Solar thermal energy and waste water management in industrial processes

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IEA SHC Task 49/IV – Solar Heat Integration in Industrial Processes

- Joint Task of Solar Heating and Cooling SHC and SolarPaces
- Co-ordination: AEE INTEC

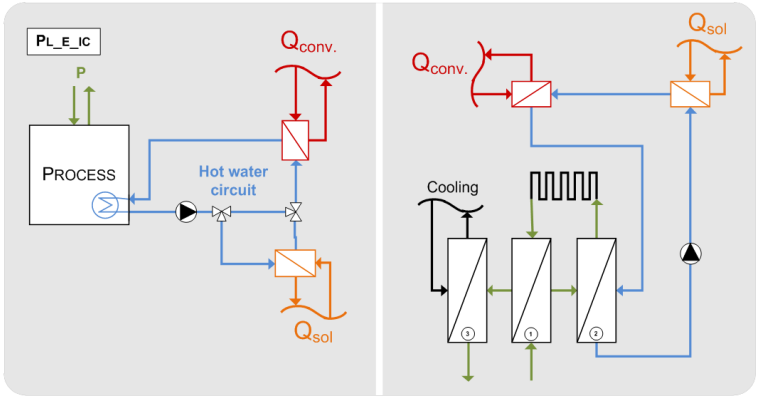
- **Start:** February 2012
- **Duration**: 4 years
- **Participants:** 15 countries
- **Research Institutes:** 21
- **Universities:** 13
- **Companies**: 22

- All industrial processes up to 400°C.
- Heat carrier using air, water, low pressure steam or oil
- All types of solar thermal collectors

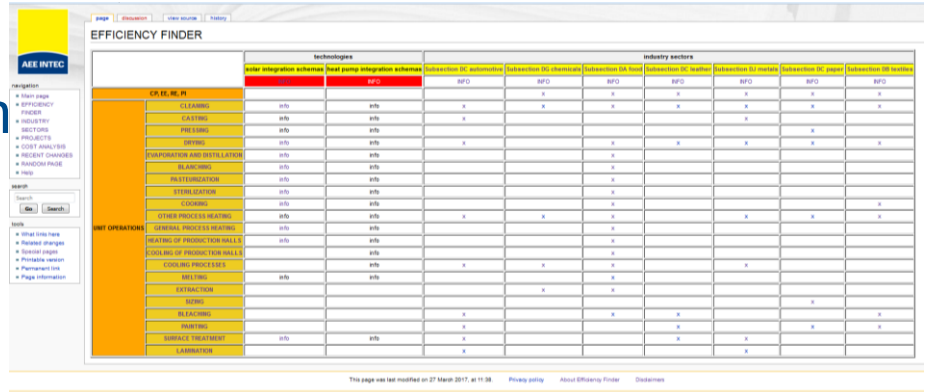
http://task49.iea-shc.org/

Design rules and production process information

- Integration Guideline and System concepts: How to integrate SHIP Practical design roles for planners and installers

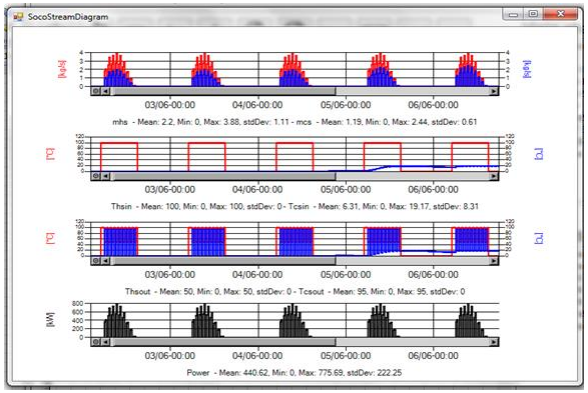


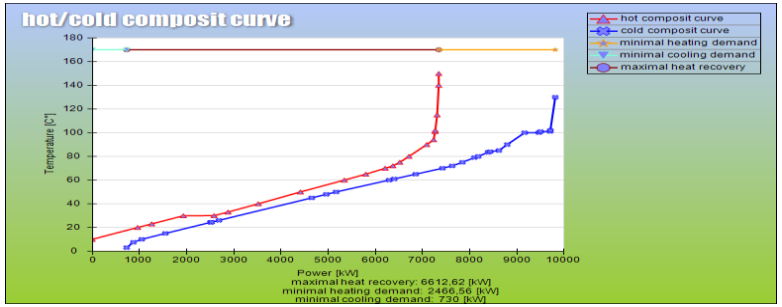
- Wiki Web-Energy efficiency finder
  - http://wiki.zero-emissions.at/index.php?title=EFFICIENCY_FINDER
  - Practical information about industrial processes, integration concepts,…

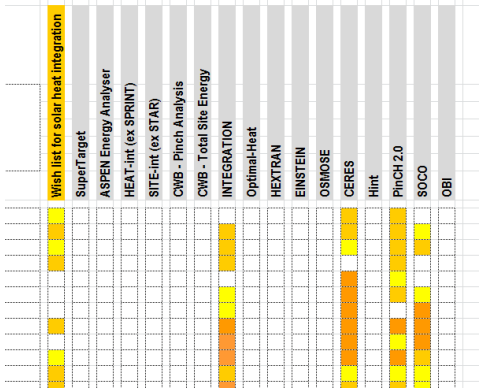


Process optimization, Process integration, Process intensification

- Software Tools for process integration in combination with SHIP
- Minimum energy demand for heat and cold
- Heat exchanger network
- Design of heat storages
- Optimum integration point for RES
- New process technologies

