Load flexible methanation in an advanced power-to-gas system

WORKSHOP (8/9.03.2021 – online)

Heat-to-Fuel interfaces to advanced Power-to-Gas and Power-to-Liquids Technologies (e-fuels)

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Director Research & Development, Clean City Team

Christof Industries Austria GmbH

Business Information

CORPORATE SECTION

Austrian proprietor-led company, 1966

oldest business unit *1846*

Turnover 2019	332 M€
Employees	2,568
Country Subsidiaries	26
Served Industries	15
Projects worldwide	+4,500
R&D	~2%

~ 80 Certificates & Licenses

MINISTRIES | UNIVERSITIES
INSTITUTES | COMPANIES

SECTORS

BRANCHES

WASTE
- WASTE to ENERGY
- HEALTHCARE WASTE
- WASTE to VALUE
- CHRISTOF CLEAN CITY

ENERGY
- RENEWABLES
- OIL & GAS
- CONVENTIONAL POWER

INDUSTRY
- AUTOMOTIVE
- CHEMICAL
- BUILDING MATERIALS
- INTRALOGISTICS
- FOOD
- METALLURGY
- PULP & PAPER
- WOOD & CHIPBOARDS

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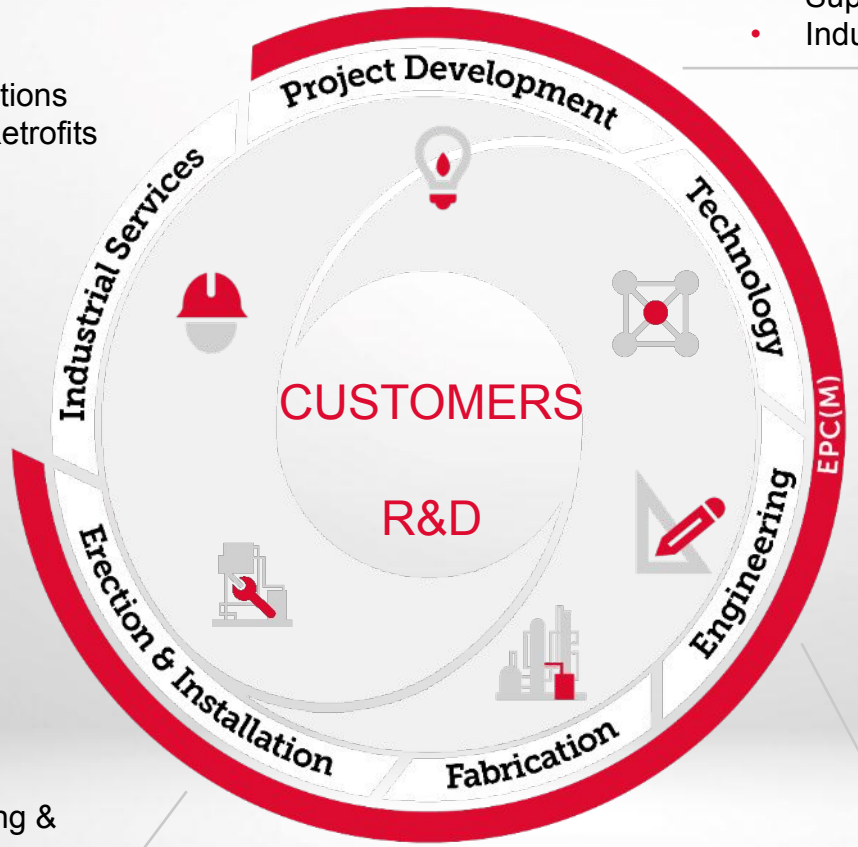
Core Business Principle

360° LIFECYCLE & CUSTOMER ORIENTATION

- Industrial Consulting Services
- Front-End-Loading (FEL) Services
- Concept Studies
- Feasibility Studies
- Project Management
- Support for Planning/Permission Processes
- Industrialisation/Process Development

- Plant Revamps, Upgrades & Modernisations
- Plant and Component Maintenance & Retrofits
- Plant De-bottlenecking & Optimisation
- Plant Relocations
- Turnarounds & Overhauls
- Oil & Gas Services
- Spares, Component Repairs & Replacements



- Waste-to-Energy/RDF Plants
- Biomass Power Plants
- Incineration Plants using Liquid & Gaseous Residues/ Waste Streams
- Industrial Waste Heat Plants
- Industrial Process Gas Cooling Systems
- Waste-to-Value Plants
- Infectious Waste Management

