fields in multiple locations around the world for over half a century, acquiring knowledge and skills that are then put into practice when developing new opportunities.

Sour fields commonly refers to reservoirs where the contents of CO₂ (Carbon Dioxide) and/or H₂S (Hydrogen Sulfide) in the produced fluids are particularly high. Sour reservoirs also include fields that have produced “non-sour” fluids for many years, but where the levels of contaminants increase with time due to reservoir souring (mainly due to sulfate reducing bacteria). We have experienced this phenomenon in many OMV fields.

Managing these fluids usually involves using state-of-the-art technologies, non-standardized equipment, sophisticated materials (e.g. corrosion resistant alloys or non metallic materials) and very high safety standards. Use of advanced technologies, special materials and higher safety standards can come at a cost, presenting commercial barriers to monetization. Fortunately OMV’s technology is continuously evolving, allowing the safe and cost-efficient exploitation of sour fields across the globe.

The operation of sour fields requires highly developed design, operational and maintenance processes, with a strong focus on safety.

Inlet manifold, Sawan, Pakistan
Status & Achievements

- Over 50 years of experience in the development and operation of sour oil and gas fields throughout the world, including:
  - Austria: Aderklaa Sour Gas Plant (2% H₂S, 16% CO₂)
  - Pakistan: Sawan and Kadanwari Gas Plant (10% CO₂)
  - Additional ongoing field developments with > 20% H₂S

- Continuously safe operation, posing no HSSE risk to personnel, local population and environment

- Development and deployment of traditional & alternative technologies to optimize processing e.g. Claus plant in Austria, large scale CO₂ removal membranes in Pakistan

Aderklaa Sour Gas Plant

One of the most important facilities within the OMV portfolio for the processing of sour gas is the Aderklaa Sour Gas Plant. Commissioned in 1962, it is capable of handling gas with H₂S concentrations of up to 2% and 16% CO₂. Despite the complex nature of the plant and its location in a populated area, OMV has managed to operate the plant with no fatality or incident in 50 years thanks to the high safety standards and excellence in operations.

Key process systems

- Acid gas removal (MDEA)
- Gas dehydration (TEG)
- Sulfur recovery (Claus Plant)
- Tail gas treatment

Results

- Long-term safe operation in a populated area (no fatality or H₂S incident in 50 years)
- High environmental standards
- Continuous optimization of processes to ensure maximum efficiency of operations

New Sour Gas Projects in the Funnel

- The OMV portfolio contains several new projects where sour gas is present:
  - Turburea-Bibesti, Romania: Up to 15% H₂S
  - Middle East: Multiple projects in development
  - Dealing with ageing fields and reservoir souring

- Applying our past experience and skills in the management of sour gas assets is of prime importance and gives us positive leverage.

- OMV intends to remain at the forefront of new technologies and state-of-the-art techniques for sour gas management.

Sour Gas fields in Pakistan

- Around 256 mn scf/d of gas and 1,100 bbl/d of condensate with up to ca 11% CO₂

Aderklaa Sour Gas Plant

- Plant on stream: 1962
- Sour gas treatment with LPG extraction
- Processes: 2% H₂S, 16% CO₂
- Plant capacity: 70 mn scf/d

Complex Developments | Sour Field Development & Operation
OMV has enjoyed success with extended reach drilling (ERD) in key reservoirs in New Zealand and Norway. ERD increases productivity and enhances recovery by maximizing reservoir drainage. It also allows OMV to access distant prospects from existing locations, reducing surface costs.

Extended Reach Drilling involves the directional drilling of long horizontal wells. Costs of drilling remote prospects or draining large fields can be inhibitive and ERD enables wells to reach a larger area from one surface drilling location and to keep a well in a reservoir for a longer distance, maximizing reservoir contact length.

