Refining industries
Refineries around the world are striving to meet ever-increasing demands for cleaner fuels while ensuring cost-efficient operations. Haldor Topsøe furnishes refiners with the opportunity to meet both these requirements when producing clean fuels.

For more than 35 years, Topsøe has been involved in the development and production of hydroprocessing catalysts. Topsøe has developed technology and catalysts for virtually all areas of hydroprocessing, from desulphurisation of light feedstocks for synthesis gas manufacture to hydrotreating of heavy resids and hydrocracking of vacuum gas oil. Topsøe’s hydroprocessing expertise offers integrated solutions including reactor internals, grading material, catalysts, process design and detailed reactor engineering.

Hydroprocessing solutions

Topsøe assists you in all aspects of hydroprocessing technology, including:

- design and revamp of hydroprocessing units
- catalysts for all hydroprocessing solutions
- reactor internals
- optimisation service
- feedstock flexibility from naphtha to resid
- hydroprocessing of a full range of renewable feeds for gasoline, jet and diesel production

Hydrogen and sulphur management

Topsøe also offers a wide range of catalysts and technologies for refinery related operations. Extensive experience with hydrogen production technologies enables Topsøe to offer innovative solutions for hydrogen plants based on a complete range of reforming technologies. Topsøe has a broad portfolio of technologies for sulphur management and removal of atmospheric pollutants, providing solutions for all refinery sulphur and NOx emission problems.
Hydroprocessing catalysts and technologies

Topsøe’s hydroprocessing catalysts and technologies include all aspects of hydroprocessing:

**HydroTech™**
Topsøe’s hydroprocessing know-how and competencies – HydroTech™ – comprise a comprehensive catalyst and technology portfolio.

With HydroTech™, Topsøe is committed to provide a unit design which is technically feasible, economically sound and safe to operate. The benefits of HydroTech™ include:

- solutions designed to meet your production objectives and product requirements
- right-sizing of the unit and design at minimal pressure thereby achieving a substantial reduction in investment and operating costs
- optimal catalyst selection which ensures the most profitable use of hydrogen and minimise product give-away
- support for continuous performance optimisation and troubleshooting during the lifetime of the unit

In the design of new hydrotreating units, Topsøe’s research and test facilities offer clients testing opportunities including detailed feedstock analyses forming the basis for tailor-made solutions.

Topsøe assists you during the entire HydroTech™ project from the first ideas and feasibility studies, through the design phase to operation. In the early project phase, Topsøe can help guide your decisions, saving valuable time and money. After the basic engineering phase, Topsøe acts as consultant including shop inspections etc., to confirm that the units meet all specifications and requirements. This ensures smooth start-up with no delays to make on-spec products. Topsøe assists in the optimisation of the project in order to continuously improve your bottom line.
Topsøe’s BRIM™ catalysts

Topsøe’s BRIM™ catalysts are based on a proprietary production technology and are characterised by superior activity and stability. BRIM™ catalysts have demonstrated improved performance and cycle length in many hundreds of hydrotreaters throughout the world, and today Topsøe’s BRIM™ catalysts are recognised to be the market leaders for most applications.

Topsøe launched the first BRIM™ catalysts in 2003 for use in FCC pretreatment, and this was followed by catalysts for ultra-low sulphur diesel (ULSD) and hydrocracking pretreatment. In 2009 we launched the next generation of BRIM™ catalysts and these have been swiftly accepted by the industry.

Selection of the best catalyst for a given service depends on operating pressure, the sulphur components present in the feed and the nature and amounts of inhibitors such as nitrogen compounds, the content of metals and feed impurities. Topsøe’s specialists are available to advise you on the right BRIM™ catalyst for your application.

Pressure drop control

Fouling of the catalyst bed reduces the void volume causing increased pressure drop, channelling and hot spots. The pressure drop increases exponentially resulting in unscheduled shutdowns.

Topsøe graded bed catalyst systems have been shown to extend operating cycles from a few months to several years. A wide range of products combating reactor bed fouling and controlling pressure drop build-up may be applied in combination. This ensures the flexibility to address all potential fouling problems in the hydrotreating reactor, because graded bed systems are tailored to meet individual hydrotreater requirements.

Reactor internals

Topsøe’s reactor internals significantly optimise operations, since the reactor internals can handle the variation of conditions during reactor start-up and throughout the catalyst cycle. All reactor internals are designed using advanced in-house computer models based on cold-flow modelling and industrial data.