- Conceptual Engineering
- Basic Engineering/ FEED Services
- Detail Engineering
- Technical Approvals & Permits

- Site Management & Supervision
- Interdisciplinary Plant Installations
- Plant Erection, Installation, Commissioning & Start-up
- Operator/User Trainings

- Fabrication of Mechanical, Electrical and Automation Systems, Components & Spares
- Pre-Assembly of Technological Components
- SKID-Mounted & Containerised Solutions
- Prototyping

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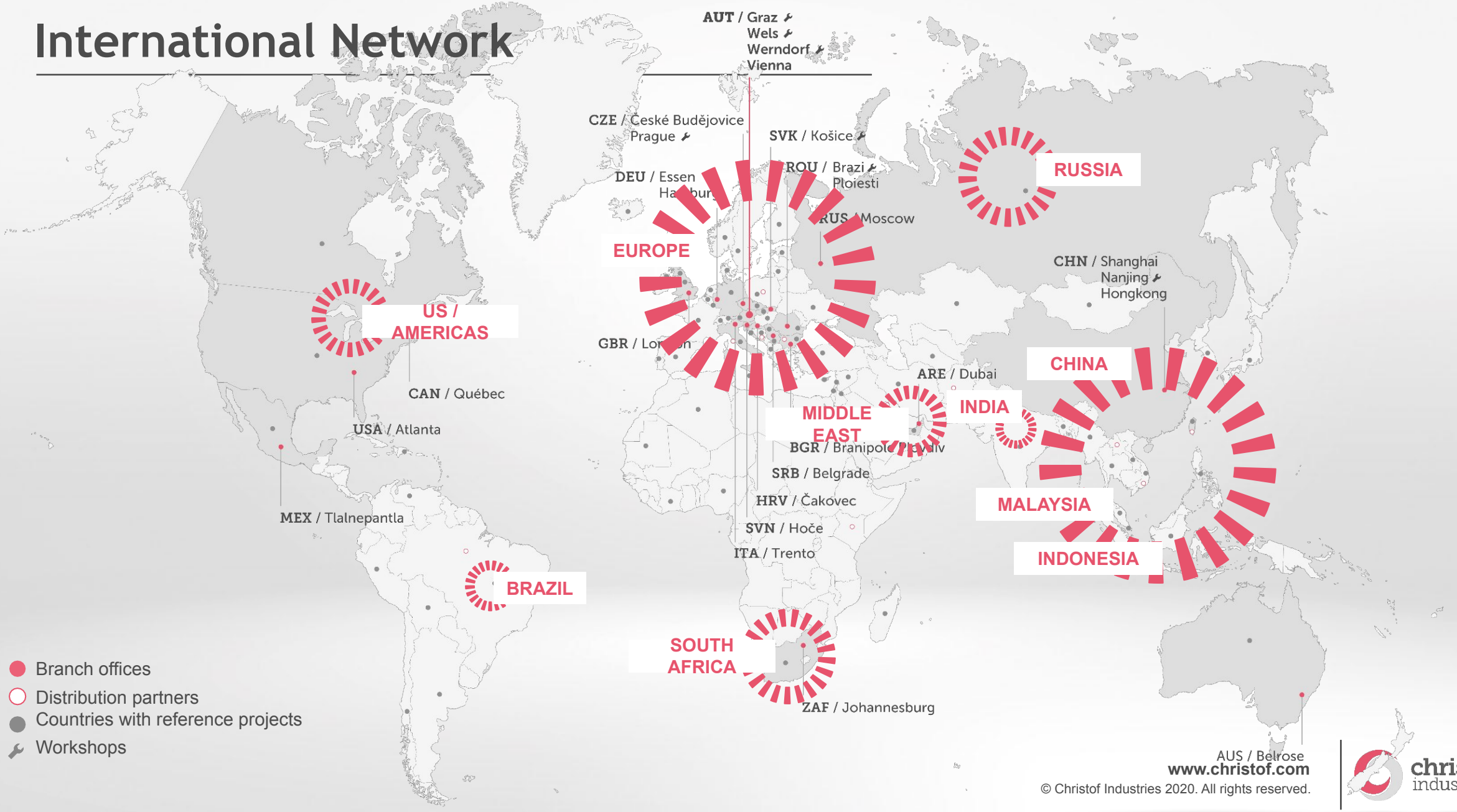
International Network



- Branch offices
- Distribution partners
- Countries with reference projects
- Workshops

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Methanation as part of Power-to-Gas (PtG) process chain

Load-flexible methanation technology for energy storage of renewable energies (wind, PV, etc.).

