

"CO₂ separation and Helium purification with SEPURAN® membrane by Evonik Industries"

2018. 2.13 第7回革新的CO₂膜分離技術シンポジウム
「エボニック製SEPURAN® 分離膜によるCO₂分離およびヘリウム精製、水素分離」

ダイセル・エボニック(株) スペシャルティ製品営業部 須川

Evonik Fibres GmbH
Application Technology SEPURAN®
Olivier Zehnacker

Outline



About Evonik and Fibres and Membranes

SEPURAN[®] Gas separation technology

SEPURAN[®] *Green* for biogas upgrading

SEPURAN[®] *Green* References

SEPURAN[®] Noble in He application

SEPURAN[®] Noble in H₂ application

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About Evonik



Our positioning

Evonik is the creative industrial group from Germany and one of the world's leading specialty chemicals companies.

What we do

Living better with Evonik

more fuel saving



CAR TIRES

fluffier



TOWELS

more elastic



MATTRESSES

healthier



NUTRITION

more effective



TABLETS

Countless products gain their special attributes through our creative power.

Who we are

Evonik at a glance

~13

Billion Euro sales in 2016

80%

Of turnover gained from
leading market positions

172

Sites

>36,000

Employees in over 100 countries

2.165 billion Euro

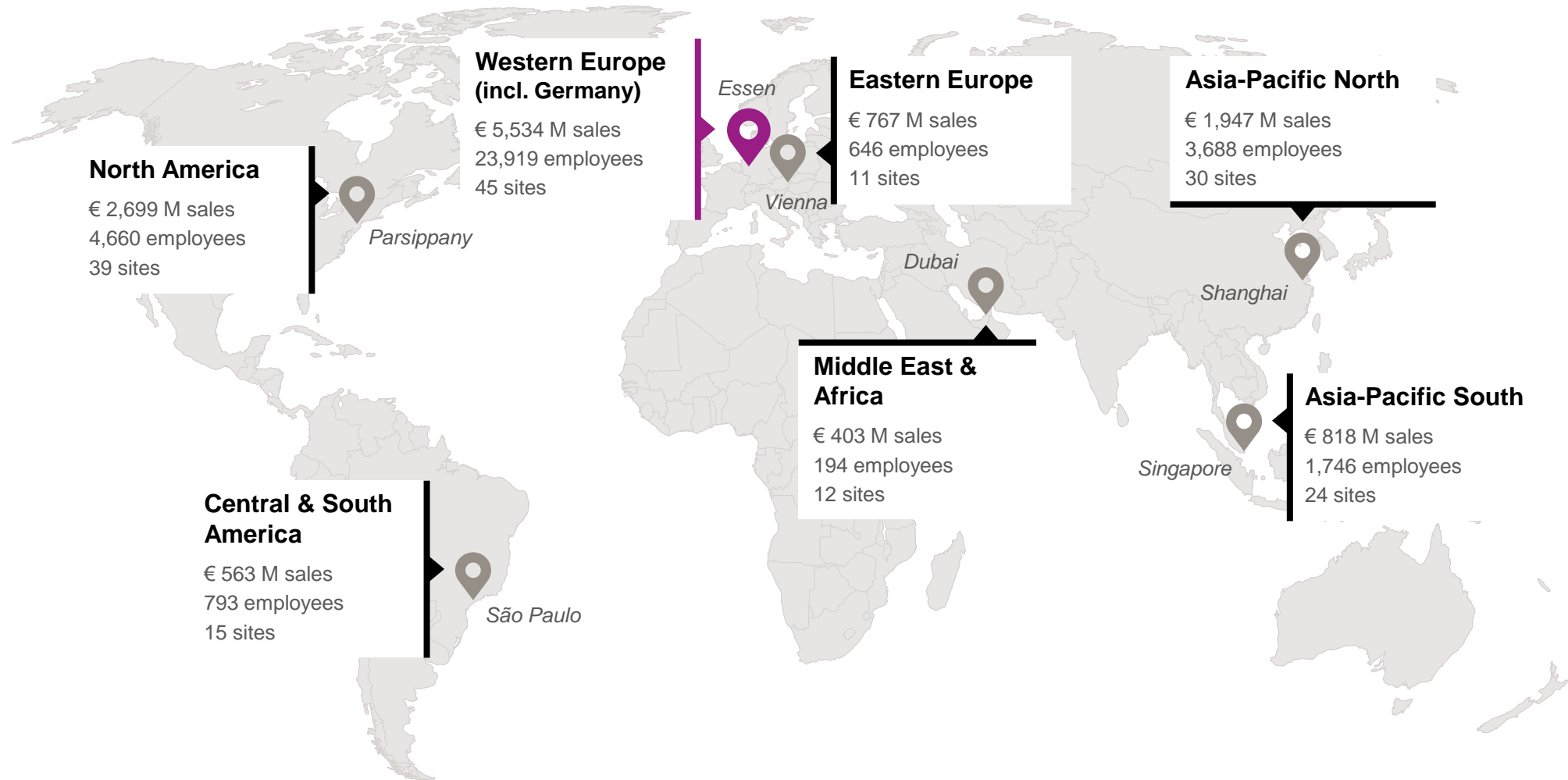
EBITDA 2016

~500

R&D projects

Where we can be found

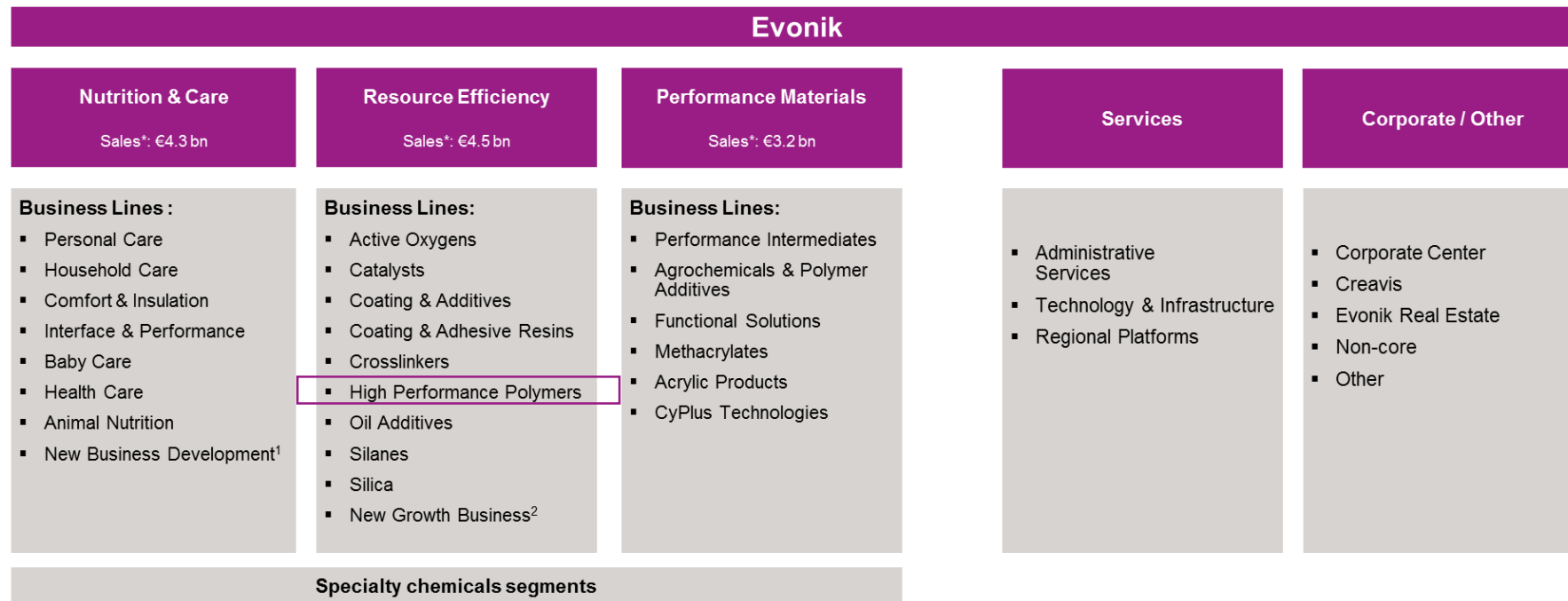
Evonik operates worldwide



Sales in 2016

An attractive company | a modern structure

- Evonik is one of the world's leading specialty chemicals companies.
- The central elements of our strategy for sustained value creation are profitable growth, efficiency, and values.
- Around 80 percent of Evonik's sales come from market-leading positions, which we are systematically expanding.
- We concentrate on high-growth megatrends, especially health, nutrition, resource efficiency, and globalization.

