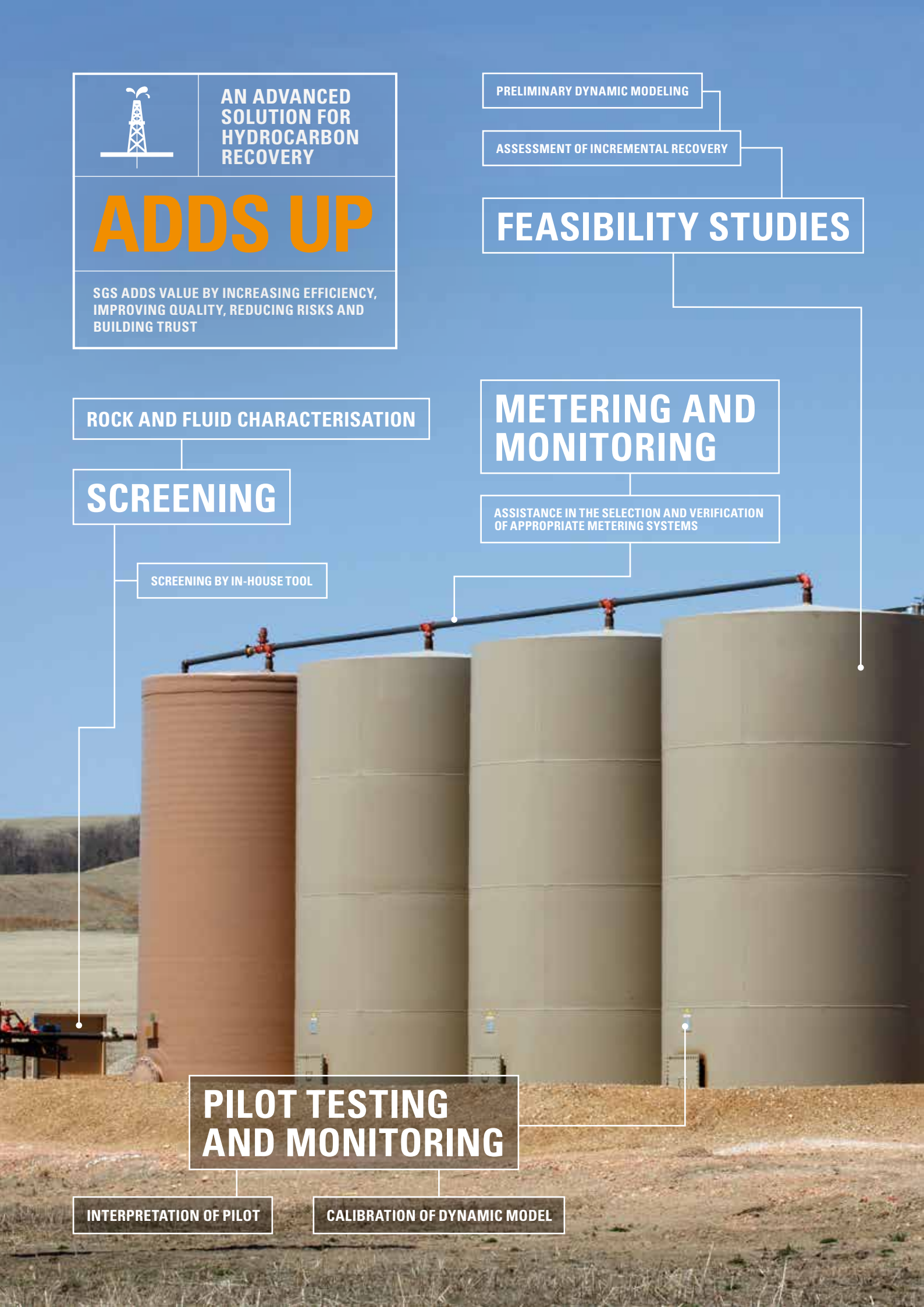
AN ADVANCED SOLUTION FOR HYDROCARBON RECOVERY ADDS UP

SGS ENHANCED OIL RECOVERY SERVICES

SGS



AN ADVANCED SOLUTION FOR HYDROCARBON RECOVERY

ADDS UP

SGS ADDS VALUE BY INCREASING EFFICIENCY, IMPROVING QUALITY, REDUCING RISKS AND BUILDING TRUST

PRELIMINARY DYNAMIC MODELING

ASSESSMENT OF INCREMENTAL RECOVERY

FEASIBILITY STUDIES

METERING AND MONITORING

ASSISTANCE IN THE SELECTION AND VERIFICATION OF APPROPRIATE METERING SYSTEMS

ROCK AND FLUID CHARACTERISATION

SCREENING

SCREENING BY IN-HOUSE TOOL

PILOT TESTING AND MONITORING

INTERPRETATION OF PILOT

CALIBRATION OF DYNAMIC MODEL

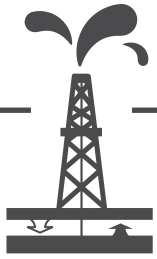

SPECIAL CORE FLOODING BY DIFFERENT INJECTORS
ROCK-FLUID CHARACTERISATION
LABORATORY INVESTIGATIONS
NUMERICAL SIMULATION OF CORE FLOODS
ANALYSIS OF LABORATORY TESTS
SELECTION OF EOR FLUID
PERFORMANCE PREDICTION
FULL FIELD PROJECT
INCORPORATION OF FIELD DATA IN DYNAMIC MODELS
UP-SCALE MODELS
DESIGN SCALE-UP TO FIELD LEVEL
RISK MANAGEMENT
PILOT DESIGN
ASSESSMENT OF GEOMECHANICS
PLAN WELL TESTS AND RESIDUAL OIL SATURATION TESTS

One of the key challenges faced by oil companies is understanding how to optimise production throughout an oilfield's entire lifecycle. This is especially true in light of recent market conditions, which have seen low oil prices and high field operation costs putting pressure on margins. These conditions demand innovative technologies that can improve oil recovery and extend the profitable lifespan of an oilfield.

PRIMARY RECOVERY

During the initial phase, or primary recovery, oil and gas production continues until the natural drive mechanisms or the original energy sources for hydrocarbon expulsion are no longer alone able to sustain profitable producing rates.

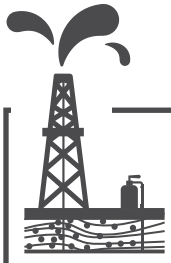
AROUND 20% RECOVERY OF A FIELD'S HYDROCARBONS



SECONDARY RECOVERY

Once natural drive mechanisms are depleted or become small for economical oil production, secondary recovery techniques are implemented to add energy to reservoir and permit additional recovery. Techniques may include water or gas injection.

