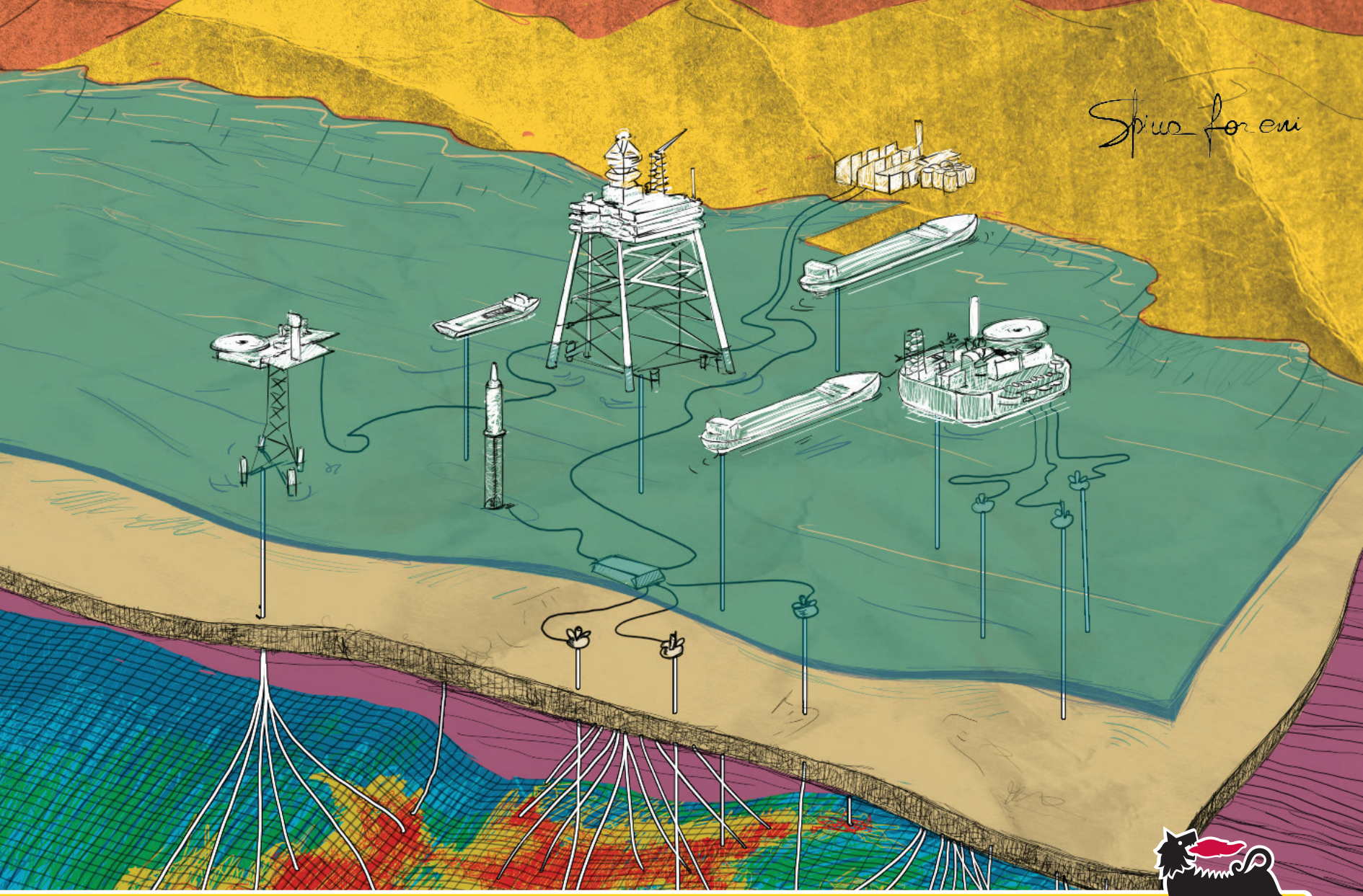

reservoir & petroleum engineering

eni

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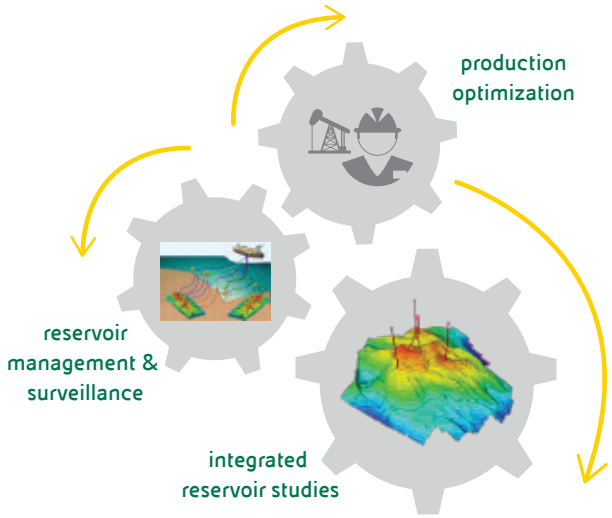
eni's vision for optimal reservoir management

The main goals of the Reservoir Engineering & Petroleum Department are carrying out integrated reservoir studies using the latest technologies and state-of-the-art tools, supporting the Business Units and Project Teams with expertise and providing guidelines for optimal reservoir management.

Our activities can be grouped into four main categories:

- integrated reservoir studies for conventional and unconventional reservoirs
- improved and enhanced oil recovery studies
- reservoir management guidelines and studies
- specialist studies

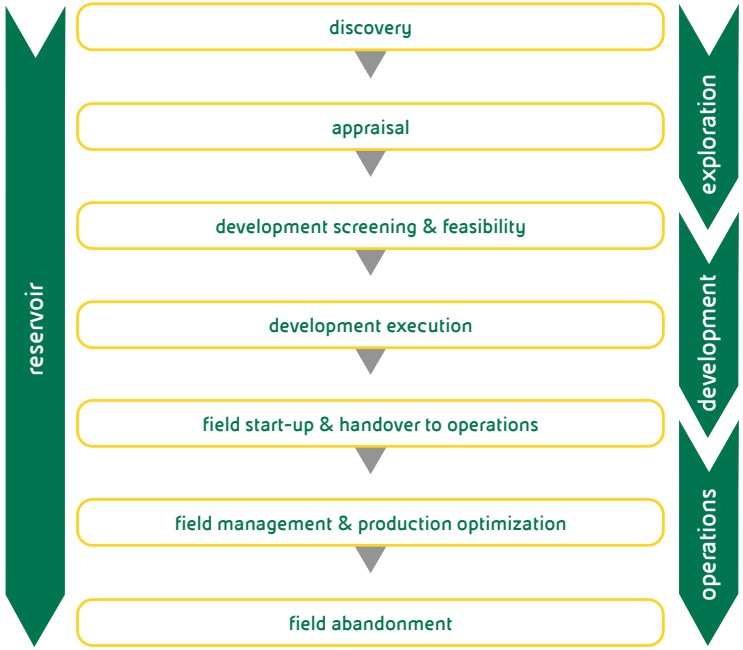


our strategy

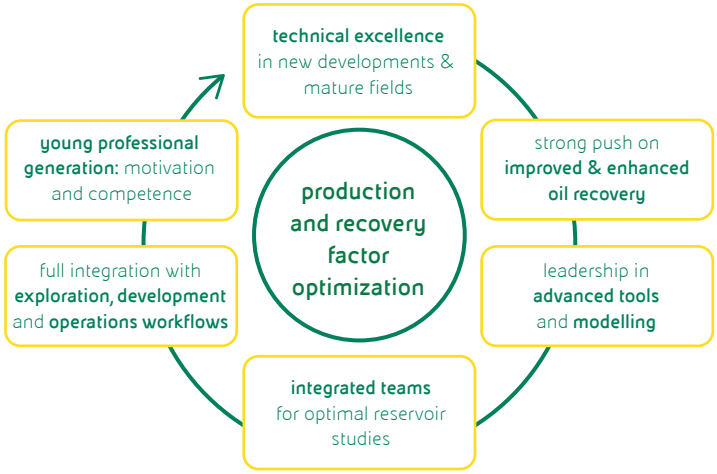
The Reservoir Engineering & Petroleum Department's strategy is to follow the entire life-cycle of any given asset from exploration to abandonment.

Integrated reservoir models and proper reservoir management practices are at the heart of this process.

Asset value is maximized by optimizing production on the short-term period, while recovery factors are increased by means of the latest technologies and state-of-the-art workflows.



Our approach is based on six pillars which leverage the excellence of our people, inter-departmental integration and leadership on advanced modelling tools.



Our efforts are concentrated on the characterization and study of complex reservoirs in many different environments from desert to deep-water. New developments are becoming more and more complex, therefore, particular attention is paid to the accuracy and robustness of our production forecasts.

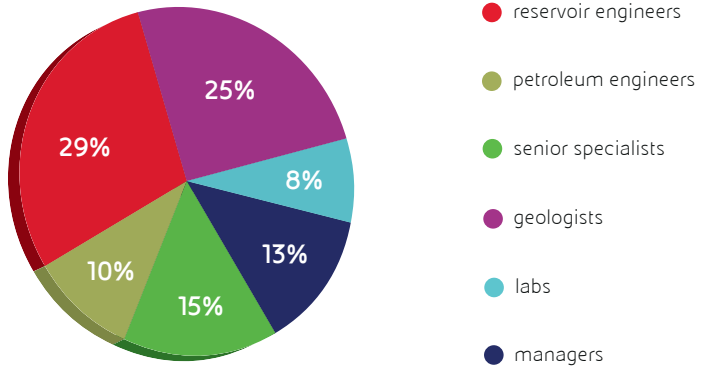
On the other hand, the bulk of the company's production comes from mature assets. These are continuously studied and rejuvenated by means of new, improved and enhanced oil recovery techniques.

our professional family

The Reservoir & Petroleum professional family consists of about 900 professionals in almost 30 different countries, about 300 of which in the Milan headquarters. The headquarter team is responsible of reservoir modelling, know-how management and best practices implementation, and carries out main reservoir studies for all the **eni** Business Units worldwide.

An average of over 100 integrated reservoir studies per year are usually performed, which represent the driving force for new ideas generation both in production optimization and new development concepts, for Green and Brown fields.

The intense technical competence is the backbone of our professional family which, along with the development and motivation of our professionals, is the key for success and boost for the generation of new development ideas.



| Current Distribution of the Reservoir & Petroleum professional family

eni reservoir & petroleum engineering technologies and workflows portfolio

We are always seeking innovative technological solutions aimed at maximizing field production and recovery factors.

