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INTEGRATE: Integrating seasoNal Thermal storagE with multiple enerGy souRces to decArbonise Thermal Energy

Work Package 4: Heat Recovery and Cooling Demand

To investigate the potential to match heat recovered from industrial processes with UK heating and cooling demand.

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Outline of the presentation:

- Outline of Work Package 4
- Overview of UK industry heat demand
- Previous methods to quantifying waste heat across UK industrial sectors
- Relevant findings
- Future tasks

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Work Package 4: Heat Recovery and Cooling Demand

To investigate the potential to match heat recovered from industrial processes with UK heating and cooling demand.

M 4.1

To map the quantity and grade of potential sources of waste heat against current heat recovery technology.

M 4.2

To quantify and predict the future cooling demand based on the roll out timetable of thermal efficiency measures in the domestic and industrial cooling sectors.

M 4.3

To correlate and match TES systems features for a particular heat source to the predicted winter heating demand.

M 4.4

To investigate the thermal characteristics required for short- and long-term storage of waste heat for later use.

M 4.5

To feedback the results from the detailed storage simulations to WPs 2, 3, 5 and 6.

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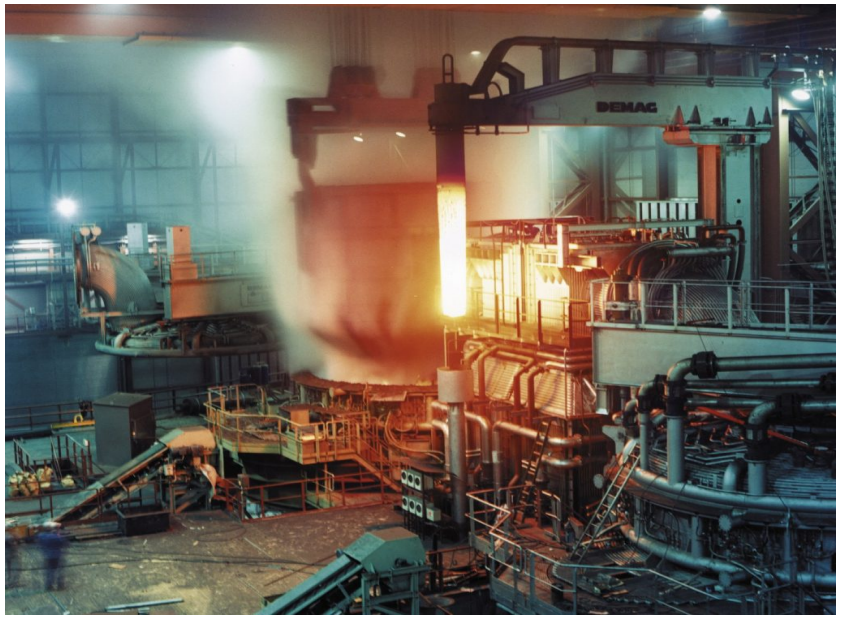
An overview of UK industry heat demand:

- The UK industrial sector is responsible for approximately 17-20% of the UK's final user energy demand.
- About 80% of the industrial energy demand is for heating purposes.
- The eight most heat intensive industries are Cement, Ceramics, Iron & Steel, Glass, Chemicals, Refineries, Paper & Pulp, and Food & Drink.
- Most heat (44%, 9 Mtoe) is used for low temperature processes. High temperature processes utilise 22% (4.5 Mtoe).

(Source: DUKES database)

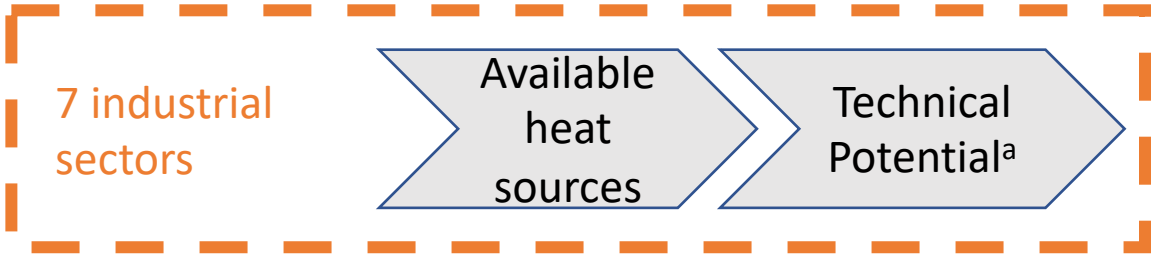


Photos:ArcelorMittal (Top); Rugby Archive: Cat. No. RC-3-6-8. Back end of Southam Kiln 7 (Bottom)