Topsøe’s reactor internals utilise a flexible and patented design, allowing easy installation and maintenance in any hydroprocessing unit. Topsøe reactor internals include liquid distribution trays, quench mixers, inlet diffusers, catalyst support beams, grids and outlet collectors. Topsøe’s proprietary distribution trays are based on the vapour assist principle providing optimal performance through the entire catalyst cycle.

The BRIM™ story

Topsøe researchers were the first to characterise the direct desulphurisation reaction route, and to introduce the terms Type I and Type II reaction sites. For many years the nature of the hydrogenation sites remained a mystery, until Topsøe researchers, in collaboration with university groups, identified and characterised the brim reaction sites.

“Throughout our catalytic development approach and a fruitful collaboration with universities, Topsøe’s brim discoveries have generated a new generation of catalysts which enable our clients to meet sharper environmental standards,” says Henrik Topsøe, Executive Vice President. “Topsøe’s unique approach lies in the ability to transfer our know-how to the production of catalysts, with more active sites and the right balance between brim sites and direct desulphurisation sites. We call this the BRIM™ production technology.”
Distillate hydrotreating
Topsøe’s full range of hydrotreating catalysts and technologies for distillate hydrotreating offers clients a single point of expertise and responsibility.

Naphtha hydrotreating
Topsøe naphtha hydrotreating technology and catalysts operate on straight-run and cracked naphtha feedstocks and can be designed for desulphurisation to ppb-levels. Special catalysts and technologies have been developed for coker naphtha services ensuring very long cycles running high silicon-containing feeds. The naphtha hydrotreating catalysts have a proven track record in feed pretreatment of steam reformers in hydrogen production or synthesis gas plants.

Kerosene hydrotreating
Topsøe’s kerosene hydrotreating technology and catalysts are used for the production of A1 jet fuel. They are applicable for desulphurisation of both straight-run and cracked kerosene feedstocks.

When combined with Topsøe’s hydrodearomatisation technology and catalysts, significant improvements of the smoke point can be achieved, allowing upgrading of highly aromatic kerosene feedstocks to high quality jet fuels.

ULSD production
Topsøe’s diesel hydrodesulphurisation technology and catalysts are used for production of ultra-low sulphur diesel (ULSD) containing less than 10 wt ppm of sulphur from straight-run or cracked feedstocks. Topsøe’s unique capabilities in this area allow cost efficient revamps of low pressure diesel hydrotreating units to ULSD production.

Depending on the operating pressure and catalyst type selected, significant aromatic saturation can be achieved in a single stage configuration, if this is required to achieve a given cetane number, or if volume swell is desirable. On the other hand, Topsøe’s reverse polysift licensed technology and catalyst may reduce hydrogen consumption associated with aromatics saturation substantially. A unique, proprietary process flow scheme is used to shift aromatics saturation, resulting in 10 to 20% lower average hydrogen consumption. A simple revamp of an existing unit can achieve substantial capacity expansion without requiring additional hydrogen or hydrogen compression facilities.

Topsøe offers a range of catalysts for colour removal in ULSD. The polysift licensed technology improves the colour to meet the most stringent specifications.
Two-stage HDS/HDA

Topsøe’s dearomatisation technology and catalyst (HDA) is especially suited for the treatment of heavy feedstocks and for large cetane lift. It is a two-step process with a first stage for sulphur and nitrogen removal followed by a second HDA stage to remove polyaromatics and reduce the total aromatic content. The Topsøe two-stage HDS/HDA process has demonstrated attractive product properties and reliable and stable performance on both straight-run and cracked gas oil feedstocks.

FCC pretreatment

Deep desulphurisation of FCC feed for the production of low sulphur gasoline is a very attractive alternative to the gasoline post-treatment technologies introduced in recent years. FCC pretreatment allows refiners to produce FCC feeds with 200 wt ppm sulphur, which will enable most refineries to achieve a sulphur content in the gasoline pool below 10 wt ppm.

With the current demand for diesel, an increasing number of pretreaters operate in high temperature mode in order to convert some of the VGO into diesel (mild hydrocracking). Topsøe catalysts show high diesel selectivity in this type of application and demonstrate excellent stability even at harsh conditions.
Hydrocracking

Topsøe’s hydrocracking experience and catalyst portfolio facilitates the optimisation of hydrocracker units with respect to yield structure, product properties, throughput and on-stream efficiency, resulting in improved refinery margins.

