
Energy Efficiency and Flexibility for Urban Industrial Production Sites through Integration of Ground Source Heat Pumps (GSHP)

INTERNATIONAL SUSTAINABLE ENERGY CONFERENCE 2018

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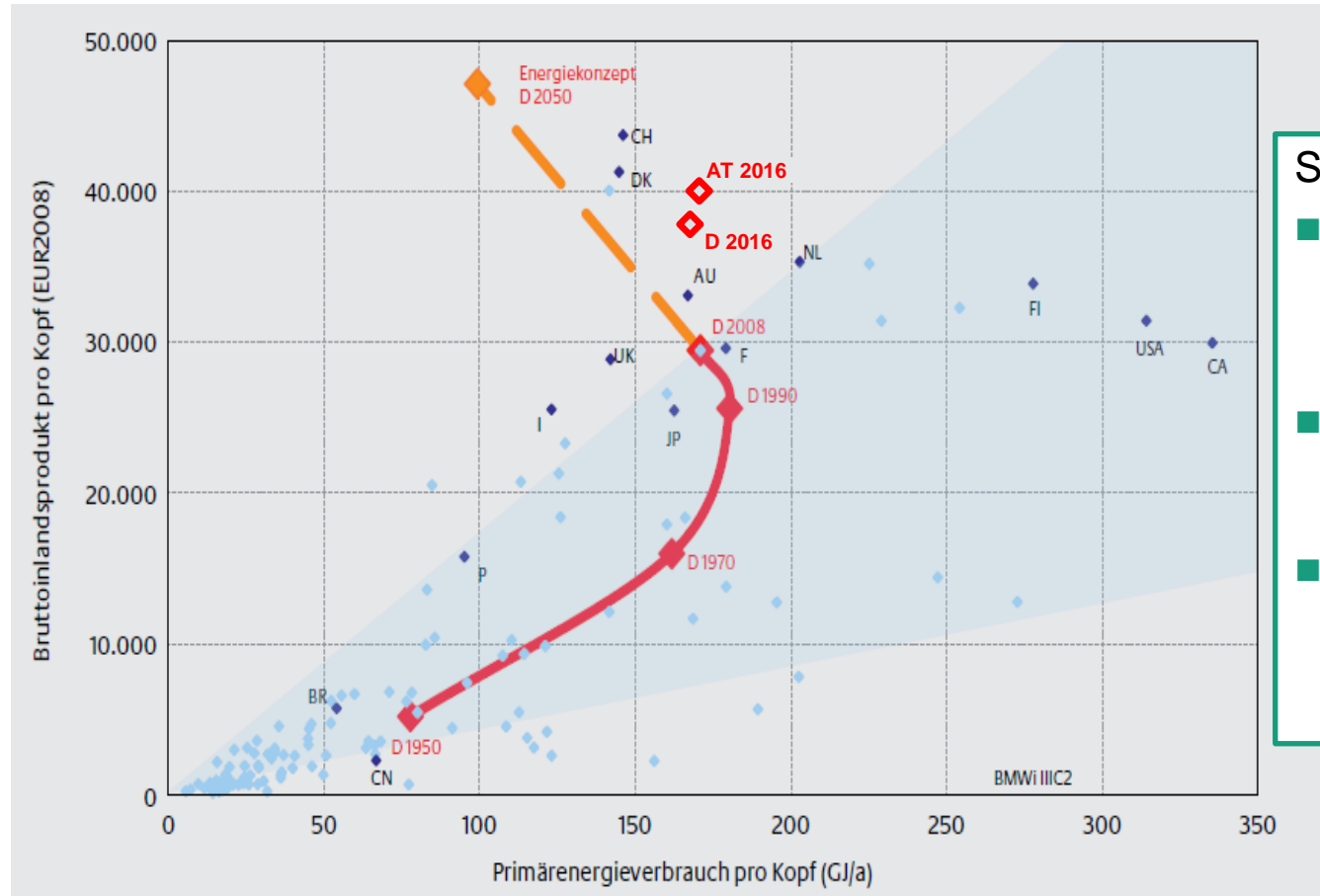
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Can resource consumption and growth be decoupled?

The “Energiewende” is the acid test



Strategic lines:

- Expansion of the use of renewable energy sources
- Decentralization of energy production
- Massive improvement of energy efficiency

Image source: BMWi

Figures source: Statistisches Bundesamt; AGEB; IEA

Optimisation finances innovation

Efficiency, effectiveness and flexibility as a whole

Efficiency strategy:

- Increasing the material efficiency
- Optimising existing processes
- Reducing energy consumption



Effectiveness strategy:

- Closing material cycles (Zero-waste processes)
- Use of secondary raw materials
- Use of renewable energy sources

- Adjust demand to supply (Demand Side)

Flexibility strategy:

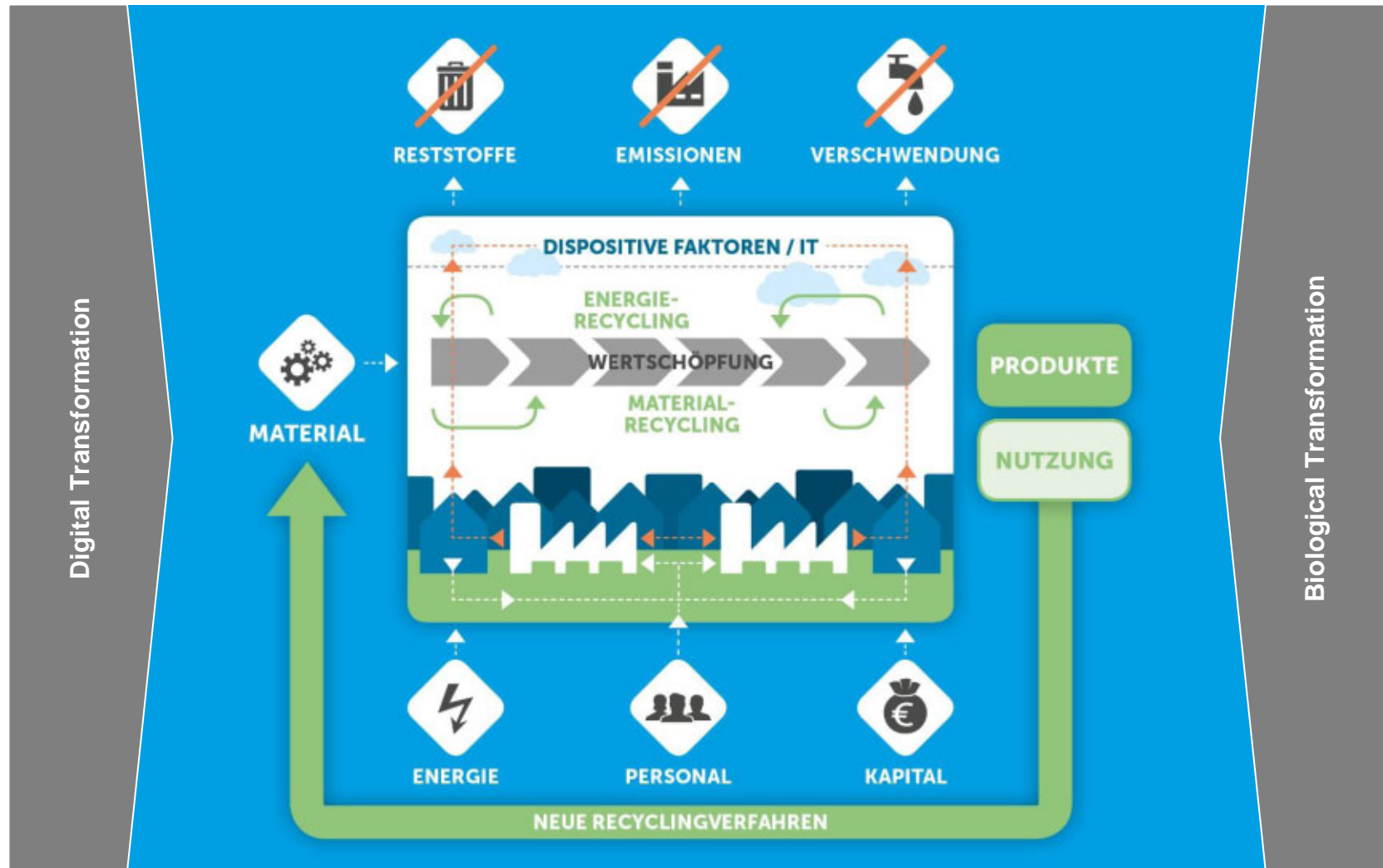
- Participation in energy
- Use of storage technologies

Management)

markets

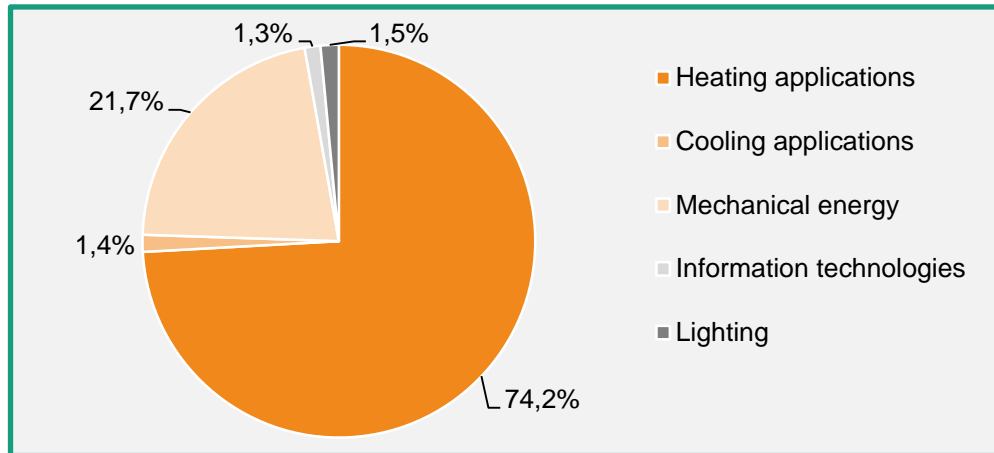
Concept of the “Ultra-efficiency Factory”