Previous approaches to estimating waste heat:

- Mckenna and Norman (2010) conducted a peer-reviewed assessment of waste heat recovery in the UK.
- The study estimated a technical potential of 10-20 TWh/yr based on averaged 2000-2004 data.

McKenna and Norman (2010) model



[a]Technical recovery potential: 50% of the recoverable sensible heat from the exhaust stream

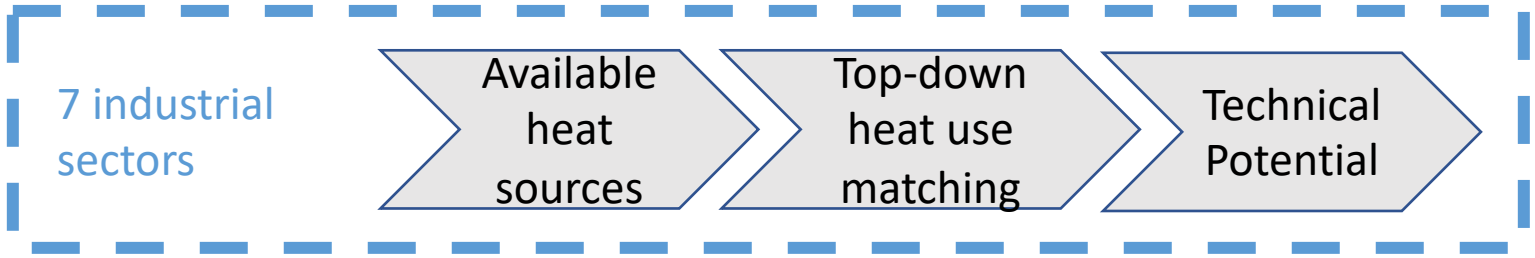
Emissions factor[1]: $K_T = \Sigma_{x=1}^{N} C_x K_x / \Sigma_{x=1}^{N} C_x$

Total site consumption: $E_{T_f} = C_T f_c / K_T$

Site heat load: $Q = E_{T_f} \eta_c / tLF$

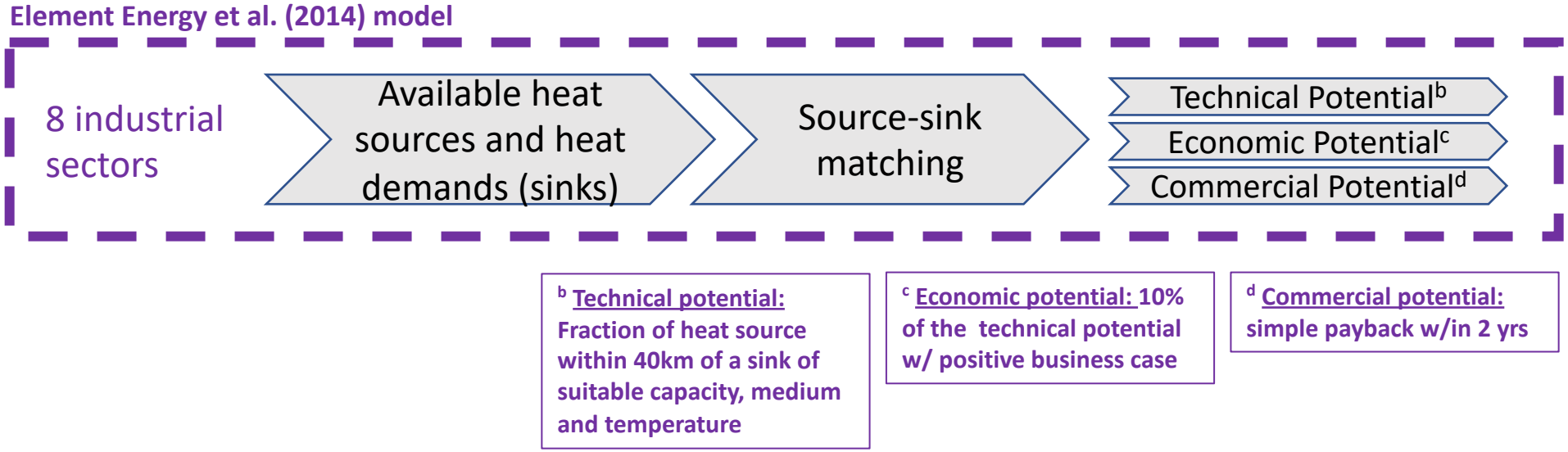
- The Mckenna and Norman (2010) approach made the simplifying assumption that a fraction of recovered rejected waste heat can always be re-used.
- Norman and Hammond (2013) updated the results of the previous work by including a greater analysis on the potential applications for re-using recovered heat.

