R&D, THE WORLD IS OUR LABORATORY

Our research organization spans the globe. Basing our specialized Research Centres and teams strategically near the regional hubs of the oil & gas industry gives us access to these regions and projects our image of R&D excellence around the world.

In full synergy with the nerve centre of Total E&P’s R&D at the Centre Scientifique et Technique Jean-Féger (CSTJF) in southwest France, these researchers are part of a multi-disciplinary network of teams working on strategic R&D programs and themes, crucial for Total’s competitiveness.

Our international network and the close ties we have forged with leading-edge public and private research bodies enable us to tap into the academic and industrial expertise available in each region. This open innovation strategy helps us access the most promising scientific and technological advances that we can leverage to deliver tomorrow’s breakthrough technologies a step ahead of our peers.

Our Research Centre in Stavanger, Norway, has enjoyed rapid growth, fostering highly efficient partnerships with industrial consortiums and universities in some of the world’s most crucial R&D programs, that will keep Total ahead in our commitment to produce better energy.

DANIEL PLATHEY
Vice President R&D, E&P
Total E&P Norway spearheads the Group’s drive to develop cutting-edge technologies in the crucial research fields of clean energy, deep offshore hydrocarbons, environment and sustainable development together with drilling and wells.

The Stavanger Research Centre draws on Norway’s historical commitment to ensure high value creation through efficient and environment-friendly management of Norway’s energy resources.

As a result of Norway’s pledge to identify ways to promote technology development and reduce costs of Carbon Capture Utilization and Storage (CCUS), the Stavanger Research Centre has doubled in size to 16 personnel in the past two years.

From its strategic position in Stavanger, the oil capital of Norway, the Research Centre profits from a well-connected technological innovation ecosystem strongly backed by the Norwegian government, fostering connectivity between the different stakeholders: e.g. Ministry of Petroleum and Energy, The Research Council of Norway, the Research Centres of Norce, Sintef, the universities in Bergen, Trondheim and Tromsø and the oil and gas operators.

With an average 13% stake in Joint Industry Projects (JIP), Total E&P Norway leverages access to an additional 87% of R&D funding from government and industry across more than 100 projects ensuring Total maintains its lead ahead of its competitors in facing the industry’s main challenges: accessing oil and gas in a cheaper, cleaner, safer and more responsible manner.

Jeremy Cutler
Stavanger Research and Development Department Manager
MAKING CARBON CAPTURE STORAGE A REALITY

WE ARE PUSHING FORWARD CARBON CAPTURE AND STORAGE (CCS) WITH TWO MAJOR PROJECTS IN NORWAY TO CUT RISKS AND COSTS, THUS ENABLING VIABLE BUSINESS MODELS
NORTHERN LIGHTS – A VITAL PART OF THE NORWEGIAN FULL SCALE CCS PROJECT

CCS is key to meeting the 2015 COP 21 climate goals. It needs to play a significant role in de-carbonizing the energy market and industrial processes. This is why the Norwegian government aims to develop for 2023/2024 the Northern Lights CO₂ transport and storage project in 2017, with partners Shell and Equinor, brings to the project its strong oil and gas reservoir experience. The first phase will provide storage for up to 1.5 million tons of CO₂ per year, captured from onshore industrial sources (cement and waste incinerator) in eastern Norway. The CO₂ will then be shipped to a receiving plant onshore, located on the western coast of Norway, before being sent through pipelines to one of several injection wells on the Norwegian Continental Shelf.

Total, which joined the Northern Lights CO₂ transport and storage project in 2017, with partners Shell and Equinor, brings to the project its strong oil and gas reservoir experience. Construction of the full-scale project including the onshore terminal is subject to the Norwegian parliament making a positive investment decision, scheduled for 2020/2021.

EXPERTISE

CO₂ TRANSPORT
Exploring CO₂ transport as part of the Norwegian CCS Research Centre (NCCS).

• Focus on CO₂ thermodynamics and fiscal metering of volumes transported. Aiming to improve the knowledge and control of CO₂ thermodynamics, in its dense phase, especially in case of depressurization with the emergence of solid phases or in the presence of impurities.

• Improving knowledge of running ductile fractures in CO₂ transport pipelines, a typically corrosion induced phenomenon, extremely stringent for CO₂. We aim to define a methodology to model this phenomenon to ensure that the sizing of the pipelines will allow them to resist.

PRESSURE RELIEF SIMULATION
The objective is to qualify VESSFIRE, a software to simulate pressure relief for equipment containing liquid and gaseous CO₂ to avoid dry ice phenomena. The solids are formed when reducing temperatures significantly, causing the formation of carbonic ice that may plug evacuation networks during the depressurization of a storage unit.