In Norway the ERD concept was implemented for Wisting Central II, to prove the concept for future development and to decrease the uncertainty of the recovery factor for development planning. ERD wells were also drilled successfully in the Maari field to increase the recovery factor of the reservoirs in New Zealand. The key challenges of the project, such as equivalent circulating density (ECD) & torque and drag, have all been successfully addressed and the use of real-time monitoring technology was a key factor for the success of the operations.
Extended reach drilling in the Maari field
ERD development in Maari has resulted in maximum production thanks to increased reservoir exposure. Initially ten ERD wells were drilled in 2009 and then another four ERD wells were drilled in 2014/2015 in the course of the Maari Growth campaign.

Technology implementation
► Field developed with fourteen extended reach wells
► Complex well paths
► Batch drilling
► Foam cementing
► Managed pressure drilling

Results
► Maximized production rates by increased reservoir exposure – 22,000 boe/d
► Maximized reservoir drainage

Maari top structure map, New Zealand

Maari MR4 extended reach well design

Maari field, New Zealand
► Production start: 2009
► Number of wells: 14
► Daily production: ~22 kboe/d
► Total depth drilled: 41,000 m
Harsh Environment Drilling is usually performed under extreme environmental conditions – such as in the cold temperatures of the North Sea and Barents Sea, battling rough sea conditions with huge waves and strong winds. OMV set a new world record here for the shallowest horizontal offshore well drilled from a floating drilling facility.

The OMV Wisting discovery is located in the Barents Sea, a harsh drilling environment classified as an environmentally sensitive area. The Wisting reservoir is only 270 m below the sea bed and has a low reservoir temperature. Despite the challenges of hydrates, and Equivalent Circulating Density (ECD) limitations for ERD drilling, the first horizontal appraisal well was drilled on time and on budget. Here, OMV was able to achieve the requisite high build rates in shallow formations to achieve the land out of the horizontal section at the target True Vertical Depth (TVD). Conductor Anchor Node (CAN) technology with a pre-installed conductor was deployed to reduce rig time, mitigate the environmental footprint and provide an early kick-off possibility.

The depletion of standard reservoirs is motivating operators to search for oil in regions that have not yet been developed. The harsh environmental areas that were previously deemed too risky to explore are now becoming the focus of many exploration projects, posing new challenges in terms of technology and logistics.
Wisting field Appraisal

The Wisting Central II well is the first horizontal appraisal well in the Barents Sea and has set a new drilling record: It is the shallowest horizontal offshore well drilled from a floating drilling facility.

The water depth at Wisting is 402 meters. The well started vertically and was successfully steered into a horizontal orientation within a 250 meter depth interval. The total length of the well is 2,354 meters and the horizontal section measures 1,402 meters.

The 17 1/2” section was pre drilled with a 12 1/4” pilot hole and subsequently opened up with a staged hole opener with motor in high Dog Leg Severity (DLS) – another industry first.

Wisting overview

- Shallow ERD, high DLS (up to 13°/30 m)
- Early drilling problem detection system
- Welltec annular barrier (WAB) utilized as barrier and liner hanger
- CAN-ductor technology utilized
- Geo-steering through the entire horizontal phase
- Well test in dynamic positioning (DP) – flow rates > 5,000 boe/d

Achievements

- Development concept successfully confirmed
- Drilled on time and on budget
- Zero environmental incidents

Wisting field, Barents Sea, Norway

Wisting overview

- Exploration/Appraisal phase
- Number of wells
- Harsh Environment Drilling
Casing while Drilling (CwD) is an enabler technology that allows OMV to unlock previously un-drillable wells. It not only reduces operational time — and therefore costs — but also minimizes exposure of problem formations. World records achieved by OMV underline its achievements using this technology.

Casing while Drilling technology is an integrated technique which utilizes casing instead of conventional drill pipe during drilling operations, allowing casing to run simultaneously. CwD technology is typically used to mitigate hazards when trouble zones are encountered. It permits the simultaneous drilling, running and setting of casing, reducing flat times while eliminating downhole problems.

