JJ-Lurgi

Engineered for you

Extending Oleochemistry:
Glycerin to Propylene Glycol
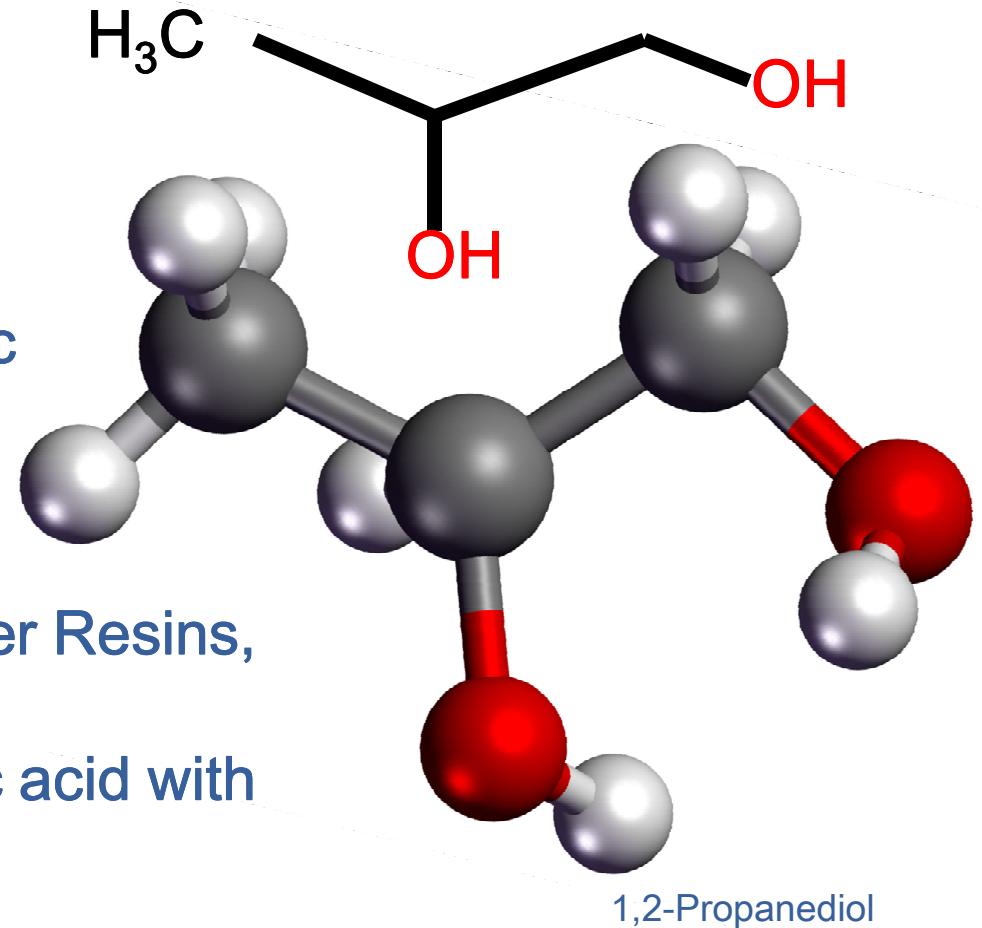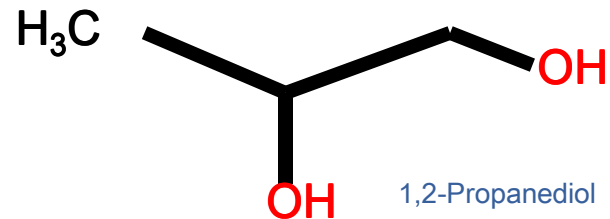## and how Industry 4.0 enters Oleochemical Industry

Why Propylene Glycol?

> Propylene Glycol (PG) = 1,2-Propanediol
PG is a versatile chemical and a non-toxic alternative to Ethylene Glycol, e.g in Functional Fluids

Main application are unsaturated Polyester Resins, glass fiber reinforced polyester resins (by polycondensation of Maleic acid & Phtalic acid with Propylene glycol)

H_3C

OH

OH

1,2-Propanediol

Why Propylene Glycol?

$$H_3C \diagup \diagdown OH$$

OH 1,2-Propanediol

➢ Propylene Glycol (PG) - as we can expect from the molecular structure and its similarity to glycerin - is soluble in water as a polar component

➢ Similar to glycerin it has a high boiling point, and a sweet taste, and is non-toxic

➢ In contrast to glycerin PG does not increase the viscosity in the same way at low temparature and high concentrations

➢ PG due to its similarity to propanol is also soluble in many organic solvents respectively can dissolve many organic components, which makes it suitable for cosmetics and pharmaceuticals

➢ PG shall not be confused with the toxic Ethylene Glycol

Why Propylene Glycol?
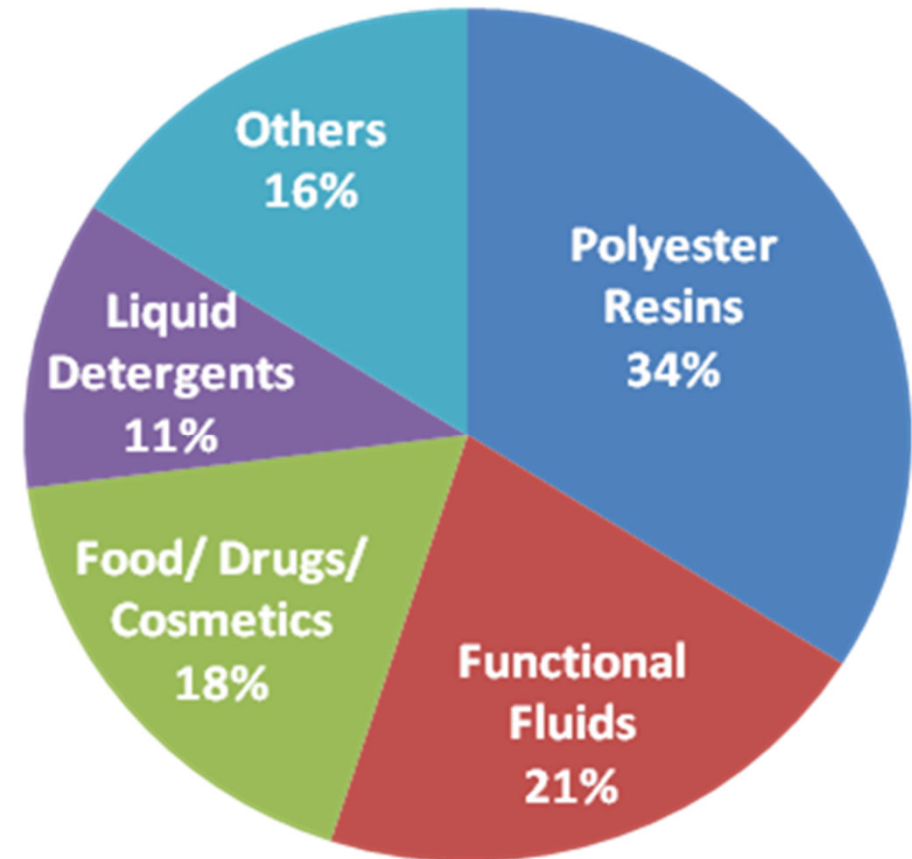
Ideal downstream product from Glycerin

Propylene Glycol: Applications

2018: Global Propylene Glycol Market	
Installed Capacity	2800 ktpa*
Demand	2200 ktpa
Demand CAGR (2012-23)	4.50%

Compound annual growth rate

Others 16%
Polyester Resins 34%
Liquid Detergents 11%
Food/ Drugs/ Cosmetics 18%
Functional Fluids 21%

