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Low-grade waste heat recovery in steel-making industry by coupling Large Heat Pump and Gas Expander

Exploring Waste Heat Recovery Technology Across Diverse Sectors

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Outline

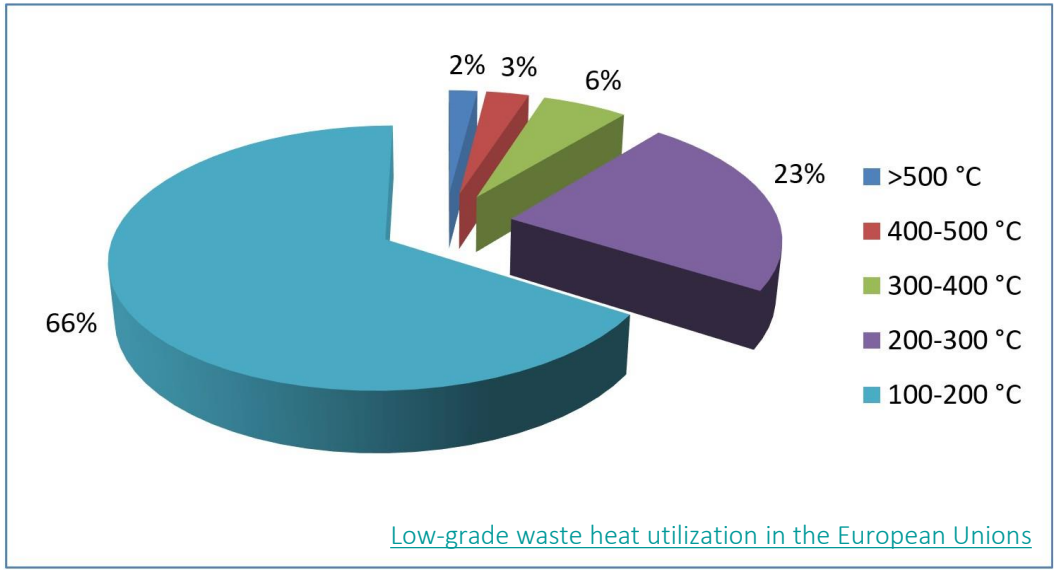
CSMT's contribution to HEATLEAP project in Action C3 - Replicability and transfer

Enhancing Replicability and Market Deployment through the technical replicability report and the replication site identification tool.

Topic covered:

- Overview of Waste Heat Recovery in Industrial Processes
- Mapping Industrial Sites with High Recovery Potential in EU27 countries plus the UK
- Temperature Ranges of Industrial Waste Heat Sources
- Exploring Heat Sources for District Heating Systems
- Standardized Data Collection for Waste Heat Recovery
- Conclusions