OMV has implemented this technology in New Zealand, Austria and Romania with great success. For example, OMV introduced CwD in the 2008 Maari drilling campaign and successfully set a new industry record at the time for the 24” surface casing (150 m). Romania set the world record for 20” casing section (503 m) and European record for 13 3/8” casing section (729 m) in 2013. CwD is currently the standard drilling practice for surface casing in Austria.
CwD campaign in Austria
The CwD technique was deployed in Austria in 2013. More than 35 wells have been drilled so far, successfully applying CwD on the top hole section. The results have been very positive: In the Vienna basin it has increased operational efficiency, saving up to 1.3 days per well. It also allows OMV to drill one to two more wells in the allotted time frame, facilitating earlier recovery of oil and gas than is possible using conventional drilling methods.

This technology mitigates drilling hazards such as lost circulation and well bore instability. Usually the formation is very soft in top hole sections and there is a chance of total loss circulations and/or pack off of BHA in the case of conventional drilling. These hazards can be avoided with CwD by having casing as a drill string due to a bigger diameter of drill pipe.

Technology implementation
► 35+ well campaign in Austria between Q2/2013 and Q4/2014 to bolster local production
► CwD technology was tested for a surface casing section with a setting depth of between 450-560 m TVD
► For a production well in Austria CwD was used for a 9 5/8” casing section with 829 m in 2017

Results and benefits
► Savings of up to 1.3 days per well CwD doubled the meters drilled per day in comparison to conventional & casing operations
► CwD is faster than conventional drilling in the top hole section (see graph)
► CwD also reduces flat time, mitigates associated drilling hazards and cuts costs

Weatherford’s Defyer 13 3/8” x 16” drillable-casing bit, used in Austria
OMV has several years of experience in high pressure stimulation. The benefits include the accelerated production of hydrocarbons leading to increased recovery and optimized field development.

Reservoirs with low permeability do not allow economic production. High pressure stimulation generates a highly conductive flow path from the reservoir to the well, thereby increasing well productivity. The type of treatments range from small skin by-pass in medium permeability reservoirs (Romania, Kazakhstan), to high pressure/high temperature (HP/HT) applications in tight gas reservoirs (Pakistan), to multistage horizontal well stimulation in both gas and oil reservoirs, offshore and onshore (Romania), where state-of-the-art technology is being used. OMV has also identified potential for economic field development using high pressure stimulation in new areas (Yemen, Tunisia). Completed studies related to tight & shale gas may also lead to future opportunities.
Multistage High Pressure Stimulation – Offshore Romania in the Black Sea

Oil production from the OMV Petrom Lebada offshore field has been improved significantly over the last years through the use of a new technology. This technology was applied for the first time in Europe by OMV Petrom in 2008. It was the first time worldwide that a viscoelastic fluid system was used for this kind of operation. Following early successes, the engineering effort now focuses on increasing value through engineering innovation and increased productivity.

Production data on eleven wells in Lebada indicate expected production increase and demonstrate the success of the technology utilized. The multidisciplinary approach has allowed OMV Petrom to save rig time in an expensive offshore environment. Normalized well productivities continue to improve and the challenge is to maintain the rate of evolution through the improved application of both new and existing technologies.

Technology implementation
- Installation of completion, degradable ball for port activation
- Multistage pressure stimulation
- Tracers to identify stages contribution and well interference
- Stimulation
  - 11 wells
  - 3 to 12 stages per well
  - 79 stages in total
OMV’s experience in choosing the right material for different fields and conditions facilitates safe and reliable operations. OMV conducts various technology projects to identify potential alternative materials. Its detailed knowledge of the application limits of materials results in the optimization of capital and operational expenditure.

One of the most important factors for operating in highly corrosive oil and gas environments is proper material selection. It influences facility integrity, plant reliability, investment costs and operating and maintenance costs. As every field is unique, different materials may need to be chosen depending on the different field conditions. Well-directed R&D and technology projects result in specific knowledge of the application limits of materials. This guarantees the safe and reliable operation of oil and gas fields on the one hand and the use of the most economic materials on the other hand, thereby avoiding overdesign.