• Exploring the use of ships for low pressure CO₂ transport at 7 bar. While the tanks will be lighter, lower temperatures will be needed, hence using more energy for cooling.

MAIN PARTNERSHIPS

CO₂ TRANSPORT
NCCS, an international research cooperation on CCS, co-financed by the Research Council of Norway, industry and research partners.

PRESSURE RELIEF SIMULATION
CARDICE JIP (CARbon Dioxyde ICE), with Gassnova, Equinor, Petrell and INERIS.

CO₂ CAPTURE, FULL-SCALE CCS
Northern Lights: Gassnova, Equinor, Shell; TCM: JV with Gassnova, Equinor and Shell
ALL-ELECTRIC SEABED PROCESSING

Total is developing cutting edge technologies to meet challenges raised by subsea power transmission, distribution, and conversion over greater distances, in deeper waters, and in harsher environments. Harnessing the potential of deep-sea containment systems, to replace platforms, our R&D teams plan to reduce field development capital expenditure. We intend to prove that these systems, containing high voltage equipment, can reach depths of 3,000 metres and transmission of up to 600 kilometres, with power levels reaching up to 200 MW. The main difficulty is to ensure that high power electronics operate under high pressure in a reliable manner. To address this issue, we are testing methods to compensate the pressure, using oil-insulated containment systems. With subsea providing a cooler environment—ambient temperature on the sea floor is on average 4°C—this cuts the need for costly and cumbersome cooling units, currently operating from topsides. The aim is to have a commercial product in 2019. Total is looking to use the technology for projects in Brazil, West Africa and the Gulf of Mexico.
EXPERTISE

FLOW ASSURANCE
Understanding and modeling the complex behavior of multiphase flow in pipelines and risers is the main challenge for research in Flow Assurance and represents the key to unlocking the value of deep offshore and long distance subsea tiebacks. The challenge for the future is now to be able to take into account the physicochemical properties of the fluid in the multiphase simulators and this is what Total is working on with Norwegian research institutes. For more details see the red box.

ALL-ELECTRIC CHRISTMAS TREES
Studying the possibility of removing all hydraulic lines in umbilical cables used to supply the necessary power, hydraulics and chemicals to subsea oil and gas wells. Hydraulic lines will be replaced with electrical power and signals to operate the many valves in the well.  
- The project’s main drive is to reduce development costs and the size of umbilical cables. For a subsea, remote oil field, it becomes critical to reduce the size of umbilicals. For instance, when these reach 200 kilometres, we aim to reduce capital expenditure by up to 20%.
- Technology already exists. Total has been using an all-electric Christmas tree since 2008 in the Dutch K5F field in the North Sea. This is a world premiere.
- Total is working with Equinor challenging suppliers to provide these all-electric Christmas trees.

SUBSEA MULTIPHASE PUMPS
With the Modular Compact Pump JIP (General Electric), Total aims to build a 12-module pump, with an outlet pressure of 120 bar, a speed of 4000 Revolutions Per Minute (RPM) and a Gas Volume Fraction consuming up to 4 MW. The challenge in developing this technology is to replace barrier fluid with process fluid to cool and lubricate bearings.
Total has also partnered with Aker to design modular booster pumps to operate in a Gas Volume Fraction (GVF) range of 30% - 90% at depths of down to 3,000 metres below sea level. Such pumps have a suction pressure of 12-90 bar and can deliver a delta pressure of ~100 bar at a GVF of 70%, with power up to 6 MW.

MAIN PARTNERSHIPS

UPGRADE LEDAFLOW®
Flow control in hydrocarbon production lines has emerged as a key factor for successful oil and gas development projects, especially in deep offshore contexts. Total’s goal is to improve precision, reliability and calculation time of flow assurance simulators. As part of this drive, Total aims to upgrade its LedaFlow® transient multiphase flow simulation software, designed to meet the challenges of oil and gas found in deep water, longer tie-backs, harsh and remote environment. One key aspect is to enhance the hydrodynamic modeling, to take into account the presence of contaminants and how these might alter the physical and chemical properties of the fluids. Another aspect is to boost accuracy in multiphase flow prediction. Our teams are also working on a new numerical solver to boost simulation speed as well as on a project to run LedaFlow® in the Cloud. LedaFlow® is the product of a decade-long collaboration between Total, ConocoPhillips and Sintef. It is commercialized by Kongsberg Digital.

