

On farm production and direct upgrading of biogas to Bio-CNG

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RES4LIVE Project

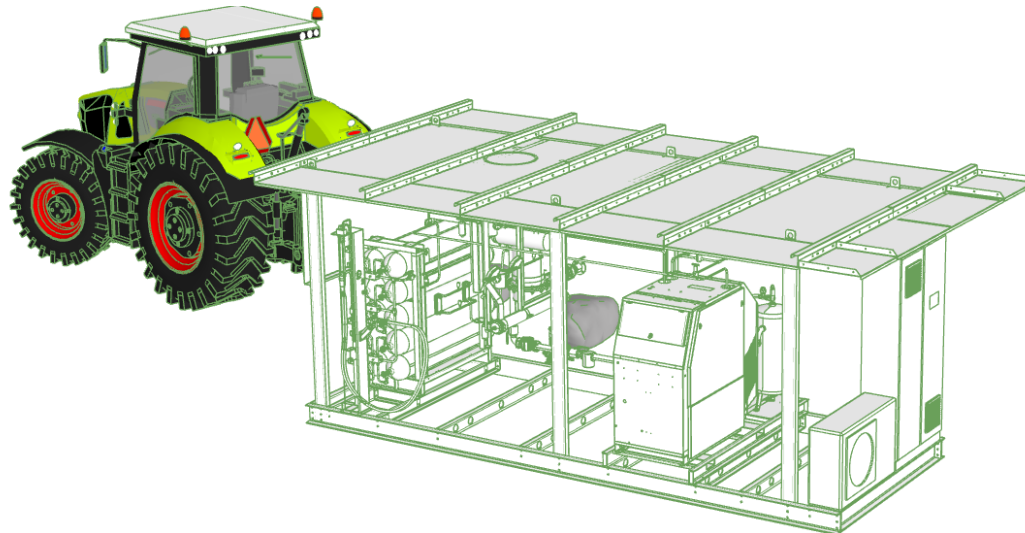
- **Project title:** RES4LIVE - Energy Smart Livestock Farming towards Zero Fossil Fuel Consumption
- **Work package 1:** Adaptation of innovative RES technologies for livestock farms
- **Grant agreement:** 101000785 (H2020)
From October 2020 to September 2024
- **Result (2024):** EU Innovation Radar designated project highlight

Task Overview

- **Objective:** adaption of a biogas upgrading kits specifically for biogas coming from manure of livestock farms (e.g. cattle, swine) with a focus on its cost-effectiveness at medium and small scales
- **Key innovations:**
 - (i) improve the pre-treatment process
 - (ii) Reduce energy consumption of upgrading line using advanced filters(low pressure membrane), higher efficiency compressor (hybrid) and cooler and membranes
 - (iii) adjust the technology for small and medium farm sizes
- **Status:** plant finally developed/engineered/running, Monitoring- and Demonstration operation with a BioCNG Farm Tractor ongoing