Symbiotic-loss-free production in urban environment

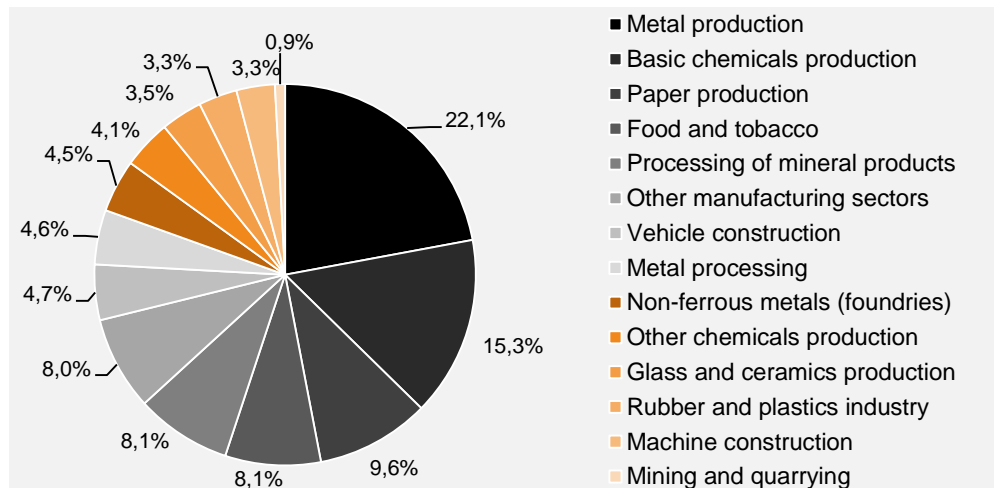


Energy use in the German industry

Heating dominates the energy consumption



Final energy consumption according to application areas 2016 [vgl. AGE B 2017]



Final energy consumption by industry [vgl. AGE B 2017]

- Heating applications dominate with 74%, followed by mechanical energy with about 22%
- 66% of the final energy consumption dominated by energy-intensive industries:

- Metal production
- Basic chemicals production
- Paper production
- Processing of mineral products
- Glass and ceramics production

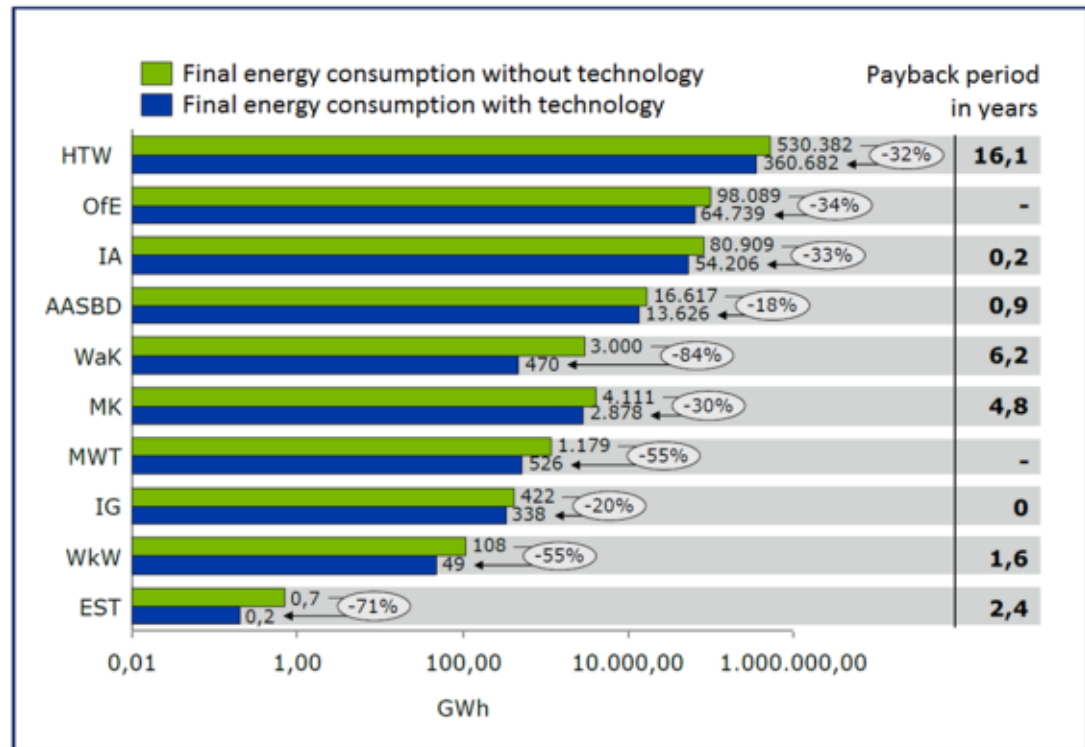
- Use of industry-specific technologies determines heat applications

