DeCrises

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De carbon DHS

IMP PAN GDAŃSK

Roadmap to decarbonization of district heating

Adam Cenian

IMP PAN

LoCaGas

Kaunas, 17.06.2026

RePower EU strategy

The aim of strategy is energetics: sustainable, secure and independent from Russian fossil fuels

How to solve this problem:

- **increased energy efficiency – avoiding losses !!**

- **biogas** and green hydrogen

Goal energy storage for winter and transport fuels

- flexible cogeneration

and

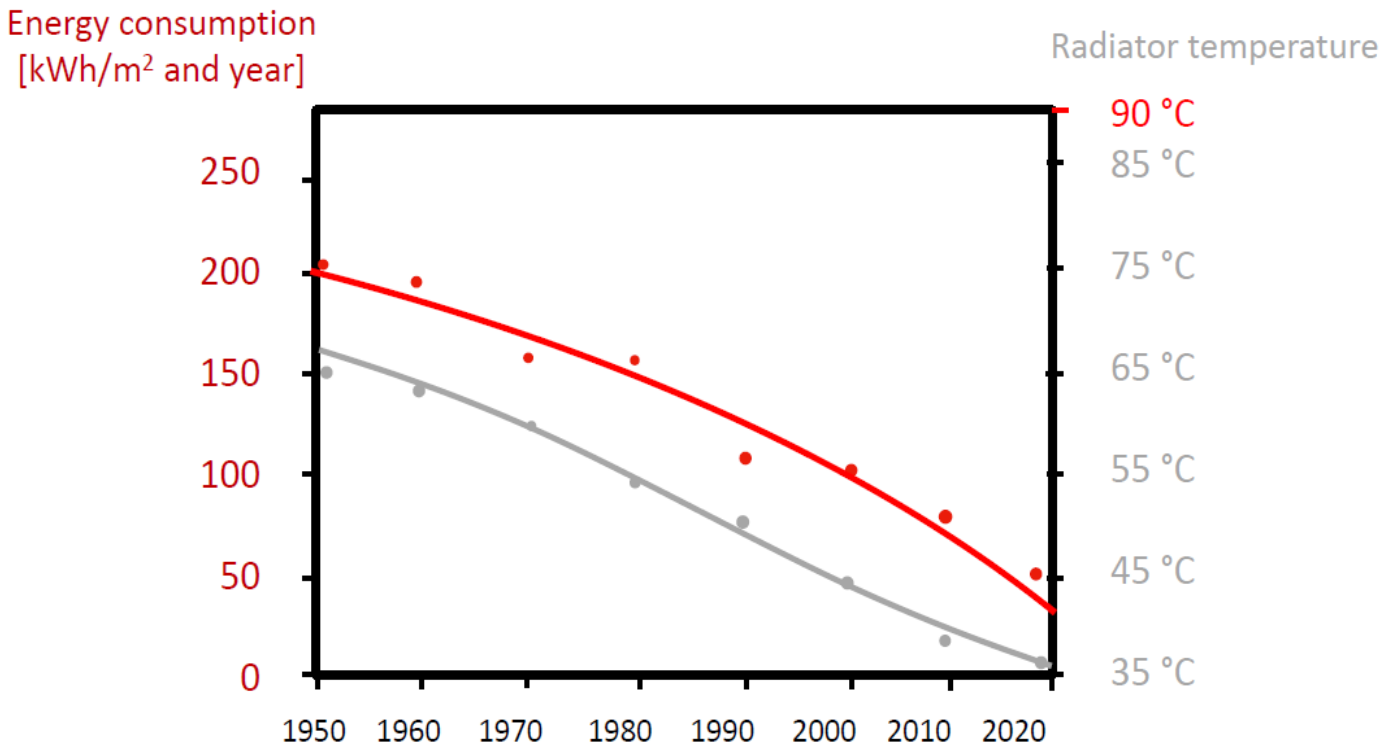
- digitalization of district heating (Hpump)

Role of energy efficiency – decreased supply temperature

Energy consumption and forward temperatures in buildings in Sweden

Role of buildings energy efficiency

Supply temperature decrease



Source: e-on

LTDH advantage and challenges

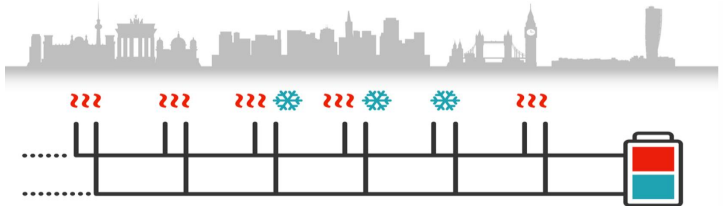
- low temperatures reduce heat losses in DH pipes
- LTDH enables inclusion of RES e.g. thermal collectors, geothermal sources, …
- enables use of low temperature waste (surplus heat)
- low temperatures reduce the thermal stress in pipes and prolong DH life
- low temperature of return flow heat enables its application for flue gas condensation
- Challenges: waste heat incorporation, energy storage and cooling

How ? - roadmap to LTDH

- New city districts with LTDH – Berlin Adlershof
  Ectogrid – Lund
- District with renovated houses - Albertslund
- District with nonrenovated houses

- Lowering temperature in whole DH grid – Łomża
- Surplus heat utilization – Kalundborg, Gdansk

Source: BSM – Beratungsgesellschaft für Stadterneuerung und Modernisierung mbH



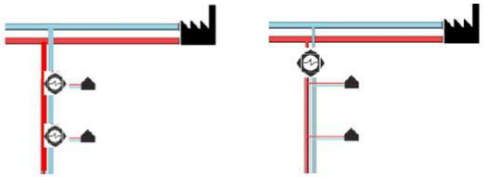
Source: e-on, http://ectogrid.com/

Source: Albertslund Kommune, Housing department, Denmark

Source: Høje-Taastrup Fjernvarme a.m.b.a., Denmark

Source: M. Dzierzgowski, IMP PAN ***PW***

Source: Kalundborg Symbiosis



Source: D. Formela, IMP PAN

New districts

New city district with LTDH – Berlin Adlershof (BTB Berlin)

Project background

62 energy efficient buildings (15 W/m²), including 5 low energy and 3 plus energy buildings

Implementation of a LTDH with bidirectional connection, allowing the owners to feed-in self-produced energy from thermal solar panels

surplus thermal energy produced by the solar thermal system fed into the district heating network can be used later (2 year period of clearing)

LTDH grid (60/40 °C) linked to the district

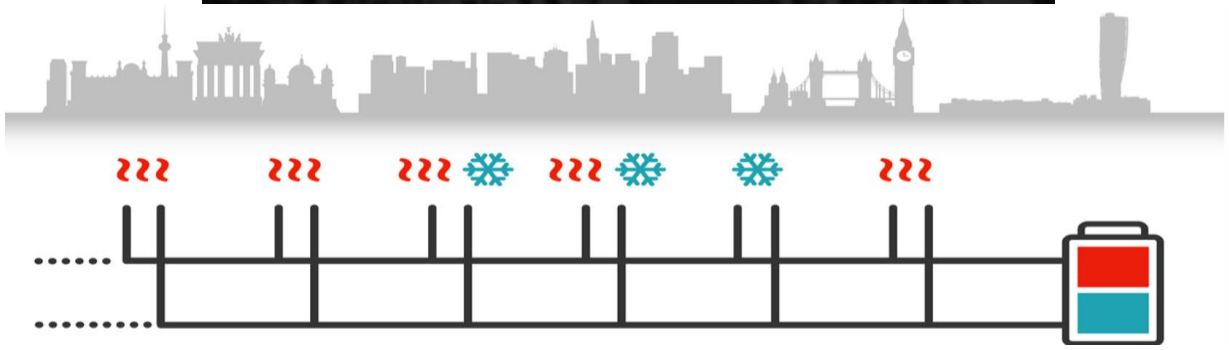
LTDH can save 65% in primary energy compared to decentral (individual) building heating systems

Source: BSM – Beratungsgesellschaft für Stadterneuerung und Modernisierung mbH

Source: Jan Gerbitz, ZEBAU, Germany

New city districts with LTDH – Ectogrid Lu

The first ectogrid™ at Medicon Village, Lund will connect 15 commercial and residential buildings with different heating and cooling demands of 1600 persons in more than 120 organizations working in life science; Medicon Village with yearly supply 3 GWh_{th} has the potential to balance as much as 11 GWh_{th}