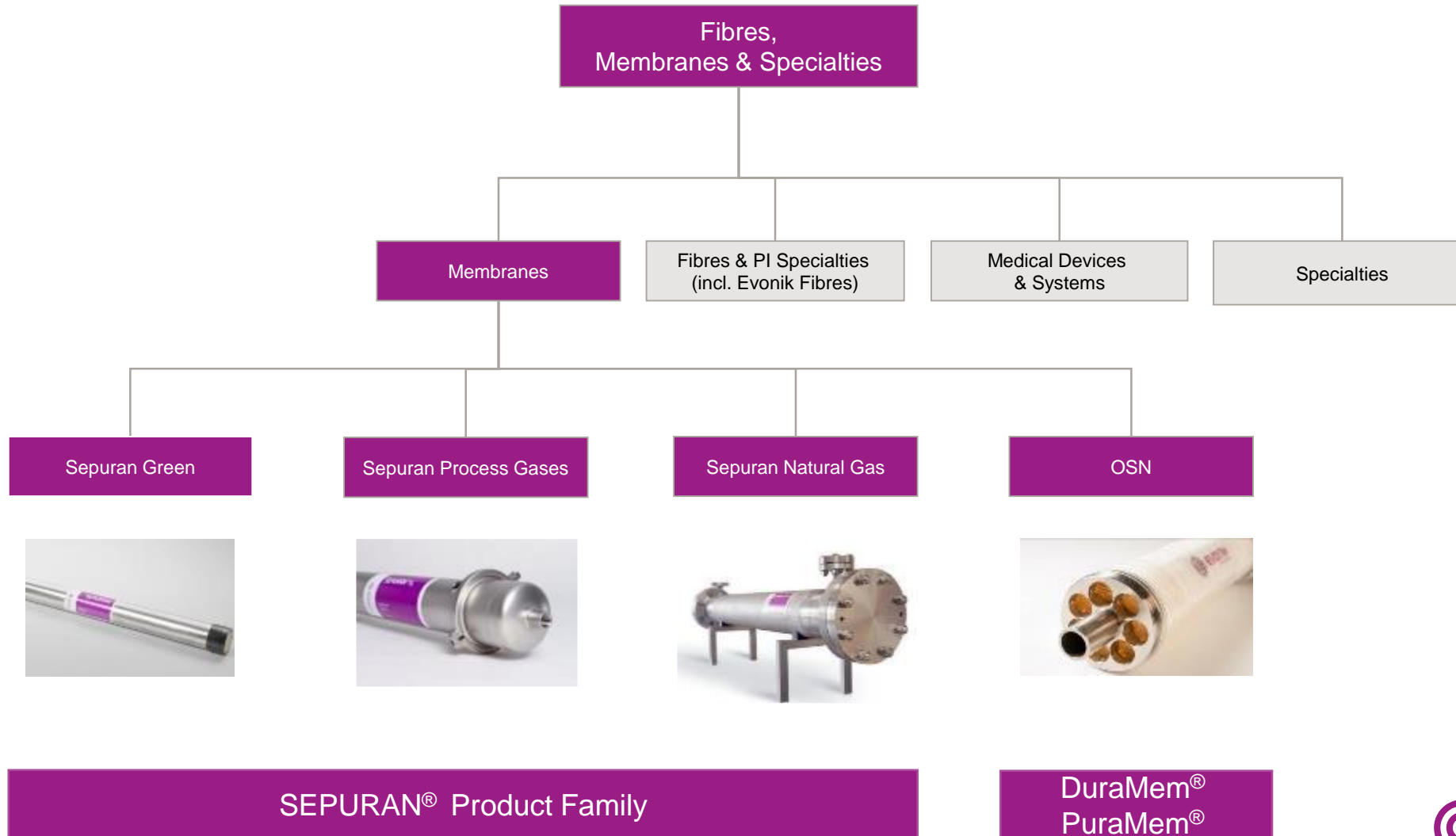


* Fiscal 2016

¹ Personal Care - PMD, Household Care - PMD, Comfort & Insulation - PMD

² Coating Additives - PMD, Crosslinkers - PMD

Breakdown of Product Line Fibres, Membranes & Specialties



Evonik Fibres GmbH, Austria



Efficient Gas Cleaning with Sepuran® Technology



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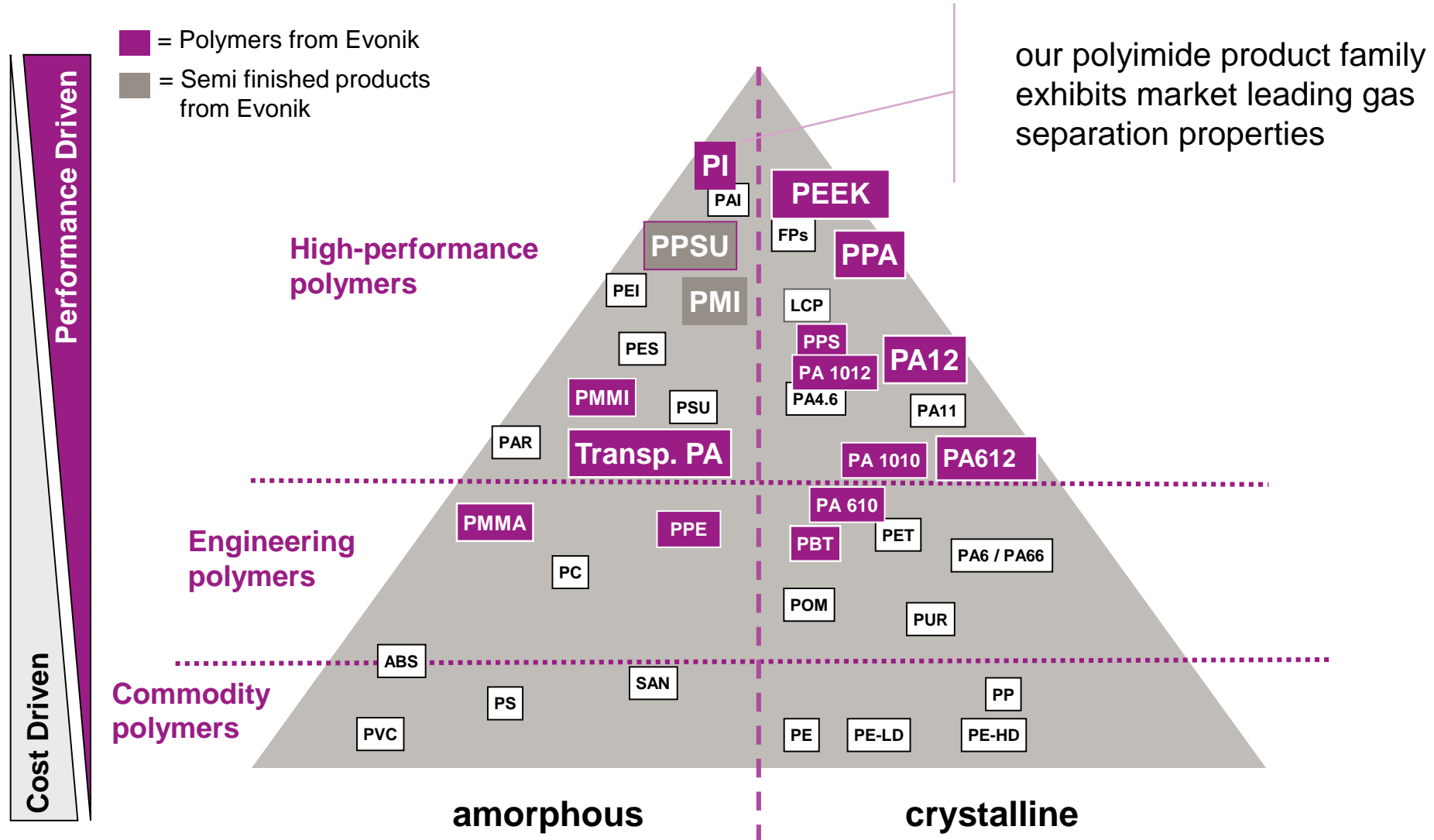
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We achieve high performances with our polymers

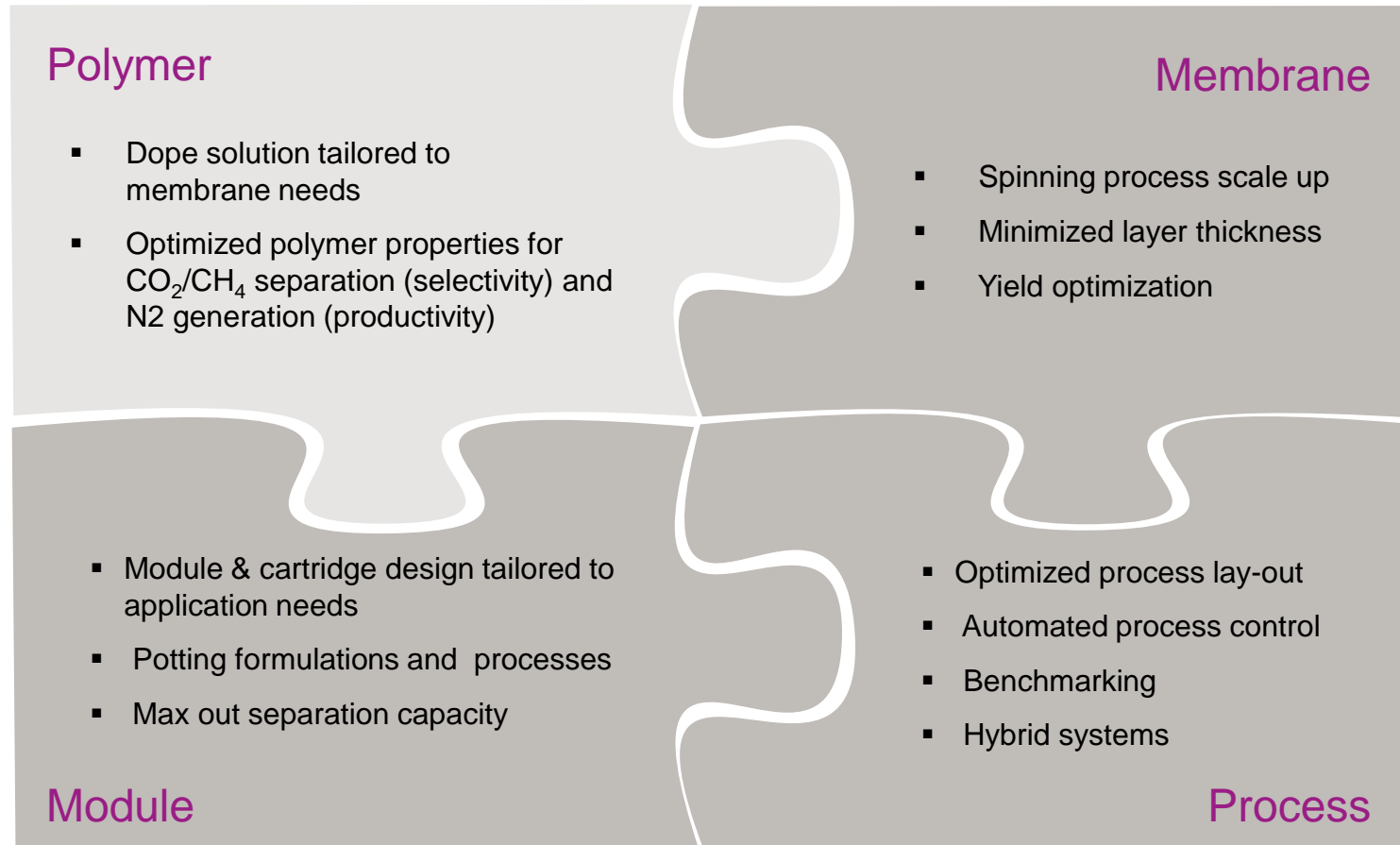


EVONIK IMPACT ON FULL VALUE CHAIN LEADS TO SUPERIOR MEMBRANE PRODUCTS

Value chain of Evonik membrane business



Excellent materials alone do not make a good membrane...



... but it all starts with the right material

Global presence with strong focus on regional Application Technology

- Business MGMT and/or AT
- Production and AT
- NBD in progress

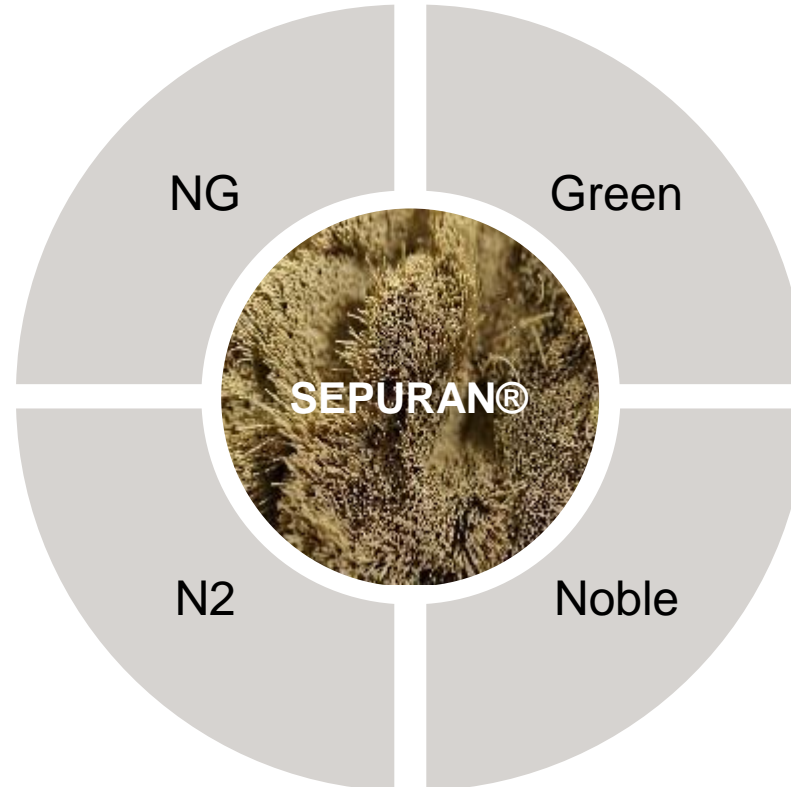


SEPURAN® Product families

- Market leading selectivity
- Long term stability
- Industry standard productivity



- On site nitrogen generation
- Purities from 95-99.5%
- Superior air-factor
- High productive modules