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VerfahrensTECHNIK
des industriellen Umweltschutzes

DEPARTMENT FÜR
Umwelt- & EnergieverfahrensTECHNIK

MONTAN UNIVERSITÄT
WWW.UNILEOBEN.AC.AT

Methanation as part of Power-to-Gas (PtG) process chain

	Syngas-Methanation	Methanation in PtG
Operation	Steady-state	Frequent start/turn-down; stand-by
Load Feedgas	Constant	Fluctuating with electrolysis
Carbon Source	CO	CO_2/CO
Plant Size	Large, industrial scale	Small to large
Feedgas Contaminations	Negligible due to gas conditioning	Depending on carbon source

⇒ either large H_2 storage tanks

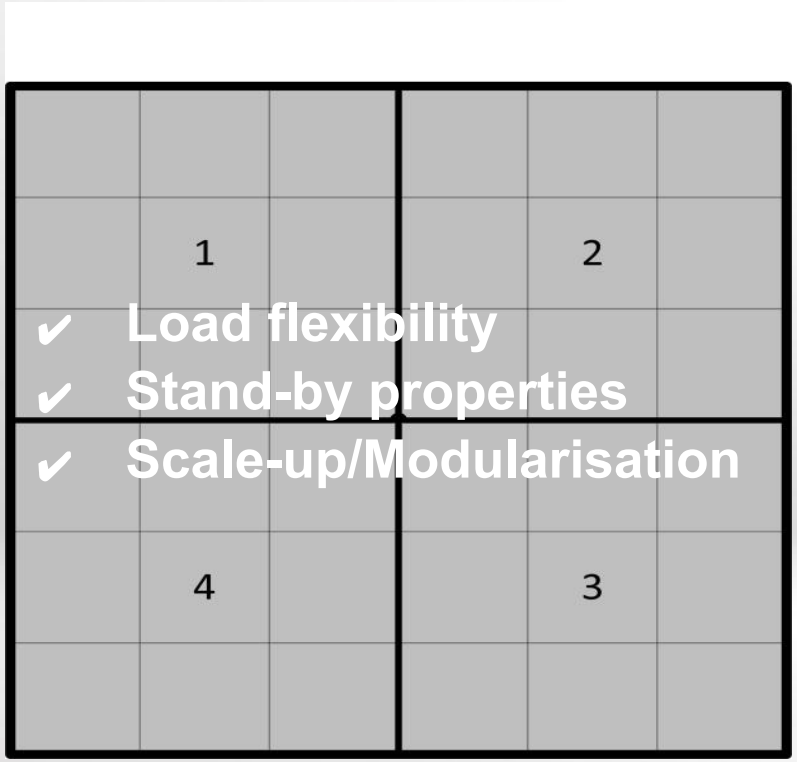
