



Ethylene
Middle East
Technology
Conference



Axens Technologies to Support Polyethylene Business

Xavier Liege

Agenda

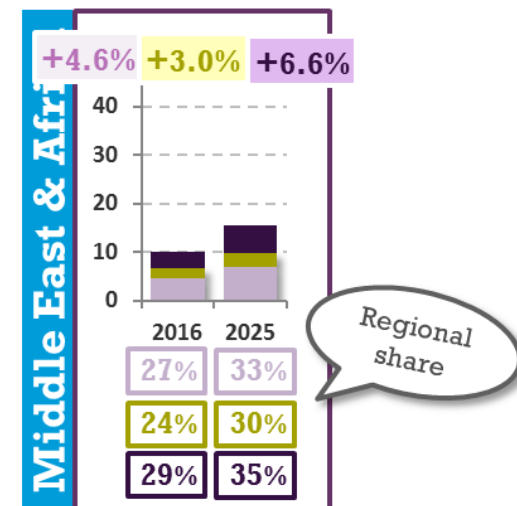
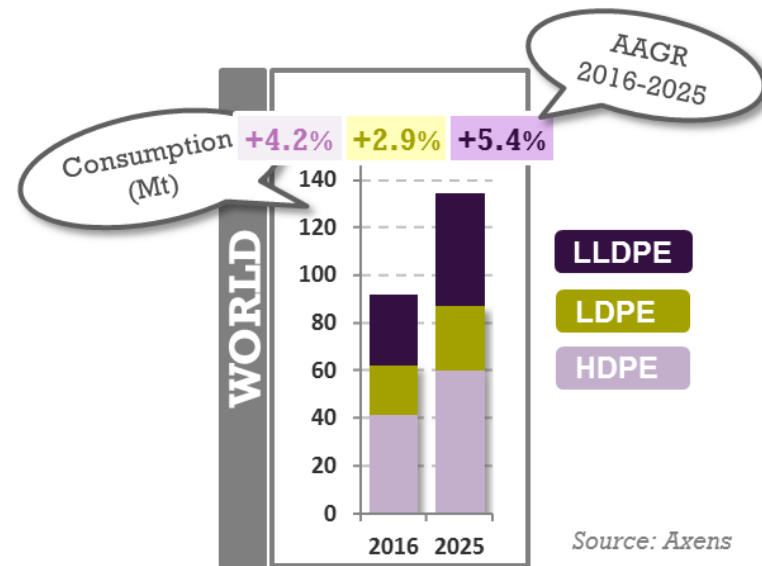
- Polyethylene Markets: Clear Growth Perspectives
- Homogeneous Catalysis Technologies
- Butene-1 and Hexene-1 Production Technologies
- For The Best of Your Project: Packages
Standardization and Modularization options

Agenda

- **Polyethylene Markets: Clear Growth Perspectives**
- Homogeneous Catalysis Technologies
- Butene-1 and Hexene-1 Production Technologies
- For The Best of Your Project: Packages
Standardization and Modularization options

Polyethylenes Market Outlook

- Their market is growing fast ...



Positive Elements for Comonomer Production Development in Middle East

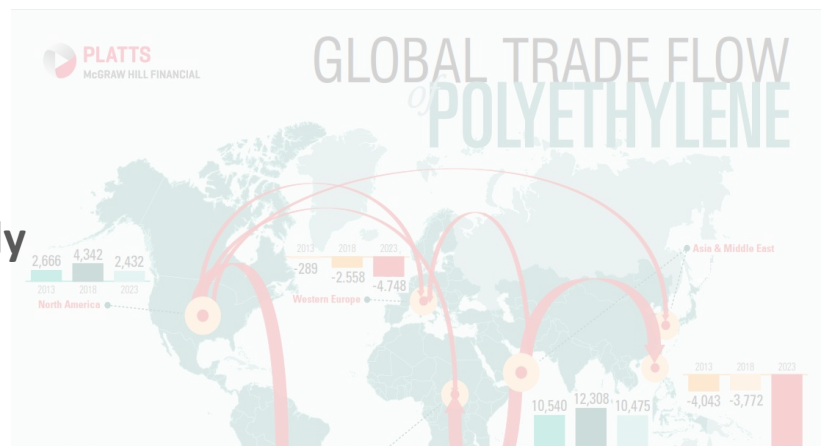
■ Uptake

- LLDPE and HDPE increasing demand worldwide and in MEA
- Local and/or export markets accessible
- Strategic location of MEA
- 1-hexene liquid comonomer