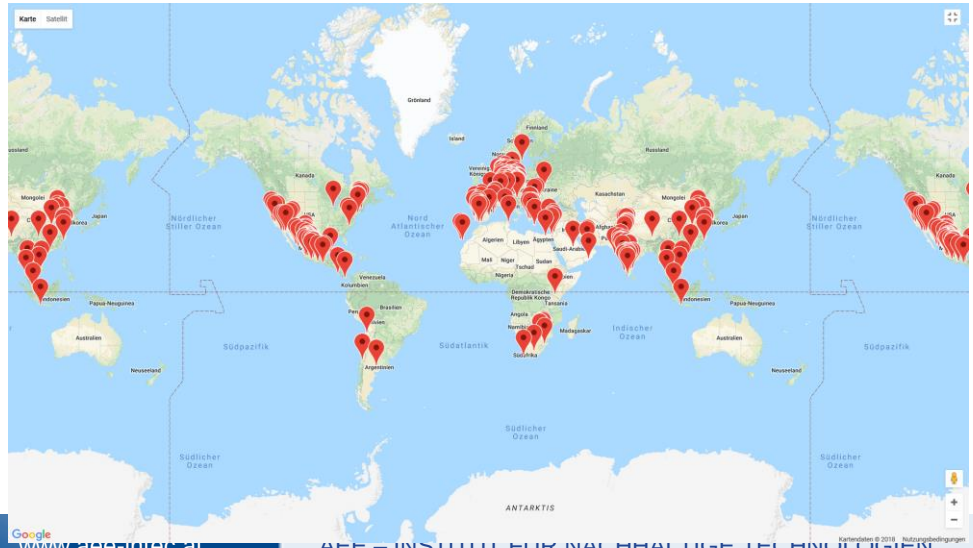


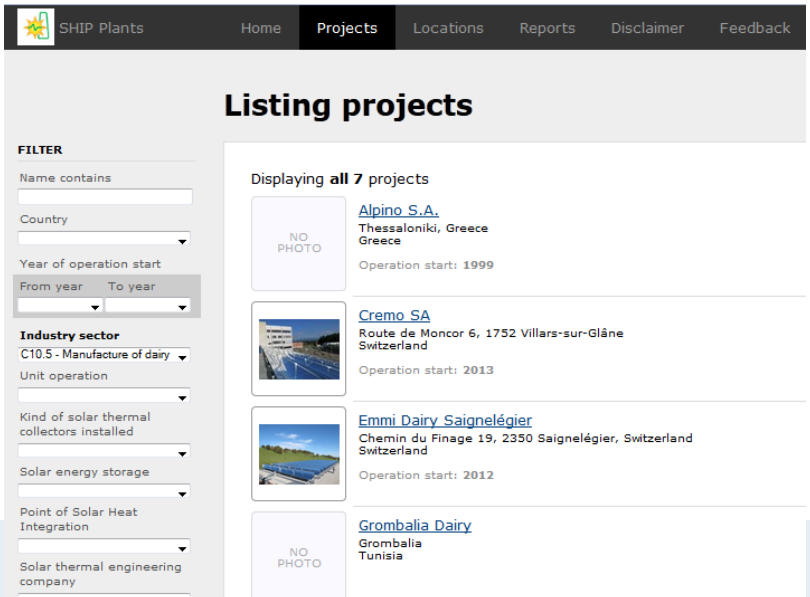




SHIP database

- www.ship-plants.info
- 271 registered installations (May 2018)
- Total capacity: 214.228 MWth
- Total square meter: 409.763 m²



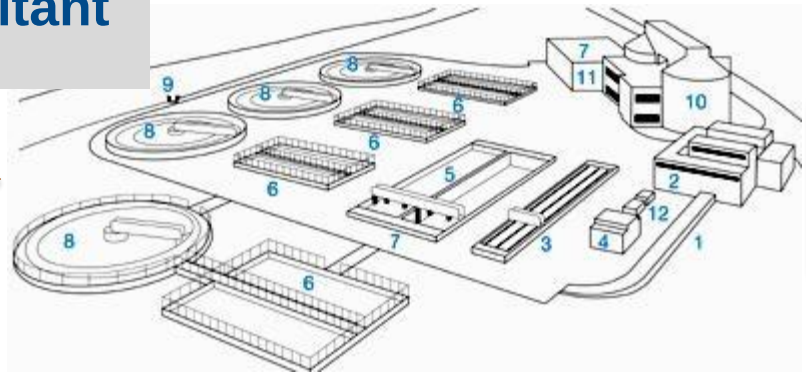


Conventional waste water treatment plants

- **20% of energy demand** of municipalities for WWTPs
- Energy demand appr. **40 kWh per inhabitant and year**

Sewage
Process water

Electricity



Unused **C,N,P, K or noble metals**

Cleaned water

- **NH_3-production** (e.g. for fertilizer: Haber-Bosch-Synthesis requires 1-2% of world energy demand)

