The Oil & Gas Upstream Cycle: Development and Production

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Oil & Gas Activity: Upstream

BASIN EVALUATION
Regional Studies in order to identify areas with Hydrocarbon potential

EXPLORATION
Licenses Acquisition, Geological Studies, Seismic Acquisition & Drilling

DEVELOPMENT
Development Plan and Drilling Facilities and Infrastructure Construction

PRODUCTION
Reservoir Management, Work-Over, Abandonment
Oil & Gas Activity: Development Phase

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Oil & Gas Activity: Development Phase

The purpose of the development process is to configure, design and implement projects for producing oil resources from new discoveries or from existing assets in line with business objectives and company strategies.

The development process is a fundamental component of the company’s strategy. Therefore technological solutions and managerial best practices updated to the best industry levels must be adopted and innovative solutions utilized in order to improve project performance in terms of safety, environmental protection, profitability, financial exposure and reduction of risk factors.
Each Development Project is structured and governed according to guidelines defined by the Company.

All the projects are based on a phase gate approach and consist of five distinct phases. Each phase has a set of **clear objectives** that, once achieved, allow the project to proceed through a gate into the next phase.

The first three phases focus on the **value identification** to ensure the selection of the «right project» which will maximise the asset value.

The last two phases focus on the **value realisation** where the defined actions must be executed efficiently. As the project is already defined only minor improvements to its value can be achieved.

In this process the **Concept Selection** phase, where the optimum development configuration is selected and outlined, plays a critical role to drive the following phases.
The objective of the **Concept Selection** phase is the identification of the optimal development concept, i.e. the technically feasible asset development **solution that maximises** the project value in terms of the best compromise among **maximum economic results** and **minimum associated risk**.

Different disciplines are involved to develop a set of studies to ensure that asset development and project execution will be done at the best reducing uncertainties.

The **Reservoir Characterization** study is a fundamental activity in the Concept Selection phase.
The Reservoir Characterization study is a multi-step construction of a model of a petroleum reservoir made with a computer, with the purpose of:

- improving the estimation of oil in place and reserves
- predicting future production
- evaluating alternative reservoir management scenarios.

A model can be subdivided into a Geological or Static Model and a Dynamic Simulation Model.
The Reservoir 3D Static Model: structural modelling

The **Structural Modelling** is the process of defining the geometrical and structural properties of the reservoir.

The Bulk Volume of the reservoir is represented through a grid, regular or irregular, made up by 3D cells whose size is defined in order to preserve the reservoir heterogeneity observed on seismic and shown by the collected well data.
The Reservoir 3D Static Model: stratigraphic modelling

The creation of a **Stratigraphic framework** is the most traditional among reservoir geologists’ tasks.

It is based on a well to well correlation in order to define the surfaces that bound the main reservoir units.

Correlations are based on the sedimentological model and on sequence stratigraphy concepts.

A correct description of the geometry of the sedimentary bodies is an essential requisite for the simulation of the production performance of a field as fluid flow takes place largely along the stratigraphic units.
The Reservoir 3D Static Model: lithological or facies modelling

The Facies Modelling is the process of assigning to each cell of the model a lithological information on the basis of the defined environment of deposition.

This step is not mandatory. In simple studies facies classification may reduce to the definition of reservoir and non reservoir rocks (i.e. of rocks that may or may not contain hydrocarbons).

In highly heterogeneous reservoirs the lithological model is built integrating the sedimentological model, a facies classification and a probabilistic approach.

Facies can be considered as the basic building blocks of a geological model since geocellular 3D modelling and stochastic simulation became available.
The Reservoir 3D Static Model: petrophysical modelling

The petrophysical characterization of a reservoir is a quantitative interpretation of well logs and core to determine its main petrophysical properties (porosity, water saturation and permeability)

The petrophysical properties control the quantity and the initial distribution of fluids (hydrocarbons in place = reservoir storage capacity) and have an impact on their movement (recoverable reserves = deliverability). They describe the reservoir quality.

Properties are distributed in the 3D model according to facies classification by assigning a value of each property to the baricenter of each cell.
Data collected in a well to get information about rocks and fluids

Cuttings

Geophysical logs

Cores

Pressure measurements WFT

Well seismic

Fluid samples

Production tests
The Reservoir 3D Static Model: OHIP

When the Static Model is completed the **OHIP** (Originally Hydrocarbons In Place) can be estimated

\[
\text{OHIP} = \frac{\text{GBV} \times \text{N/G} \times \text{PHI} \times (1 - \text{Sw})}{\text{FVF}}
\]

**GBV** - Gross Bulk Volume of the reservoir;  
**N/G** - Net to Gross thickness ratio;  
**PHI** – Porosity (pore volume per unit volume of rock);  
**Sw** - Water saturation (fraction of the pore space filled by water);  
**FVF** – Formation Volume Factor

**OHIP** represent the volume of hydrocarbons contained in the reservoir prior to any production activity.

**OHIP** can be estimated in two ways:

- **DETERMINISTIC**: the output is a unique value obtained with fixed parameters in the equation

- **PROBABILISTIC**: parameters of the equation are varied and combined using statistical methods and multiple outputs are obtained. The output are called P10, P50 and P90 and represent the percentile of the frequency distribution
Main target of the reservoir simulation activity is the construction of a numerical model suitable to identify the best actions for maximizing the asset value and supporting relevant decision making processes.