Source: e-on, Sweden

Old renovated districts

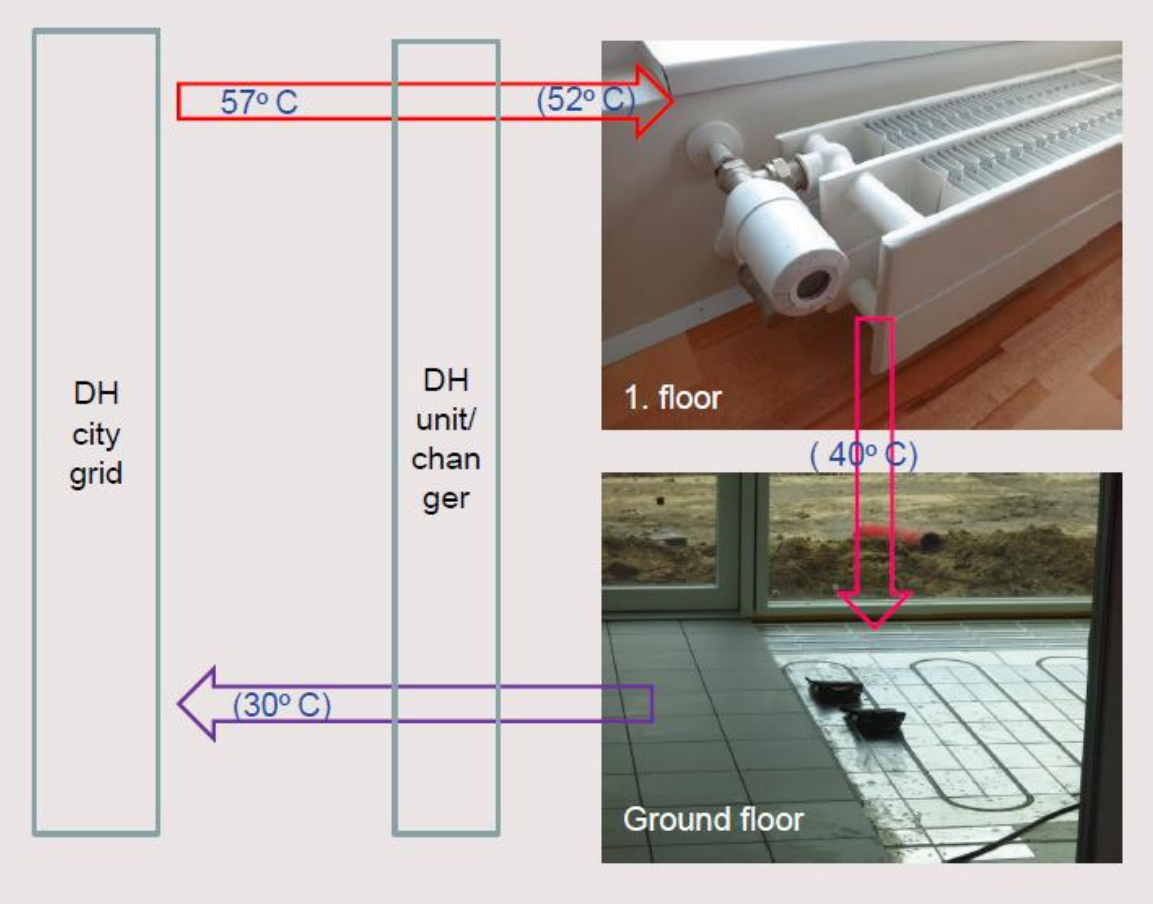
Low temperature grid in renovated houses Albertslund

New measures: insulation of roof and walls

Isolation of windows, toillets and new radiators

Source: Albertslund Kommune, Housing department, Denmark

Low temperature grid in renovated houses Albertslund



More than 50% reduction of heat bills enable to pay debts

Source: Albertslund Kommune, Housing department, Denmark

Old non-renovated districts

Low temperature grid in non-renovated houses in Sønderby

75 houses built in 1999 connected as one consumer through one district heating station with a heat exchanger

- all fitted with underfloor heating and a hot-water tank (boiler)
- heat losses in damaged pipelines were 41 - 48%

- TwinPipe system, series 2, size 76 and smaller with Logstors alarm-system X4, provides a precise identification of error location
- supply temperature of 55 degrees is sent from the mixing arrangement
- Consumer supply temperature 45 - 50 degrees
- return temperature is lowered to 30 to 20 degrees
- Legionella problems decreased by low volume tanks
- LTDH lower heat loss (still 13 %)
- LTDH is sensitive to consumer habits (the bad ones)

LTDH is sustainable solution even for non-renovated houses with floor heating

Source: Høje-Taastrup Fjernvarme a.m.b.a., Denmark

Modernized DH grid

Lowering temperature in whole DH grid – Łomża/Poland

Verified heat demand: 73,71 MWt; 860 substations, length 160 km
heat losses of DH grid: - 12,5 %

Goal 2022 : to convert the whole existing DH into LTDH
Supply T: from **121 / 65°C** in 2017 to **89 / 48 °C** in 2022
Decreased heat production from coal from **100** to **11,6 %** in 2022

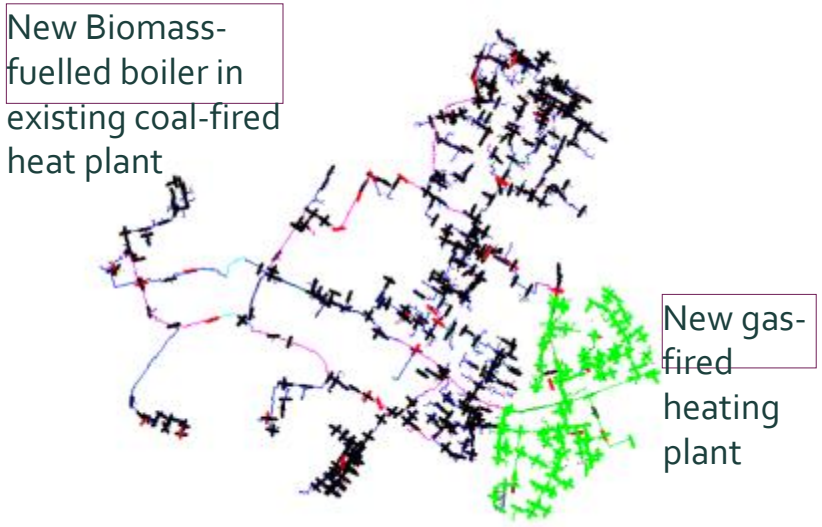
*Łomża City. Source: M. Dzierzgowski, IMP PAN, **PW***

Results: decreased mass flow; increased temperature drop - decrease of heat consumption in the buildings

Result: decrease of seasonal DH heat losses
Average seasonal DH return temperature:

,

Fuel: 52,0% Biomas, 36,4% Gas, 11,6 % Coal



Surplus/waste heat

Brunnshög in Lund

Project background

Lund is a fast-growing city with close to 120 000 inhabitants,

Lund University, research facilities MAX IV and the European Spallation Source (ESS) resulting in huge amount of surplus heat

Science Village Scandinavia will cover 100 ha and in 2050 up to 40 000 people will live and work in Brunnshög

65 °C supply line, 35 °C return line

construction commenced autumn 2017, first delivery planned on 2019

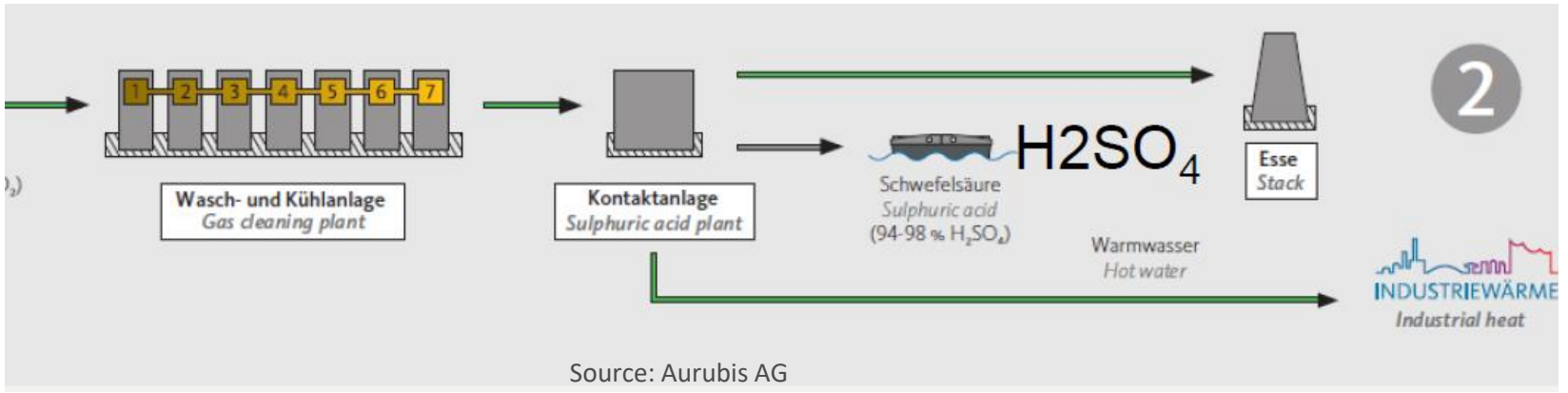
Vision image of Brunnshög I. Source: Kraftringen Energi AB