■ Production

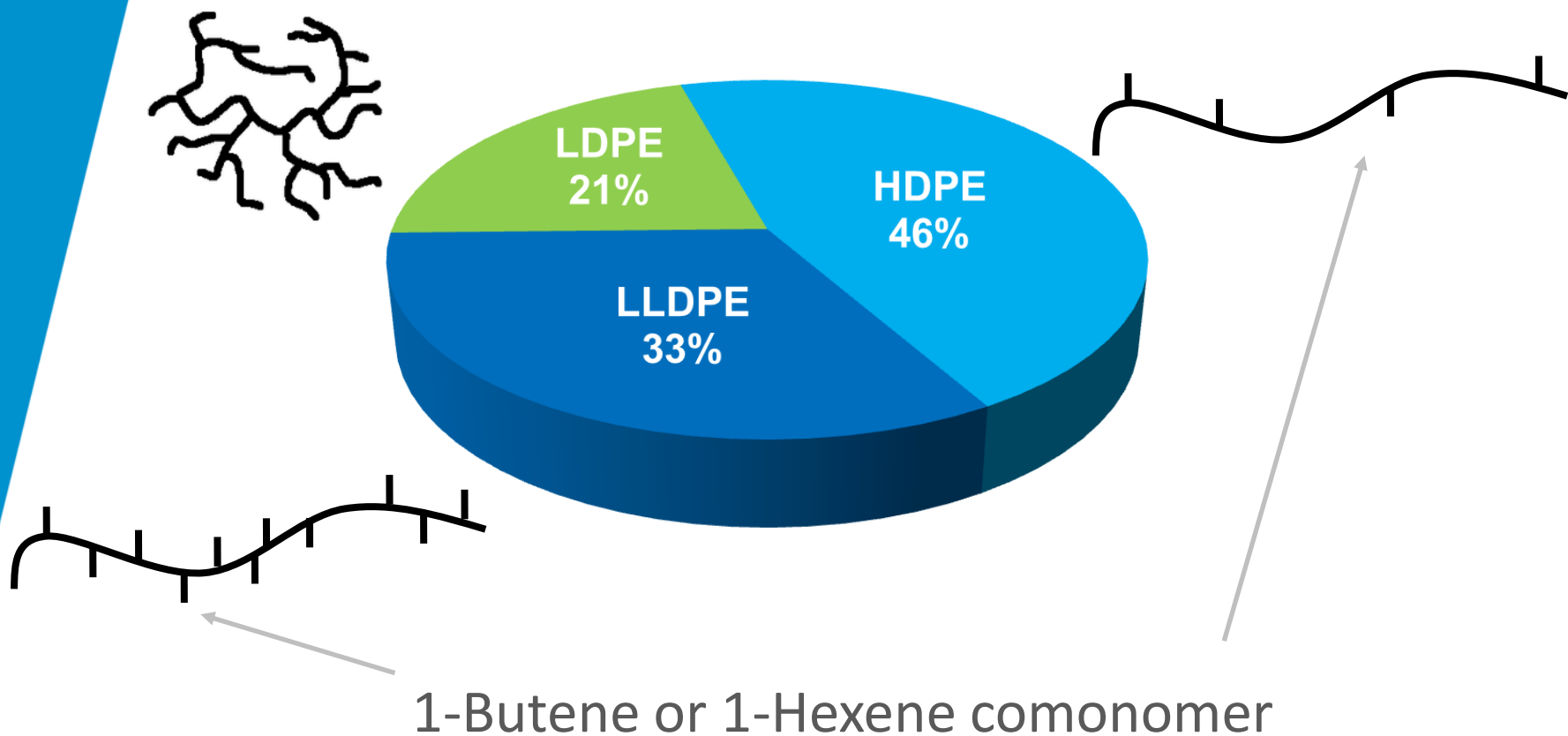
- On-purpose technology ready
 - › High quality
 - › High yield

[**AlphaButol** dimerization
process for **1-butene**



[**AlphaHexol** trimerization
process for **1-hexene**

Comonomers Market



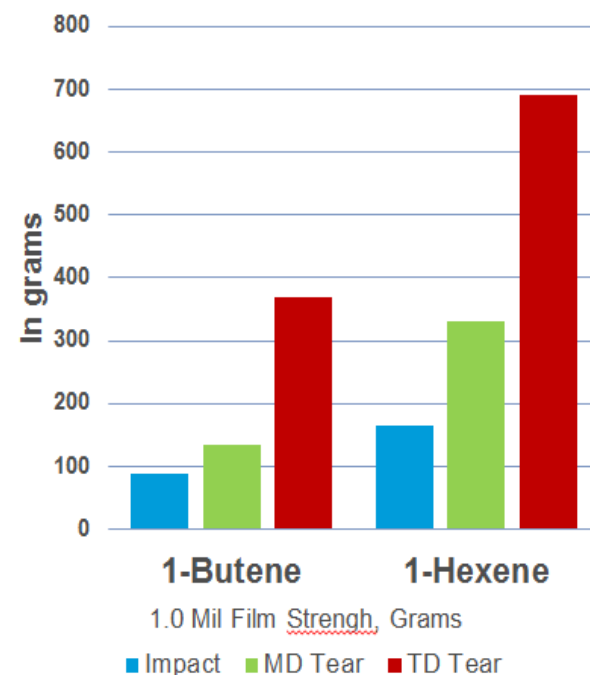
Driven by LLDPE & HDPE : AAGR ~ +5-7 %

Properties Enhancement, Comonomer Pricing

- Comonomer selection= f (properties / application)
 - Mechanical resistance,
 - Translucence, ...
- End products properties drive comonomer pricing

LLDPE import market prices Southeast ASIA – 02/2016	
Comonomer used	Price, USD/tons
1-Butene	1 100
1-Hexene	1 300

Source : IHS chemical – Asia/India Plastics & Polymer - issue 373 Feb 2016



Agenda

- Polyethylene Markets: Clear Growth Perspectives
- **Homogeneous Catalysis Technologies**
- Butene-1 and Hexene-1 Production Technologies
- For The Best of Your Project: Packages
Standardization and Modularization options