Quelle: https://www.stadt.sg.ch/home/

IEA SHC Task – Solar Energy in Industrial Water and Wastewater Management

- To improve the conditions and increase the applications of **solar driven separation and water purification technologies in industrial applications**
- Reduce the water and energy demand (CO_2 emissions) in industry (process water) and water purification plants (communal and industrial)

  - Task in definition phase
  - Duration: 2018 – 2022
  - Joint Task with SolarPaces

Source: REWACEM

IEA SHC Task – Solar Energy in Industrial Water and Wastewater Management

Solar Thermal

Solar photons

Membrane distillation

Pervaporation, Vacuum evaporation, Rectification, Humidification-Dehumidification,…

Photoctalytic Water Decontamination and Disinfection Systems

- Link between industrial separation demand, technologies and exergy heat sources
- new solar thermal collectors' concepts for industrial water treatment
- Technological, economic and political barriers for up-scaling systems and technologies

Membrane Distillation MD - Principle

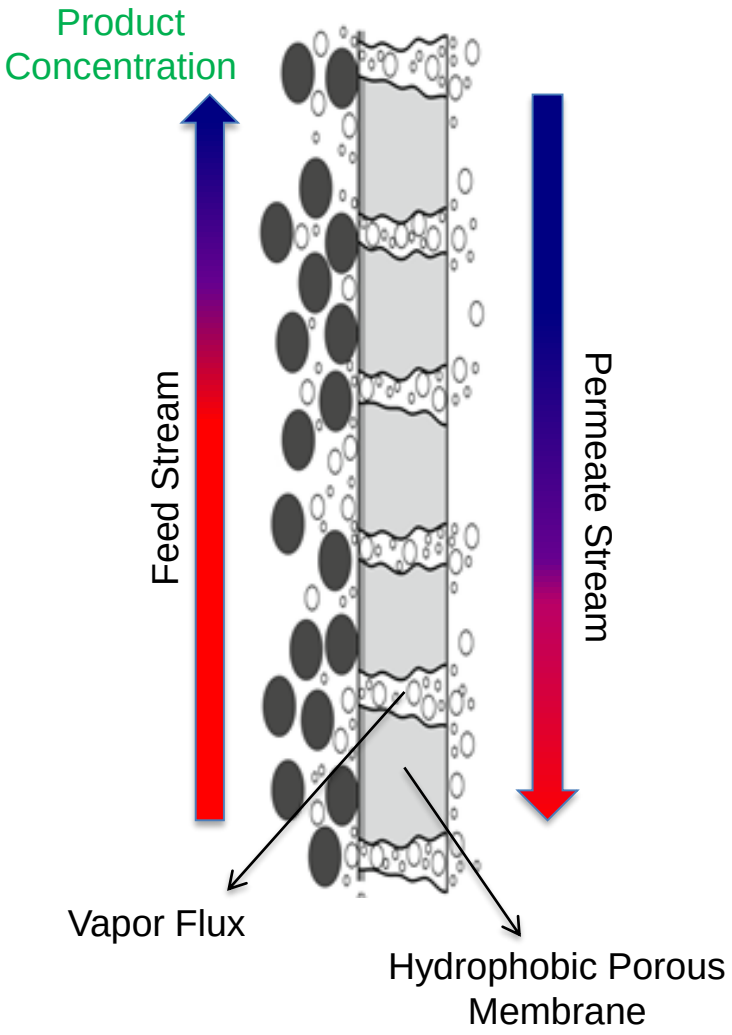
Non-Isothermal Membrane Separation Process

Driving force: Partial vapor pressure difference (induced as ΔT)

