

RNG WORKS

Technical Workshop & Trade Expo
Music City Center · Nashville, TN
Sept. 30-Oct. 1, 2020



EVONIK
Leading Beyond Chemistry

Evonik Membranes and CO₂ removal

Field experiences from more than 365 references

RNG WORKS

Nashville, TN Sept 30- Oct 1, 2020

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Evonik Background & Technology portfolio

Biogas upgrading technologies

Membranes & design, short introduction

Effect of biogas constituents

Lessons learned

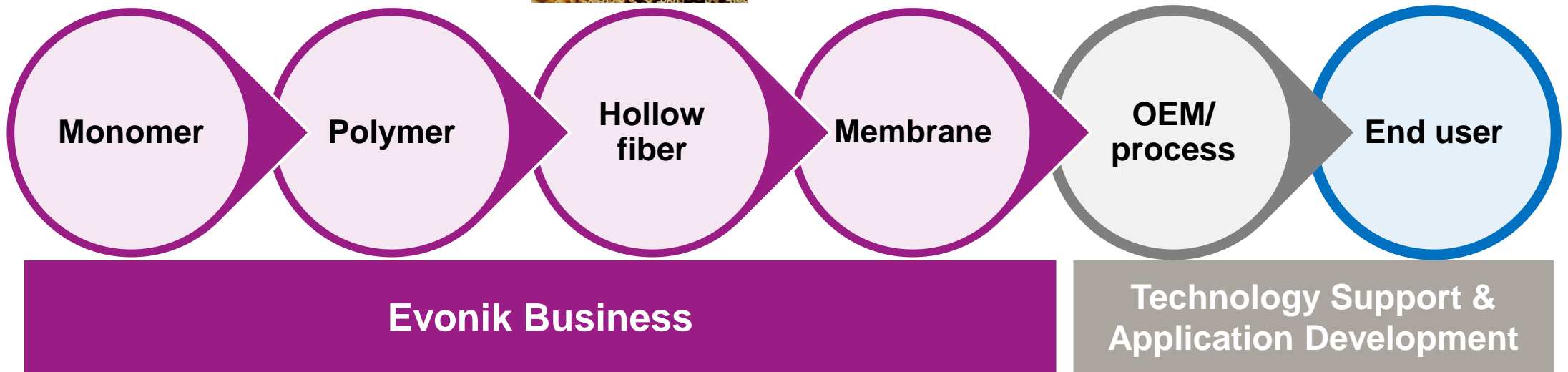
EVONIK Background



- ✓ Chemical corp, top15
- ✓ Membrane in growth strategy, amongst 3D printing
- ✓ Patented 3 stage membrane system
- ✓ Selective membrane process, > 99% yield



Value Chain



Product portfolio





Evonik Background & Technology portfolio

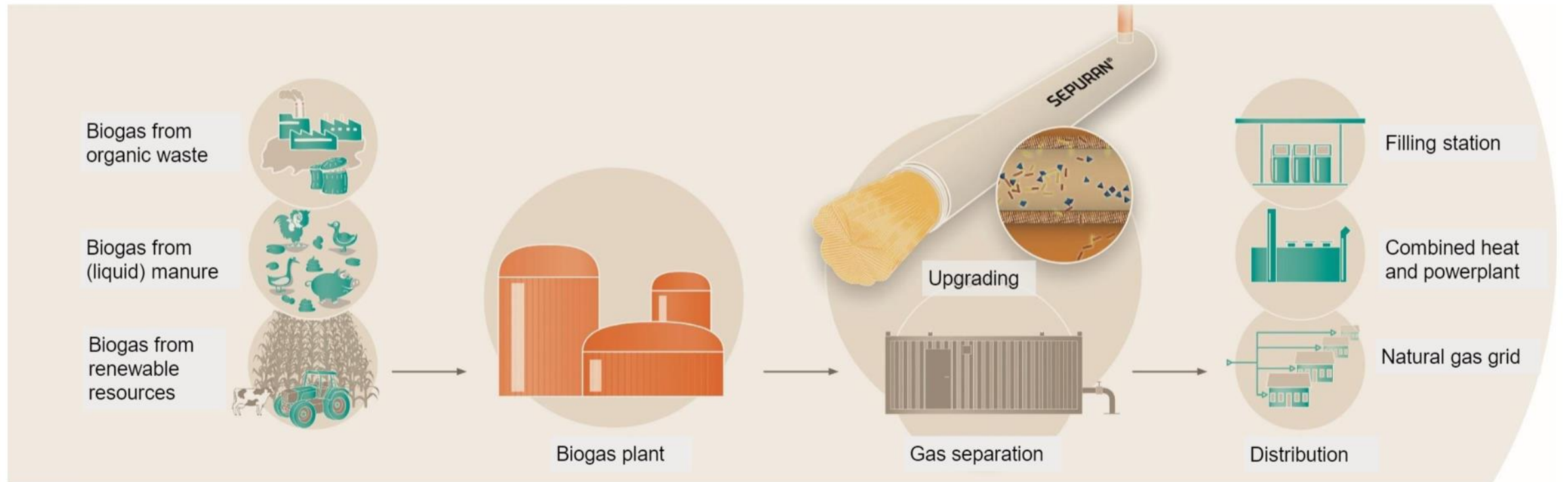
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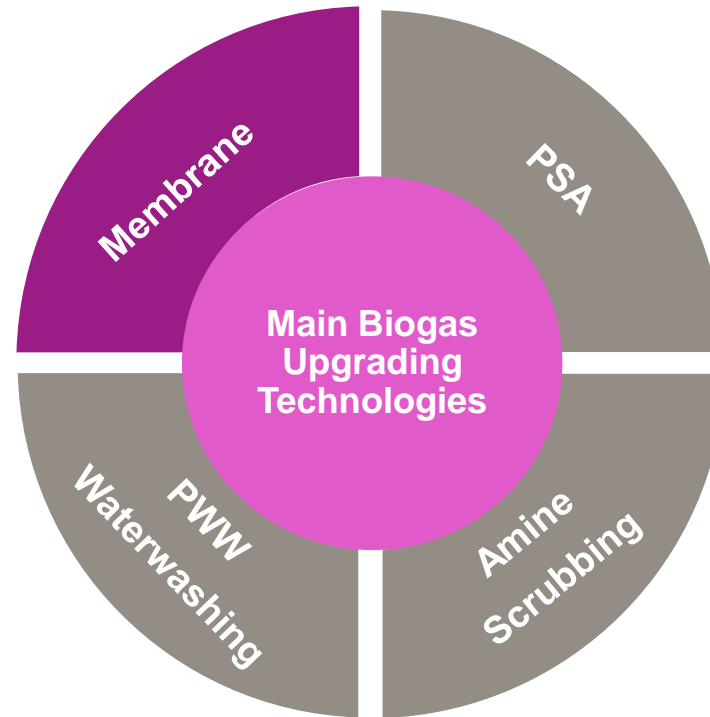
Biogas upgrading