Topsøe’s hydrocracking catalysts and licensed technology may be used for all conversion ranges:

High pressure hydrocracking

Topsøe’s high pressure hydrocracking licensed technology and catalysts are especially suited for operations requiring high conversion. The technology can be improved to provide maximum middle distillate yields such as diesel and jet fuels.

HPNA

All “full conversion” hydrocracking processes are subjected to the adverse effects caused by the formation of Heavy Poly-Nuclear Aromatic (HPNA) compounds. If not removed from the hydrocracking reaction system, they will continue to build up in the recycle oil stream to cause rapid deactivation of the catalyst by coking and fouling of the reactor effluent heat exchangers and air cooler.

Topsoe engineers have developed an elegant solution to the HPNA problem that the industry has been living with over the past 50 years. The solution is to separate the heavy HPNAs from the unconverted oil, which will allow a reduction of the existing bleed by up to 80%. Topsoe’s HPNA concentrator requires the addition of only three small pieces of equipment, there is no reoccurring cost and only a minor increase in utilities requirements. The payback for Topsoe’s HPNA concentrator is typically in the order of half a year.

Mild hydrocracking

Topsoe’s mild hydrocracking technology and catalysts allow a medium conversion of heavier feedstocks to lighter and more valuable products.
Staged partial conversion and back-end shift
Staged partial conversion is a new FCC pretreatment technology designed to produce low sulphur FCC feed to allow ultra-low sulphur gasoline (ULSG) production without gasoline post-treatment while co-producing high quality EN 590 diesel.

Topsøe's back-end shift technology significantly reduces the end-point of diesel stocks by selective hydrocracking of the heavy hydrocarbons present in the back-end of the distillation range resulting in high diesel yields and moderate hydrogen consumption.

Hydrocracker feed pretreatment
Topsøe's hydrocracker feed pretreatment BRIM™ catalysts are an integral part of Topsøe’s hydrocracking processes.

Renewable feeds
As the world’s resources grow scarce, it is essential to focus on feedstocks for renewable fuels which do not deplete global water and land resources.

Topsøe’s HydroFlex™ technology has been developed for hydrogenation of oxygen containing feedstocks. It provides full feedstock flexibility, which means that it is possible to produce clean fuels from feeds ranging from organic waste products and pyrolysis oils to oil from oil seeds.

The HydroFlex™ technology allows the production of gasoline, fuel and diesel. The resulting fuels are fully compatible with the existing fuel infrastructure, making it possible to assimilate renewable fuels directly into the existing fuel systems without any adjustments.

Any renewable oil can be hydrotreated in a stand-alone unit or by co-processing with diesel in a refinery. Topsøe has experience designing stand-alone units as well as co-processing units.
Hydrogen production

Features of excellence
Topsøe offers a range of innovative technologies for hydrogen production based on steam reforming of hydrocarbons. These technologies are continuously improved by integrating new catalysts and technology features – based on knowledge acquired from our in-house R&D as well as industrial experience with our catalysts and designs. Topsøe hydrogen technology is applicable for the design of new plants as well as for revamps.

Common features of Topsøe’s hydrogen technologies are:
- high energy efficiency and feedstock flexibility
- tailor-made and flexible design
- high on-stream availability
- low investment and maintenance costs

Topsøe’s product portfolio includes catalysts, licensing of technologies, engineering of processing units, supply of hardware and technical services during design and operation of the plant. Proprietary know-how makes Topsøe a valuable business partner.

The hydrogen process
Topsøe offers catalysts and technology for all steps in the hydrogen production process, including feed purification, prereforming, steam reforming and CO conversion.

Steam reforming
The steam reforming process is the heart of the hydrogen production process, and the right choice of technology is crucial for the overall plant economics. Topsøe offers a range of steam reforming technologies designed to meet clients’ needs and enabling clients to obtain the lowest hydrogen production cost possible:

The radiant wall steam reformer operates at low steam to carbon ratios, unmatched high average heat fluxes, and at high outlet temperatures.

The Haldor Topsøe Convection Reformer (HTCR) is a heat exchange steam reformer in which the process gas is heated mainly by flue gas. An HTCR is very compact and suited for new hydrogen units and for revamps for capacity increase of existing plants.

The Haldor Topsøe Exchange Reformer (HTER) is a heat exchange steam reforming technology in which the reaction heat is provided by hot process gas. The HTER is used in combination with a radiant wall steam reformer for additional capacity.

