



Biocat – Power to Gas technology by Biological  
methanation

Integration to a resource treatment plant

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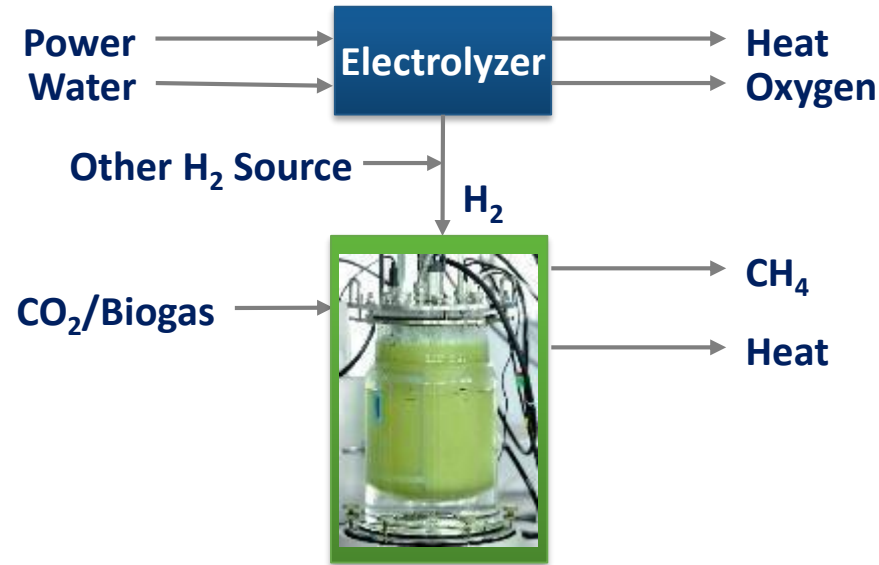
# What is the Power-to-gas ?

## Charging the natural gas grid

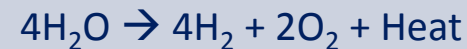


- Excess renewable power
- Grid congestion
- CO<sub>2</sub> emissions
- Established grid, storage and uses for natural gas.
- Decarbonization
- Need for renewable gas