Surplus heat from Aurubis copper factory in Hamburg

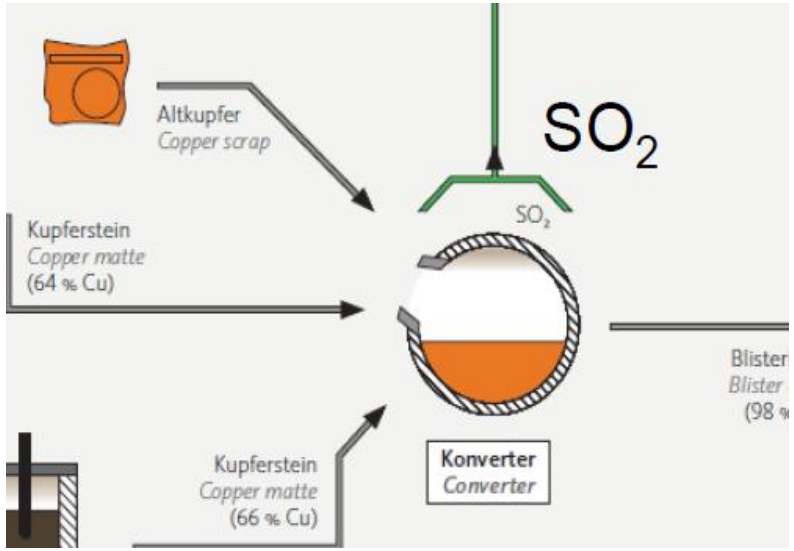
Aurubis AG, headquartered in Hamburg is the world's leading provider of non-ferrous metals, especially the largest copper producer in Europe

SO_2 released during melting copper matter is cleaned and turned to sulfuric acid in exothermic process – releasing heat

- **three** production lines
- each provides **18 MW**$_{th}$ - sufficient to supply HafenCity East;
- 2 other lines will also be implemented in the future
- annual CO_2 emission in HafenCity East will be limited to **4,500 t**



Source: Aurubis AG

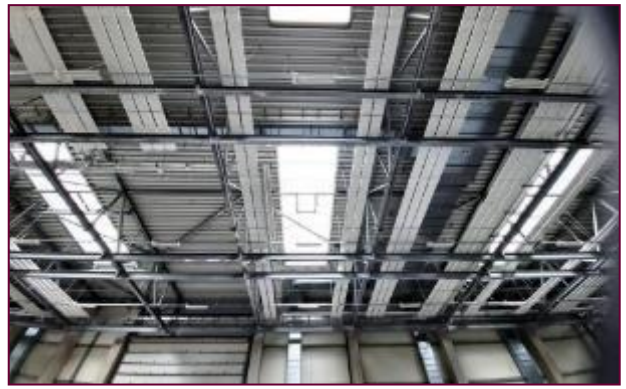


Surplus heat utilization in onside LTDH grid

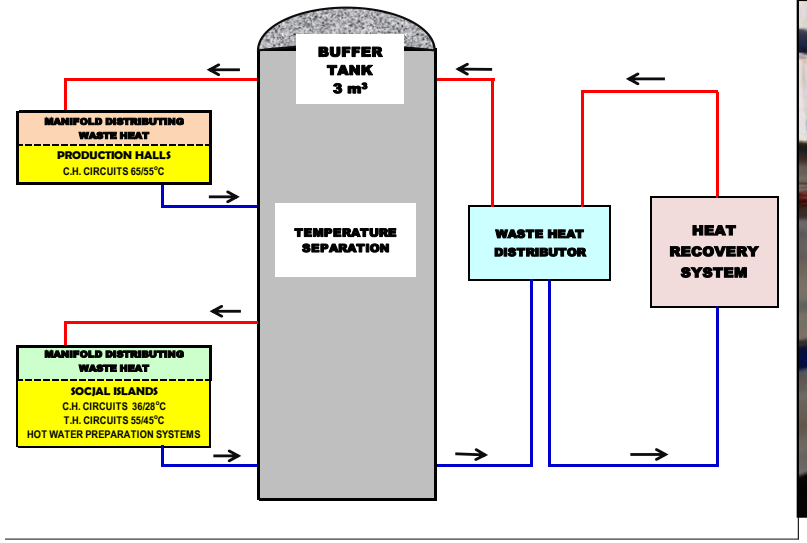
Surplus heat from products cooled after soldering in furnace (630 kW_{th} at 70°C) used for

- space heating (radiant heaters at 65/55°C, and floor heating - 36/28°C),
- ventilation with recuperation (55/45°C)
- domestic hot water preparation. (45÷50°C)

Up to 40 % of the surplus heat is used for heating purposes; the rest is dissipated by fan air cooler placed at the roof.



Radiant heaters



Floor heating

Sources: Foto: Zehnder, H. Raab

Source: D. Formela, T. Zurek – IMP PAN Gdansk

RePower EU strategy

The aim of strategy is energetics: sustainable, secure and independent from Russian fosil fuels

How to solve this problem:

- increased energy efficiency – avoiding losses !!
  - biogaz and green hydrogen

Goal energy storage for winter and transport fuels

- flexible cogeneration

and

- digitalization of district heating (Hpump)

Why biogas?

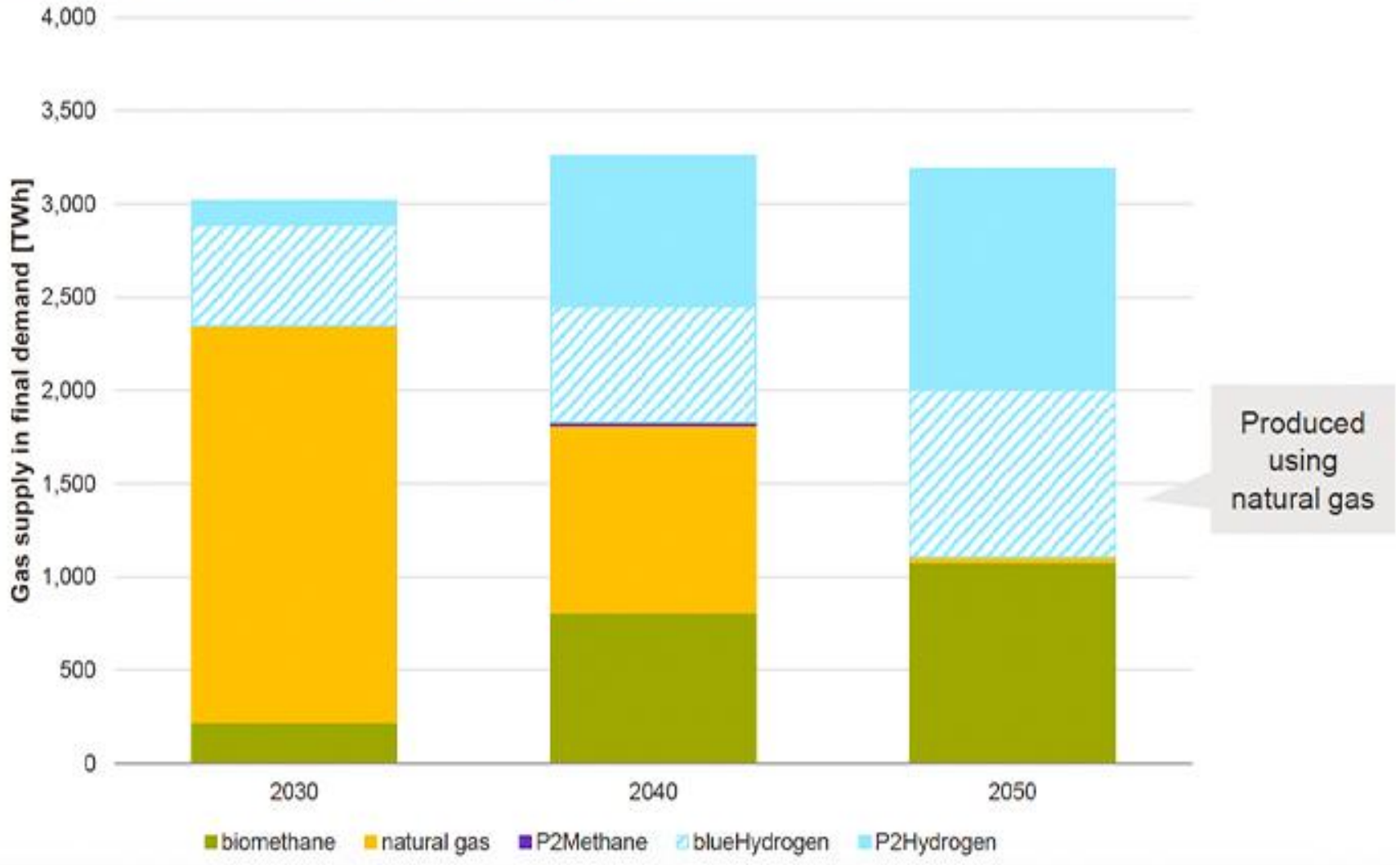
- **RES unstable (dunkel flaute)**

- **Biomethane valuable fuel for grid stabilization, district heating (CHP) and transport**
  Existing gas grids

- **Hydrogen expensive and more hard for transport and storage**
  necessary for long term full-decarbonization

Cost-optimal gas supply mix in final demand (EU27)