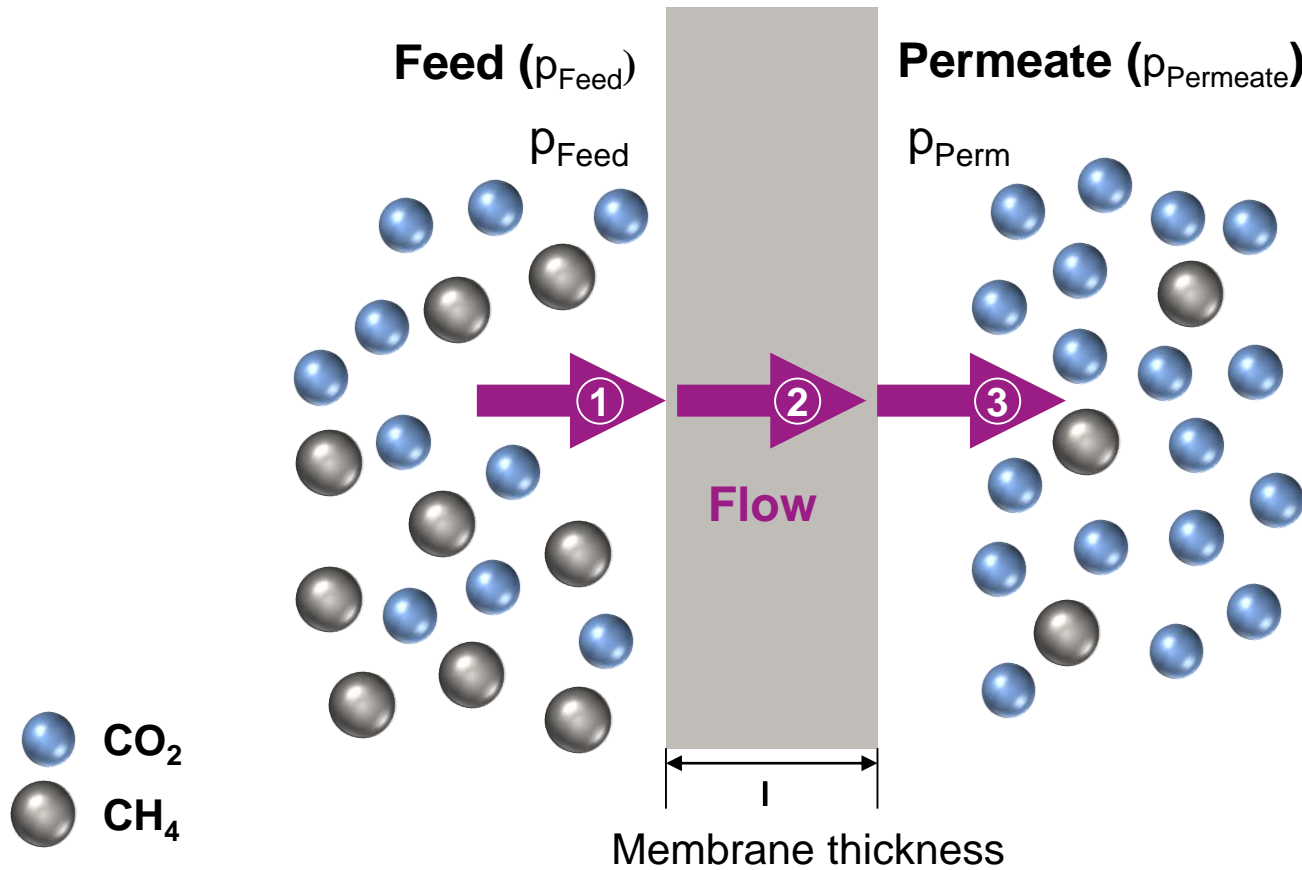
- Market leader in Biogas upgrading units



- He recovery from Source gas or Diluted streams
- H2 recovery
- H2/CO ratio adjustment
- CO concentration



MEMBRANES ARE OFTEN CHARACTERIZED BY THEIR SELECTIVITY AND PERMEABILITY



Transport mechanism

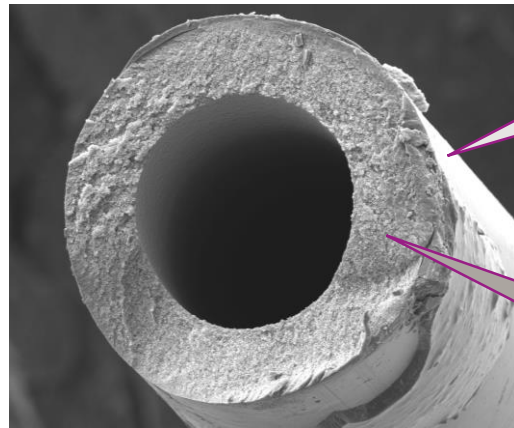
$$p_{\text{Feed}} > p_{\text{Perm}}$$

- 1 Sorption feed side
- 2 Diffusion through membrane
- 3 Desorption permeate side

Separation mechanism

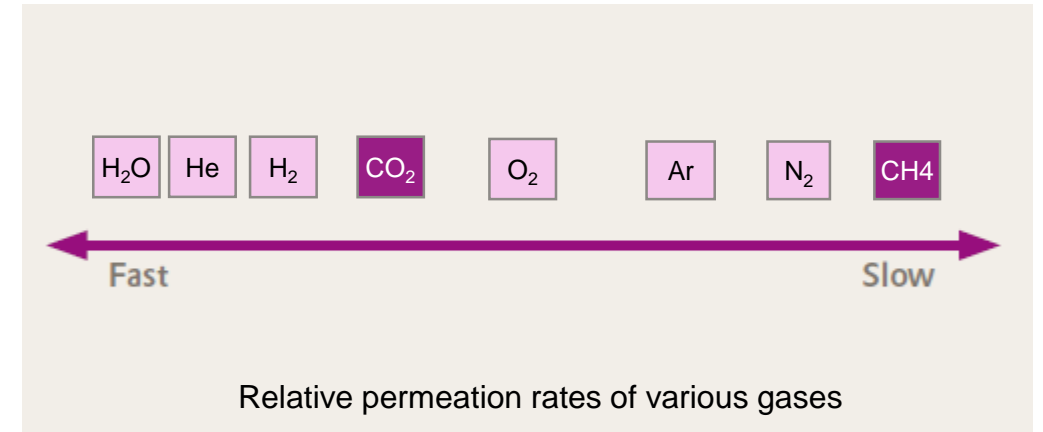
Differences in flow across the membrane lead to enrichment of the quicker component in the permeate.

ILLUSTRATION OF A GAS SEPARATION PROCESS IN A HOLLOW FIBRE MEMBRANE



Selective layer on the outside

Porous substructure for mechanical support



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SEPURAN® Gas separation technology