# What is Biological methanation ?



1) Electrolysis



2) Methanation



**Net Reaction**

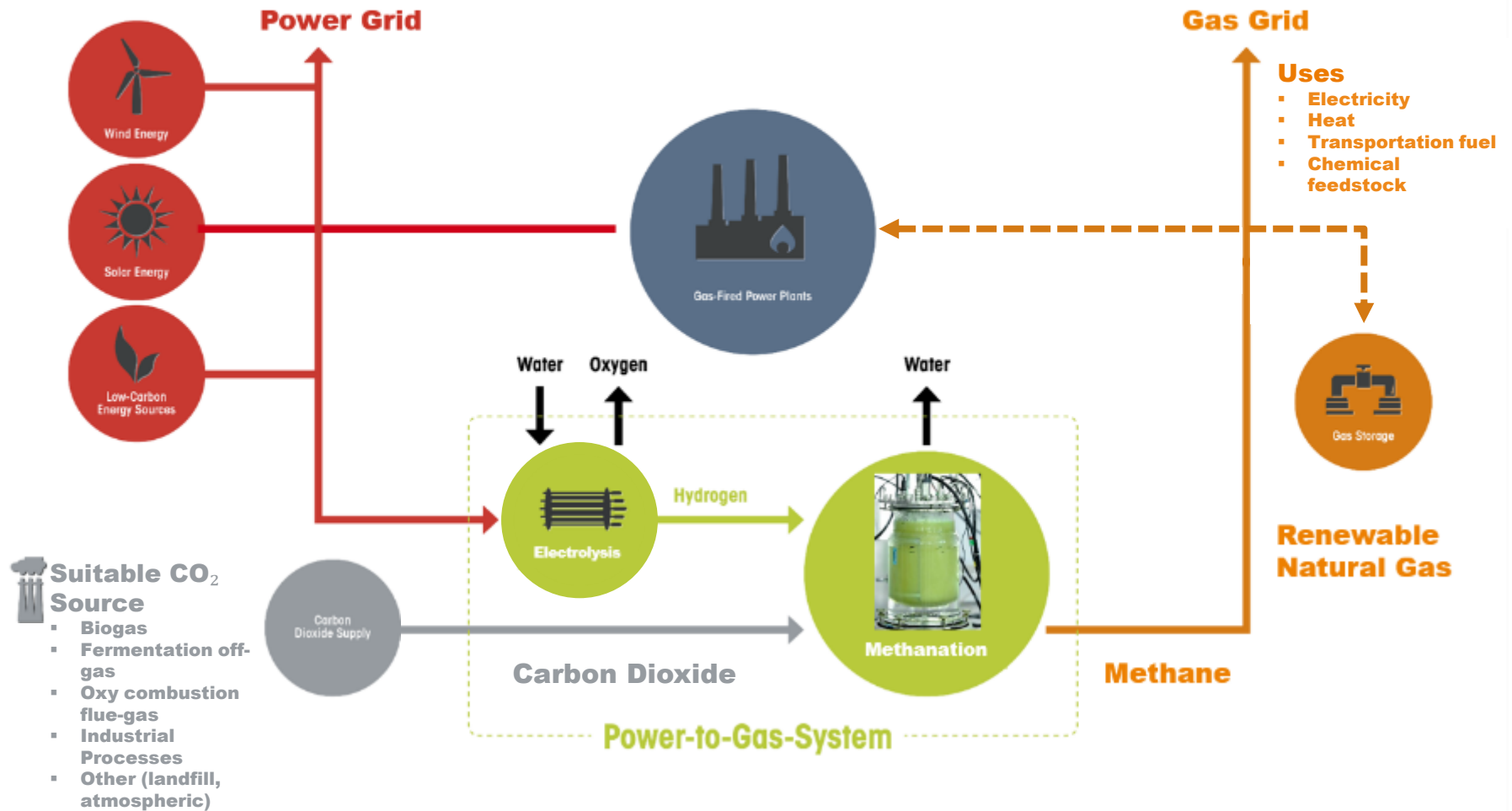


**Operating Conditions:**

Temperature 62°C, Pressure 1 to 10 bar(a)

# Opportunities for process integration

## Power-to-Gas Energy Storage



# Electrochaea Executive Summary

Electrochaea's vision is to become the world's leading technology provider in power-to-gas energy storage

## ▪ Opportunity

- Conversion of low cost energy and carbon dioxide into natural gas, leveraging existing infrastructure
- Decarbonization of power generation, transport fuel, and industrial processes

## ▪ Technology

- Proprietary, simple and robust biocatalytic methanation system
- Dynamic and scalable process to meet a broad range of conversion and storage applications (1 to >100 MW)

## ▪ Execution

- Expert team with proven track record
- 1 MWe commercial scale operation commissioned in 2016
- 1 MWe plant erected in 2017-2018
- 10 MWe study for Hungary

## ▪ Funding

- Consortium of venture and strategic investors with 1:1 non-diluting capital



**Mich Hein, PhD**  
**Managing Director**

- Co-founder and managing partner at Nidus Partners
- Passionate entrepreneur
- Raised \$50 Mio for start-ups



**Doris Hafenbradl, PhD**  
**CTO**

- 20 years of experience in biotech and pharmaceutical industries
- Expert in hyperthermophilic archaea



**Markus Forstmeier, PhD**  
**VP Business Development**

- 15 years of experience in renewable energy and water treatment space
- Closed major partnerships and contracts >\$25 Mio

