

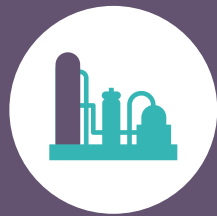
PETROCHEMICALS

# PARAMAX<sup>®</sup>

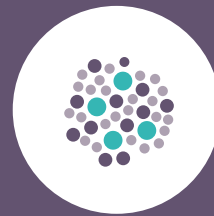
PROCESSES  
TOWARDS  
AROMATICS

**Axens**  
SOLUTIONS

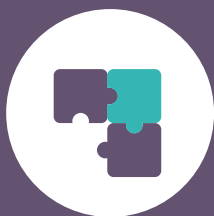
Axens Group provides a complete range of solutions for the conversion of oil and biomass to cleaner fuels, the production and purification of major petrochemical intermediates as well as treatment and conversion options for natural gas. The integrated offer includes technologies, equipment, furnaces, modular units, catalysts, adsorbents and related services. From feasibility studies to unit start-up and follow-up throughout the entire unit cycle life, Axens Group is ideally positioned to cover the entire value chain while ensuring the highest level of performance with reduced environmental footprint.



Over  
**3,000**  
industrial units  
under license



Over  
**70,000**  
tons of catalysts and adsorbents  
each year coupled with  
catalysts services



Over  
**500**  
modular units  
references



Over  
**2,000**  
furnaces references



Offices in  
**15**  
countries

# THE ALLIANCE OF MARKET-LEADING TECHNOLOGIES



Paraxylene is an essential chemical building block in the production of a diverse range of polyethylene terephthalate (PET) and fiber consumer products. In recent years, annual growth in consumption has increased to 5% per year; well above GDP.

ParamaX® technology suite is a combination of top-of-the-line processes designed for the production of high-purity paraxylene, but also other aromatic molecules such as metaxylene, orthoxylene, benzene and toluene.

ParamaX® alliance brings together a number of players in aromatics: Axens, ThyssenKrupp Uhde and ExxonMobil; itself a recognized operator.

With the support of this alliance, the licensee benefits from a vast portfolio of commercially proven, pack-leading technologies that meet the most stringent of market requirements, available only through Axens licensing.

Axens coordinates technologies from various actors, optimizing materials and energy between all units to offer unique synergies and optimal economic performance for the operator.

## COMMERCIAL EXPERIENCE

Although the alliance is a recent market entrant, the relevance and competitiveness of ParamaX® has remarkably earned immediate acceptance in the industry. ParamaX® captured almost half of the awarded capacity since alliance's initial successes in the early 2000's.

As of today, Axens has licensed more than 30 ParamaX® aromatics complexes and more than 400 process units for the production and transformation of aromatics.

This industry recognition highlights ParamaX® technology suite's unrivalled features, including:

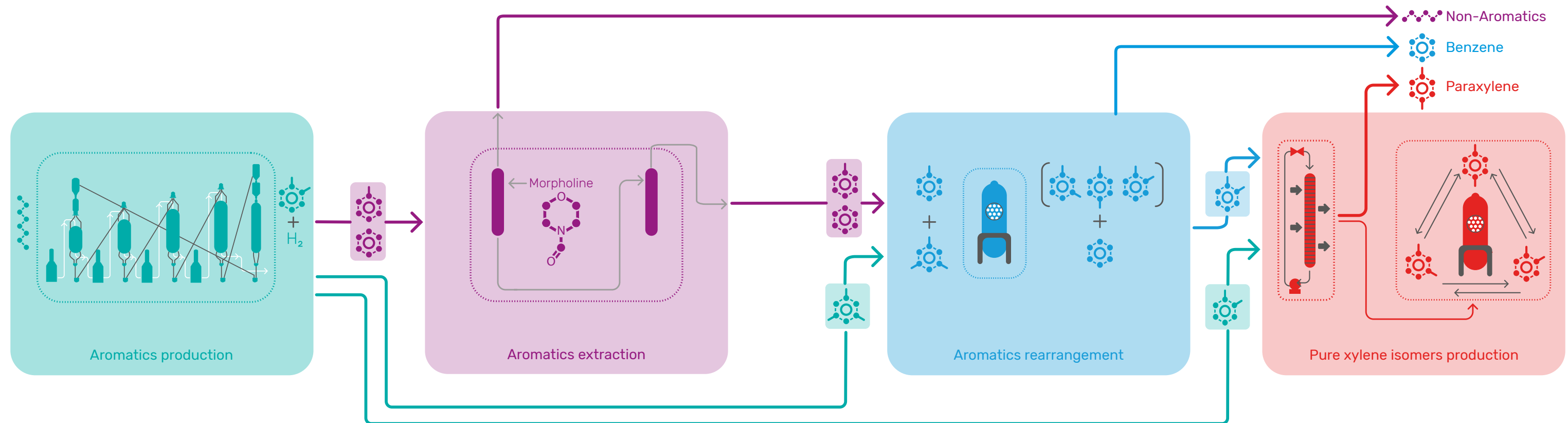
- **Industrially proven technologies** delivering lowest investment and refined aromatics production costs.
- **Second generation Energy Efficient** engineering solution for overall thermal integration of the complex.
- Unmatched capabilities to develop **high capacity designs**.
- Unique **reliability and availability** of process units.
- **Premium tailor-made services** and support from basic design to operation and follow-up.



thyssenkrupp

# THE ARCHITECTURE

Aromatics complexes generally consist of four core blocks that all play a major role in producing petrochemical grade aromatics, providing the foundations for success in the end-user's project.



4

5

➔ ParamaX® block functions

## AROMATICS PRODUCTION

Aromatics are commonly produced by the naphtha reforming route which allows selective production of a wide range of valuable aromatics within the aromatics complex. The reforming unit can be diversely fed with naphtha from topping or any conversion process after the necessary pretreatment. Light aromatic-type pyrolysis gasoline from Steam Cracking are sometimes used together with reformate.

## AROMATICS EXTRACTION

Light naphtha cuts are the most difficult to reform. The benzene-toluene cut of the reformate contains a significant amount of unconverted non-aromatics that need to be separated to produce on-specification benzene to the market and toluene to the rearrangement block.

Non-aromatics such as benzene and toluene co-boilers are removed as part of the extraction process. Extractive distillation is typically considered, while liquid-liquid extraction is an alternative technology.

## AROMATICS REARRANGEMENT

In order to direct and increase production of the desired aromatics, an aromatics rearrangement block can be considered to convert toluene and C<sub>9</sub>+ aromatics cuts.

Several technologies are available and offer significant impacts on paraxylene and benzene production in particular.

Paraxylene selective technologies enable major reductions in overall paraxylene production costs, as well as cost-effective xylenes loop debottlenecking capabilities.

## PURE XYLENE ISOMERS PRODUCTION

C<sub>8</sub> aromatic cuts produced within aromatics production and aromatics rearrangement blocks are processed in the so-called xylenes loop where paraxylene is purified and other xylenes converted to paraxylene.

Different routes for ethylbenzene valorization can be envisaged if conversion to xylenes or to benzene is preferred.

From the xylenes loop, high purity metaxylene or orthoxylene can be produced as an option.

# PARAMAX® COMPLEX

The aromatics complex is tailored to the end-user's production objectives. The wide range of technologies available in the ParamaX® Suite allows unique optimization capabilities to precisely fit a requested product slate for downstream needs or optimal economic performance. Performance optimization is further enhanced by the strong synergies between technologies, allowing for single-source licensing of the full complex.

## ● Aromizing™ - Continuous Catalyst Regeneration Naphtha Reformer

Aromizing™ is the core of aromatic rings production. The technology drives performance, offering economic gains and operability, while the catalyst drives greater yields.