Temperature Distribution in Industrial Waste Heat

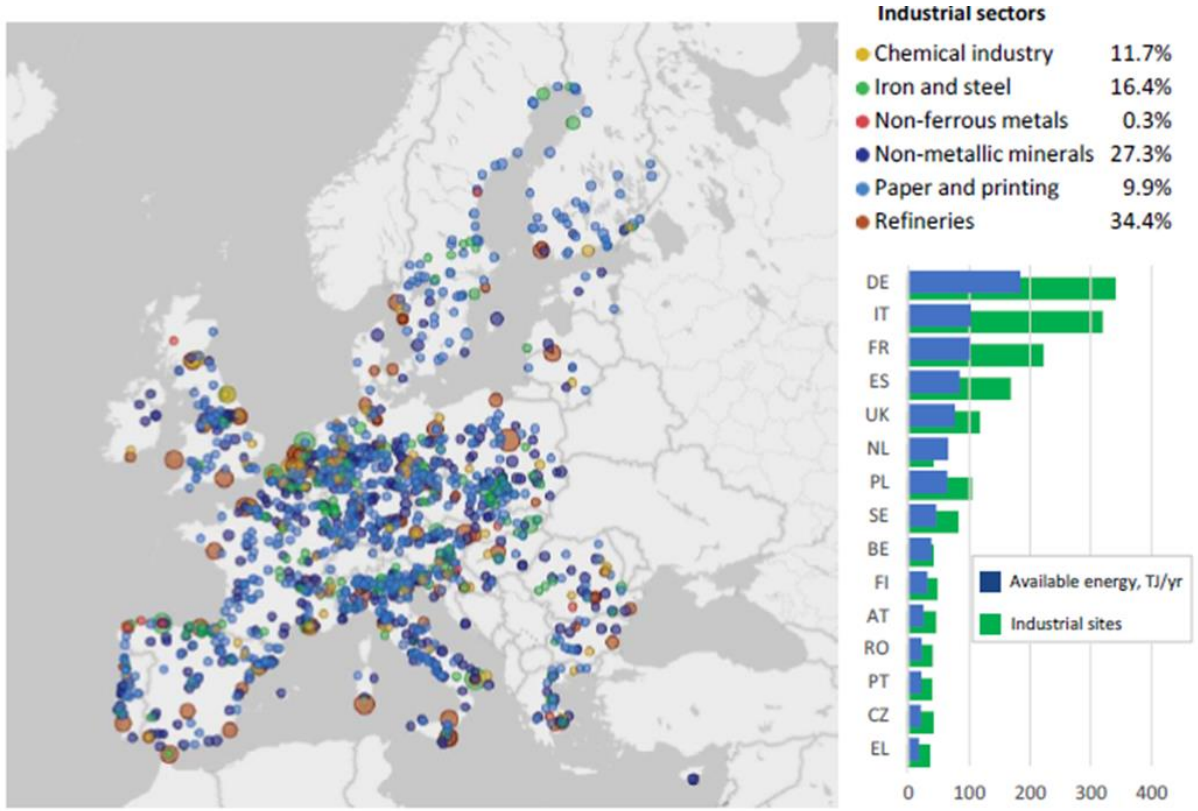


Low-grade waste heat utilization in the European Unions

Grade Waste Heat: Abundant and Promising Opportunity

- Grade Waste Heat is the most abundant source of waste heat across various industries
- Industrial actors have a promising opportunity to harness its potential
- Temperature range between 30°C and 250°C offers significant availability in certain industrial processes

Mapping Industrial Sites with High Recovery Potential



Significant potential for thermal energy harvesting

- Policymakers should take **regional characteristics into account**, such as the concentration of pulp and paper industry in Scandinavian countries and the prevalence of waste-to-energy plants in Western Europe, when developing targeted strategies for harnessing waste heat.
- The **non-metallic minerals industry is a prominent sector** found across all EU countries

Only 25% of the total energy input in these industries is utilized as thermal energy, resulting in a staggering 75% of thermal energy derived from primary fuels being wasted.

M. Astolfi et al., 'The Path to Tapping into a Large CO2-free European Power Source', 2022

Temperature Ranges of Industrial Waste Heat Sources

The potential of LHP technology in EU Countries is huge due to the different types of heat sources identified in an industrial process.

Heat pumps need to be tailored to specific applications:

- Processes below 100°C, can be implemented in the paper, food, and chemicals industries;
- For temperatures between 150°C and 200°C, HPs need special refrigerants and compressors;
- At temperatures above 200°C, direct electrification of industrial processes is generally preferable over HPs.

J. Ling-Chin at al., in Energy Conversion - Current Technologies and Future Trends, IntechOpen, 2019. DOI: 10.5772/intechopen.78701

