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Decarbonising the forging industry using thermal energy storage (TES) based waste heat recovery technology

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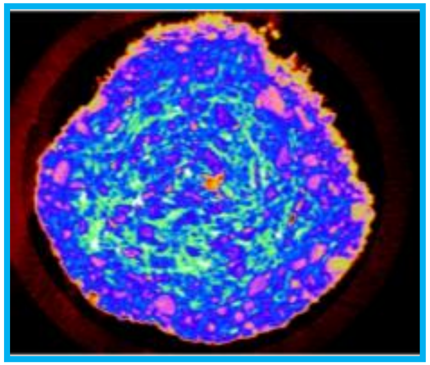

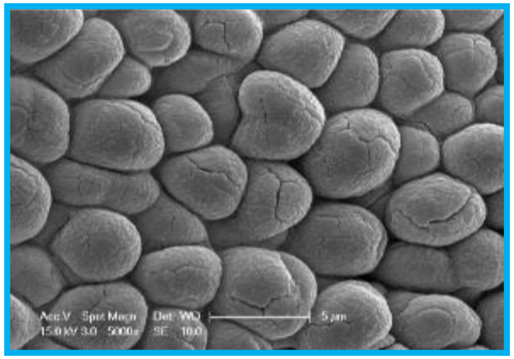

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- Overview of UK Forging Industry
- Forging industry decarbonisation – the challenges
- Thermal energy storage (TES) based solution
- Examples of UK efforts to decarbonise forging industry

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Overview of the UK Forging Industry

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- Introduction
- UK Forging Industry data (2023)
- Net zero challenge

- £1.1Bn turnover
- 42 UK Forges employ 5,500 directs
- 240,000T produced annually
- More closed die than open die
- Good mix of ferrous and non-ferrous

- Within the 42 forges
- At least 650 forge and heat-treatment furnaces are utilized
- Split is approximately 2:1 in favour of gas-fired furnaces
- Around 1,000 GWh energy is consumed
- Representing at least 175,000T direct CO_2 emissions annually

- Traditional foundation industries – a number of which are still family run businesses
- High capital equipment replacement cost
- Long life of well-maintained assets

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Forging industry decarbonisation – The big picture and the scale of challenges (A)

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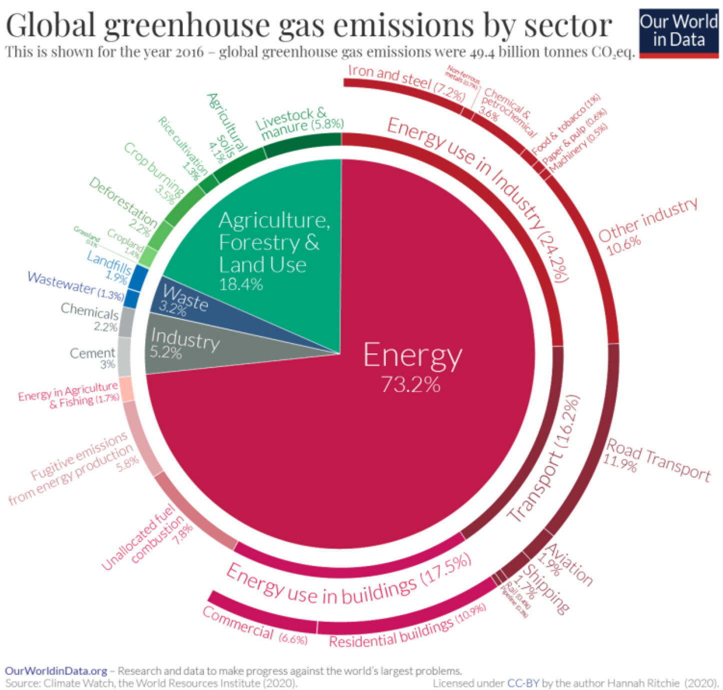
CO_2 emission is mainly from energy sector but driven by other sectors



Industry 30%
- Energy Consumption Related Emission – 24.2%
- Direct Emission – 5.2%

Transport 16.2%
- Road – 11.9%; Rail – 0.4%; Aviation – 1.9%; Shipping – 1.7%

Buildings 17.5%
- Commercial – 6.6%
- Residential – 10.9%

- Industry sector accounts for ~30% of global carbon emission, with over 80% due to energy consumption
- Energy and industrial sectors are coupled, so their decarbonization needs to be addressed in a coupled manner

https://ourworldindata.org/

Forging industry decarbonisation – The big picture and the scale of challenges (B)