Biogas Upgrading Technologies



(Photo credit: Durr-Megtec.com)



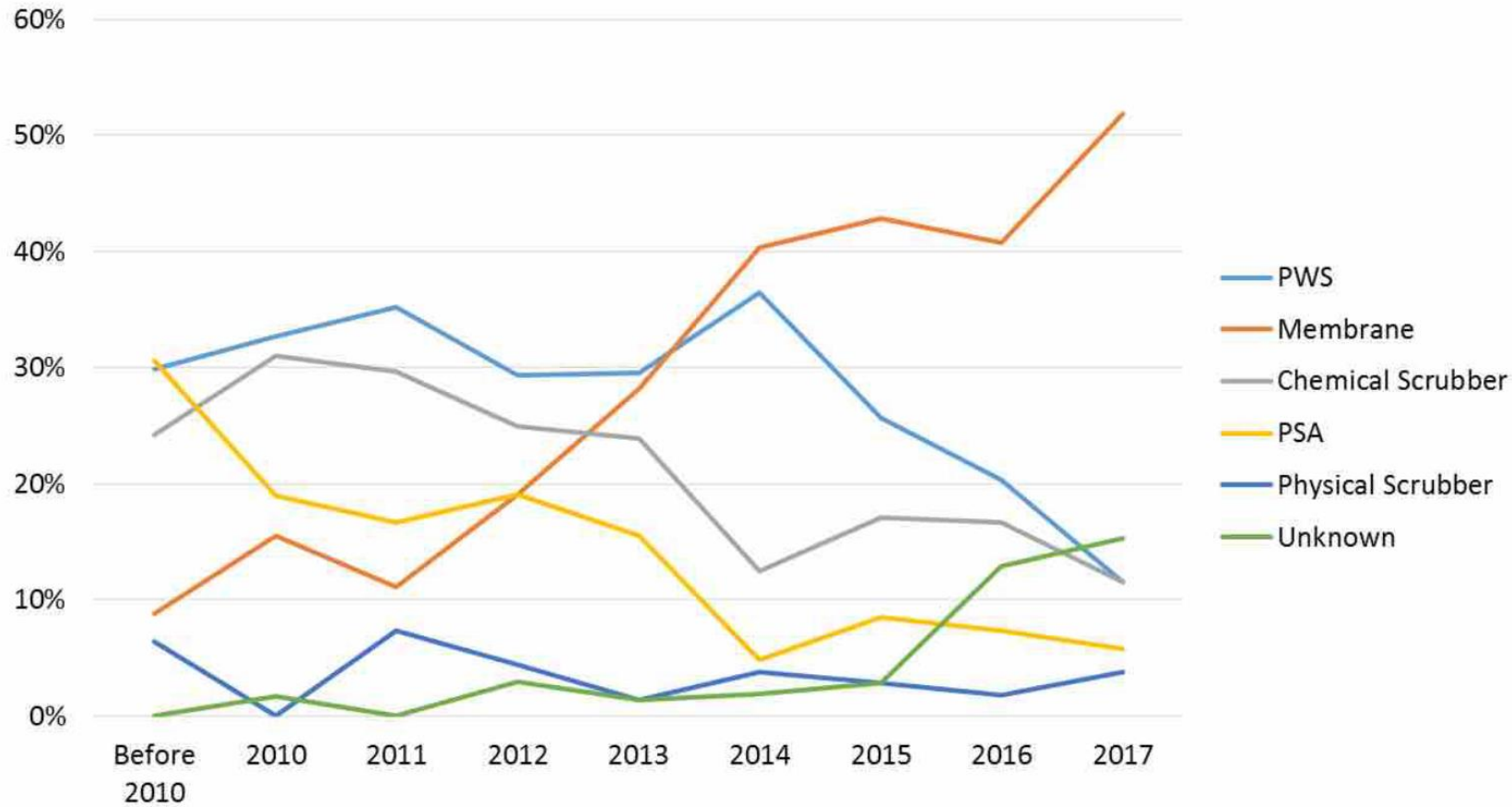
(Photo credit: Gasplus.com)



(Photo credit: Hz-Inova.com)

