NEFI
NEW ENERGY FOR INDUSTRY

ENERGIE INSTITUT an der Johannes Kepler Universität Linz

klima+ energie fonds

A techno-economic and macro-economic concept study of waste heat utilization of a cement plant

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GMUNDEN
HIGH TEMPERATURE HEAT LINK R&D

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DECREASE PRIMARY ENERGY DEMAND THROUGH INDUSTRIAL WASTE HEAT UTILIZATION

- Waste heat potential of 65-100 GWh/a gas-equivalents (HHV); at ~400°C, 10 MW_{th}
- Gas reduction potential of up to 50 GWh/a (HHV)

INNOVATIVE APPROACHES

- Heat extraction, heat storage, heat transport, and operation

INDUSTRIAL PROCESS STEAM PROVISION OVER 1500 M

B2B ENERGY COOPERATION

KEY FACTS

Duration: 09/18 – 07/21

Project Volume: € 1,257,366

TU WIEN IET INSTITUT FÜR ENERGIETECHNIK UND THERMODYNAMIK Institute for Energy Systems and Thermodynamics

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TECHNOLOGICAL CONSIDERATIONS

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UP TO 27 CONFIGURATIONS WERE ANALYZED → MOST PROMISING CONCEPTS (4) WERE EVALUATED

OPERATION CONDITIONS

- Cement plant: continuous operation, but planned and unplanned interruptions can occur; shut down in winter period
- Dairy plant: continuous operation, but has demand fluctuations (+/- 50% per hour)
- Guarantee of supply: is achieved with gas-boiler backup and heat storage

HEAT EXTRACTION

- Ceramic hot gas filter with finned tube heat exchanger
- **Plain tube heat exchanger**

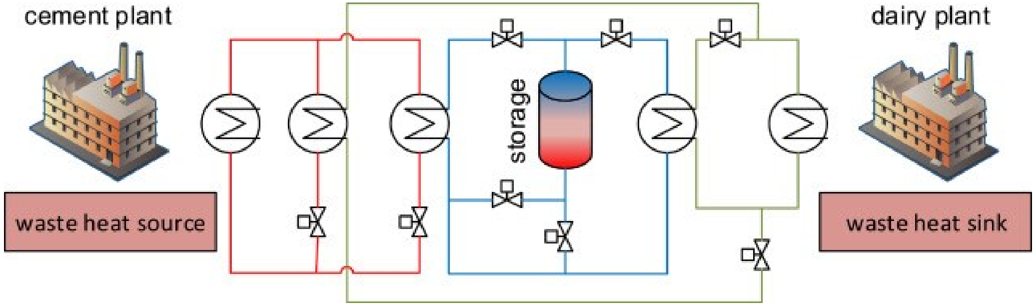
HEAT TRANSPORT

- Pressurized water (45 bar, ~240°C)
- CO_2 (100 bar, ~350°C)
- **steam** (10-**25 bar**, ~210-**250°C**)

HEAT STORAGES

- fixed-bed particle storage of 6 MWh, 70 MWh, 330 MWh, 5500 MWh

Concept: heat recovery (red), storage (blue), transportation (green)



Source: Puschnigg et al. (2021) "Techno-economic aspects of increasing primary energy efficiency in industrial branches using thermal energy storage," Journal of Energy Storage, vol. 36, https://doi.org/10.1016/j.est.2021.102344, 2021.