Baseline demand assumptions with high gas availability



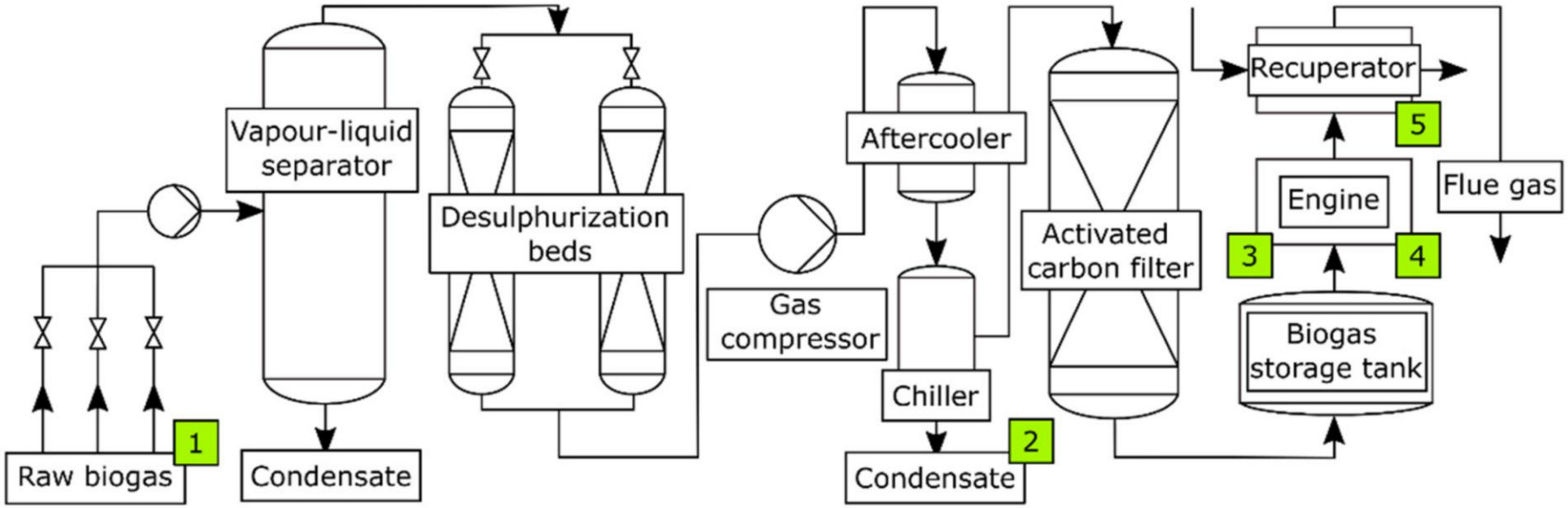
H2 - Lobbing

Znaczenie paliw gazowych:
+ opłacalność
+ bezpieczeństwo energetyczne
+ zrównoważoność

Important issues for biogas production

- Substrate choice, their storage (odours) pretreatment
- Technology choice (wet, dry or hybrid)
- CHP or biomethane production (gas cleaning and enriching)

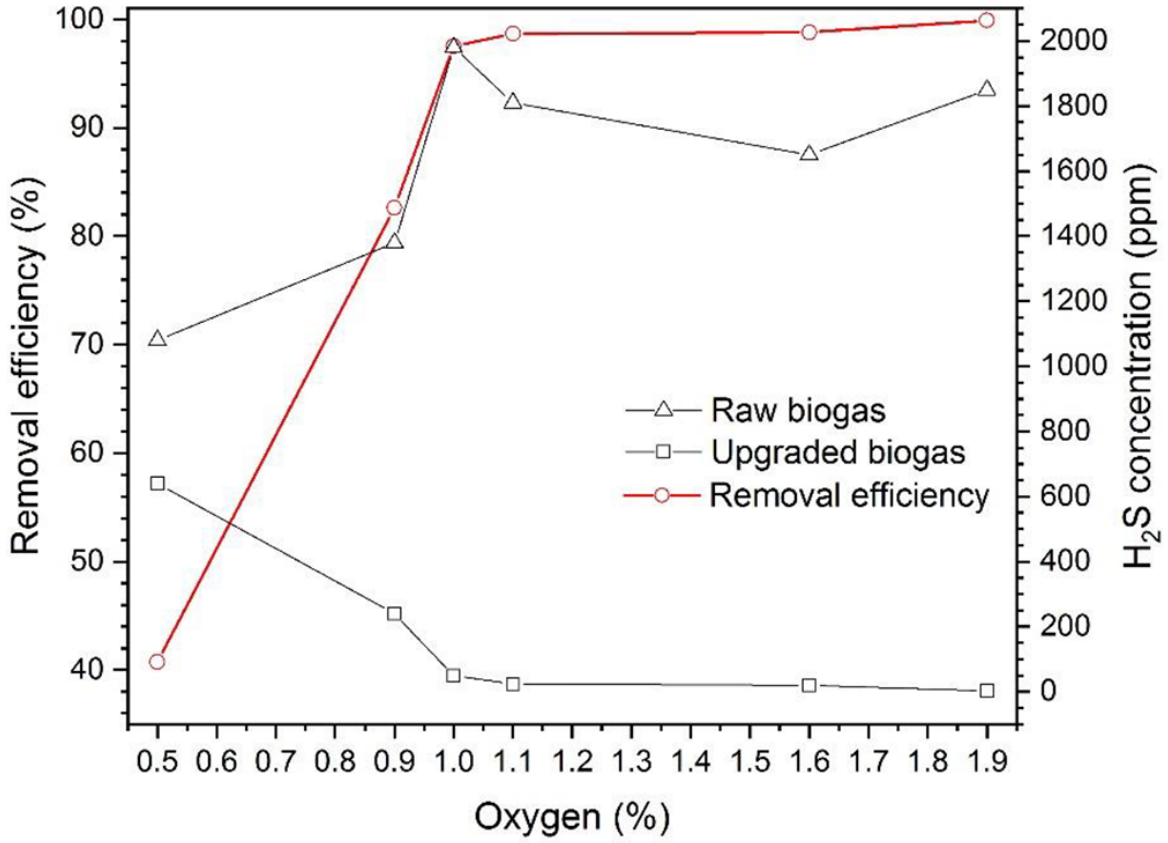
Cleaning of landfill biogas especially important



Konkol, I.; Cebula, J.; Świerczek, L.; Piechaczek-Wereszczyńska, M.; Cenian, A. Biogas Pollution and Mineral Deposits Formed on the Elements of Landfill Gas Engines. *Materials* 2022, *15*, 2408. https://doi.org/10.3390/ma15072408

Desulphurisation

$$MnO_2 + 2H_2S \rightarrow MnS + S + 2H_2O,$$



I. Konkol, J. Cebula, A. Cenian. Oxidization of hydrogen sulfide in biogas by manganese (IV) oxide particles, Environ. Eng. Res. 2021; 26(2): 2020 190343, DOI: 10.4491/eer.2019.343

Important issues for biogas production

- **Waste heat utilisation**
  - + heat transport
  - + biogas transport to place its utilisation (PE pipes)
  - + increased heat demand (breeding of fishes, algies, agriculture)
  - + heat storage
- **Biogas enrichment (various technologies) or methanation**

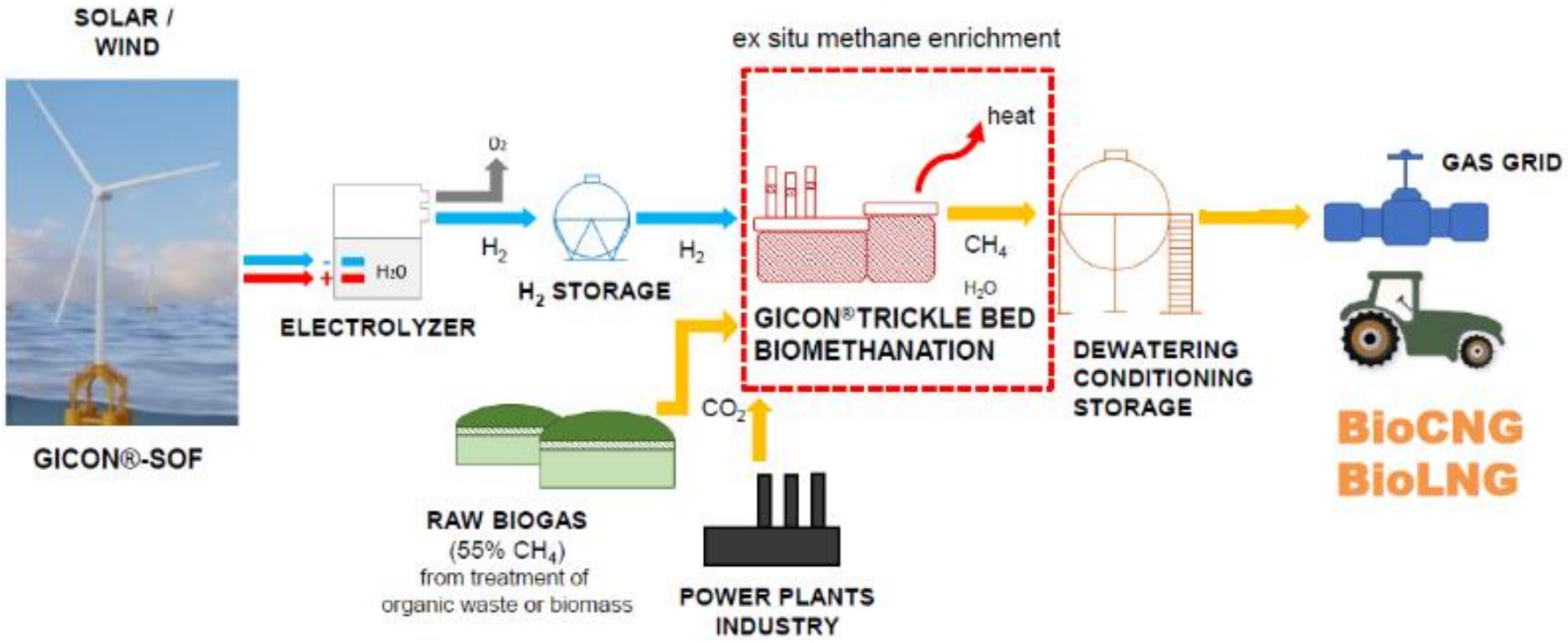
Methanation

Increased biomethane production

process chain and sector coupling

GICON®

biological methanation
biomethanation
biological methaneenrichment
hydrogenotrophic process



$$4H_{2(g)} + CO_{2(g)} \xrightarrow{\text{hydrogenotrophic Archaea}} CH_{4(g)} + 2H_2O_{(g)} \qquad \Delta H_R^0 = -165KJ/mol$$

$$2H_2O_{(g)} \longrightarrow 2H_2O_{(l)} \qquad H_K^0 = -85KJ/mol$$

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- biogaz and green hydrogen

Goal energy storage for winter and transport fuels

- **flexible cogeneration**

and

- electrification and digitalization of district heating (Hpump)