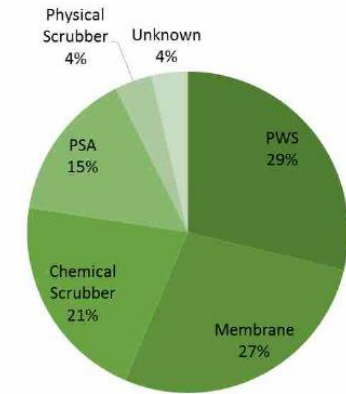
Biogas Upgrading: Technology Analysis

Technology development as % of total installations

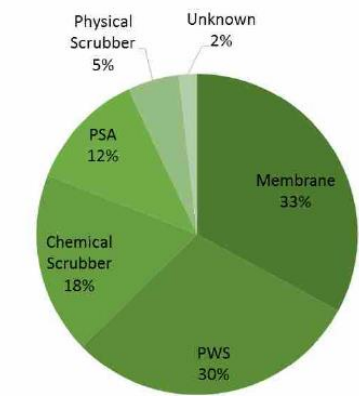


(Lems 2019) DMT presentation at Biocycle Apr-2-2019

Total share of installations by technology



Share of upgrading capacity by technology





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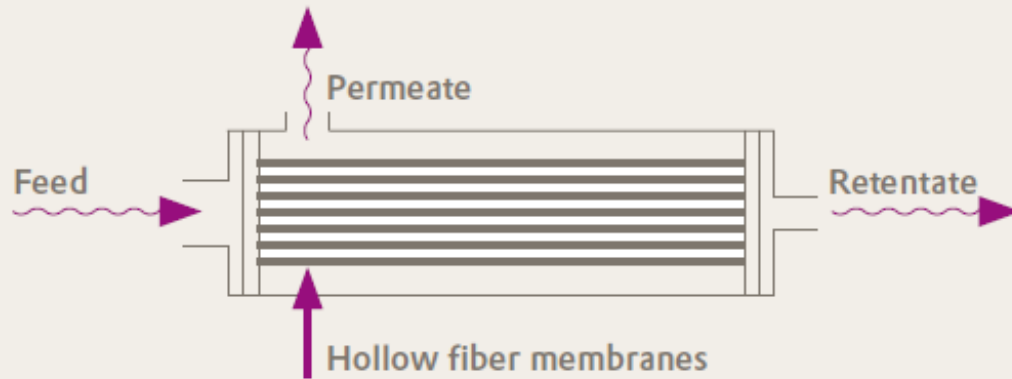
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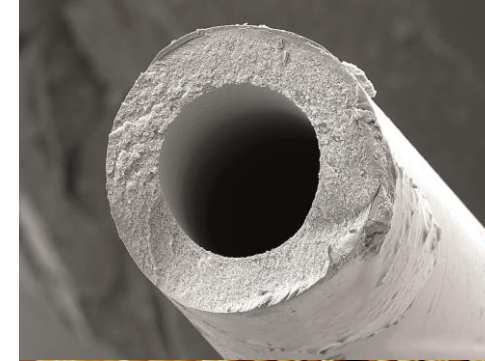
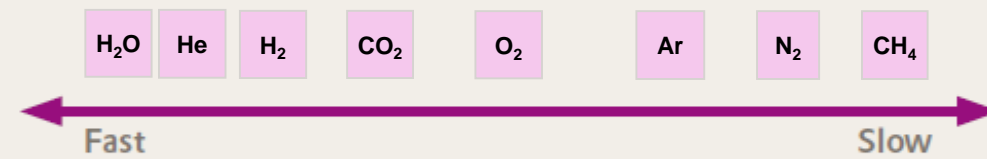
Lessons learned

Gas-separation processes using a hollow fiber membrane

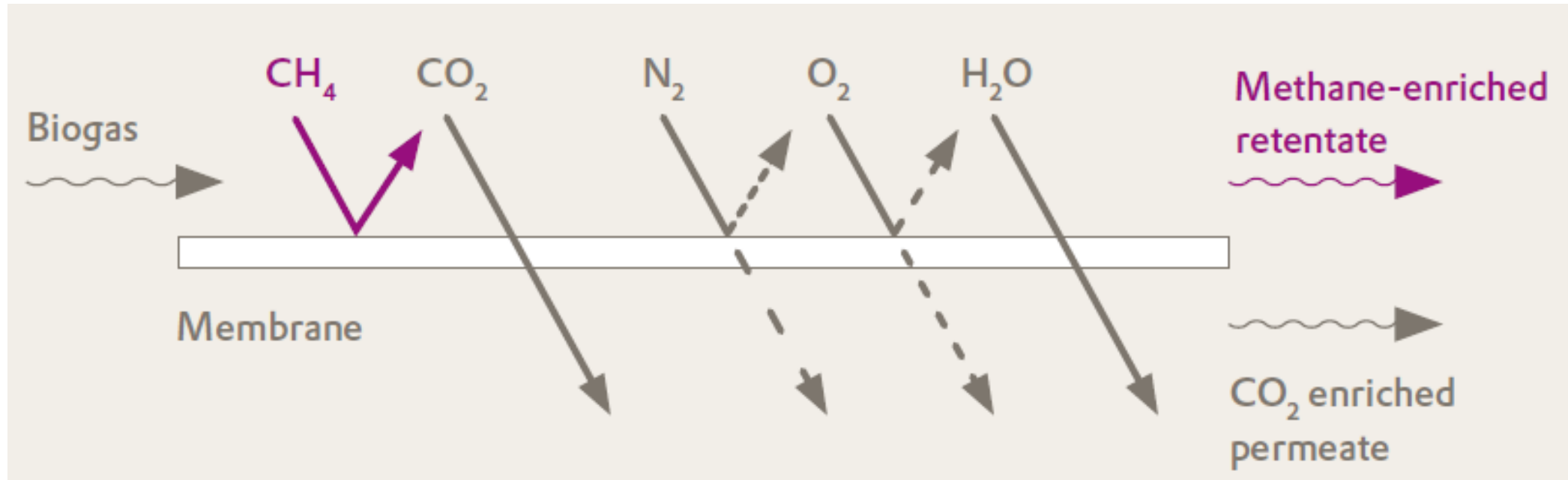
Mode of operation of a membrane module for gas separation – bore side feed



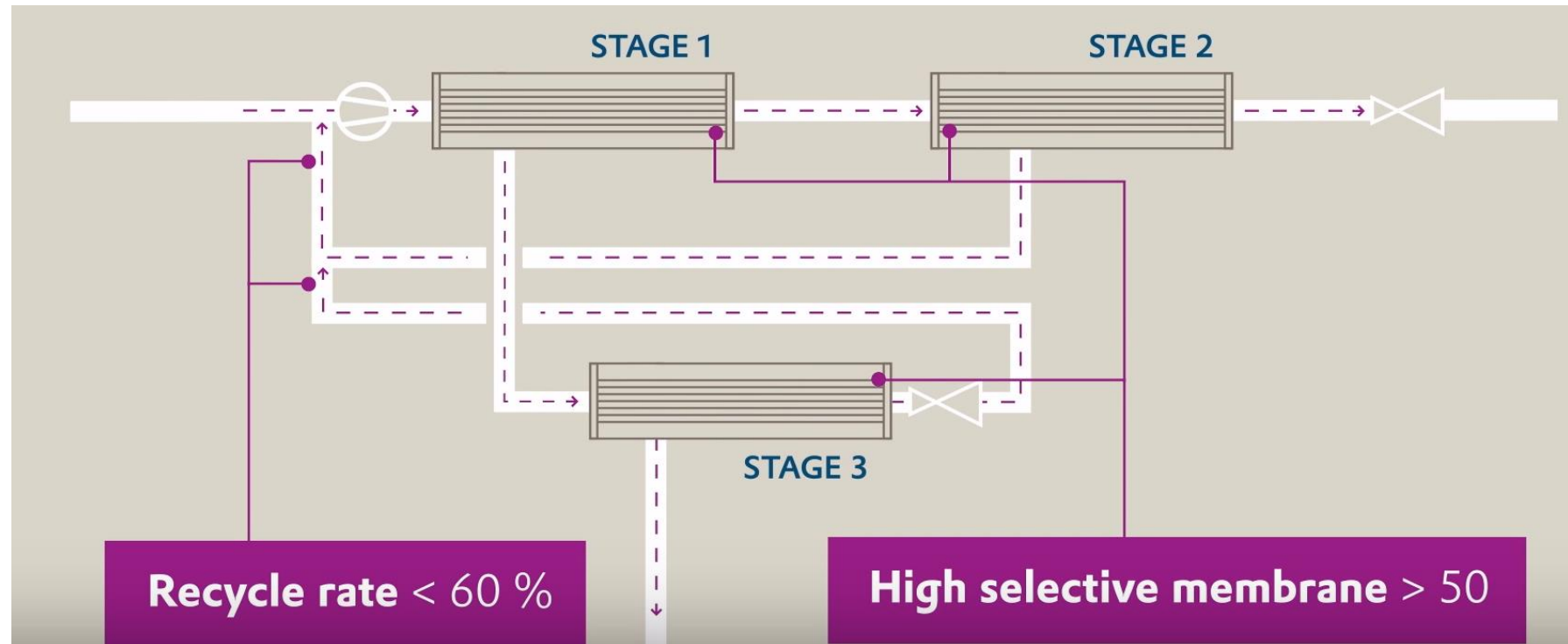
Relative permeation rates of various gases