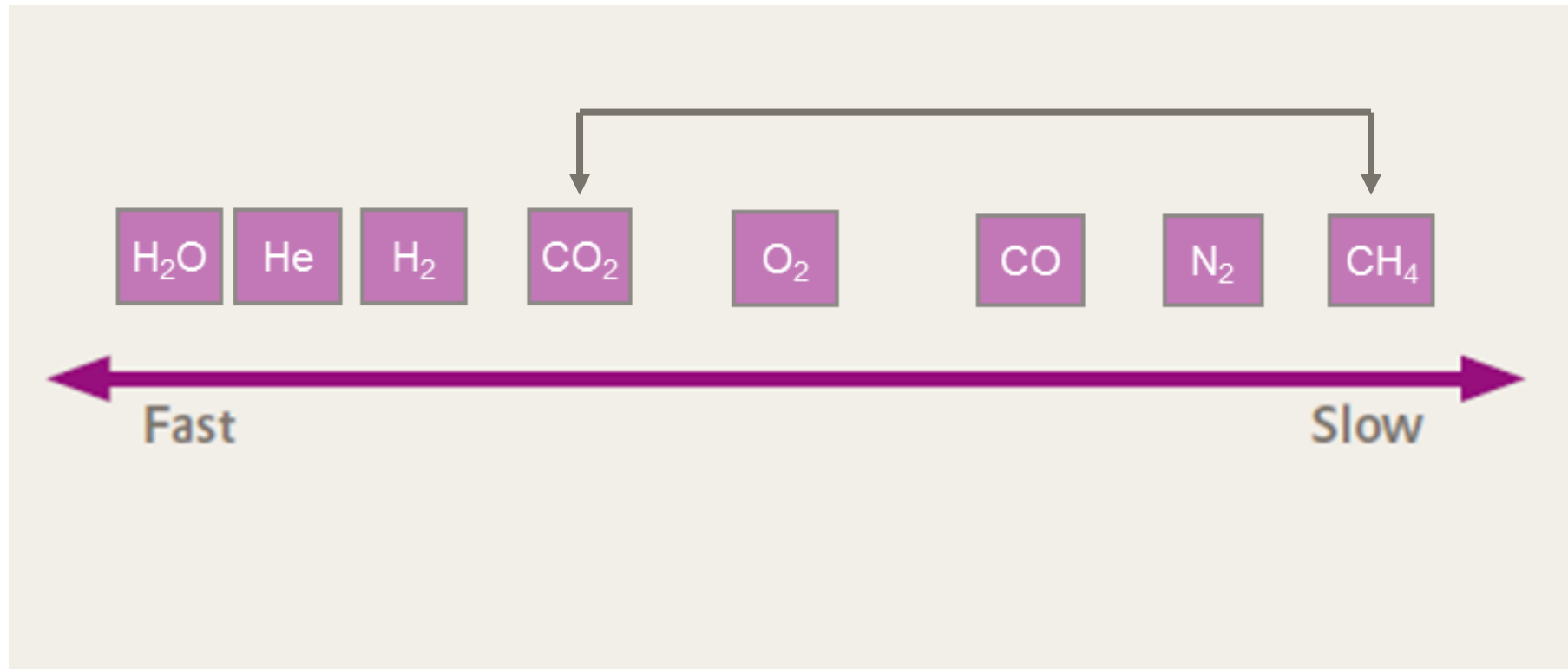
SEPURAN® *Green* for biogas upgrading

SEPURAN® *Green* References

SEPURAN® Noble in He application

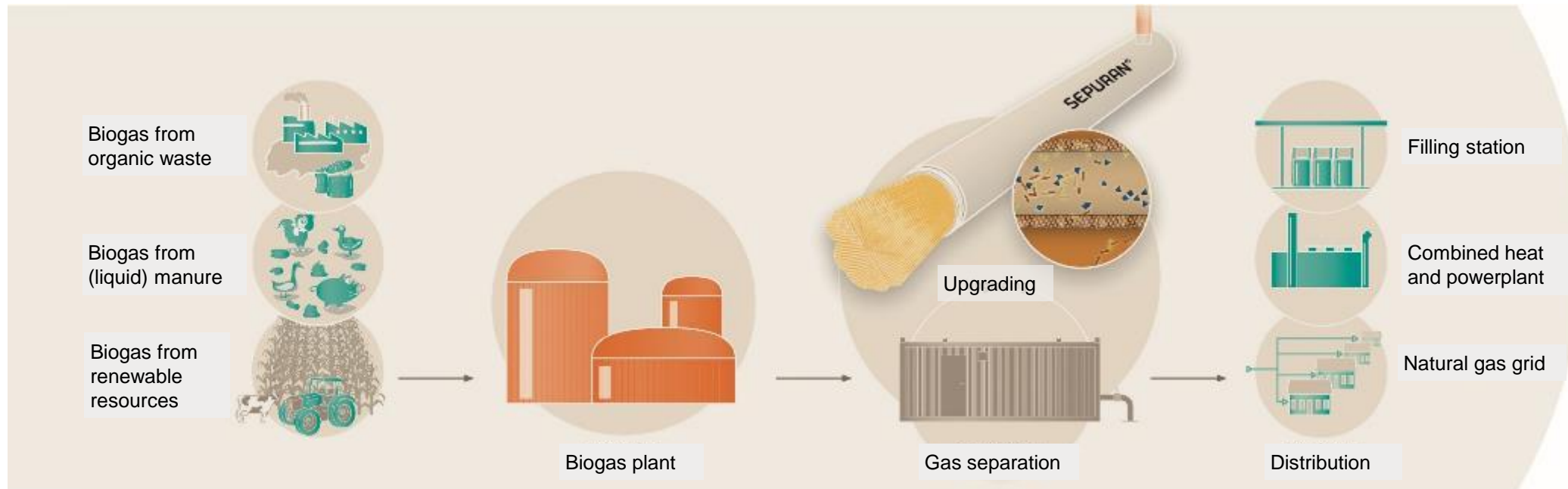
SEPURAN® Noble in H₂ application

CO₂ Separation from Biogas with Sepuran® Green

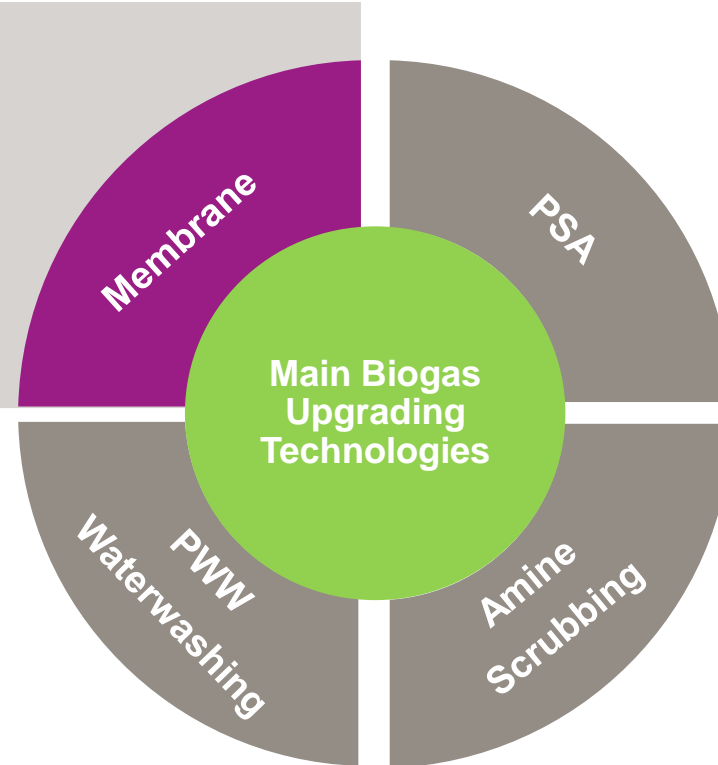


SEPURAN® Green for upgrading biogas

Evonik's contribution to an efficient biomethane purification process

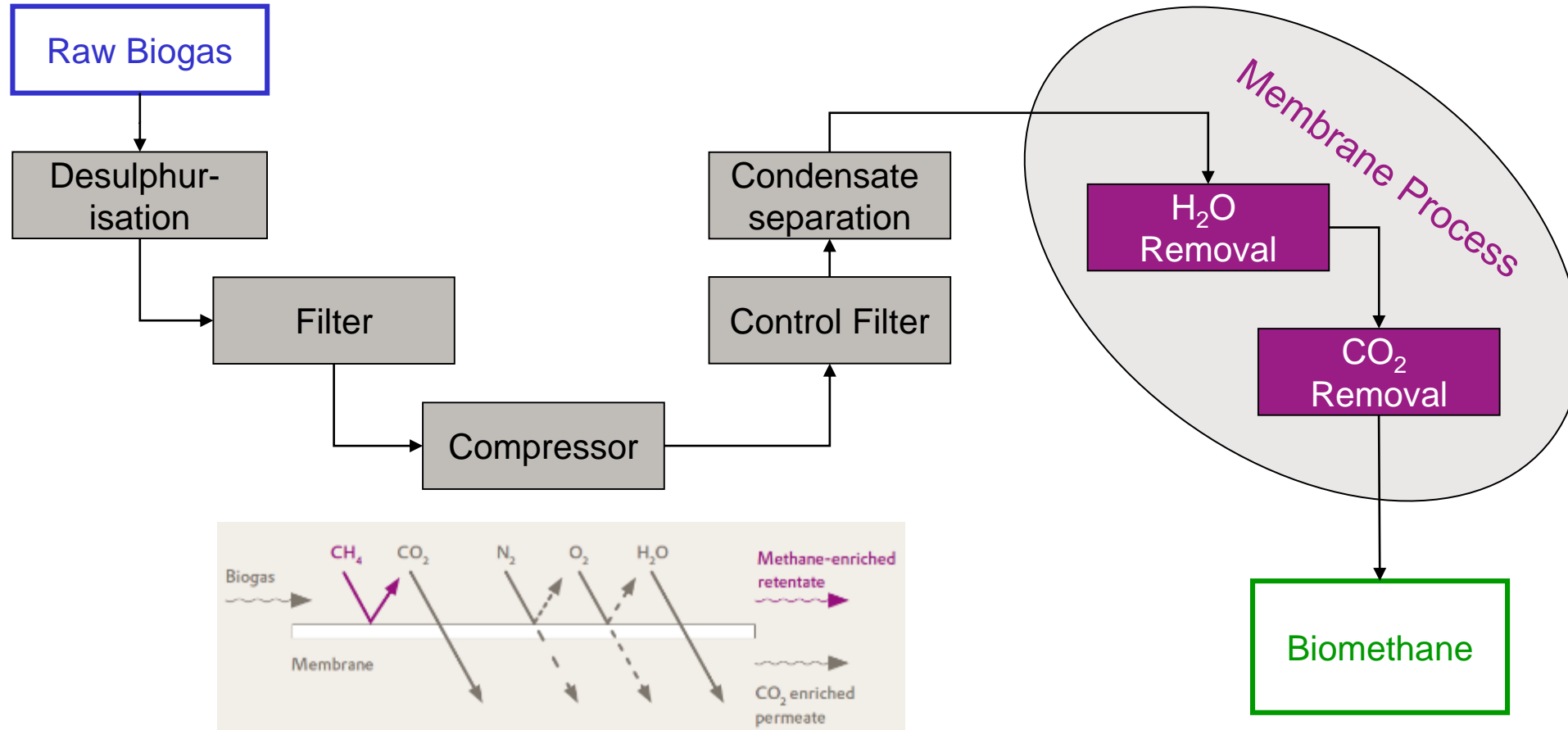


Traditional technologies dominate the biomethane market in EU today

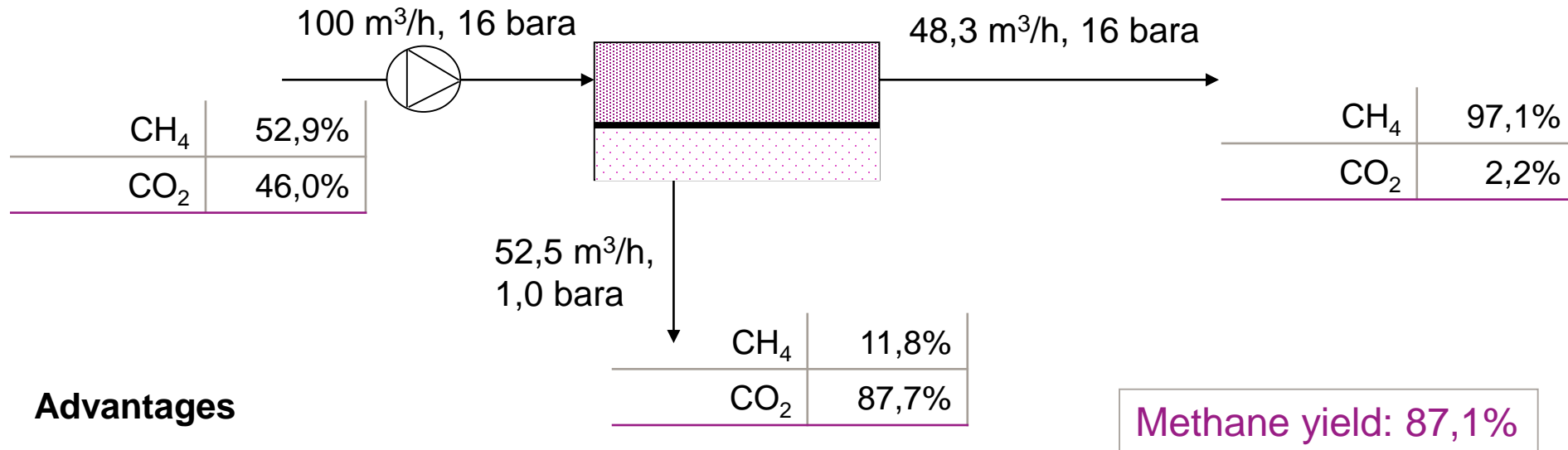


The membrane removes CO₂ and dries the biogas at the same time

Process steps of biogas upgrading with SEPURAN® Green Membranes



Single stage process with SEPURAN® Green



Advantages

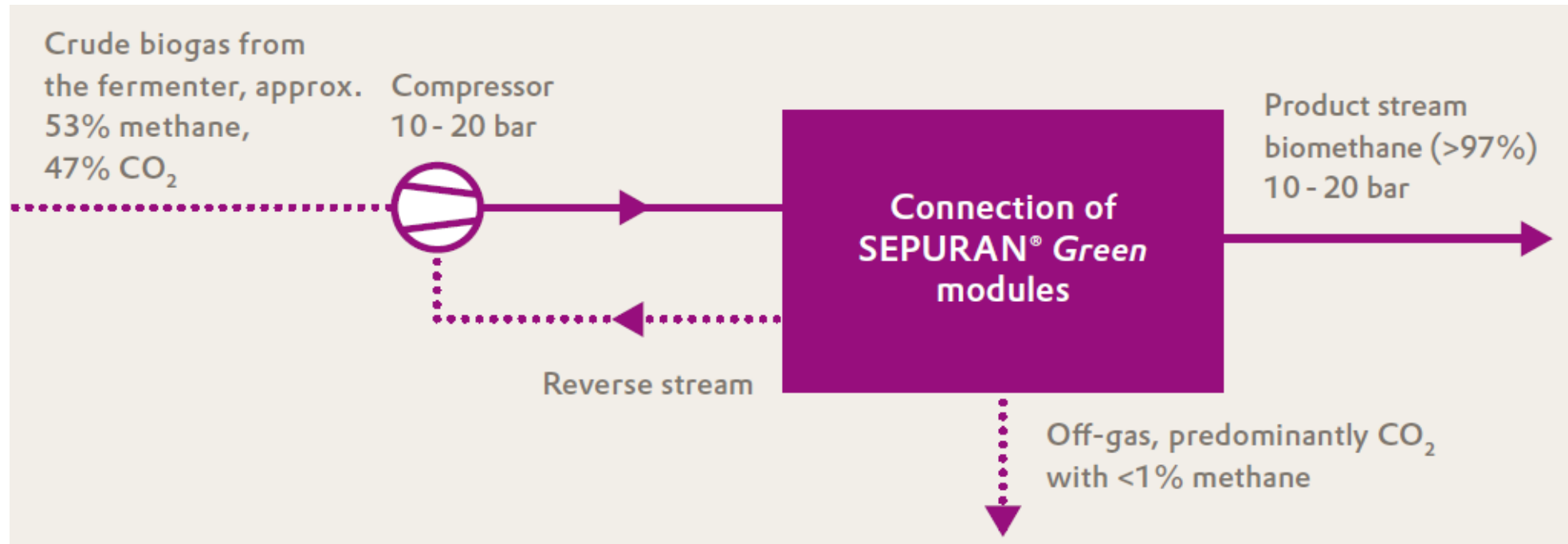
- Few membrane modules required
- Especially useful for fuel gas stations