⇒ or adapted methanation process

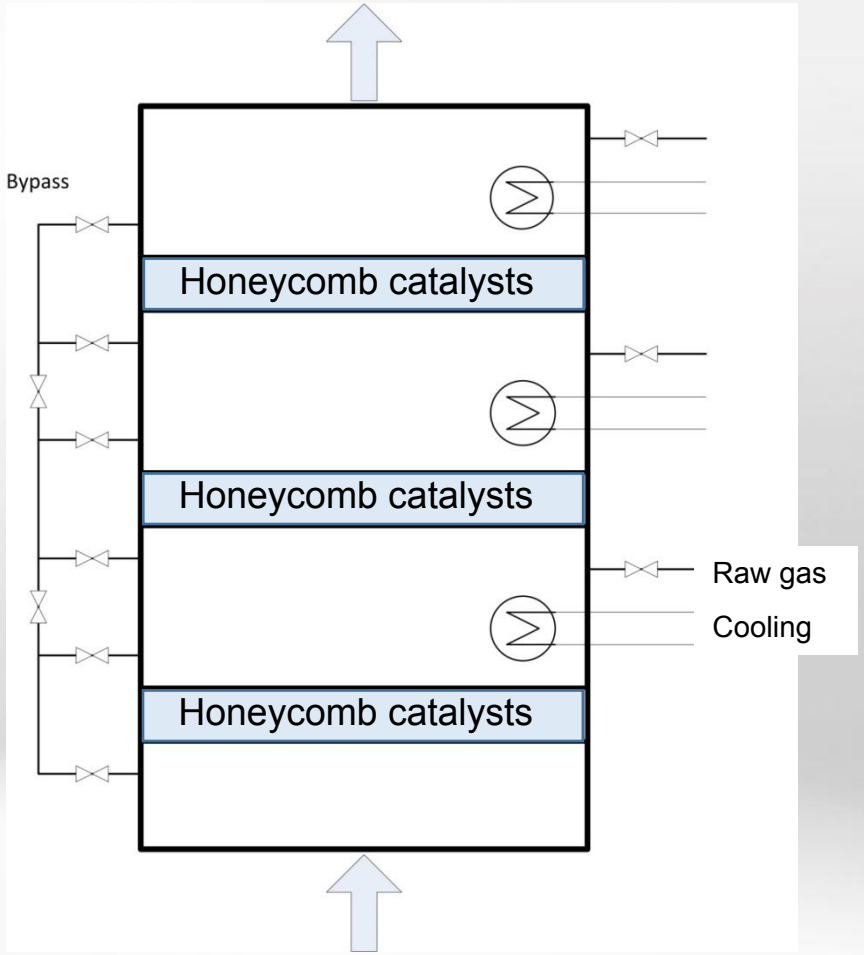
Reactor concept

Arrangement of honeycombs in compartments:

⇒ cyclic operation enhance load flexibility

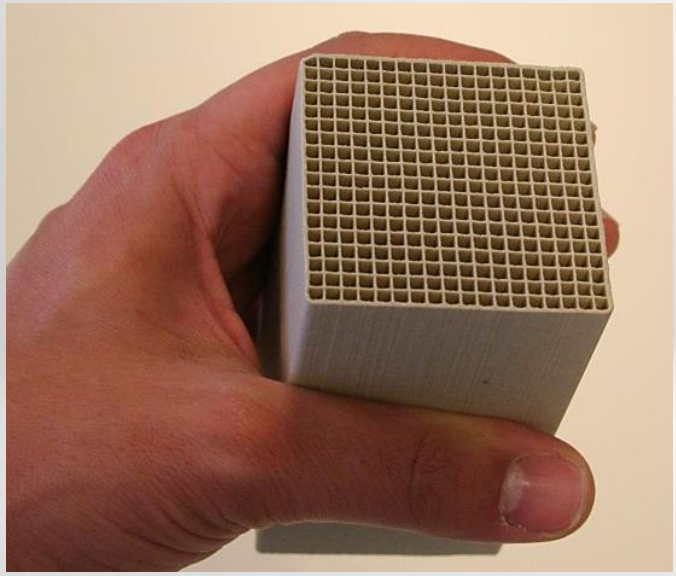
⇒ ceramic carrier enables heat storage

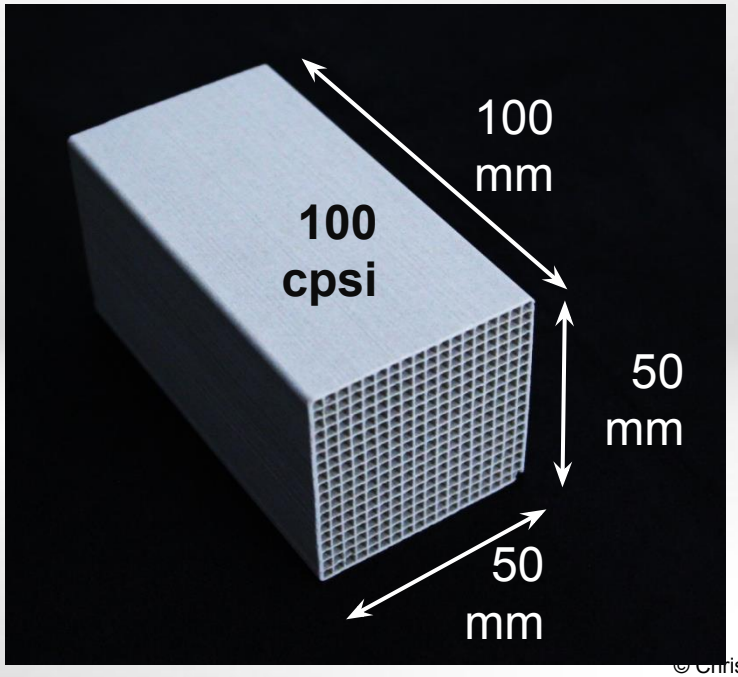




Ceramic honeycombs as methanation catalyst

- Carrier material: Cordierite high thermal shock resistance
- Wash-coat with Nickel as catalytic active material
- Catalyst and heat storage medium
- Simple scale-up/modularisation, improved stand-by properties and significantly higher load flexibility, smaller Δp





