

Oil refining

**A major engineering and construction group
providing leading-edge solutions to the
oil refining industry worldwide**



Strategic asset planning

TechnipFMC is the ideal partner during the critical phase of planning and optimizing future investment

With a strong track record in refinery optimization projects, TechnipFMC has experience in all the technological fields affecting present and future developments in oil refining.

Technology selection

With decades of cooperation with highly renowned technology licensors and catalyst suppliers and its strong technological expertise, TechnipFMC ensures a completely independent selection of the best technologies to meet specific project and client targets.



Cost estimates, value engineering, project risk management

Our vast experience in executing lump-sum turnkey contracts gives clients the benefit of realistic cost estimates, value engineering expertise and project risk management capabilities.

Refinery profitability master plans

Refinery profitability master plans based on the linear programming modeling technique are used extensively to support the conceptual design of grassroots and revamped refineries. This includes the integration with petrochemicals thanks to our position as a leading licensor of ethylene and petrochemical technologies.

An integrated study typically includes:

- ▶ Market analysis
- ▶ Refining scheme optimization with the PIMS linear programming tool
- ▶ Technology selection
- ▶ Conceptual definition of new units, utilities, and offsites
- ▶ Plot plan investigation
- ▶ Investment cost estimation
- ▶ Economic and financial evaluation

Conceptual design



Basic design



Front-end engineering design (FEED)

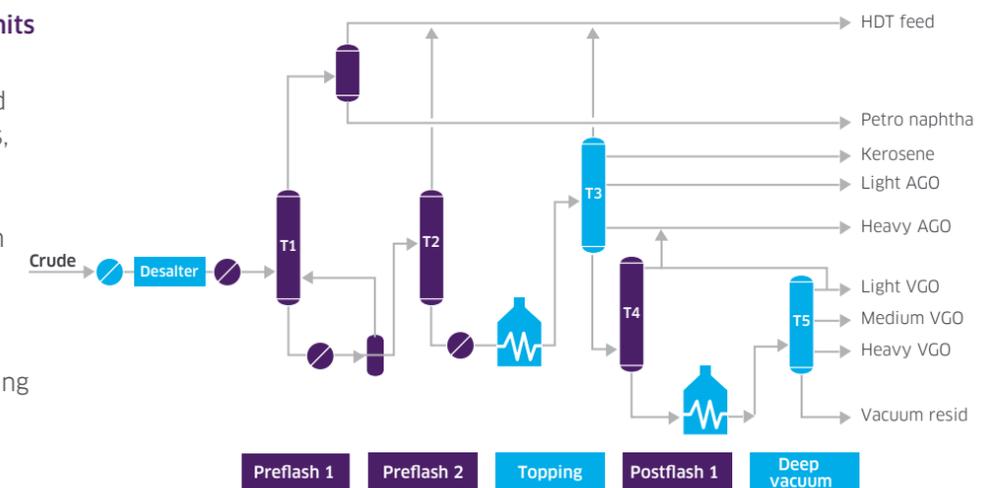
Open-art technologies and know-how

TechnipFMC has developed in-house technologies and know-how to improve product quality and maximize energy savings.

Crude and vacuum distillation units

We have delivered nearly 70 atmospheric distillation units and over 50 vacuum distillation units, most of them based on in-house technology. Optimization studies on internals, trays, grids, random packing, and structured packing have demonstrably improved product quality.

Software developed in house using Pinch technology optimizes heat exchange and maximizes energy savings.



Progressive crude distillation*

Limited high-level heating and reduced operating pressures

Our progressive crude distillation process is a three-point solution to the energy dissipation issue.

First, we split the crude preheating operation and separate, at intermediate heat levels, the cuts vaporized at these temperatures. This avoids superheating the light cuts and degrading the thermal levels associated with drawing off the heavy cuts. This approach limits high-level heat input and increases

the thermal level of the heat that can be recovered at pump-arounds and draw-offs.

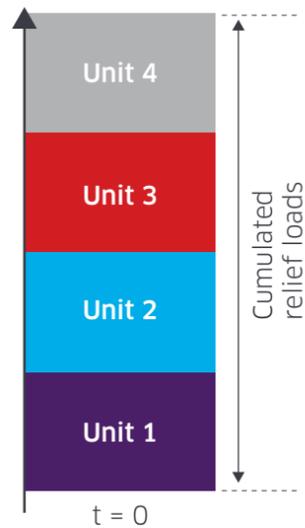
Second, we operate the columns at the lowest possible pressures to reduce the heat level required for separation and minimize the required heat inputs.