The oil industry's state-of-the-art technologies and "best-in-class" software are currently used by **eni** for reservoir characterization, modelling and management. In addition, we are collaborating with several universities and research institutes in order to develop knowledge and competencies in various areas of reservoir and petroleum engineering.

In this brochure, we will cover the following topics:

- Reservoir Characterization
- Reservoir Geomodelling
- Reservoir Dynamic Simulation
- Uncertainties Evaluation & Risk Analysis
- Geomechanics
- Reservoir Management
- Improved & Enhanced Oil Recovery Techniques
- Unconventional Reservoirs

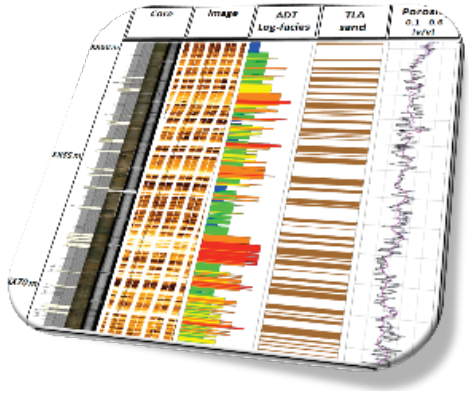
reservoir characterization technologies

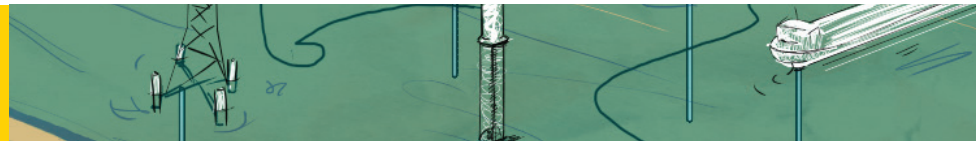
Reservoir characterization requires a multidisciplinary team effort. It involves systematic integration of well log and core analysis data with mud logging, pressure, production and seismic data in order to generate an accurate petrophysical model to be used in reservoir studies. Reservoir characterization comprises main steps like operational follow-up, data gathering and QC, quick-look interpretation, fluid contacts and compartments identification, integrated petrophysical characterization, facies and properties identification and characterization. All these activities can be conducted for any kind of reservoir, namely: clastics, carbonates, naturally fractured, tight, thin beds and unconventionals.

e-tlac
eni thin layers analysis and characterization

thin layers analysis and characterization

e-TLAC™ is **eni**'s new proprietary model-based methodology to study very thin layered reservoirs. It allows the evaluation of thickness and main petrophysical properties (porosity, water saturation) of alternated sand/shale thin beds, as well as a detailed estimate of hydrocarbons-in-place (OHIP) that may not be properly identified by conventional log surveys.

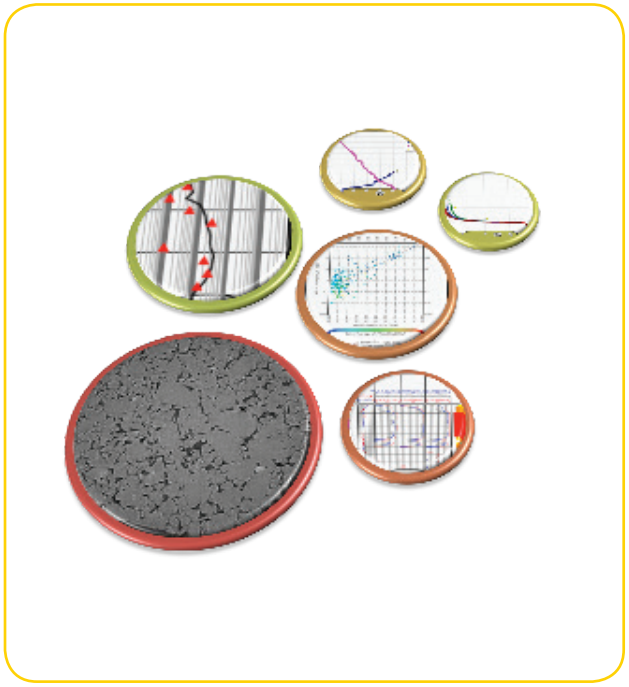




carbonate petrophysics

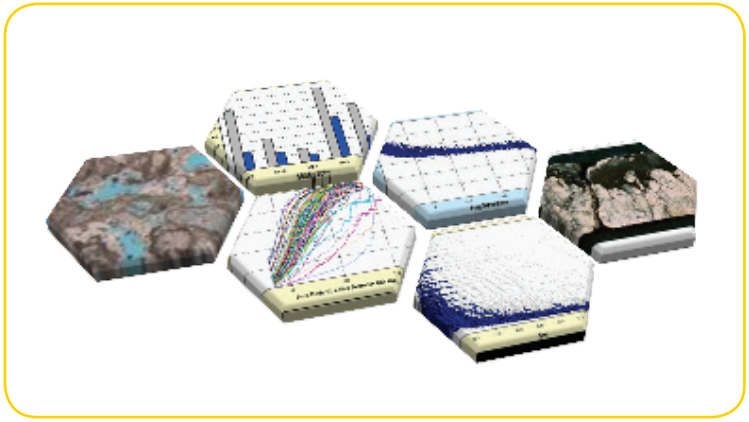
Carbonate rocks are described and classified by integrating paleoambiental, sedimentological and petrophysical features as diagenesis.

The high complexity of the porous system in carbonates requires an accurate multi-scale analysis. Core-log integration is crucial for a proper formation evaluation.



reservoir rock typing (RRT)

Reservoir Rock Typing is a supervised core propagation approach, allowing the definition of classes with a well-defined permeability/ porosity relationship.



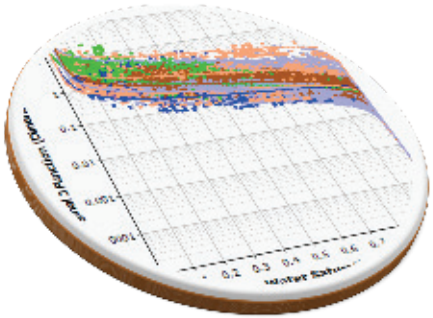
Core data, in particular Mercury Injection Capillary Pressure (MICP) curves, are used "a priori" to define the Core RRTs, that are in turn used as a training data set for the log recognition.

Propagation along the non-cored intervals is done by means of a great variety of supervised and unsupervised facies classification methods, like the kNN (k Nearest Neighbor).

advanced saturation data analysis and modelling

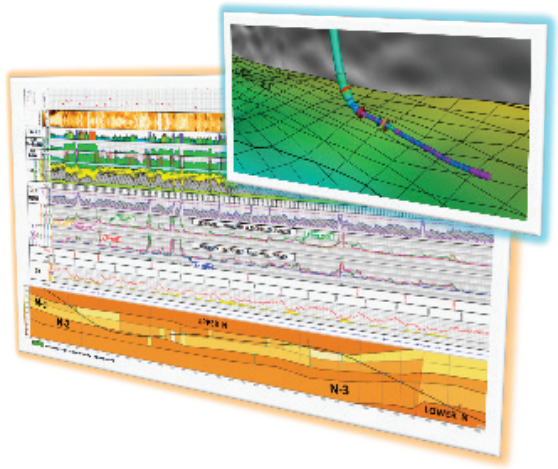
eni has defined an integrated workflow which focuses on the identification of facies, called "J-Facies", through the definition of "log derived J-Function" and their comparison with the "capillary pressure derived J-Function".

This allows a more reliable estimate of fluid contacts and petrophysical properties from logs at reservoir scale.



proactive geosteering and landing

Recent developments in measurement-while-drilling (MWD) and logging-while-drilling (LWD) technologies are giving a new strong impulse to geosteering and well placement methodology.



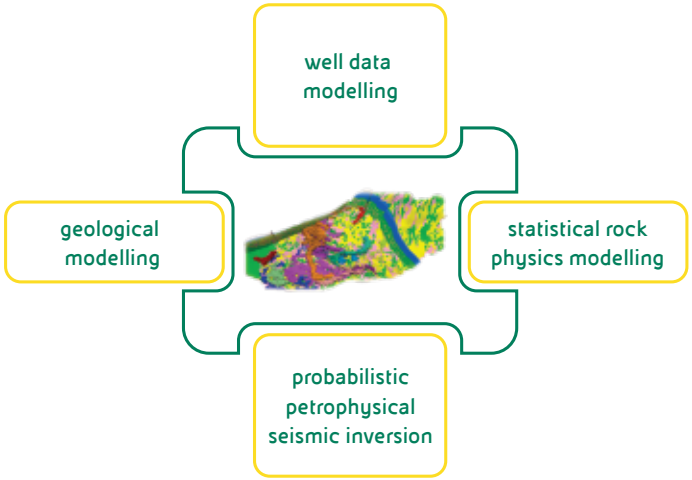
An interactive workflow, integrating real time operation follow-up and log interpretation with 3D reservoir model continuous updating, has been defined to achieve optimal well placement.

New log modelling processes are under development to increase the quality and reliability of the quantitative reservoir characterization based on LWD in highly deviated/horizontal wells.

eni's recent experience, in the Barents Sea and in Alaska, demonstrated the great potential of this approach.

advanced seismics-petrophysics integration

eni developed an innovative multi-step process of reservoir characterization conditioned with seismic-derived attributes and associated uncertainty (Presume).



The workflow includes:

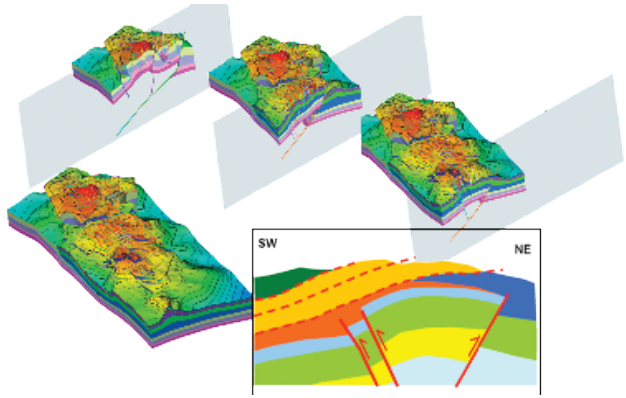
1) Well characterization and modelling to generate a log-facies classification coherently defined in a petro-elastic space.
2) Statistical rock physics modelling to link wells and seismic data in a probabilistic framework handling uncertainties.
3) Probabilistic petrophysical seismic inversions providing 3D probability of elastic attributes.
4) Geostatistical modelling of well facies and properties, constrained by seismic probabilities.

reservoir geomodelling technologies

eni workflows deploy state-of-the-art 3D tools in the geological modelling of complex reservoirs. A constant follow up and testing of new technologies allows us to be continuously updated and constantly driving the development of new tools.