Energy efficiency technologies in industry

Results of a recent study

Innovative and **commercially available** technologies and systemic solutions that are still **largely unexploited**, but in the long run have a **high potential** to become **economical** and to induce a **noticeable increase in efficiency in the manufacturing sector** (falling order):

1. High temperature heat pump (HTW)
2. Optimisation software for energy network systems (OfE)
3. Intelligent drive solutions (IA)
4. Automatic shutting-off of stand-by compressed air networks (AASBD)
5. Water as refrigerant (WaK)
6. Magnetic cooling (MK)
7. Microwave technology (MWT)
8. Intelligent DC networks (IG)
9. Honeycombed ceramic heat exchanger (WkW)
10. Energy efficient control cabinet cooling (ESK)



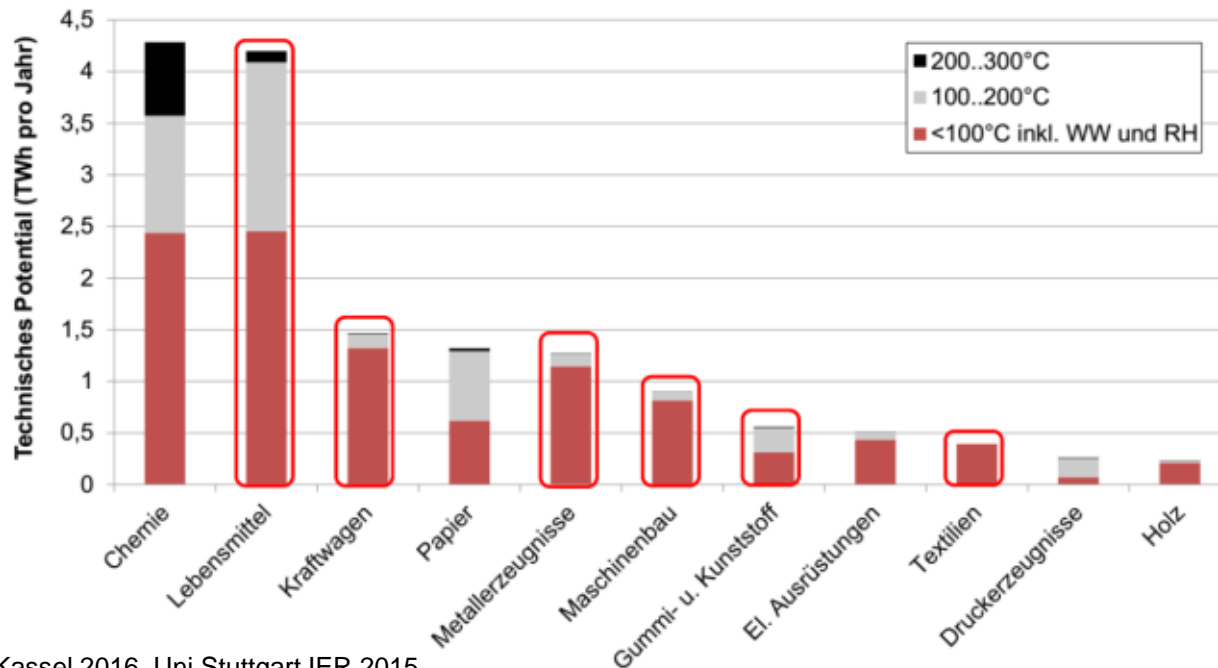
Source: Kube, M. et al. (2017)

Alternative heat generation in industry

High-temperature heat pumps – potentials

Potential for heat pumps in the German industry:

- Today's technical potential ($T \leq 100 \text{ °C}$): 121 TWh (23 % of the industrial demand)
- Future technical potential ($T \leq 140 \text{ °C}$): 170 TWh (32 % of the industrial demand)
- Practically feasible are currently approx. 4-8 % of the industrial demand