JJ-Lurgi - A joint venture between Air Liquide Global E&C Solutions GmbH Germany and Jebsen & Jessen SEA
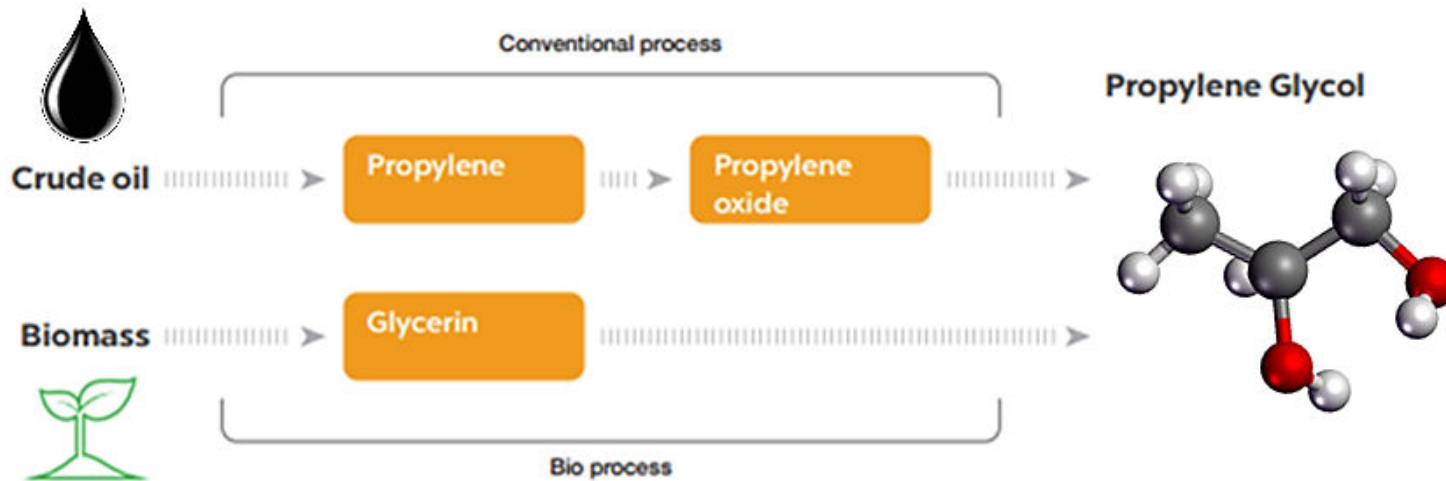
Sizeable & growing market

➢ More and more applications call for 'green', glycerin available from biodiesel and oleochemistry
➢ Conventional route more complex and more expensive

Oxidation of Propylene with organic hydroperoxides to Propylene oxide $\quad CH_3CH=CH_2 + RO_2H \rightarrow CH_3CHCH_2O + ROH$
Followed by hydration and ring opening to Propylene glycol $\quad\quad\quad CH_3CHCH_2O + H_2O \rightarrow C_3H_8O_2$

Simultaneous Dehydration and Hydrogenation of Glycerin $\quad\quad\quad C_3H_8O_3\ -H_2O + H_2 \rightarrow C_3H_8O_2$
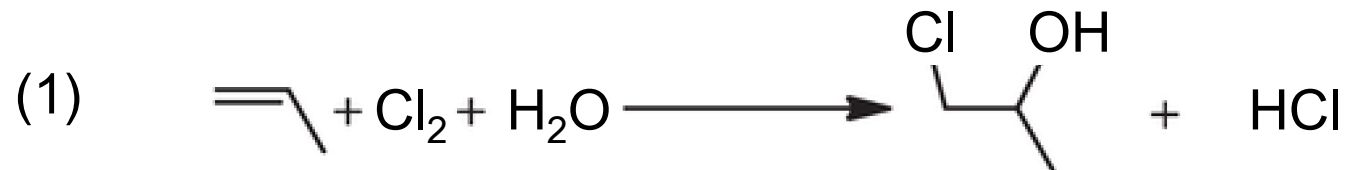
In China the old and less environmental friendly chlorohydrination (1) process of propylene to **Monochloropropanol** followed by epoxidation (2) to **Propylene oxide** is the major route. While in the rest of the world direct oxidation of propylene (see previous page) is dominating
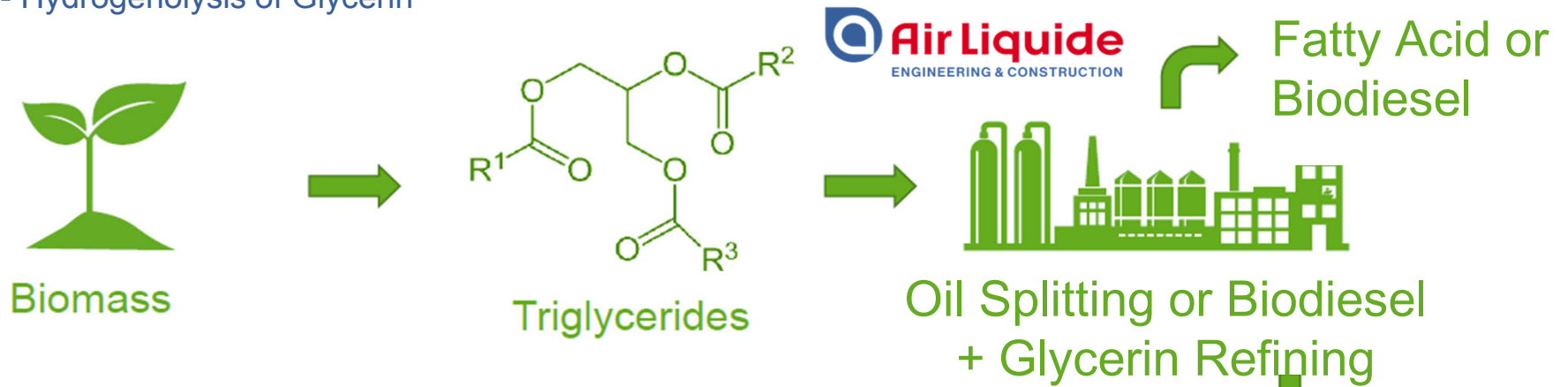
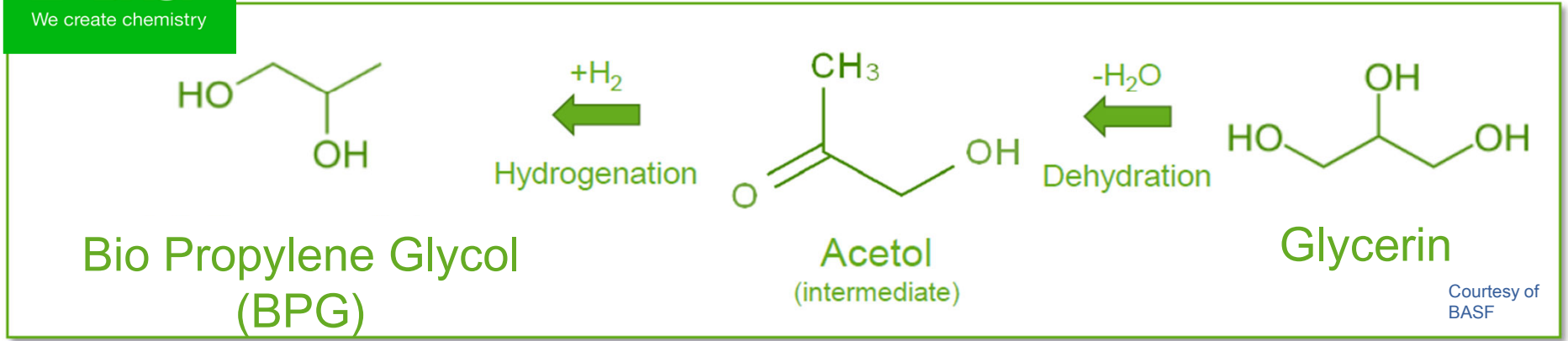## Chlorohydrination (old process, also called Hydrochlorination)

(1) $\diagup\diagdown + Cl_2 + H_2O \longrightarrow$ (Cl, OH) $+$ HCl

(2) (Cl, OH) $+ Ca(OH)_2 \longrightarrow$ (O) $+ CaCl_2 + H_2O$

BioPG: Process Schematic

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Safe, Sustainable Process

Green Chemistry - Hydrogenolysis of Glycerin

Biomass → Triglycerides → **Air Liquide** ENGINEERING & CONSTRUCTION → Fatty Acid or Biodiesel

Oil Splitting or Biodiesel + Glycerin Refining

BASF We create chemistry

Process & catalyst developed by BASF

Bio Propylene Glycol (BPG) ← $+H_2$ Hydrogenation ← Acetol (intermediate) ← $-H_2O$ Dehydration ← Glycerin

Courtesy of BASF

Hydrogenolysis is a chemical reaction whereby a carbon–carbon or carbon–heteroatom single bond is cleaved or undergoes lysis (breakdown) by H_2. The heteroatom may vary, but it usually is Oxygen, Nitrogen, or Sulfur. A related reaction is hydrogenation, where hydrogen is added to the molecule, without cleaving bonds. Usually hydrogenolysis is conducted catalytically using H_2.