“Filtering out” the CO₂



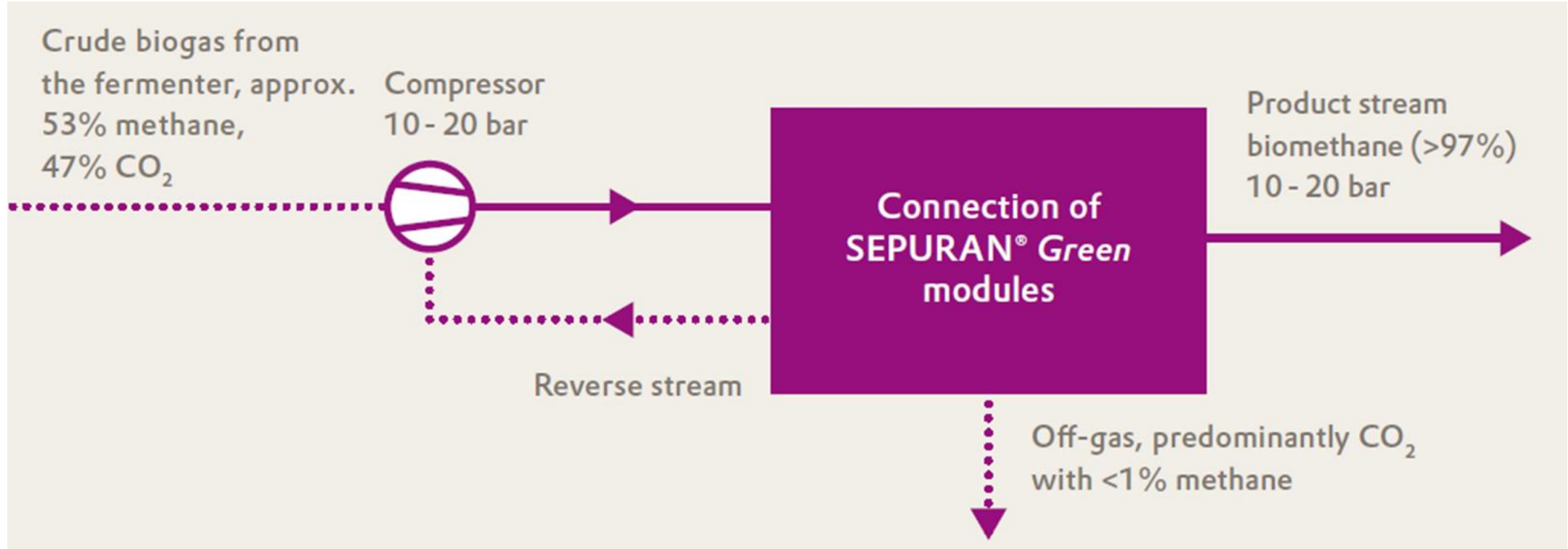
Movie SEPURAN® GREEN (1:48 min). How does it work?



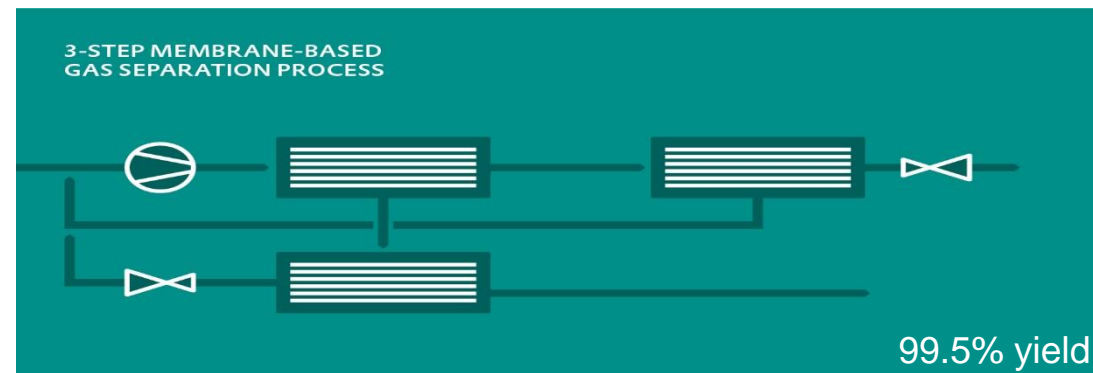
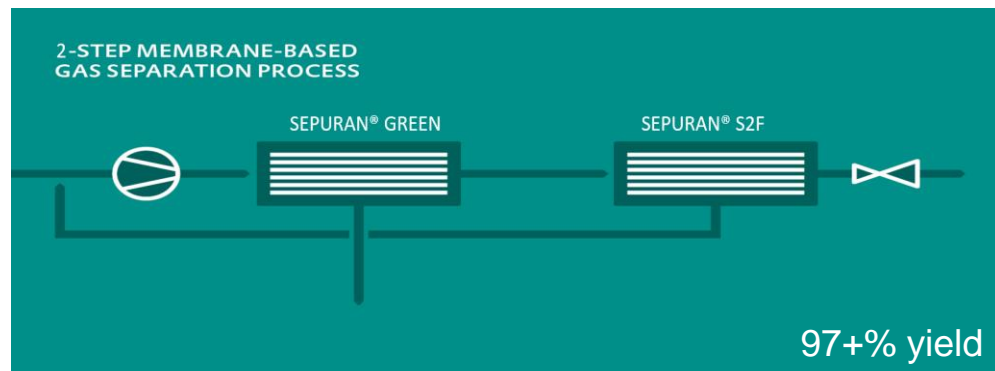
Click [HERE](#)

https://www.youtube.com/watch?v=C2jW0NkCKmw&list=PLEgRVFItDRZkzIGpIOR4_QmygpfCKYGSe