ADDITIONAL 15%-20% RECOVERY OF A FIELD'S HYDROCARBONS



ENHANCED OIL RECOVERY

Increasing a reservoir's lifespan requires application of special techniques, commonly referred to as enhanced oil recovery (EOR). EOR methods increase hydrocarbon recovery factors by improving displacement efficiency, reducing residual oil saturation and adding drive mechanisms – stimulating the flow of oil trapped in the reservoir. EOR methods can be divided into the following main groups: chemical, miscible or solvent injection, thermal, and other techniques like low salinity water injection, or warming up the reservoir fluid by injection of steam or in-situ combustion.

ADDITIONAL 5%-20% RECOVERY OF A FIELD'S HYDROCARBONS

WHAT IS ENHANCED OIL RECOVERY (EOR)?

Enhanced oil recovery (EOR) is the implementation of various techniques to increase production from a hydrocarbon field by improving displacement efficiency, reducing residual oil saturation and adding drive mechanisms – stimulating the flow of oil trapped in the reservoir. Applied by itself or in combination with secondary recovery techniques (e.g. waterflooding, gas injection), EOR offers the potential to generate 5 percent to 20 percent incremental oil production above both primary and secondary recovery mechanisms.

WHY EOR?

Primary and secondary recovery processes, in general, can extract up to around 35 percent of the oil in a reservoir. However, when EOR methods are implemented, depending on the reservoir, up to 70 percent of oil present in a reservoir can be recovered.

WHY SGS?

SGS has extensive experience in reservoir management across a wide array of project types. In particular, during the last decade, SGS has been involved in a variety of improved oil recovery (IOR) and enhanced oil recovery (EOR) projects for oil and gas operators. To date these have mostly involved studies in the North Sea, North Africa and Eastern Europe.