Commercial catalyst

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Laboratory scale methanation plant

- Up to 3 reactors in series equipped with honeycombs or commercial bulk catalyst
- Feed gas: H_2, CO_2, CO, CH_4, N_2
- Intermediate cooling
- Gas analysis before and after each reactor possible

p_{max} = 20 bar
T_{max} = 700 °C
$\dot{V}_{max}$ = 50 NL/min

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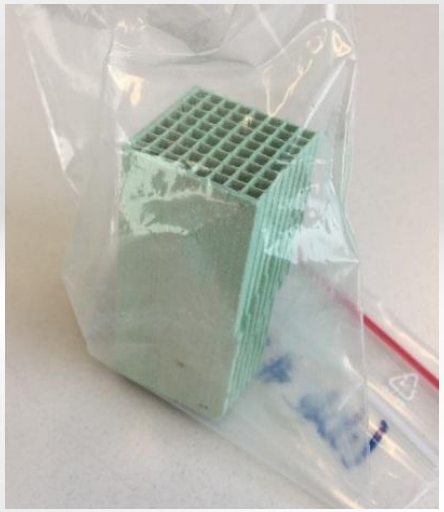
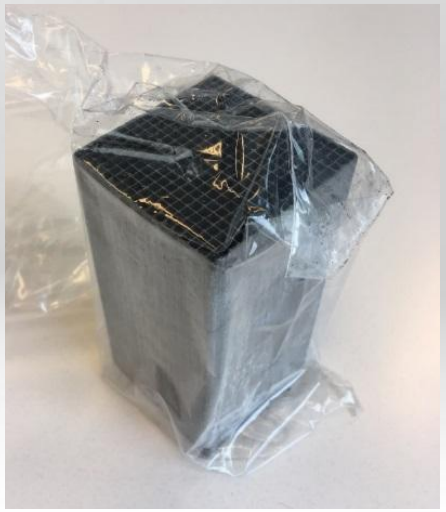
Honeycomb catalyst development

- Goals:
  - Stable bond of wash-coat
  - Repeatable coating procedure
  - Long-term & consistent methanation performance

- Wash-coat parameter variation
  - Honeycomb base material
  - One-step/two-step
  - Wash coat material: water/ethanol
  - Usage of ceramic binder
  - Solid content, viscosity, pH-value
  - Coating/drying procedure: time, speed
  - Calcination: temperature, #





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Zawodnik, Wolf-Zöllner, „Herstellung und Testung von Wabenkatalysatoren für die Methanisierung von kohlenstoffhaltigen Prozessgasen im Labormaßstab, 2021

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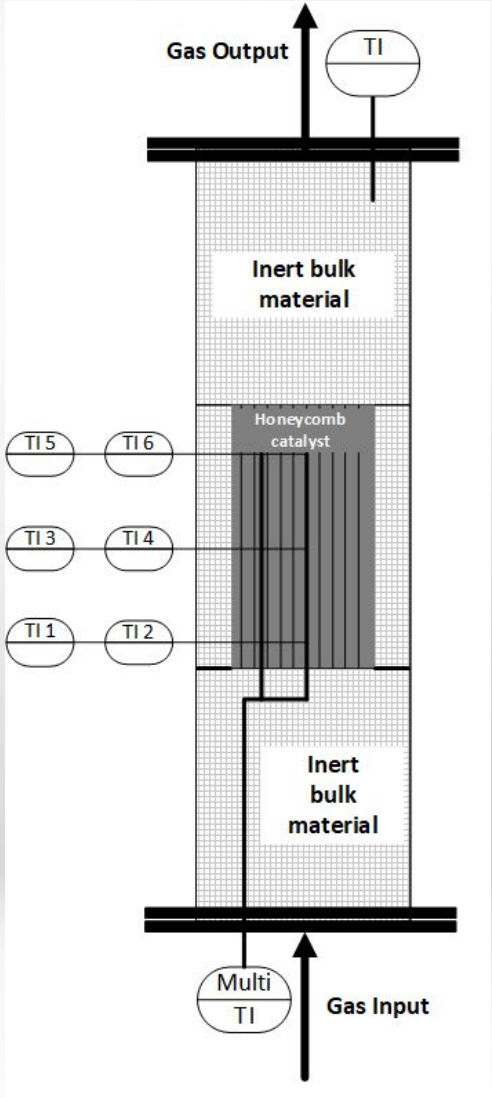
Methanation experiments