1,2,3-Propanetriol "Glycerin"

$- H_2O$

Acetol

$+ H_2$

1,2-Propanediol

Overall reaction: $- O_2$
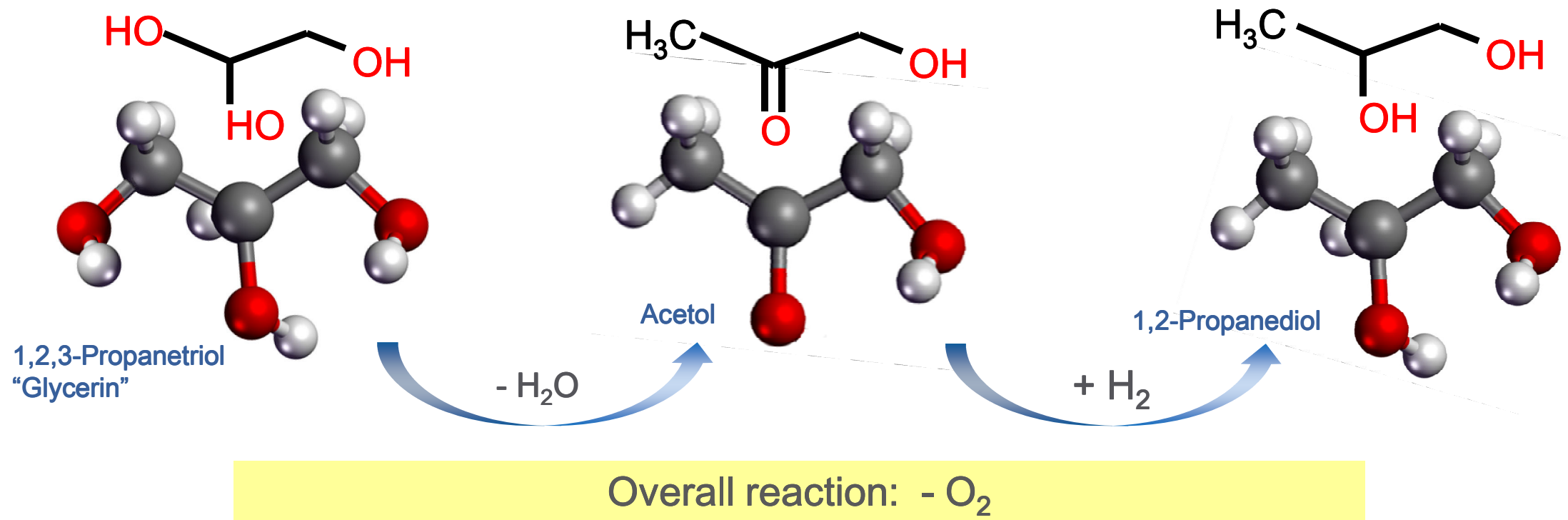
General principle of hydrotreating

Hydrogenation catalyst

1. H_2 dissolves into the catalyst surface as H^+

2. The heteroatom of the organic molecule temporary bonds weakly to the catalyst surface and then reacts with the hydrogen