Third, we determine the number of fractional crude distillation stages so withdrawn streams meet refinery requirements.

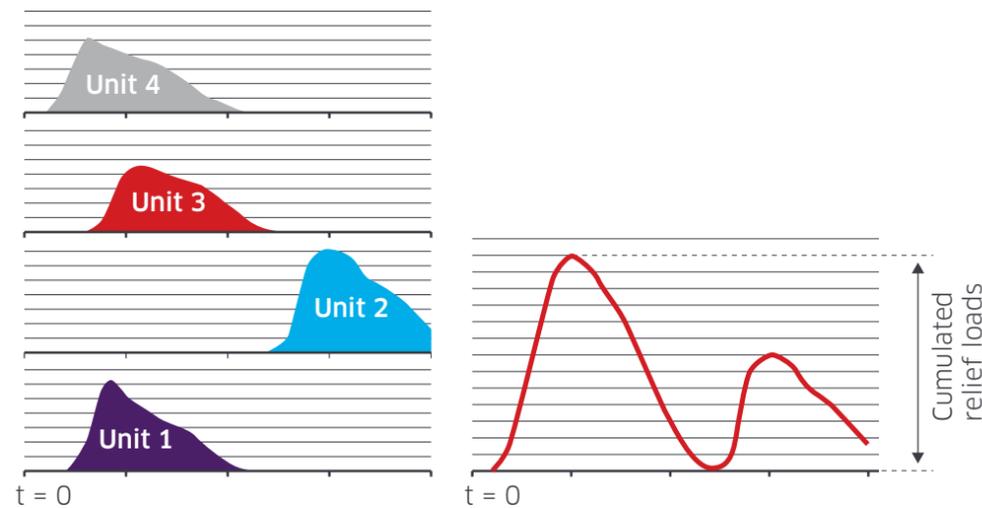
In revamp projects, the progressive distillation concept is a very efficient and economical solution for greatly increasing the crude capacity of existing ADU/VDU units without replacing or modifying any major pieces of equipment, such as heaters, main towers, overhead condensing systems, and feed pumps.

* Patented process developed by TechnipFMC in partnership with Total

Conventional approach



Dynamic approach



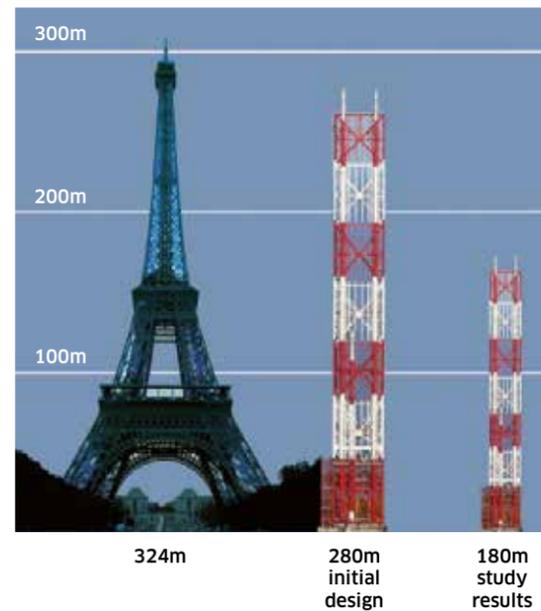
Application of dynamic simulation and TechnipFMC's in-house methodology to a 400,000 bpsd grassroot refinery

Dynamic simulation and flare load reduction

Modeling emergency scenarios enables us to predict realistic relief loads and accurately assess the required flare system capacity. TechnipFMC has acquired strong experience in building dynamic models for equipment such as crude distillation units, light hydrocarbon cuts splitters, aromatic complexes, and hydrotreatment reaction loops.

Rigorous application of an internally developed methodology, coupled with dynamic simulation, can be applied to:

- ▶ Revamps that may demonstrate the possibility of accommodating additional relief loads within existing flare headers, yielding substantial investment savings.
- ▶ Engineering design of large, high-conversion refineries leading to reduction in the number of relief valves, main header sizes, flare radiation diameter, and associated installation costs.