### ★ BENEFITS

- Cost-effective side-by-side design
- Best-in-class regeneration design
- Access to the award-winning Symphony™ catalyst portfolio
- Environmentally friendly

## ● Arofining™ - Selective Olefins Removal

Arofining™ technology is an aromatics purification process for the selective hydrogenation of olefins, diolefins and styrenics while preserving highly valuable aromatics.

### ★ BENEFITS

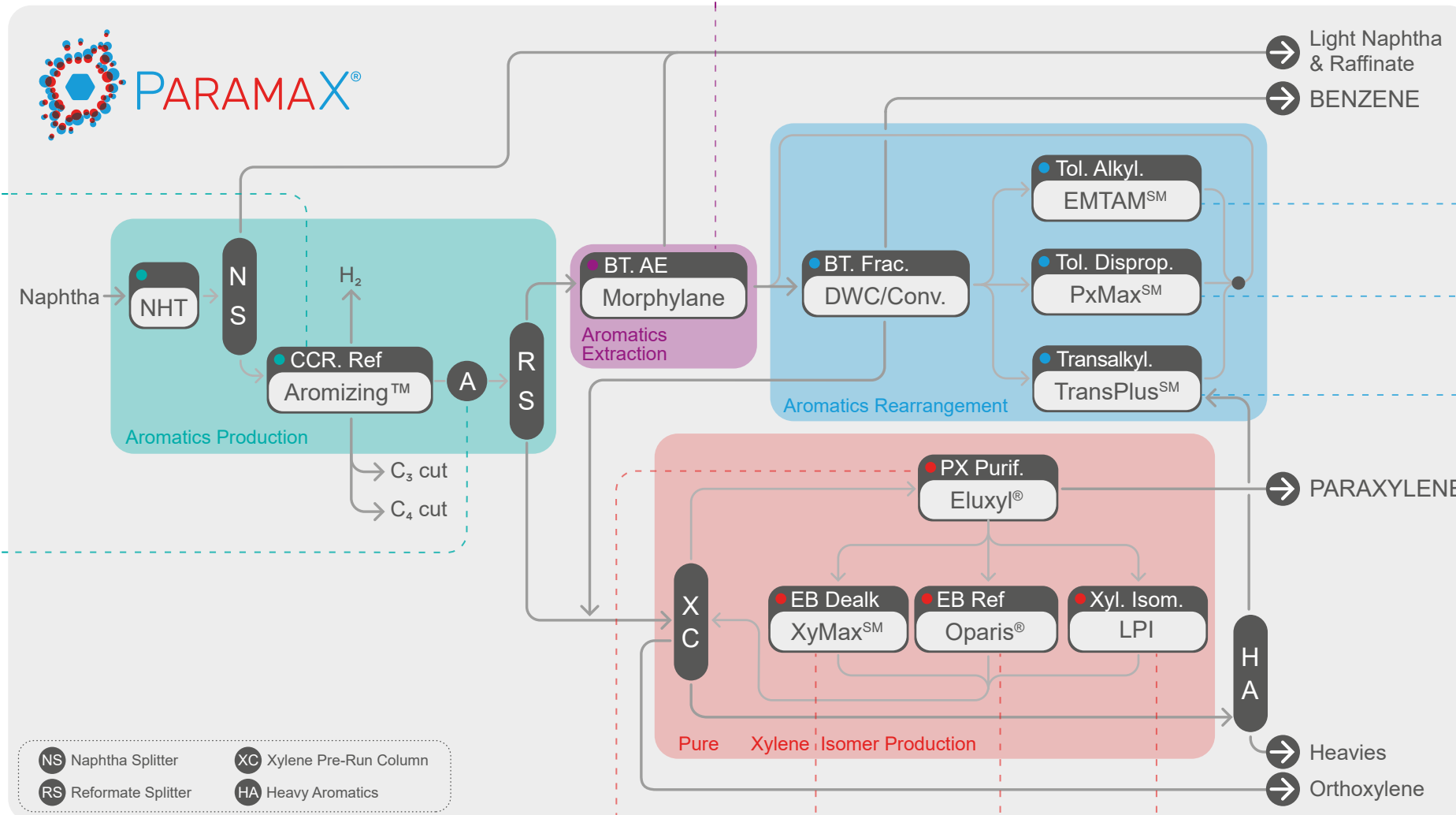
- Avoids logistics issues associated with clay treaters
- Cost-effective hydrogenation process
- Improves end-user revenue

