Fluid Catalytic Cracking

World class FCC experience and capability
**Largest**

- Regen in the world - South Korea
- 33 countries around the world
- >250 RCC/FCC residue catalytic cracking/ fluid catalytic cracking projects in the last 50 years
- 159 FCC Projects since 1990
- >40 New Units at 14 grassroots refineries

**UK**
- 22 x EPC Projects
- 37 x EPCm Projects
- >30 FCC Projects in the last 10 years
Amec Foster Wheeler has an extremely positive and proactive HSSE culture and a proud safety record.

To strengthen its culture and reinforce the commitment to HSSE performance at all levels of the organisation, Amec Foster Wheeler developed and maintains its Beyond Zero program.

Beyond Zero provides the mechanism to achieve the vision of sustainable, world-class HSSE performance across Amec Foster Wheeler’s global operations.

For many years the company has had a goal of zero harm to people and the environment and wants to be recognised as a true world leader in HSSE.

To do this it must have sustainable performance improvement - not only reaching target zero this year, but going beyond this to achieve it next year and the year after that.

By leading by example, Amec Foster Wheeler not only sets new standards for the health and safety behaviour for its workers but will also take its positive influence out into the environment in which we live and work.

Amec Foster Wheeler’s HSSE management system is certified to AS/NZS 4801, OHSAS 18001:2007 and ISO 14001:2004 (Environmental).

Our HSSE commitment
Putting safety first - Doing the right thing

Why Amec Foster Wheeler?
From concept to commissioning and beyond

Amec Foster Wheeler is one of the few companies that provide support throughout the complete life cycle of a project. Our regional operations are supported by teams of experts in our global network of offices.

Our world class safety record, systems, people and technical knowledge means that regardless of size, complexity or location, we have the skills, experience and creativity to add value throughout the entire asset lifecycle.

We are independent with no ties to any licensor or manufacturer. Our experience with all licensors and a large spectrum of operating units provides a unique ability to help all clients.

» Technical consultancy
» Studies
» Front-end design
» Project management
» Detailed engineering
» Procurement
» Supply chain management
» Construction
» Commissioning
» Training & development
» Asset support
» Operations & maintenance
» Environment & sustainability
» Decommissioning
Fluid Catalytic Cracking

We are one of the world’s most experienced contractors in the engineering and construction of residue catalytic cracking/fluid catalytic cracking (RCC/FCC) units, with a track record stretching back more than 50 years. In the last 50 years we have undertaken well over 250 RCC/FCC projects: design and construction of over 40 new units, and more than 200 revamps, expansions, upgrades and turnarounds for over 50 refineries in 33 nations.

We have completed projects with all major RCC/FCC technology process providers. This continuing involvement with diverse process technologies has placed us in a uniquely authoritative position in engineering, construction, commissioning, start-up and operation of new and revamped catalytic cracking units. We have developed a very detailed knowledge of the complex range of mechanical issues associated with these technologies.

We have a core team of specialists with a wealth of RCC/FCC experience, ensuring that we can anticipate and overcome the challenges presented by even the most complex revamps or new equipment installations. With our value engineering skills and constructability expertise, we deliver practical innovative solutions to meet our clients’ objectives – shorter turnarounds, lower cost, lower risk, quality with operational reliability, plus world-class safety and start-up performance.

“The key to success is planning... and planning early.”

A complete range of services:

- Consultancy services whenever you need them
- Detailed knowledge and close relationships with all RCC/FCC licensors
- Detailed Design with in-house analysis and FEA (Finite Element Analysis) capability
- Capability to manage and close relationships with proprietary designed key manufacturers of complex equipment and materials (e.g. cyclones, refractory, special valves, expansion joints)
- Integration studies for a new unit within an existing refinery
- Heavy lift and transport studies
- Constructability studies
- Turnaround studies and detailed planning
- Full EPC (engineer, procure, construct) and project management
- Detailed Engineering method statements
- Management of field fabrication of very large equipment at site, refractory lined, exotic material.