Main energy input is only the electricity for a single compressor (150-280 psi)



New developments in 2 and 3 Stages Process

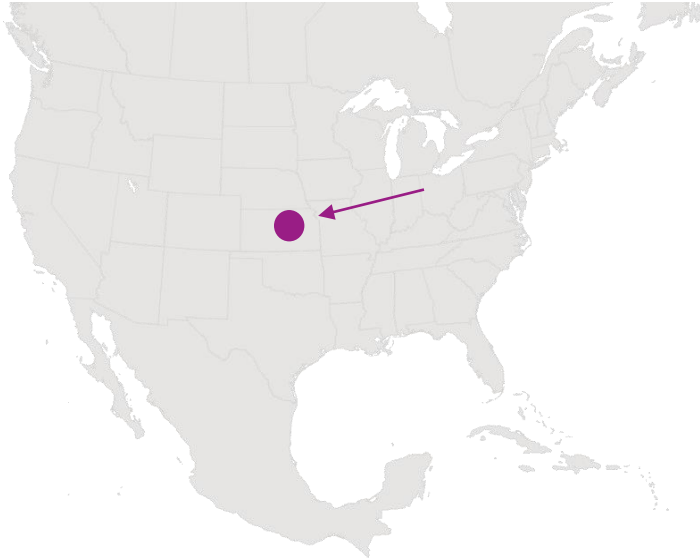


- ✓ Using 1 single compressor
- ✓ More yield with more stages
- ✓ Patented 3 stage: high efficiency, no TOX needed
- ✓ 2 stage with 2nd fast stage: cost effective solution
- ✓ More selectivity at T_{low} and more capacity at T_{high}
- ✓ 1st stage cool, 2nd stage warm (+ energy recovery)



Enerdyne, Kansas, US – Land Fill Gas

Lawrence, Kansas, US



Enerdyne Upgrading Facility



Client: Enerdyne, Landfill Group

Biogas: Land Fill

Upgrading: 1600 scfm Biogas

Methane: 98+ Vol% CH₄

SEPURAN® Green piped in a rack



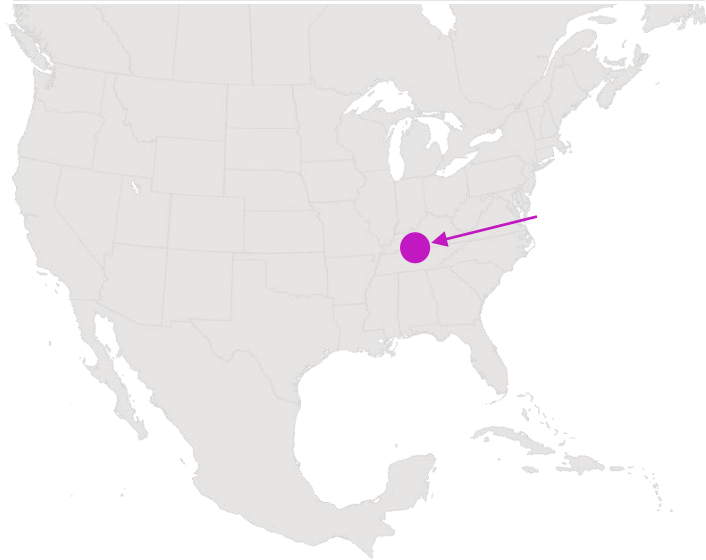
Operating Pressure: 162 psi

Process: 2-stage
membrane

Downstream: Gas grid
to households &
industry

DMT, AMP Americas, Fair Oaks, IN, Dairy Digester Gas

Fair Oaks, Indiana, US



2018 Innovation of the Year!



Biogas Upgrading Facility



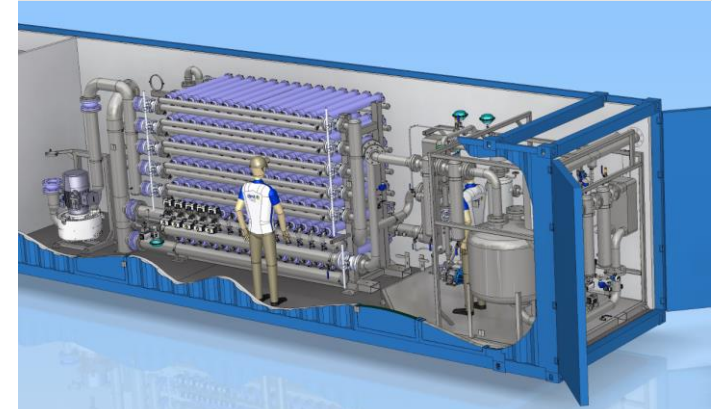
Client: DMT-CGS
with AMP Americas

Biogas: Dairy Digester Gas

Upgrading: 1500 SCFM

Methane: 98+ Vol% CH₄

SEPURAN® Green piped in rack



Operating Pressure: 250 psi

Process: 2-stage
membrane

Downstream: Pipeline
injection to
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: 4000 scfm Biogas
Methane: 97+ Vol% CH₄

Disgester – 5 new ones installed



Operating Pressure: 232 psi
Process: membrane
Downstream: CNG & gas grid injection CO₂-liquefaction sold to respective industry

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: 1250 scfm Biomethane
Methane: 97+ Vol% CH₄

Operator and membrane container



Operating Pressure: 232 psi
Process: 3-stage membrane
Downstream: CNG – bottle trailer - distribution at public CNG stations