## ● Eluxyl® - PX Purification

Eluxyl® technology employs a state-of-the-art, simulated counter-current adsorption concept for paraxylene purification and production from a C8 aromatics stream. Eluxyl® is an innovative technology enabling the end user to capitalize on future molecular sieve improvements.

### ★ BENEFITS

- Benchmark technology for paraxylene purification
- Proven lowest CAPEX & OPEX technology
- Unmatched SCS (Sequential Control System) reliability and tuning capabilities



## ● Morphylane - BT. Aromatics Extraction

Cost-effective extractive distillation technology. Thanks to the recognized superior characteristics of its patented solvent (N-Formylmorpholine), Morphylane has achieved a major breakthrough in aromatics extraction technology.

### ★ BENEFITS

- Achieves 99.95%+ benzene purity
- No solvent decomposition, corrosion or toxicity issues
- Lowest solvent consumption
- Lowest CAPEX

## ● EMTAM™ - Toluene Alkylation with Methanol

Paraxylene yield can be increased thanks to the low cost utilization of methanol in toluene in the EMTAM™ process. EMTAM™ enables unique product slate flexibility from zero to conventional benzene co-production for greatest resilience to changing market conditions.

### ★ BENEFITS

- ParamaX® scheme with the highest paraxylene selectivity
- Selective paraxylene process
- Enables massive reduction of paraxylene cost of production
- Advantage of strong product slate flexibility

## ● PxMax™ - Toluene Selective Disproportionation

PxMax™ process is the industry benchmark selective toluene disproportionation (STDP) process. The STDP enables rearrangement of aromatics to boost the production of benzene & xylenes from toluene.

### ★ BENEFITS

- Benchmark catalyst for toluene disproportionation
- Selective paraxylene process
- Enables tremendous paraxylene cost of production reduction
- Ultra high IRR solution

## ● TransPlus™ - Heavy Aromatics Transalkylation

The TransPlus™ process is the low-cost, high-conversion solution to effectively upgrade C9+ heavy aromatics and toluene/benzene to higher-value products (mixed xylenes and high-purity benzene).

### ★ BENEFITS

- High conversion per pass
- Very low aromatic ring loss
- Highest tolerance to heavy aromatics
- Low OPEX

## ● XyMax™ - EB Dealkylating Xylenes Isomerization

XyMax™ efficiently converts ethylbenzene (EB) to valuable benzene while restoring xylenes to an equilibrium mixture in paraxylene-depleted raffinate streams.

### ★ BENEFITS

- Benchmark catalyst for EB dealkylation isomerization
- Highest EB conversion rate
- Highest activity
- Drastic reduction of paraxylene production costs

## ● Oparis® - EB Reforming Xylenes Isomerization

Oparis® harnesses chemistry to maximize paraxylene selectivity thanks to ethylbenzene (EB) to xylene isomerization while restoring the xylene equilibrium of paraxylene-depleted raffinate streams.

### ★ BENEFITS

- Benchmark catalyst for EB reforming isomerization
- High selectivity in isomerization to paraxylene
- Highest paraxylene production rate
- Highest EB conversion rate

## ● LPI™ - Liquid Phase Xylenes Isomerization

Liquid phase isomerization offers unique market performances, mitigating the drawbacks of vapor-phase xylene isomerization with excellent savings in CAPEX & OPEX. It is also the technology of choice for isomerization of ethylbenzene-depleted C8 aromatics streams.