With increasing interest in the refinery/petrochemical interface, emphasis has been placed in recent years on maximising production of propylene from catalytic cracking units. Our considerable experience in this area includes propylene purification units, enabling product suitability for use as either a chemical or polymer grade.
All components within FCC have a design life but the operational life achieved depends on how the unit is operated and the quality of installation. The aggressive environments encountered within the main vessel’s reactor and regenerator are caused by high temperatures and erosion due to the circulation of hundreds of tonnes of abrasive catalyst. Continued operation beyond the anticipated design life can compromise future operational reliability.

The effects of increased run times between turnarounds

All operators seek longer run times between FCC turnarounds. The norm was historically three years, but now five or six years are being successfully achieved. Assuring operational reliability over this increased timeframe takes more thought, planning and accurate prediction of component replacement requirements.

With a three-year run, it was always possible to make patch repairs for reliable operation until the next planned turnaround; by stretching to a five-year run, this stop-gap approach greatly increases the risk of failure.

With increased periods of time between turnarounds, it is good practice to start planning for the next, and the one after that, even before the current turnaround is completed. For a three-year campaign, this would mean predicting component life for the next six years. By increasing operating cycles to five or six years, this pushes the prediction horizon to 10 or 12 years.
An early start

As soon as possible after a turnaround, and at least three years before the next, a study should be carried out to determine the optimum solution for the next shutdown. This allows sufficient time for the study/licensor selection, the licensor package development/engineering and equipment procurement/manufacture.

Key steps in the study phase

- **Client needs**
- **Process/technology improvements**
- **Maintenance requirement**
- **Feasible options**
- **Licensor selection**
- **Cost estimate**
- **Engineering & construction**
- **Planning turnaround duration**
- **Risk/’What if’ analysis**
- **Conclusion and execution strategy**

Typically a study generates a large range of options for required component changes. These can include new heads complete with cyclones, entire sections of regenerator shell, or new reactors. Cost-wise, there may be minimal capital cost difference between the options, as costs are balanced between turnaround labour for repair against those of the new component with offsite fabrication and installation.

When the advantages of reduced turnaround time, reduced risk to the turnaround, improved reliability and the opportunities for process improvements are taken into account, then the option for larger component changes often becomes more attractive.

A study carried out as part of turnaround planning can result in reduced risk, lower costs, increased run time and improved process performance.

**Critical success factors**

Key factors to be considered in planning all FCC turnarounds include:

- Working safely
- Assuring future operational reliability
- Minimising downtime through meticulous planning
- Managing the risk of ‘unknowns’ such as emergent work or components not fitting
- Delivering the lowest overall cost
- Capitalising on opportunities for process improvements

There are some key ‘ground rules’ that should be applied:

- Maximise pre- and post-turnaround activities
- Maximise work that can be done offsite
- Adopt a ‘fit-first-time’ approach
- Take advantage of the latest proven technology; this applies not only to the process improvements but also to mechanical design and refractory installation

**Key considerations include:**

- Client needs - desired turnaround, business or market drivers
- Process/technology improvements - increase operational profit, reliability, and meet future environmental requirements
- Maintenance requirement - predicted component replacement and refractory repairs
- Licensor selection - an opportunity with associated yield advantages; plus any debottlenecking requirements
- Cost estimate - in the order of +/-30% for the overall turnaround project
- Engineering, procurement & construction strategy - method of delivery, crane requirements, logistics, outline of the basic method of site assembly and shutdown execution
- Planning & turnaround duration - detailed schedules demonstrating plant downtime
- Risk/’what if’ analysis

“With an early start, it’s possible to turn a turnaround into an opportunity.”
Process improvements

Process technology improvements are driven by external factors, such as market prices for feedstock and products, and legislative requirements for environmental emissions or product specifications.

Each turnaround is an opportunity for the refiner to exploit the price differential between the FCC feedstock (generally atmospheric residue or vacuum gas oil and residue) and products.

There are also wider considerations which relate to the units connected to the FCC.

Following a change to process configurations the FCC must still work effectively. To ensure the unit is still in heat balance, a check is required on the coke yield. An increase liberates more combustion heat.

A simple side-by-side FCC may require modifications to burn more coke, generating more heat. As the coke yield increases this may include pushing the regenerator to its design temperature limit, changing the operation to run in partial burn with external CO firing or by adding catalyst coolers.