3D structural modelling of complex reservoir

Detailed 3D reconstructions of the reservoir geometry – even in the presence of complex fault patterns and very heterogeneous stratigraphic sequences – are performed using the most advanced technologies, based on structural and sedimentological modelling, seismic interpretation and wells data.



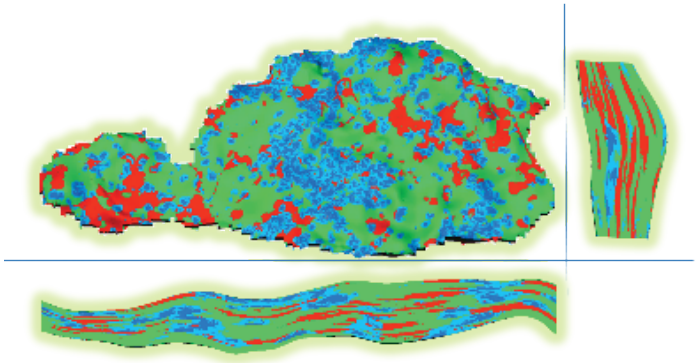
facies and properties distribution

eni has a long history of cooperation with the main geostatistical schools and research centers. **eni**'s methodology allows the integration and quantitative use of all available data in a 3D model.
Advanced proprietary techniques and unique software have been developed to facilitate and improve this integration.

Multiple Point Statistics (MPS)

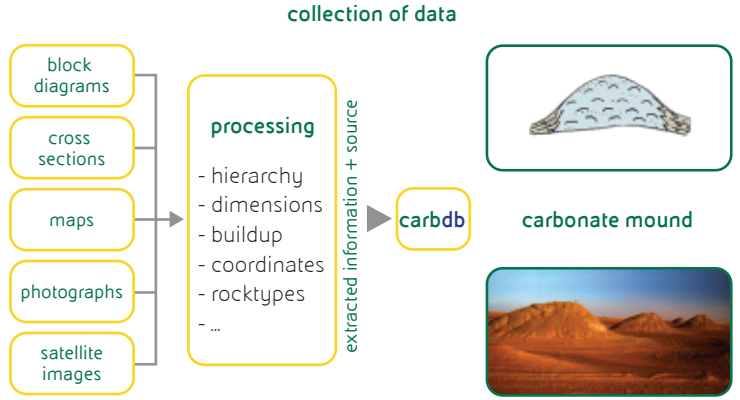
eni has many years' experience in this geostatistical technique and is currently working on the new non-stationary Multiple Point Statistics.

MPS borrows patterns from "training images" and is able to better reconstruct the internal reservoir geology, providing a more realistic quantification of uncertainty.



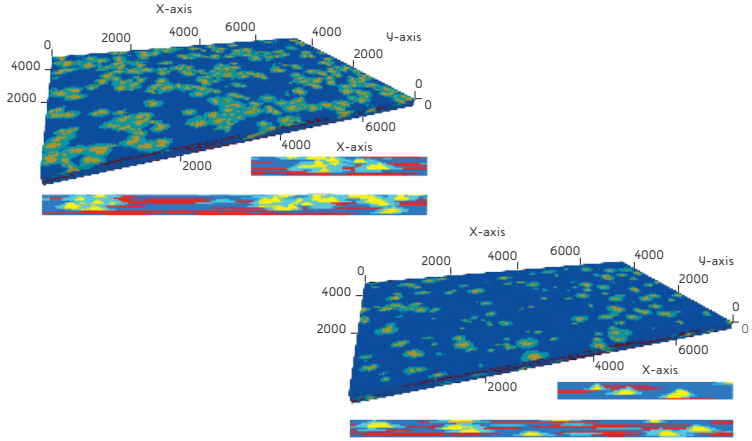
3D digital library of sedimentary environments

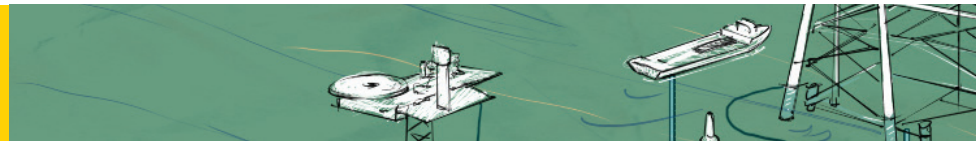
eni has developed a proprietary 3D digital library (CarbDb) of sedimentary environments and relevant geological bodies for carbonate and clastic reservoirs to help the interpretation and search of analogues.



training images for 3D geomodelling

eni has developed "Tetris Ti Generator", a 3D proprietary software for Training Images construction and management.



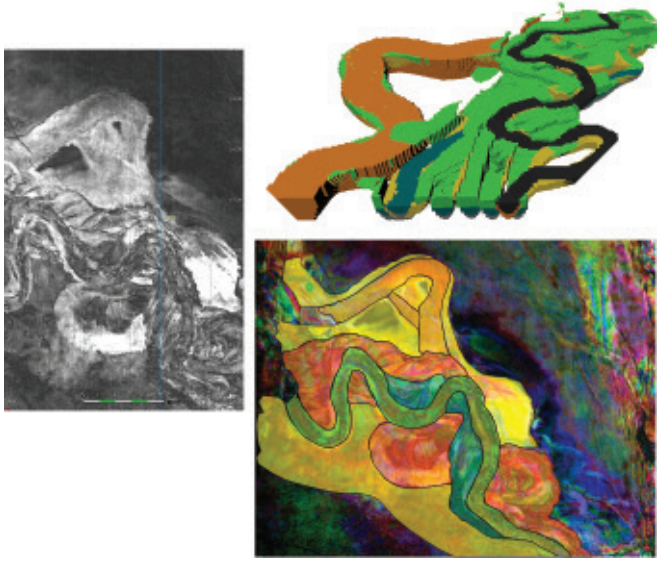


Simple geological objects can be interactively built to create new complex geological structures to be used in conditioning geostatistical facies simulations.

3D meandering channel systems modelling

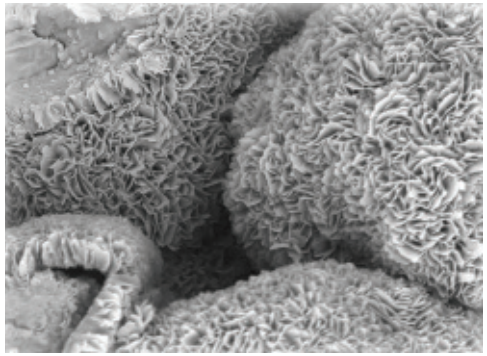
Meandering channel systems and associated deposits at reservoir scale can be modeled using a process-based and stochastic software.

3D sedimentological models are used in **eni**'s methodology as Training Images for the new non-stationary MPS technique.



geostatistical distribution of diagenesis (GEDI)

eni has implemented an integrated approach for diagenesis characterization and simulation, aimed to obtain an accurate prediction of flow performance in reservoirs where original relationships between depositional facies and petrophysical properties distribution have been altered by diagenesis.

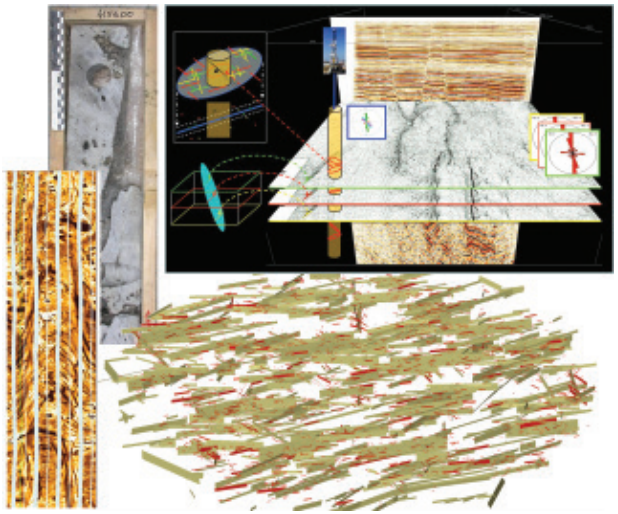


fractured reservoirs geological modelling

eni has many years' experience in working on fractured reservoirs. An integrated approach, using core seismic data and analogue outcrops, allows the simulation of complex faulted-fractured reservoirs and the quantitative evaluation of the petrophysical properties to be applied to the reservoir simulation.

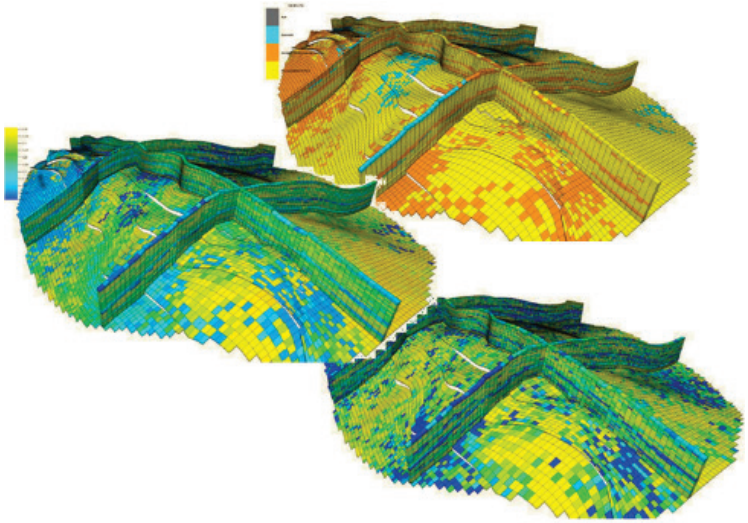
Examples of some of the proprietary tools and workflows we have developed:

- OFRA - Optimal Workflow Definition for Fractured Reservoirs
- SIBILLA - Continuity and Curvature Seismic Attributes Lineament Screening and Fracture Planes Definition



upgridding and upscaling

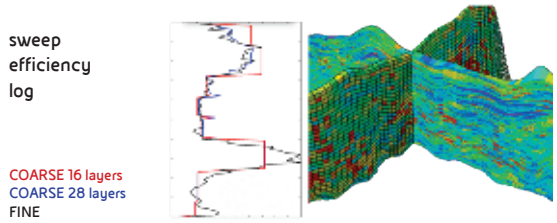
eni has developed an optimized upgridding and upscaling workflow for complex models aimed at preserving flow relevant heterogeneity components at the different scales.