Intermediate Provider for Polymer Producers since 70's

- Among the suite of **homogeneous catalysis** licensing

[> 110
references

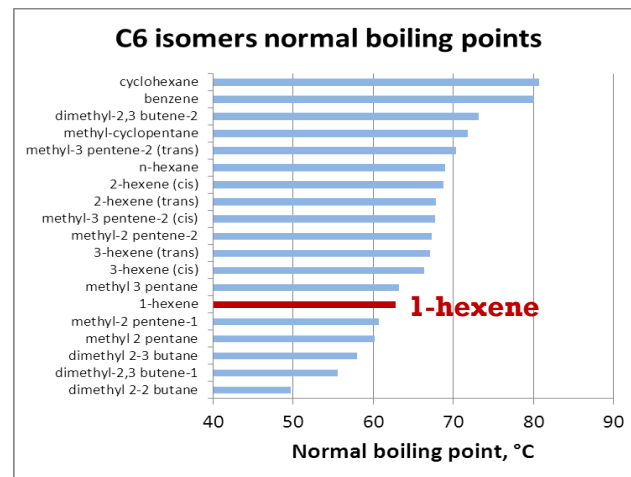
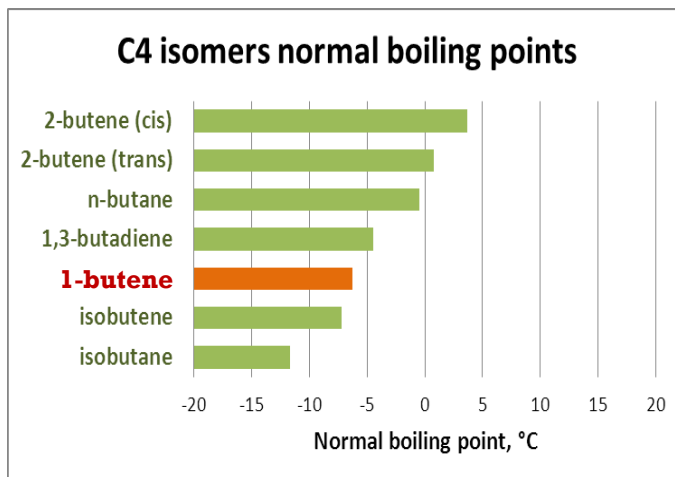
- Extensive, continuous R&D involvement
 - Development started in the 60's
 - Pr Chauvin Nobel Prize in Chemistry 2005
 - Legacy to his team



Laureate Nobel Prize Yves Chauvin

Comonomers Sourcing

1-butene and 1-hexene in C4 and C6 fractions



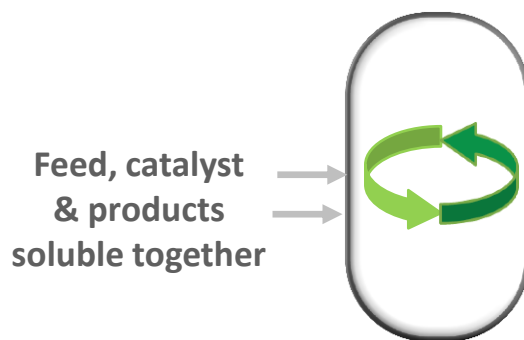
- 1-butene and 1-hexene sourcing?
 - 1-butene from C4 challenged by MTBE limitation
 - Beyond simple distillation to extract the desired isomer
 - New technology answers: on-purpose ethylene oligomerization



AlphaButol® & AlphaHexol™ dedicated processes for
polymer grade 1-butene and 1-hexene

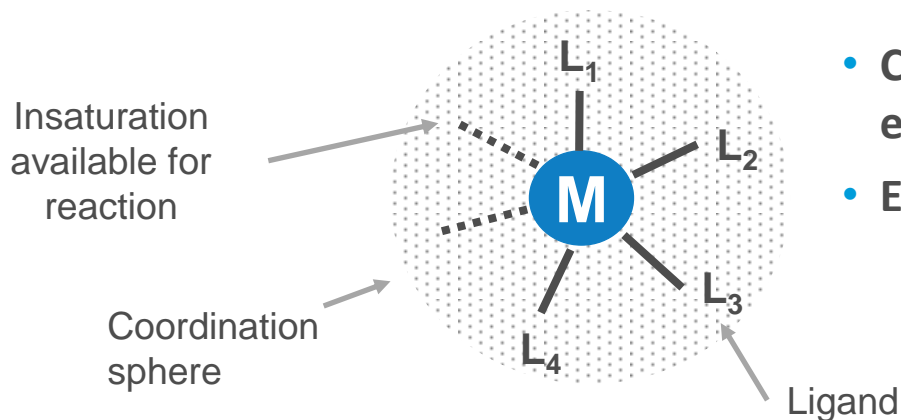
Chemistry Principles

■ Homogeneous catalysis



- Near perfect distribution
- Continuous poison control by catalyst renewal
- Ease of heat removal and accurate T control

■ Isomer specific taylor made catalyst



- Controlled active metal electronic configuration
- Ensure desired isomer formation