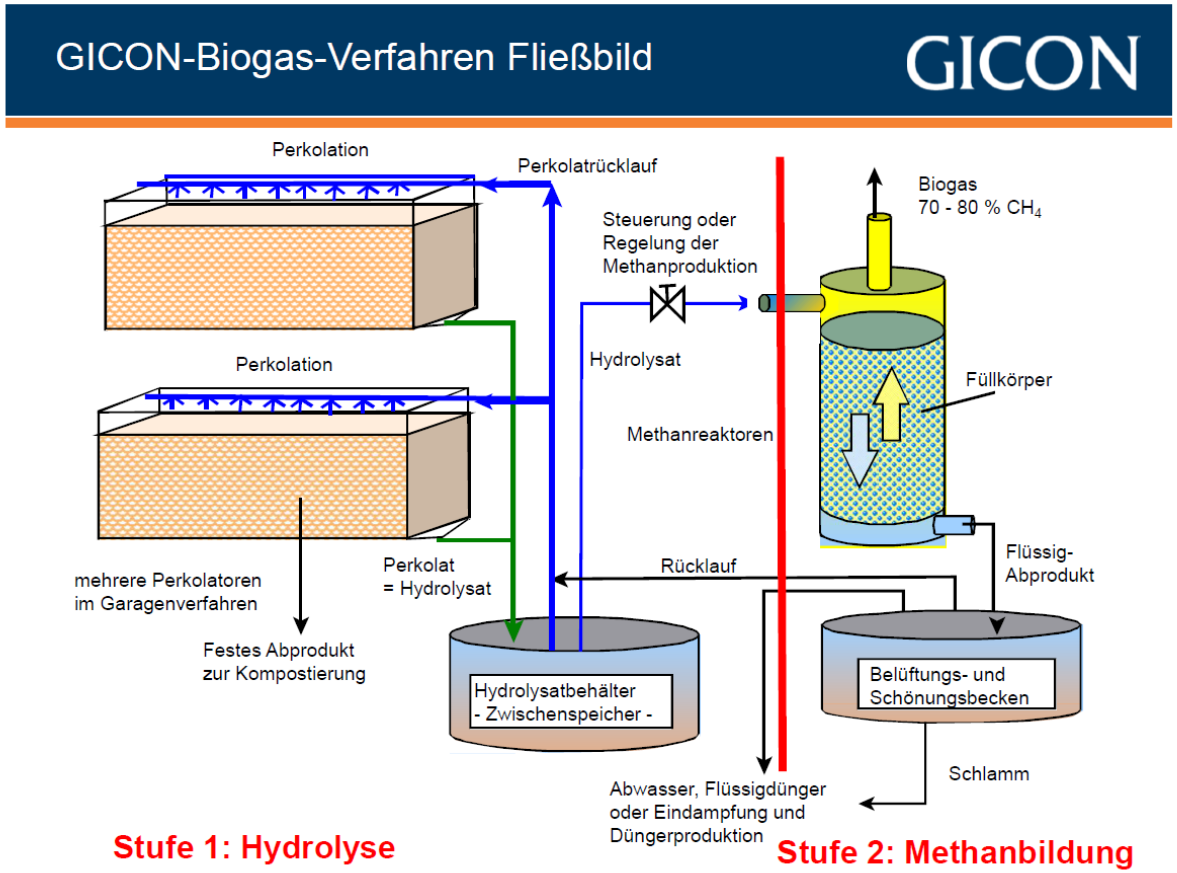
Cogeneration (CHP) based on biomas

In the case of wet biomas waste better is its utilisation in biogas powerplant (water is crucial for the process performance)

Dry biomass (forest or agricultural) can be easier utilized in combustion or gasification/pyrolysis process.

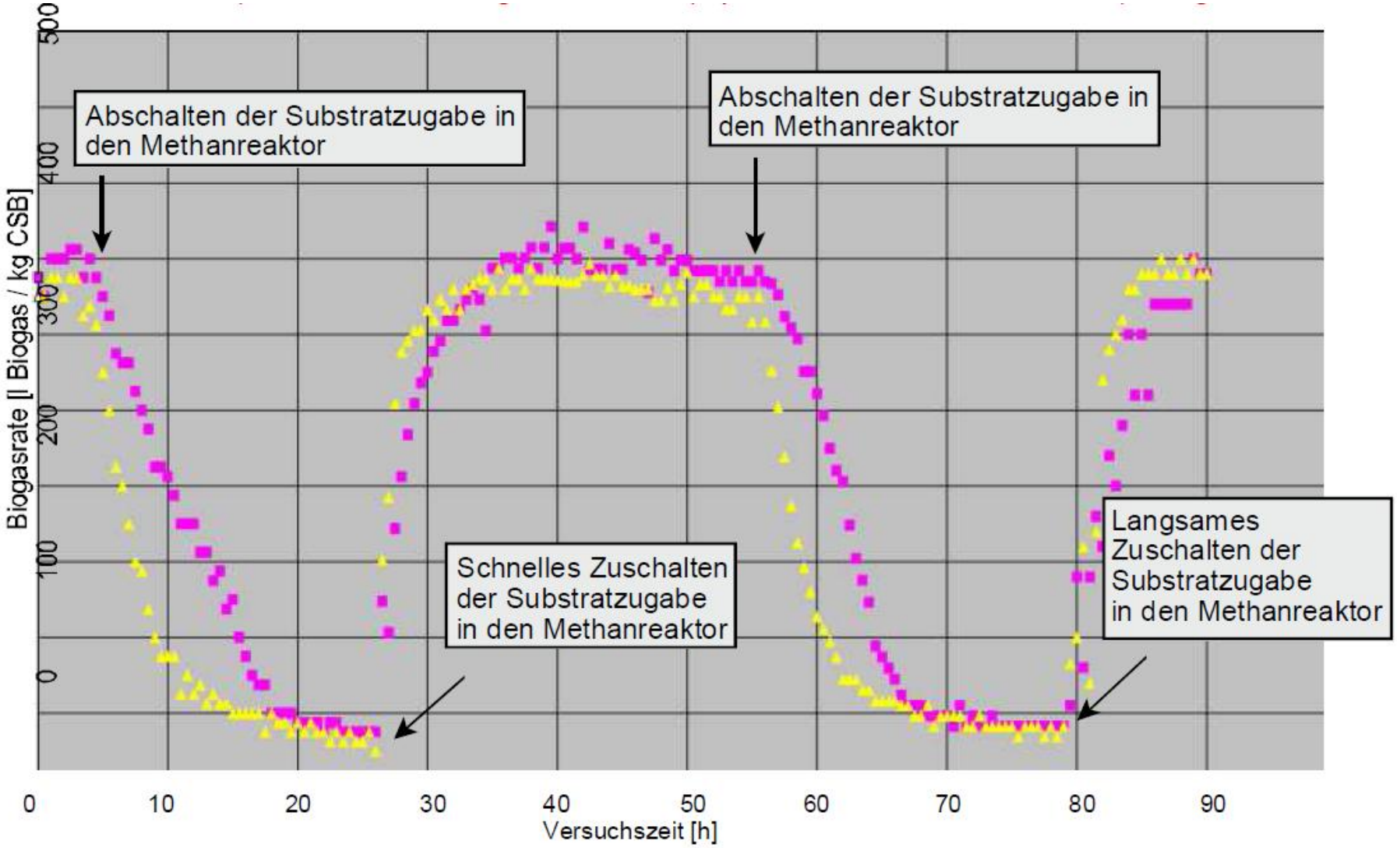
Dry/wet 2-stage fermentation
GICON – Cottbus