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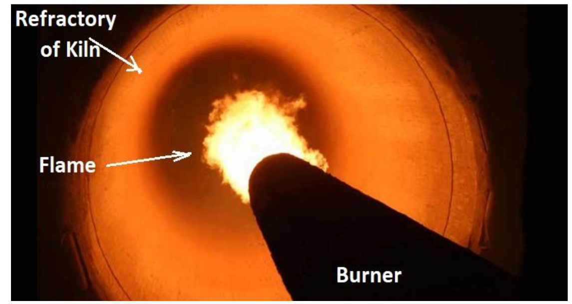
Foundation industry (metal, glass, cement, ceramics, chemical & papermaking) hardest to decarbonize

Global carbon emission from steel sector ~8%

Steel Industry – Ironmaking



Cement Industry – Rotary Kiln

Global carbon emission from cement industry ~8%

Global carbon emission from glass sector ~0.5%

Glass Industry – Glassware making

Ceramic Industry – Ceramic Firing Furnace

Global carbon emission from ceramic industry ~2%

Chemical sector ~5%; Papermaking ~0.33%; Food & Drinks ~0.88%; Non-ferrous metals ~0.25%

Global total carbon emission in 2023 ~37.4 billion tons (Gt)

- **Carbon emissions of metal forming is estimated to be ~10-30% of total the ferrous and non-ferrous metal sector carbon emissions: ~0.8-2.5% of global carbon emissions.**
- **Energy consumption accounts for >80% of the emission.**

Forging industry decarbonisation – The big picture and the scale of challenges (C)

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Main challenges in forging industry decarbonization

https://www.tfgusa.com/metal-forging-processes-methods/

- **Medium to high temperature operations, often with strict heating curves;**
- **Using conventional technologies, with a combination of continuous and batch operations;**
- **Electrification is challenging; often low efficiency, heat pumps do not work in most cases**
- **Waste heat abundant but with a low value chain;**
- **Lots of small & medium sized companies scattered around different regions:**
  - **Crucial industrial sectors, matter to national security;**
  - **Low margins make the adoption of new technologies difficult to justify and finance.**

https://assets.publishing.service.gov.uk/government; UK Industrial Decarbonisation Strategy, BEIS, March 2021

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Thermal energy storage (TES) based solution – the concept of TES

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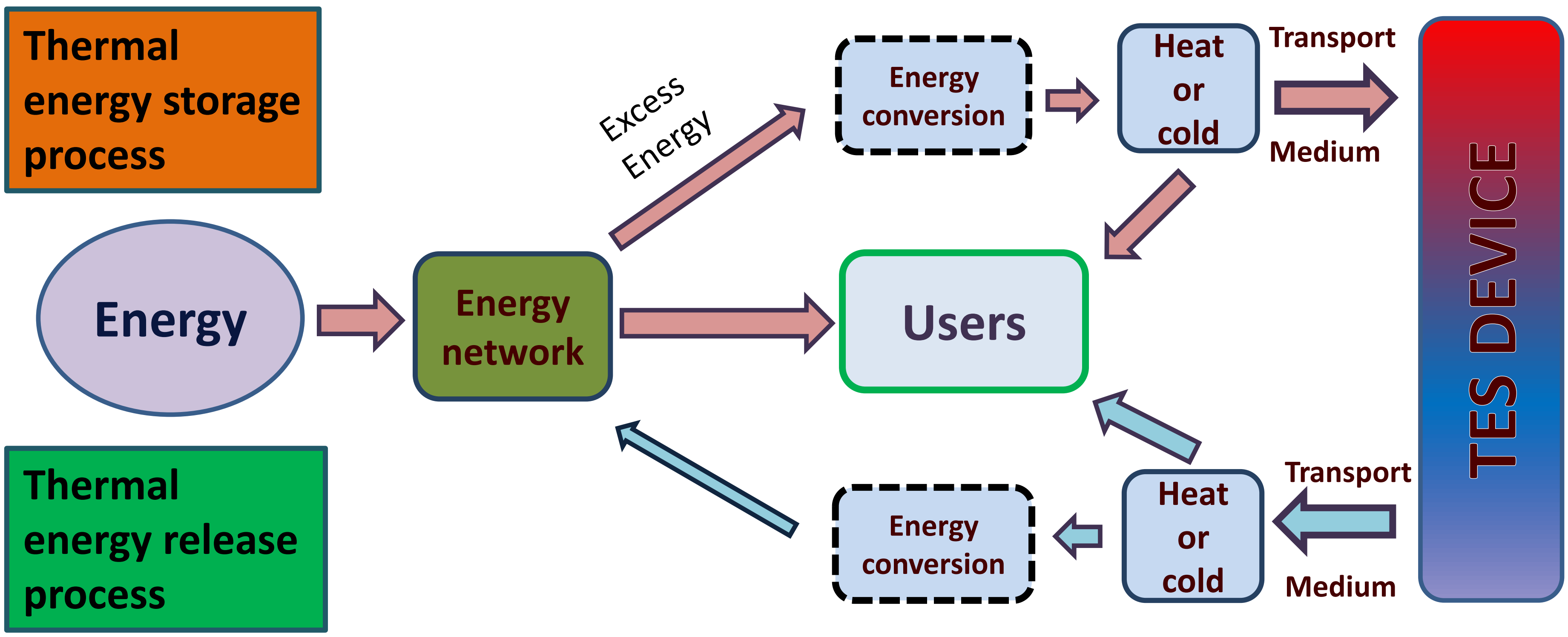
How TES works?