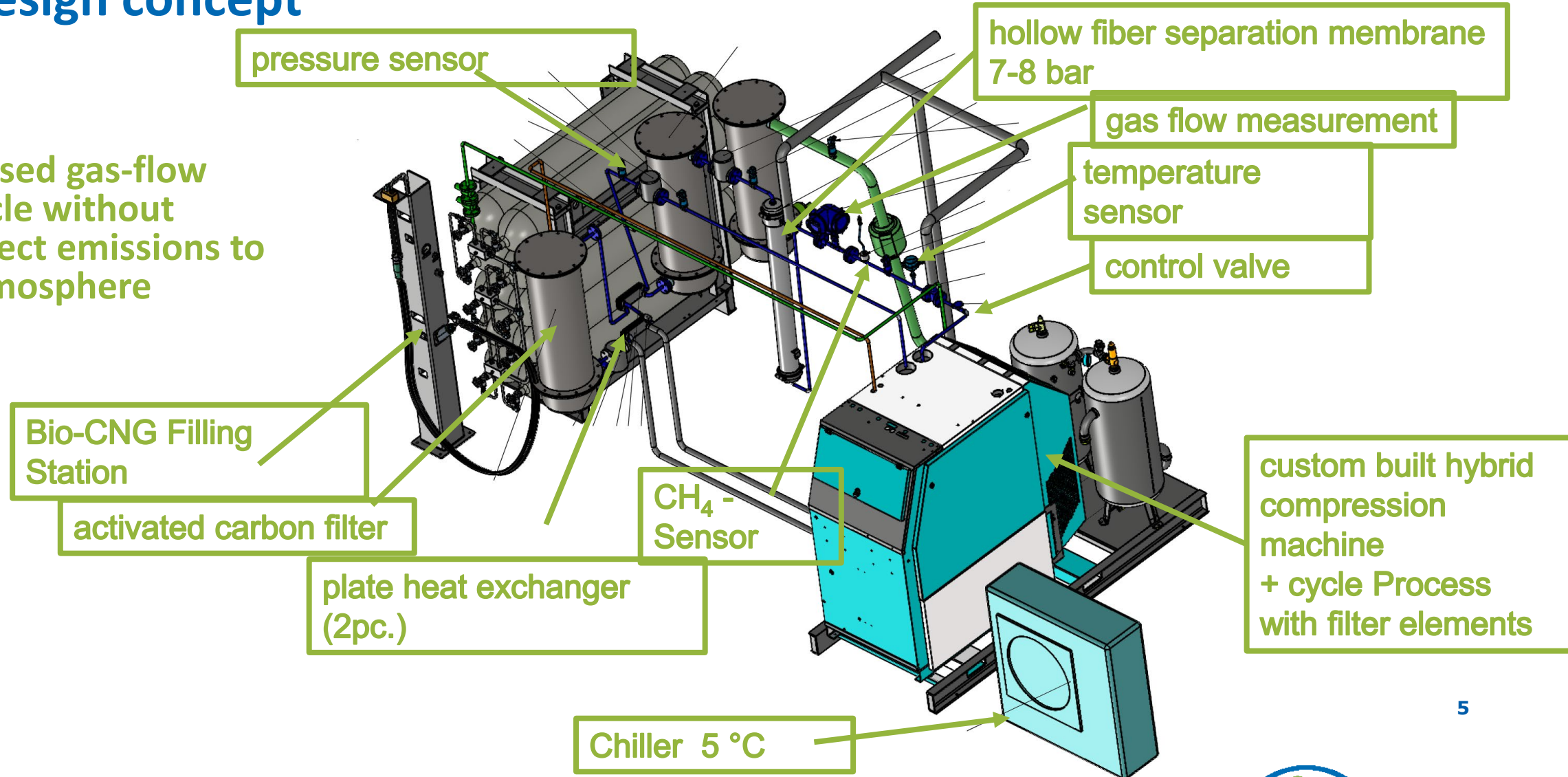
Biomethane as fuel for On-farm tractor propulsion

- Especially for agricultural livestock farms, off-grid biogas upgrading (6 and 12 Nm³ h⁻¹)
- Fuel production from biogas predestined for energy use in agriculture
- For the economic viability of micro-treatment plants, technically simplified plant concepts must be developed
- low specific investment costs and at the same time to guarantee the safety requirements