Agenda

- Polyethylene Markets: Clear Growth Perspectives
- Homogeneous Catalysis Technologies
- **Butene-1 and Hexene-1 Production Technologies**
- For The Best of Your Project: Packages
Standardization and Modularization options

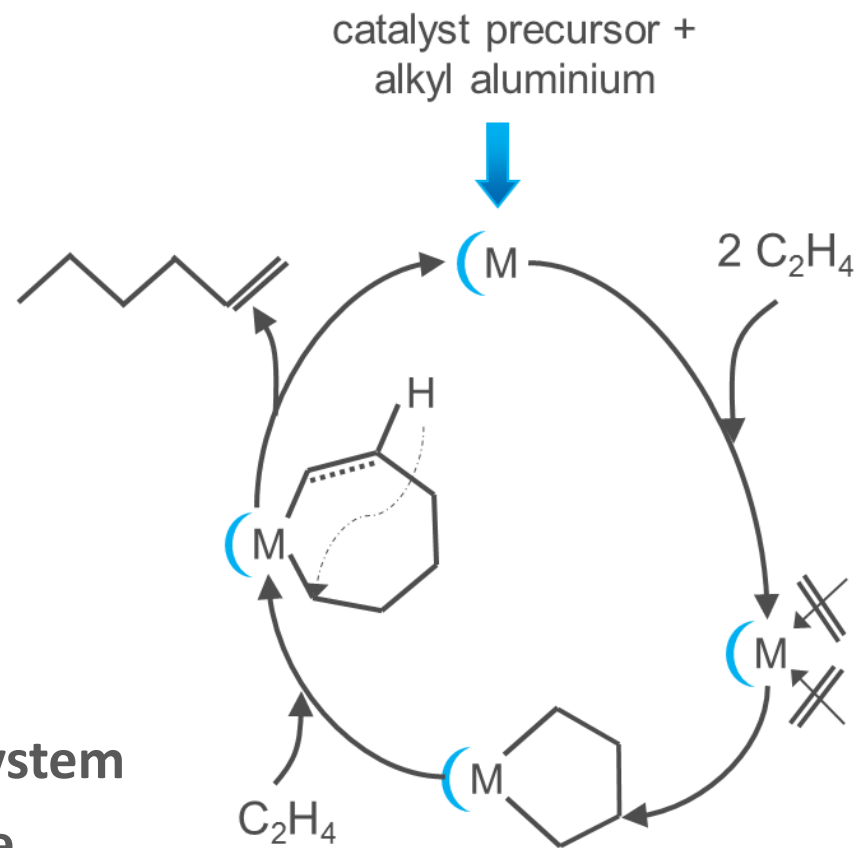
- Strong similarity AlphaHexol / AlphaButol

› Mechanism,

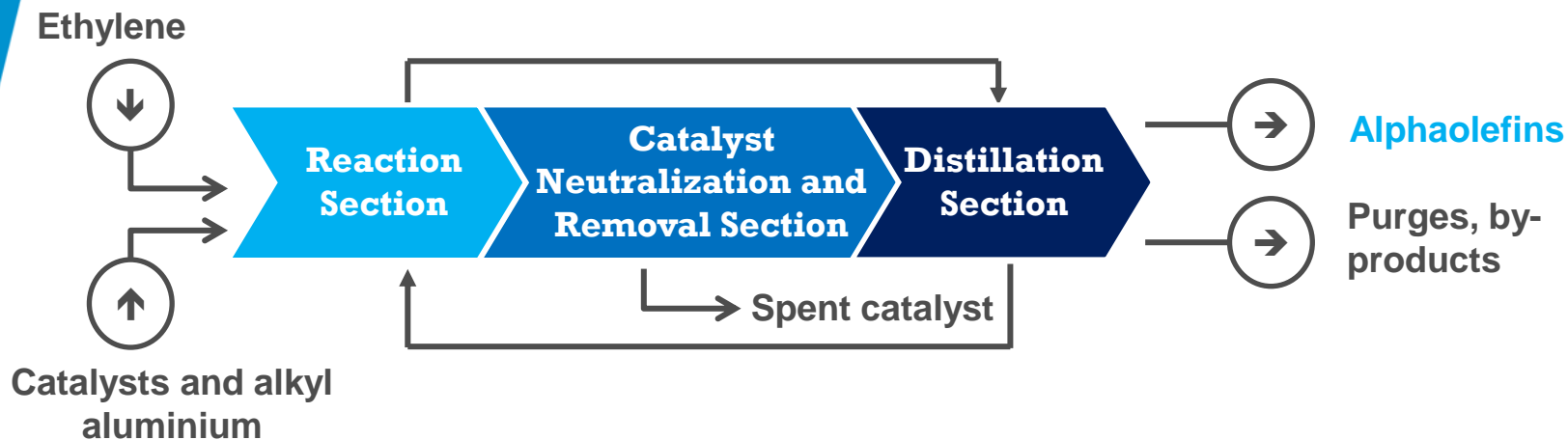
- › Same β hybrid transfer principle
- › Same TEA alkyl aluminium
- › High selectivity
- › High product purity
- › No Cl, no aromatics

Axens' know-how

- Unique patented catalytic system
- Selectivity from metallacycle shaped stability

