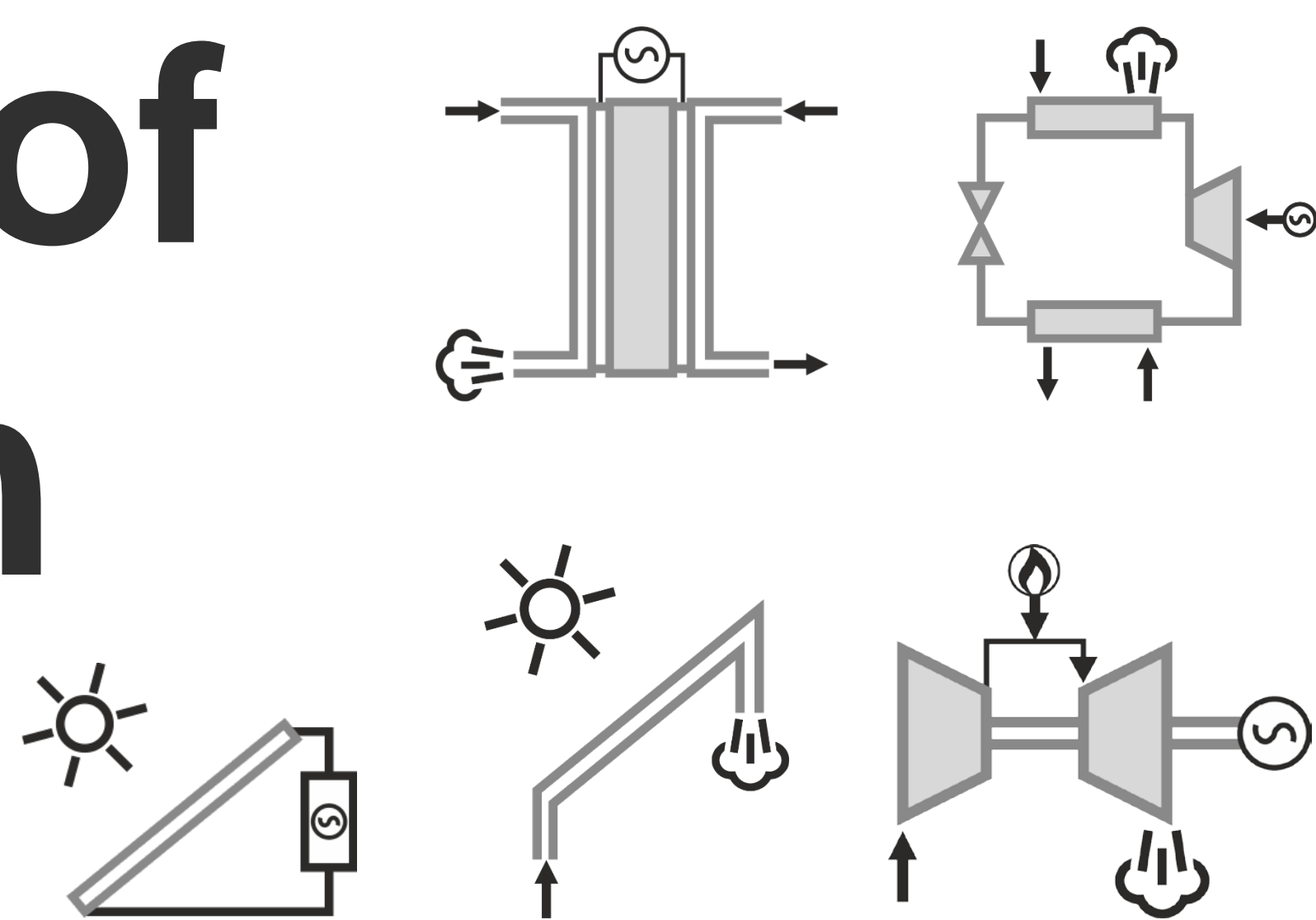


Energy efficient process of industrial heat generation

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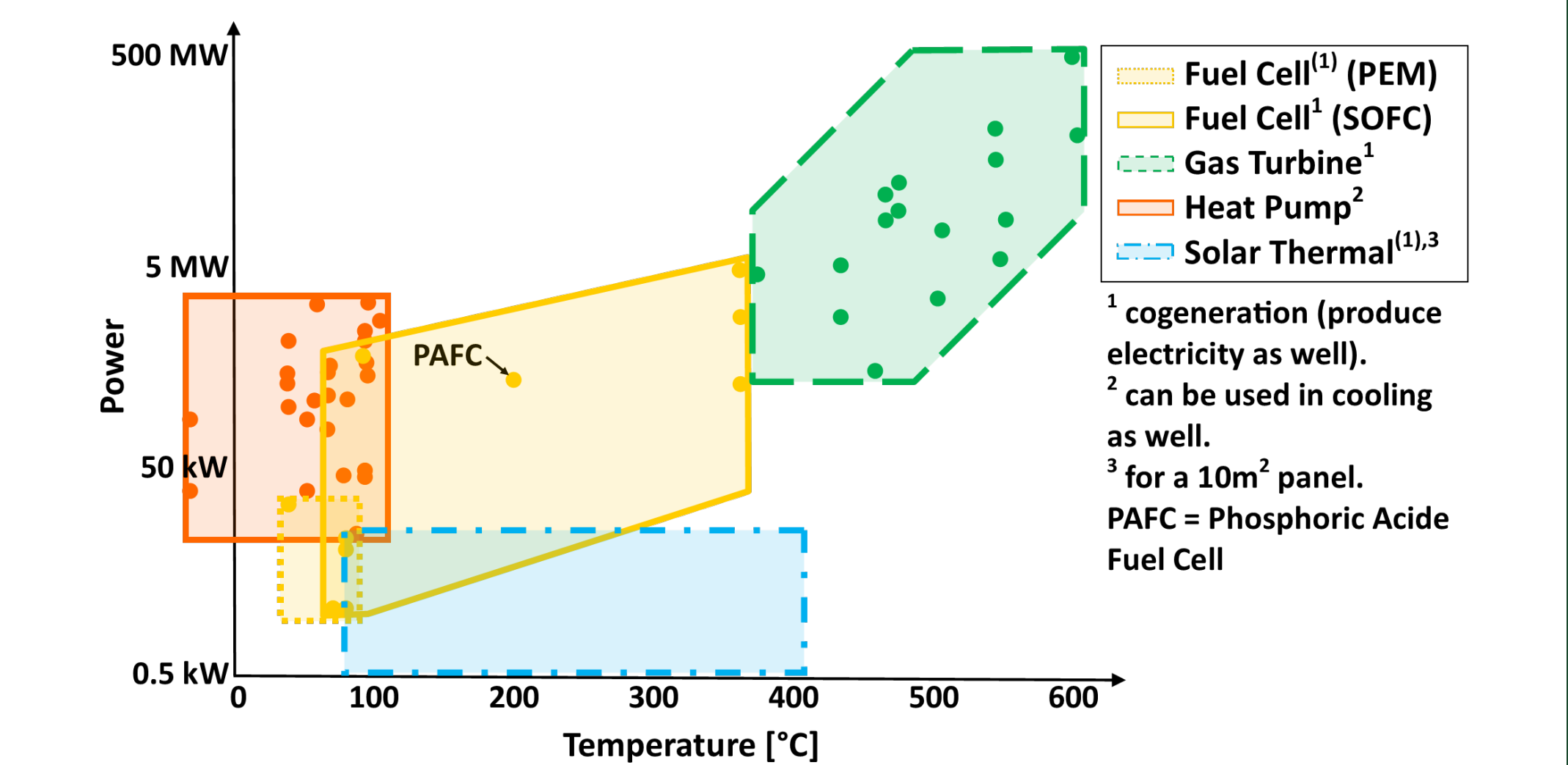


1 Introduction

- **Analysis** of heat generation process (fuel cell, gas turbine, heat pump, photovoltaic, solar heating)
- Clear and concise **description** of types of heating devices
- **Case studies** in different industrial sectors (brewery, sensor production, polymer, packaging, injection molding)

2 Method overview

- Comparison of temperature and power capacity of several industrial heating device available on the market.



Power and temperature capacity of existing processes.

- Fact sheet with description and examples of application of each type of heating system.
- Case studies of several industrial sectors.

4 Conclusions

- The main results of this task has been to create short, simple, and precise documents able to inform industrial people with an overview of industrial heat generating methods and their usages as well as an outlook into the near future.

3 Results: fact sheets and case studies sheets

Fact sheets are concise and contains:

- a clear **description** of the process mechanism
- three **examples** of the process applications
- **pros and cons** of the process
- **properties** such as temperature range and power density range

Link to fact and case studies sheets:



Fact Sheet: Fuel Cells

Background
Fuel cell is a technique to produce electricity using two fluids (oxygen-rich and hydrogen-rich gases). Fuel cells are made of a cathode, an anode and an electrolyte (Figure 1). Different types of fuel cell technologies, called after their electrolyte composition, exist: Alkaline fuel cell (AFC), Polymer electrolyte fuel cell, also called Proton Exchange Membrane fuel cell (PEM), Phosphoric Acid Fuel Cell (PAFC), Solid Oxide Fuel Cell (SOFC), and Molten Carbonate Fuel Cell (MCFC). Fuel cells convert the chemical energy from a fuel into electricity and heat [1].