The workflow combines internal solutions, state-of-the-art commercial software and diagnostic analysis to assess coarse model effectiveness.

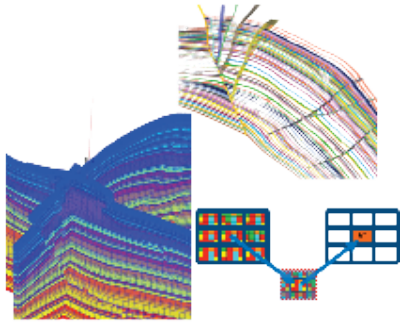
sequential up-gridding (SUpG)

eni SUpG is a layer aggregation technique to develop optimal coarse grids, minimizing the heterogeneity loss in the upgridding process and preserving flow-relevant permeability contrast.



e-Dyrect™:
eni dynamic reservoir effective coarse transmissibility

e-Dyrect™ is a software developed by **eni** to upscale geomodel permeability by computing coarse effective transmissibility.
The software enables the use of cost-efficient and cost-effective coarse scale models reproducing the fine scale behavior of geological models, without impairing the study time-scale.

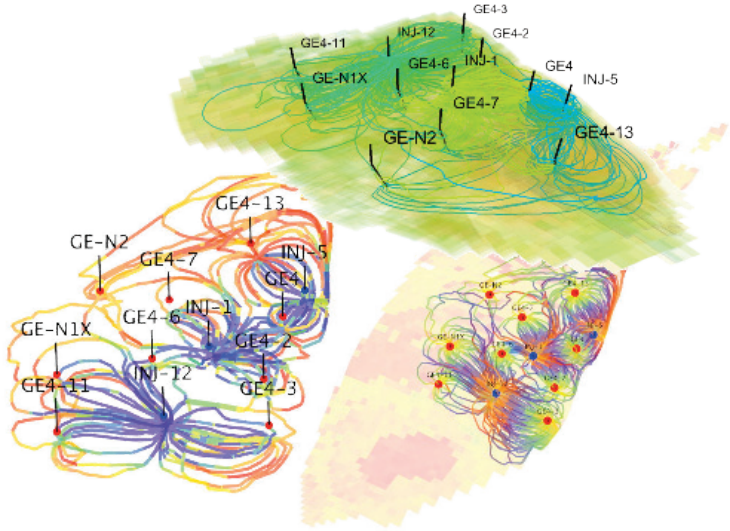


reservoir dynamic simulation technologies

Petroleum & Reservoir Engineering teams use some of the oil industry's most state-of-the-art technologies and "best-in-class" software for reservoir dynamic simulation.

streamlines

eni has many years' experience on streamline simulations for geological model ranking, evaluation of large and complex models, field surveillance, water-flooding and Enhanced Oil Recovery (EOR) techniques optimization.



computer assisted history match (CAHM)

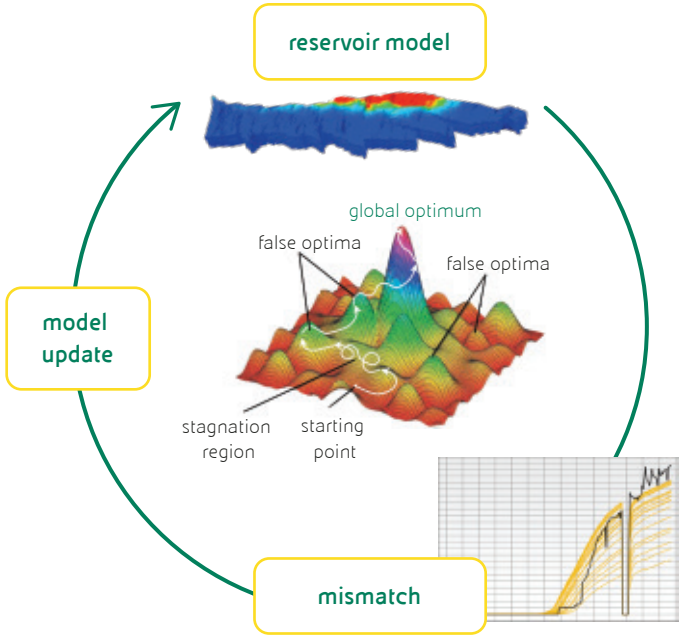
eni has been working for a long time on the development of innovative CAHM techniques.

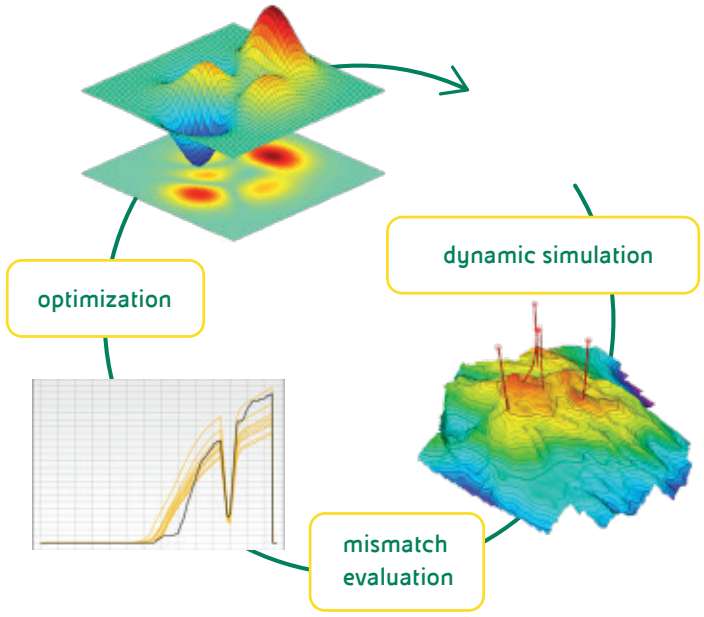
The use of state-of-the-art software packages automates and intelligently designs reservoir-simulation runs, helping reservoir engineers to achieve faster and more-reliable results from multiple realizations, being able to manage the simultaneous analysis of tens of parameters.

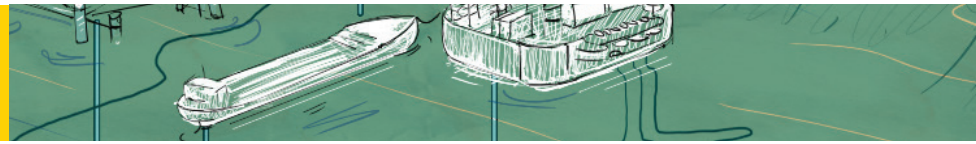
ensemble-based history matching

eni is highly active in the latest developments for ensemble-based history matching and has carried out one of the first worldwide field applications of this methodology.

Other applications have been performed to improve and enhance the technique for an effective use of complex reservoir models, as well as multiple history matching, risk analysis and robust scenario optimization.







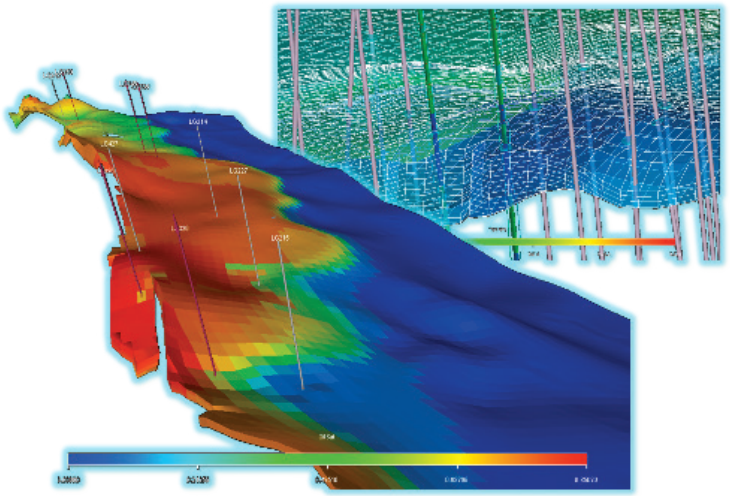
forecast optimization

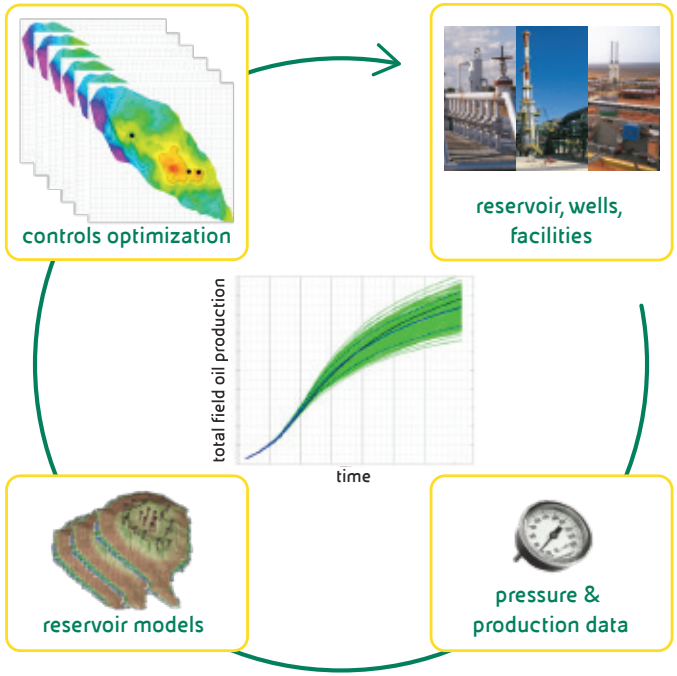
Aimed at optimizing production and overall economics, these techniques provide an efficient investigation of a range of field-development optimization options, from well-locations and completions to injection rates, in order to rapidly find suitable combinations that maximize the specified objective functions.

eni's experience comes from in-house R&D activities, industrial projects and collaboration with prominent universities.

closed loop and continuous model updating

eni is developing a reservoir management workflow capable of continually updating reservoir models on the basis of data coming from multiple sources – production sensors, remote sensing and time-lapse seismic – limiting the "model aging" and continuously monitoring production.

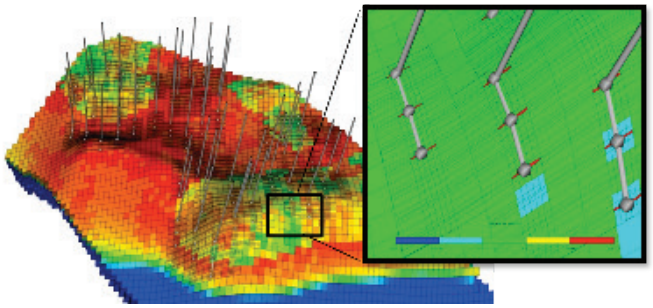




advanced fluid flow simulation

eni has deployed a new generation simulator to deal with very complex models in an unprecedented manner.