Disadvantages

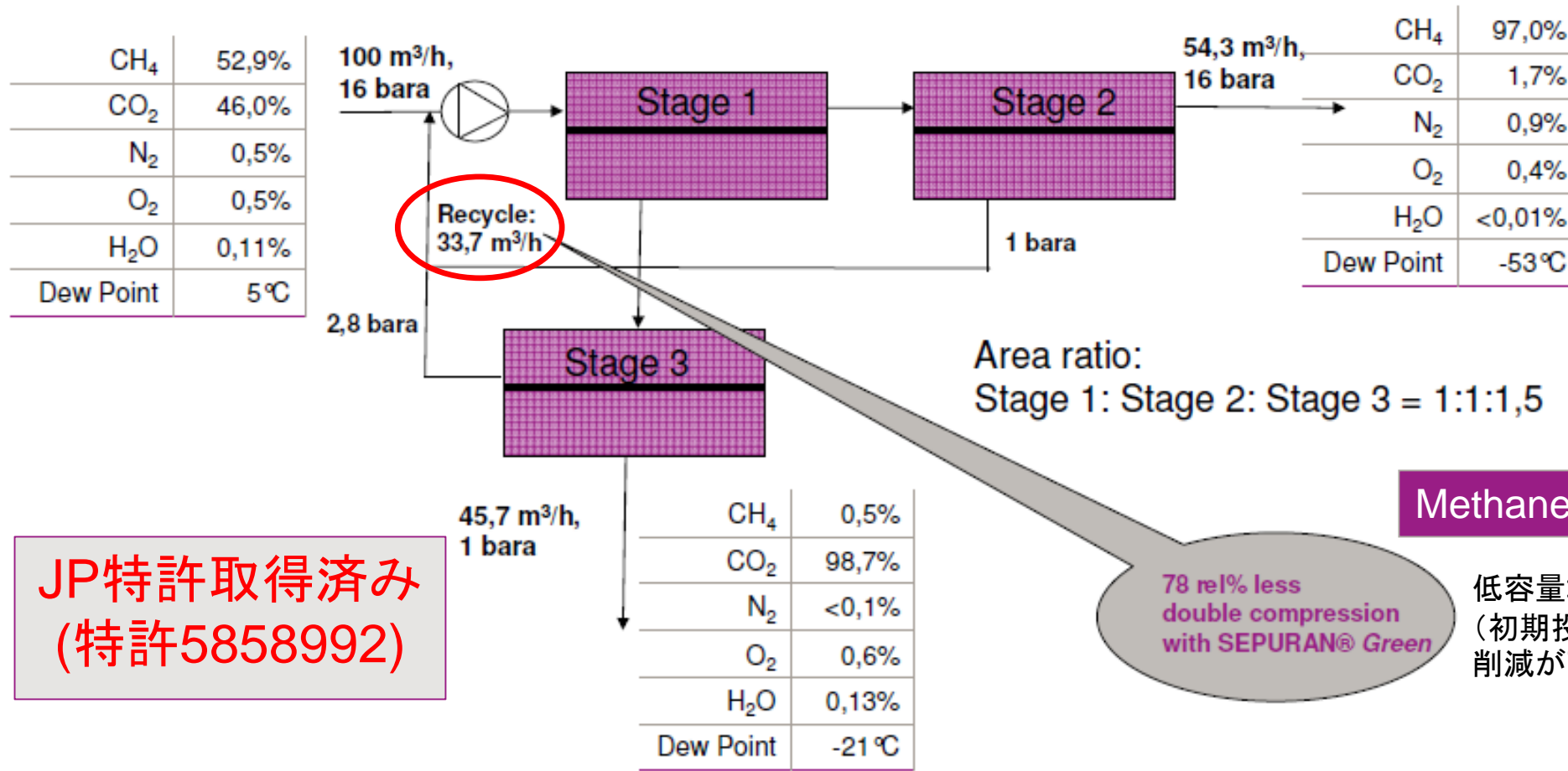
- Low methane yield
-

Three step biogas upgrading process patent with SEPURAN® Green is a game changer!

For the first time membrane technology could offer complete separation!



Evonik Process with SEPURAN® Green



Methane yield: 99.6%

**JP特許取得済み
(特許5858992)**

**78 rel% less
double compression
with SEPURAN® Green**

低容量コンプレッサ1個で対応可能
(初期投資&ランニングコストの大幅削減が可能)

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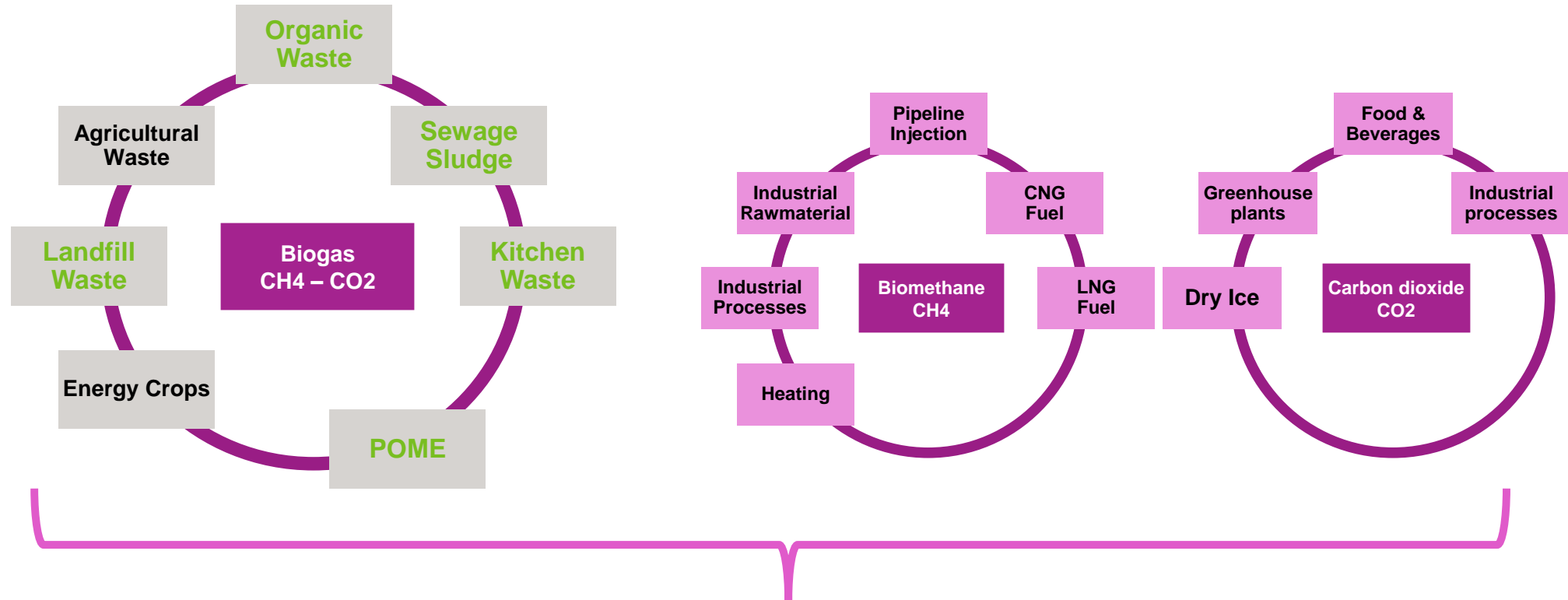
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SEPURAN® *Green* References

SEPURAN® Noble in He application

SEPURAN® Noble in H₂ application

Substrates are changing from crops to waste streams.



- Government Support**
- Legal Framework & Standards
 - Tax benefits & incentives
 - Environmental restrictions

- Industrial & private motivation**
- Sustainability & GHG saving mind-set
 - Promote „greener“ produced products as such
 - Giving up convenience

2017: > 140 Global references of upgrading plants supplied with SEPURAN® Green



Sepuran® Green membrane can be used in small-, mid- and large scale installations.

Country	Quantity	Size [Nm³/h]			
		1-199	200-499	500-999	> 1000
Austria	3	●●	●		
China	2		●		●
Denmark	2			●	●
France	11	●●●	●●●●●●	●	
Germany	13	●	●●●	●●●●●●●●	●
Italy	1				●
Japan	1	●			
Korea	2	●			●
Netherlands	6	●●●●●		●	
Norway	1		●		
Sweden	2		●	●	
Switzerland	8	●●●●●●	●●		
Thailand	2	●●			
United Kingdom	23		●	●●●●●●●	●●●●●●●●

* not all installations are displayed here yet

And 60+ more plants already...

EnviTec-Biogas GmbH, Saerbeck DE – “Minhe-Project” in China

Penglai, Shandong Province, China



EnviThan Container, Gasholder



Client: Shandong Minhe Biological
Sci-tech Co. Ltd.
Biogas: Chicken Manure
Upgrading: 2 x 1,000 Nm³/h Biomethane
Methane: 97,0 Vol% CH₄

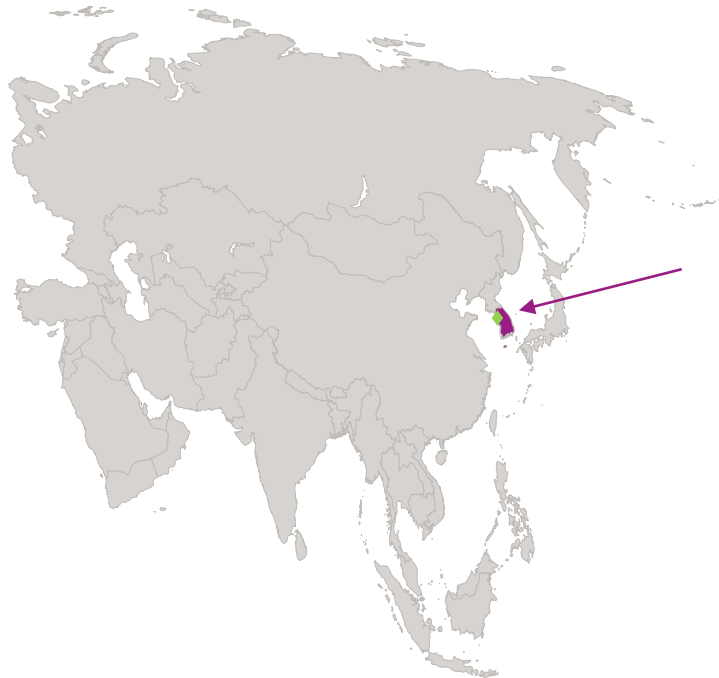
Operator and membrane container



Operating Pressure: 16,0 bar
Process: 3-stage membrane
Downstream: CNG – bottle trailer
filling plant -
distribution at public
CNG stations

Yesco ES, Seoul City SK – City Gas Project in South Korea

Seoul City, Seoul, South Korea



Yesco's upgrading "Mefin"



Client: Yesco, ES, City Gas Seoul
Biogas: Sewage sludge from WWTP
Upgrading: 1,500 Nm³/h Biogas
Methane: 97,5 Vol% CH₄

SEPURAN® Green piped in a rack



Operating Pressure: 9,8 bar
Process: 3-stage membrane
Downstream: Gas grid injection to supply private households & industry

Tecno Project Industriale, Curno IT – “Montello-Project” in Italy

Montello, Region Bergamo, Italy



Montello Waste Treatment Plant



Client: Montello
Biogas: Municipal Waste
Upgrading: 5 x 1,250 Nm³/h Biogas
Methane: 97,0 Vol% CH₄