The excess heat liberated can be used to raise steam to run the main blower drive and the wet gas compressor.

Conversely, if the unit runs on a clean hydrotreated feed with low conversion, the unit may be in heat deficit and require additional heat input by burning more fuel in the regenerator. This might occur when maximising clean distillate production which, for transport fuels, normally requires post-processing to remove sulphur, adjust density and boost cetane.

Changes to unit feed and product configurations may require modifications to any pollution abatement equipment. Modifications may be required because of changes to environmental legislation. Key FCC atmospheric pollutants that should always be considered include NOx, SOx and particulates.

Controlling atmospheric pollutants

NOx is created in the regenerator from the oxidation of feed nitrogen captured on the coke and reaction with atmospheric nitrogen. The level of NOx generation can be modified by careful control of the oxidation conditions in the regenerator and can sometimes be improved by changing the regenerator arrangement. Catalyst additives, such as combustion promoter, also affect the levels of NOx generated. Use of other technology, such as selective catalytic reduction, might also be required. This end-of-pipe solution is well-proven, reacting ammonia over a catalyst with the flue gas NOx to form diatomic nitrogen and water.

Regenerator SOx emissions can be controlled using additives in the catalyst. These promote the formation of hydrogen sulphide in the reactor which reduces the quantity of sulphur entering the regenerator. Any sulphur entering the regenerator is oxidised to sulphur dioxide or sulphur trioxide. Alternatively, and often complementing additives, the whole flue gas can be scrubbed with an aqueous solution. This has the added benefit of removing particulates.

Lastly, catalyst particulates can be seen as visible emissions from a FCC flue gas stack. There is a range of options that can achieve different flue gas particulate emission levels.

Close coupled primary/secondary cyclones can achieve 210 mg/Nm³. Add-on abatement technologies can achieve lower emissions that are typically demanded by permitting authorities (see table, above right).
Choosing the best technology

If changes are needed to the reactor or regenerator, a licensor will be an integral part of the pre-turnaround study. Most licensors will sell their technology into a competitor-designed unit. This enables refiners to choose the best technology solutions to meet their current challenges and future business plans. The best response is received when a professionally written specification is issued for competitive tender and evaluation, considering the technical advantages, reliability, proven track record and, most importantly, the commercial viability.

### Flue gas particle emission abatement technologies

<table>
<thead>
<tr>
<th>Abatement technology</th>
<th>Particle emission level mg/Nm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough cut tertiary</td>
<td>150</td>
</tr>
<tr>
<td>Fine tertiary with fourth stage filter</td>
<td>70</td>
</tr>
<tr>
<td>Whole gas filtration</td>
<td>10</td>
</tr>
<tr>
<td>Electrostatic precipitator</td>
<td>30</td>
</tr>
<tr>
<td>Wet gas scrubber</td>
<td>20</td>
</tr>
</tbody>
</table>

Turning a turnaround into an opportunity

Wear and tear means that maintenance-driven shutdowns on FCCs are inevitable. Therefore, the opportunity for process technology improvements arises at each shutdown. The challenge is for the refiner to maximise the benefits of the maintenance turnarounds by looking for new business opportunities or margin enhancement opportunities.

In executing the project, it is important to apply rigorous project management best practice to the scope definition and development to ensure the right technology and technical solution can be delivered safely, at the right cost and in the right time-frame to deliver the expected return.

Operators should consider establishing maintenance requirements early and look to combine this scope with other improvement opportunities. Rather than separate budgets for process improvement and for maintenance work, a more holistic view is more likely to deliver the optimum solution.
Life of asset services
Amec Foster Wheeler

We deliver projects, from concept to commissioning and beyond.

For any development, we start adding value from day one, helping our customers to evaluate the opportunity, screen options, select the right option, and then realise the revenue as quickly as possible.

We deliver value at the front end, then can bring our global EPC skills and experience to bear, developing the right execution strategy, and then delivering on time, safely, cost effectively, and right first time. Right through the life of your asset we can provide the right support, from turnarounds and brownfield projects through to long term asset support, performance improvements, through to through to asset conversion, closure and remediation.