Percolation/ packed bed



- Flexible CHP

Flexible gas production - temporal characteristics



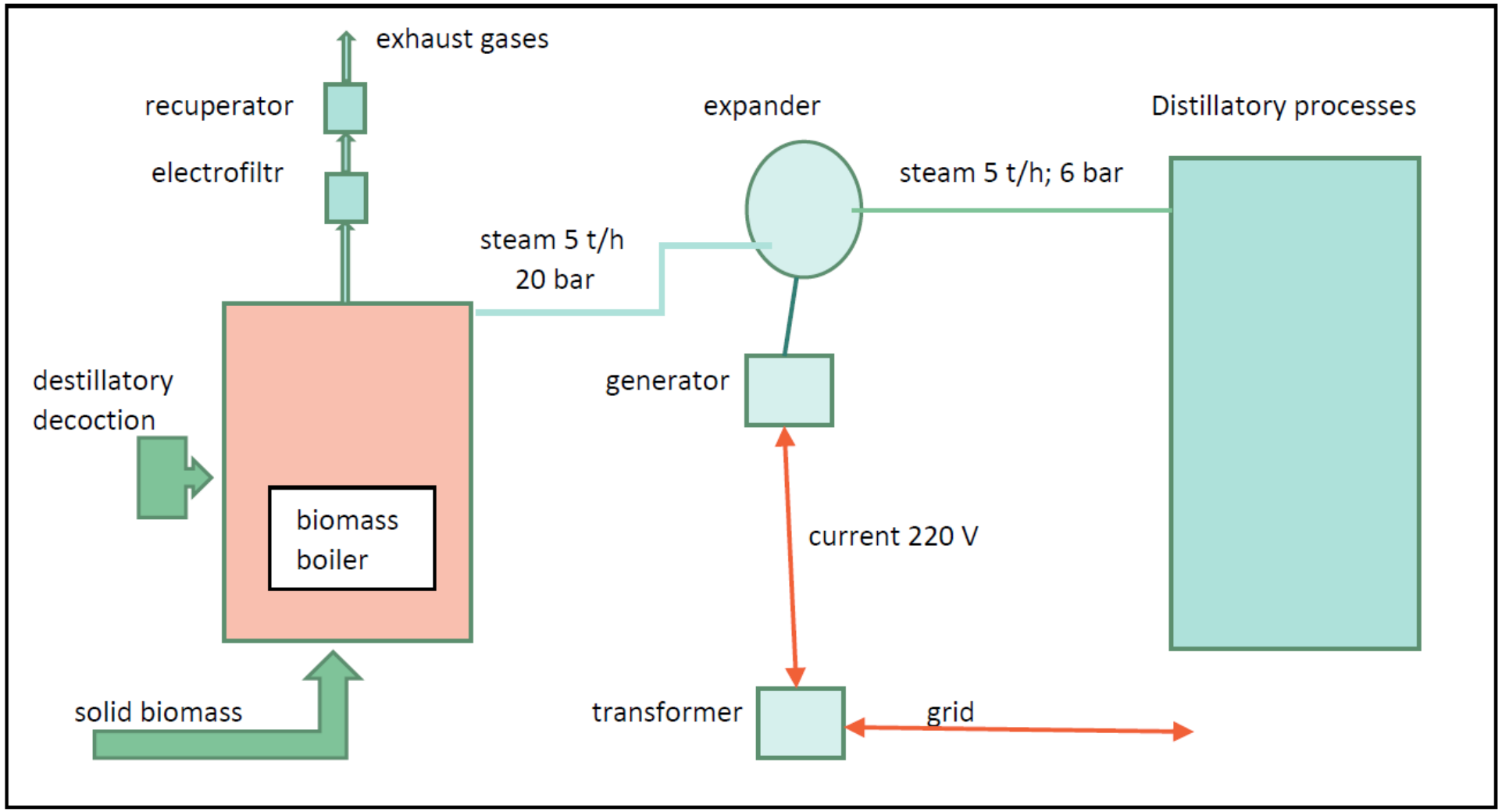
CHP in Polmos Żyrardów (Belvedere)

POLMOS Zyrardów - Belvedere

Polmos Zyradów system
EFFECT
187 kW electricity and 4 MWh
OPERATING HOURS/YEAR
8000 h
ELECTRICITY
187 Wh
SIMPLE PAYBACK TIME INVESTMENT
5,5 years
RAW MATERIAL
Wood chips, forest residue, etc.
MOISTURE IN RAW MATERIAL
above 40%
MODEL
Boiler UTSR, Schmid
Expander Heliex HP 145

CHP in Polmos Żyrardów (Belvedere)

INSTALLATION SCHEME



CHP in Polmos Żyrardów (Belvedere)

Biomas boiler

Technologic steam

5 tonnes / h;

20 bar

CHP in Polmos Żyrardów (Belvedere)

Expander

187 kW

P 20 bar to 6 bar

CHP in Polmos Żyrardów (Belvedere)

Heat recovery system from flue gas

To increase the efficiency, it was installed :

– Economizer 1 to heat the water supplied to boiler;
heat power : 370 kW, flue temp : 250/150 C,
temp. water: 100/160 C,

– Recuperator 2 to heat condensate in condensate container,
heat power : 145 kW, flue temp : 150/111 C,
temp. condensate: 70/95 C,

– Economizer 3 to heat air to the boiler, heat power: 370 kW,
flue temp: 111/96C, temp. water: 45/70 C,

– Recuperator 4 to heat the return of space heat system

heat power: 387 kW, flue temp: 96/56C, temp. water: 45/55 C,

CHP in Polmos Żyrardów (Belvedere)

POLMOS Zyrardów - Belvedere

Polmos Zyradów system

EFFECT

187 kW electricity and 4 MWh

OPERATING HOURS/YEAR

8000 h

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187 Wh

SIMPLE PAYBACK TIME INVESTMENT

5,5 years

RAW MATERIAL

Wood chips, forest residue, etc.

MOISTURE IN RAW MATERIAL

above 40%

MODEL

Boiler UTSR, Schmid

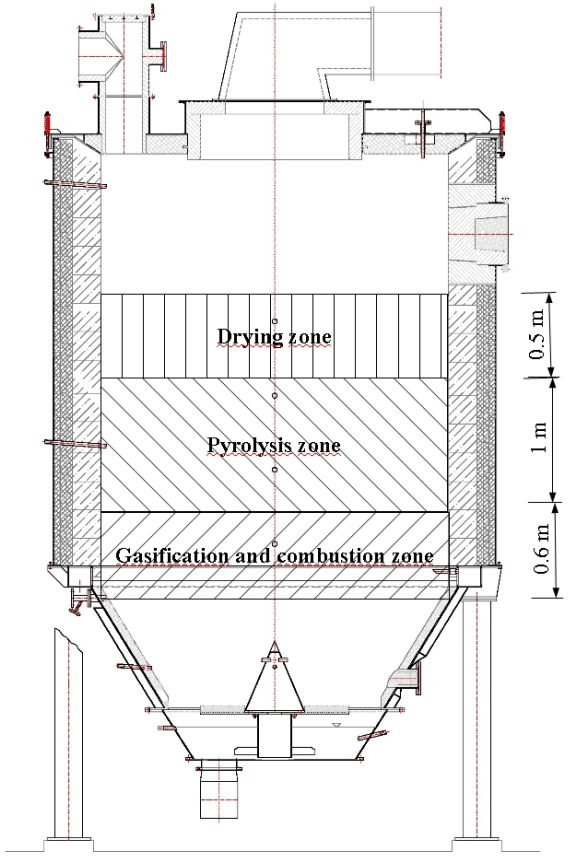
Expander Heliex HP 145

Gasification installation 1,5 MW_t

Gasification of chicken and turkey feathers in Indykpol

Turkey feather

Chicken teathers



Surplus/waste heat at high temperature

10 kWe ORC system utilizing surplus heat from drying

- Localized: Skawina k/Krakowa
- Cooperation: IMP PAN and ENKI Ltd in frame of Biostrateg Project
- Start: July 2021
- Heat source: drying process

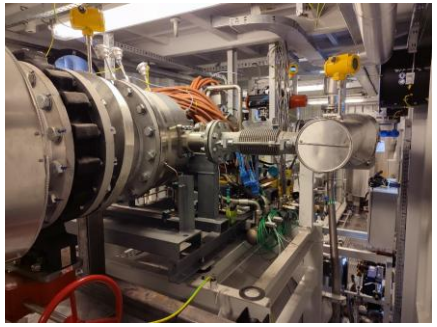
ORC SYSTEM – MARANI ORC300 – 300 kWe prototype

Waste heat: 400 °C

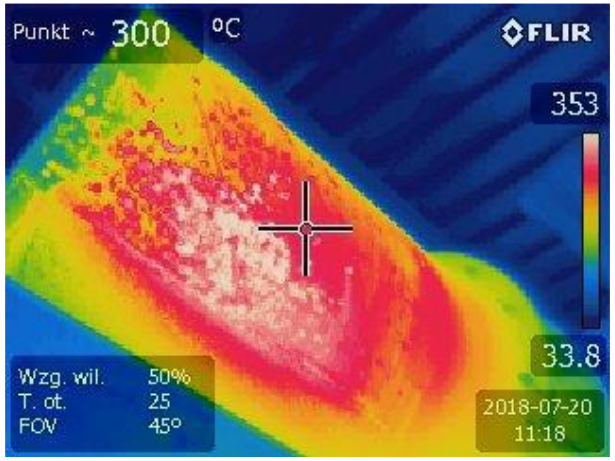
Heat flow > 2 GWt

ORC Power : 300 kWe [design point]

ORC efficiency: 16,5 % [design point]