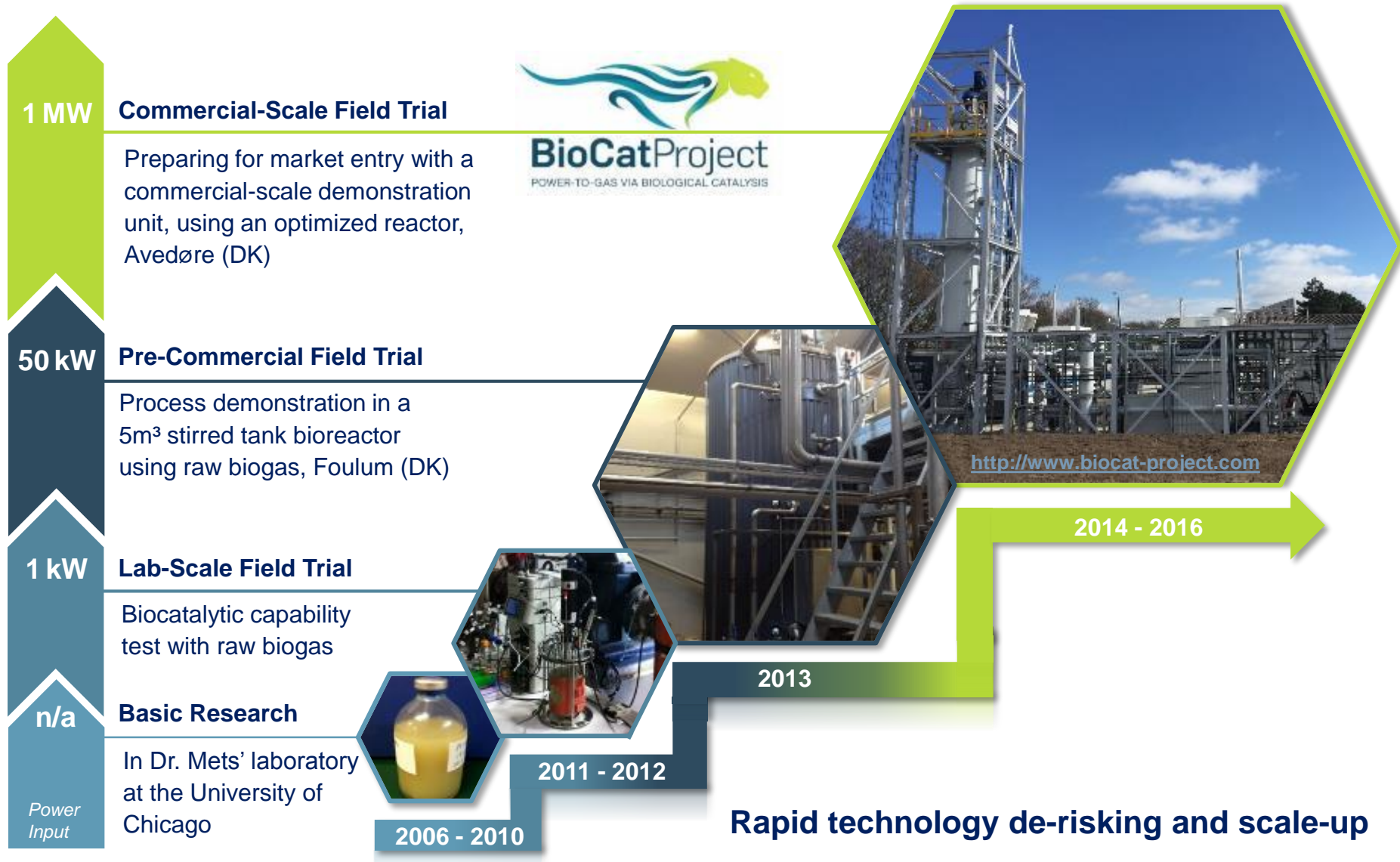


**Laurent Lardon**  
**Biocat Project Leader**

- 15 years of experience in development and technology maturation of biological processes
- Anaerobic processes and Process Control specialist