Sources: Solar Uni Kassel 2016, Uni Stuttgart IER 2015

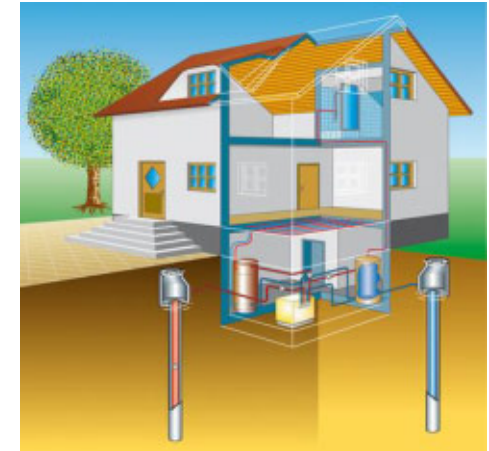
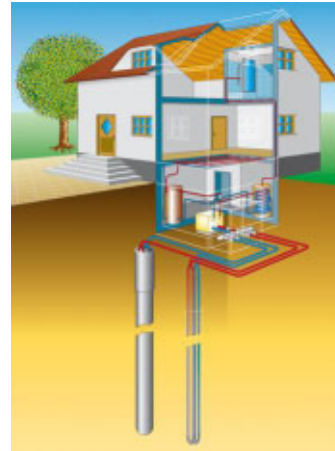
(High-temperature) heat pumps in application

State of the art, applications

Residential heat pumps:

- Heat source: Environment (air, ground, groundwater)
- Heat sink: Heating system, air condition., hot water

→ standard solutions



High-temperature (industrial) heat pumps:

- Heat sources: process waste heat, cooling units, compressed air generation, etc. **Shallow geothermal?**
- Heat sinks: hot air, hot water, steam, etc.

→ individual system integration **Seasonal storage?**



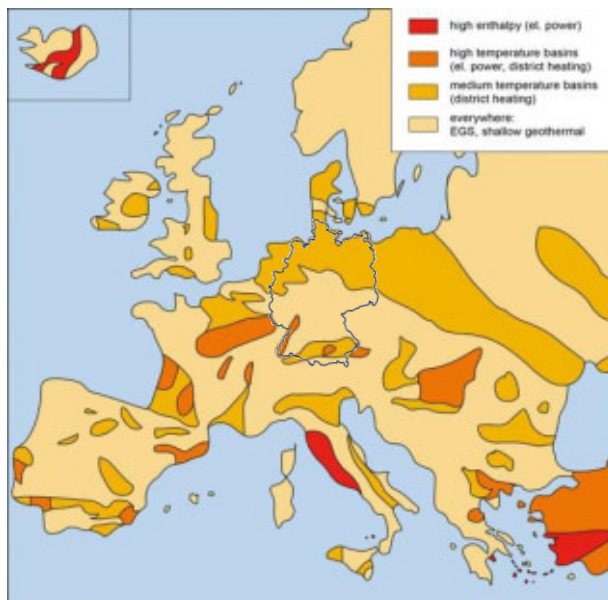
Two-stage high-temperature heat pump with flow temperatures up to 98 ° C

Source: University of Stuttgart IER 2015; Image sources: Bundesverband Wärmepumpe e.V., Ochsner Wärmepumpen GmbH

The heating turnaround in the factory

Shallow geothermal energy – base load capable source

- Shallow geothermal energy (< 400 m depth) in Europe widely used economically
- The output and type of heat pumps can also vary widely in industry



- Temperatures are constant from approx. 20 m depth and independent of weather conditions
- Temperature gradient of 3 K / 100 m below 15 m depth
- Ground temperature: approx. 25 °C in 400 m depth in Germany (regional slight variations)