Evonik Background & Technology portfolio

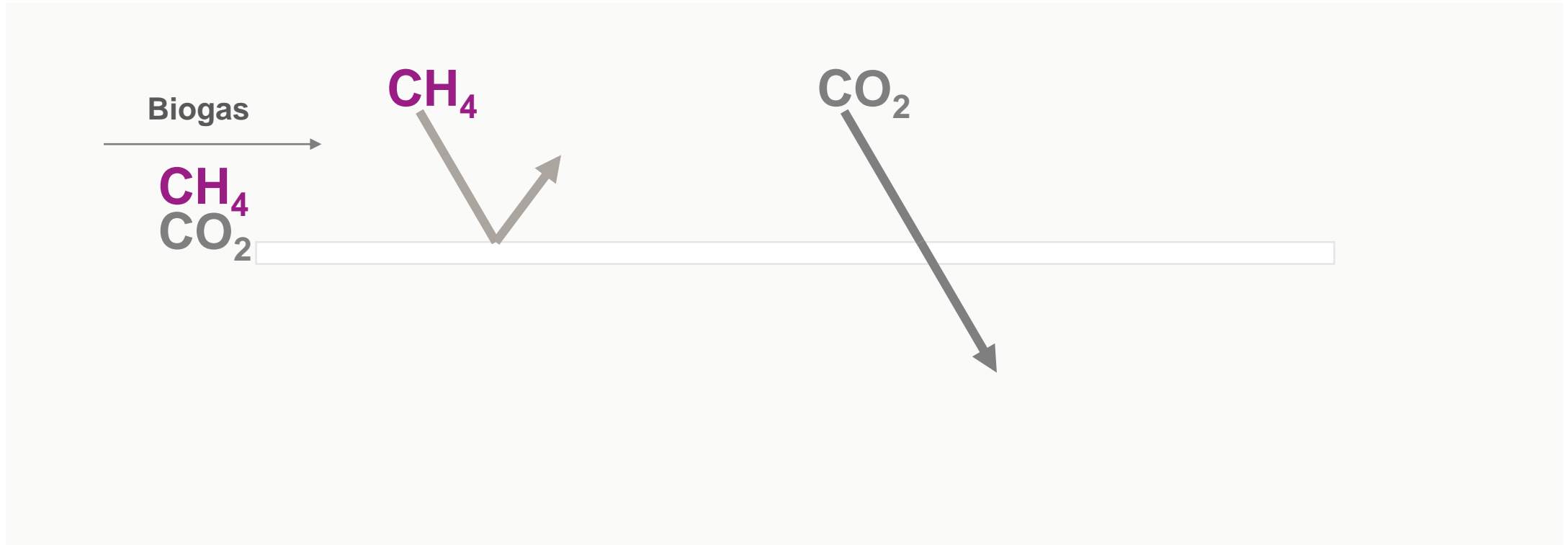
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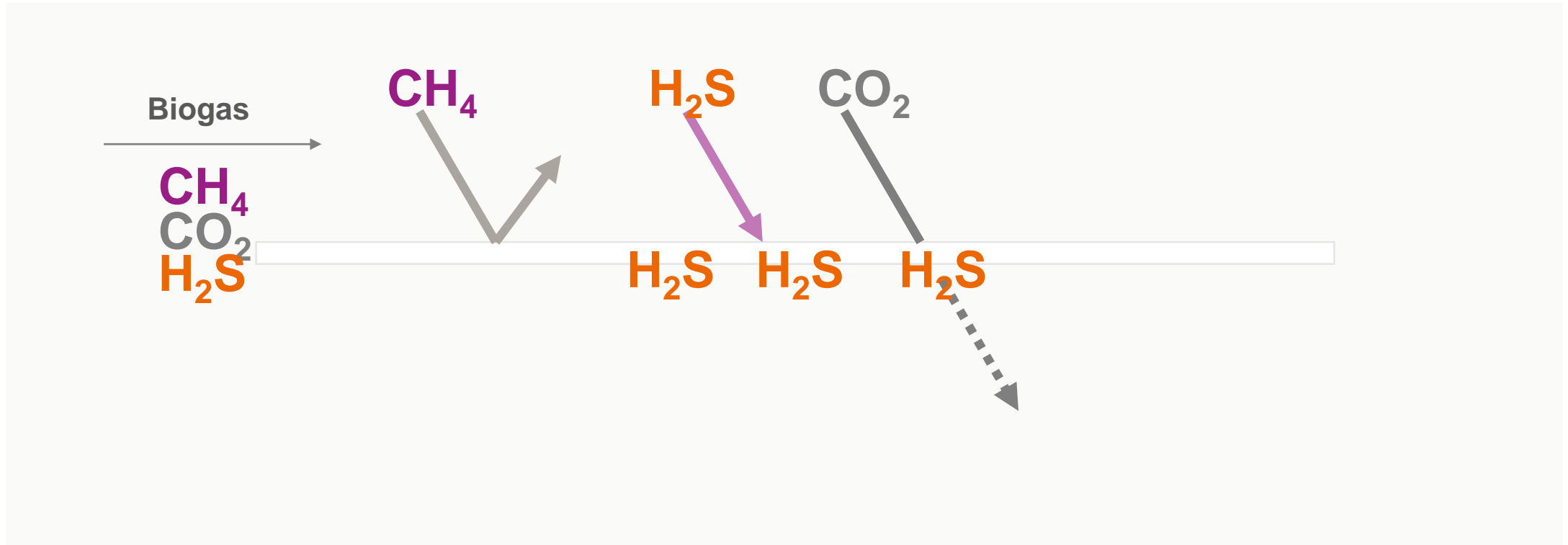
Effect of biogas constituents