SGS' expertise in EOR covers a broad range of activities from screening and feasibility studies, integrated reservoir studies, pilot design, full field static and dynamic modeling; to financial calculations, laboratory experiments, core flooding, risk management and Health, Safety and Environment (HSE) studies. In EOR, miscible gas injection, polymer injection, and steam injection are major areas of expertise for SGS.

SGS has developed innovative technologies and integrated workflows to support the field operator in the selection of appropriate and economically feasible EOR technologies. Our extensive EOR experience, along with our hydrocarbon analytical capabilities, is why SGS adds up to be the ideal choice for supporting your EOR project.

OGC UPSTREAM SERVICES PORTFOLIO

Cased Hole Wireline

- E-line and slickline units
- Well and pipe integrity
- Well intervention
- Well production
- Well perforation
- Downhole sampling

Testing and Production

- Surface well test
- Multiphase meters
- Drill stem testing and tubing conveyed perforating
- Heliportable test separator
- Bottom hole sampling

Reservoir Analytical Services

- Advanced reservoir fluids laboratories (e.g. PVT, EOR, production chemistry)
- Portable laboratory services
- Well site chemistry kits
- Advanced sampling and analyses
- Geological studies (e.g. CA, RCA, SCAL, EOR, FD)

Metering and Flow Measurement

- Custody transfer
- Hydrocarbon allocation
- Emission measurement
- Calibration
- Metering operations, training and consultancy

Advanced Reservoir Quality

- Lithological analysis and Interpretation
- Mineralogy
- Geochemistry
- Drill cuttings analysis (QEMSCAN)

Gearhart Engineering

- Redback™ drilling tools
- Licensed pipe threading
- Engineering and design
- API & ISO 9001 oilfield manufacturing

Subsurface Consultancy

- Geophysics
- Seismic processing and interpretation
- Regional and reservoir geology
- Petrophysics
- Reservoir engineering
- Drilling and completions
- Facilities engineering

Equipment Inspection

- Drill pipe and tubular
- Bottom hole assembly
- Rig mast and handling equipment
- Non-destructive testing
- Mobile hard banding

INNOVATIVE, MARKET LEADING SERVICES AND SOLUTIONS

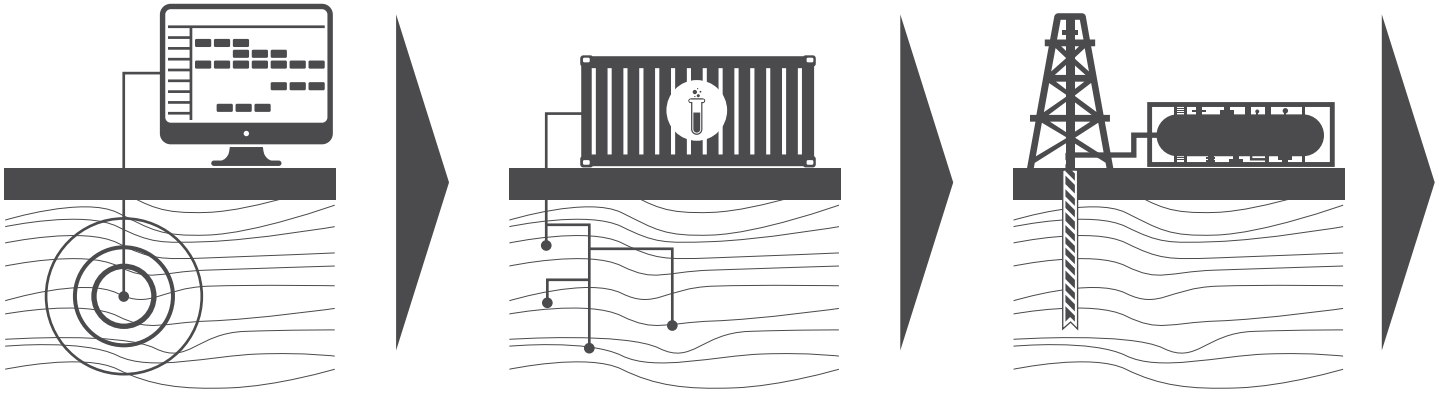
GLOBAL NETWORK OF MORE THAN 1 800 OFFICES AND LABORATORIES

DEDICATED, FIT-FOR-PURPOSE MOBILE LABORATORY CAPACITY

QUALIFIED, CUSTOMER-FOCUSED, EXPERT TEAMS

LABORATORY TESTING AND SIMULATION MODELING THROUGHOUT ALL EOR PHASES

TRUST IN SGS



SCREENING

LABORATORY INVESTIGATION

PILOT TEST AND MONITORING

MAKING EOR WORK FOR YOU

Each EOR project is unique, filled with its own particular challenges. What works for one oilfield might not work for another. That's why at SGS we focus on building customised and innovative solutions. We invest in the development of inhouse tools and workflows based on our experience and expertise.

