Most of the world’s oil & gas resources have already been discovered, and over half was produced in the last century. It is thought however that only about 35% of the oil in the ground is actually recovered using conventional methods, leaving 65% or more behind. With an estimated average of 1% increase in global output equating to around 1½ years of worth of world demand, then it is clear that maximizing production from existing or mature fields would have a key role to play in future energy supply.

The economic case is equally strong, extending production and prolonging the payback from existing facilities increases return on capital and with the necessary planning and management can ensure long term competitive production. Total is proud of its pedigree here, and boasts one of the lowest production cost aggregates of all its peers.
UNDERSTANDING FIELD MATURITY

While there is no fixed definition, and different companies apply different criteria, the general industry consensus is that a field is mature once its production plateau starts to show sustained decline. At Total we do not lose sight of our original production targets, however in most cases we exceed these.

PRACTICAL CONSIDERATIONS

Forestalling the natural decline of mature fields is a core strategy for Total, however it is not without its challenges, and there are many practical issues to be addressed.

- **Asset integrity and depreciation** (corrosion, damage, end of life and obsolescence). Are production facilities still fit for purpose? They may be damaged or needing repair or obsolete due to changing environmental and safety requirements.
- **Reservoir maturity** (loss of pressure, water and/or gas content) may require additional modeling and characterization.
- **Fit for purpose** (needs vs means) as reservoir characteristics change, are site facilities still appropriate? (For example, power and/or treatment facilities?).
- The impact of additional developments such as: infill drilling, field extensions with satellites and tie backs, facility debottlenecking, perhaps not originally envisaged.
- **Water management**, mature fields produce a lot of water. As a global average, the major IOCs produce about 2/3rd water vs 1/3rd oil, so around the world companies are dealing with around 200 Mb of water per day.

**Key figures**

60% of world production comes from fields

> 20 years old
Total employs a pro-active and innovative strategy towards optimizing field life and delaying natural attenuation. This strategy, a combination of management vision and technical understanding has enabled us to post one of the lowest rates of decline among IOC’s. These pages outline technical methodologies, however we also implement many cost saving initiatives that can be applied, such as remote operations, or collaborative and shared logistics.

**INFILL DRILLING**

For improved recovery new wells can be drilled in the spaces between the depleting wells of an existing pattern. To avoid negative impacts on the existing well pattern however a precise understanding of the subsurface is required along with controlled directional drilling. When performed from the Dunbar platform in the UK in 1993, a then world record “tight turn” deviation of 51° over 30m was achieved to remain in position in the Brent reservoir, this helped enable an additional 4.5 Mb oil to be made available.

**4D SEISMIC**

When applying 3D seismic the contrasts between water, oil and gas are visible. However 4D seismic, or “repetitive 3D” enables us to track fluid movement over time and locate remaining reserves for the best placement of infill wells. This is especially effective when pre-production 3D surveys are available as a baseline.
SUBSEA MULTIPHASE PUMPS (MPP)

Reservoir pressures decrease over time, and the quantity of gas in oil produced increases. The installation of multiphase pumps (oil+water+gas) either at the surface or on the seabed in deep water can mitigate this and prolong production as gas contents rise. Installing such pumps deep offshore during development at CLOV, in Angola, as part of the project brown field program means that field life extension has been planned for in advance.

ELECTRICAL SUBMERSIBLE PUMPS (ESP)

Installed in well just above the producing layer, ESP’s extend well life as they effectively increase well pressure. They are more efficient than other forms of artificial lifting. Total has used ESP’s at many installations, such as: Pointe Noire Grands Fonds (PNGF) and N’Kossa (Congo) and Anguille, Torpille and Grondin (Gabon).

ENHANCED OIL RECOVERY (EOR)

Conventional methods rarely achieve recovery factors above 35%. EOR can increase this, by as much as 15%, a considerable economic return for an existing installation. Total has extensive experience in many EOR technologies, using various fluid types, plus considerable research invested in developing new technologies such as Total’s own “SWIM” (Smart Water Injection Methodology) that fine tunes the composition of the injection water (salinity, ionic content etc), for individual reservoir conditions.