The simulation model supports:
- the definition, evaluation and selection of the best development scenario
- the identification of the most appropriate production optimization interventions
- the calculation of the production profiles that will be the basis for the estimation of the relevant recoverable reserves.
Management of the uncertainty: model continuous updating

The management of uncertainty and risk is one of the most important issues in the oil and gas industry.

At the beginning of the development phase data available are few and the uncertainty in the model outputs is high. At this time is a common practice to evaluate multiple alternative scenarios for reservoir development and management.

As soon as new data are available the model must be updated, new volumetrics and profiles computed and the impact of the new results on the project evaluated.

This can be achieved in a fast and effective way only through the integration of the different disciplines.
New generation of reservoir dynamic models

Eni is developing a reservoir management workflow capable of continually updating reservoir models on the basis of data coming from multiple sources like production remote sensing and time-lapse seismic, limiting the “model aging” and continuously monitoring and optimizing production.

Thanks to the availability of a new generation of software and the hardware capabilities of the Green Data Center huge models with hundreds of millions of cells can be run in a very small time and continuously updated.
The Development Scenario

The development scenario is comprehensive of:

- Number of wells and their location
- Type of wells
- Type of completion
- Well behaviour (production rate, prod. period, expected pressure evolution, ...)

Other important factors to be taken into account:

- How wells will be connected to the terminal
- Costs of wells and facilities
- Time to first oil (start of the production)
Cost of a Well

Today, a typical **land-based** oil or gas well costs about **2-5 M€**

The costs for an **offshore well** average nearly **10-25 M€**

*Ultra Deep Water Drillship SAIPEM 10000*

Daily Rate: **1200 K€**
Costs of a E&P project

- **Exploration is the cheapest phase of oil industry**

- Nevertheless exploration budget of a major is comparable to economic balance of a small country.

- Exploration activity including a regional study, a 3D seismic survey over 1000 km², drilling a 3000 m deep well in offshore may need investments of 60-130 M€

- A further Exploration-Appraisal campaign (5 years, 2 wells): 100-200 M€

- Development project investments usually ranges between many tens and thousands millions of euro.

- The investments of small projects (onshore, 1-2 wells to drill, already existing facilities,...) are around 50-100 M€, while complex big projects (offshore/deep offshore, several platforms, tens of wells, new production facilities, ...) can have investments of 1-20 B€
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Production in the oil and gas industry is the phase during which hydrocarbons are extracted from an oil or gas field through a set of available wells, connected to a pipeline system (production network) treated and sent to market through pipelines or by ship.

Production in an oil field can last several years (up to 40), depending on the size of field and how expensive it is to keep the wells and production facilities running.

During that time the field is continuously monitored through a “Reservoir Management and Production Optimization” activity, whose objectives are:

- To update and validate the reservoir dynamic model (history match) and the reservoir management strategy (workover, new production facilities)
- To identify wells/facilities revamping requirements
- To define and assess the technical and economical feasibility of well interventions (change of producing level or of type of completion, matrix stimulation operations)
Reserves and Recovery Factor

It is physically impossible to recover and produce all of the oil in the ground.

**Reserves** are the amount of HC discovered in a field that can be economically produced with the available technology and the defined development scenario.

The ratio of reserves to the total amount of oil in a particular reservoir is called the *recovery factor*.

\[
\text{RECOVERY FACTOR} = \frac{\text{RESERVES}}{\text{OHIP}}
\]

The recovery factor is amongst the most important parameters that characterize oil and gas reservoirs and it influences many decisions that lead to successful field development plan.

Over time, technology improved a lot in many countries but with field complexity also increasing, the result is that overall RF has often changed very little.

As an example in 2017 the expected recovery factor for the fields located in the Continental Shelf of UK was 43% almost the same as that estimated in 2004 (42%).
World Oil & Gas Reserves

World Oil Reserves (2017)
1,680,004 million barrels as at 31st December

- Europe: 1%
- North America: 14%
- Africa: 7%
- Russia and C. Asia: 7%
- Middle East: 48%
- Asia - Pacific: 3%
- Central South America: 20%

World Natural Gas Reserves (2017)
201,178 billion cubic metres as at 31st December

- Europe: 2%
- North America: 6%
- Asia - Pacific: 7%
- Africa: 9%
- Central South America: 4%
- Russia and C. Asia: 82%

439,659 million barrels as at 31st December

43,544 billion cubic metres as at 31st December

Source: eni_World Oil & Gas Review 2018
Oil & Gas Reserves Leaders

The world Top Ten Oil Reserves Holders

The world Top Ten Gas Reserves Holders

Source: eni_World Oil & Gas Review 2018
Reservoir drive mechanisms and types of recovery

Reservoir parameters that affect recovery factors are: reservoir rock properties, fluid properties and reservoir drive mechanisms.