ALL-ELECTRIC SEABED PROCESSING

FLOW ASSURANCE

ALL ELECTRIC CHRISTMAS TREES

SUBSEA MULTIPHASE PUMPS

Kongsberg - multiphase flow in deep offshore.
HIGH PRECISION ENVIRONMENTAL RISK ASSESSMENT AND INDUSTRIAL SAFETY

IMPROVING MAJOR ACCIDENT PREVENTION AND ENVIRONMENTAL RISK ASSESSMENT (ERA) IS AT THE HEART OF TOTAL’S COMMITMENT TO PRODUCING ENERGY IN A SAFER AND MORE RESPONSIBLE MANNER

ASSESSING ENVIRONMENTAL RISK OF OFFSHORE ACUTE OIL

To boost accuracy and standardization for offshore installations in case of acute oil spills, Total is a key partner in developing a new internationally applicable environmental risk assessment (ERA Acute) methodology and tool. It provides quantitative assessment of environmental impact, damage and risk of acute oil spills covering sea surface, shoreline, water column and seafloor. The method uses oil drift simulations and Valued Ecosystem Components (VECs) data as input and allows impact and recovery times calculations for VECs using continuous risk functions, which better predict the effects of small spills and mitigation measures compared to the MIRA methodology, currently used by the oil industry in Norway, and by Total. Based on a selection of relevant and documented oil spill incidents (Deepwater Horizon, 2010, and Exxon Valdez, 1989), the methodology and tool could be validated against field data. One of our main objectives is for ERA Acute to be recognized by the scientific community as a state-of-the-art methodology for assessing acute oil spills environmental risk, and obtaining Norwegian regulators and stakeholder support as the preferred methodology for the Norwegian continental shelf (NCS). The aim for Total is for ERA Acute to become the method of choice at Group level.
MODELING TOOL TO PREDICT MARINE SPECIES BEHAVIOR

Total is working with DHI and other partners on MARAMBS (Mobile Animal Ranging Assessment Model Barents Sea), a tool that will predict the whereabouts of vulnerable marine species and sea birds year around to help the oil and gas industry plan their activities in an environmentally sound manner. The tool’s area of focus is the Barents Sea with special attention to the ice edge, closing a knowledge gap. It will make use of information gained by several Norwegian academic institutes and make innovative analysis that is ideally suited for de-risking the Norwegian oil and gas industry.

The tool, which is delivered as an online risk analysis software, combines observations and cutting edge dynamic habitat modeling to simulate distribution, behavior and migration processes. It also models environmental stressors, such as an oil spill or noise from seismic studies, and simulates their effect on the modeled species. It is anchored in Norwegian national strategies, and EU directives for the protection of the Arctic. A hydrodynamic model has been developed, with 2015-2016 data implemented. Industry partners (Total, ConocoPhillips and Equinor) have also tested the tool.

EXPLOSION RISK FROM REALISTIC RELEASES

Improve understanding of explosion strength and characteristics that arise in case of ignition of an actual methane jet release. The aim is to evaluate the influence of initial cloud turbulence and heterogeneity of the concentration field on the blast loads in a real release scenario. Our target is to test the robustness of current modeling approaches that rely on equivalent quiescent clouds, improve FLACS code to bring more realism in the simulations so that the explosion mitigation strategy can be focused on truly hazardous sequences.

KFX SIMULATOR

Develop modeling capabilities of KFX, a software solution for simulation of dispersion, fires and explosions in congested areas, to include new hazards from mature fields, complex streams (CO₂), LNG. Studying:
- cryogenic effect of LNG releases
- fire from mature field streams
- ability to model full fire protection

WATER CURTAIN

Assess the effectiveness of water curtains as an active mitigation solution against explosion escalation via experimentation. We intend to better understand how much water to use, to reduce overall costs, and whether combining water with other chemical compounds (such as dissolved alkali metal compounds) improves the tool’s usefulness. Our target is to develop modeling capabilities in support of new designs or retrofits, with the ability to achieve more compact layouts and reduce design loads for new projects.

RISK INFORMED DECISION SUPPORT IN DEVELOPMENT PROJECTS (RISP)

Develop methods and criteria that use experience, knowledge and insight acquired over the years to provide robust and timely risk-based decisions concerning the design and operations of any new development project. Instead of using traditional quantitative risk assessments and detailed simulations, we aim to use existing knowledge for well-known threats (influencing factors, typical design loads, etc.) and fund our decisions on simplified approaches when possible. We are also focusing on new hazards and new threats induced by the heightened use of digitalization in platforms and long distance handling processes. In 2019, we aim to develop methods for fire loads, ship collisions, helicopter accidents and toxic loads. We will also propose changes in regulatory frameworks and standards.