Norman and Hammond (2013) model



Previous approaches to estimating waste heat:

- Element Energy et al. (2014) provided a transparent platform that allows DECC to establish the potential for heat recovery across a wide range of scenarios.



Limitations of previous methodologies:

- Not actual site data: archetype processes mapped to the individual sites, whereas in reality, site and technological characteristics are heterogeneous[2].
- Limited data due to commercial confidentiality and competition constraints.
  - CO_2 emissions as proxy for fuel use[1]
- One source to one sink with one technology: if a source or sink has been used, both are no longer available.
- The total potential can be under-estimated:
  - Top 88% of EU ETS emitters

Photo: AFP

[1] DEFRA, 2007b. EU Emissions Trading Scheme: Approved Phase II National Allocation Plan 2008–2012. DEFRA, London
[2] Department of Energy and Climate Change, The potential for recovering and using surplus heat from industry (Final Report), 2014.c

Relevant findings:

1. The largest heat user is the iron and steel sector with a demand around 213 PJ, with the chemicals sector being the second largest at 167 PJ[2-3]

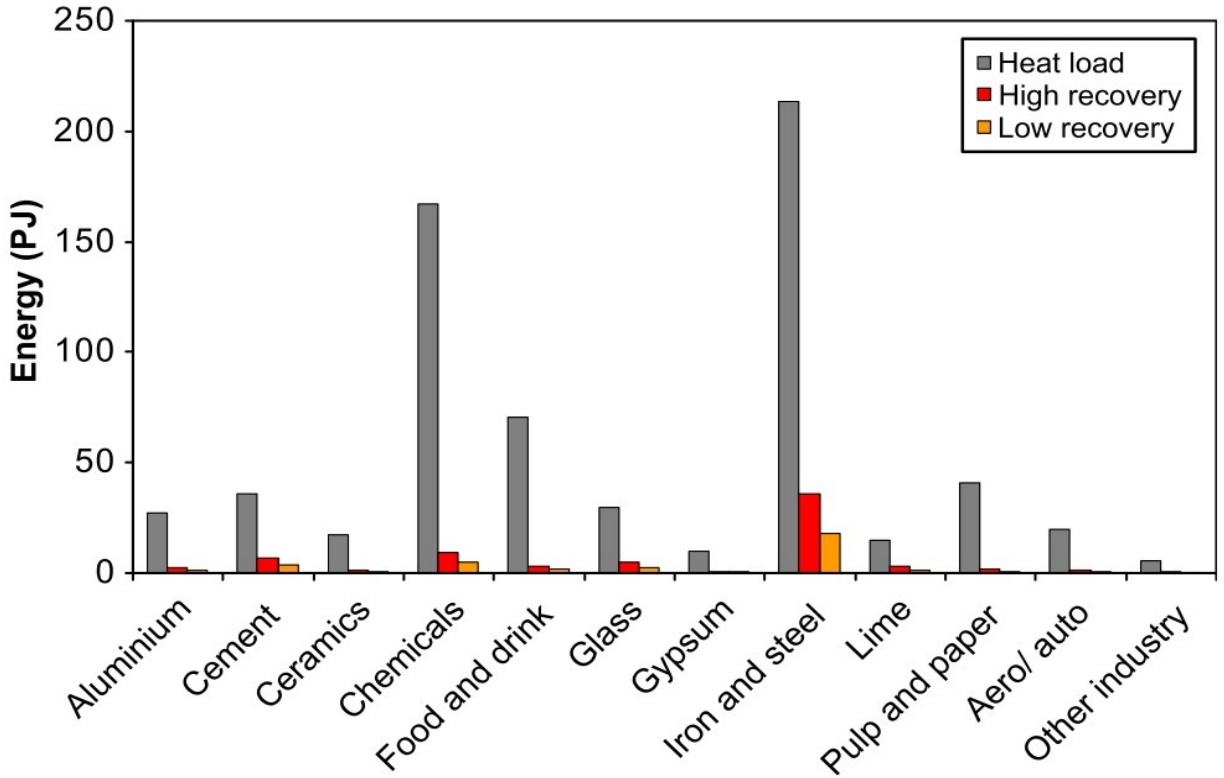


Figure 1. Energy use for heat (annual heat load) and estimated recovery potentials for industrial sectors[2].

[2] Department of Energy and Climate Change, The potential for recovering and using surplus heat from industry (Final Report), 2014.c
[3] Mckenna et al., 2010, Spatial modelling of industrial heat loads and recovery potentials in the UK, Energy Policy 38, 5878 (2010)c

Relevant findings:

1. The largest heat user is the iron and steel sector with a demand around 213 PJ, with the chemicals sector being the second largest at 167 PJ[2-3]

Based on 73 sites, 467 heat sources and 1090 heat sinks [1]

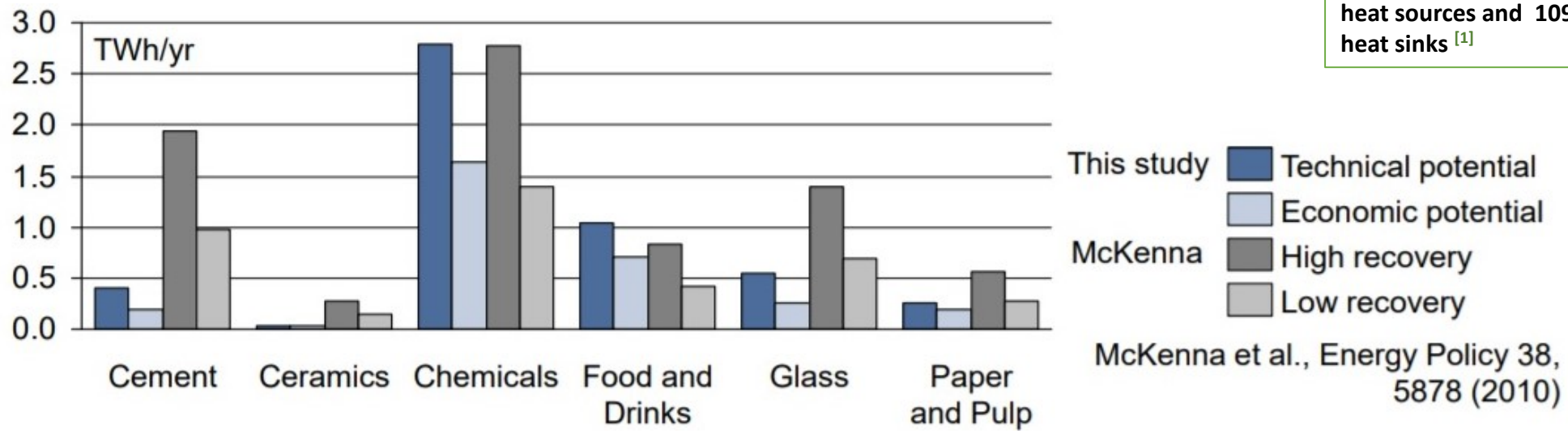


Figure 2. The estimate of the potential for heat recovery per site in the UK (except for the Iron & Steel Industry)[2].