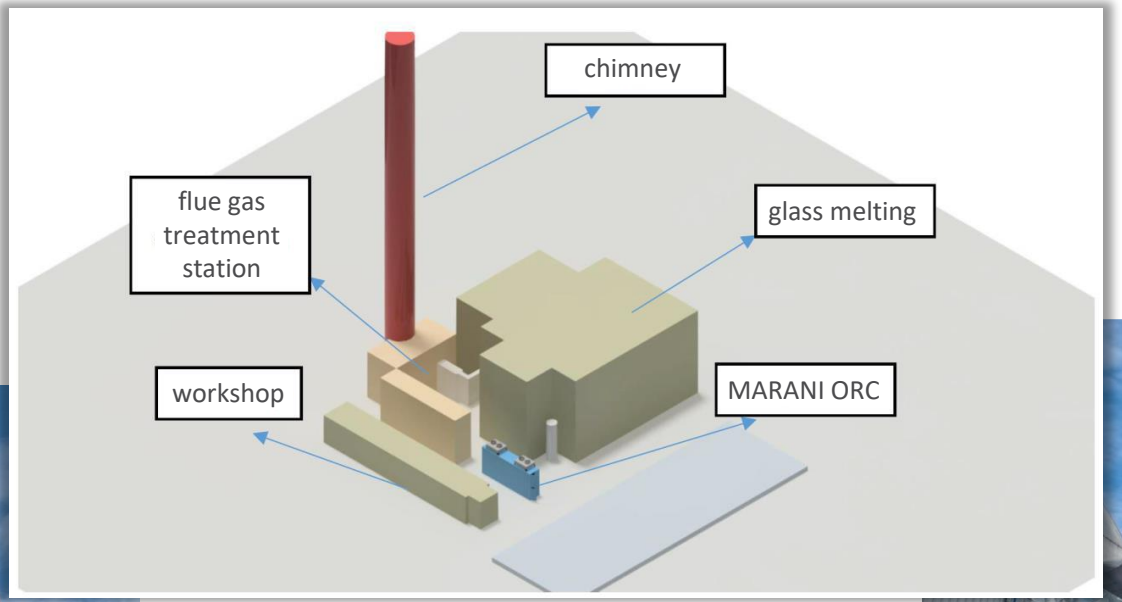
Ciągły układ topienia szkła



Pole temperatury układu spalin

ORC SYSTEM – MARANI ORC300 – 300 kWe

- assembly completed
- filling with working fluids
- prior to testing and commissioning at the industrial plant



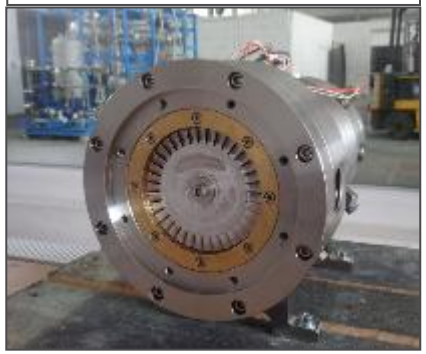
Microturbines and compressors up to 300 kW

Turbina ORC o mocy 300kW

Turbina ORC o mocy 30kW

Turbina ORC o mocy 15kW

Turbina ORC o mocy 10kW



Sprężarka o mocy 10kW

Turbina gazowa o mocy 30kW

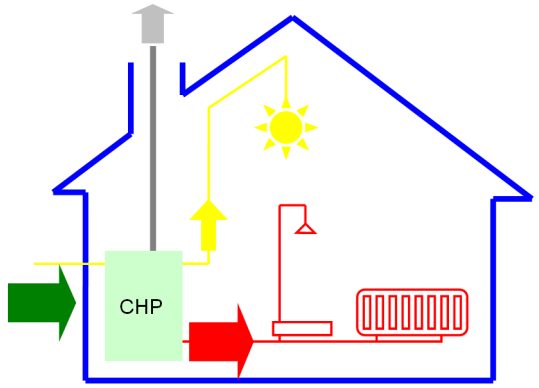
Microturbines and compressors up to 300 kW

ORC CHP system (2,5 kWe/25 kWt for single family house

Project

Prototype

Patented solution



modelowe kompleksy agroenergetyczne

Financed by National Centre for Science and Development – project POIG.01.01.02-00-016/08 „Model agroenergetic systems as example of distributed cogeneration based on lccal and renewable energy sources”

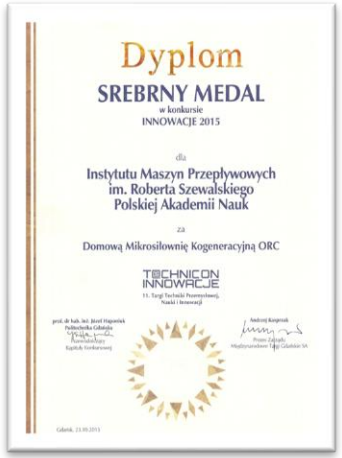
Technical data:

Dimensions: 160x74x74(175) cm

Thermal power: 25 kWt

Electrical power: 2,5 kWe

Fuel: biomass (pellet)



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Goal energy storage for winter and transport fuels

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and

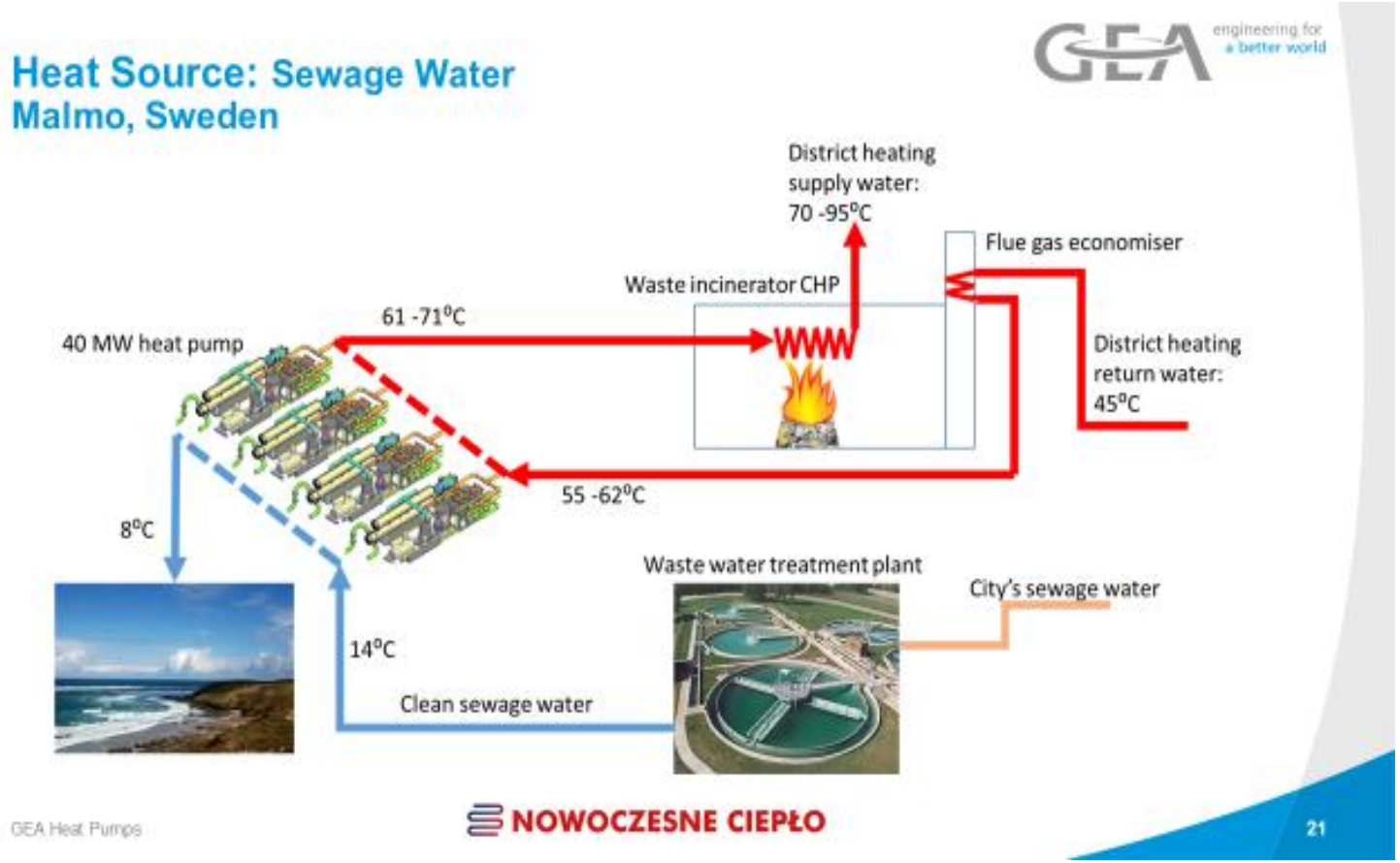
- **electrification and digitalization of district heating (HPump)**

Surplus/waste heat at low temperature

Waste heat from water cleaning facility

40 kW system in Malmö

- Ammonia Heat Pump – from 14°C to 8°C.
- Return water stream 45°C
  economizer to 55-62°C,
  HP 61-71°C,
  Boiler on waste to 70-91°C.
- HP
- Emission reduction: 50 000 ton CO_2.