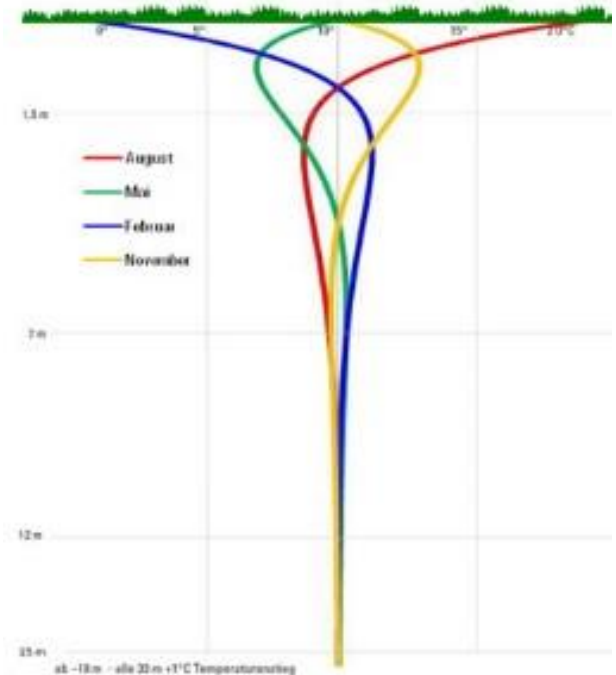


Image sources: EGEC – European Geothermal Energy Council, erdwaermepumpe.at

Energy efficient and sustainable manufacturing

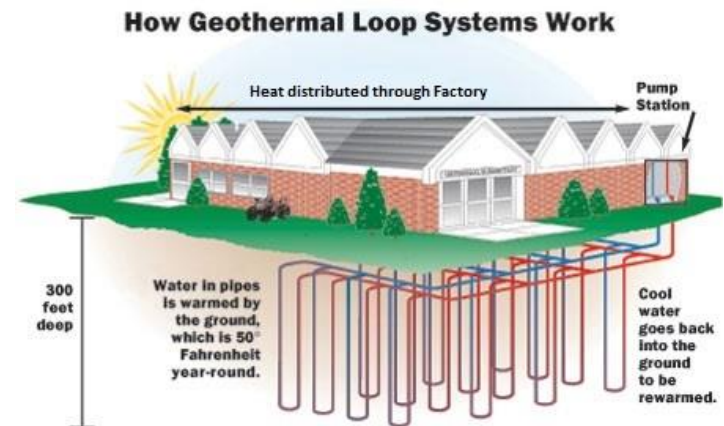
Criteria for integration of ground source heat pumps

Criteria category	Criteria	$W_{criteria}$
Location criteria	Subsurface (geological) conditions	3
	Environmental effects of heating and cooling supply	2
	Security of supply	2
Process criteria	Energy-related applicability (temperatures, required output)	3
	Investment, maintenance and operating costs	3
	Share of heating and/or cooling demand on the total energy demand of the process	2
	Influence of energetic process parameters on product quality	1
	Influence on production and process layout design	1
Total		17

Overarching goal:

→ Increasing the degree of self-generation and decoupling from energy market dependency

Image source: sbs-renewables.com



Integration of ground source heat pumps in industry

Analysis of individual production processes – method

- Manufacturing processes analysed according to DIN 8580 as well as under certain conditions (e.g. different materials, industries, etc.)
- Important processes, including basic operations: melting, extraction, evaporation, distillation, drying, cleaning, washing, preheating, etc.
- Criteria weighting to be specified on a case-by-case basis

Main Group (DIN 8580)	No. of analysed processes	
	Total	Below 140 °C
1 – Casting	30	16
2 – Forming	5	1
3 – Cutting	13	1
4 – Joining	6	-
5 – Coating	24	14
6 – Changing substance properties	27	3
7 – Process engineering processes	27	4
8 – Industrial processes under specific conditions (materials, etc.)	119	72
Total:	251	111

DIN 8580

Integration of ground source heat pumps in industry

Analysis of production processes – results (excerpt)

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Gruppen	Verfahren	Energiekennzahl	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
aus dem körnigen oder pulverförmigen Zustand	Laser Sintern	~ 23600 kWh/MA															
	Wirbellsintern	~ 23600 kWh/MA															
	thermisches Spritzen	332 kW															
	Phosphatieren	~ 23600 kWh/MA															
	Elektrostatische Beschichtung	~ 23600 kWh/MA															
	Pulverbeschichtung mitteldichter Faserplatten	223 kW															
	Kunststoffpulver	~ 23600 kWh/MA															
	Elektrostatisches Beschichten	~ 23600 kWh/MA															
aus dem flüssigen Zustand	Anstreichen / Lackieren																
	Heißspritzverfahren	332 kW															
	Lackrocknung	286 kW															
	Wasserlackbeschichtung																
	Haftwassertrocknung	280 kW - 1120 MWh															
	Zwischentrocknen	280 kW - 1120 MWh															
aus dem ionisierten Zustand	Schmelztauchen	~ 23600 kWh/MA															
	Emaillieren / Glasieren	~ 23600 kWh/MA															
	chemisches Beschichten	~ 23600 kWh/MA															
	galvanisches Beschichten	~ 23600 kWh/MA															
aus dem gas/dampfförmigen Zustand	Stromloses chemisches Vernickeln	~ 23600 kWh/MA															
	Vakuumbeschichten	~ 23600 kWh/MA															
	Beschichten durch Löten																
	Auftragsweichlöten	~ 23600 kWh/MA															
	Auftragshartlöten	~ 23600 kWh/MA															
	Gummierung	~ 23600 kWh/MA															
Beschichten in dem Fahrzeugbau	Kunststoffüberzüge	~ 23600 kWh/MA															
	Lackieren (mehrschichtig)																
	Unterbodenschutz (Korrosionsschutz)																
	Hohlraumkonservierung (Korrosionsschutz)																
	Peripheriebehandlung																

Integration of ground source heat pumps in industry

Analysis of production processes – results (excerpt)

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Suitable production processes for heat supply by GSHP (excerpt)