# Rapid technology de-risking and scale-up



# How it Began: Chicago, USA

Dr. Laurens Mets' Laboratory, University of Chicago

The seeds were planted in the laboratory of Dr. Laurens Mets at the University of Chicago

- Demonstration of high efficiency conversion of carbon dioxide and electrical energy into methane
- Optimization of a unique strain of Archaea
- Filed patent applications on stirred cell system and bioelectrochemical systems

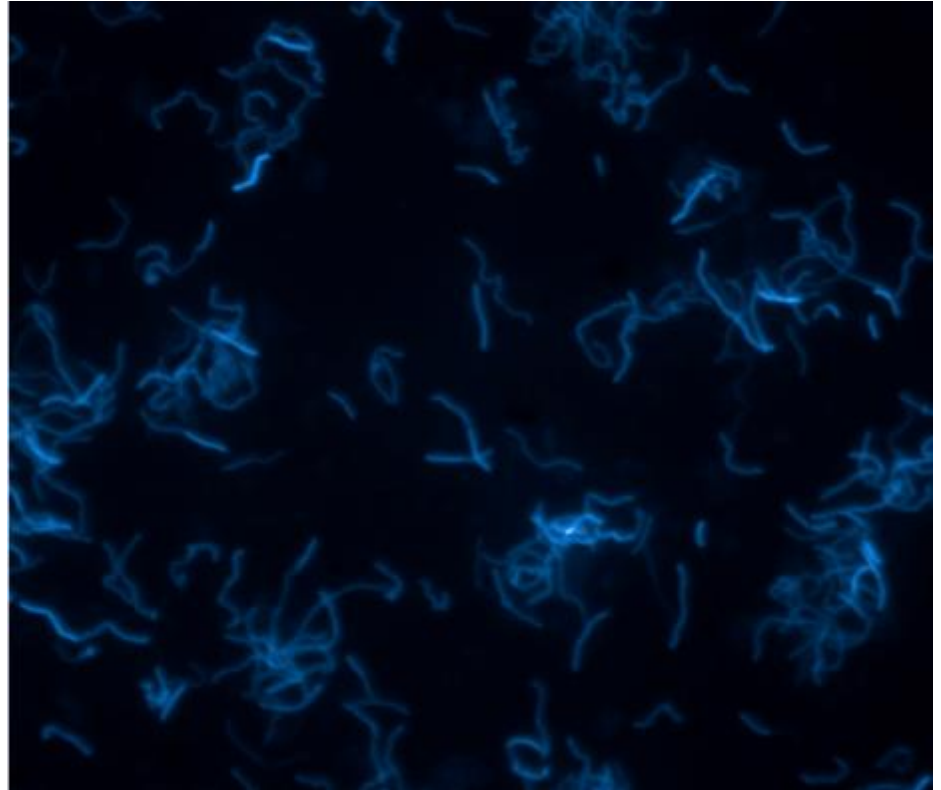




# How it Began: Chicago, USA

Dr. Laurens Mets' Laboratory, University of Chicago

- Highly efficient biocatalysis with Archaea in stirred cell reactors and in bioelectrochemical systems was established
- Scalability towards commercial storage of renewable energy was demonstrated



# Foulum, Denmark

## Foulum Project "Carbon Dioxide to Methane – System Integration"

- In 2012, Electrochaea.dk proposed the project "Carbon Dioxide to Methane – System Integration" with its partners Aarhus University, EON and NEAS Energy
- The 12mio DKK project was supported with a 6.6mio DKK grant from EUDP and additional project support from Electrochaea LLC, EWZ, and Energie 360°



# Foulum, Denmark

## Continuous Operation for 3 600hrs

- The reactor operated in 4 800 liters of reactor volume for 3 600 hours, demonstrating scalability and process efficiency
- product gas was used in the local CHP generator



# The BioCat Project

Avedøre, Denmark

- As part of the Foulum project, Electrochaea.dk identified potential sites for its first megawatt scale reactor, called “BioCat”, with the capacity to inject biomethane into the Danish gas grid
- Funding for the project was secured from the ForskEI program in 2014
- Detailed engineering and construction for the BioCat Project began in 2015 after completion collaboration agreements among the Project Partners





# The BioCat Project, Avedøre

Can We Reach High Efficiency at this Scale?