The SGS Advanced Technologies and Innovation Centre (ATIC) is the home of our fully equipped laboratory dedicated to the development of new applied technologies for laboratory and field operations for our customers. The ATIC, combined with our global fixed and mobile laboratory capacity, and our organisational agility, enables us to provide unique, custom-made solutions for each and every customer.

SGS provides innovative services and solutions for all steps required by EOR projects. We apply advanced testing and engineering methods, and integrate laboratory data with field studies, to develop a comprehensive analysis of your reservoir. Understanding your exact needs allows us to select the EOR methods best suited to increasing recovery from your reservoir (e.g. waterflooding, gas injection, chemical EOR, thermal EOR, gas recycling).

Our EOR workflow typically covers the following elements: screening and feasibility studies, laboratory investigation, pilot test, field implementation and modelling.

SCREENING

Optimising incremental hydrocarbon production requires a rigorous screening approach. Identifying the optimal process to yield the highest return with the minimum investment requires a deep understanding of the reservoir and an in-depth knowledge of EOR technology.

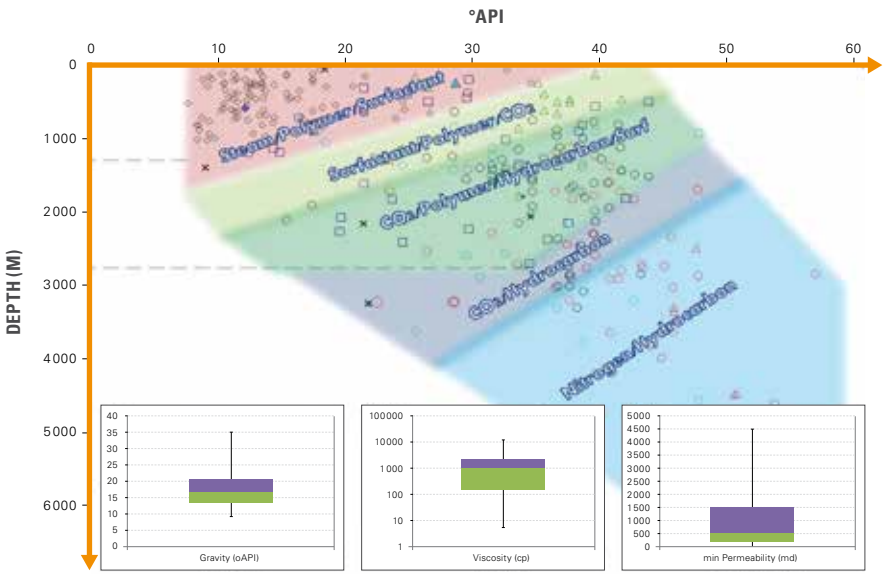
An evaluation must determine which sophisticated development approach can be implemented in order to realise maximum returns. This effectively means combining economic know-how with high-end technical expertise to optimally increase recovery.

In order to determine the optimal process for your reservoir, SGS engineers employ an in-house screening tool, which contains a detailed EOR database.

The screening tool incorporates industry standard criteria based on reservoir properties, predictive model development, dynamic simulation, and identification of critical parameters to reduce screening uncertainty.

SCREENING AT SGS

- In-house screening tool based on a comprehensive database of worldwide EOR applications
- Comparison of your asset to analogue fields
- Preliminary feasibility analysis/study
- Upfront identification of key uncertainties and risks



FULL FIELD MODELING

METERING AND MONITORING

RECOVERY INCREASE

LABORATORY INVESTIGATION

SGS' modern fixed and mobile laboratories provide a wide range of fluid analytical services, wherever you are in the world. In addition to standard laboratory tests (e.g. PVT studies for fluid characterisation, specific PVT tests for the evaluation of all EOR techniques, routine and special core analysis, coreflooding, production chemistry, fluid sampling), tailor-made tests are also performed. Specialised fluid characterisation and reservoir condition coreflooding, using in-situ fluids and a range of injectants, are performed to tailor an EOR process for your specific reservoir. After the laboratory program, a numerical simulation is also carried out using the laboratory data to support the pilot test's design.