TechnipFMC Process Technology in refining

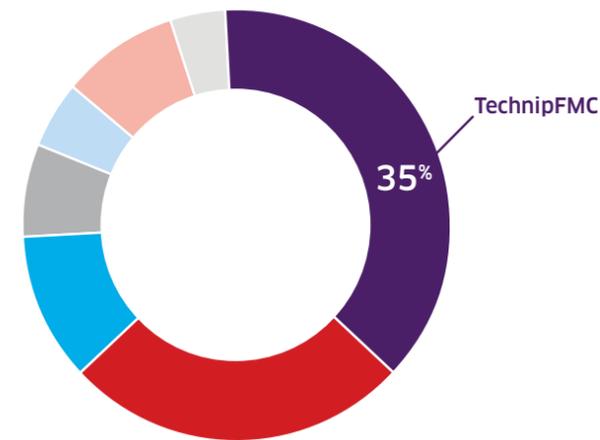


First largest hydrogen plants on multiple feedstocks for PKN. Plock, Poland – 111,000 Nm³/h; started in 1997

TechnipFMC offers an expanding portfolio of onshore process technologies in petrochemicals, refining, hydrogen and syngas, polymers and gas monetization. Steam-reforming technology for hydrogen plants and fluid catalytic cracking used in refineries are key components of the portfolio, managed by TechnipFMC Process Technology, a global business supported by a team of seasoned technologists and two research centers, one in Europe and one in the U.S.

Market leader in hydrogen

Since pioneering the steam reforming process in the early 1960s, TechnipFMC has continually advanced its process technology and know-how to maintain its leadership in hydrogen plant design and execution and its unparalleled performance in safety, efficiency, cost-effectiveness, and environmental compliance.



We have provided our proprietary steam reforming technology in more than 270 plants worldwide, with unit capacities ranging from 1,000 to 224,000 Nm³/h, geared mainly to refinery applications requiring high reliability.

Global alliance with Air Products

In 1992, TechnipFMC and Air Products established an alliance to design and supply hydrogen plants for all "over-the-fence" supply needs worldwide. This arrangement has contributed to more than 35 plants that supply over 2,000 mmscfd (2.2 million Nm³/h) of hydrogen, mainly to major refiners.

Fluid catalytic cracking and residual fluid catalytic cracking

Our fluid catalytic cracking process (FCC), developed jointly with Axens, IFPEN, and Total, offers refiners superior operating performance, increased profitability, and considerable feedstock and product flexibility. To date, we have licensed over 60 grassroot units and performed more than 250 revamp projects.

High olefins fluid catalytic cracking

The high olefins fluid catalytic cracking (HOFCC) process provides a cost-effective and commercially proven option to maximize production of polymer-grade propylene from a catalytic cracker. HOFCC has been commercially proven to convert greater than 20 wt% of heavy feedstock to propylene. We have licensed 7 DCC units with a total feed rate of over 300,000 barrels per day.



World's first largest single-train hydrogen plant for Syncrude, Canada, 224,000 Nm³/h (+75 MW power); in operation since 2004

Project implementation

Once a project has been optimized, TechnipFMC can provide worldwide engineering, procurement, and construction services

Catalytic pyrolysis process

Catalytic pyrolysis process (CPP) is a high-severity catalytic process that maximizes production of ethylene and propylene in varying proportions from heavy, low-value feedstocks. The process was developed and commercialized by SINOPEC RIPP. TechnipFMC is a licensor of this process outside of China. The first commercial CPP unit achieved startup in 2009.

Refinery off-gas recovery

Using proprietary technology, TechnipFMC can recover valuable products from refinery off-gases. We have revamped existing refinery off-gas units and designed grassroots units for increased capacity and recovery of olefins. Our advanced contaminant removal technology applications ensure product quality for downstream petrochemical processes, acting as a bridge between refining and petrochemicals.

Propylene recovery units

Based on extensive C3 splitter experience with proven vapor/liquid equilibrium and demonstrated contaminant removal knowledge, TechnipFMC designs propylene recovery units that produce on-spec polymer-grade propylene and reduce energy consumption and capital investment. Additionally, our technology team has expertise in C3 splitter heat pump designs and conventional C3 splitter designs using low-level heat sources.

BenzOUT™ technology: Higher octane, reduced benzene

BenzOUT™ technology is a reformate alkylation process that helps our refining clients increase gasoline octane and meet benzene regulations without using hydrogen. Developed by ExxonMobil Research and Engineering Company, BenzOUT™ technology is licensed by Badger Licensing LLC, a joint venture between affiliates of TechnipFMC and ExxonMobil.