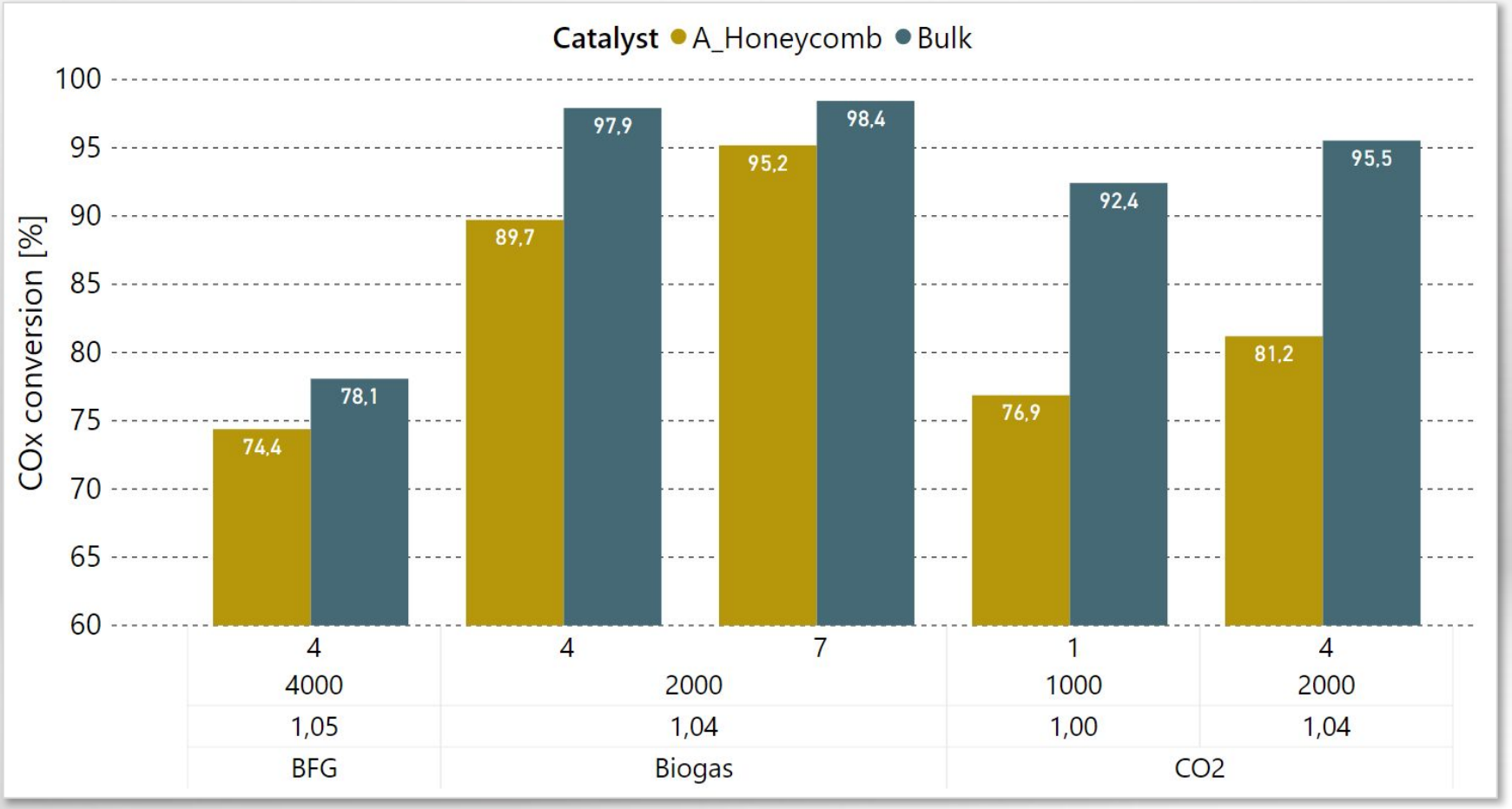
- Variation in activation procedure (reduction with H_2)
- Experiments for/with
  - CO_2 methanation
  - Blast furnace gas ($BFG_{synthetic}$)
  - Biogas (45 vol.-% CO_2, 55 vol.-% CH_4)
  - H_2/CO_2 = 1.0, 1.04, 1.05
  - GHSV & pressure variations
  - Comparison to bulk catalyst

- Repeatable performance over multiple weeks
- Stable Δp across methanation test rig
- No loose coating material detected