Corrosion inhibitors to reduce carbon steel corrosion show application limits regarding high temperature and represent increased operational expenditure, especially in mature fields. Economically viable, alternative materials for specific conditions therefore have to be identified. OMV has longstanding experience in material selection in line with ISO 15156 and has been operating sour gas fields with H₂S contents up to 2% and gas fields with CO₂ contents up to 16% safely for many decades. Furthermore OMV’s portfolio comprises fields with temperatures of up to 180°C.

<table>
<thead>
<tr>
<th>Material</th>
<th>Application</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon steel (incl. corrosion allowance and corrosion inhibitor treatment)</td>
<td>Dry and wet gas, Condensate, Water</td>
<td>Low CAPEX, Easily available, Easy processing, Corrosion is predictable and can be controlled by inhibitor treatment</td>
</tr>
<tr>
<td>Cladded carbon steel</td>
<td>Wet gas (for specific vessels)</td>
<td>Combines low costs of carbon steel with corrosion resistance of stainless steels</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>Wet gas (at temperatures below resp. threshold for chloride induced pitting), Water</td>
<td>Corrosion unlikely, Low OPEX (no need for corrosion inhibitor)</td>
</tr>
<tr>
<td>Glass fiber reinforced plastic</td>
<td>Water</td>
<td>No corrosion anticipated, Low OPEX (no need for corrosion inhibitor)</td>
</tr>
</tbody>
</table>

Laboratory test results of corrosion rates for various steels

Material concept for a gas condensate field
Material selection for a gas field

Optimizing the balance between investments and operating costs is very important, while taking into account the physical and chemical conditions of the produced fluids. Appropriate material selection for specific oilfield conditions is a key requirement for the safe operation of oilfield equipment. The graph shows a simplified flow diagram for a planned Central Processing Facility (CPF) in a gas field where four different materials have been identified as appropriate. Using the most expensive material does not necessarily mean using the most appropriate material, for example stainless steels have application limits where carbon steel in combination with corrosion inhibitors might work successfully.

Material selection in the Höflein gas field

The Höflein gas condensate field in Austria has been producing for around 30 years. The gas contains approximately 16% CO₂, which poses a serious corrosion threat. The material selected has generally been carbon steel, while critical components are made of 13% Cr steel. Despite the high corrosivity, the corrosion rates are negligible with 0.005 mm/year, as carbon steel equipment is protected by a corrosion inhibitor that has been selected and optimized by the in-house laboratory. The corrosion inhibitor is injected downhole via capillary string providing protection to both the subsurface and surface equipment. Even higher production rates and increased flow velocities can thereby be handled in a safe and reliable way.

Results

- Achieved actual corrosion rates of approx. 0.005 mm/year, in comparison to expected uninhibited corrosion rates of more than 10 mm/year
OMV's TECH Center & Lab is the in-house technology center and laboratory for Exploration and Production supporting all OMV Upstream operations worldwide. Highly qualified experts cooperate across disciplines, providing extensive experience and expertise to guarantee tailor-made solutions.

Unique competencies based on longstanding experience throughout the OMV Upstream world
The TECH Center & Lab acts as the center of competence within Upstream, providing analyses, testing, research and consulting for all global OMV assets. The laboratory’s portfolio comprises technologies enabling all Upstream core processes throughout the whole lifetime of an oil or gas field to facilitate safe operations, optimized risk and cost, and maximum production output.

The experts and highly skilled technicians cover disciplines such as geology, sedimentology, petrophysics, high pressure technique, chemistry, geochemistry, metallurgy, corrosion, materials science and petroleum engineering. All disciplines are supported by the in-house workshops, facilitating the development and manufacturing of special equipment that is required but not commercially available.

Being involved in projects throughout all OMV Upstream activities worldwide gives the TECH Center & Lab the unique opportunity to identify, test and evaluate new technologies for potential roll-out into the OMV Upstream community. The TECH Center & Lab thereby acts as a global platform for technology and knowledge transfer within the OMV Upstream world.
Formation Characterization
Supplies key expertise for reservoir characterization delivering detailed core and image-based sedimentological descriptions of carbonate and clastic reservoirs, interpretation of depositional environments, litho- and sequence stratigraphy and qualitative and quantitative petrographic analyses (thin-sections incl. cuttings, XRD, SEM, LPSA etc.).