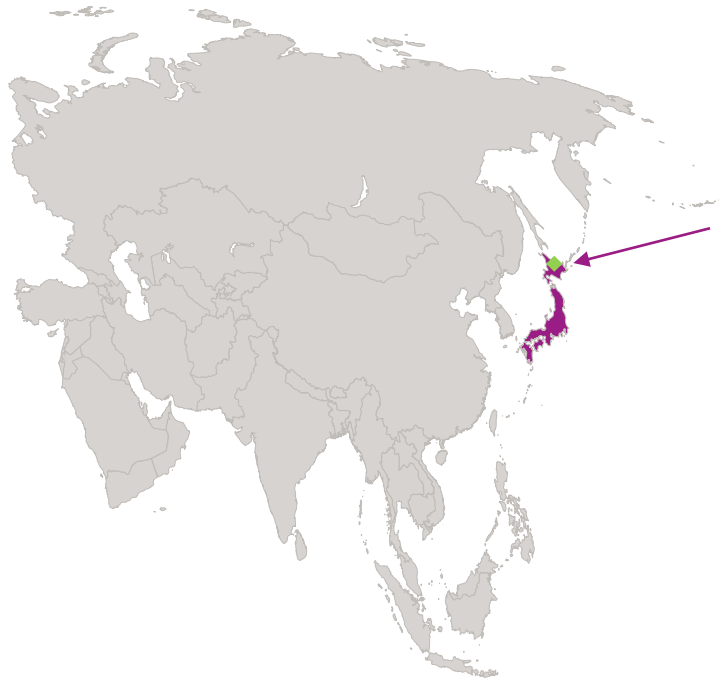
Disgester – 5 new ones installed



Operating Pressure: 16,0 bar
Process: 3-stage membrane
Downstream: CNG & gas grid injection CO₂-liquefaction sold to respective industry

Hipotech, Hokkaido Japan – 1st reference in Japan

Hokkaido, Japan



Upgrading unit and storage



Client: Hipotech/Tomoe
Biogas: Food Waste
Upgrading: 10 Nm³/h Biogas
Methane: 99,0 Vol% CH₄

3-stage membrane unit



Operating Pressure: 10,0 bar
Process: 3-stage membrane
Downstream: CNG - distribution

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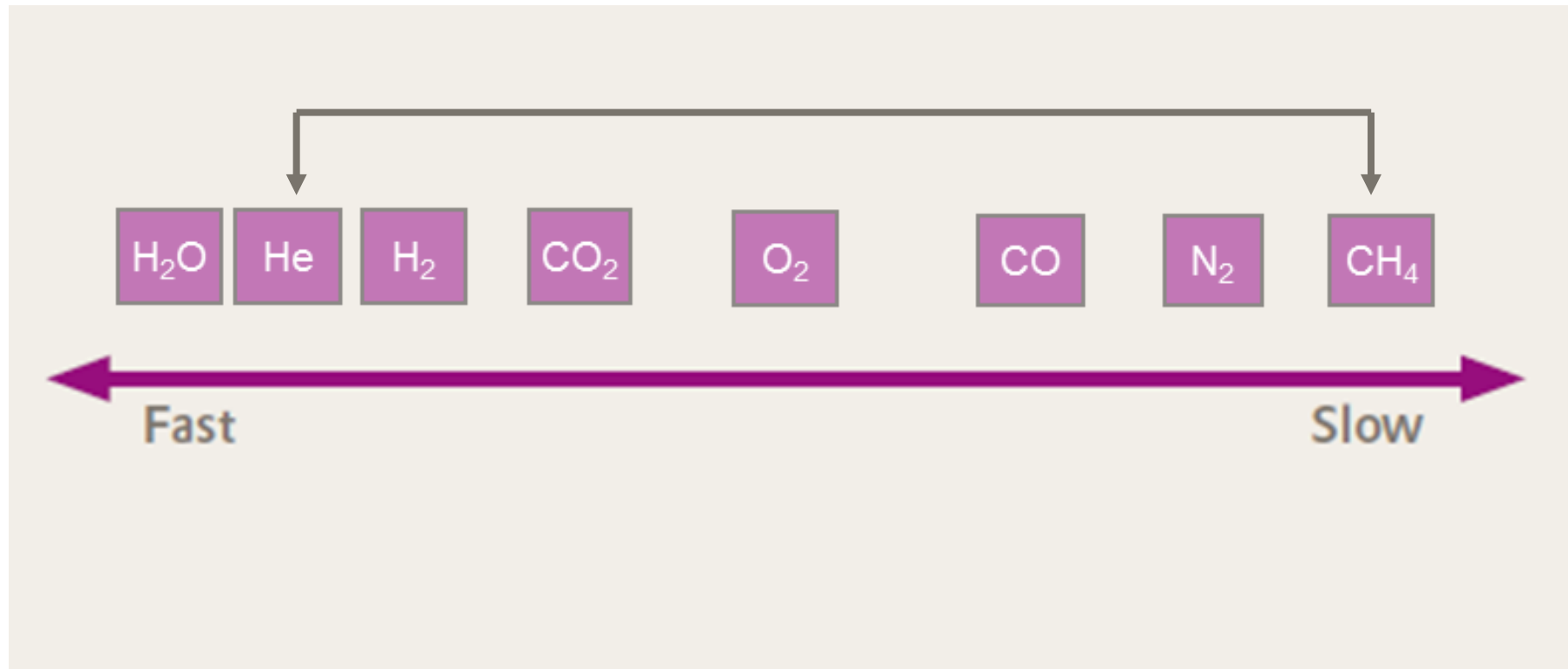
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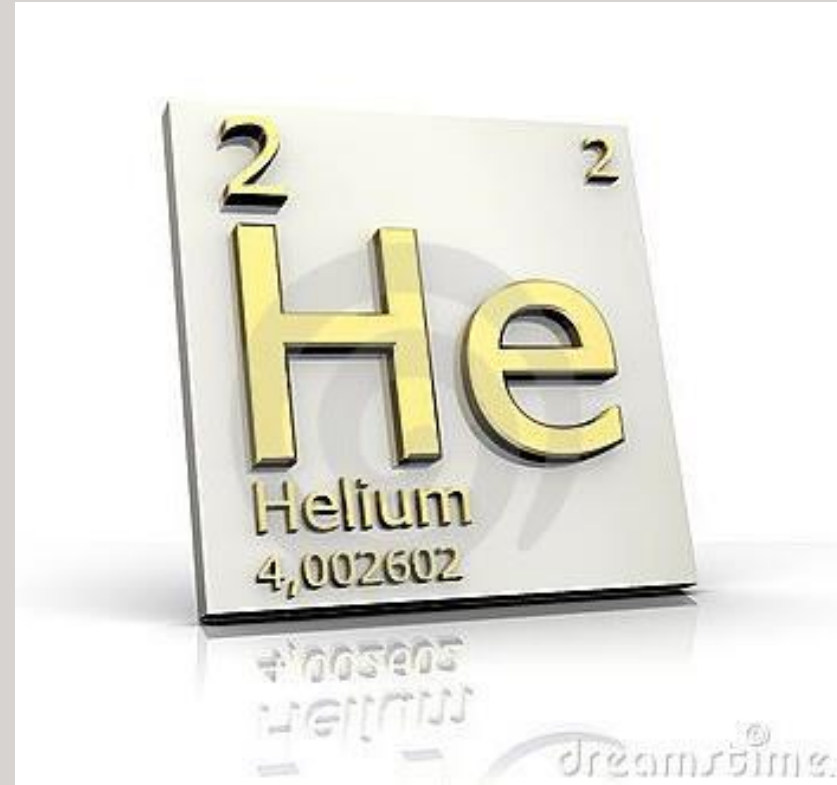
SEPURAN® Noble in H₂ application

Helium Purification from Natural Gas with Sepuran® Noble

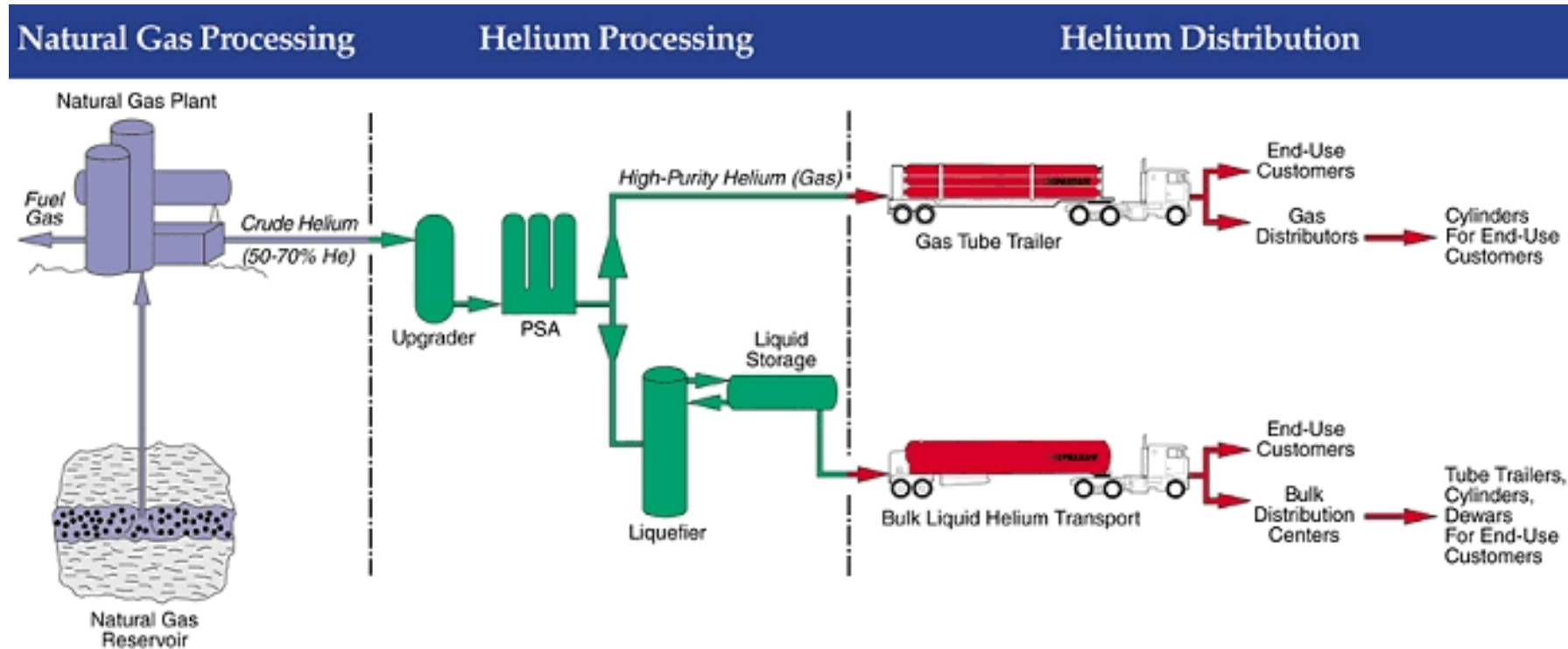
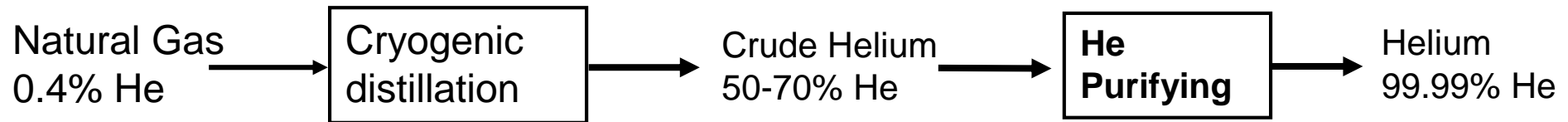