3. The hydrotreated molecule leaves the catalyst surface
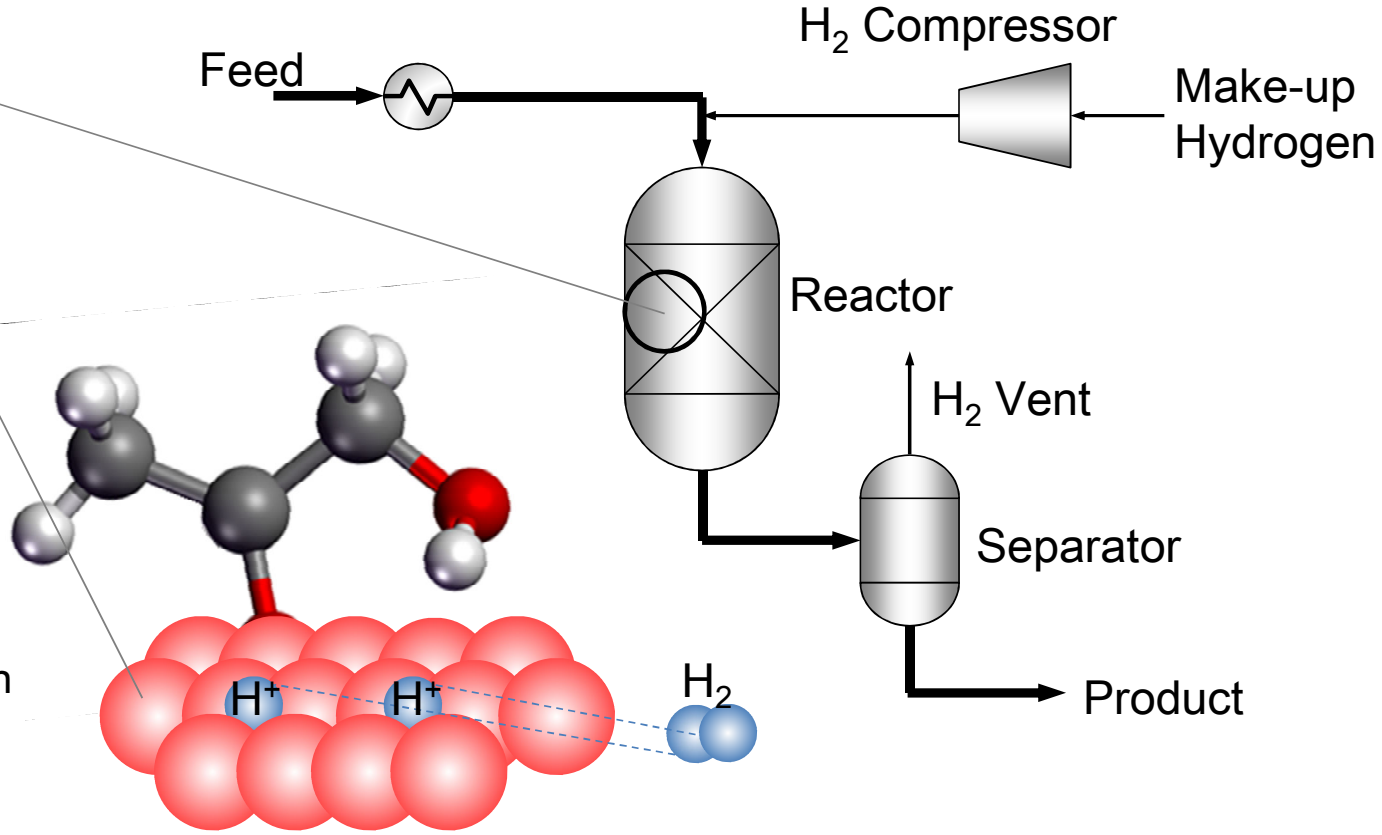
H_2 Compressor

Feed

Make-up Hydrogen

Reactor

H_2 Vent

Separator

H^+ H^+ H_2

Product

## General principle of heterogenic catalytic hydrotreating
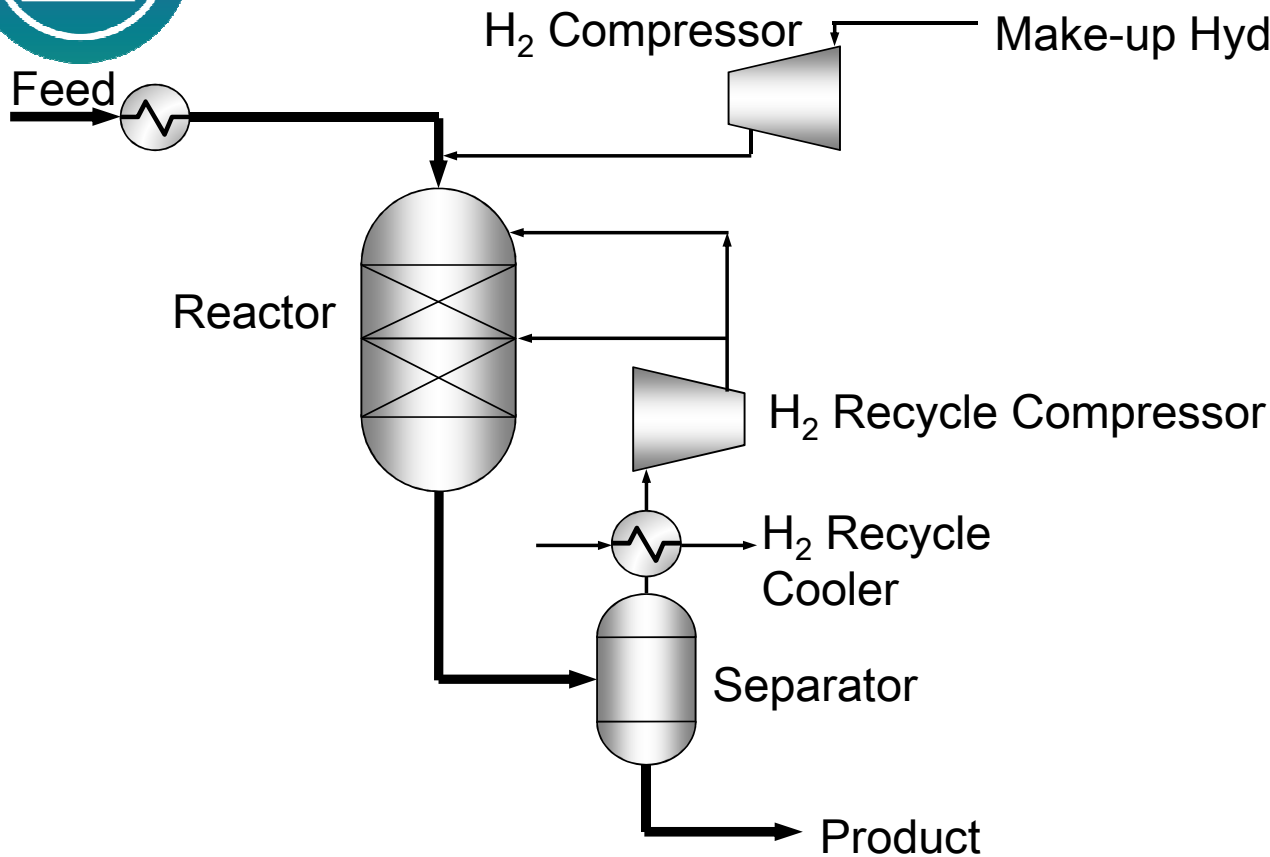
In case of high exothermic heat it might be necessary to cool the reactor by quenching with cooled recycle H_2 , depending on the selected hydrotreating process to prevent unwanted side reactions or temperature runaway

Pro: H_2 at 200°C has a spec. heat capacity of 14.5 kJ/kgK

Con: H_2 has a low density

General principle of heterogenic catalytic hydrotreating
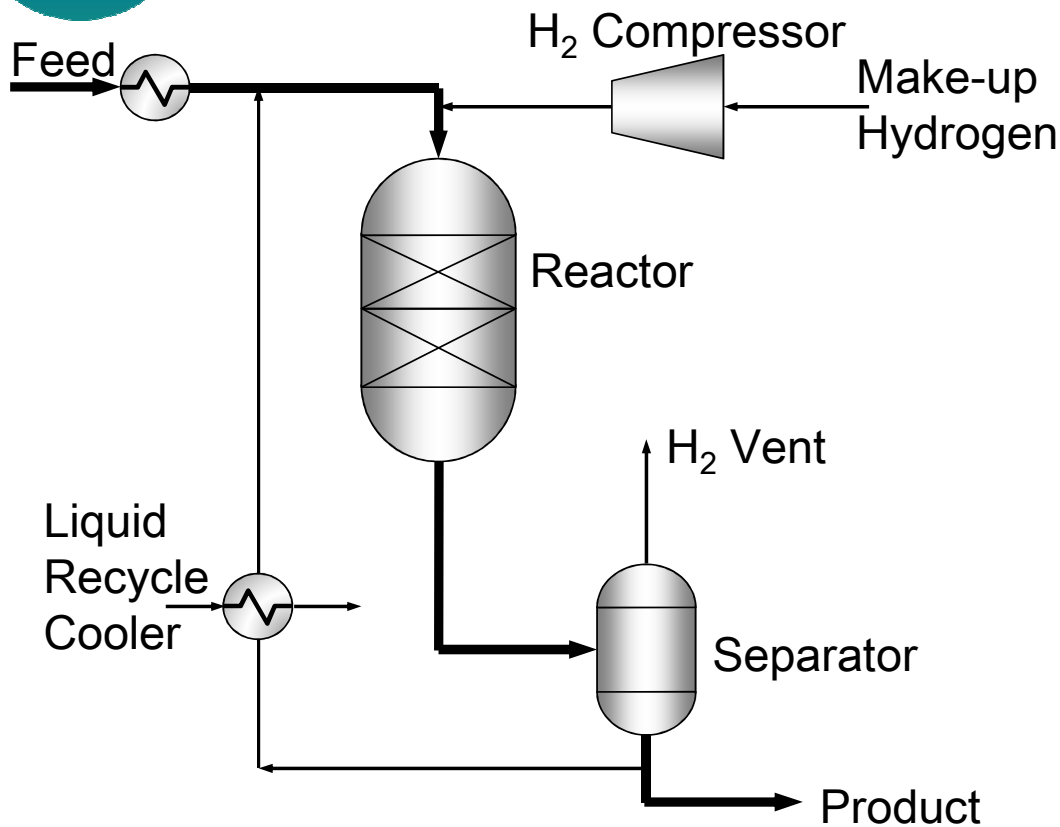
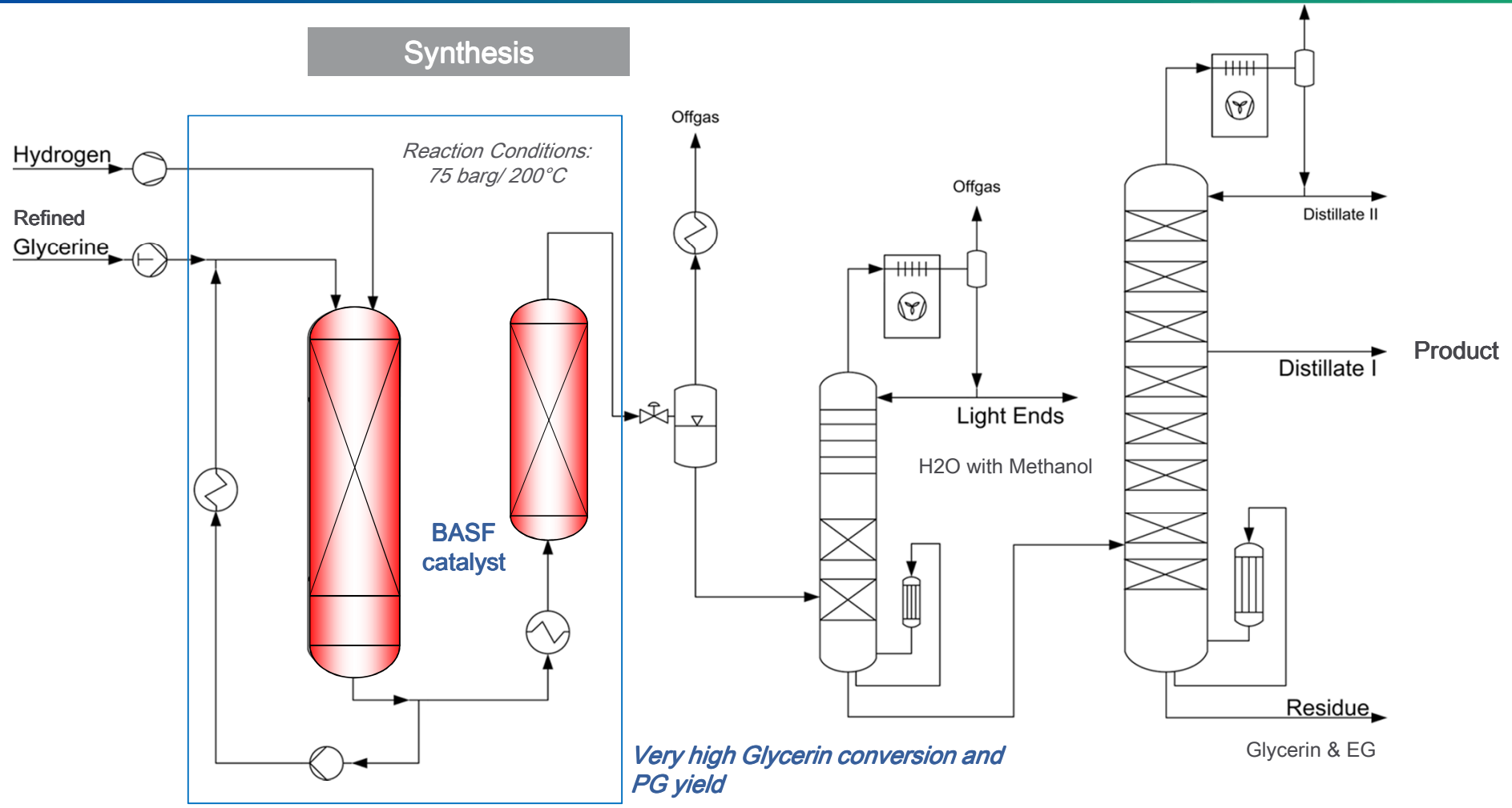In case of high exothermic heat it might be necessary to cool the reactor by recycling reacted product back to the reactor inlet, depending on the selected hydrotreating process to prevent unwanted side reactions or temperature runaway