Materials & Corrosion
Supports all OMV assets concerning all corrosion and material-related questions and challenges throughout the whole lifetime of an oil or gas field focusing on corrosion management, material selection & corrosion inhibitor evaluation. Failure analysis results in the improvement of specifications and is used to challenge suppliers during technical audits.

Petrophysics & Reservoir Technology
Provides petrophysical services such as RCA and SCA including planning and consultancy, as well as integrated studies supporting EOR projects. In addition, reservoir fluids under varying pressure and temperature conditions are investigated with respect to their phase behaviour and physical properties.

Fluid Analytics & Production Chemistry
Offers an extensive range of fluid analytics (e.g. analysis and characterisation of produced water, natural and process gases, liquid hydrocarbons, process fluids), flow assurance (assessment of paraffin & scale inhibitors, emulsion breakers) and support for well testing & stimulation, water handling, PWRI, IOR & EOR and tracer studies.
Geosciences

- Applied Structural Geology
- Petroleum Systems Modeling
- Play and Prospect Generation
- Seismic Data Acquisition, Processing and Imaging Modeling
- Reservoir Geophysics
- Geophysical Reservoir Monitoring
The use of modern applied structural geology techniques can boost exploration efficiency significantly – giving OMV a clear head start, even when subsurface data is not available.

Applied structural geology facilitates the prognosis of subsurface structures in complexly deformed areas – an aspect of paramount importance for the generation of drilling prospects. Challenges include lack of well control and poor imaging quality of seismic data, whereby drilling prospects have a high structural risk. In order to de-risk the structure, OMV constructs balanced cross-sections that are the key to unravelling subsurface structures and generating admissible interpretations. The construction of cross-sections is done by integrating surface and subsurface data and information from the regional setting. The integration and construction work is performed using high-end 3D structural-modelling software. Kinematical forward modelling is applied to unravel the evolution of a structure or region through time, while restoration and balancing techniques are used to validate structural models and interpretations.

Furthermore fault seal analysis is conducted in fault bounded prospects to assess possible cross-fault flow - an important knowledge gain for Exploration and Production related topics (e.g. compartmentalization, reliable volumes and fluid estimates).

The main benefits of applied structural geology are: Improve the assessment of prospect risks (structure and trap, charge and timing, seal), lower the uncertainty on volume-estimates, and expand the regional understanding of complex deformed areas.
The image below shows the data integration (Points 1-4), a construction tool (Point 5), as well as the final constructed section (Point 6) and its partial restoration (B).

**Technology benefits**
- Improved prospect and lead mapping based on consistent structural models
- Reduced exploration risk with respect to the following risk elements: structure and trap presence, seal presence and quality, charge timing
- Detailed documentation ensures future confirmability

### Structural Modelling – Kirthar Fold Belt, Pakistan

The Kirthar fold belt is tectonically deformed with high potential to trap hydrocarbons in antclinal structures. The complex structures of the fold belt have been poorly understood with no consistent structural and kinematic model available prior to the project. Surface and subsurface data were integrated with regional geodynamic constraints in order to construct balanced structural sections. These sections were then used as guidelines for seismic interpretation of leads and prospects.

- Surface and subsurface data were integrated with regional geodynamic constraints to construct balanced structural sections.
- These sections were then used as guidelines for seismic interpretation of leads and prospects.

### Fault Seal Analysis – North Sea Prospect

The analysis helped to de-risk a fault-bounded prospect in the North Sea. The image below shows a 3D view of the main fault with the projected horizon cut-offs of all stratigraphic intervals. The constructed model was used to assess cross-fault relations between reservoir and non-reservoir. For areas of reservoir-reservoir juxtaposition the calculated fault rock attributes helped to estimate fault seal capacity. Furthermore, permeability values of fault rocks and hydrocarbon column height were evaluated.