Manufacturing process	Classification according to DIN 8580 or industry sector	Temperature level	$S_{process}$ (only process criteria)
Bonding with chemically setting adhesives	Main group 4, Subgroup 4.8.2	80 °C – 180 °C	6
Application of anti-corrosion agent (underbody protection)	Main group 5	90 °C – 110 °C	7
Gumming	Main group 5	120 °C – 130 °C	8
Tempering	Main group 6, Subgroup 6.2	110 °C – 120 °C	9
Etching	Woodworking industry	50 °C – 80 °C	9
Boiling	Chemical industry	100 °C – 110 °C	10
Production of plastics (LDPE, HDPE, PVC)	Plastics industry	80 °C – 100 °C	7
Processing of plastics (LDPE)	Plastics industry	120 °C – 140 °C	8
Drying	Ceramics industry	20 °C – 120 °C	10
Bleaching	Textile industry	60 °C – 100 °C	9
Pad-Roll-Process	Textile industry	40 °C – 60 °C	7
Desizing and Powertex-Process	Textile industry	40 °C – 60 °C	7
Washing and drying	Textile industry	30 °C – 100 °C	10

High-temperature heat pumps in the German industry

Best-practice examples – factories in urban environments

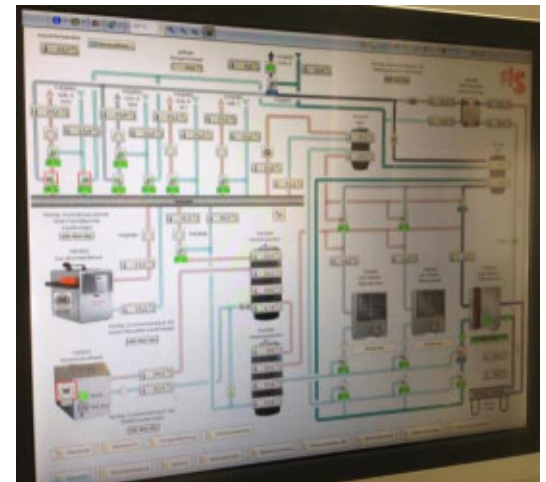
- WITTENSTEIN AG Fellbach, Baden-Württemberg – sustainable solutions for energy supply:

- Production process as well as CHP waste heat usage for heating supply of the neighbourhood in winter
- „energetic coupling“ of production facilities



- Hermos AG, Bayern (SME) – Energy supply concept by means of an **Energy Centre** for self-supply includes:

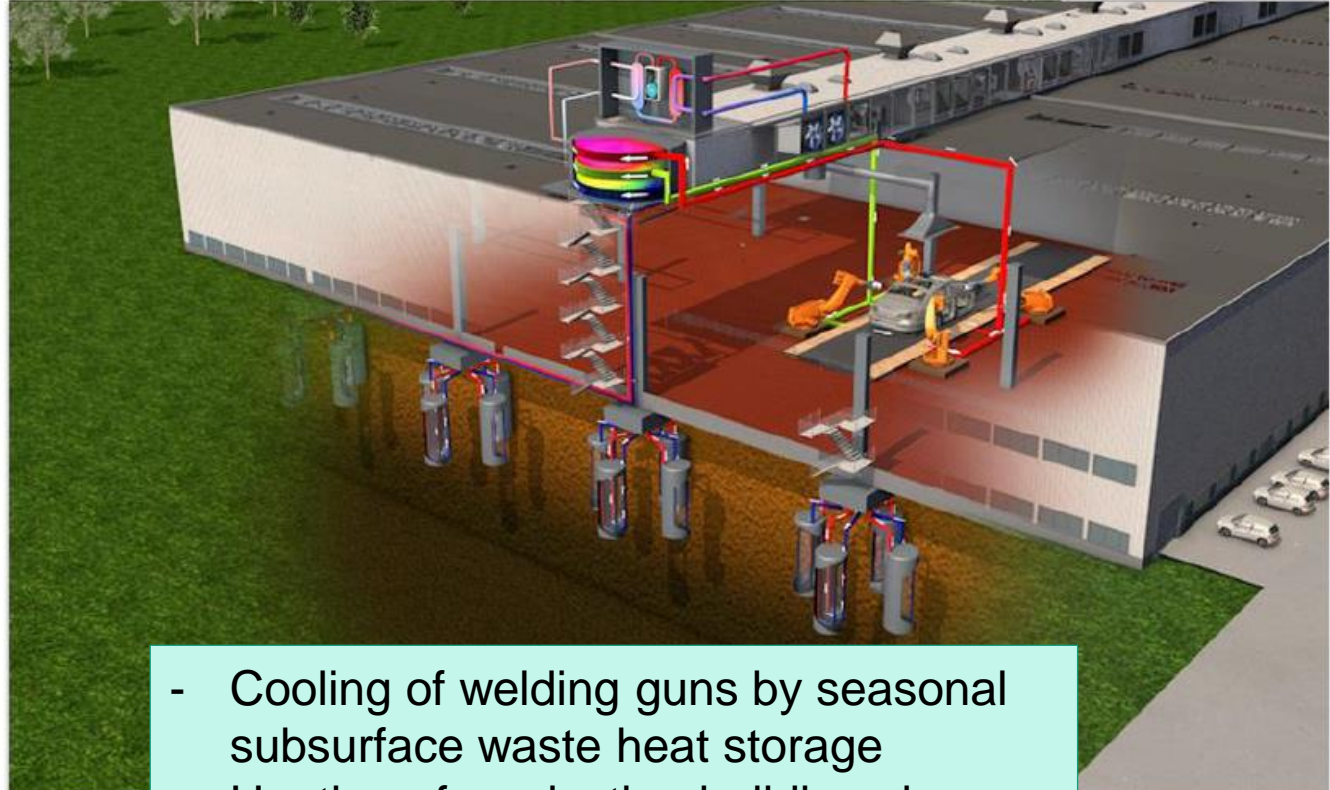
- 2 reversible air-water heat pumps: 60 kW
- 1 reversible brine-water heat pump: 75 kW
- Passive cooling by borehole heat exchangers
- Photovoltaic system: 400 kW_p