Results of methanation experiments with honeycomb catalyst

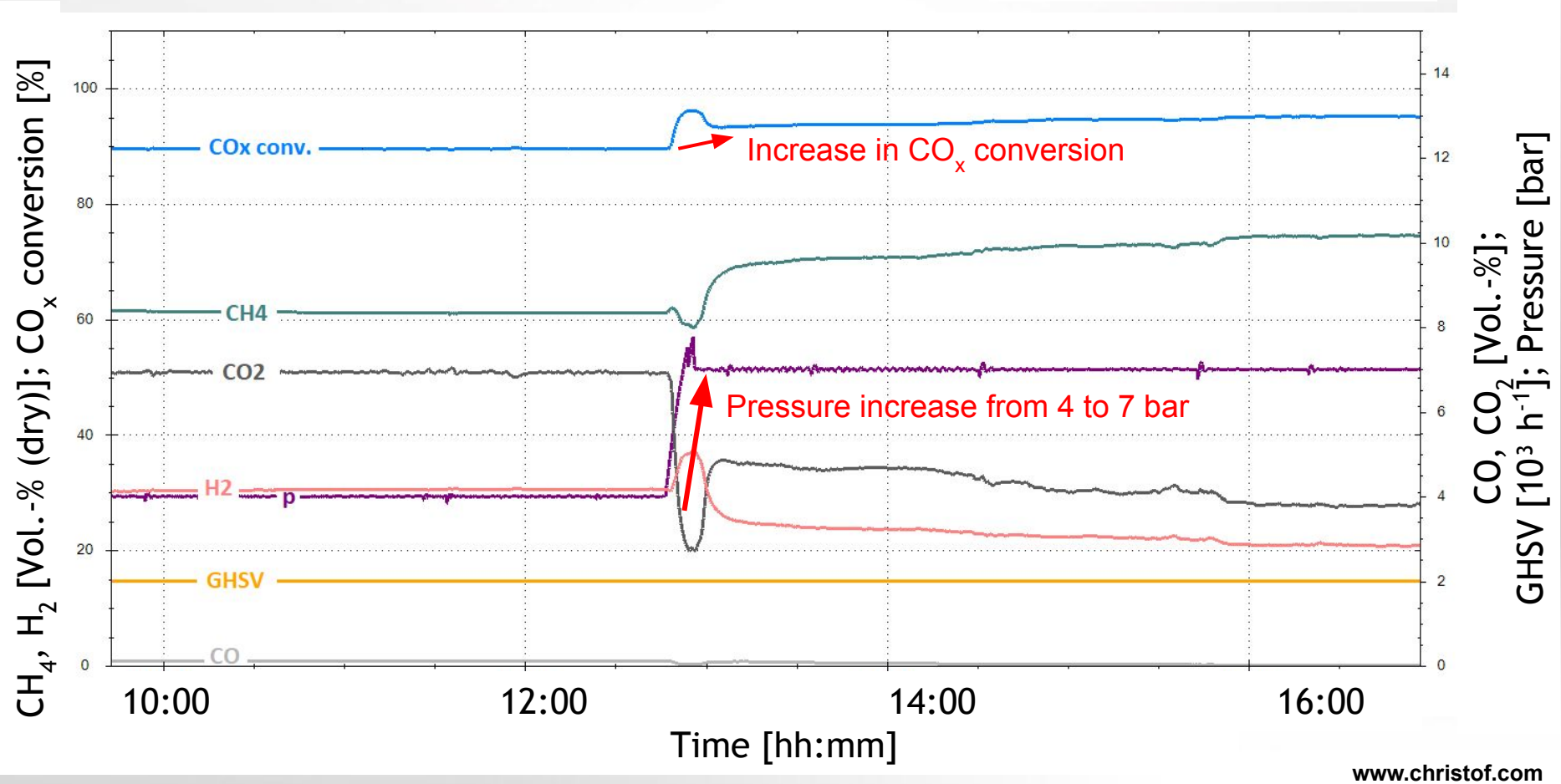
- H_2:CO_2 = 1, 1.04, 1.05
- GHSV variation (1000, 2000, 4000 h^{-1})
- Pressure variation (1, 4, 7 bar)
- Comparison to bulk catalyst



Results of methanation experiments with honeycomb catalyst

Pressure variation (4 to 7 bar increase) Constant GHSV at 2000 h^{-1}, 4% H_2 excess rate