[2] Department of Energy and Climate Change, The potential for recovering and using surplus heat from industry (Final Report), 2014.c
[3] Mckenna et al., 2010, Spatial modelling of industrial heat loads and recovery potentials in the UK, Energy Policy 38, 5878 (2010)c

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2. The sectors vary strongly in their major waste heat sources[2][4]

Sector	Functional unit	Diversity of waste heat source characteristics	Major waste heat sources
Iron & steel	Tonne steel	+++	Hot solid steel (hot rolling), coke oven gas. Off-gases from BOF/EAF furnaces
Pup & paper	Tonne paper	+++	Exhaust air from drying machines, water discharges
Cement	Tonne clinker	+	Hot gases from kilns (various temperatures)
Oil refining	Barrel of oil processed	+++	Cooling water and low temperature flue gases
Chemicals	kWh final energy input	+++	Cooling and process water, furnace and boiler exhaust, condensates
Glass	Tonne glass	+	Melting surface exhaust gas (differentiated types)
Food & drink	kWh final energy input	+++	Condensates from evaporation/distillation/cooling, flue gases from baking and drying
Ceramics	Tonne product	+	Hot gases from firing process in kilns
Power	kWh electricity	+	Cooling water, gas turbine exhaust gas

[2] Department of Energy and Climate Change, The potential for recovering and using surplus heat from industry (Final Report), 2014.
[4] L. Waters, Energy Consumption in the UK July 2017, Department for Business, Energy & Industrial Strategy, London, 2017.

3. Dominant heat sinks identified in each sector[2]

Process Type	Sub process Type	Heat Sinks Descriptions	Iron and Steel	Pulp and Paper	Cement	Glass	Ceramics	Oil Refining	Food and Drinks	Chemicals
High Temperature Processes	Furnaces	Combustion air preheating	+		+	+	+			+
	Steam Boilers	Water preheating								+
	Steam Boilers	Combustion air preheating								+
Low Temperature Processes	Boilers	Water preheating		+	+	+	+	+	+	+
	Boilers	Combustion air preheating		+	+	+	+	+	+	+
Drying	Low Temperature Drying	Air preheating		+	+		+	+	+	+
	High Temperature Drying	Air preheating		+	+		+	+	+	+
Space Heating	Space Heating	Water preheating		+	+	+	+	+	+	+
	Space Heating	Combustion air preheating		+	+	+	+	+	+	+

[2] Department of Energy and Climate Change, The potential for recovering and using surplus heat from industry (Final Report), 2014.

4. Heat is mainly recovered and reused using heat exchangers[2]

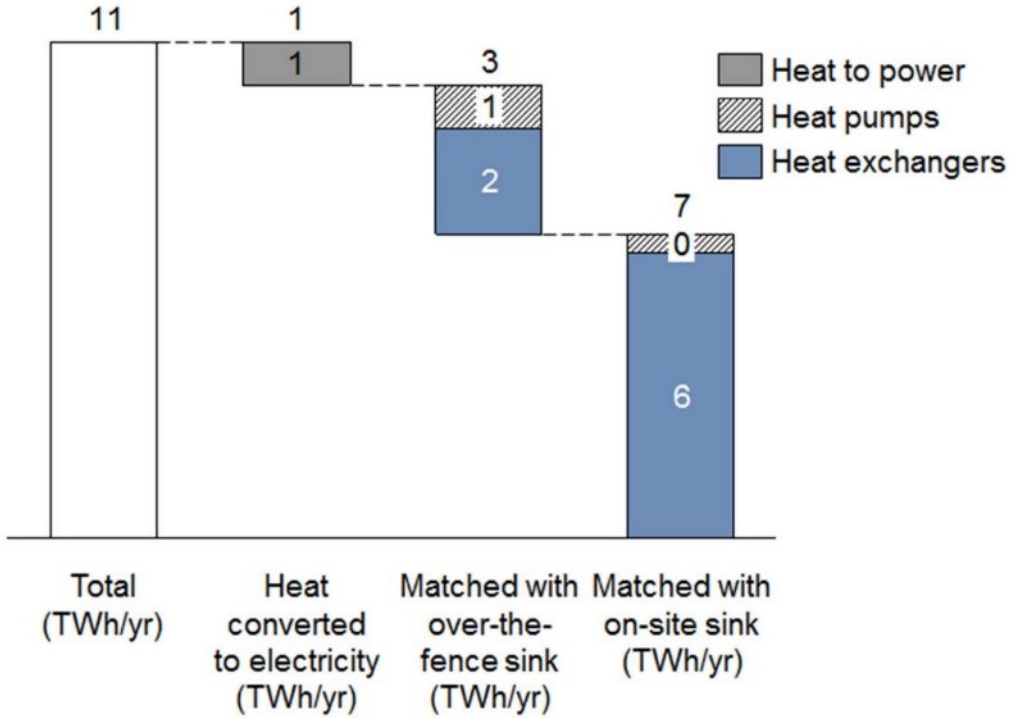

Figure 3. Application type of recovered heat in the technical potential, for different technology categories [2]