FRAMEWORK CONDITIONS

FRAMEWORK CONDITIONS HAVE CHANGED SUBSTANTIALLY

PRICE LEVEL OF FEBRUARY 2020 INITIALLY APPLIED

- For CAPEX evaluation
- Gas price: 25 €/MWh

PRICE LEVEL AUGUST 2022

- Gas price: 230 €/MWh
- Increase of more than 10 times

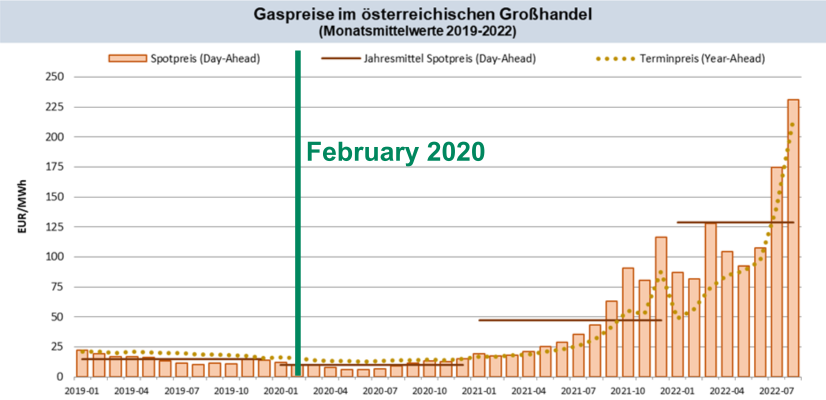
CARBON EMISSION REDUCTION POTENTIAL

- 22 000 ton of CO_2 per year

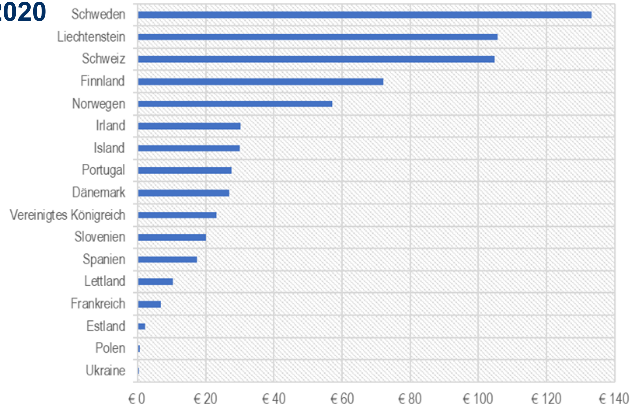
EVALUATION OF CONCEPTS

- Without storage: K0
- With operational storage: K5, K10 (6 MWh_{th})
- With day storage: K10 (330 MWh_{th})

gas price development
Source: E-Control



CO_2 taxes outside EU ETS 2020
Source: own illustration based on World Bank - Carbon Pricing Dashboard



MODELING DATA FOR TECHNO-ECONOMIC AND MACRO-ECONOMIC ASSESSMENT

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Key modeling parameter	value
investment costs (CAPEX):	K0: ~23 million € (least investment cost concept) K9: ~44 million € (concept of highest investment costs) CAPEX of K5 and K10 are between the CAPEX of K0 and K9
running costs (operating costs; OPEX):	2% of the investment cost are annually considered
economic observation period (useful life):	10 years
interest rate:	6%
specific fuel costs	25 €/MWh for gas and further 2.4 €/MWh for gas network
substituted amount of primary energy	K0: 42 GWh (HHV) K9: 54 GWh (HHV)
funding (especially investment funding):	Up to 30% of investment cost
CO_2 emission savings:	0.24 t/MWh

→TECHNO-ECONOMIC ASSESSMENT:

- net present value (NPV), amortization, annuity
- Sensitivity analyses by varying gas price, gas substitution, CO_2 prices, funding, interest rates, useful lifetime

→ MACRO-ECONOMIC ASSESSMENT: gross regional product, net exports, private consumption, employment

TECHNO-ECONOMIC ASSESSMENT

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INHOUSE TECHNO-ECONOMIC TOOL IS APPLIED, DETAILED RESULTS ARE CONFIDENTIAL

CONCEPT K0 (LEAST COST INTENSIVE)

- CAPEX of € 23 million and gas substitution of 42 GWh (HHV), no storage is included
- Economic viability is not given → negative NPV
- Considering a subsidy of 30% on investment cost and an CO_2 price of 50 €/t → still negative NPV
- A CO_2 price of around 150 €/t is estimated to reach economic viability
- Gas substitution and hence cost savings through waste heat utilization cannot compensate the high investment costs

CONCEPT K9 (MOST COST INTENSIVE)

- CAPEX of € 44 million and gas substitution of 54 GWh (HHV), 330 MWh_{th} storage is included
- Economic viability is not given → negative NPV