Consultancy services
► Environmental
► Marine and coastal
► Geotechnical
► Permitting and regulatory
► Community and social affairs
► Water and wastewater
► Transportation

Project delivery
► Feasibility studies, concept and pre-FEED
► Cost and schedule planning and control
► Technology integration
► FEED design
► Engineering and procurement
► Fabrication and construction
► Project management
► Start-up and commissioning
Amec Foster Wheeler has an outstanding track record in executing refinery projects, from world-scale grassroots refinery complexes, to major expansions and revamps, complex turnarounds, refinery/petrochemicals integration, clean fuels projects to meet new legislation, residue upgrading to produce higher-value products, right through to smaller maintenance-type projects and ongoing asset support. We also have over a century’s worth of fired heater experience.

**Asset management**

- Due diligence and site assessments
- Asset integrity and optimisation
- Operational readiness and implementation planning (OIP)
- Operator training, systems and management
- Operations & Maintenance term services
- Brownfield upgrades and expansions
- Shut-downs/turnarounds
- Dutyholding
- Late life management
- Mothballing and decommissioning
Industry experience

Amec Foster Wheeler has experience in the execution of FCC unit realisation and revamping.

Star Petroleum Refinery Company (SPRC) refinery

**Scope of work**
- Client required improvement in gasoline and propylene yields and improvement in ongoing reliability
- Pre-FEED, FEED for SPRC refinery at Map Ta Phut, Rayong, Thailand
- Detailed engineering, procurement and construction management

**Project execution**
- Reactor technology was upgraded through total replacement of all internals and riser system
- Execution was completed piece-large
- Bespoke support systems were developed to suit the configuration during the replacement of the stripper section
- All first-stage regenerator primary and secondary cyclones and other internal components were replaced in parallel, piece-small through a large shell window
- Second-stage regenerator secondary cyclones were replaced piece-large in-situ (external cyclones)
- Precision survey utilised through equipment fabrication and turnaround execution with successful ‘fit-first-time’ of installed equipment

**Highlights**
- Simultaneous revamp of RFCCU Reactor and Regenerator

Total Raffinaderij Antwerpen refinery

**Scope of work**
- Existing refinery revamp - FCCU 2 unit regenerator cyclones replacement as part of the 2018 turnaround at the refinery in Antwerp, Belgium

**Project execution**
- Replacement regenerator cyclones along with head, overhead line, air distributor, spent catalysts standpipe and distributor
- No plot space for a major crane
- Crane limited to lifting head only
- Cyclones and large air distributor removed installed whilst head removed. Frame designed on air distributor to support cyclones
- Giant trial assembly of head cyclones and air distributor in vendors works to confirm all fit

Pertamina Balongan refinery

**Scope of work**
- Detailed Engineering
- Study and FEED for revamp of refinery in Indonesia
- Inspection
- Heavy lift consultancy
- Construction management
- Commissioning

**Project execution**
- Regenerator cyclone Replacement old head reused.
- Head 16.4 metres diameter.
- Lift weight approaching 700 tonnes.
- Replacement riser and stack
- Due to transport restraints and costs, existing head will be reused
- Novel methods developed to minimise turnaround duration. New cyclones and Plenum assembled pre-turnaround in head frame
- Head deflection analysis to avoid damage of refractory during lifting
Milazzo Refinery

**Scope of work**
- Upgrading of reactor design, new reactor top head
- New cyclones system and internals
- New riser and spent catalyst standpipe
- New additional tertiary and fourth stage separators
- New turbo-expander
- New regenerator spent catalyst distributor and air rings
- New flue gas lines complete of special valves, expansion joints and supporting system

**Project execution**
- Modular design to minimise pre T/A works during the plant operation
- Laser scanning
- Pre T/A works from March 2014 up to end of April 2015. All works completed within the project schedule
- T/A May 2015, mechanical works 51 days
- New turbo-expander installed within 12 months from the delivery at site