Lessons learned

Evonik Sepuran[®] Green running with pretreated Biogas

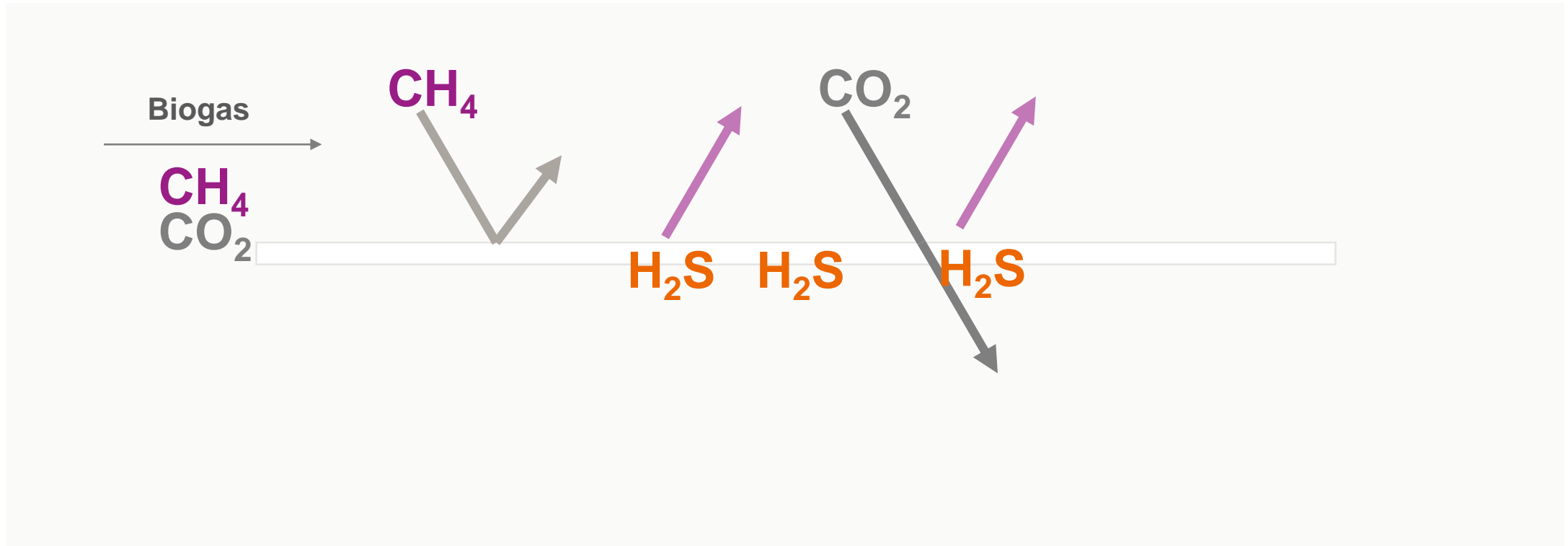


H₂S Sorption on Evonik SEPURAN® Green

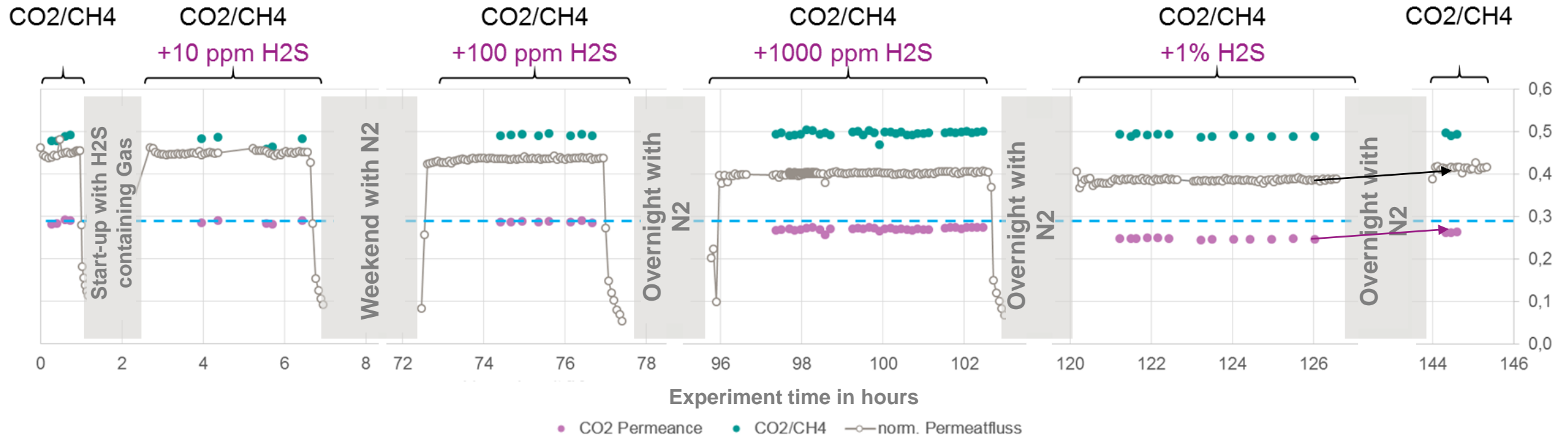


Evonik SEPURAN® Green can be onsite regenerated

Regeneration of Evonik SEPURAN® Green running with pretreated Biogas



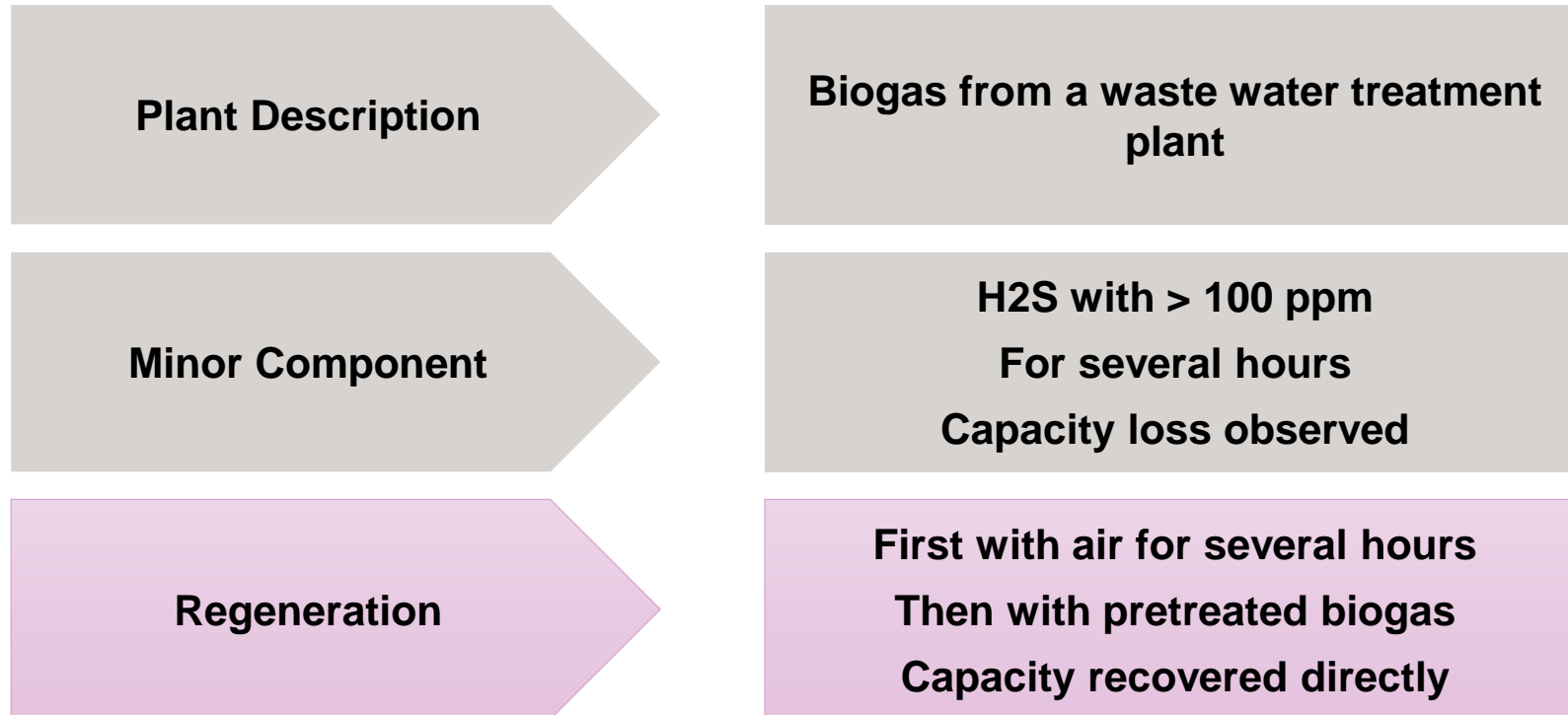
Effect of H₂S concentration on SEPURAN®



- ✓ No change in selectivity
- ✓ Up to 100 ppm H₂S, no change in SEPURAN® Membrane performance
- ✓ Membranes bounce back with H₂S free gas