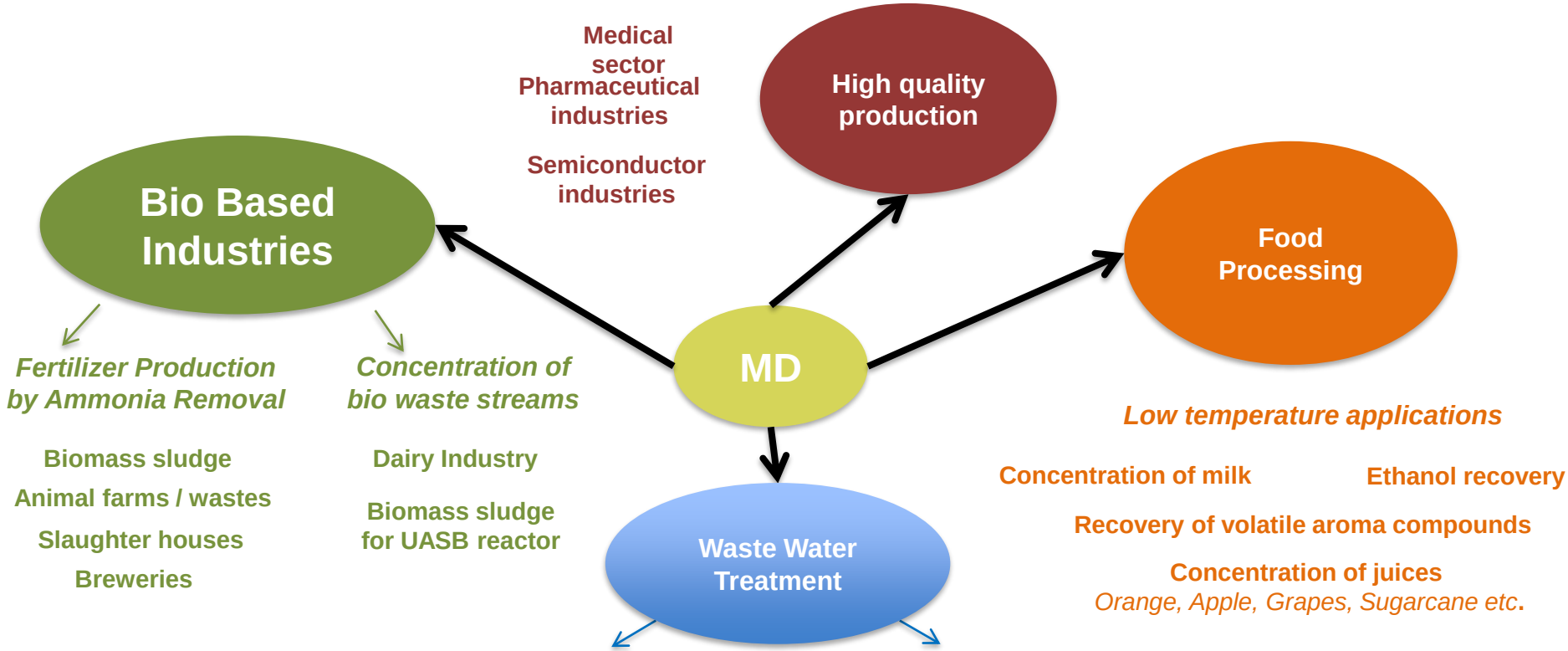
Vapor phase flux

Lower Thermal and Electrical energy demand

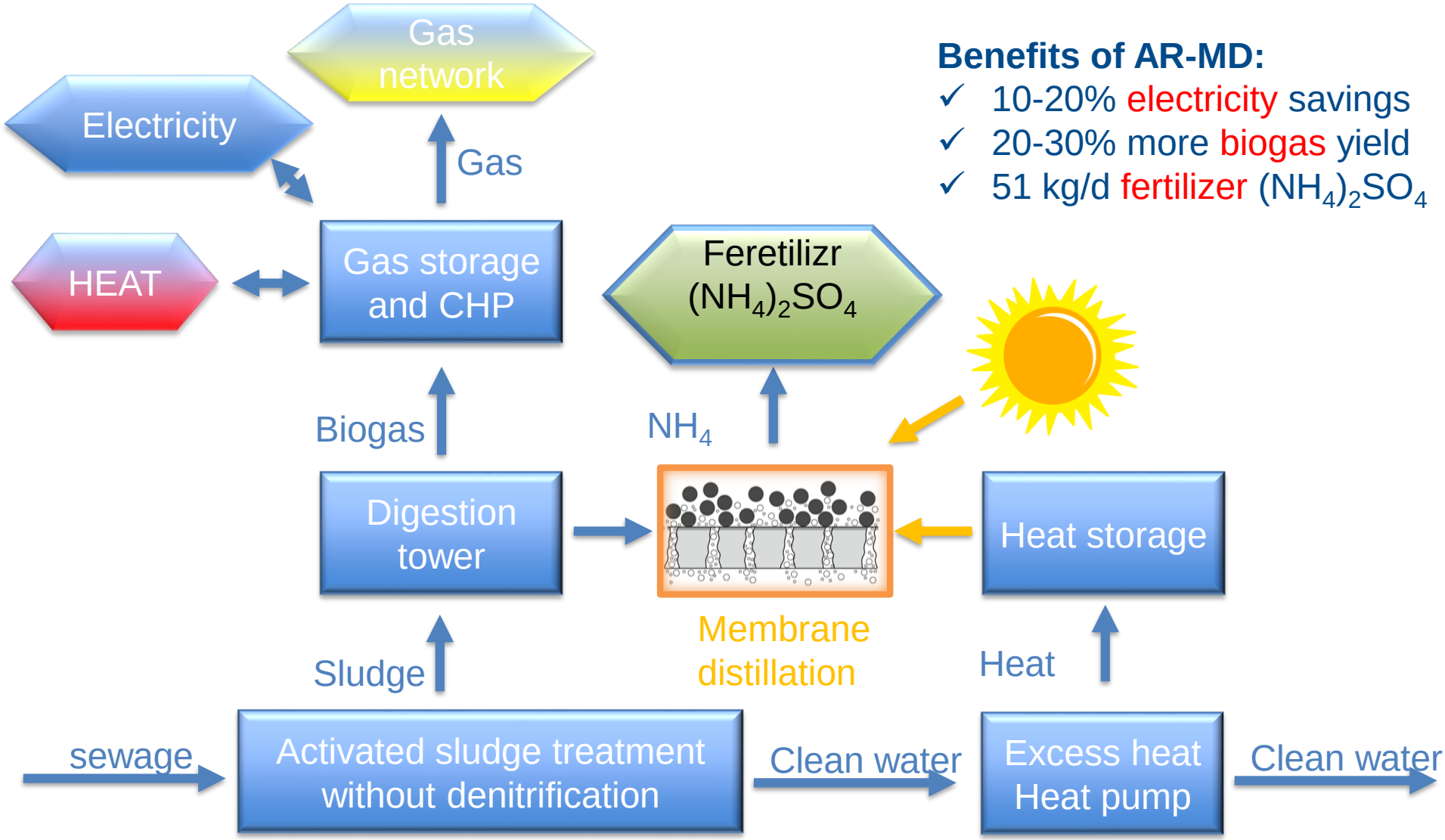
Integration potential for Waste Heat or Solar Energy