We started with a greenfield site adjacent to the planned gas testing and gas injection site for HMN's commercial grid in Copenhagen



# The BioCat Project, Avedøre

## Managing Full Site and System Integration

The methanation reactor and balance of plant systems were contracted to Zeton, Inc., in Enschede NL





# The BioCat Project, Avedøre

## Managing Full Site and System Integration

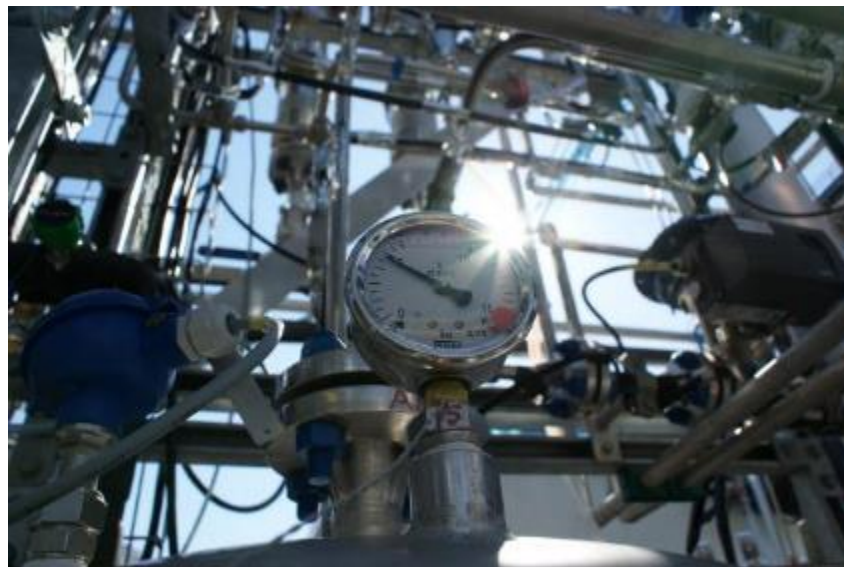
The biomethanation reactor, agitator and balance plant were laid in place in less than one day



# The BioCat Project, Avedøre

## Aiming for Grid Injection

Biocatalyst inoculation and first conversion of CO<sub>2</sub> to methane in April