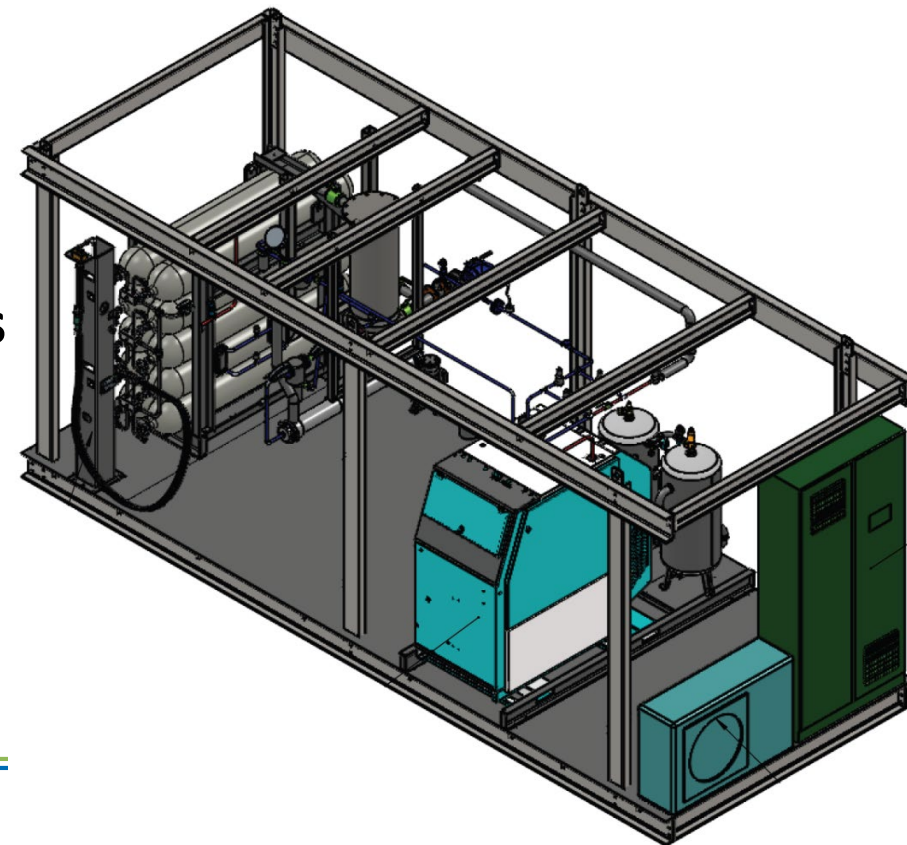
Design concept

- closed gas-flow cycle without direct emissions to atmosphere



Technical characteristics of Micro-Bio-CNG plant

- plant operates as a fully **closed cycle process**
- **10-12 Nm³ h⁻¹ raw biogas dewatered**, oil separated, NH₃ separated and fine particles separated
- **4-5** of the 12 Nm³ h⁻¹ are **concentrated** to a CH₄ content of **around 97%**.
- 4-5 Nm³ h⁻¹ are highly compressed to CNG with the same compressor (@~250bar)
- **off-gas flow with about 80% CO₂** content and the rest CH₄ is completely recycled back into the biogas storage
- system components are **thermally insulated** and **zones** at risk of frost are permanently protected
- BioCNG **filling process** takes about **5 minutes**



Novelty of Micro-Bio-CNG plant

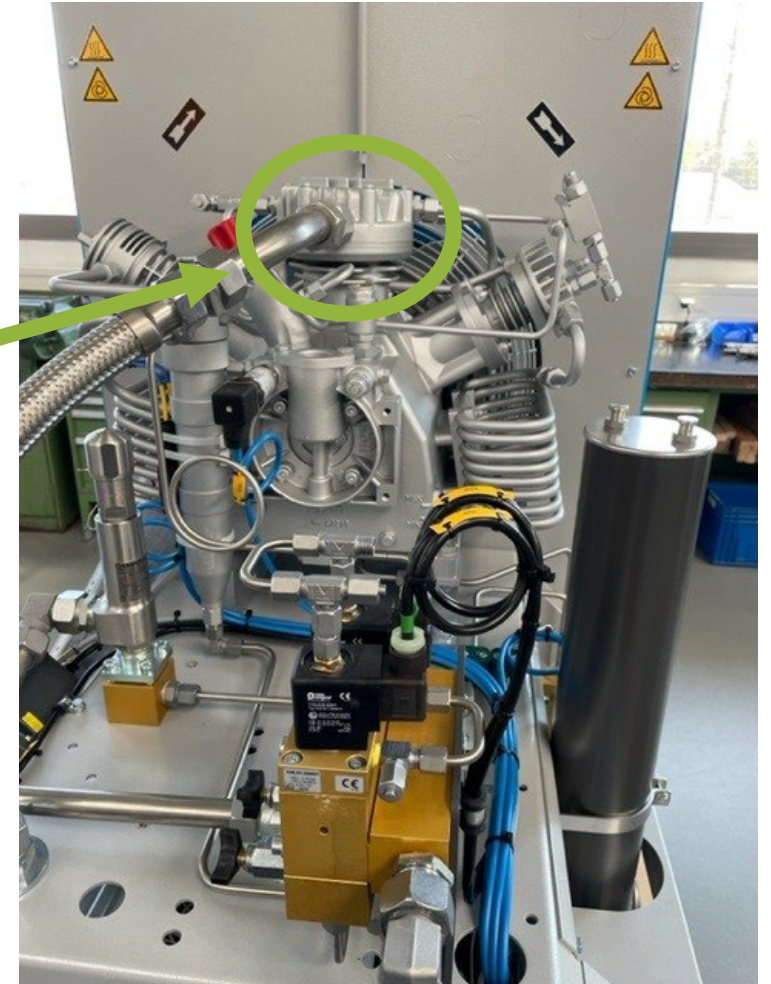
- very simplified and compact design in terms of compression
- 1-stage (single membrane) process for CH₄ concentration instead of a multi-stage
- no direct emissions at the Biomethane-, and compressed to Bio-CNG plant
- hybrid compressor > gas permeation [>95% CH₄ biogas] and CNG high compression can be managed with just one compressor block
- 20ft open frame >>no closed zones/rooms where explosive zones can develop