Membrane distillation examples for applications



Ammonia recovery membrane distillation (AR-MD) at WWTP

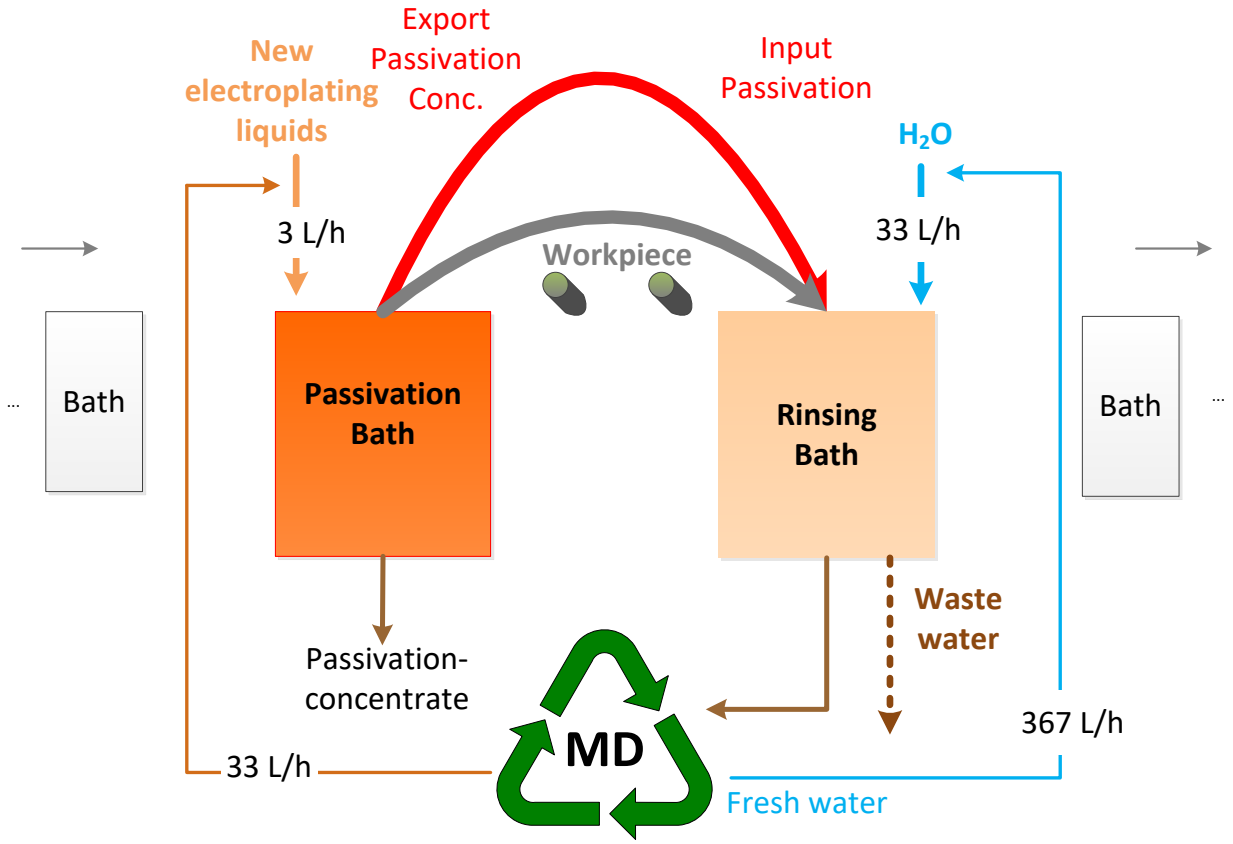


Benefits of AR-MD:

- ✓ 10-20% electricity savings
- ✓ 20-30% more biogas yield
- ✓ 51 kg/d fertilizer $(NH_4)_2SO_4$