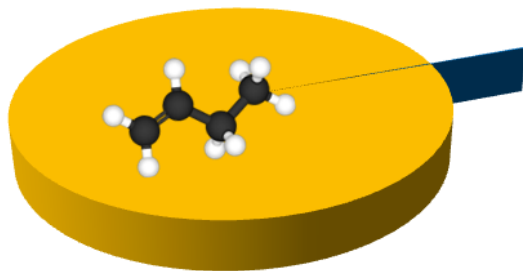


Overall Blockflow & Product Quality



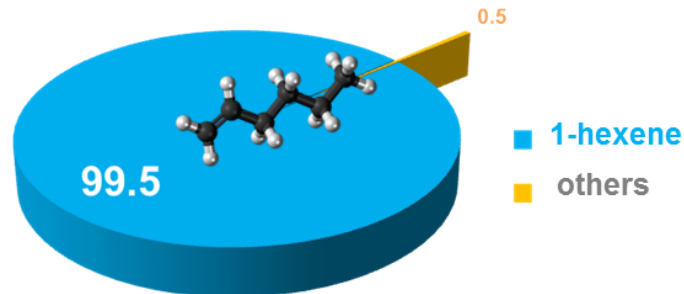
■ High quality products

AlphaButol: polymer
grade 1-butene



Product to storage. Industrial.
data from test run.

AlphaHexol: polymer
grade 1-hexene



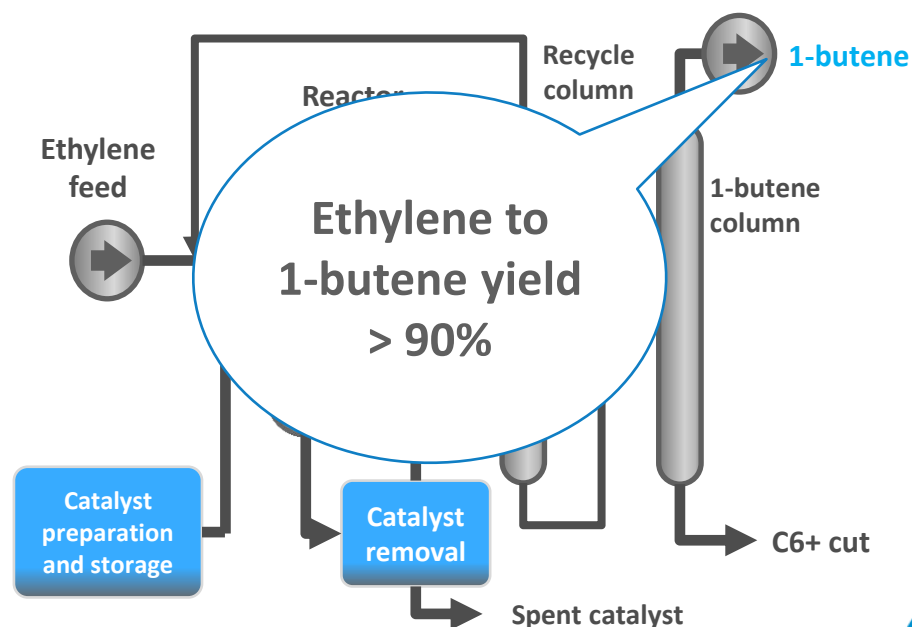
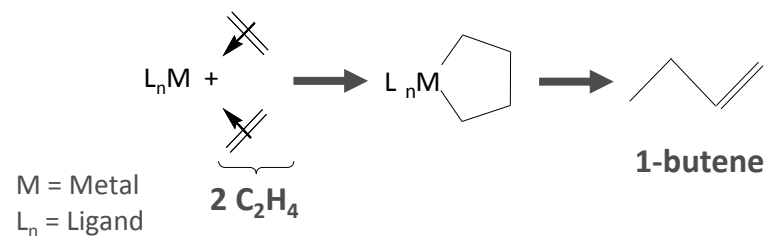
Pilot data sample GC

Polymer Grade 1-Butene from Ethylene

AlphaButol Key Features

Selective ethylene dimerization mechanism

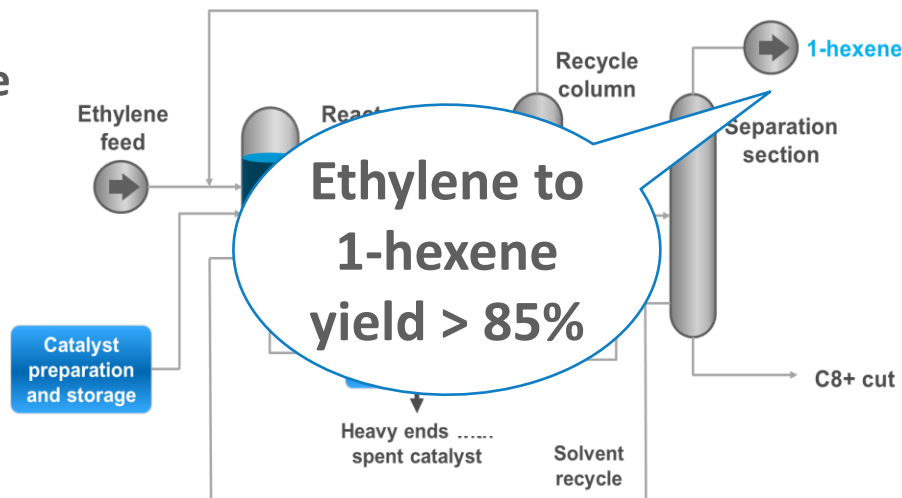
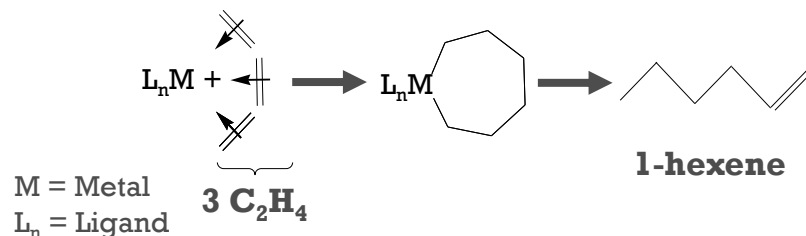
- Polymer grade 1-butene for LLDPE & HPDE
- Process simplicity and ease of operation
- High flexibility
- Low operating temperature and pressure
- Operating in liquid phase with no solvent required
- No heat input to the reaction section
- Carbon steel equipment