Custom-built hybrid compressor



Point of
discharge of the
gas for the step-
intermediate
biogas
purification and
return to
compressor
stage 2



Key Performance Indicators of the BioCNG pilot plant (first year of monitoring)

- 10-12 Nm³ h⁻¹ raw biogas plant at LVAT pilot farm – running since 07/2023

key indicator	$\bar{x}$	SD	n
specific energy consumption [kWh _{el} /Nm ³ BioCNG]	0,94	0,15	14896
separation pressure hollow fiber membrane [bar]	7,83	0,47	18771
separation temperature hollow fiber membrane [°C]	57,44	2,49	18771
methane concentration [%]	96,75	1,28	29771
start-up time until BioCNG production OK [min]	26,78	5,49	9

Full cost calculation €/kg BioCNG fuel

- Production costs for agricultural BioCNG
 - Biogas costs of 0.5 €/kgCH₄, electricity costs of 0.2 €/kWh and a depreciation period of 10 years assumed
 - 10 m³/h plant (**built**) 2.25 €/kg BioCNG fuel
 - 35 m³/h plant (**built**) 1.51 €/kg BioCNG fuel
 - 65 m³/h plant (**planned**) 1.37 €/kg BioCNG fuel

Defossilization of agriculture and forestry

- Key figures that illustrate the enormous potential of this technological solution for defossilizing agriculture and forestry
 - **1 cow = 289 Nm³* biomethane / year** (*FNR) = 208 kg bio-CNG/ year = **4000 car kilometers**
 - **1 tonne of wheat straw = 250 Nm³* biomethane** (*Atres Group) = 180 kg bio-CNG/ = **3600 car kilometres**

Defossilization of agriculture and forestry

- As a non-fossil fuel, bio-CNG can also be used efficiently in tractors and trucks, thus making a significant contribution to fuel self-sufficiency in agriculture.
 - 1ha ploughing with rotary plough = 25.52kg Bio-CNG (*KTBL; Conv.F. -Diesel/CNG 1.25)
 - With the biomethane (CNG) from the manure of a cow (*FNR) more than 8 ha of ploughing can be carried out annually with a rotary plough (*KTBL; Conv.F. -Diesel/CNG 1.25)

Conclusion and Outlook

- Technology offers the **opportunity to de-fossilize agriculture and forestry**
- **Farms** can **produce fuel** for tractors **from** their own field **residues** and livestock manure in an economical way
- Brings **CAPEX** and **OPEX** costs for these very small plants to a **competitive level**
- **Small fleet sizes** of 3 tractors to 10 cars feasible
- **Easy scalable** to 10, 20 and 30+ kg BioCNG h⁻¹ within the designed 20ft frame
- Economics: goals < **€1.8 €total** (OPEX + CAPEX) per kg of BioCNG; < **10 years** amortization period for the system
- **Necessity** to make GHG quotas monetarily usable also for the operators of such small biofuel plants

Thank You!