### Integrated Fault Seal Studies

- **Technology implementation and results**
  - 1D Triangle and 3D Allan Diagrams
  - Lithology juxtaposition and cross fault relations
  - Fault rock attribute calculations
  - Leaking points, spill points, HC column heights & volume estimations
  - Fault permeability plots, capillary pressure plots
  - Field compartmentalisation and cross-fault flow estimates during production
  - Improved understanding of risk and uncertainty

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**A**  
1. Slanted view, integration of data, section construction and final section in MOVE software  
2. Geological map  
3. Dip and strike from outcrops  
4. Formation tops from well  
5. Seismic data  
6. Bisectors (red) used to guide horizon construction  
7. Final balanced cross section with coloured formations  

**B**  
1. Restored section, line length and area balanced

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**Geosciences | Applied Structural Geology**
OMV has excellent skills in basin modeling and organic geochemistry to be applied for conventional and unconventional projects.

Petroleum systems modeling is a standard tool to assess the hydrocarbon potential of a sedimentary basin with a focus on source rock distribution and quality, oil-source and oil-oil correlation and the modeling of prospects' access to charge. Numerical 3D basin models deliver an understanding of the thermal maturity of source rocks and the associated timing of petroleum generation and expulsion and phase prediction. In near-field exploration, basin modeling studies focus on the simulation of migration pathways and the distribution of accumulations, thereby serving as a tool in the play definition and prospect ranking process.

The OMV Petroleum Systems Group generates robust 3D basin models around the globe to evaluate entire basins, defined acreage areas or individual drilling prospects (e.g. Black Sea/ Bulgaria, New Zealand, Abu Dhabi, Tunisia, Madagascar).

Petroleum systems modeling has developed into a powerful tool for the risking and ranking of prospects, plays and basins. It has become a driving force for improved decision-making.
Business Impact
- Reduced exploration risk with regard to hydrocarbon charge
- Reduced uncertainty with regard to expected hydrocarbon volumes
- Reduced costs through improved decisions
- Improved Well Design (Pore Pressure Prediction)

Map-based 3D Basin Modeling in the Ghadames Basin

The Ghadames Basin in the south of Tunisia is a mature hydrocarbon province with numerous oil and gas fields present in Paleozoic and Mesozoic reservoirs. Due to the excellent geological and organic geochemical data coverage of the region, the Ghadames Basin is ideal for a high-end basin modeling study.

A calibrated 3D basin model was constructed to understand migration pathways, the distribution of oil and gas accumulations and to locate near-field opportunities. Risk index maps were created for various reservoir layers to identify the likelihood of traps being filled.

The basin modeling results play a vital role in the prospect definition and ranking process and deliver support for actual drill or drop decisions.

Ghadames Basin, Tunisia
- World class Paleozoic Source Rocks ("Hot Shales")
- Various Reservoir Levels (Paleozoic, Mesozoic)
- Mature Hydrocarbon Province
- Near-field Opportunities
Play and prospect generation is a critical element in any exploration company’s toolbox. This tool relies on the proper application of multiple technologies combined with the interpretational skills of OMV explorers.

Play and prospect generation allows OMV to increase production in the vicinity of mature fields by adding new resources next to the existing infrastructure. It involves feeding the exploration funnel by basin-scale creative play concepts and making sure that resource replacement is on track.

In addition to generating step-out or wild-cat drilling targets, both near-field and frontier exploration require new play concepts which could revitalize existing fields or open up new exploration play fairways in an un(der)explored basin. The challenge for near-field exploration is to fully understand the petroleum systems in an existing field and to try to find the upside potential via the integration of various geosciences data sets. The challenge for frontier exploration is the ability to look at the basin on a regional scale and see beyond the data gaps, e.g. by using play fairway analysis.

The use of various technologies should culminate in the definition of plays and leads/prospects in any exploration program, anywhere in the world.

This play type cartoon summary of deepwater Bulgaria was developed by OMV using vintage 2D seismic data, prior to the acquisition of the very large 7,800 km² 3D seismic survey over the block.
The Oligocene Varna Cone. This concept was developed by OMV to predict numerous slope and basin floor complexes providing multiple reservoir targets in offshore Bulgaria and Turkey.