Pro: Liquid has a higher density than H_2

**Con:** Most organic liquids at 200°C have a spec. heat capacity of 2 to 2.5 kJ/kgK, i.e. 6 to 7 times less than H_2

BioPG: Process Schematic

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Synthesis

Hydrogen

Refined Glycerine

Reaction Conditions: 75 barg/ 200°C

BASF catalyst

Offgas

Offgas

Light Ends

H2O with Methanol

Distillate II

Distillate I → Product

Residue

Glycerin & EG

Very high Glycerin conversion and PG yield

Proven Quality

➔ No oligomers (C4, C5, C6+)

➔ No di- or tripropylene glycols formed in reaction

➔ A high quality product:
  - Technical and Pharma Grade PG
  - Purity > 99.5 %, usually 99.8 %
  - Clear liquid, odorless, tasteless
  - Note: Kosher and halal certificates are depending on feedstock origin
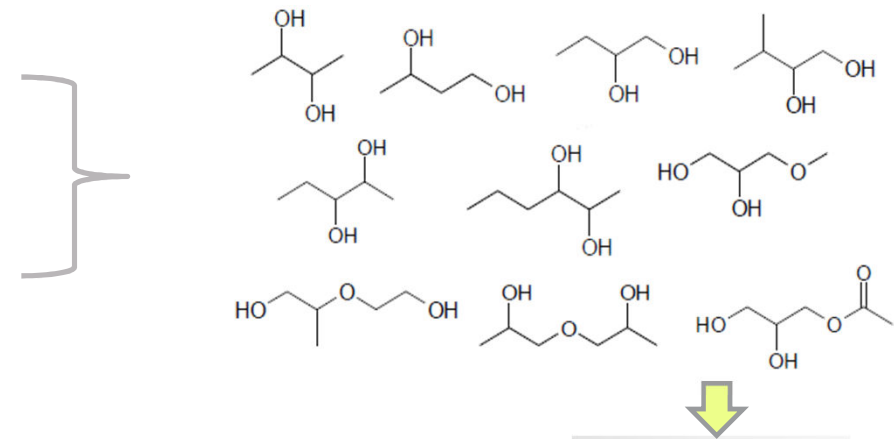
Quality identical to Petro-based PG, but with "green label"

Commercial Reference

Bio-based process is commercially proven and reliable

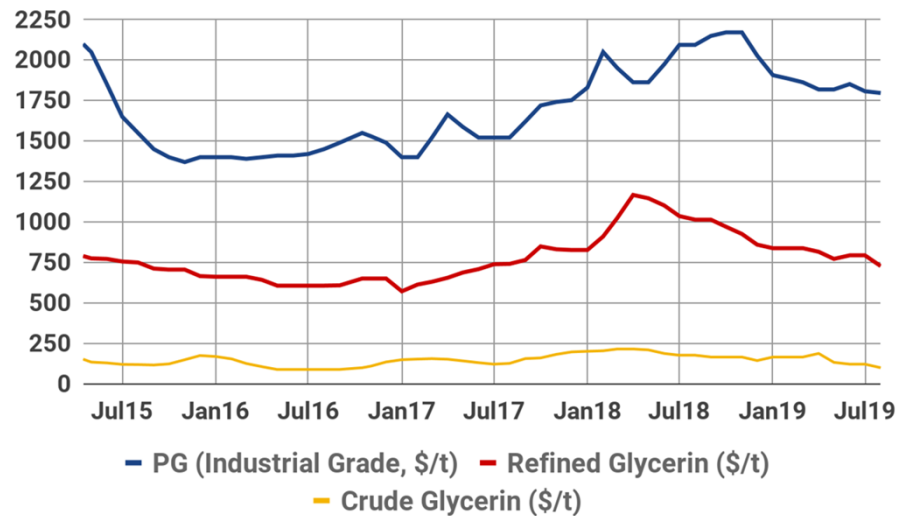| Refined Glycerin | Refined Glycerin | Bio Propylene Glycol |

Glycerin to Bio Propylene Glycol

- ➢ Operating 20,000 tons/year plant in Belgium since June 2012

- ➢ One plant with 30,000 tons/year under construction in Poland

- ➢ One plant with 40,000 tons/year under engineering phase in Europe

Competitive: Drop-in replacement

BioPG is attractive starting from Crude Glycerin

BioPG Production Cost · Downstream/ Purification
- Positive · Negative · Sum

Attractive Margin

Waterfall chart values: Ref. Glycerin 1019, Byproducts -34, Chemicals 140, Utilities 108, Direct Costs 56, Dep (15yrs) 125, ROCE (10%) 187, Factory 1601, Margin 196, Market Price 1797