**Highlights**
- Pneumatic test of existing/new pressure parts
- Mechanical/refractory lining works planning

Ploiesti Refinery

**Scope of work**
- New reactor top head, new plenum chamber e cyclones system + new 13 nozzles welded to the existing reactor shell
- Reinforcement of the existing reactor supporting structure/foundations and pipe racks
- New stripper and debutaniser towers

**Project execution**
- Pre T/A March-May, T/A= 27 days mechanical works
- Shop trial fit of cyclones system
- Reactor head/plenum/cyclones system pre-assembling on temporary structures
- Foundation reinforcement using chemical bolts and carbon fiber plates
- Equipment templates to anticipate piping erection
- Pre-assembled anchor bolts for new towers

**Highlights**
- Dimensional checks of new components versus existing ones
- Extensive execution of shop functional test (e.g. flapper valve with new cyclone fully assembled)
- Refractory lining installation/curing/dry-out

Stanlow Refinery

**Scope of work**
- Design, engineering, procurement and construction management services
- Concept development, design and overseeing the manufacture and delivery of the new regenerator head and cyclones. Supported Essar with transportation and lifting

**Project execution**
- Revamp to replace regenerator cyclones
- Planning for the turnaround started in 2009, with the new regenerator head and cyclone assembly being delivered to site as planned on 24 March 2013
- Huge crane being delivered to site in over 120 containers
- The turnaround began in early October 2013

**Highlights**
- 450-tonne unit, the world’s largest transported regenerator head and cyclone assembly
- The new head and cyclone assembly was lifted to 70 metres above the ground and into its final position in just over three hours

The two new regenerator overhead line sections, weighing 54 tonnes and 69 tonnes, were then successfully installed, all ahead of schedule

The ‘seeds of success’ of this project were sown with its early start, developing the concept in pre-FEED, with our strong and experienced team then seeing the work through to site

Meticulous planning, attention to detail and turnaround best practice – optimising offsite and pre-turnaround work and minimising work during the turnaround - delivered a safe and successful outcome
Trecate Refinery

**Scope of work**
- New reactor top head, new riser and cyclone system
- New regenerator top head and cyclone system
- New s&t and a/c heat exchangers
- Debutaniser reboiler and cat. Naphta stripper
  overhead condenser modification
- Pumps impeller and electric motors replacement

**Project execution**
- Pre T/A 6 months, T/A=26 days mechanical works
- Temporary structures for regenerator/reactors top heads and relevant cyclone systems pre-assembling

**Highlights**
- Mechanical/refractory works carefully planned to match very tight project schedule
- Construction/maintenance teams coordination

Aspropyrgos Refinery

**Scope of work**
During the years 3 major T/A have been carried out on the existing FCC units:
- New reactor top head, new riser and cyclone system
- New regenerator top head and cyclone system and flue gas line main valves and expansion joints
- New feed injection section
- New wet gas compressor
- New S&T and A/C heat exchangers
- Replacement of C3/C4 splitter column
- Pumps modification/replacement

**Project execution**
- T/A= 31 days mechanical works
- Shop trial fit of cyclones systems
- Reactor head/plenum/cyclones system pre-assembling on temporary structures
- Waterjet cutting of existing reactor head
- Detailed planning of T/A sequence

**Highlights**
- Refractory works for maintenance reasons
- Removal of coke in reaction circuit
- Coordination of construction and maintenance teams
### Other projects