Refining proprietary equipment

Our proprietary equipment offerings for fluid catalytic cracking technologies include:

- ▶ Trouble-free, high-efficiency feed injectors for optimal yields
- ▶ Riser termination devices (RS2) and/or vapor quench to minimize undesirable post-riser reaction
- ▶ Stripper structured packing for high-catalyst flux and reduced steam consumption
- ▶ Well-proven catalyst coolers with individual tube isolation for reliability
- ▶ Low-maintenance, high-efficiency combustion air rings
- ▶ Spent catalyst distributors for lower NOx and reduced maintenance



Design development is supported by the most advanced optimization methods and techniques, including constructability analysis, energy audits, HAZOP studies, dynamic simulation, and plant reliability analysis.



Project management

For more than 50 years, TechnipFMC has demonstrated its ability to successfully manage industrial projects of all types and sizes and in all parts of the world. Our experience covers every type of service and contract, from project management consultancy services to lump-sum turnkey, in all types of contractual relationships.



Procurement

A key element in executing any project is procurement. TechnipFMC is a global player that sources competitively, managing procurement through a team of about 1,000 professionals assigned to project task forces. These teams procure, expedite orders, inspect incoming equipment and materials, manage delivery and logistics, and identify new suppliers.



Construction

TechnipFMC has unique expertise in managing simultaneous mega-projects. Sharp methods and processes enable us to deliver projects with the highest standards of safety and quality. Competence in designing and managing construction activities is evident across our operating centers. This ensures access to the best knowledge about local construction markets.

Our construction organization includes a Construction Methods Center in Abu Dhabi. This center aims to increase TechnipFMC's supervisory resources, develop construction methods and processes, and foster long-term construction partnerships.

TechnipFMC is one of few contractors capable of delivering complete world-class refineries.

Deep conversion of the 'bottom of the barrel'

Technology references

Increased crude conversion to motor fuels and further processing at the "bottom of the barrel" continues to drive the development of the oil refining industry.

In this field, TechnipFMC has acquired significant experience, technological competence, and references. Our experience modeling refinery configurations for bottom-of-the-barrel processing helps us recommend the appropriate economical technical solutions for our clients.



Recent experience in EPC and FEED projects for bottom-of-the-barrel upgrading:

	Total N° Units in the last 15 years	Client	Unit Capacity bpd	Licensor	Completion
Delayed coker	19	MIDOR	27,500 (revamp)	BECHTEL	2016
		SATORP	100,500	FOSTER WHEELER	2013
		HYUNDAI OB	52,000	UOP	2012
		SK, ULSAN	60,000	UOP	2010
		CANADIAN NATURAL	156,000	ABB LUMMUS	2008
		MIDOR	30,000	CONOCO PHILLIPS	2001
Residue FCC	7	PETRONAS	2 X 70,000	AXENS	2019
		TAKREER	127,200	TechnipFMC	2015
		SONATRACH	20,000	UOP	2014
		QATAR PETROLEUM	60,000	AXENS	2008
Visbreaker	6	PREEMRAFF	50,000	SHELL GLOBAL SOLUTION	2009
Solvent deasphalting	3	MIDOR	20,200	UOP	2016
		GRUPA LOTOS	330 t/hr	KBR (Rose)	2010
Residue HDC/HDT	3	PETRONAS	176,500	CLG	2019
		BAPCO	68,000	CLG	2016
		LUKOIL BURGAS	47,000	AXENS (H-Oil)	2010
		QATAR PETROLEUM	51,000	AXENS (Hyvahl)	2008

Recent experience in EPC and FEED projects for VGO conversion:

	Total N° Units in the last 15 years	Client	Unit Capacity bpd	Licensor	Completion
Hydrocracker	15	MIDOR	20,800 (2nd stage)	UOP	2016
		BAPCO	58,000	CLG	2016
		SATORP	59,000	CLG	2013
		Confidential	30,000	UOP	2011
		GRUPA LOTOS	41,000	SHELL	2010
		TOTAL (Gonfreville)	53,000	AXENS	2007
FCC	15	SATORP	32,700	AXENS	2013
		RSC IRAQ	35,000	S&W/AXENS	2014
		SK, ULSAN	60,000	UOP	2014
		SCOP	31,500	UOP	2010
		REFICAR	35,000	ExxonMobil	2010



High-quality motor fuels

Technology references

TechnipFMC has continued to implement technical solutions to cope with the most stringent environmental regulations currently in force, or anticipated in the future, in leading countries. TechnipFMC has executed a large number of environmentally driven revamp projects aimed at improving product specifications..

Gasoline

Current requirements are for sulfur-free gasoline, with a trend toward reduced benzene, olefins, and aromatics content while maintaining RON specifications.

Specification/technical solution

Benzene (1% vol.)