Models not running with standard tools due to high computational time or unsolvable convergences issues can now be efficiently managed.



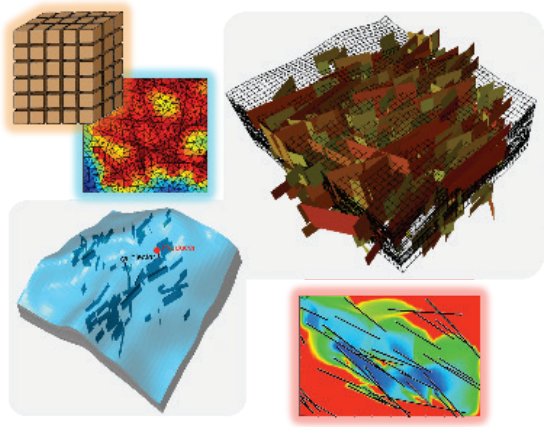
Finer and finer geological models are directly simulated, evaluating the impact of fine-scale heterogeneity on complex recovery processes (e.g. miscible gas injection, polymer flooding).

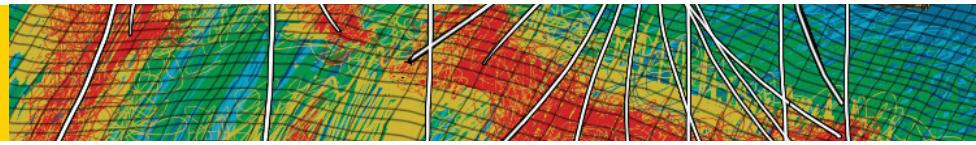
fractured reservoirs dynamic modelling

Large-scale fracture systems represent fundamental risks and opportunities for field development. Fluid flow simulation can be effectively run using computationally efficient methodologies where high-resolution simulators and geomodelling software are fully exploited by means of proprietary tools and workflows.

embedded discrete fracture model (EDFM)

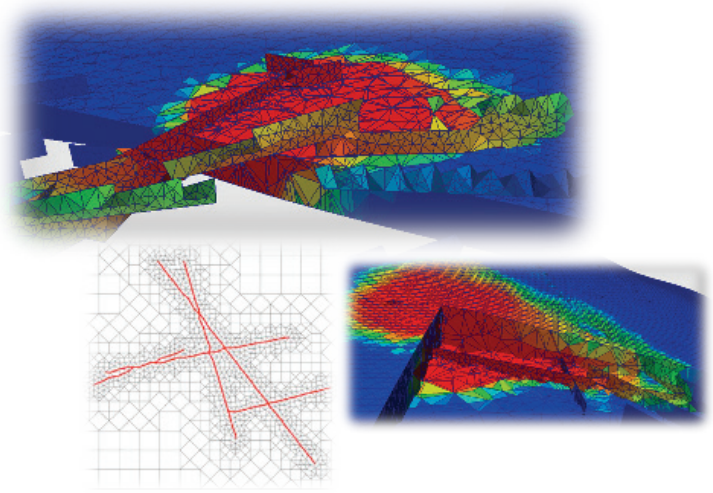
Fractures are embedded in the corner point gridding geometry formulation as an additional degree of freedom by means of non-neighboring connections with background matrix blocks.

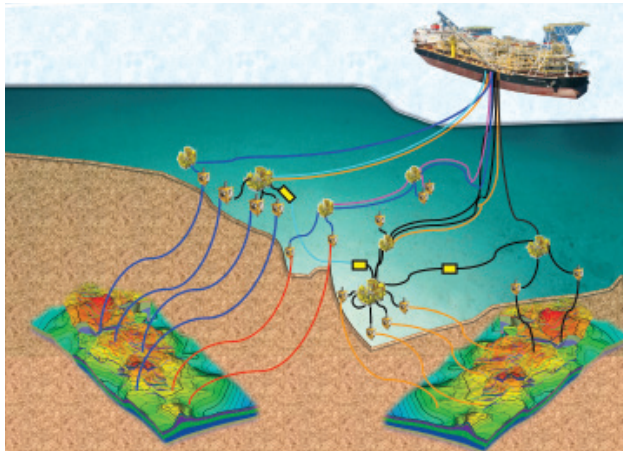




fully unstructured discrete fracture modelling (FUDFM)

A fully unstructured discretization is used to capture fractured porous media complexity, and is simulated using finite volumes and last generation reservoir simulators.

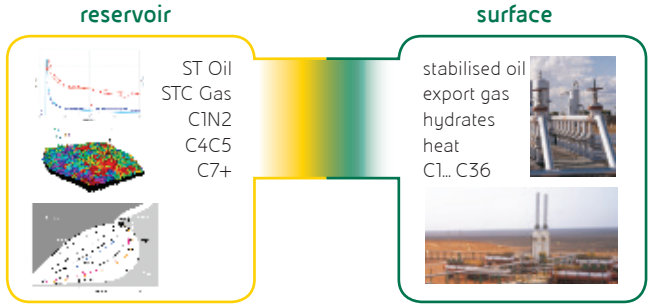




eni has also developed new solutions to effectively couple reservoir and process models by applying "lumping" and "delumping" techniques. This coupling allows to improve the accuracy of process separation efficiency.

integrated asset modelling

eni has developed a proprietary methodology to couple the reservoir-network and process in a single modelling system, in order to evaluate: interaction between fields connected to the same facility, interaction between the reservoir network and process, impact on production of any facilities upgrade and alternative development scenario to optimize production maximizing the Net Present Value of the asset.

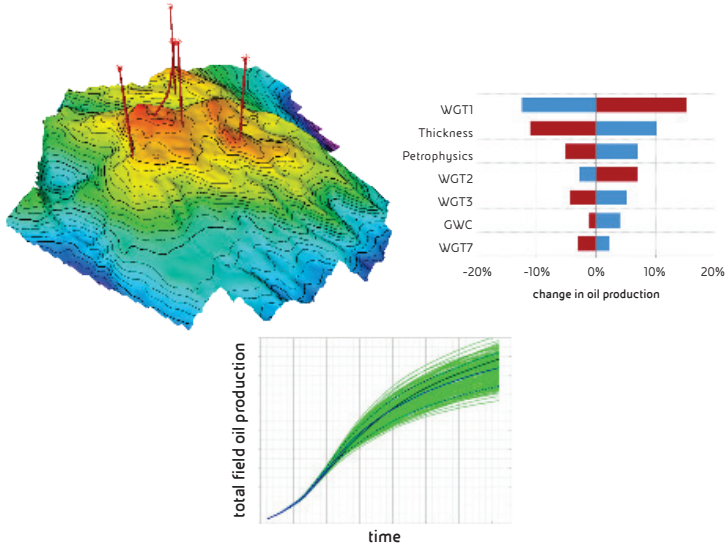


uncertainties evaluation & risk analysis technologies

e-rare — risk analysis for reservoir

e-rare™ is an **eni** proprietary methodology to perform risk analysis of a given reservoir.

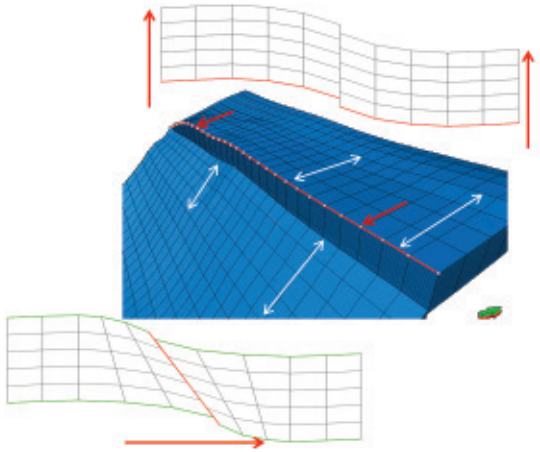
The main components are sensitivity analysis for fast screening, sampling of the uncertain parameters and large-scale dynamical simulations, efficiently organized to get a proper characterization of model-based forecast uncertainty.

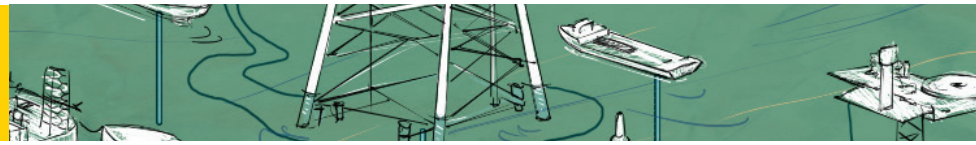


e-strudel — structural uncertainty design with elastic gridding

eni recently developed an innovative methodology for the full reservoir structural uncertainty handling.

Structural features – reservoir depth, thickness, fault throw, fault inclination and position – are easily introduced in uncertainty modelling and risk analysis workflow.





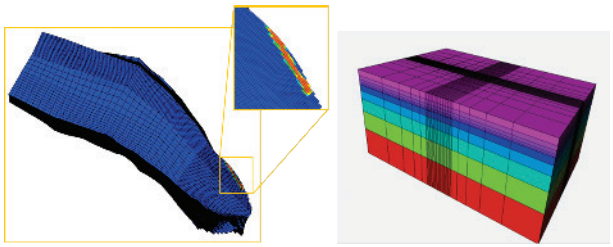
geomechanics technologies

initial stress state evaluation

Definition of the initial stress state is an important issue.
This information can have a huge impact on drilling and production activities and is fundamental for the initialization of numerical models.
eni uses an inversion procedure to evaluate the stress state along a well trajectory based on mini-frac/leak-off tests, image logs and proper geomechanical characterization.

reservoir scale geomechanical modelling

eni has developed a state-of-the-art workflow to perform a numerical simulation of the geomechanical behavior of the reservoir by means of complex Finite Element models including the under/over/side-burden and reproducing their correct geological description.