Unit process	Low-grade heat source	Temperature (°C)
Boilers	Flue gases	110-260
Air compressors	Waste heat from the compressor system	30-60
Heating/Cooling network	Condensate from steam heating and spent cooling water from cooling systems	60-90
Industrial sector		
Petrochemical	Stack gas from crude distillation	156
	Stack gas from vacuum distillation	216
	Exhaust from ethylene furnace	149
Iron/Steel Making	Waste gas from coke oven	200
	Blast furnace gas	93
	Blast stove exhaust	250
Aluminum	Exhaust from aluminum casting with a stack melter	121
Food and Drink	Extracted air from cooking with fryers or ovens	150-200
	Exhaust from drying with spray/rotary dryers	110-160
	Water vapor from evaporation and distillation	100
Textile	Dyed wastewater from drying	90-94
	Exhaust for fabric drying and finishing	180
	Wastewater rejected by a heat exchanger	58-66
Paper	Wastewater from slag flushing in a furnace	65-85
	Waste steam from slag flushing in a furnace	95-100
	Cooling water from furnace wall cooling	35-45
Cement	Exhaust from cement kilns using 5 or 6-stage preheaters	204-300
	Hot air discharged from clinker coolers	100

Exploring Application in Diverse Sectors

- ## Sewage water

The EU Directive 2018/2001 recognized wastewater as a renewable heat source. Wastewater from domestic, industrial, and commercial developments maintains considerable amounts of thermal energy after discharging into the sewer system.

- ## Data center

Digitalization influenced the rapid growth of data centers which facilitate the storage and access of data when required. Data centers are run by electricity and the functioning of different equipment release heat. So, all the electricity input is converted to heat.

Exploring Heat Sources for District Heating Systems

Assessing the Viability of Various Heat Sources

- Sewage water emerges offers high temperature, long-term stability, and proximity to urban areas;
- Industrial waste heat shares similar advantages, except for long-term stability;
- Even low-temperature heat sources like ambient water and district cooling return can be successfully utilized;
- Newer options like flue gas and solar heat storage have emerged after 2000, potentially playing a significant role in future district heating systems.

A. David et al., Energies 10, 4, 578, 2017; doi: 10.3390/en10040578

Type of Heat Souce	Temperature	Stability/Security	Proximity to urban area
Sewage water	○	○	○
Ambient water	◊	○	○
Industrial waste heat	○	□	◊
Geothermal water	○	○	□
Flue gas	○	◊	◊
District cooling	□	◊	○
Solar heat storage	○	○	◊

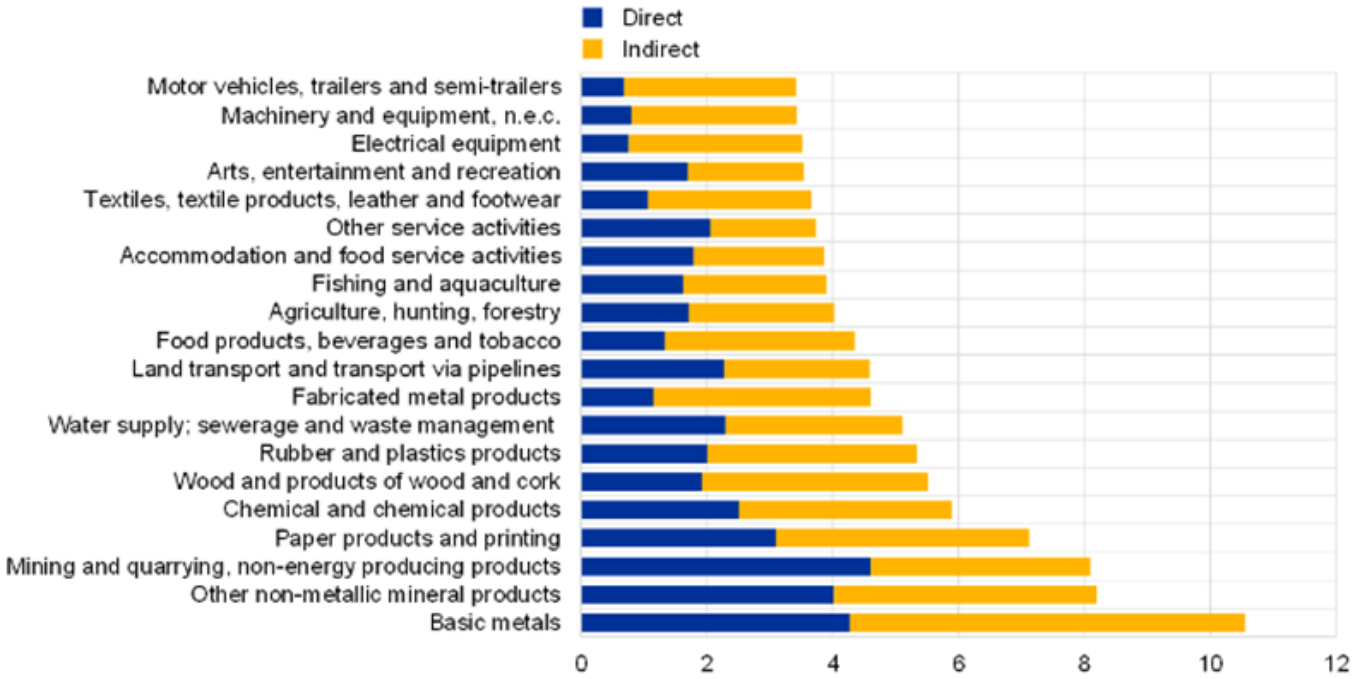
Characteristics of heat sources used by HP:
○ high ◊ medium □ low