Project „Galvano-MD“

Membrane distillation for energy efficient recovery of electroplating liquids

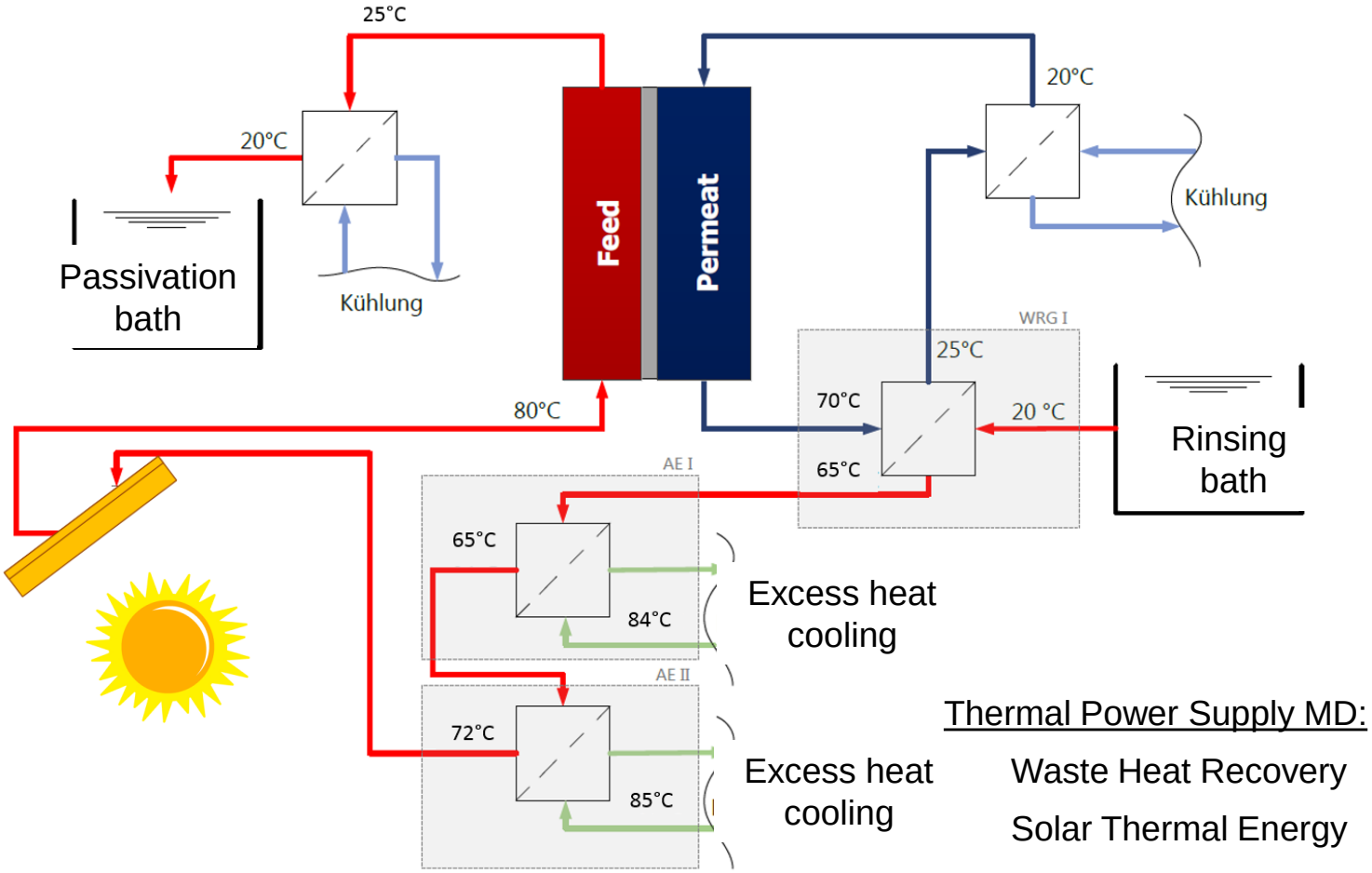


Saving:
60%
≙ 195 m³/a recycled electroplating liquids

Saving:
93%
≙ 2.200 m³/a
recycled rinsing water
≙ reduction of galvanic waste water

Project „Galvano-MD“

Membrane distillation for energy efficient recovery of electroplating liquids



Thermal Power Supply MD:

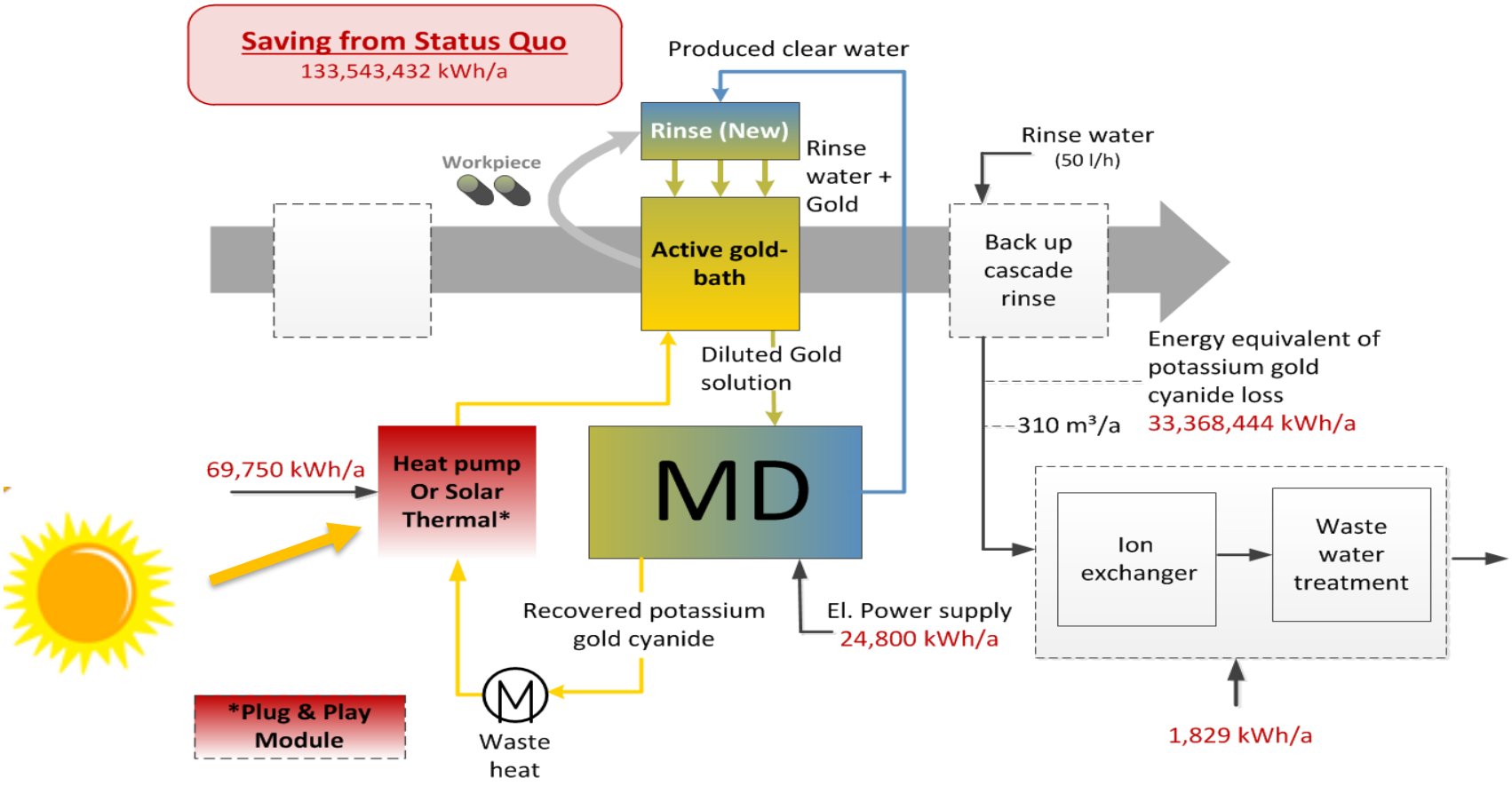
Waste Heat Recovery

Solar Thermal Energy

EU - Project „REWACEM“

MD for recovery of gold and palladium streams

Membrane distillation as low-ex separation technology for recycling valuables from process baths in printed circuit board - PCB industry



EU - Project „REWACEM“

MD for recovery of gold and palladium streams

- Demand reduction and recovery of potassium gold cyanide 68.2% (recovery rate of 80%) by the MD-System

- Over a LCA savings of **133,543,432 kWh/a**

  ~ 43 000 to CO_2 equivalents/year

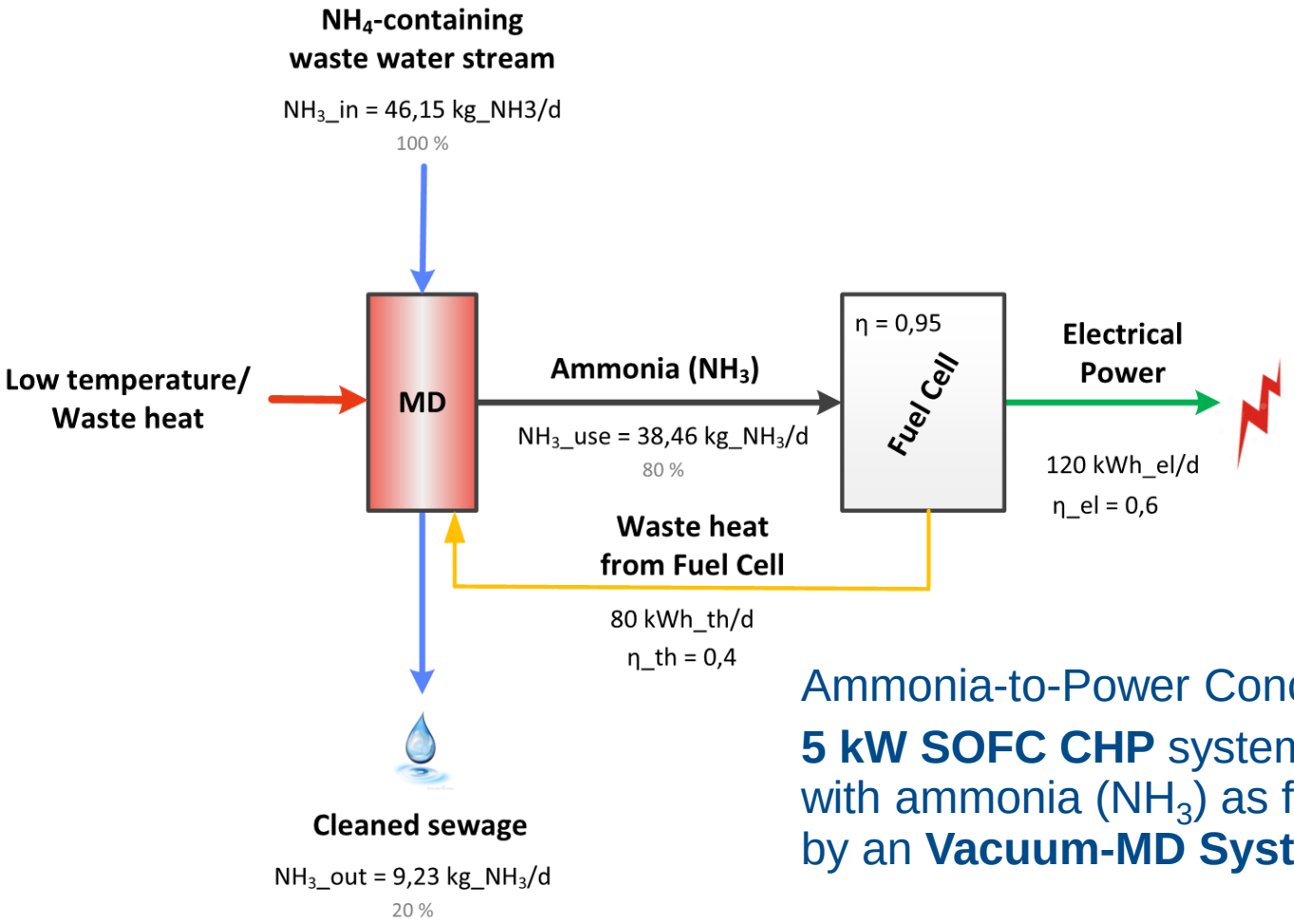
  Emission factor Austria: 0,17679 kg CO2-eq / kWh