AlphaHexol Key Features

Selective ethylene trimerization mechanism

- Similar to AlphaButol, backed by extensive industrial experience in homogeneous catalysis
- Polymer grade 1-hexene suitable for LLDPE & HPDE
- Efficient ethylene feed use
- Process simplicity and ease of operation
- High flexibility
- Mild operating temperature and pressure
- Carbon Steel Equipment



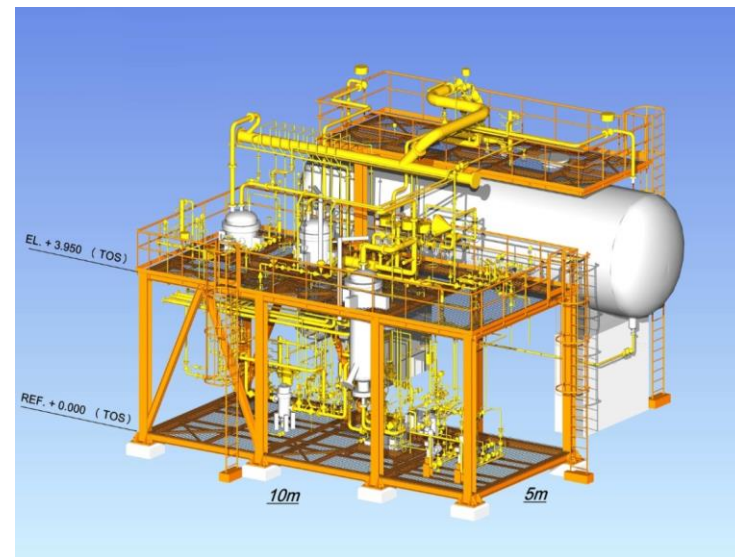
Agenda

- Polyethylene Markets: Clear Growth Perspectives
- Homogeneous Catalysis Technologies
- Butene-1 and Hexene-1 Production Technologies
- **For The Best of Your Project: Packages
Standardization and Modularization options**

Towards Standardization?

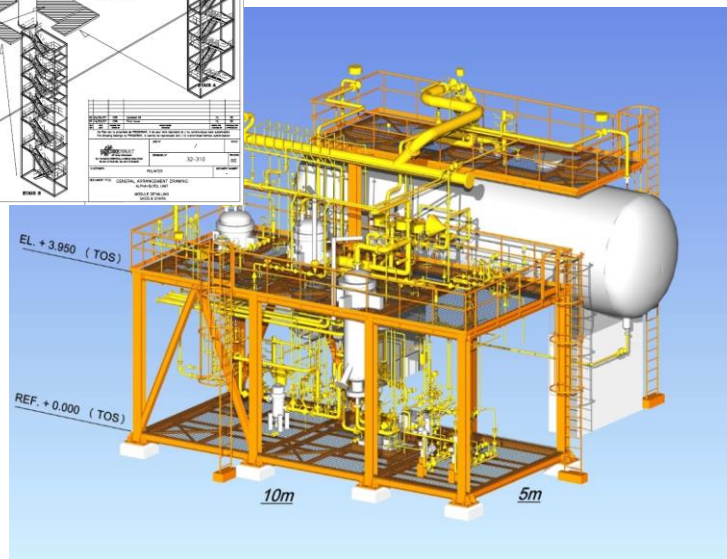
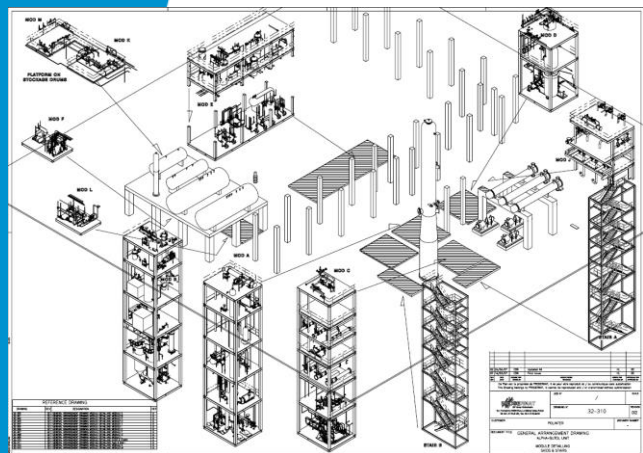
Catalysts and alkyl aluminium

- Alkyl aluminium → TEA
 - Same for AlphaButol and AlphaHexol
 - Mutualized in dual 1-butene + 1-hexene complex
 - Sophisticated although quite standard section for all our designs



Time and cost savings if standardized to another level ?