# Who are these bugs?

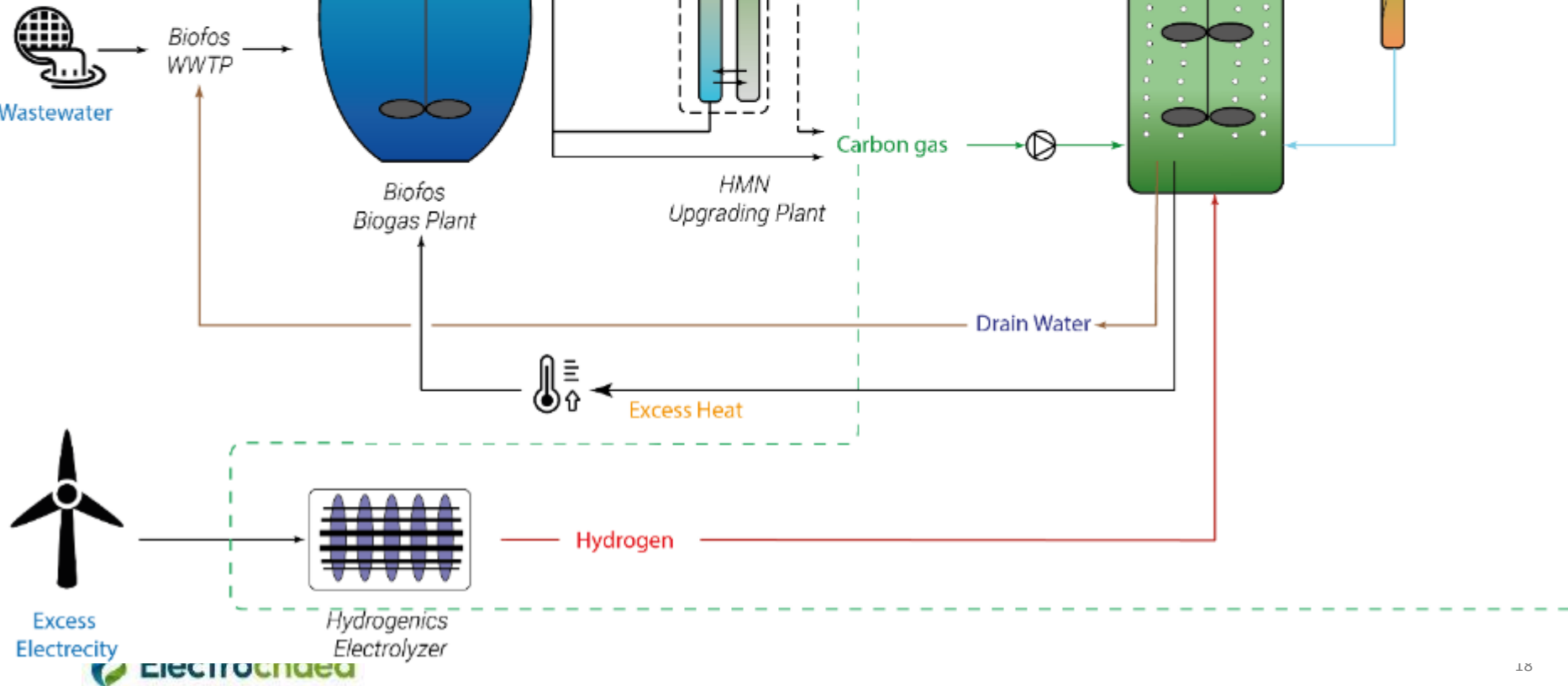
- Here our most valuable employees, the Archaea should be presented



# A methanation reactor integrated to a Wastewater Treatment Plant

Demonstrates:

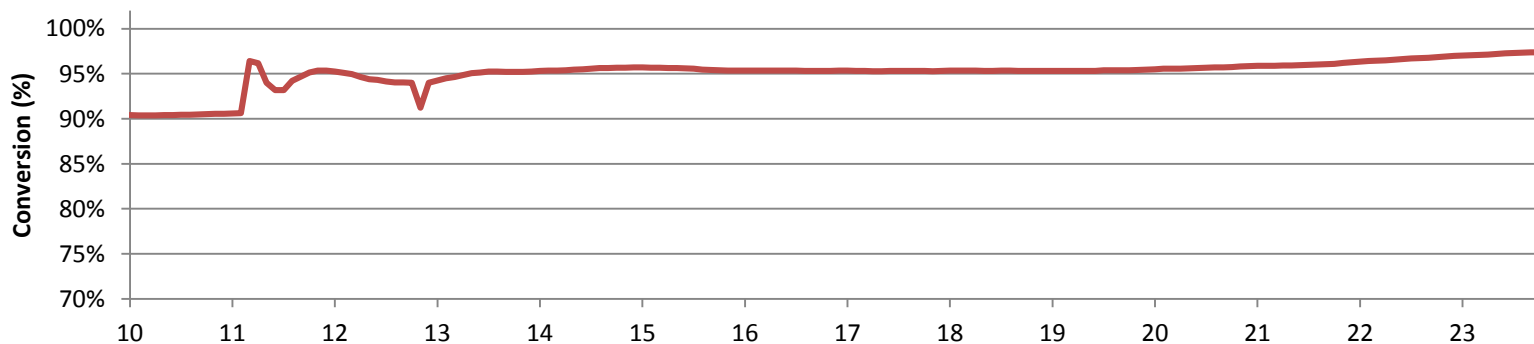
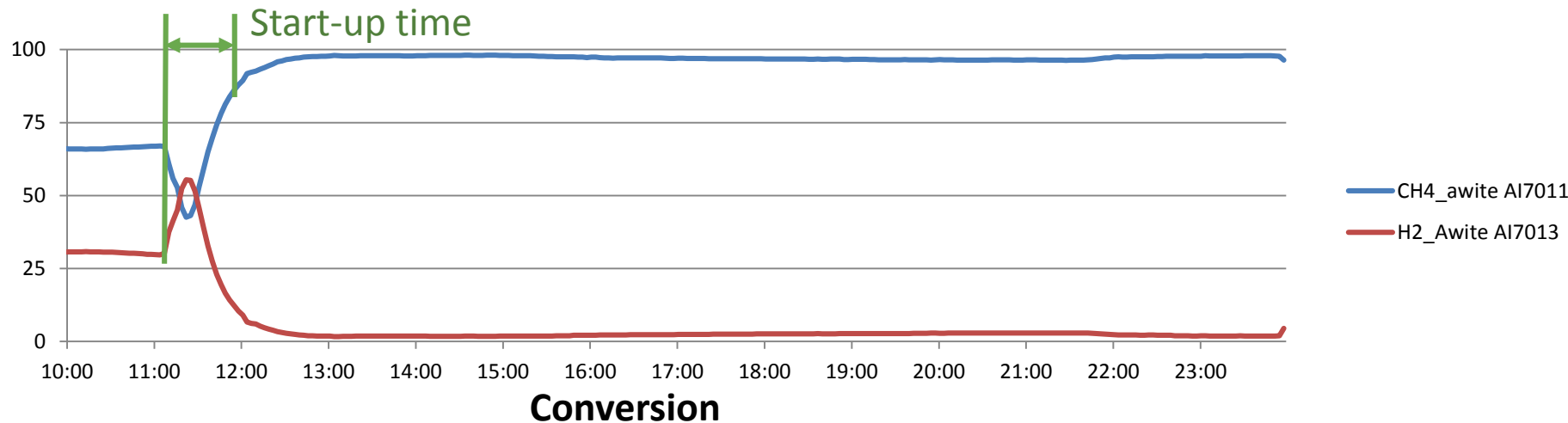
- Energy Storage
- Biogas upgrading
- Process symbiosis