Helium applications

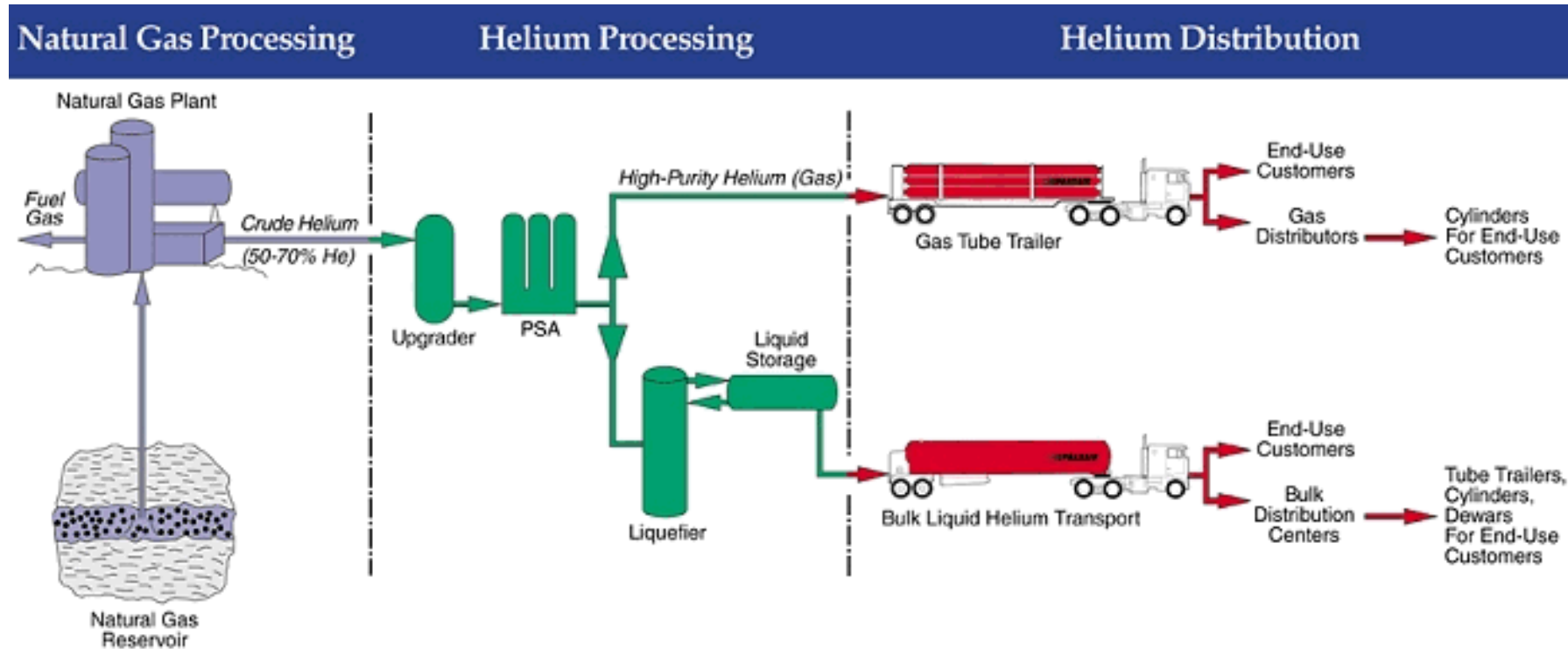
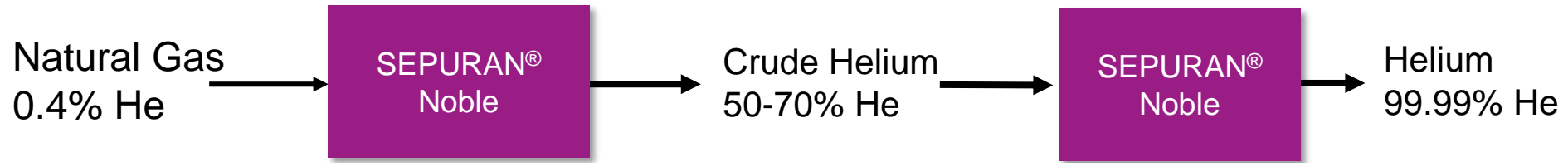
- Helium upgrading and purification from natural gas source
- Helium recovery from end user applications
 - MRI's
 - Electronics
 - Leak detection
 - Lifting/ballooning
 - Optical fibers



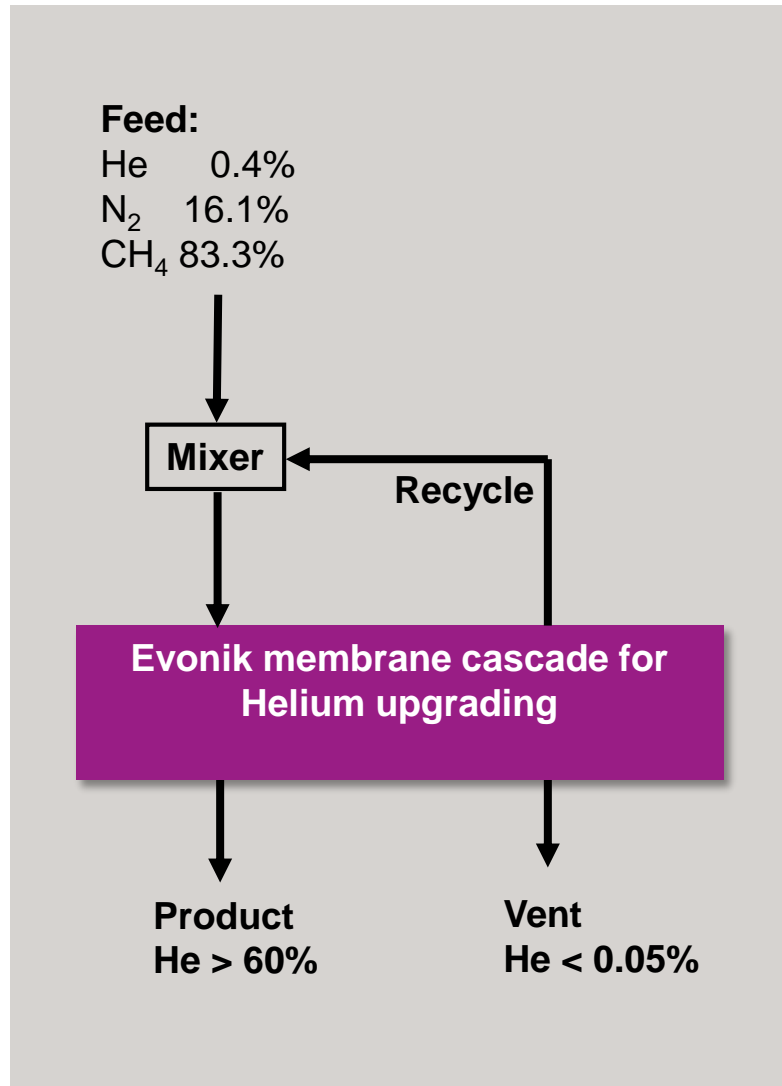
Conventional Helium upgrading and purification process



Conventional Helium upgrading and purification process



Example: Upgrading of pretreated He to Crude He



- ✓ Low He containing Feed gas can be upgraded to crude He in one compression step.
- ✓ Calculations are based on 20 bar(a).
- ✓ The He recovery is > 95%.

Membrane state of the art was:

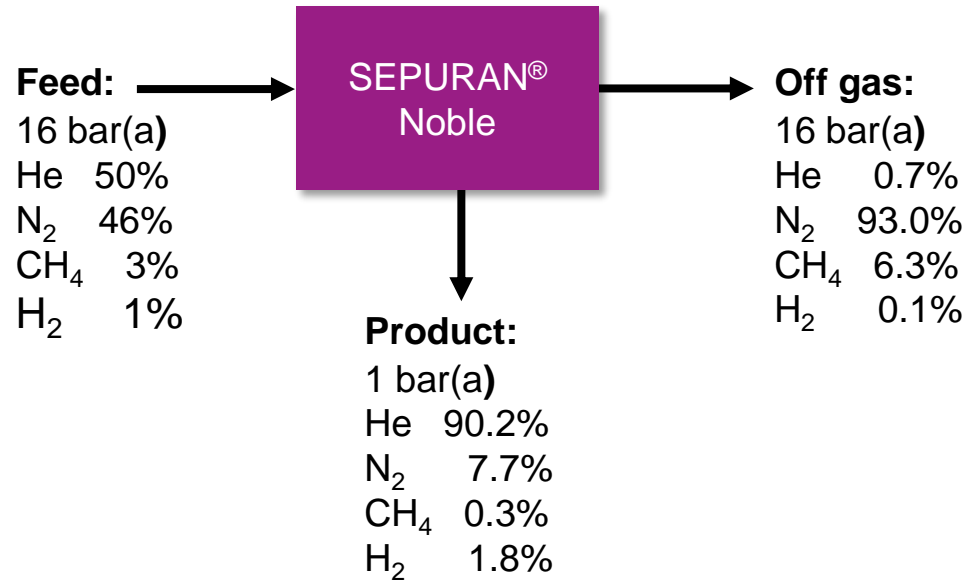
A Helium containing fuel gas can be upgraded in one step from 0.4% He to 10% He. The He recovery is 62% (at 25 bara)

Helium upgrading and purification process – first large scale reference



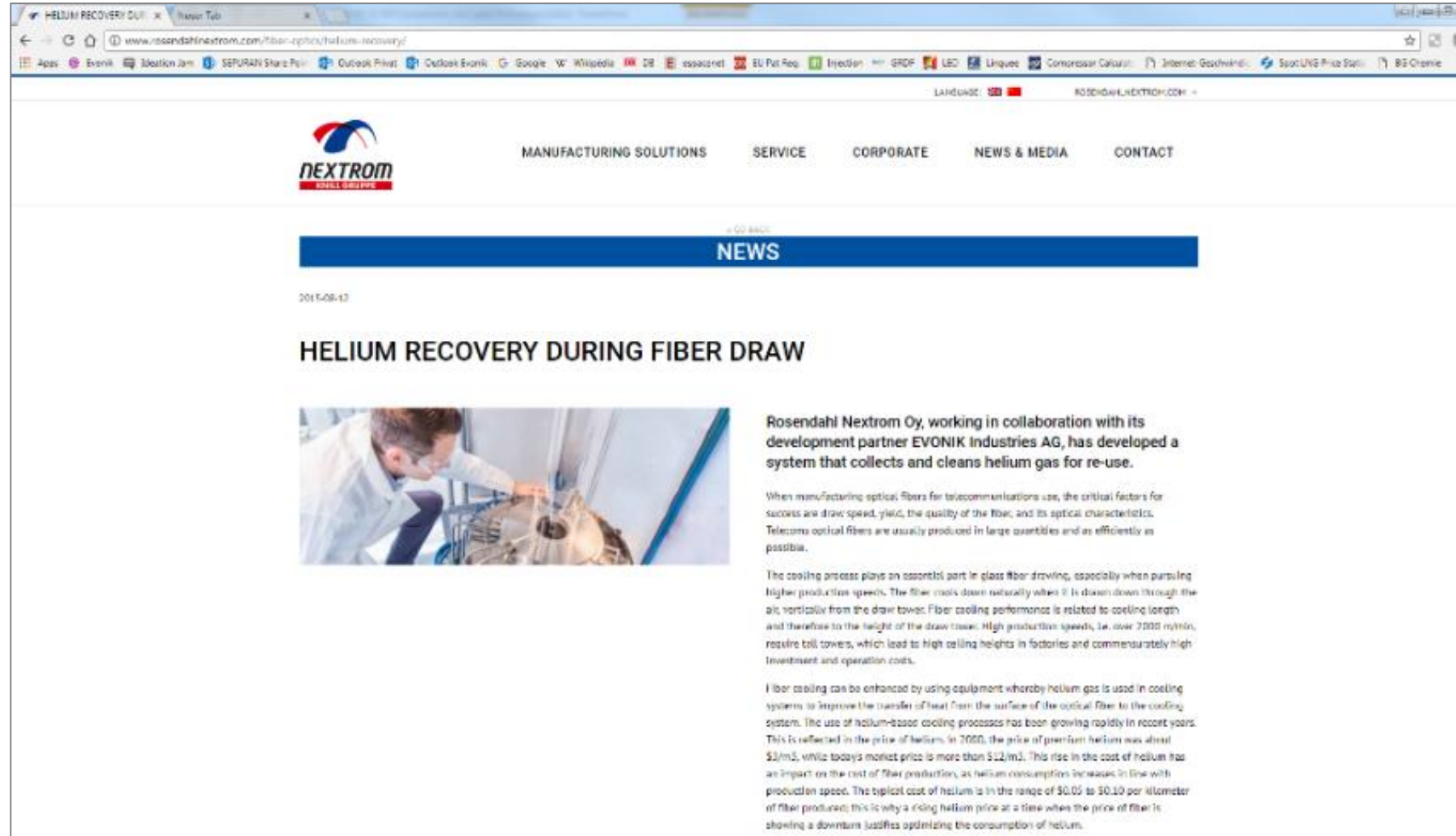
Source: The Linde Group

Example: Upgrading of Crude He to pure He



- ✓ Crude He with only 50% can be upgraded to more than 90% in a one stage process.
- ✓ The He recovery is > 99%.
- ✓ This gas can go into the further processing to reach high purity He (Grade A).