- Waste water reduction of 5,487 m³/a;

- Monetary saving of recovered valuables € 1,950,000 EUR/a

Project: „*Ammonia-to-Power*”

Energy Recovery from ammonium-containing Substances by means of Vacuum-Membrane Distillation and Ammonia-Fuel Cell

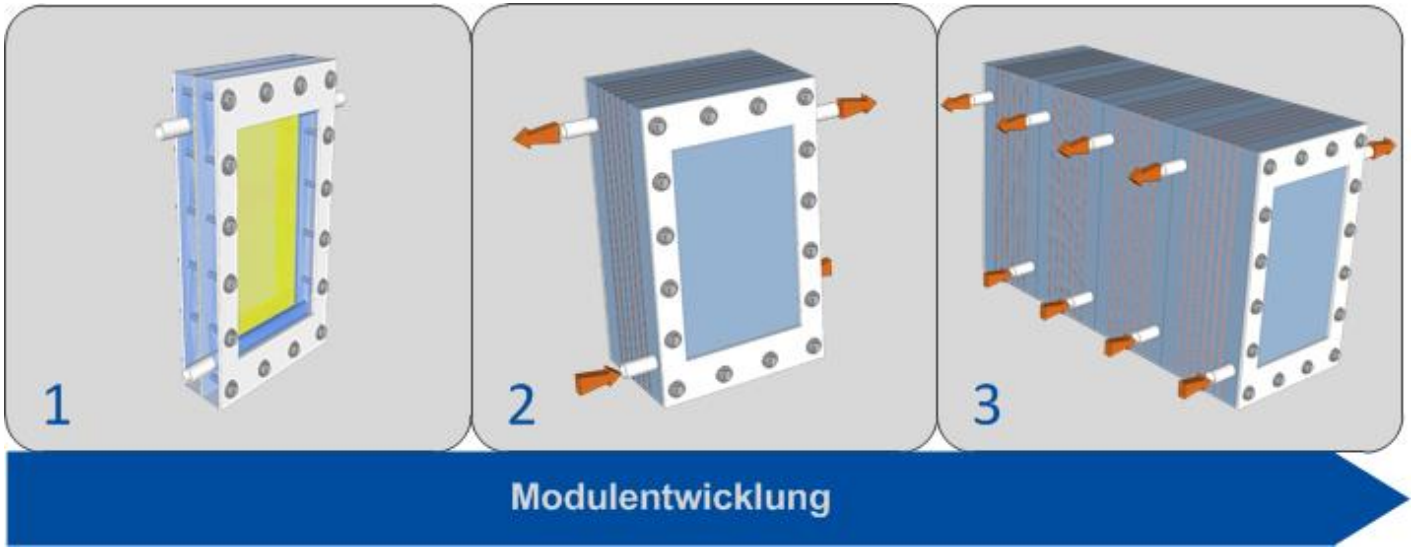


Ammonia-to-Power Concept:

5 kW SOFC CHP system operated with ammonia (NH_3) as fuel provided by an **Vacuum-MD System**

Possible applications of N-MD/Fuel Cells

- Waste streams from industry like food, tanneries and rendering industry
- Biogas plants and waste water treatment plants
- Motorway service stations
- Airports, train stations,…
- Multi family houses?
- …



Key messages

- In sewage and process water a huge potential for energy saving and resource recovery exist
- The energy for driving technologies for recovery should be supplied by renewable energy sources (solar thermal e.g.) and excess heat
- By exchanging existing process technologies the potential for low exergetic energy sources (like solar thermal, excess heat,…) can be increased
- Membrane Distillation as one of those emerging technologies has a large variety of different applications like printed circuit board industry, food industry, chemical industry, galvanic industry, pulp and paper, bio refineries,…
- WWTP can change their role from energy consumer to and nutrient and energy supplier - technology change as well integration in energy grids (electricity and gas) and heat networks

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IDEA TO ACTION