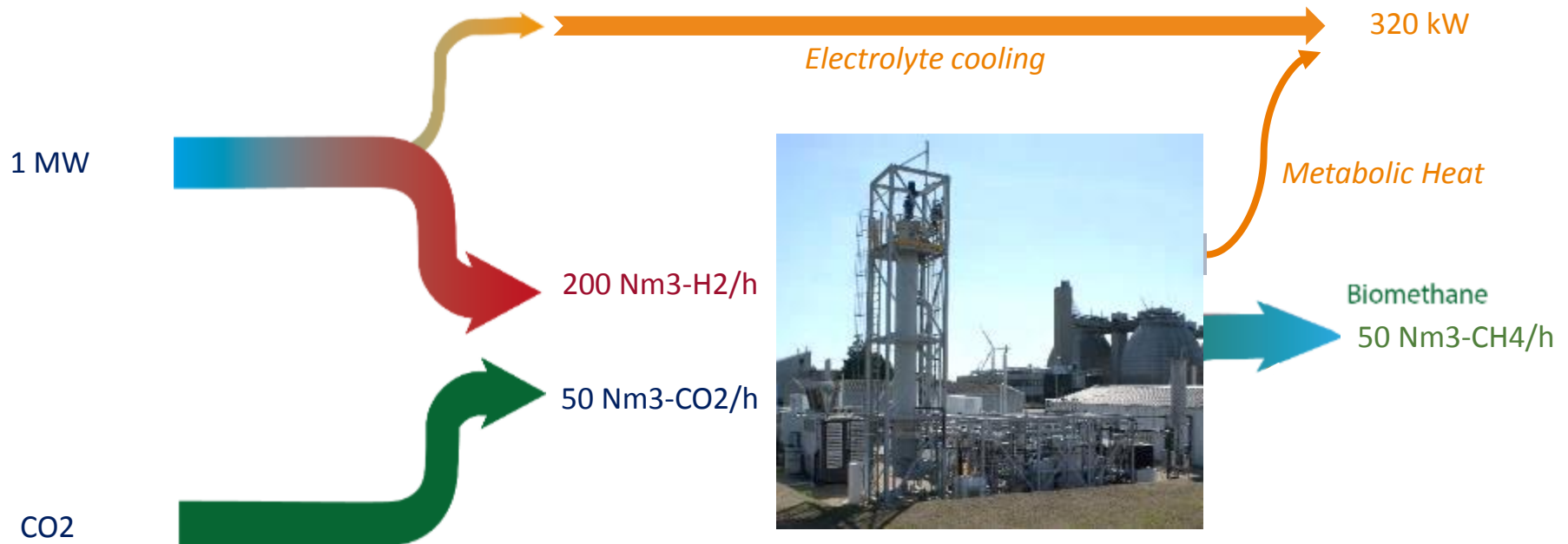
# Operational results

- Cold start in 45 minutes after 60 hours idle
- Methane content > 97% before polishing
- CO<sub>2</sub> conversion > 98%



# BioCat: Biological methanation system in Megawatt scale

- Conversion of excess renewable power into biomethane



- Proprietary Bio-Catalyst (4 patents), in-house system design & operation
- Scaling: to 10 MW and 50 MW systems and regionally
- Competitive Advantage: dynamic operation, high tolerance to impurities



# The Future

## Continue Operation of BioCat Plant – Integration to WWTP

- Electrochaea and the project partners intend to continue operating the BioCat reactor and electrolyzers as a commercial scale power to gas facility
- Commercial sale of renewable biomethane to the Danish gas grid, to demonstrate conditions for economically viable power to gas conversion in Denmark
- Serve as a reference facility for future projects

### Intensify industrial symbiosis

- Heat exchange from the electrolyzers
- Scaling of Oxygen injection to activated sludge.

### Environmental Technology Verification

- 1000 hours of operation
- Different operation modes: continuous, power-regulation, biogas / CO<sub>2</sub>



# Business model and growth strategy

Be the key technology provider for biological methanation

## Focus on key markets

### Tap multiple revenue streams

- Payments for feasibility studies on special feed gases
- Fee for initial engineering of BioCat core and interfaces
- Royalties for utilization of proprietary bio-catalyst
- Operation & maintenance fees

## What are the next steps?

- Expand BioCat plant size to grid scale at 10 MW and 50 MW
- Secure contracts and financing to execute first grid scale project
- Expand technology and IP advantage
- Reduce overall system cost
- Engage with industrial partners to identify first of a kind 50 MW project

# Partners and Investors



**HYDROGENICS**  
SHIFT POWER | ENERGIZE YOUR WORLD



**Audi**  
Vorsprung durch Technik



**HMN**  
GASHANDEL



**INSERTO**  
BUSINESS SERVICES

**NEAS ENERGY**



**MVP** ///  
MUNICH VENTURE PARTNERS



**energie360°**



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**ECOSUMMIT AWARD**  
Fame and Fortune for the Best Smart Green Startups

**Bronze medalist 2016  
in early stage category**



**Thank you for your attention and questions**

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