Our goal is to minimise the timeline in the early EOR stages by optimising the experimental matrix. How? Simply by making proposals that contain the services and solutions that you really need.

Our detailed yet practical EOR questionnaire helps us to fully understand your needs and to offer tailor-made, fully-integrated solutions.

In addition to our worldwide analytical laboratories, our mobile FluidPro PAL™ can be easily shipped to any destination to facilitate analysis. These mobile laboratories provide you with a dedicated facility for PVT studies, production chemistry, sampling services and high pressure/high temperature fluid transfer services, wherever required: be it on the platform, at a centralised location or as a stand-alone remote facility. Having dedicated, customisable testing facilities available onsite helps us minimise the associated costs in sample transportation.

SGS LABORATORY SERVICES

- Specialised laboratory analyses
- Tailor-made experiments
- Fully-equipped mobile laboratories
- Cutting-edge technologies and methods tailored to reservoir characteristics
- Integrated solutions
- Precision results
- Customer-focused, expert staff

PILOT TEST, MONITORING AND EVALUATIONS

Pilot tests, and single well tracer tests, play a key role in our systematic and staged evaluation of potential EOR implementations. Field pilot tests are conducted to address key technical and commercial uncertainties, plus to establish associated risk from application of any potential EOR method in a specific reservoir. A pilot is an option to reduce risk and we will advise you in weighing the benefits of the pilot against other available alternatives to reduce risk.

We help you to mitigate key uncertainties and risks by clearly defining the objectives of the pilot at the beginning of the project. Pilot objectives could include:

- Evaluation of EOR process recovery efficiency in the reservoir of interest
- Assessment of the effects of reservoir geology on process performance
- Collection of additional data for model calibration and predictions
- Identification of operational issues
- Economics
- Combination of any/all of the above.

Once the pilot objectives are established, we deliver a fit-for-purpose pilot test design and a simulation model of the pilot test for your reservoir.

Our multidisciplinary expert team assist you during the design, implementation, monitoring, field data validation and interpretation of the pilot test. Static and dynamic models are continuously updated based on the obtained results.

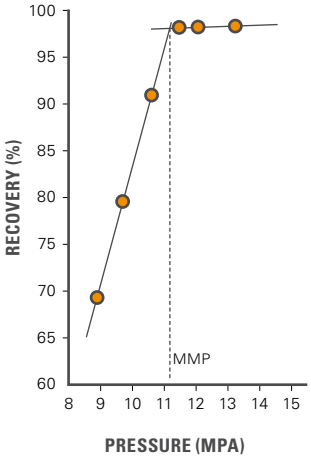
Our technical support and guidance accompanies you throughout the pilot phase.

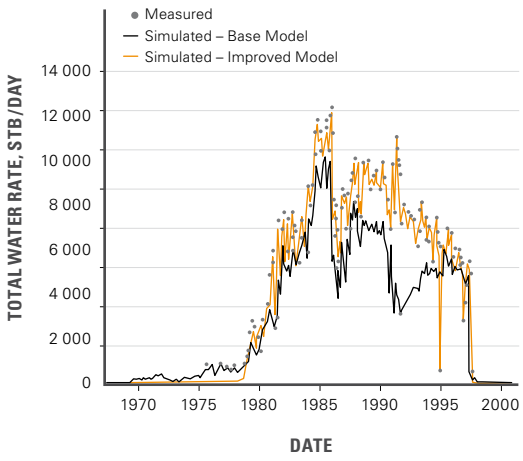
SGS PILOT TESTS

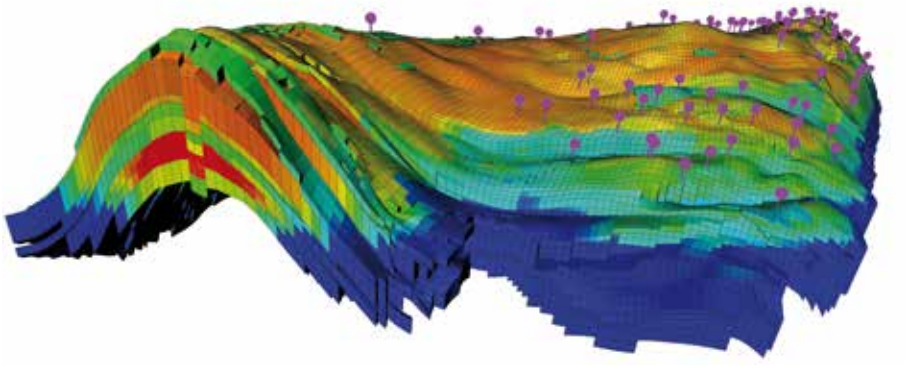
- Expert advice on pilot benefits, pre-pilot tests and potential alternatives
- Tailored pilot design to mitigate risks in your field