Price Trends in the US (USD dollars per ton) — PG (Industrial Grade, $/t), Refined Glycerin ($/t), Crude Glycerin ($/t)
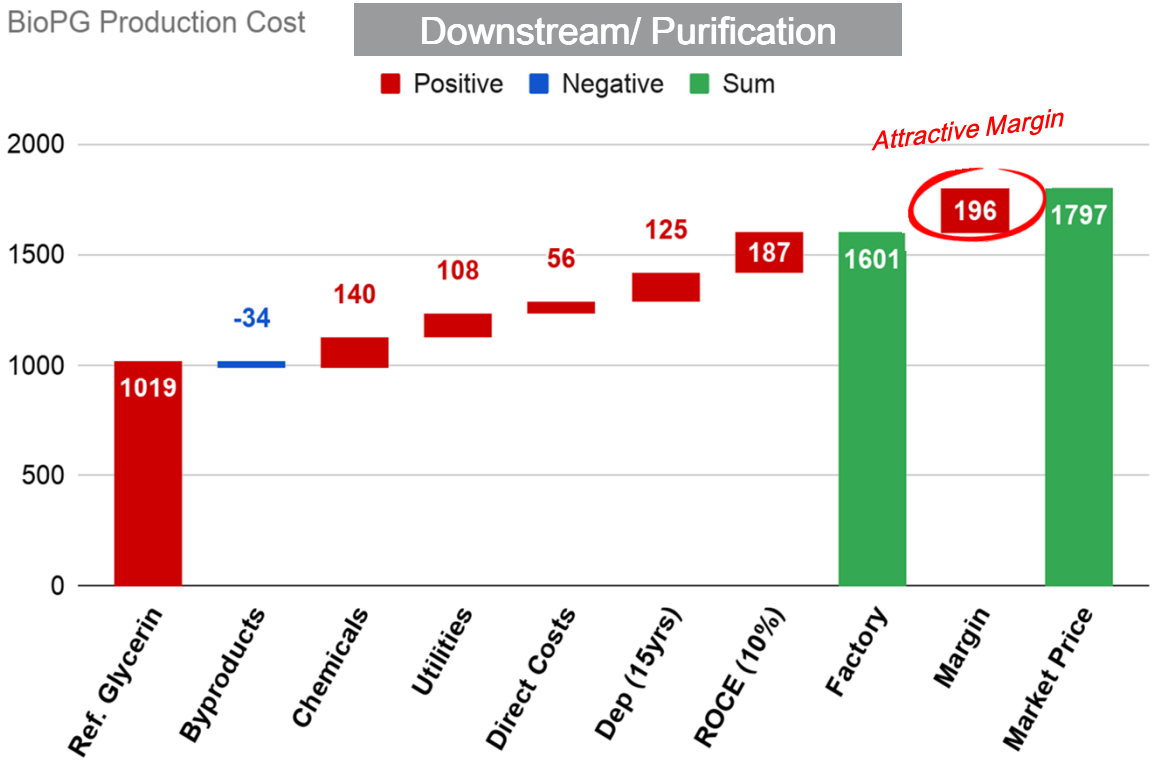
Industry 4.0 and IIoT

Internet of the Things (IoT) has already become reality, and we are continuously upgrading our homes to Smart Homes. Devices and g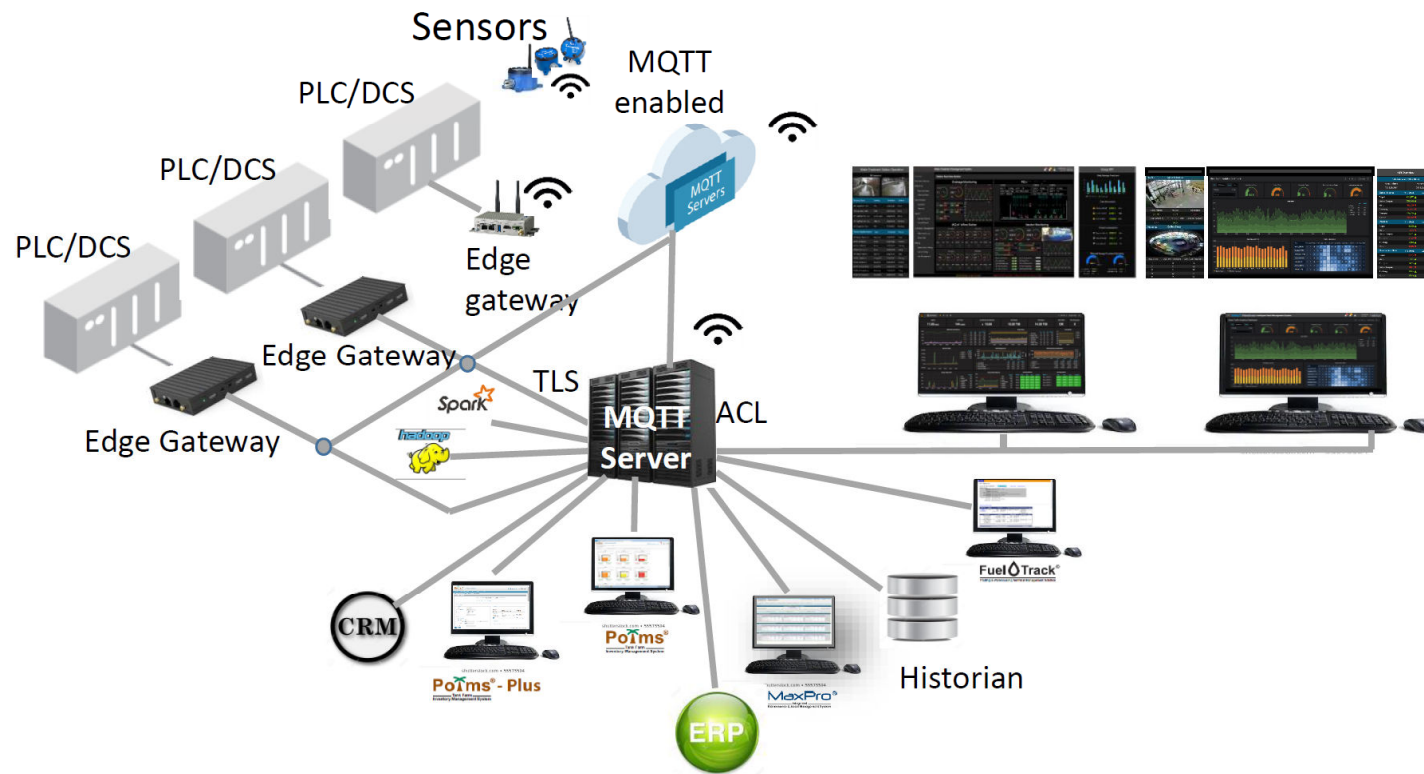adgets are becoming cheaper and more affordable, but the life period of smart gadgets is not suitable for industrial use

In the manufacturing sector the Industrial Internet of the Things (IIoT) is getting more and more common. In the chemical industry the reliability of the process and occupational safety plays the most important role, especially at high temperatures, in hazardous areas, or with explosive mixtures

Industry 4.0 and IIoT has high requirements towards reliability and must comply with highest industrial standards

Industrial Internet of the Things (IIoT)

1. **Edge Gateways** or **MQTT Enabled Devices**: Securely transmit and receive data from edge-of-network devices directly, via the **MQTT Transmission Module** or through an edge gateway

2. **An MQTT Server:** Enables MQTT clients for both operational and business applications to securely connect, publish, and subscribe to data from edge gateways

3. **The MQTT Engine Module:** Gives our platform the ability to bi-directionally communicate with an MQTT server

4. **The Platform:** The universal industrial application platform for HMI, SCADA and IIoT software applications

MQTT = MQ Telemetry Transport
MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol
It is also ideal for mobile applications because of its small size, low power usage, minimised data packets, and efficient distribution of information to one or many receivers
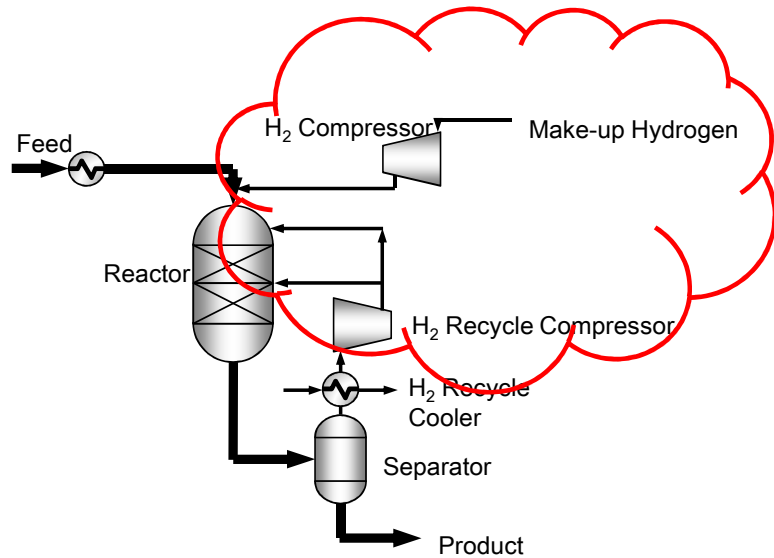
Remote infrastructure management (RIM)

Feed

H_2 Compressor — Make-up Hydrogen

Reactor

H_2 Recycle Compressor

H_2 Recycle Cooler

Separator

Product

The H_2 compressor of a hydrotreatment plant is one of the core equipment and one of the costliest equipment. The H_2 is a raw material for the conversion, and a heat transfer medium for reactor cooling.