The potential of GEX technology in EU Countries

GEX technology can be implemented in basic metals, mining and quarrying, paper and printing, and chemical sectors. Those sectors can be relevant for the GEX installation due to the overall input from electricity and gas.

(percentage of total output in 2018)

ECB Economic Bulletin, Issue 1/2022, 2022



Direct use: consumption of gas as a primary energy source by industrial sectors,

Indirect use: utilization of gas indirectly through other sectors' inputs (especially downstream industrial sector).

Standardized Data Collection for Waste Heat Recovery

Data collection for evaluation of heat recovery potential from industrial processes

Date:	
Company:	
Type:	
Reference person:	
e-mail	
tel.	
Examined process/es:	

Technical data:

Note: starred data are mandatory for a preliminary evaluation

Cold source:

Heat Source (*):	e.g. Water, Air, ..		Mandatory data
Physical status:	Liquid/Vapour		
Inlet Temperature (*):		°C	Mandatory data
Outlet Temperature (*):		°C	If required
Flow rate (*):		mc/hr	Mandator
		kg/s	
Thermal power available:		kWt	

Hot source:

Heat Source (*):	e.g. Water, Air, ..		Mandatory data
Physical status:	Liquid/Vapour		
Inlet Temperature (*):		°C	Mandatory data
Outlet Temperature (*):		°C	If required
Flow rate (*):		mc/hr	Mandator
		kg/s	
Thermal power required:		kWt	If any

Economical data

Daily operating hours		hours/day
Yearly operating hours		hours/year
Electricity average cost		€/MWh
Heat average cost		€/MWht

Tool for waste heat recovery ensures standardized identification of suitable plants for HEATLEAP technology.

The tool, captured data assess replication potential in other Energy-Intensive Industries, does not take into account the financial part but it is a support to find possible stakeholders.

Networking activity:

Horizon INCUBIS - Platform that integrates matchmaking functionalities, ranking tools, feasibility tools, best practices, guidelines, training materials and funding opportunities, functioning as a toolbox for the delivery of Incubator services for factories that manage heat residues (link tool).

Conclutions

- Various heat sources offer immense potential for LHP installations, but each source requires specialized planning, design, and implementation.
- Sewage water and ambient water are reliable heat sources for LHPs, providing long-term stability and proximity to urban areas. Industrial waste heat shares similar advantages, except for long-term stability;
- Industries in sectors such as metal products, food, textiles, and electrical equipment are potential candidates for gas expander technology.
- However, heat pumps face higher investment costs compared to subsidized technologies, limiting their wider adoption. Policy support and innovation will be needed to reduce upfront purchase and installation costs.
- A tool compliant with Energy Efficiency Directives has been developed to collect specific data and promote the adoption of these technologies in the market.
- The technical report and the tool set the basis to foster a wide replication of the WHR solutions and to design innovative Business Models.

Thank you for your attention!

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Project info