The basement structure in the Habban field area in Yemen is well defined by 3D seismic data and shows a non-systematic relationship to the distribution of the overlying salt.

Results
- Reprocessing of the vintage 2D seismic with the latest PSDM CBM technology led to a new interpretation of the near-field exploration opportunities.
- Modern salt tectonics interpretation techniques explained a dry hole and delineated new drillable fractured basement prospects.

Results
- Systematic evaluation of the regional geology led to the definition of various play types not considered before.
- Follow-up 2D and 3D seismic surveys provided a proof on concept and led to drillable, play-opener prospects in deepwater Bulgaria.

Bulgaria offshore
- Play concepts defined
- Predicted Oligocene reservoir fairways pre-3D
- Drill-ready targets as mapped on 3D seismic
Extended geophysical expertise enables OMV to base complex management decisions on high-quality onshore and offshore seismic data, using state-of-the-art acquisition systems to deliver data fit for imaging the subsurface with the most sophisticated algorithms.

Successful subsurface imaging relies on acquiring high-quality 2D and 3D seismic data, and starts with the design of optimum recording parameters and geometry. Geophysical data acquisition is the most cost-intensive stage in the geophysical workflow, and so demands particular care. The in-house processing and imaging capabilities of the OMV Center of Excellence (CoE) for Geophysics ensure a high standard of quality control over contractor processing.

OMV’s expertise in seismic acquisition design and modeling enables it to determine optimum acquisition parameters as a basis for more detailed planning. The acquisition parameters are defined and the necessary documentation provides support throughout the whole process from tender to contract preparation. The CoE offers HSSE support for seismic data acquisition in such a way that personnel, the environment, assets, and OMV’s reputation are protected.
In-house processing and imaging capabilities are another key competency. OMV’s Seismic Processing Centre has grown over four decades and is an integral asset to the company. State-of-the-art processing tools and workflows are implemented regularly within the Center of Excellence for Geophysics for land data (e.g. wide azimuth processing, internal multiple attenuation), marine data (e.g. broadband processing, advanced multiple attenuation flows), and for seismic imaging (e.g. Kirchhoff, Beam and Reverse Time Migration).

With this setup and strong cooperation with CGG – a world-leading provider of geophysical services – OMV ensures high quality seismic imaging products for the ventures. In particular, developing and re-developing fields covered with vintage data greatly benefit from the continuously improved in-house technologies and workflows.

**Vienna Basin**

This project in the Vienna Basin, Austria is a prime example of the benefit of modern seismic data imaging tools on a vintage dataset within a complex geologic environment. First, the re-processing and merging of eleven different seismic surveys established a new geophysical basis for the (re-) development of oil and gas fields in the Vienna Basin. State-of-the-art processing tools and OMV’s long-standing expertise related to the basin resulted in an outstanding 2,000 km² seismic volume fit for modern interpretation techniques.

Common Reflection Surface (CRS) processing was also applied on a highly prospective area within the seismic volume to further enhance pre-stack data quality. This was then followed by Controlled Beam Migration (CBM): A multi-arrival alternative to Kirchhoff migration that can provide cleaner images as well as improved signal-to-noise ratio and steep-dip imaging in complex geological settings.

Combined CRS and CBM significantly improved the delineation of thrust sheets and sedimentary features.

A precise seismic image and sub-surface model can ensure major savings during every phase of operation.
A dedicated reservoir geophysics team at OMV maximizes the value of information for subsurface characterization. Decreasing uncertainty in this area by using comprehensive geophysical datasets undoubtedly has a significant impact on all kinds of Upstream projects.

Conventional seismic data provide sufficient areal coverage but are often limited in vertical resolution. In contrast, well logs provide excellent resolution but are valid only within a small area around the well. By combining the strength of both worlds, detailed lithology and fluid property volumes can be generated to enable superior interpretations and robust estimates of pore fluid distribution and key reservoir parameters such as net pay and porosity.