A compressor failure not only can cause a loss of production: It can lead to irreversible catalyst damage, or even to temperature runaway
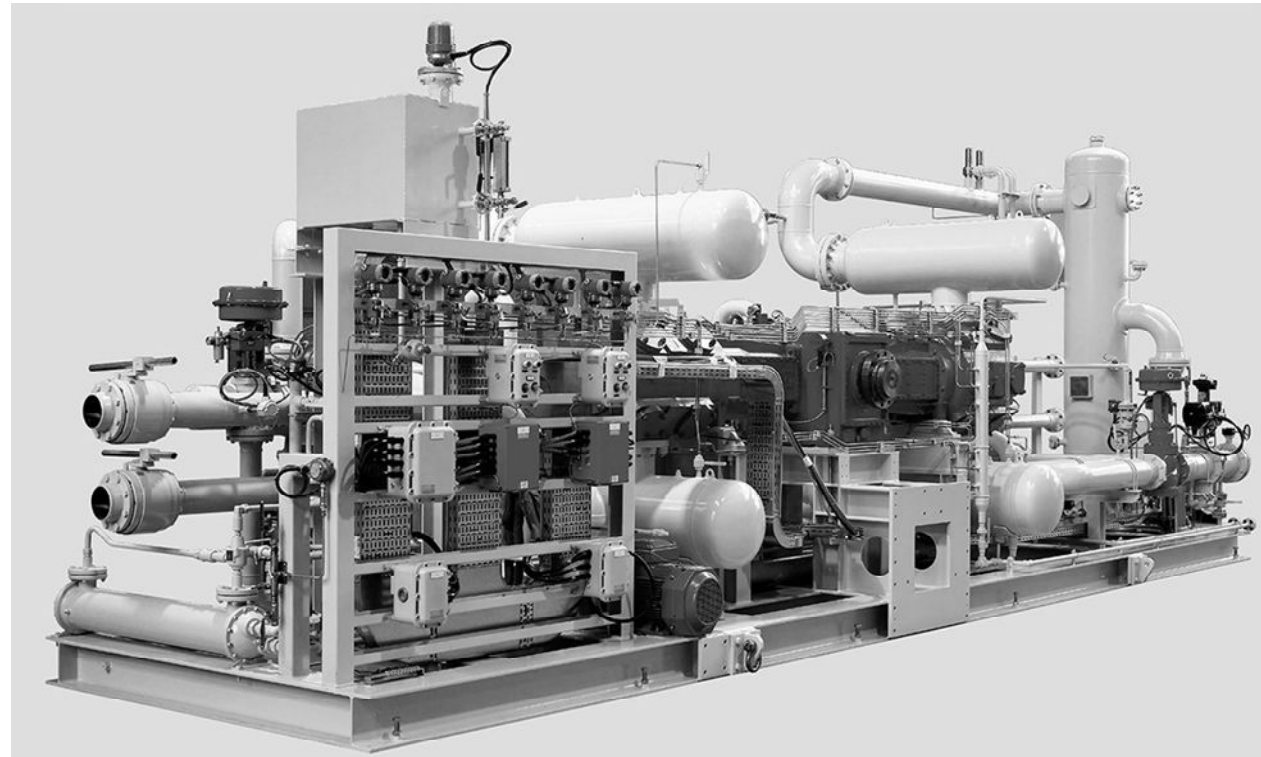
Continuously monitoring the health of the H_2 compressor allows for preventive maintenance, realistic production and capacity planning

Protect and monitor your remote infrastructures and lower the cost of maintenance for their entire lifecycle

# Industrial Internet of the Things (IIoT)

JJ-Lurgi

DNR has won the first Industry 4.0 / IIoT project from PT Smart (Sinarmas) for their 7 units of Margarine & Shortening Plant at Marunda, Indonesia

Some Highlights:

Continuous quality monitoring and recording

Energy data reporting

Ammonia (refrigerant) compressor unit monitoring

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POIms®
Tank Farm
Inventory Management System

POIms® - Plus
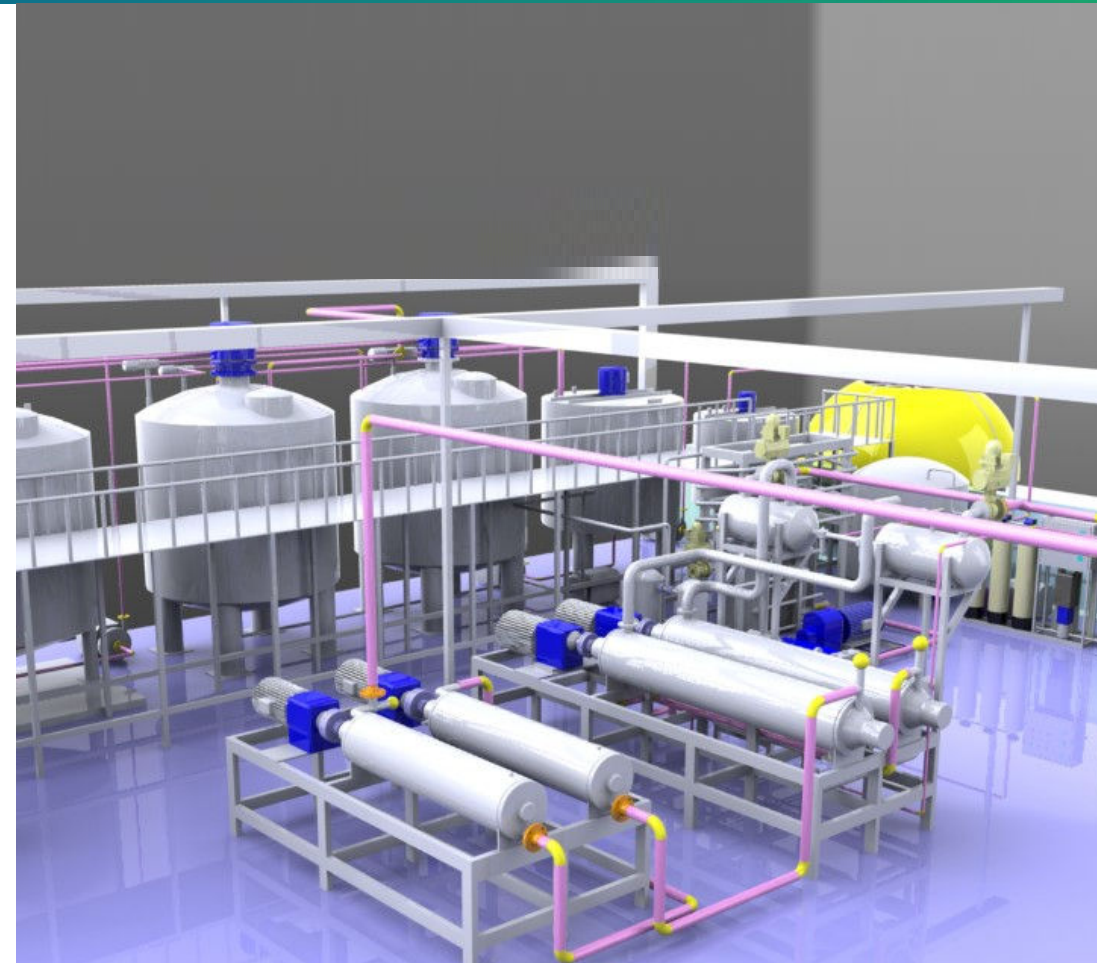
POIMS continuously measures and computes the inventory of the entire tankfarm with high accuracy by interfacing with tankfarm instruments in real time