The reservoir drive mechanism supplies the energy that moves the hydrocarbons located in the reservoir toward the wellbore as fluid is removed near the wellbore.

- **Primary Recovery**
  - Use the natural energy of the reservoir (from aquifer, gas cap or dissolved) to produce the fluid or artificial lift devices

- **Secondary Recovery** (IOR – Improved Oil Recovery)
  - Add energy to the reservoir (injecting water and/or gas)

- **Tertiary Recovery** (EOR - Enhanced Oil Recovery)
  - Improve the sweep efficiency (injection of other fluids, thermal recovery, chemicals).
Tertiary Recovery: EOR - Enhanced Oil Recovery Techniques

A way to further increase oil production is through the tertiary recovery method or EOR. Although more expensive to employ on a field, EOR can increase production from a well to up to 75% recovery.

- EOR methods entail changing the actual properties of the hydrocarbons
- EOR techniques are used after primary and secondary recovery or at the initial stage of production
- There are three main types of EOR, including thermal recovery, chemical flooding and gas injection.
Tertiary Recovery: EOR - Enhanced Oil Recovery Techniques

Thermal recovery introduces heat to the reservoir to reduce the viscosity of the oil. First applied in Venezuela in the 1960s.

Chemical injection EOR helps to free trapped oil within the reservoir. This method introduces long-chained molecules called polymers into the reservoir to increase the efficiency of waterflooding.

Gas injection used as a tertiary method of recovery involves injecting natural gas, nitrogen or carbon dioxide into the reservoir.

Carbon dioxide EOR (CO2-EOR) is the method that is gaining the most popularity. While initial CO2-EOR developments used naturally occurring carbon dioxide deposits, technologies have been developed to inject CO2 created by industrial processes.
CO₂ EOR Contributing Mechanisms

Carbon Dioxide is the fluid most commonly used for miscible displacement because:

- Miscibility (depending on P, T and oil characteristics)
- Oil swelling
- Reducing oil viscosity & density
World Oil & Gas Production

Source: eni_World Oil & Gas Review 2018
Oil & Gas Production Leaders

The world Top Ten Oil Producers

The world Top Ten Gas Producers

Source: eni_World Oil & Gas Review 2018
Decarbonisation and Carbon neutrality

Decarbonisation is the process of reducing the carbon-hydrogen ratio in the energy sources. When referred to the global engagements against climate changes it means all the policies that are/will be implemented to reduce the use of fossil fuels especially those with high carbon dioxide emissions.

Carbon neutrality, or having a net zero carbon footprint, refers to achieving net zero carbon dioxide emissions. This can be achieved in two ways:
- by balancing carbon emissions with carbon removal
- eliminating carbon emissions altogether (the transition to a "post-carbon economy").

Carbon neutrality is used in the context of carbon dioxide-releasing associated with transportation, energy production and industrial processes.

As the world is moving towards a carbon-neutral future, global fossil fuel demand continues to grow. This challenges the oil & gas industry to meet the increased need for energy while simultaneously reducing overall emissions.
Eni is a member of the OGCI (Oil and Gas Climate Initiative) a CEO-led initiative made up of thirteen oil and gas companies (producing about 30% of global oil and gas) that collaborate on actions to reduce greenhouse gas emissions from the oil and gas industry’s operations, while still meeting the world’s energy needs.

OGCI investments are focused on three objectives:
Carbon capture and storage (CCS) prevents carbon dioxide (CO2) from being released into the atmosphere. The technology involves capturing CO2 produced by large industrial plants, compressing it for transportation and then injecting it deep into a rock formation at a carefully selected and safe site, where it is permanently stored.

The Global CCS Institute is the world’s leading authority on carbon capture and storage (CCS) – an international climate change organisation whose mission is to accelerate the deployment of CCS as an imperative technology in tackling climate change and providing energy security.
ENI contribution to a low carbon future

In the **short term**, Eni’s strategy is based on three pillars:
ENI contribution to a low carbon future

In the **short term**, Eni’s strategy is based on:

1. **Energy efficiency and direct GHG emissions reduction** of operated activities with the aim of reducing upstream emission intensity by 43% compared to 2014 by 2025. This objective will contribute to the target of improving the carbon efficiency index by 2% a year by 2021 compared to 2014, that will be pursued by all Eni business units;
ENI contribution to a low carbon future

In the **short term**, Eni’s strategy is based on:

2. **Low carbon and resilient Oil & Gas portfolio**: Eni’s hydrocarbon portfolio has a high incidence of natural gas (>50%), a bridge solution to a low-emission future. The main upstream projects underway have an average portfolio break-even at a Brent price of around $25/barrel and are therefore resilient even in low-carbon scenarios.
3. Development of renewable sources and green business with a circular approach: the promotion of renewables aims to reach an installed electrical power of over 1.6 GW by 2022. With regard to green business, the start-up of the Gela biorefinery by 2019 and the completion of the second phase at Venice biorefinery by 2021 are expected.
Moving towards a low carbon future

- Switch Coal to Gas
- Energy efficiency
- Renewable energy
- CO$_2$ Capture and Storage (CCS)
«Il futuro è di chi lo sa immaginare!»

Enrico Mattei