- ▶ Pre/post fractionation

Aromatics (35% vol.)

- ▶ Benzene saturation
- ▶ Isomerization/reforming integration
- ▶ Blending optimization

Sulfur content (50-10 ppm wt max.)

- ▶ FCC feed pretreatment (mild hydrocracking) and FCC gasoline selective hydrogenation

Diesel oil

Diesel specifications require a reduction in sulfur content down to 10 ppmw; improved cetane number; reduced density, polyaromatics, and total aromatics content; and a 95% reduction in distillation point temperature.

Specification/technical solution

Sulfur content, cetane, and aromatics contents

- ▶ Deep hydro-desulfurization unit

Density and final boiling point

- ▶ Fractionation and blending optimization

Recent experience in EPC and FEED projects for implementation, within a refinery, of a complete set of technologies for the gasoline pool

Client	Refinery Capacity bpd	Completion
PETRONAS ⁽⁵⁾	300,000	2019
TAKREER ⁽⁶⁾	127,200	2015
SONATRACH ⁽¹⁾	81,000	2014
SCOP ⁽²⁾	140,000	2010
SATORP ⁽³⁾	400,000	2009
PETROVIETNAM ⁽⁴⁾	148,500	2009

(1) NHDT, CCR, Isomerization, RFCC

(2) NHDT, CCR, Isomerization, VGO HDT + FCC

(3) NHDT, CCR, Benzene Extraction, Alkylation, Mild HCK + FCC

(4) NHDT, CCR, Isomerization, RFCC, RFCC Naptha Sweetening

(5) NHDT, CCR, SC, RFCC

(6) RFCC, RFCC Naptha HDS, Alkylation

Recent experience in EPC and FEED project for hydrotreatment

Client	Unit Capacity bpd	Licensor	Completion
PETRONAS	92,000	Haldor Topsoe	2019
BAPCO	50,000	UOP	2016
SATORP	49,450	UOP	2013
PKN	47,000	TP/ALBEMARLE	2010
ECOPETROL	57,000	AXENS	2010

Upgrader projects

Technology references

The continual decline in crude oil quality is introducing more “synthetic” crudes from non-conventional sources such as heavy crudes and production from “oil sands.”

Oil sands

TechnipFMC’s involvement in the design and construction of the Alberta oil sands primary upgrading processes in Canada includes diluent recovery, vacuum distillation, and delayed coking technologies. We also have designed and built hydrogen production units to support the oil sands secondary upgraders.

One particular aspect of these technologies is the very large capacity of process units such as the delayed coker with a capacity in excess of 150,000 bpsd, or the steam reformers producing 200,000 Nm³/h of hydrogen.



Burgess

Emission control and environmental protection

Recent projects have complied with increasingly stringent requirements for gas emissions (including CO₂), water protection, noise, and safety.



Hydrogen and CO₂ management

In 2009, TechnipFMC launched HyN•DT, the Hydrogen Network Design Tool – an optimization tool for hydrogen and CO₂ management in refineries. It allows us to integrate, in a single model, all the hydrogen and CO₂ producers and users within the refinery, evaluate production and recovery options, and find the most economically attractive solution. This service, at the crossroads of the refining and hydrogen worlds, uses the specific competences of each to maximize the efficiency of every asset.

Sulfur recovery units

TechnipFMC applies various technologies in designing sulfur recovery units, achieving recovery rates of up to 99.9%. Tail gas clean-up units, process gas absorbers, and amine treatment units are designed with in-house technology and know-how, applying various types of amine solutions.

Water treatment

Our experience in conceptual studies for water reuse employs recent technologies such as membrane bio reactors, ultra-filtration, downstream standard bio treatment, and reverse osmosis. Overall water management, taking

into account cooling water supply and water recycling, allows us to meet the most stringent final reject conditions within TechnipFMC standards for design of wastewater treatment facilities.

Zero flaring

TechnipFMC has the experience and capabilities to design new flare systems and check existing networks. These include dynamic simulation and automatic systems to reduce flare loads. Zero-flaring concepts have been used successfully in our most recent refining projects.

France

Marie-Christine Charrier

Tel: +33 1 47 78 34 86

marie-christine.charrier@technipfmc.com

Italy

Antonio Di Pasquale

Tel: +39 06 6598 3203

antonio.dipasquale@technipfmc.com

US

Ken Krug

Tel: +1 281 848 5155

kenneth.krug@technipfmc.com

Discover more. **TechnipFMC.com**

© TechnipFMC plc 2019