Successful regeneration with H₂S-free air flow followed by pretreated Biogas

Biogas WWTP PLANT



Terpenes hiccup

Membranes bounced back to nameplate capacity after renewal of carbon beds

APEX | Bachenbülach Plant

Plant Description

3 Stages Process – 20 scfm Biogas
From all types of organic waste

Minor Component

Terpenes
Capacity loss observed

Regeneration

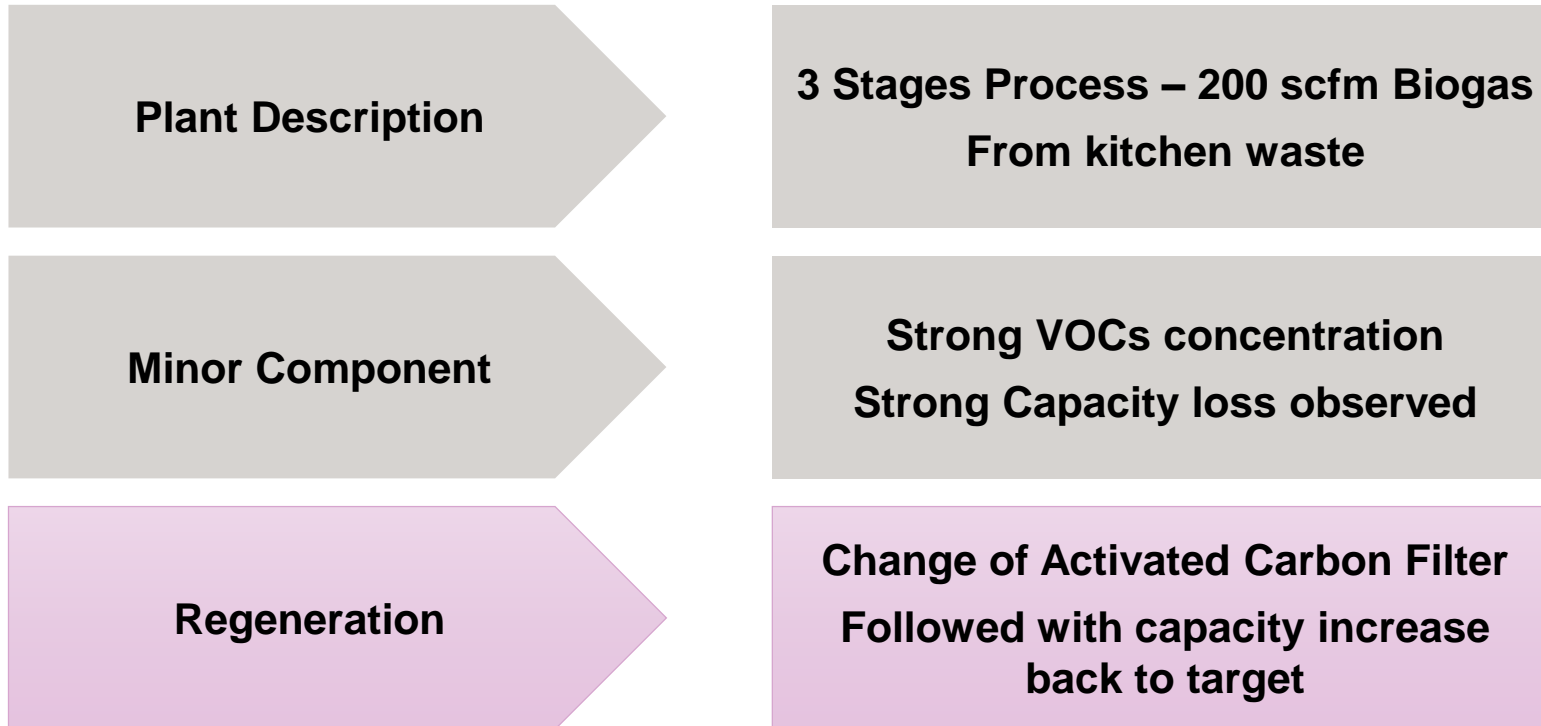
Change of Activated Carbon Filter
Followed with capacity increase
back to target



VOC hiccup

Membranes bounced back to nameplate capacity after renewal of carbon beds

Gastechnik Himmel | Vienna plant



Oil hiccup

Membranes bounced back to 90% after years flushing with clean gas

Modules at Biogas Upgrading Plant in Germany

2012: Modules in operation

Two Evonik Membrane Modules in operation (A and B)

2013: Oil contamination

**Capacity dropped to 55%
Module transfer to other plant**

2013: Other plant

Capacity recovered to 90% after feeding clean gas.

2019: Present

Membranes still operate at 90% of their original capacity.



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Conclusion

Conclusion

- ✓ More and more biogas upgrading units have membranes
- ✓ 99.5+% methane recovery with 3 stage membrane system possible
- ✓ Pretreatment of constituent (VOC, H₂S) is essential
- ✓ Membranes bounce back, clean gas restores them

Strategic Tools



Highest Selectivity
>99% Yield



Excellent
support



Finding the most
cost effect solution



OEM's



Trust, Speed,
Openness, Performance



Thank you for your attention!
Any questions?

Don't waste it!



EVONIK

Leading Beyond Chemistry

Erik Hoving is the Senior Technology Manager at Evonik with a more than 24 years of membrane experience in the Industry. Mr. Hoving is a demonstrated leader in his field and also serves as a member of the Coalition of Renewable Gas Advisory Board. Erik holds a Master in Chemical Engineering and a Master of Business Administration Innovation, Enterprise and the Circular Economy.



Another great day at Capitol Hill to talk with #Congress about #RenewableGas and #Sustainability.



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