Decision makers can access tankfarm inventory information conveniently and securely through the POIMS Web-Portal to gain timely accurate information on inventory that allows to make informed decisions

POIMS interfaces with tank gauging devices to collect the product quantity and temperature measurements of the tanks in real time for consistent and continuous tank gauging.
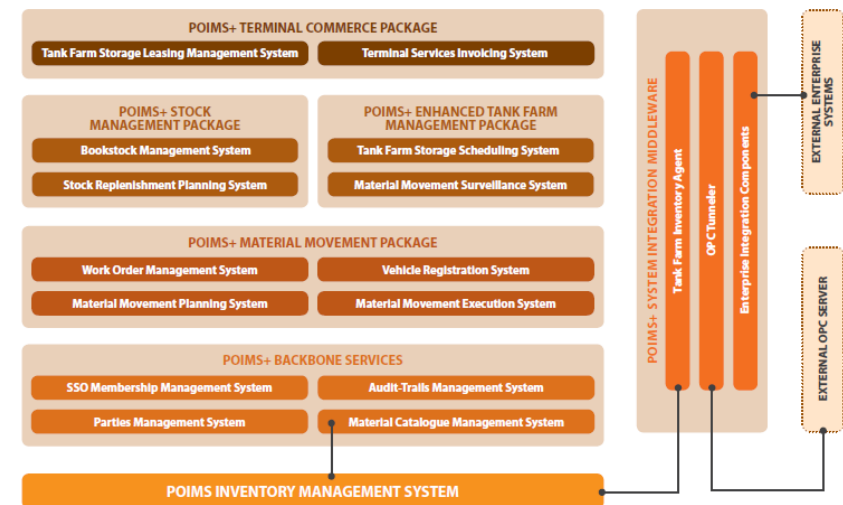
POIMS helps to overcome the limitations of manual tank dipping, which is both error-prone and lacks timeliness

Often the conventional inventory information has become scattered in multiple systems with some even being managed manually, and sometimes problems increase when the tankfarms are located in different geographical locations involving diverse workforce
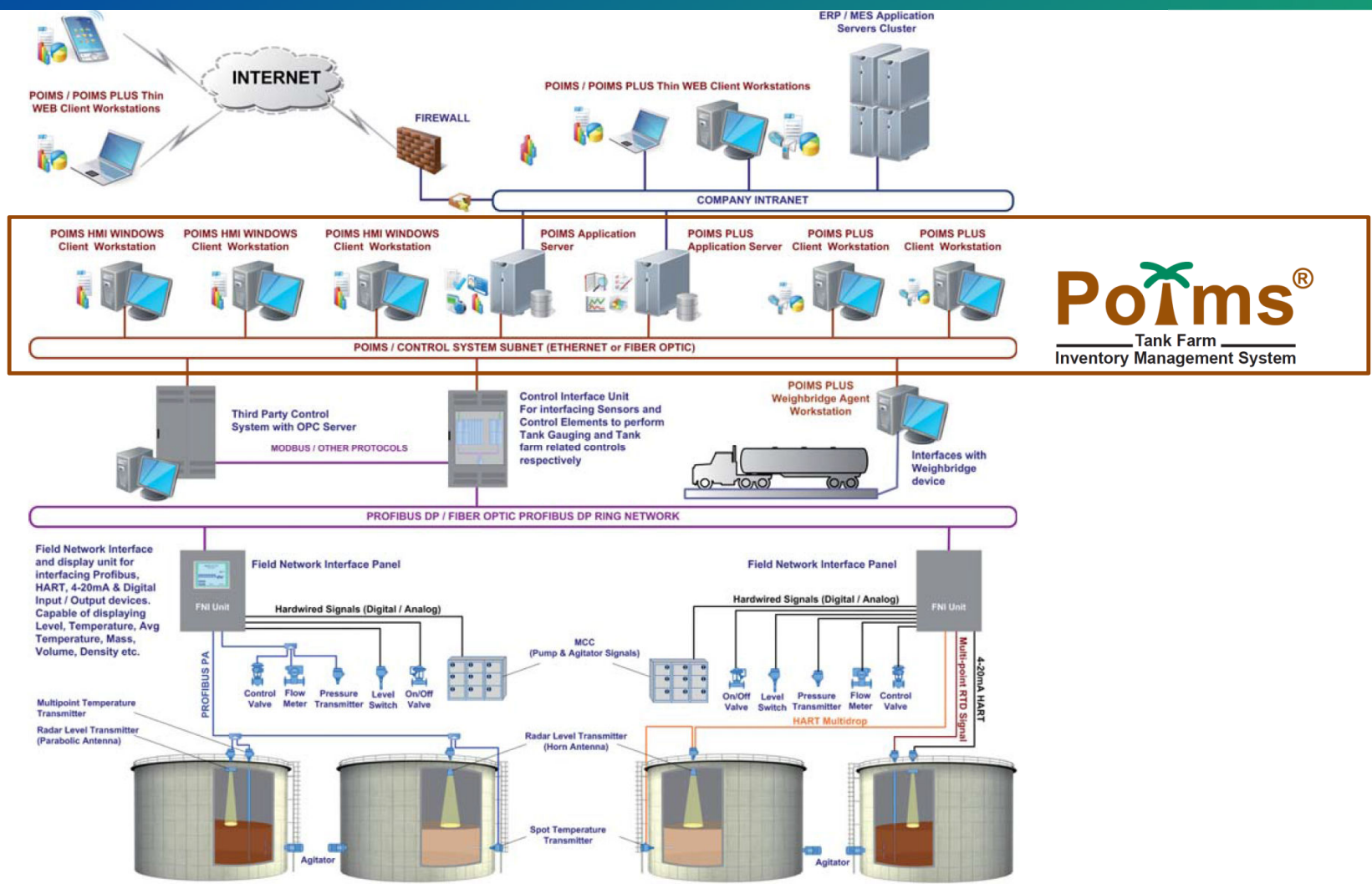
POIMS Plus utilizes all functionalities of POIMS Tank Farm Inventory Management System to provide advanced capabilities in order fulfillment tracking, material movements management, stock accounting and enhanced tankfarm management

POIMS Plus for oleochemicals can support in managing the trading of products and raw materials in order to buy and sell at the most profitable time

POIMS+ TERMINAL COMMERCE PACKAGE
Tank Farm Storage Leasing Management System | Terminal Services Invoicing System
POIMS+ STOCK MANAGEMENT PACKAGE | POIMS+ ENHANCED TANK FARM MANAGEMENT PACKAGE
Bookstock Management System | Tank Farm Storage Scheduling System
Stock Replenishment Planning System | Material Movement Surveillance System
POIMS+ MATERIAL MOVEMENT PACKAGE
Work Order Management System | Vehicle Registration System
Material Movement Planning System | Material Movement Execution System
POIMS+ BACKBONE SERVICES
SSO Membership Management System | Audit-Trails Management System
Parties Management System | Material Catalogue Management System
POIMS INVENTORY MANAGEMENT SYSTEM
POIMS+ SYSTEM INTEGRATION MIDDLEWARE | Tank Farm Inventory Agent | OPC Tunneler | Enterprise Integration Components
EXTERNAL ENTERPRISE SYSTEMS | EXTERNAL OPC SERVER

Palm Oil Inventory Management System

JJ-Lurgi

Who we are:
JJ-Lurgi a joint venture between Air Liquide Engineering & Construction (formerly *LURGI*) and Jebsen & Jessen Southeast Asia, Singapore.

Lurgi's expertise in oils & fats technologies dates back more than 100 Years

Air Liquide strengthened its position in IIoT and Industry 4.0 with their 100% owned DNR PROCESS SOLUTIONS PTE LTD, Singapore

JJ-Lurgi - A joint venture between Air Liquide Global E&C Solutions GmbH Germany and Jebsen & Jessen SEA

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Discover more at :

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JJ-Lurgi

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