Helium recovery in optical fiber industry with SEPURAN® Noble



The screenshot shows a web browser window displaying the Nextrom website. The page features the Nextrom logo and a navigation menu with categories: MANUFACTURING SOLUTIONS, SERVICE, CORPORATE, NEWS & MEDIA, and CONTACT. A blue banner at the top of the content area reads 'NEWS'. Below this, the date '2015-08-13' is shown. The main heading is 'HELIUM RECOVERY DURING FIBER DRAW'. To the left of the text is a photograph of a person in a white lab coat working with equipment. The text on the right describes the collaboration between Rosendahl Nextrom Oy and EVONIK Industries AG on a helium recovery system. It details the challenges of fiber drawing, such as cooling length and tower height, and explains how helium-based cooling systems improve heat transfer and reduce costs by optimizing helium consumption.

HELIUM RECOVERY DURING FIBER DRAW

Rosendahl Nextrom Oy, working in collaboration with its development partner EVONIK Industries AG, has developed a system that collects and cleans helium gas for re-use.

When manufacturing optical fibers for telecommunications use, the critical factors for success are draw speed, yield, the quality of the fiber, and its optical characteristics. Telecom optical fibers are usually produced in large quantities and as efficiently as possible.

The cooling process plays an essential part in glass fiber drawing, especially when pursuing higher production speeds. The fiber cools down naturally when it is drawn down through the air, vertically from the draw tower. Fiber cooling performance is related to cooling length and therefore to the height of the draw tower. High production speeds, i.e. over 7000 m/min, require tall towers, which lead to high ceiling heights in factories and commensurately high investment and operation costs.

Fiber cooling can be enhanced by using equipment whereby helium gas is used in cooling systems to improve the transfer of heat from the surface of the optical fiber to the cooling system. The use of helium-based cooling processes has been growing rapidly in recent years. This is reflected in the price of helium. In 2000, the price of premium helium was about \$3/m³, while today's market price is more than \$12/m³. This rise in the cost of helium has an impact on the cost of fiber production, as helium consumption increases in line with production speed. The typical cost of helium is in the range of \$0.05 to \$0.10 per kilometer of fiber produced; this is why a rising helium price at a time when the price of fiber is showing a downturn justifies optimizing the consumption of helium.

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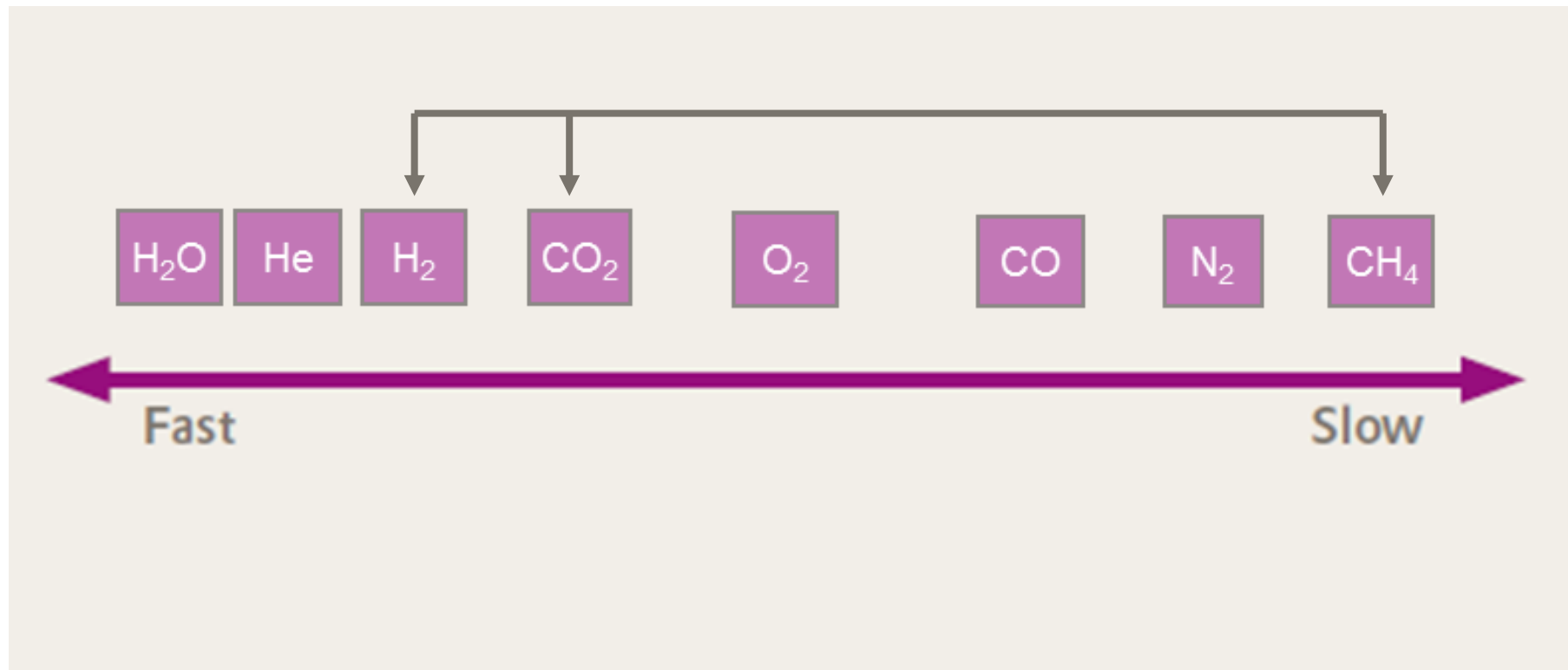
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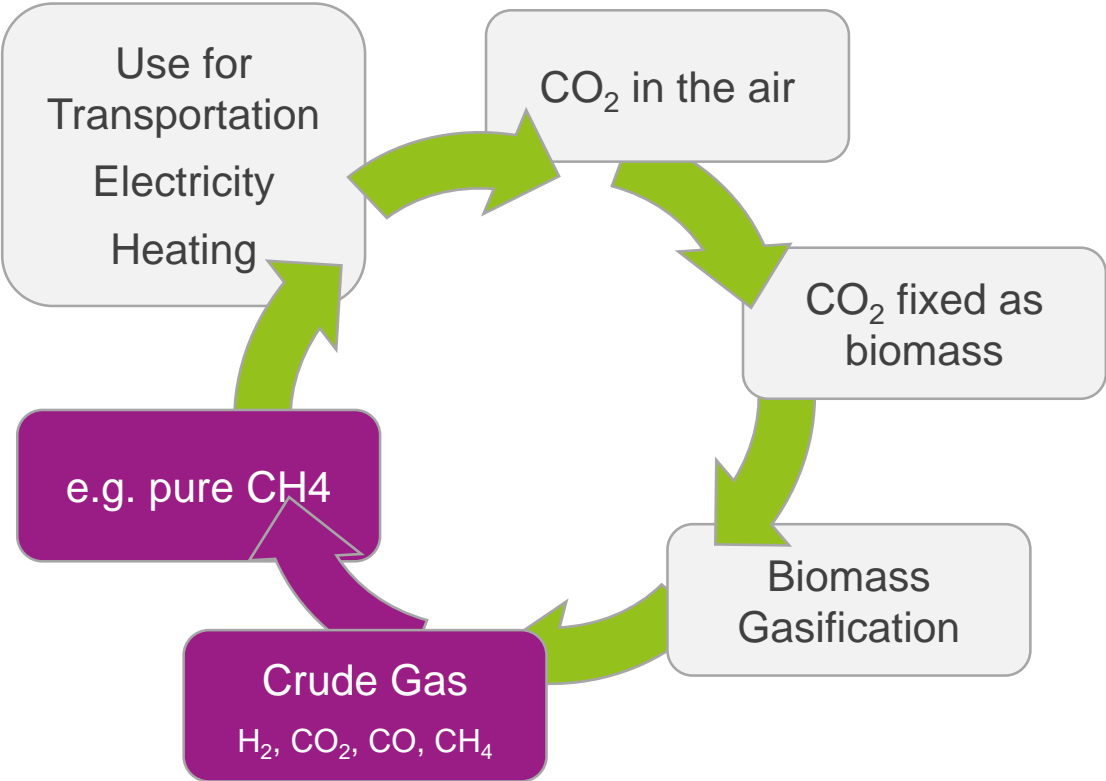
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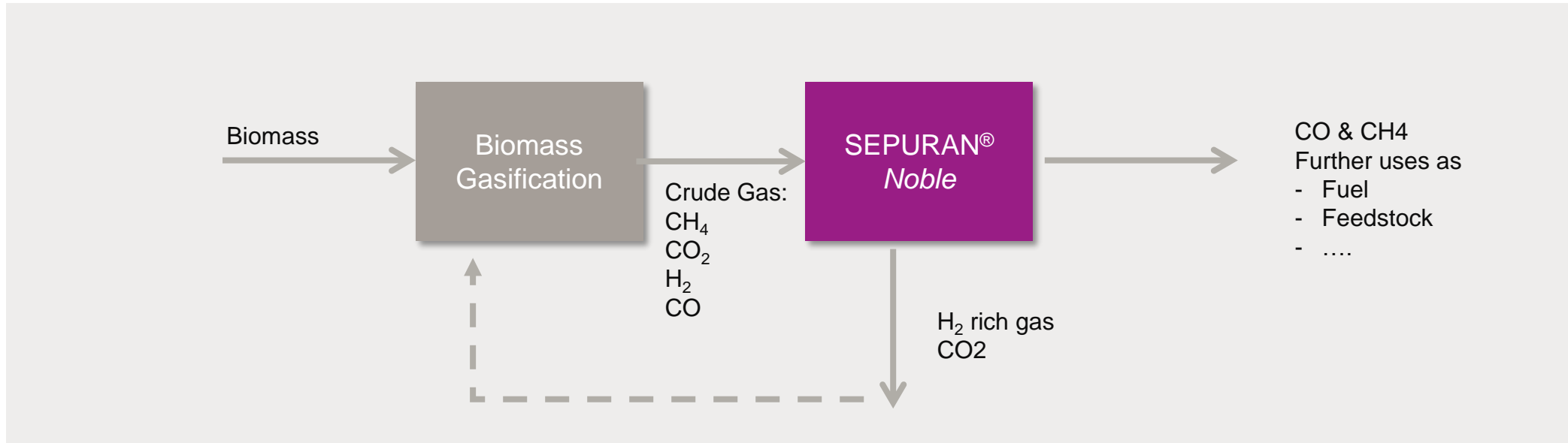
H₂ & CO₂ Separation from e.g. Biomass Gasification with Sepuran® Noble



To close the CO₂ cycle, Crude Gas upgrading is the key step



H2 & CO2 Separation from Biomass Gasification with Sepuran® Noble



- High recovery of CO & CH₄ due to high membrane selectivity
- Separation of CO₂ & H₂ for recycle from CO & CH₄

Sepuran® Membranes for your separation applications

Sepuran® Membranes for your separation applications