Figure 1: Schematic of a fuel cell [2].

Example of applications:

- 1 kW electricity and 1.8 kW heat system for residential CHP [3].
- 400 kW electricity and ~450 kW heat system for industrial supply or backup supply [4].
- 59 MW electricity power plant in South Korea [5].

Advantages

- No moving part
- Emit quasi no pollutant such as NOx, CO or SOx
- High efficiency up to 70%
- Suitable for cogeneration
- Complementary with a gas turbine cycle
- Versatility due to construction using modules allowing large range of power (from W to MW)
- Versatility of applications due to the variety of fuel cell types

Disadvantages

- Expensive
- New technology → reliability is yet unknown
- Emit CO2 when fuel other than hydrogen is used
- Fuel production can be problematic (pollution and/or low efficiency)

Properties

Temperature range:	60°C - 370°C
Power range:	1.8 kW _{heat} - 47 MW _{heat} (combined module)
Fuel range:	Hydrogen, natural gas, biogas, methanol, ethanol
Power density range (kW _{heat} par surface area):	1.1-2500 kW _{heat} /m ² (median: 10 kW _{heat} /m ²)
Service life:	3000 operating hours - 10 years
Price range:	n.a.

References

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Case studies sheets are two-sided pages of analysis of a company in a particular industrial sector containing:

- a **description** of the firm
- a **schematic** of the system analysed
- the **goal** of the study
- the **results** of the analysis
- a **conclusion**
- the possible **improvements** separated into simple and complex solutions

Case Studies: Packaging Sector

Description:
The industry provides development, design, decoration, and production solutions. The firm creates packaging in the form of plastic cups and lids. The industry is using a process called sleeving, the mechanism uses steam to shrink the sleeve to the shape of the article. The used steam is rejected into the atmosphere. There is potential to reuse the energy released. Several solutions are analysed in terms of energy saving, cost, and feasibility. The energy consumption solutions could reduce up to 65%. Other solutions propose to give or sell the energy to a heating network.

Goal:
The aim is to determine the best way to reuse the steam used in a sleeving process. The analysis is made in terms of energy, economy, and feasibility.

Analysis:
Eight different solutions were analysed in terms of functionality, cost, and efficiency. Four of these solutions are presented below. Other solutions, such as using the rejected steam to produce electricity using an organic ranking cycle, were also studied. The designs presented are:

1. The rejected steam is used to preheat the water.
2. Using a compressor to reheat the steam and being able to reuse it directly or to store it in the water storage.
3. Using compression, the superheated steam is used to heat the water instead of the steam boiler.
4. Using the heat of the used steam for a district heating.

Explanation:
Heating circuit with water in blue, steam in red and residual water in gray.

Figure 1: Schematic of the heating circuit.

Figure 2: Four different designs for steam reuse.

These four different designs have each advantages and disadvantages. The main pros and cons are the following:

1. The first solution uses the rejected steam to preheat the water. This design only needs a compressor and a heat exchanger. The heat exchanger could be also spared by injecting the steam directly into the water storage.
2. Vapour recompression would be a simple solution as only a compressor is need. However this solution is not feasible because the rejected steam contains not only water vapour but also air. That is because the sleeve machine is an open system where air is mixed with the steam.
3. The rejected steam is superheated using compressors. The heat gained can be used to directly evaporate the water and thus bypass the steam boiler. This case can reduce the oil consumed by the steam boiler but add electric energy consumption due to the compressors.
4. The last design is the most simple of all, the heat from the rejected steam is given or sold to a district heating. This solution can only be made since a district heating exists in the location of the firm.

A disadvantage of the systems is that the rejected steam contains a high percentage of air. This prevents the usage of vapour recompression. The designs use the heat of the rejected steam and air mixture to either preheat the water, evaporate the water, or use it in another system. As district heating interests more and more community, a company which cannot reuse steam or other sources of heat should always considers this solution.

Conclusion:
For this particular system and due to the air contained in the rejected steam, the best solution was found to be the use of the excess heat into the district heating.

Improvements:

Easily implemented:	Complex implementation:
• District heating	• Evaporation of the water using compressed air and steam mixture

Partners:

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