SMART TECHNOLOGY & ASSET MANAGEMENT

Asset management is key in ensuring economically sustainable production. At various locations globally, Total has “smart rooms” remotely checking and coordinating its operating systems. These are able to undertake various diagnostic activities like platform and well performance monitoring. Employing systems such as: Remote Metering Monitoring, or RAID (Remote Assistance Intervention and Diagnosis), which uses Smart Signal technology to remotely monitor operational parameters of machinery anywhere around the world. Potential mechanical problems can be identified and remedied to prevent failure. Extending this concept further, the innovative Project Brown Field (PBF) program employed deep offshore in Angola means that future maturity issues are anticipated and technical solutions implemented long before problems arise.
At Total we understand that wherever we operate in the world we must build on lessons learned. We must progress by implementing our new and innovative technologies to our existing installations thus bringing extended production across our operated network.

“Total’s Projects Brown Field program, implemented in Angola, aims to limit the natural decline of the producing fields and maximize the production of the existing FPSOs with: infill wells, enhanced activation by seabed multiphase pumping, topside debottlenecking and tie-back of satellite fields.”

Jean-Hervé MORARD, PBF Director

ESP & POWER MANAGEMENT AT PNGF, CONGO

The installation of Electrical Submersible Pumps (ESPs) at our PNGF asset has significantly enhanced and extended production, however the switch from compressor driven gas lift to the more efficient ESPs has meant additional electrical demand. Upgraded turbines were installed to deliver the extra power. Undertaking this as part of an obsolescence program minimised any unnecessary costs, demonstrating the need for careful planning. Today for many installations closer to shore, centralised onshore power generation is often a viable alternative.
The Abu Al-Bukhoosh field in Abu Dhabi started production in the mid 1970’s with an initial forecast production capacity of 194 Mb over 20 years. Today, 40 years and more than 500 Mb later, oil is still flowing. The original recovery factor of 16% has been increased to over 42%. This has been by continual adaptation and the application of a broad range of technological knowhow. Technologies such as well stimulation, directional drilling, repressurization, miscible gas injection, plus the installation of capillary velocity strings to introduce foamers, along with the introduction of complex well architecture with multiple horizontal drains have all contributed to this success. Additional advanced technologies including “SWIM” (Smart Water Injection Methodology) EOR are today being considered to further maximize the productivity of this field.

Tunu is a giant Indonesian gas field located in shallow water to the east of Borneo Island in the Mahakam delta. Initial well spacing was large at 1,600 m. To enhance production in maturity, the well spacing was progressively reduced, to 1,100 m, then to 800m. The new spacing means many additional wells, requiring either the existing platform to be extended or remote wellhead platforms to be built and tied back. So as to prevent or mitigate any adverse impacts to the local fishing community, additional measures were agreed and undertaken during shallow drilling. These included short term temporary relocation, and compensation in the form of the provision of solar lighting and contributions to public facilities.

The Alwyn area development came on stream in 1987. Production was initially from Alwyn Brent (predominantly oil) and Statfjord (gas plus condensate). After a decline a second primarily oil field (Dunbar) was developed along with a small satellite, Ellon, in 1995. Subsequent developments and tie-backs bringing on stream the Trias, Grant, Nuggets and Forvie North fields have ensured ongoing production, however one of the main features of the Alwyn area is its variety of fields (oil, gas condensate and dry gas) and production has evolved from predominantly oil (75% in 1987) to mostly gas (75% by end 2006). This proportion is likely to increase in the future reaching more than 85% gas by 2020. One of the keys to success here has been asset and field management in changing from predominantly oil to gas. Technologies used to extend field life include; water, then miscible gas injection, increasing export compression (accommodating gas), upgrading electrical power systems, and reservoir blowdown to mobilise gas and improve oil recovery.
Total is a major energy player committed to supplying affordable energy to a growing population, addressing climate change and meeting new customer expectations. Those commitments guide what we do. With operations in more than 130 countries, we are a global integrated energy producer and provider, a leading international oil and gas company, and a major player in solar energy with Total Solar and our affiliate SunPower. We discover, produce, transform, market and distribute energy in a variety of forms, to serve the end customer.

Our 98,000 employees are committed to better energy that is safer, cleaner, more efficient, more innovative and accessible to as many people as possible. As a responsible corporate citizen, we focus on ensuring that our operations in more than 130 countries worldwide consistently deliver economic, social and environmental benefits. Our ambition is to become the responsible energy major.