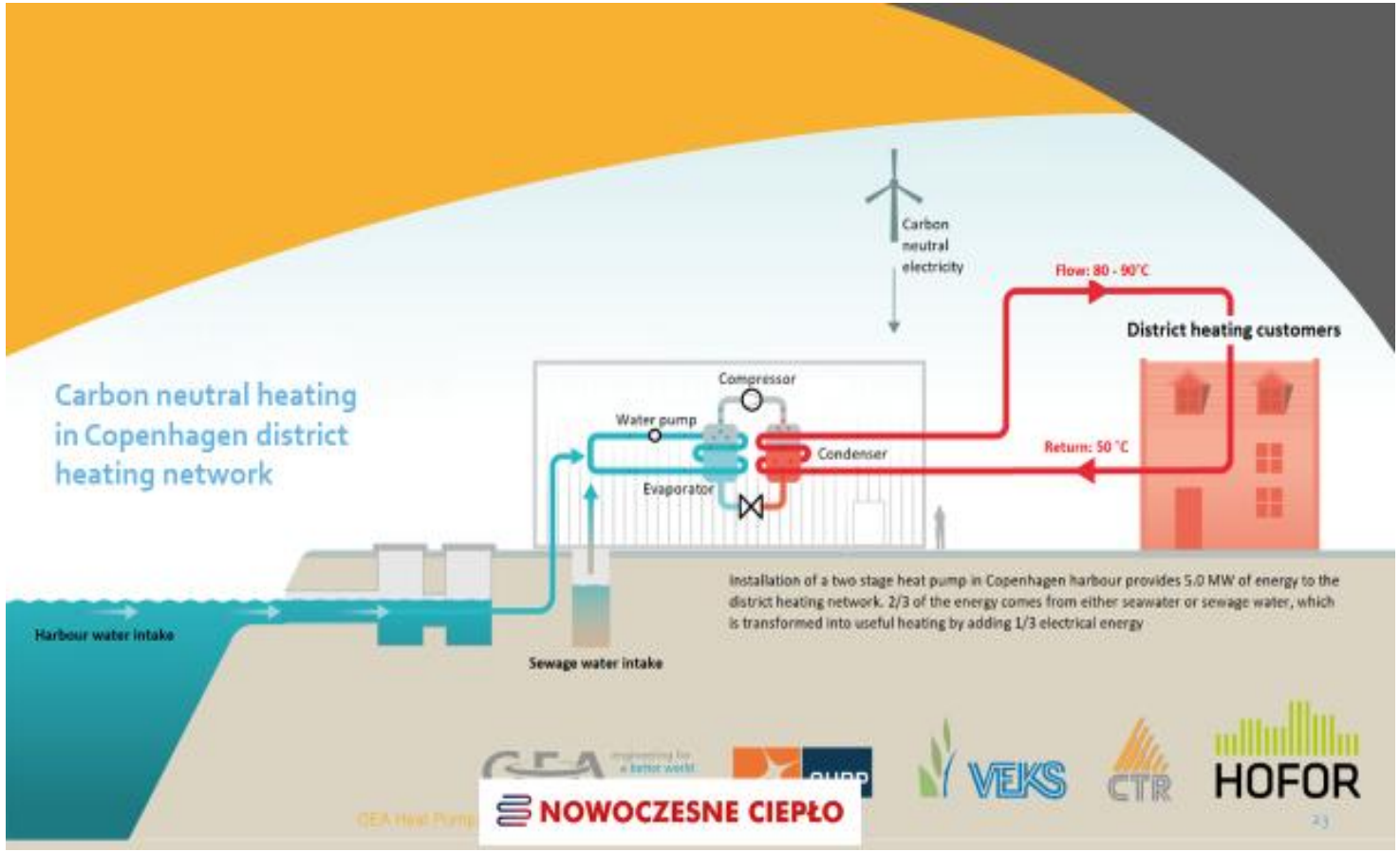


Source : GEA.

Waste heat from water cleaning facility

2-step HP 5 MW in port Copenhagen

- Cleaned sewage and see water
- Return flux 50°C heated by HP to 80-90°C.
- COP ~ 3
- 1.7 MWe from wind farm



Source: GEA

Waste heat from water cleaning facility

18,4 MW in Oslo from untreated sewage water

- Plain heat exchangers
- In rock 300 m deep
- 3800 m^3 ścieków/h to 2 HPs.
- Exit temperature 4-5 °C.
- About 7,8 % of heat to city DH system

Long distance ultralow temperature heat transfer

Source: Kalundborg Symbiosis

Kalundborg City:
Densely populated industrial sites; thus, a substantial amount of surplus (waste) heat

Heat transfer – long distance

Is it economically feasible to transfer heat (~ 20 C) 20 km away ?

Solution:
Uninsulated pipes with central heat pump at final destination

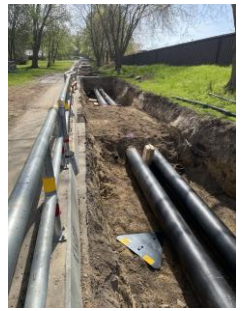
Estimated payback time around 12 years

Interreg South Baltic | Co-funded by the European Union | BES

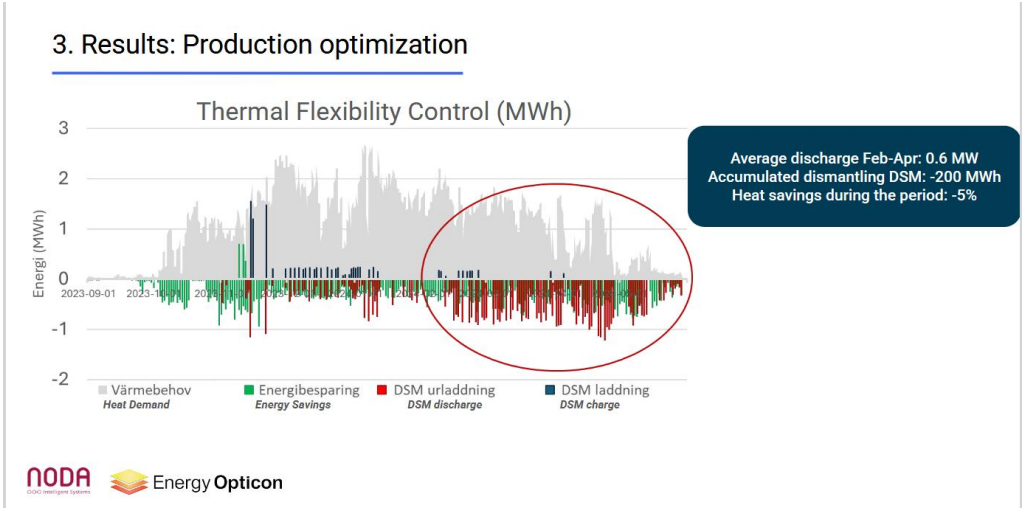
Digitalisation of DH: sources, grid state, consumer satisfaction

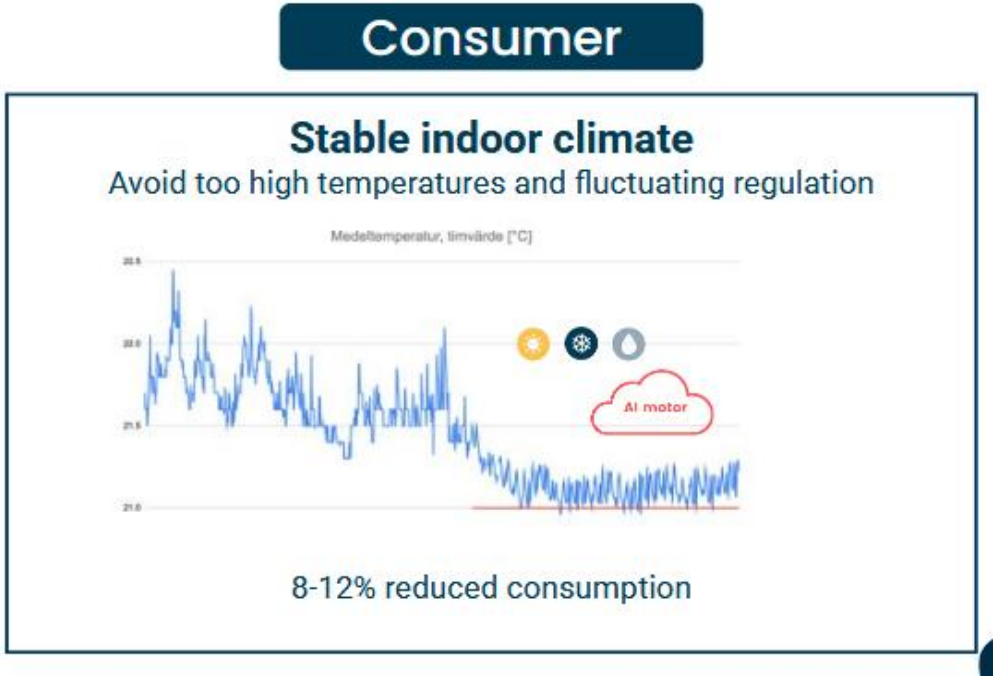
Concrete duct

Asbestos culvert



Source: Öresundskraft





Source: NODA