### ★ BENEFITS

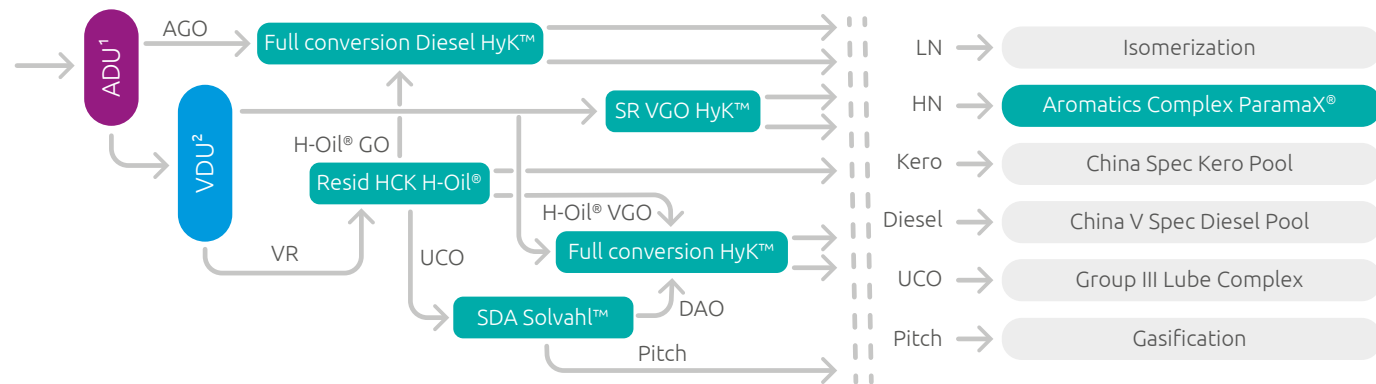
- Costless Isomerization technology
- Equilibrium xylenes production
- Strong synergies for reduced paraxylene cost of production

# DEVELOPING SYNERGIES OUTSIDE THE BATTERY LIMITS

A rocky outlook for motor gasoline fuels and paraxylene growth is spurring investors and operators to develop resilient Crude-to-Chemicals or Gasoline and Chemicals integrated Complexes.

## CRUDE-TO-PARAXYLENE EXPERIENCE

Building on Axens' comprehensive portfolio and expertise in Crude-to-Paraxylene, the company has successfully delivered the complete design of the first-of-its-kind complex to the industry.



<sup>1</sup>/ Atmospheric Distillation Unit  
<sup>2</sup>/ Vacuum Distillation Unit

Key features of this scheme are:

- Maximum liquid yield with highest heavy naphtha selectivity
- Maximum paraxylene selectivity with Oparis® EthylBenzene Reforming Isomerization technology
- Cost-effective configuration with only proven technologies
- Highest plant availability and reliability

This achievement demonstrates the extensive expertise and engineering capabilities of Axens in successfully developing world-scale, complete refineries and petrochemical complexes.

## INTEGRATED PARAMAX® & GASOLINE POOL EXPERIENCE

Optimizing a complex that meets both gasoline & aromatics objectives is no small task, as aromatics production places significant stress on gasoline pool specifications.

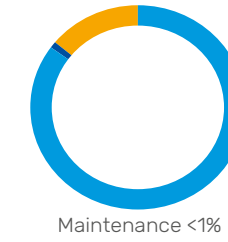
The availability of a complete portfolio of clean fuels technologies from a single technology provider contributes to project profitability, thanks to seamless and efficient overall optimization.

Alliance's unique portfolio of aromatics rearrangement and xylenes isomerization technologies allows a degree of freedom to thoroughly achieve operators' objectives with optimal economic performance.

Experience, competitiveness and the robustness of proposed optimizations have won Axens a number of major awards all over the world and a market leading position.

## { CASE STUDY }

Net feed costs represent about 85% of a state-of-the-art naphtha to PX complex operating costs.