Biogas	CO_2	CH_4
[Vol.-%]	45	55



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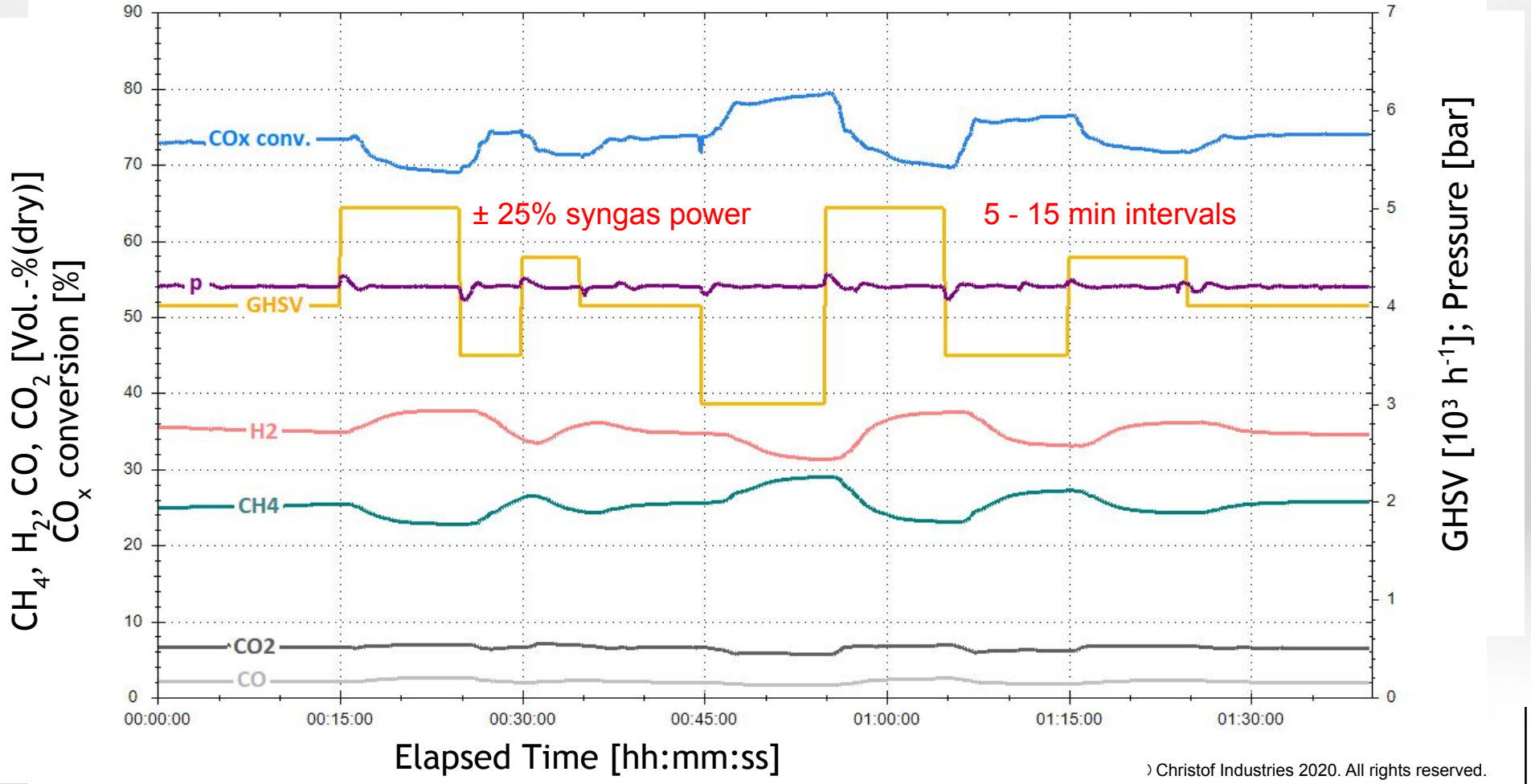
Results of dynamic methanation experiments with honycombs

GHSV variation (2000 - 5000 h^{-1})
p = 4 bar, 5% H_2 excess rate

BFG	N_2	CO_2	CO	CH_4	H_2
[Vol.-%]	~ 48	~ 23	~ 25	0	~ 4



Summary

Honeycomb Catalyst development:

- Stable bond of wash-coat, no loose coating material
- Repeatable coating procedure
- Stable Δp across methanation test rig
- Honeycombs catalytically active
- Long-term & consistent methanation performance
- Repeatable performance over multiple weeks

Project developments with the key messages:

- Energy storage (short-seasonal-long-term) in the form of H2 and CH4
- Energy transport via gas grids
- „Greening“ of energy sources renewable fuels
- Strengthening the competitiveness of renewable energies
- Significant reduction in greenhouse gas emissions

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