Based on the short list of technologies selected according to industry relevance and ensuring operating range coverage of media and temperature

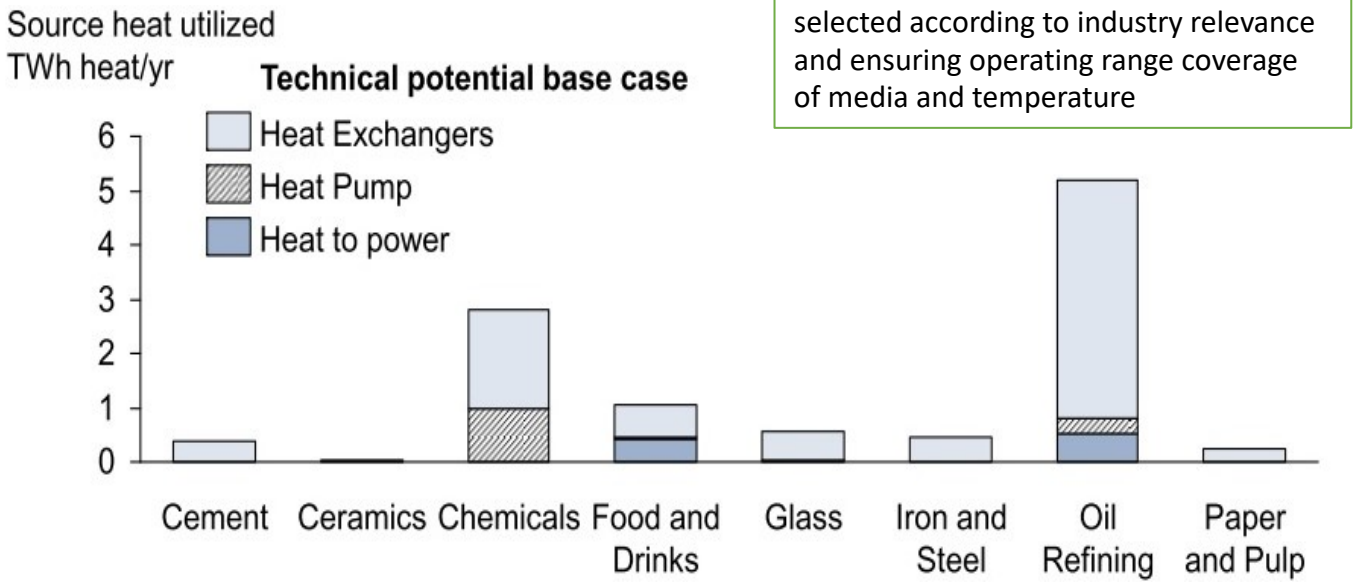

Figure 4. Technical potential vs. Type of Heat Recovery Technologies in each sector[2]

Heat Exchanger

Heat Pump

[2] Department of Energy and Climate Change, The potential for recovering and using surplus heat from industry (Final Report), 2014.

Photos: GETO Live (Top); Studio van Assendelft (Bottom)

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Next steps:

Identify the dominant heat sources, sinks and recovery processes based on archetypal mapping of industrial processes (M4.1) ☑

Update the database, e.g. heat source, sinks, recovery technology, by considering those sites that were not included in the old database (M4.1) ☑

Identify resources for the roll out timetable of thermal efficiency measures in the domestic and industrial cooling sectors (M4.2)

Progress:

1. **Heat source**:
   - Total heat load (MW_{th}) profile
   - At least 100 identified sites
   - based on an updated CO_2 emissions* database
   - Methodology by Element Energy et al. (2014)

2. Heat sinks/ recovery tech:
   - Final Report by Element Energy et al. (2014)

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Thank you for listening.