The Topsøe Bayonet Reformer (TBR) provides hydrogen production with low hydrocarbon consumption and little or no steam export as well as a uniquely low production of carbon dioxide per unit of hydrogen in the TBR.
Sulphur management and NOx removal

Topsøe offers unique technologies and catalysts for efficient cleaning of refinery off-gases, based on the integration of catalyst, process and engineering knowledge.

Removing sulphur – WSA

Topsøe’s Wet gas sulphuric acid technology (WSA) recovers sulphur from refinery off-gases and produces commercial-grade concentrated sulphuric acid.

The WSA technology meets clients’ requirements for compliance with sulphur emission standards while producing no undesired by-products and providing efficient heat recovery. Capital and operating expenses are low.

The WSA process uses proprietary Topsøe catalysts – the VK-W series – developed for the conversion of sulphur dioxide (SO₂) into sulphur trioxide (SO₃) in the presence of water vapour. The catalysts feature high activity and stability.
Removing sulphur and nitrous gases – SNOX™
The SNOX™ process is an innovative process which removes sulphur dioxide, nitrogen oxides and particulates from refinery flue gases. The sulphur is recovered as concentrated sulphuric acid and the nitrogen oxides are reduced to free nitrogen.

The process is based on catalytic reactions and does not consume water or absorbents. Neither does it produce any waste, except for the separated dust.

In addition the SNOX™ technology can handle other sulphurous waste streams. This is highly interesting in refineries, where for instance H₂S gas, sour water stripper gas and Claus tail gas can be led to the SNOX™ plant, thereby saving investment in other waste gas handling facilities.

Removing nitrous gases – the SCR DeNOx process
The SCR (Selective Catalytic Reduction) DeNOx process is the most efficient process for removing nitrogen oxides – NOx – from gases without creating any secondary pollutants.

Topsøe’s SCR DeNOx technology and DNX® catalyst series are the result of extensive in-house research and development and can be tailored to meet any client or legislative requirements.
Fuels of the future

To meet the future needs of refiners and provide useful solutions to the world’s energy challenges, Topsøe has devoted extensive research efforts to the development of catalysts and technologies for alternative fuel production methods.

**TIGAS**

Topsøe’s TIGAS technology (Topsøe Integrated Gasoline Synthesis) offers a simple and flexible method for converting synthesis gas into gasoline. The synthesis gas may be produced from a range of feeds including biomass such as waste wood, land fill or black liquor from the paper industry. The TIGAS technology can also process associated natural gas from oil fields, converting gas otherwise flared into gasoline.

The TIGAS fuel is fully compatible with existing engines and fuelling stations, allowing easy integration into the existing infrastructure.

**DME**

Topsøe has accumulated a solid knowledge base for development and implementation of dimethyl ether (DME) technologies. Today DME is primarily used as a substitute for LPG gas, and DME is also a potential alternative to diesel fuel. With Topsøe’s DME technology, DME can be produced from methanol as well as hydrocarbon feed and efficient heat integration ensures cost and energy efficient operations.

**GTL**

Topsøe’s gas-to-liquid technology (GTL) can convert natural gas into liquid diesel fuel, putting to use the natural gas often found at oilfields.

**CTL**

Topsøe’s coal-to-liquid technology (CTL) can convert coal into liquid diesel fuel.

**SNG**

Topsøe’s Recycle Methanation Process – TREMP™ – constitutes an important step in the production of substitute natural gas (SNG) from carbonaceous feedstocks such as coal, petcoke and biomass. Topsøe’s TREMP™ technology ensures an efficient heat recovery and thereby improves plant efficiency.
Haldor Topsøe
– your partner in business

For more than 70 years, Topsøe has focused on developing the best catalyst and technologies in the world. Topsøe has a long term commitment to the market, providing customers with excellent service.

The Topsøe business model is unique, integrating all aspects from fundamental knowledge to practical implementation to achieve optimum industrial efficiency.

The synergy between research and development, process design, engineering, catalyst production and sales from the basis of the continuous optimisation of our catalysts and technologies.

For several projects, refiners have selected Topsoe to supply multiple technologies. These clients benefit from a more uniform quality of the documentation and valuable project time is saved.

With Topsøe you will have a competent and reliable partner for today and for the future. We are known for our commitment to catalysis – a commitment we share with our clients.
The information and recommendations have been prepared by Topsøe specialists having a thorough knowledge of the catalysts. However, any operation instructions should be considered to be of a general nature and we cannot assume any liability for upsets or damage of the customer’s plants or personnel. Nothing herein is to be construed as recommending any practice or any product in violation of any patent, law or regulation.