MAIN PARTNERSHIPS

ERA ACUTE
JIP ERA Acute with Equinor, Norwegian Oil and Gas Association (NOROG), the Research Council of Norway (DEMO 2000).

PREDICT SPECIES BEHAVIOR
JIP MARAMBS with the Research Council of Norway (Petromaks2), ConocoPhillips, Equinor.

AIRRE
JIP with Gexcon, DNV GL, Shell, GRTgaz, INERIS.

KFX SIMULATOR
JIP with DNV GL, ConocoPhillips, Equinor and ENI.

WATER CURTAIN
JIP DOWSES, with DNVGL, Shell, Woodside.

RISP
JIP RISP, with Equinor, ENI, ConocoPhillips, Lundin Petroleum, Wintershall, Petroleum Safety Authority Norway, Norsk and NOROG.
FULLY AUTOMATED OIL RIGS

TOTAL IS AT THE CENTRE OF AN INDUSTRY DRIVE TO FULLY AUTOMATE OFFSHORE PLATFORMS IN A BID TO IMPROVE SPEED, ACCURACY, HEALTH AND SAFETY WHILST CUTTING OPERATING COSTS.

GAME-CHANGING DRILL FLOOR ROBOT

As part of the oil and gas industry’s push to fully automate rig floors, Total is testing the world’s first robotic drilling on Deepsea Atlantic, Equinor’s semi-submersible rig. The move will be a step-change in speed and safety when handling equipment on the drill floor. The drill floor robot is the world’s strongest electric manipulator arm with a lifting capacity of 1,500 kg on a three-metre arm. It includes a tool interface whereby dedicated tools will be shifted within seconds. Early studies indicate that the drill floor robot can save six to twelve rig days per year and eliminate at least 500 manual operations, thus significantly reducing costs. The robot is all-electric and self-contained with hardware controls integrated inside the robot body. This means that installation and integration are reduced to only connecting power, communication, safety chain and air for obtaining explosion proof status. It will present a paradigm shift in safe and efficient drill floor handling. The first drill floor robot was installed on a land rig at the Ullrøg Drilling and Well Centre in Stavanger which is part of the Norwegian Research Centre (NORCE).
EXPERTISE

P&A CASING REMOVAL
We intend to develop cheaper, safer and less time consuming Plug and Abandonment (P&A) operations, carried out when a well has reached the end of its lifetime. Whereas current P&A operations require conventional milling to remove a section of the casing, Total is investigating using rocket fuel technology, a fuel with very high energy density, to melt the casing safely and effectively in an offshore environment.

WELL SCREENING
Assess ways to have a better understanding of the well situation at the end of its life in order to put in place the most appropriate plug-in system to reduce expenditure. Total believes a plurality of technologies are needed to screen a well effectively:
- Working with GE’s Baker Hughes for well screening to obtain more information prior to P&A using a combination of different technologies such as advanced acoustics implementing gamma ray, neutron and electromagnetism.

REPLACING CEMENT
We aim to replace cement plugs to significantly reduce plug length from 50 metres to two metres. Alternative materials include:
- Bismuth based alloy, which cools and expands on solidification. It is also very viscous, thus filling all existing gaps.
- Polymer, an artificial rock that can be pumped like cement, shrinks 0.5 percent, compared to 3-4 percent for cement. It also has one thousand times less permeability than cement, which means it offers lower risk of leakage (with the University of Stavanger).

MAIN PARTNERSHIPS

ROBOT PILOT ON DEEPSEA ATLANTIC
Equinor, Eni, RCN Nabors, Odfjell, Johan Sverdrup licence and RCN.

DRILLING DATA HUB
Project led by International Research Institute of Stavanger (IRIS), with ENI, AkerBP, Sekal, Research Council of Norway and Equinor.

DRILLING AUTOMATION DADPC
Project led by IRIS, with ENI, AkerBP, Sekal, Repsol, Equinor, Odfjell drilling, the Research Council of Norway and Nabors.

1. Now NORCE (Norwegian Research Centre AS)
Total is a major energy player committed to supplying affordable energy to a growing population, addressing climate change and meeting new customer expectations.

With operations in more than 130 countries, we are a leading international oil and gas company and are developing a low-carbon electricity business.

We produce and market fuels, natural gas and electricity from gas and renewable sources for our business customers and consumers.

Our 100,000 employees are committed to better energy that is safer, more affordable, cleaner, and accessible to as many people as possible. Our ambition is to become the responsible energy major.