From Idea ... to Implementation



Operating
15 kta
1-butene plant



Ready to Plug In Concept ... Drivers ?

- Site specific decision depending on several factors

- **Safety / Conditions**

- › Implementation within operating process units
- › Workforce in dedicated equipped workshops
- › Harsh climates
- › ...

- **Cost & Schedule**

- › Reduced time to production, better NPV
- › Skilled and adapted tools & workforce at yard → efficiency
- › Workforce availability ensured
- › Price
- › ...

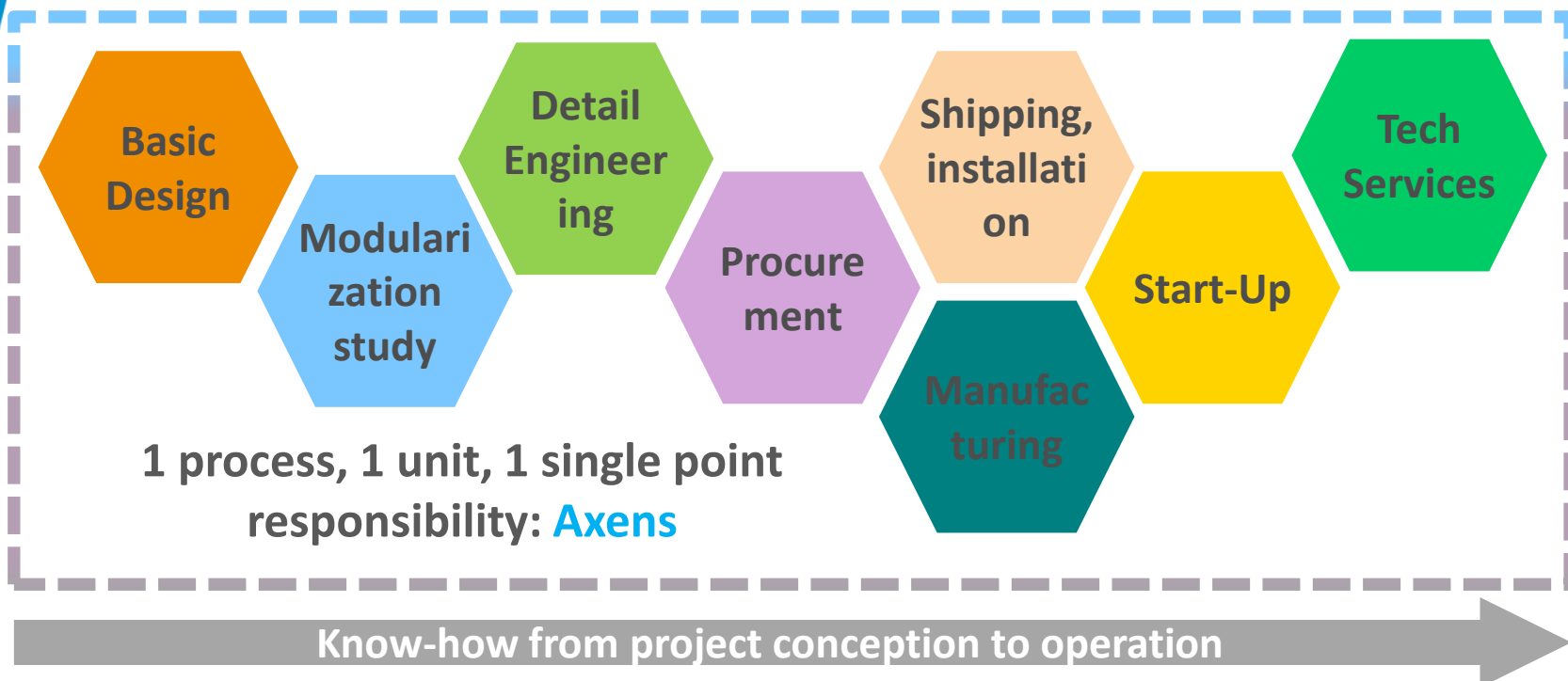
- **Technical**

- › No limitation due to hot, cold, off-shore conditions
- › Remote area troublefree
- › Plot space optimization
- › ...