Sources: WITTENSTEIN AG, Hermos AG

Best Practice Example: Volkswagen AG, factory Emden

Think Blue. Factory. – Energie
Geothermiefeld in Emden



- Cooling of welding guns by seasonal subsurface waste heat storage
- Heating of production buildings in winter

Source: Volkswagen AG

Project "SynErgie" – Energy-flexible Automobile Factory

p. R.

Strom

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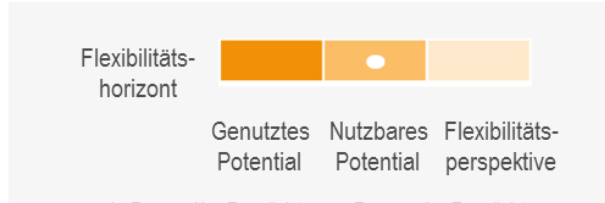
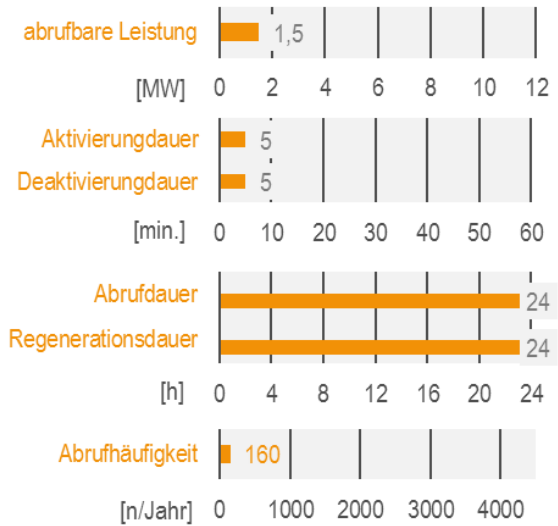
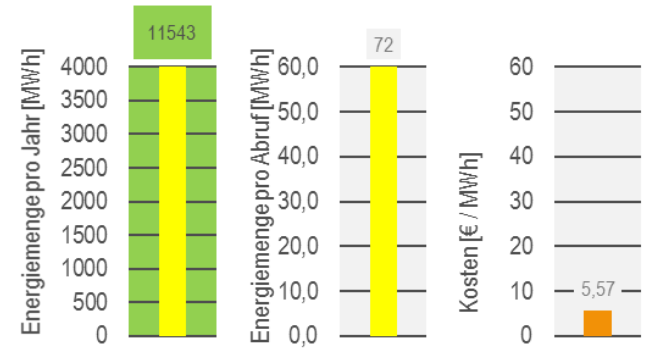
Gas

-

n. R.

Maßnahmenbeschreibung

– Integration eines Wärmepumpen-Systems zur Nutzung von Prozessabwärme, mit dem Ziel einer flexiblen Versorgung mit Prozesswärme und -kälte der Prozesse VBH und KTL in der OF



*p. R. – positive Regelleistung; n. R. – negative Regelleistung

Vorgehen bei der Ermittlung des Flexibilitätspotentials

1. Ermittlung Heizbedarf VBH, Kühlbedarf KTL, Leistungen Versorgungsanlagen (Bestand)
2. Identifikation von genauen Integrationspunkten für WP in der OF:
Ziel: Kopplung der VBH- und KTL-Bäder durch eine Wärmepumpe
3. Dimensionierung und Auslegung des benötigten WP-Systems, inkl. Aufstellung eines Regel- und Steuerkonzepts für den flexiblen Betrieb
4. Berechnung des Flexibilitätspotentials

Annahmen

- Prozessabwärme KTL kann mithilfe eines WP-Systems zur VBH-Beheizung genutzt werden

Datengrundlage u. Rahmenbedingungen

Wärme- und Kälteverbrauchsprofile der zwei Produktionsprozesse in der Lackierung (Energienengen, Temperaturbereiche): 15 Min. / 1 h
 - Bestehende Versorgungskonzepte für Prozesswärme und -kälte in VBH und KTL (Erzeugertechnologien, Leistungen, Temperaturbereiche, aktuelle Regel- und Steuerkonzepte)

Thank you for your attention!

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for a sustainable world*

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