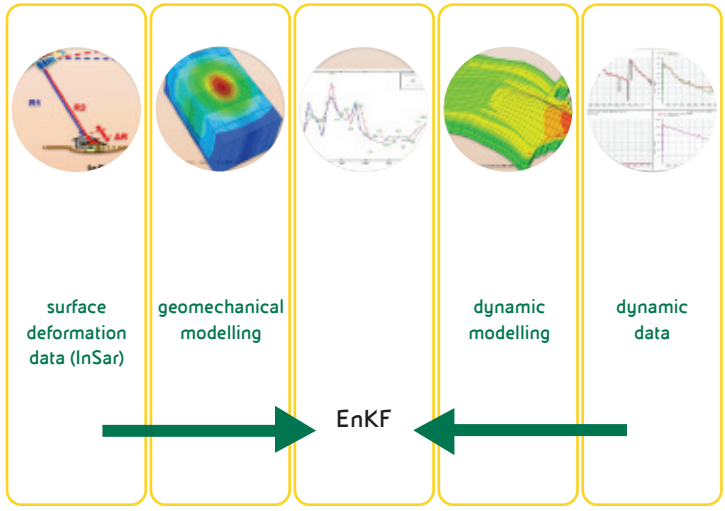


This allows the evaluation of stress changes in the reservoir and the surrounding rocks, compaction of the producing layers and subsidence at the surface.

geomechanical HM and geodetical data assimilation

Displacement patterns induced by injection/production operations can supply a map of reservoir fluid movements and lead to the identification of drained/undrained zones with an estimate of the corresponding pressure change, even in regions located far from producing wells.

eni has developed an integrated workflow to use this kind of data (acquired with GPS and Insar techniques), together with standard dynamic measurements (such as pressure data or water cut) to improve reservoir characterization. Methodologies adopted in the workflow range from ensemble methods and CAHM techniques to simpler inversion procedures.

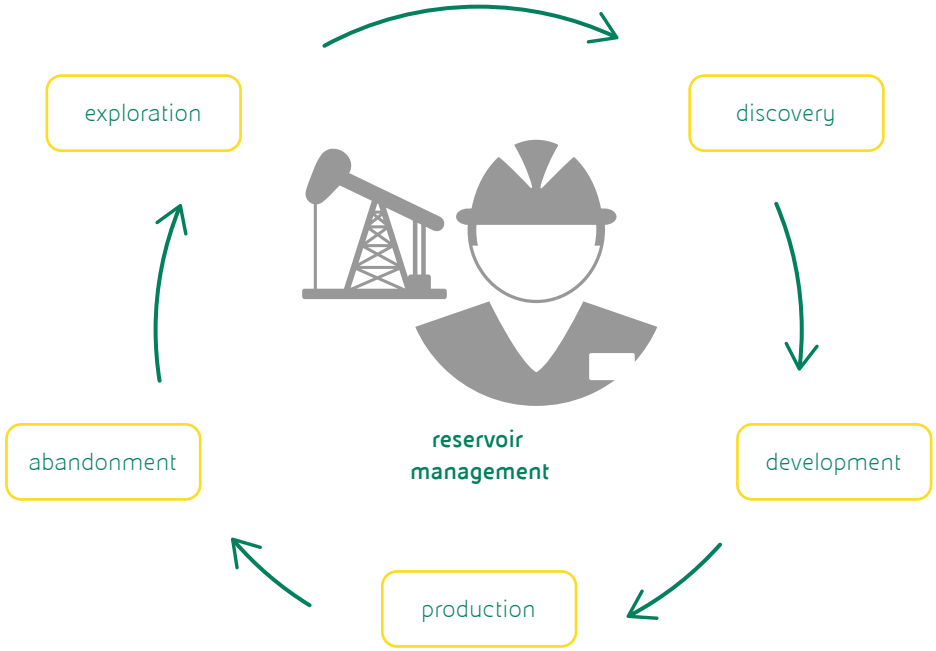


reservoir management and technologies

Our reservoir management philosophy provides guidelines for operations, decisions and strategies in order to maximize the economical return of an asset during its entire lifecycle.

This continual approach, implemented from appraisal and development phases to abandonment, allows defining the expectations for the asset.

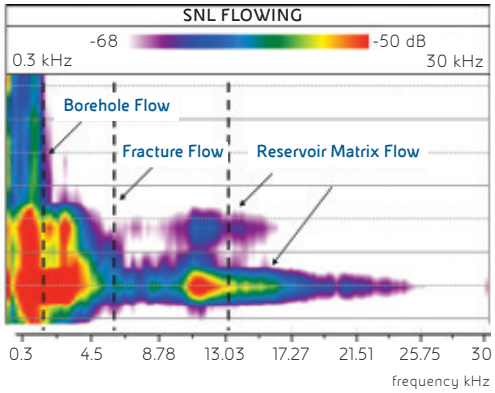
Nowadays, the possibility of real-time monitoring data acquisition, automated surveillance and workflows increases the speed of the decision-making process, optimizing production and final recovery factor. The Reservoir Management Plan represents, for each asset, the dynamic document containing the actions to be implemented in order to achieve goals and defined objectives.



reservoir monitoring & surveillance

New technology like DTS (Distributed Temperature Sensing using Fiber Optic) and Completion Chemical Tracers for downhole flow profiles have been successfully applied worldwide.

Fluid movement detection behind casing has been improved using SNL (Spectral Noise Log).



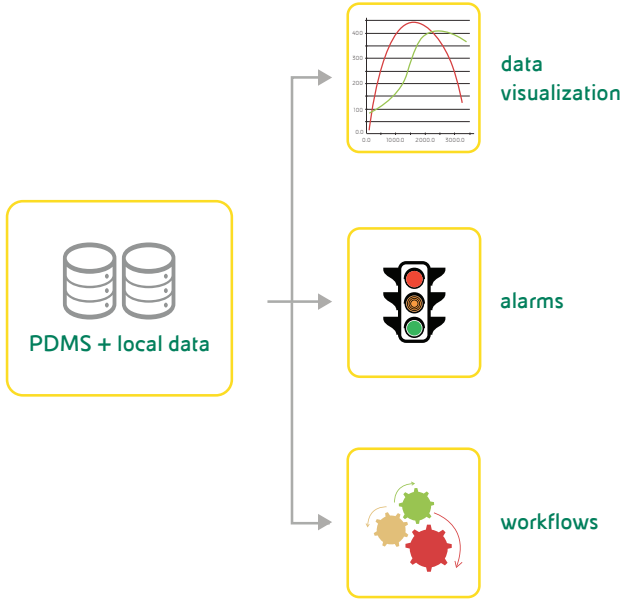
Production Logging strings without centralized spinners, based on Oxygen Activation principles, have been acquired for use in challenging environments.

Interwell tracers have been deployed in many waterflooding schemes in order to understand flow patterns and improve the volumetric sweep efficiency.

reservoir data management

A standardization of data management is being promoted, with the adoption of a new tool, called Production Data Management System (PDMS), to customize workflows for production data management, perform back-allocation, shortfall analysis and automatic reporting.

Assets with large numbers of wells and information will benefit dramatically, providing engineers with the key figures related to field/well performance, triggering automatic warnings and scheduling complex workflows.



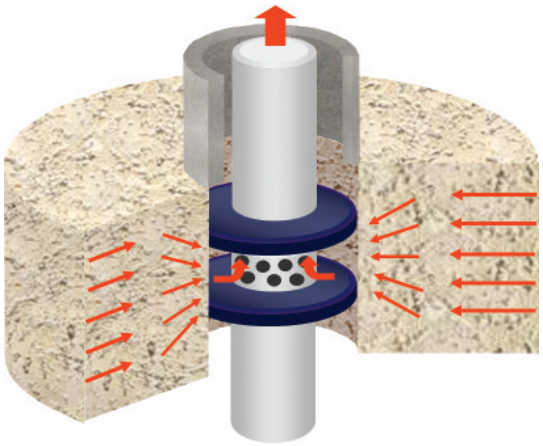
well testing - miniDST

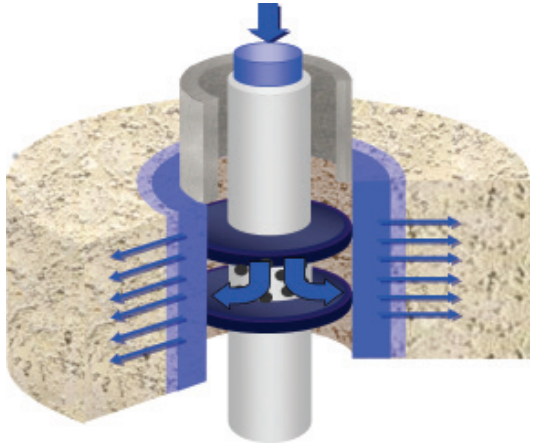
A miniDST may be considered as a kind of "short-time-scale" well test. User-friendly miniDST Design Charts™ have been developed by **eni** to identify the reservoir scenarios where MiniDSTs can be successfully applied, and handle some degree of uncertainty in the input parameters.

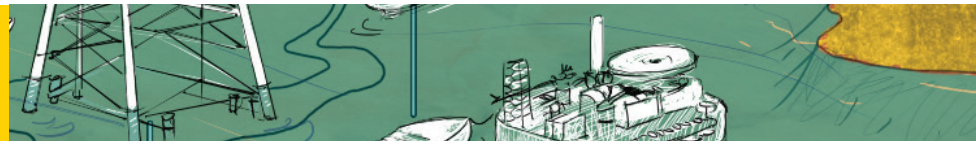
injection testing

Injection testing provides the key parameters of the well-reservoir system when a conventional well test cannot be performed and particularly when hydrocarbon flaring is limited by regional regulations. **eni** has patented a proprietary technology for field operations and interpretation workflow (WO 2007/134747).

eni has carried out successful injection testing in oil and gas wells in Kazakhstan, Algeria, Norway and the UK.