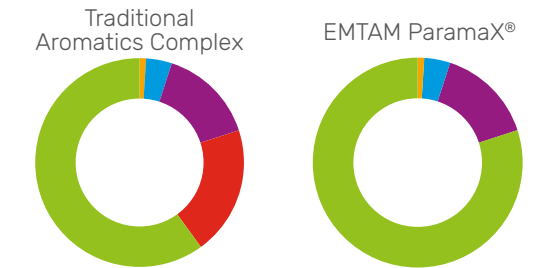


Significant savings can therefore be achieved thanks to:

- incorporation of alternative cost-advantaged feed,
  - increase of aromatics to paraxylene ring usage.
- EMTAM, PX-selective toluene alkylation with methanol technology meets these two objectives, thanks to the co-feeding of low cost methanol and non-production of benzene and gas from toluene.



The positive impact on material balance is presented below, based on the same naphtha feed rate to the ParamaX® Complex.



Legend for charts: Paraxylene (Green), Benzene (Red), Raffinate (Purple), Light Ends (Blue), Heavies (Orange).

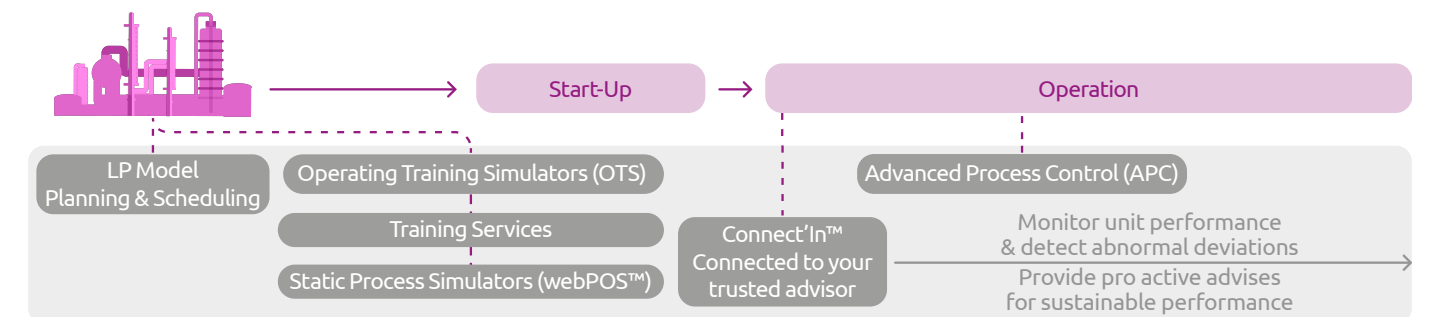
Already commercially available, EMTAM ParamaX® enables major savings compared to traditional aromatics complexes, thanks to drastically reduced paraxylene production costs, as illustrated by the figures above:

- 20% CAPEX reduction,
- Up to 35% naphtha feed reduction,
- More than 30% utility savings.



## ParamaX®, a world of services

Axens role in the success of end-user's projects does not end at the acceptance of the unit performances. Axens guides and supports its licenses' day to day operations and profits through a full suite of services, including:

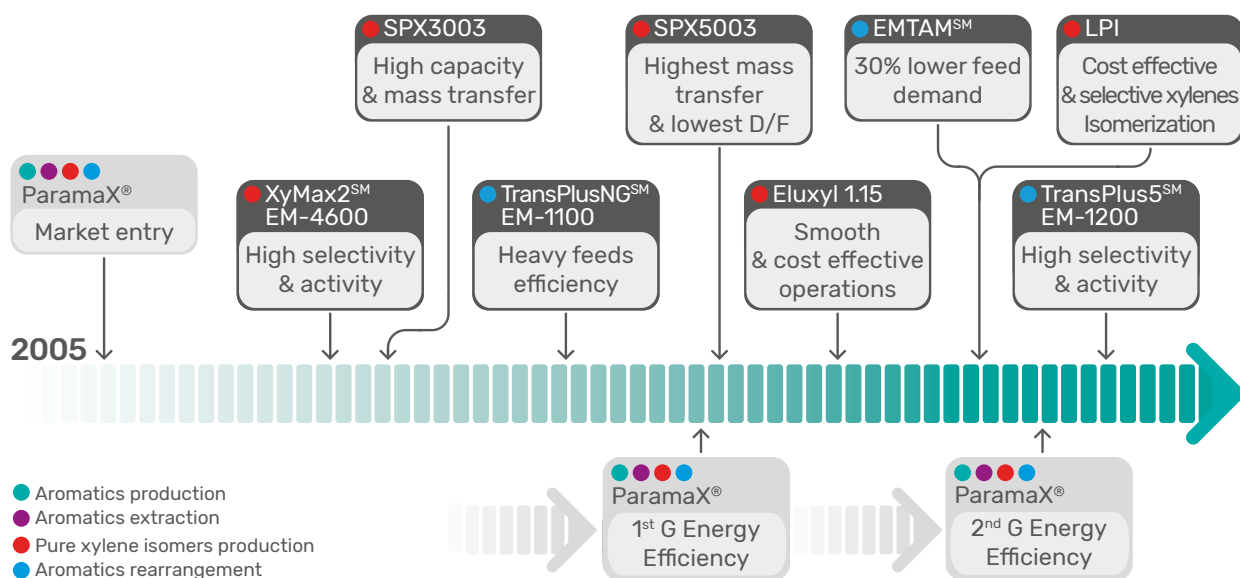


- **Operator training simulators (OTS)** powered with licensor high fidelity models, commissioning and operation experience are the best training tools available.
- **Axens ParamaX® complex webPOS™** boost an engineer's effectiveness up to the next level and is for instance run by licensee to optimize naphtha feed sourcing and production planning.
- **Advanced Process Control (APC)** uses a model-based predictive control technology that drives the process towards the desired targets through the manipulation of several variables simultaneously while observing all process constraints. APC strategy for ParamaX® is focused on unit stabilization, PX production maximization and energy savings.
- **Connect'In™ solution** is the combination of high fidelity reaction models, live analysis of Axens experts and unequal access to expertise coming from technical assistance on a large install based of process units across the globe. Thanks to automatic data collection, analysis and prediction, Connect'In™ will enable users to monitor their ParamaX® complex performances making easier the decision process using what-if tools comparing the current performances with expected ones while changing operating conditions.

# COMMITMENT TO INNOVATION

Alliance continuously invests in R&D in order to offer its licensees the highest project profitability.

Supported by extensive industrial feedback, these efforts keep proposed catalysts/sieve products and technologies at the cutting edge of technology.



Thanks to continuous efforts in R&D, the ParamaX® Suite offers the most competitive and advanced complexes, with reductions in investment, feedstock and energy consumption.

## PARAMAX® ENERGY EFFICIENCY DESIGN

Powering an aromatics complex accounts for around 10 to 15% of operational costs. It offers significant potential for improvement of end-user profitability.

Harnessing a decade of development and experience, Axens employs a thermal integration scheme evaluation tool to propose tailor-made designs to operators that guarantee the best energy consumption performance in terms of cost control, operational flexibility and safety.



This approach is integrated in the CEED™ or “Custom and Efficient Early Design” that Axens offers each of its licensees.

In addition to systematic screening methodology, Axens is continuously implementing innovative and patented engineering solutions to improve overall performance. The recently marketed second generation Energy Efficient design has already won multiple awards.

50% OPEX savings

Energy >130°C is recovered

Energy lost at 85°C in average

CAPEX increased by 0%

Energy losses through air coolers divided by /2

OIL REFINING



PETROCHEMICALS



GASES



ALTERNATIVES  
& RENEWABLES



WATER



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Axens is a Group providing a complete range of solutions for the conversion of oil and biomass to cleaner fuels, the production and purification of major petrochemical intermediates as well as all of natural gas treatment and conversion options. The integrated offer includes technologies, equipment, furnaces, modular units, catalysts, adsorbents and related services, commercialized under “Axens Solutions”, “Heurtey Petrochem Solutions” and “Axens Horizon” brands.