<table>
<thead>
<tr>
<th>Client and location</th>
<th>Unit capacity (BPSD)</th>
<th>Description of project</th>
<th>Scope of work*</th>
<th>Licensor</th>
<th>Year of completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESTL</td>
<td></td>
<td>▶ Replacement of both Reactor and Regenerator Heads and cyclones</td>
<td>E+ assistance to ISAB</td>
<td>Exxon</td>
<td>Ongoing</td>
</tr>
<tr>
<td>ISAB Priolo, Italy</td>
<td>37,700</td>
<td>▶ Replacement of both Reactor and Regenerator Heads and cyclones ▶ New internals for the Orifice chamber</td>
<td>E+ assistance to ISAB ▶ UOP ▶ Stone &amp; Webster also involved in some specific portions</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>Pertamina Balongan, Indonesia</td>
<td>125,000</td>
<td>▶ RFCC major revamp ▶ Regen replacement Cyclones and other Works</td>
<td>EPaCa</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>S-Oil South Korea</td>
<td>669,000</td>
<td>▶ New HS-FCC ▶ New technology largest regen in the world</td>
<td>Detailed FEED then PMT</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>Total Antwerp Belgium</td>
<td>104,000</td>
<td>▶ FCC2 regen head ▶ Cyclone O/H Line and bellows replacement</td>
<td>EPc</td>
<td>Ongoing</td>
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<tr>
<td>Essar Stanlow, UK</td>
<td>270,000</td>
<td>▶ FCC revamp ▶ Redesign of external riser &amp; regen air distributors</td>
<td>FEED, EPCa</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>SARLUX Sarroch, Italy</td>
<td>94,000</td>
<td>▶ Revamp of FCC ▶ Regenerator revamp ▶ Air blower replacement ▶ Wet gas compressor replacement ▶ Expander replacement ▶ CO boiler modification</td>
<td>FEED + EPC</td>
<td>UOP</td>
<td>Ongoing</td>
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<tr>
<td>BSR Dung Quat Vietnam</td>
<td>130,000</td>
<td>▶ RFCC Revamp Pre- FEED ▶ FEED Replacement Cyclones in both Regen and Reactor</td>
<td>Es/FEED</td>
<td>2016</td>
<td></td>
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<tr>
<td>OMV-PETROM Petrobrazi Refinery, Romania</td>
<td>35,000</td>
<td>▶ Revamp ▶ RX/regenerator ▶ Main fractionator ▶ GasCon unit ▶ LPG fractionator</td>
<td>FEED + EPC</td>
<td>UOP</td>
<td>June 2015</td>
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<tr>
<td>Hellenic Petroleum Refinery Aspropyrgos, Greece</td>
<td>50,000 (Reactor/ Regenerator)</td>
<td>▶ Revamp of the reactor head and cyclones replacement of the existing FCC unit</td>
<td>EP</td>
<td>ExxonMobil STC-II</td>
<td>2015</td>
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<tr>
<td>Milazzo Refinery Milazzo, Italy</td>
<td>52,000</td>
<td>▶ Revamp ▶ Reactor/regenerator ▶ Expander (new)/fractionator + GasCon</td>
<td>FEED + EPCm ▶ UOP (expander) ▶ KBR (reactor/ regenerator) ▶ Amec Foster Wheeler Fract + GasCon</td>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>Client and location</td>
<td>Unit capacity (BPSD)</td>
<td>Description of project</td>
<td>Scope of work*</td>
<td>Licensor</td>
<td>Year of completion</td>
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<tr>
<td>ESSO Port Jerome, France</td>
<td>260,000</td>
<td>FCC revamp</td>
<td>FEED, EP</td>
<td>UOP</td>
<td>2013-2014</td>
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<tr>
<td>SARLUX Sarroch, Italy</td>
<td>320 t/h flue Gas</td>
<td>Revamp of the flue gas line to turboexpander, Revamp of CO boiler, Replacement of air blower</td>
<td>EPCM</td>
<td>UOP</td>
<td>2012</td>
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<tr>
<td>Samref 2013 Saudi Arabia</td>
<td>400,000</td>
<td>FCC revamp reactor cyclones with new top head and replacement mid section of regen</td>
<td>E, BDP, Cs</td>
<td>UOP</td>
<td>2010-2013</td>
</tr>
<tr>
<td>Hellenic Petroleum Refinery</td>
<td>50,000 (Reactor/Regenerator)</td>