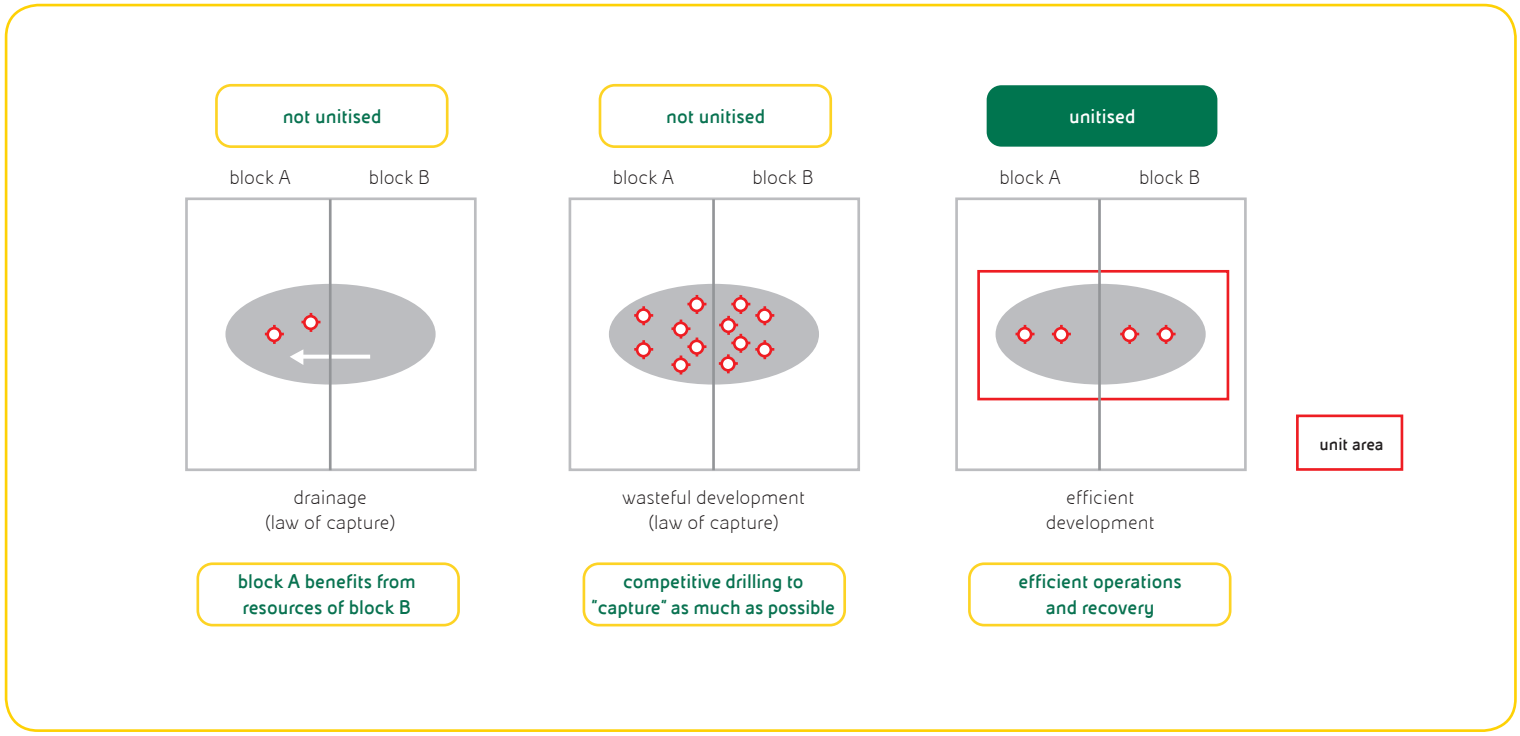






unitizations & redeterminations

eni has more than 20 ongoing Unitization and Redetermination negotiations worldwide. Unitization happens once in the life of a field when a reservoir straddles one or more license boundaries. The purpose is to facilitate development of the field as a unit so that hydrocarbon recovery can be maximized and the associated costs minimized in order to attain the highest efficiency. A dedicated multidisciplinary team based in UK manages all the unitization process for the Reservoir Engineering & Petroleum Department.

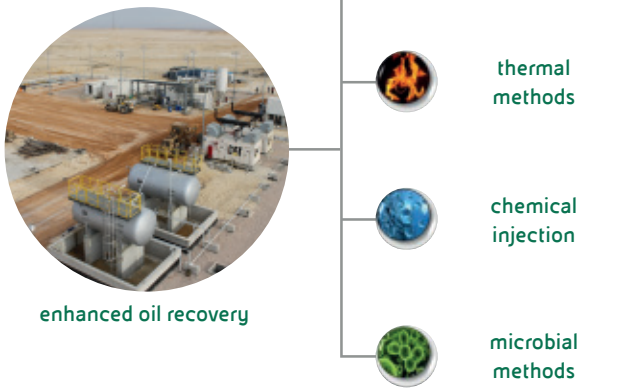


improved & enhanced oil recovery

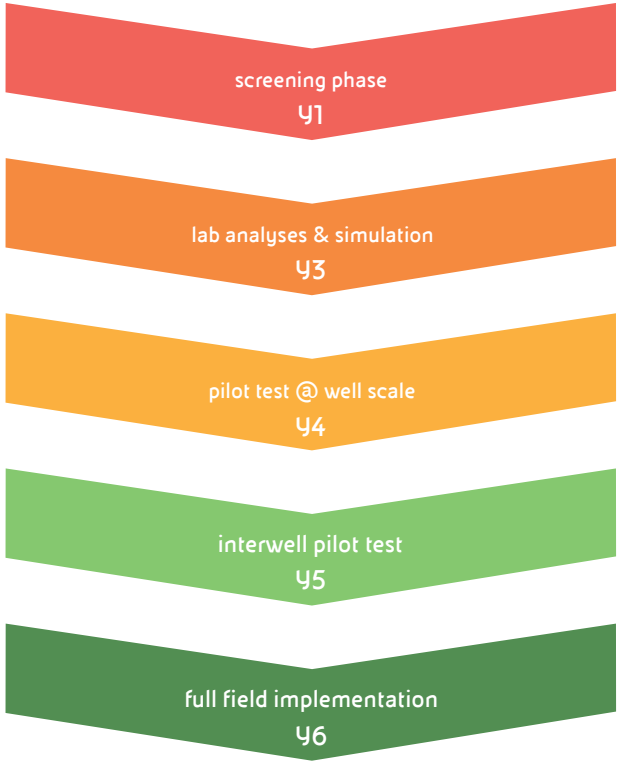
Global energy demand is forecasted to rise by over one-third between today and year 2035. As the relatively easy oil reserves deplete, focus will shift to development of extremely complex reservoirs in challenging environments.

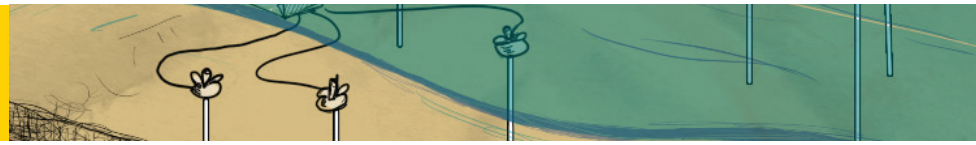
Another source of supply to fill the void will be from Enhanced Oil Recovery (EOR) techniques applied to existing fields. EOR includes any technique that alters the fluid flow properties and thus recovers hydrocarbons that are not produced during primary and secondary depletion.

EOR techniques can be grouped into three main families: thermal, gas injection and chemical methods. Besides the above groups, there are other emerging techniques such as Microbial EOR.



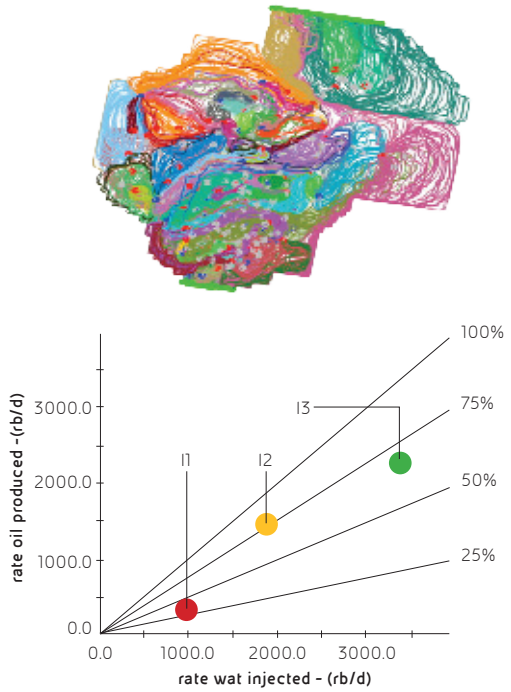
eni is active in every EOR technique and has developed an internal workflow for EOR implementation that spans the screening phase up to full field deployment.





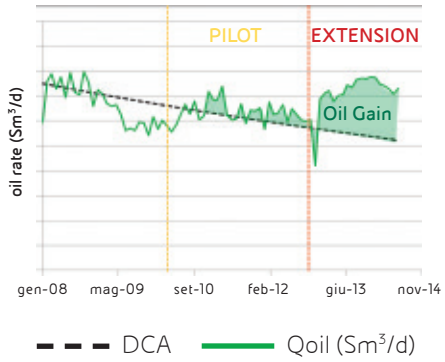
optimizing waterfloods

eni has defined an internal workflow to monitor and optimize waterflooding schemes by means of streamlines simulation. By identifying water flow pattern and worst performers in terms of water injection, it is possible to reallocate water rates among the best injectors, thus optimizing sweep efficiency and overall recovery factors.



Streamline simulation: identification of the worst injectors in terms of sweep efficiency

eni is also active in all water conformance techniques. The recent injection of thermally activated polymers in a Tunisian field has shown very good results. These polymers plug preferential water paths, diverting the water injection flow to other reservoir areas, contacting previously unswept oil.



Results of first campaign of thermally activated polymers injection in a Tunisian well

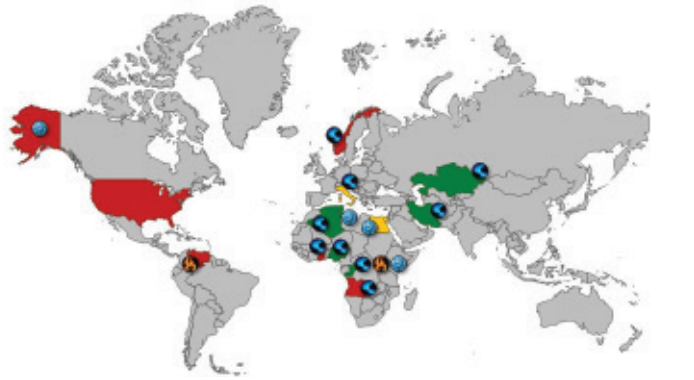
EOR screening

eni has developed an internal tool for quick EOR screening purposes that selects the optimal EOR technique for a given field and provides a set of published analogues for the chosen methods.

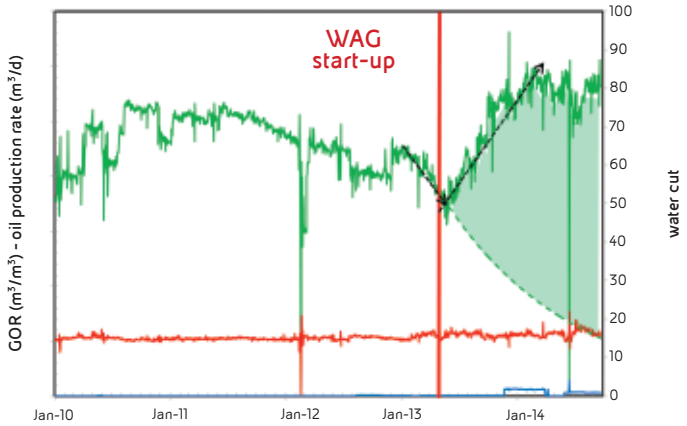
EOR projects

eni has launched many EOR projects worldwide. Given our reservoir portfolio characteristics, the main focus is on gas injection techniques, chemical EOR and low salinity flooding.