SCALE UP TO FULL FIELD MODELING

The pilot test results are evaluated by an expert SGS team. The acquired data is quality-controlled to enable effective use in the calibration of the reservoir model. SGS EOR specialists provide a full field redevelopment plan based on the updated static and dynamic reservoir models and all proceeding steps taken in the staged evaluation and development process. This in turn provides an effective reservoir management tool to deliver optimum recovery and economic returns.







SGS FULL FIELD MODELING

- Multidisciplinary expert team
- Worldwide track record in field development and redevelopment of conventional, non-conventional, and EOR fields
- Experience in economic evaluation and reserve certifications

METERING

Depending on the EOR method selected, the implementation of any EOR programme changes the composition of the hydrocarbon streams in the surface facilities (e.g. pipelines).

In the case of enhanced recovery of heavy oil, specific metering challenges need to be addressed. As such, any installed metering systems need to be verified and potentially adapted. This is to ensure that they continue to provide accurate and reliable measurement of throughput and that the maintenance of closed loop (multiphase) flow control, and monitoring of the phase envelopes of hydrocarbons and related product is achievable.

SGS is the leading global provider of measurement related engineering consultancy, metering management, verification, inspection and testing services to the petroleum and chemical industries. We are therefore ideally placed to provide the specialist services associated with the implementation of EOR projects.

SGS holds UKAS accreditation (Type A Inspection Body) to cover the design, review, and testing of hydrocarbon measurement systems. We also hold certification under the European Measuring Instruments Directive (MID).

Our measurement specialists have expertise in EOR project implementation. Their experience ranges from fiscal and allocation measurement system operations and independent system audits to flow meter selection and verification. This allows them to apply industry specific best practices.

SGS experts can assist in the selection and verification of appropriate metering systems for miscible, immiscible and chemical injection processes, including the metering of CO_2 (e.g. for breakthrough detection), surfactants, alkaline agents, as well as water injection rates associated with steam heating. Accurate measurement of EOR flood materials may contribute to a reduction of costs associated with improved flood-fluid material supply and inventory management.

SGS FULL FIELD IMPLEMENTATION

- Support for the complete range of common EOR monitoring techniques, including tracer surveys, cased hole logging surveys and seismic monitoring
- Excellent track record in reservoir fluid monitoring
- Accurate metering facilities and services

MONITORING

Monitoring of reservoir flow behaviour is paramount in determining the vertical and areal sweep efficiency in the reservoir. Feedback provides insights into the sweep performance that can then be applied to optimise the EOR process (e.g. injectant selection, dosage).

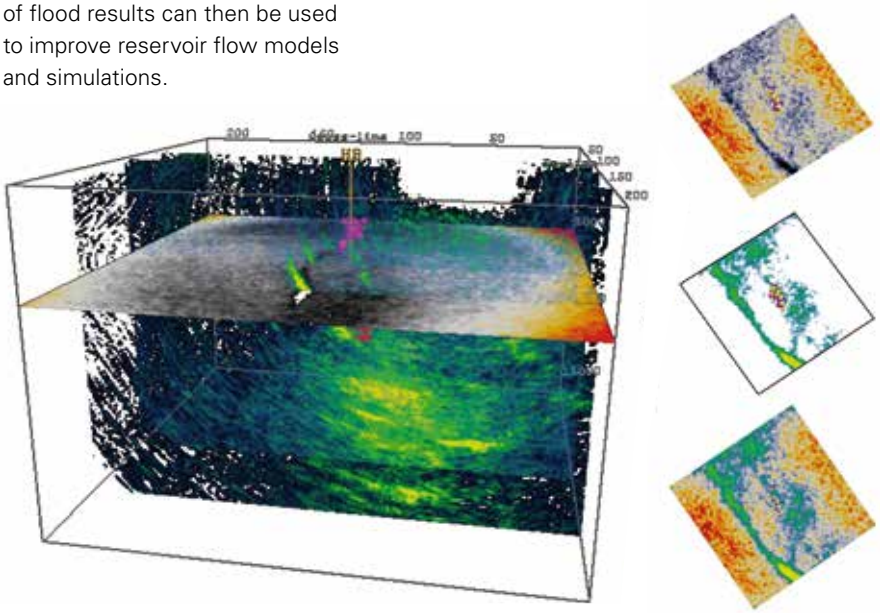
SGS provides support for the complete range of common EOR monitoring techniques, including tracer surveys, cased hole logging surveys and seismic monitoring.