2022: CONSIDERING NEW FRAMEWORK CONDITIONS

- K0: A gas price of approximately 85 €/MWh is estimated for economic viability (without any funding or CO_2 price)
- K9: A gas price of approximately 120 €/MWh is estimated for economic viability (without any funding or CO_2 price)

MACRO-ECONOMIC ASSESSMENT

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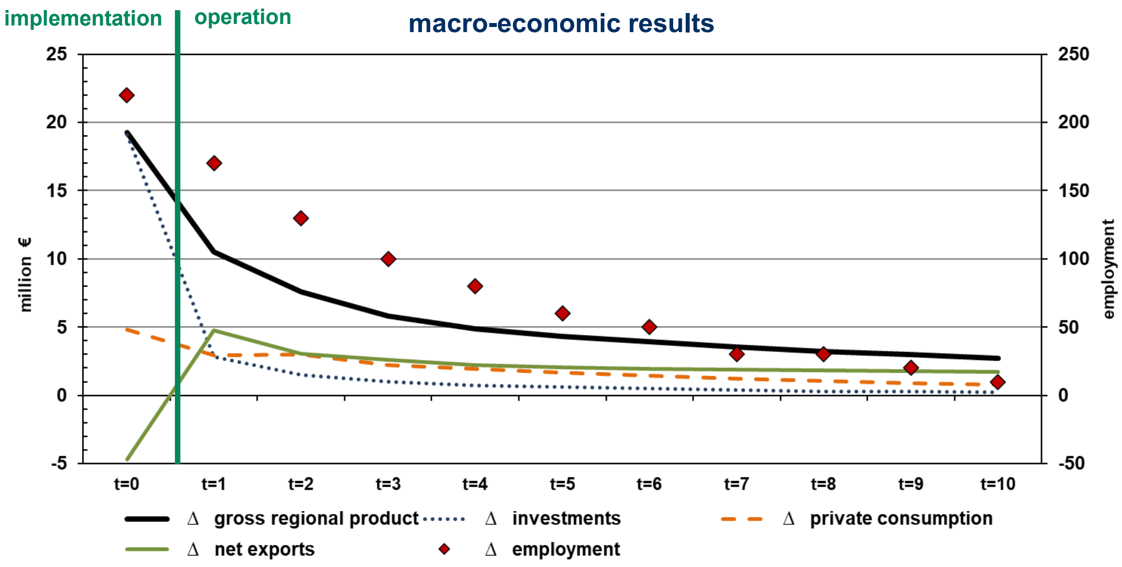
INHOUSE TOOL “MOVE” IS APPLIED

POSITIVE DEVELOPMENTS

- Investment impulses in year t=0
- Positive effects on the regional trade balance (net exports) → decrease fossil energy imports
- Mutli-round effects

YEARLY AVERAGE EFFECTS (FROM YEAR 0 TO 10)

- Gross regional product (GRP): +6.2 million €
- Investments: +2.5 million €
- Private consumption: +2.0 million €
- Net exports: +1.7 million €
- Employments: +80
- CO_2 emissions: -9 660 tons



Source: Energieinstitut an der JKU Linz

CONCLUSION AND OUTLOOK

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ECONOMIC FEASIBILITY DEPENDS MAINLY ON

- The amount of substituted gas, the gas price, the number of storage cycles (charging/discharging)
- The future development of the European emission allowance price CO_2

2020: ECONOMIC FEASIBILITY

- The project is not feasible for each concept. Fossil driven systems are still too inexpensive.
- Gas substitution cannot compensate the high investment costs

2022: ECONOMIC FEASIBILITY

- The ongoing energy crisis changed framework conditions substantially
- High gas prices have a positive effect on the economic viability, which makes the project economically feasible (although geopolitical incidents are of course negative)

POSITIVE MACRO-ECONOMIC EFFECTS

- An average increase of the gross regional product of 6.2 million € per year
- An average increase in employment of 80 employees per year

APPROPRIATE BUSINESS MODEL NEEDS TO BE DEVELOPED

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THANK YOU!

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