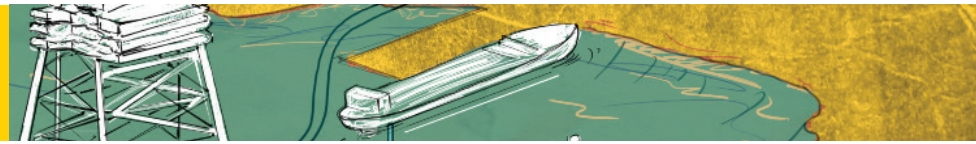
eni has many years' experience in dealing with large and challenging miscible gas injection schemes worldwide, injecting hydrocarbon and sour gas. Water Alternate Gas (WAG) is currently being implemented in Algeria with excellent results and impressive production gain.



- study
- pilot
- full field implementation
- gas injection
- thermal EOR
- chemical EOR

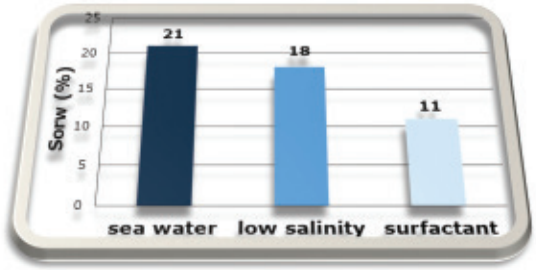


| Production gain in an Algerian well soon after WAG start-up



Several pilots and projects of chemical EOR are currently on-going. **eni** has recently started polymer flooding at a mature asset in Egypt. A surfactant-polymer EOR will be deployed in a West African asset, while an interwell pilot of low salinity polymer will be launched for a giant onshore field in Egypt.

| EOR polymer plant, Egypt



| SWCTT results for a West African field. Reduction of irreducible oil saturation after sea water, low salinity and surfactant flooding

eni has robust experience in low salinity flooding, starting from in-house core flooding, well pilot as log-inject-log and single well chemical tracer tests (SWCTT), 3D sector modelling of the chemical/physical processes and interwell pilots. Several projects are currently on-going, showing promising results of this interesting EOR technique.

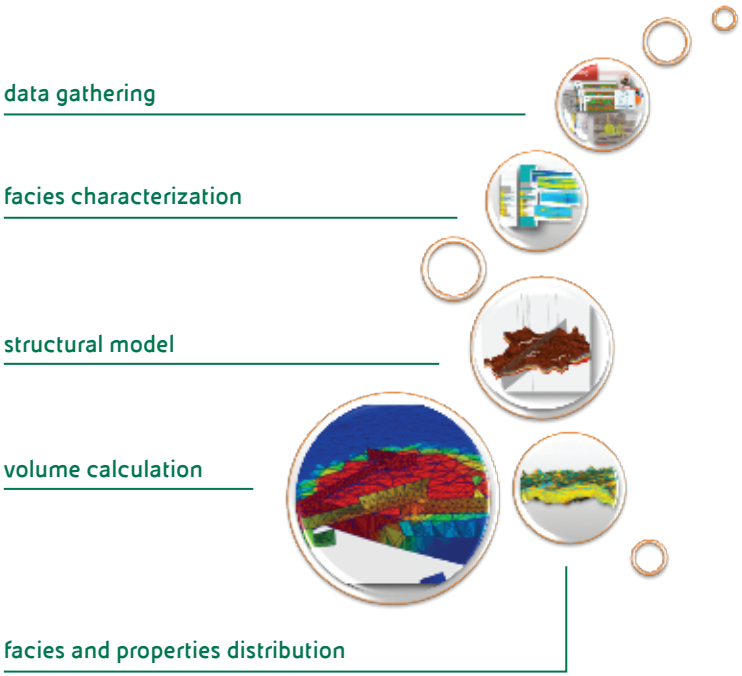
unconventional reservoir technologies

SSM - Shale Static Model

The SSM – Shale Static Model approach differs from the well-known conventional workflow, mainly in facies characterization and volume calculation steps. In shale reservoirs, indeed, part of the hydrocarbon is adsorbed to organic matter and production occurs exclusively after stimulation operations.

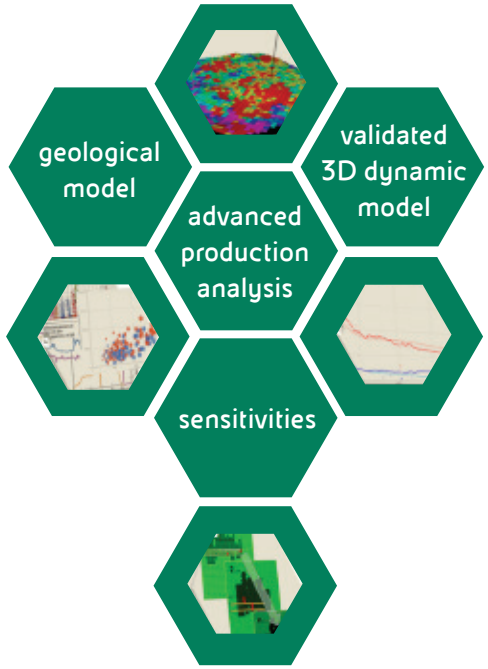
Well productivity is not only linked to formation petrophysics characteristics, but also to geomechanical and geochemical properties. Volume calculation involves free and adsorbed hydrocarbons.

SSM could give a clearer picture of vertical and lateral variability of reservoir and non-reservoir facies to drive well placement, maximize horizontal wells exposure and enhance advanced stimulation operations in sweet-spot areas, minimizing costs and optimizing production.



SDS - Shale Dynamic Simulation

Dynamic modelling for shale reservoir, due to the peculiar production mechanism, needs to address and integrate geological models, stimulation results, microseismic survey data, advanced production analysis and adsorbed gas production. The methodology involves the use of advanced modelling techniques which consider non-Darcy flow effects, and modified dual porosity/dual permeability approaches to explicitly model the specific dynamic of the fluids in the system.
3D dynamic modelling is used to maximize the performance of horizontal wells, estimate drainage area per well, define optimum well placement and spacing and perform production forecasts.

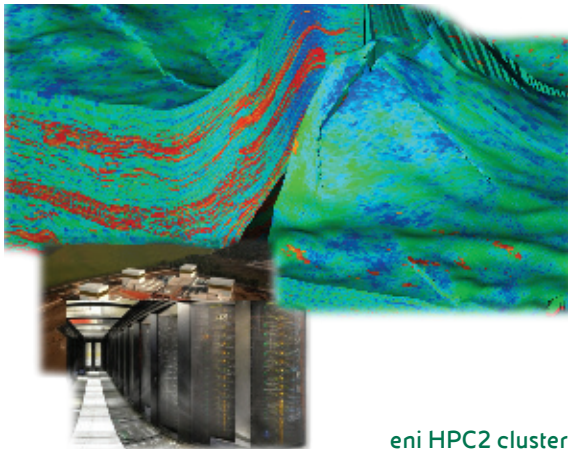


towards the future

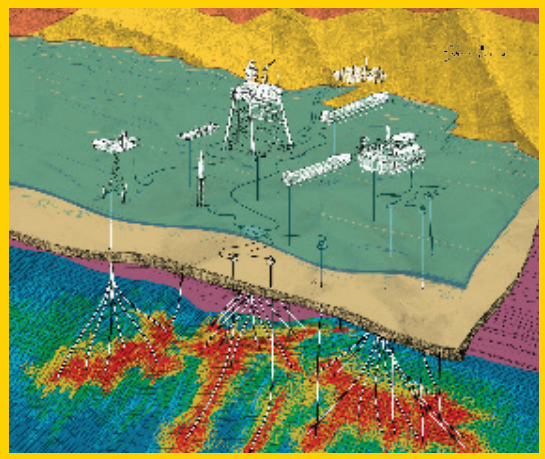
eni is always on the leading edge of reservoir study, modelling and simulation, deploying a new generation of high resolution simulators and innovative workflows developed to face the challenges of the most critical and complex assets.

The capability to simulate highly detailed geological models in economical timeframes and trying to avoid or reduce upscaling is crucial to provide robust answers for a stronger and faster decision-making corporate process.

The winning combination of top-class computational efficiency, state-of-the-art modelling software, best-in-class professional competencies and efficient workflows is the key for the success for winning the challenges of the future in an unprecedented manner.



eni HPC2 cluster



Since 2010 **eni** has been communicating with talented young people from all over the world in various disciplines.

The cover art for this brochure was created by Leonardo Spina, a young Italian illustrator. The opera is based on an assembling method of different visual elements, all strictly taken from the real world and scientific aspects. Outcome of the process are colorful and hyper realistic illustrations made valuable by the personal touch of the artist. As he says: "In my artworks, I like to mix 50' comics style and décollage, adding my rough and personal artistic touch, to give to the whole composite a contemporary mood".

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March 2015

eni at a glance

eni is an integrated energy company employing more than 84,000 people in 83 Countries in the world.

eni engages in oil and natural gas exploration, field development and production, as well as in the supply, trading and shipping of natural gas, LNG, electricity, fuels and chemical products.

Through refineries and chemical plants, **eni** processes crude oil and other oil-based feedstock to produce fuels, lubricants and chemical products that are supplied to wholesalers or through retail networks or distributors.

eni operates in engineering, oilfield services and construction both offshore and onshore, focusing on the execution of technologically-advanced mega-projects mainly located in frontier areas.

eni's strategies, resource allocation processes and conducting of day-by-day operations underpin the delivery of sustainable value to all of our stakeholders, respecting the Countries where the company operates and the people who work for and with **eni**.

Cooperation, integration, innovation, inclusion of people, operational excellence and responsibility drive **eni**'s work in the continuous interaction with all the stakeholders. These elements lead to wise investment choices, prevention of risks and the achievement of strategic objectives in the short, medium and long term.

In 2014 **eni** confirmed its presence in the Dow Jones Sustainability indices and in the FTSE4Good index.

main figures for 2014

- Net profit: € 1.33 billion
- Cash flow from operations: € 15.09 billion
- Net borrowings: € 13.71 million
- Leverage: 0.22
- Hydrocarbon reserves: 6.6 billion boe
- Hydrocarbon production: 1.598 mmboe/d
- Worldwide gas sale: 89.17 bcm
- Retail sales in Europe: 9.21 mmtonnes

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