<td>Wet gas compressor section circuit replacement</td>
<td>E (Ca)</td>
<td>ExxonMobil</td>
<td>2011</td>
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<tr>
<td>Essar Stanlow, UK</td>
<td>270,000</td>
<td>FCC regenerator cyclone replacement with new head 14m dia 450 tonne lift (Shell)</td>
<td>E, BDP, P</td>
<td>UOP</td>
<td>2009-2013</td>
</tr>
<tr>
<td>SARAS Sarroch, Italy</td>
<td>445 t/h Flue Gas from FCC Catalyst Regenerator</td>
<td>Revamp of existing CO boiler</td>
<td>EP</td>
<td>---</td>
<td>2009</td>
</tr>
<tr>
<td>Mažeikių Nafta Refinery</td>
<td>60,000</td>
<td>Revamp and maintenance</td>
<td>Basic design + E</td>
<td>UOP</td>
<td>2009</td>
</tr>
<tr>
<td>Nizhnekamsk Refining and Petrochemical Complex</td>
<td>1 million tons/year</td>
<td>New grass roots refinery, deep conversion and petrochemical complex</td>
<td>FS, Licensors selection, FEED, LLI procurement assistance</td>
<td>Axens</td>
<td>2008</td>
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<tr>
<td>Exxon - Sarpom Trecate, Italy</td>
<td>35,000</td>
<td>Revamp and maintenance</td>
<td>EPCM</td>
<td>Exxon</td>
<td>2007</td>
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<tr>
<td>IOCL Paradip India</td>
<td>300,000</td>
<td>Grassroots FCC</td>
<td>FEED, M</td>
<td>UOP</td>
<td>2005-2006</td>
</tr>
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<td>Salavat Russia</td>
<td>120,000</td>
<td>New FCC (SGS/Shell)</td>
<td>FEED, E</td>
<td>UOP</td>
<td>2006-2006</td>
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<td>Client and location</td>
<td>Unit capacity (BPSD)</td>
<td>Description of project</td>
<td>Scope of work*</td>
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<tr>
<td><strong>Total</strong>&lt;br&gt;Antwerp, Belgium</td>
<td>96,700</td>
<td>▶ Unit revamp</td>
<td>Basic design + FEED</td>
<td>UOP</td>
<td>2005</td>
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<td><strong>Hellenic Petroleum Refinery</strong>&lt;br&gt;Aspropyrgos, Greece</td>
<td>44,000</td>
<td>▶ Replacement of regenerator head and cyclones&lt;br&gt;▶ installation of new wet gas compressor&lt;br&gt;▶ major revamping of the gas-con section</td>
<td>E(Cm)</td>
<td>Exxon</td>
<td>2004</td>
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<tr>
<td><strong>Tamoil Raffinerie de</strong>&lt;br&gt;Collombey, Switzerland</td>
<td>15,750</td>
<td>▶ New Unit (RFCCU)</td>
<td>EPC</td>
<td>Axens</td>
<td>2004</td>
</tr>
<tr>
<td><strong>Raffineria di Milazzo</strong>&lt;br&gt;Milazzo, Italy</td>
<td>42,500</td>
<td>▶ Revamp and maintenance of existing FCC unit</td>
<td>EP</td>
<td>Lummus</td>
<td>2000</td>
</tr>
<tr>
<td><strong>TotalFina</strong>&lt;br&gt;Antwerp, Belgium</td>
<td>---</td>
<td>▶ FCC/AlkyFeed revamp</td>
<td>Basic design + EPCm</td>
<td>---</td>
<td>2000</td>
</tr>
<tr>
<td>ExxonMobil</td>
<td>---</td>
<td>▶ Reactor Replacement. 900Te lift by Gantry system and strand jacks also involved changing of Standpipes and additional five pairs of Regen cyclones</td>
<td>EPC</td>
<td>---</td>
<td>2001</td>
</tr>
<tr>
<td>ExxonMobil</td>
<td>---</td>
<td>▶ Regen Head replacement 17m Dia.&lt;br&gt;650Te Lift 20 pairs of cyclones</td>
<td>EP</td>
<td>---</td>
<td>2006</td>
</tr>
</tbody>
</table>

*Glossary of scopes*

BDP = basic design package  
Cs = construction services  
E = engineering  
EPaCa = engineering, procurement assistance, construction assistance  
EPC = engineer, procure, (construction)  
EPCa = engineering, procurement, construction  
EPCm = engineering, procurement, construction management  
E (Cm) = engineering, construction management  
EP = engineering and procurement  
Es = estimating  
FEED = front end engineering design  
FS = feasibility study  
LLI = long lead items  
M = management  
PMT = project management team
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