[Key constraints review allow identifying the interest of modularization for each project

Advantages of Modularization through Axens

■ Axens **one stop shop** advantage



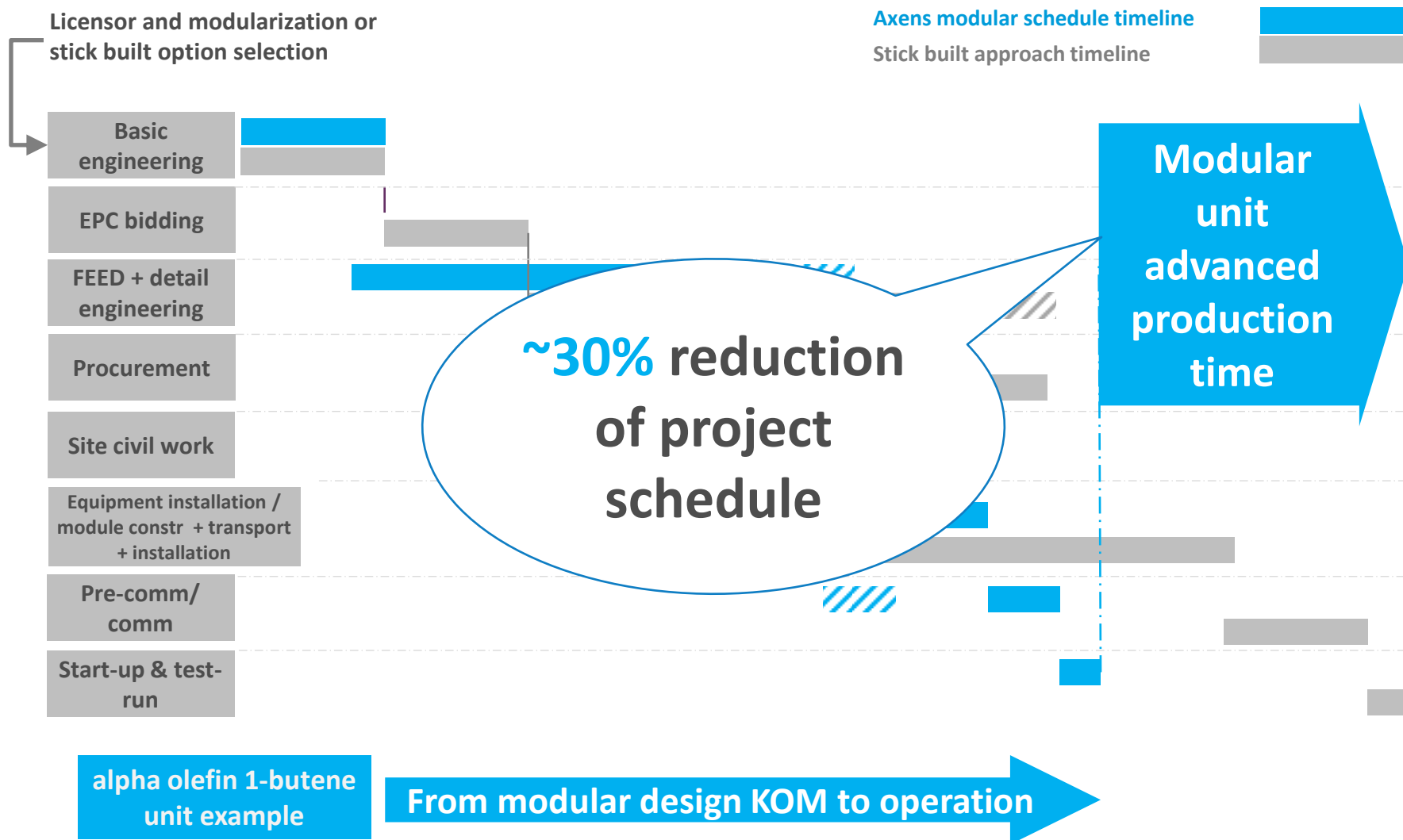
- Shared know-how, process understanding and commitment
- No losses (time, technical) at interfaces between various actors
- Schedule efficient: lower time to production thus increased NPV

Need to Be Really Convinced of Axens One-Stop-Shop Advantage ?

- Jeopardizing safety, cost, schedule and operability is a real concern related to manufacturing
 - On a stick-built plant site: surprising but seen in real life...
-
- [

 - Make **your project safe**
 - Do it **right from the first with Axens**
 - skilled licensor and modularized solution provider

Schedule Efficiency with Axens Modularization



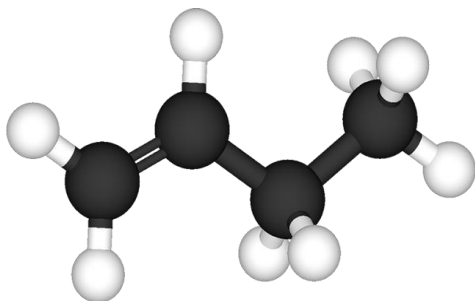
1-Butene & 1-Hexene Comonomers for PE

AlphaButol & AlphaHexol Take-Aways

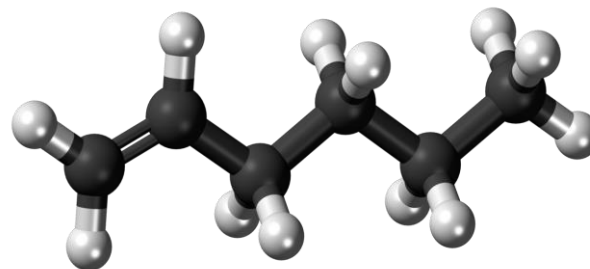
- Excellent match to sustain comonomers demand and growth
- High purity comonomers, high performance polymers
- Highly efficient ethylene use, CAPEX effective solutions

➤ **Highly selective technologies matching market demand**

AlphaButol



AlphaHexol





Ethylene
Middle East
Technology
Conference



THANK YOU