Our specialists can assist in the design and interpretation of tracer surveys, and in turn liaise with SGS reservoir engineering experts to refine or validate reservoir flow simulation models.

In addition, SGS has extensive expertise in the completion of cased hole logging surveys and can provide support in the implementation of cased hole wireline logging surveys to monitor and evaluate variations in production rates resulting from the applied EOR method.

SGS geophysical experts can assist in the design, processing and interpretation of 4D seismic surveys in order to determine the effectiveness of the selected EOR method. Our reservoir engineers and geoscientists evaluation of flood results can then be used to improve reservoir flow models and simulations.

The application of these monitoring methods along with our integrated interpretation approach facilitates an evaluation and potential adaptation of EOR methods that fully optimises your hydrocarbon production.



ENHANCED OIL RECOVERY SERVICES AT SGS

SCREENING

- Rock and fluid characterisation
- Comparison to analogues
- Screening by inhouse tool

FEASIBILITY STUDIES

- Uncertainty analysis
- Preliminary dynamic modeling
- Assessment of incremental recovery
- Economic analysis

LABORATORY INVESTIGATIONS

- Innovative, tailormade experiment design for specific EOR techniques
- Additional standard techniques
- Rock-fluid characterisation
- Special core flooding by different injectors

ANALYSIS OF LABORATORY TESTS

- QC and interpretation of laboratory tests
- Numerical simulation of core floods
- Selection of EOR fluid
- Model calibration based on laboratory results

PILOT DESIGN

- Definition of pilot objectives
- Design pilot facilities
- Plan well tests and residual oil saturation tests
- Assessment of geomechanics
- Dynamic simulation of planned pilot

PILOT TESTING AND MONITORING

- Monitoring of technical and operational performance of the pilot
- Interpretation of pilot and calibration of dynamic model
- Facilities evaluation
- Update of economical analysis

DESIGN SCALE UP TO FIELD LEVEL

- Plan full field implementation
- Up-scale models
- Facility assessment
- Economic analysis
- HSE
- Risk management

FULL FIELD PROJECT

- Incorporation of field data in dynamic models
- Performance prediction
- Optimisation of reservoir, operational and economic performance

METERING AND MONITORING

- Assistance in the selection and verification of appropriate metering systems
- Assistance in the design and interpretation of common EOR monitoring techniques:
  - Tracer surveys
  - Cased hole logging surveys
  - Seismic monitoring

BENEFITS

SGS ADDS UP

SGS is the world's leading inspection, verification, testing and certification company. Recognised as the global benchmark for quality and integrity, we employ over 85 000 people and operate a network of more than 1 800 offices and laboratories around the world. We are constantly looking beyond customers' and society's expectations in order to deliver market-leading services wherever they are needed.

We have a history of undertaking and successfully executing large-scale, complex international projects. With a presence in every single region around the globe, our people speak the language and understand the culture of the local market and operate globally in a consistent, reliable and effective manner.

We provide innovative services and solutions for every part of the oil, gas and chemicals industry. Our global network of offices and laboratories, alongside our dedicated team, allows us to respond to your needs, when and where they occur. Our reputation for independence, excellence and innovation has established us as the market leader in providing services that improve efficiency, reduce risk and deliver competitive advantage for you.

FOR MORE INFORMATION ON SGS ENHANCED OIL RECOVERY SERVICES CONTACT OGC@SGS.COM OR VISIT WWW.SGS.COM/OGC

- IMPROVED EFFICIENCY
- INCREASED PRODUCTIVITY
- REDUCED RISK

WWW.SGS.COM

WHEN YOU NEED TO BE SURE

SGS