Extensive expertise in reservoir geophysics is essential for the characterization and delineation of hydrocarbon reservoirs and thus for the success of exploration and production projects. Close cooperation between geophysicists and interpreters is critical for addressing the prospectivity of new and mature reservoirs.

A reservoir geophysics project supports the identification and delineation of prospects and delivers input for characterizing the internal geometry and quality of reservoirs. Typical reservoir geophysics workflows comprise Amplitude versus Offset (AVO) analysis, rock physics studies, seismic inversion, and seismic attribute studies.

Assessment of reservoir sand distribution using spectral decomposition technology.
Nawara Development project, stochastic inversion

The Nawara Development project is a key strategic infrastructure project to allow Tunisia to unlock its gas resources in the south. For OMV, this joint project with ETAP is a substantial part of its growth story in Tunisia and within its international portfolio.

Challenging geological conditions in the Nawara field complicate seismic imaging, while sub-seismic reservoir layers and interbed multiples hamper the possibility of quantitative interpretation of deterministic seismic inversion deliverables. Stochastic seismic inversion technology is based on pre-conditioned seismic and multiple well information and has allowed OMV to overcome the difficulties and get probabilistic results, as well as assessing the volumetric estimates. Interpretation of the results is based on previous rock physics analysis, converting elastic properties into quantitative interpretation.

Results

- The volume of sand probability calculated based on multiple realizations of Impedance-Vp/Vs from stochastic inversion allowed OMV to assess the uncertainty.
- It was also used to evaluate the ranges of reservoir parameters, an important predictor of the performance and economics of producing fields.

Nawara Concession, relative P-Impedance inverted from a Mid-Stack Seismic Mega-Merge

Section through the volume of sand probability, calculated on the basis of multiple realizations of Impedance-Vp/Vs from stochastic inversion

Nawara, Tunisia

The Nawara Development project is a key strategic infrastructure project for Tunisia enabling the unlocking of South Tunisia’s gas resources.
Geophysical reservoir monitoring is crucial for optimizing production at OMV. Improved/Enhanced oil recovery (IOR/EOR) by fluid and steam injection is an important technique used in many of OMV’s mature reservoirs.

Monitoring subsurface processes is crucial for optimizing production from these reservoirs. In particular fluid injection for IOR/EOR requires knowledge of the fluid migration, and its effect on the reservoir rock and the hydrocarbon distribution within the reservoir. Recent studies demonstrate that permanent reservoir monitoring (PRM) reveals changes in the subsurface; however the interpretation is often ambiguous.

IOR/EOR techniques can cause reactivation of existing shear faults and new opening of cracks which in turn emit seismic energy. Microseismic monitoring is used to detect and localize the sources of these seismic waves, thereby providing insight into the propagating fluid front and efficiency of the injection. Similar applications of microseismic monitoring are related to the stimulation of tight gas or monitoring of underground gas storage.

Microseismic is a multidisciplinary endeavor that requires close cooperation between Geophysics, Geology, Geomechanics, and Reservoir Engineering to establish a comprehensive understanding of IOR/EOR efficiency. In general, microseismic monitoring is OMV’s preferred tool to optimize stimulation of tight gas, gas storage surveillance, and IOR/EOR projects.
Microseismic Monitoring in the Tazlau field, Romania

In the Tazlau field in the north-east of Romania Improved Oil Recovery using water injection started in 1949. Microseismic monitoring was applied with concurrent water injection at ~1,000 m depth. The integrated interpretation of microseismic data from the onshore field showed that the current water injection program for IOR into the reservoir was inefficient.

A significant discrepancy between the eastern and western parts of the area became evident. The low PSH ratio in the western part suggests high fracture density above the target formation and thus a less favorable environment for water injection.

Technology implementation and results

- Microseismic monitoring with concurrent water injection performed at ~1,000 m depth
- A discrepancy was discovered between the eastern and western parts of the area
- Water injection was switched from K-II to the upper K-I formation to improve efficiency
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