- TES Device contains TES materials
- Transport medium may serve as the TES storage medium

Thermal energy storage (TES) based solution – TES technologies

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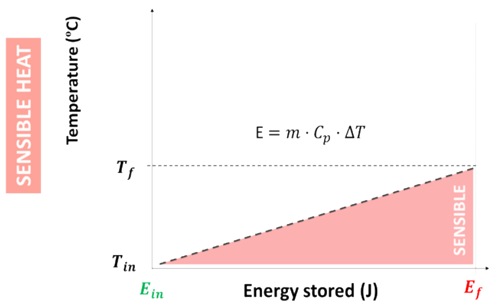
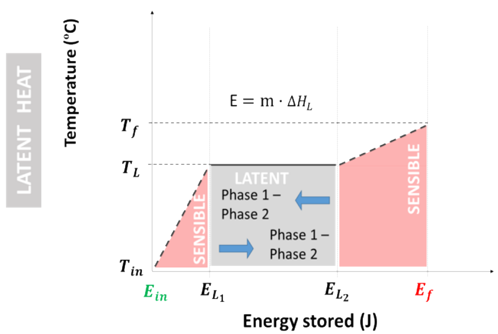
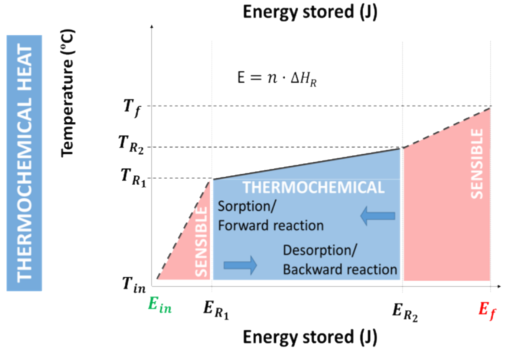
Three major technology categories, examples and technology readiness level (TRL)



Sensible heat storage stores thermal energy through raising or reducing temperature of a material.

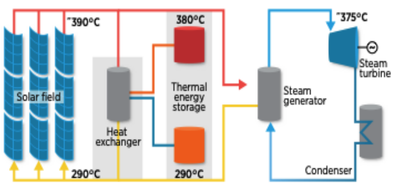


Latent heat storage stores thermal energy through a phase change process of a materials – commonly known as Phase Change Materials (PCMs) based TES

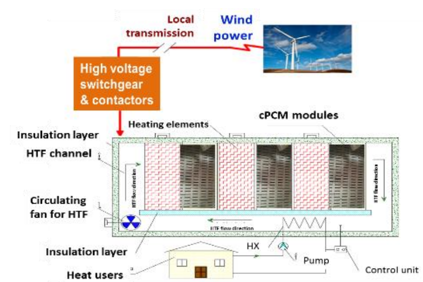


Thermochemical heat storage stores thermal energy through reversible chemical reactions and/or a sorption process.

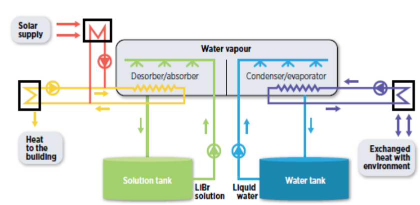
Examples



Solar heat storage for Concentrated Solar Power



PCM heat store for curtailed wind for space heating



Sorption heat storage for district heating & cooling

High TRL

Sensible TES Already in use 200+ years

Latent (PCM) TES TRL at 2- 5

Thermo-chemical TES TRL at 1-3

Low TRL

Thermal energy storage (TES) based solution – Examples of TES operating conditions

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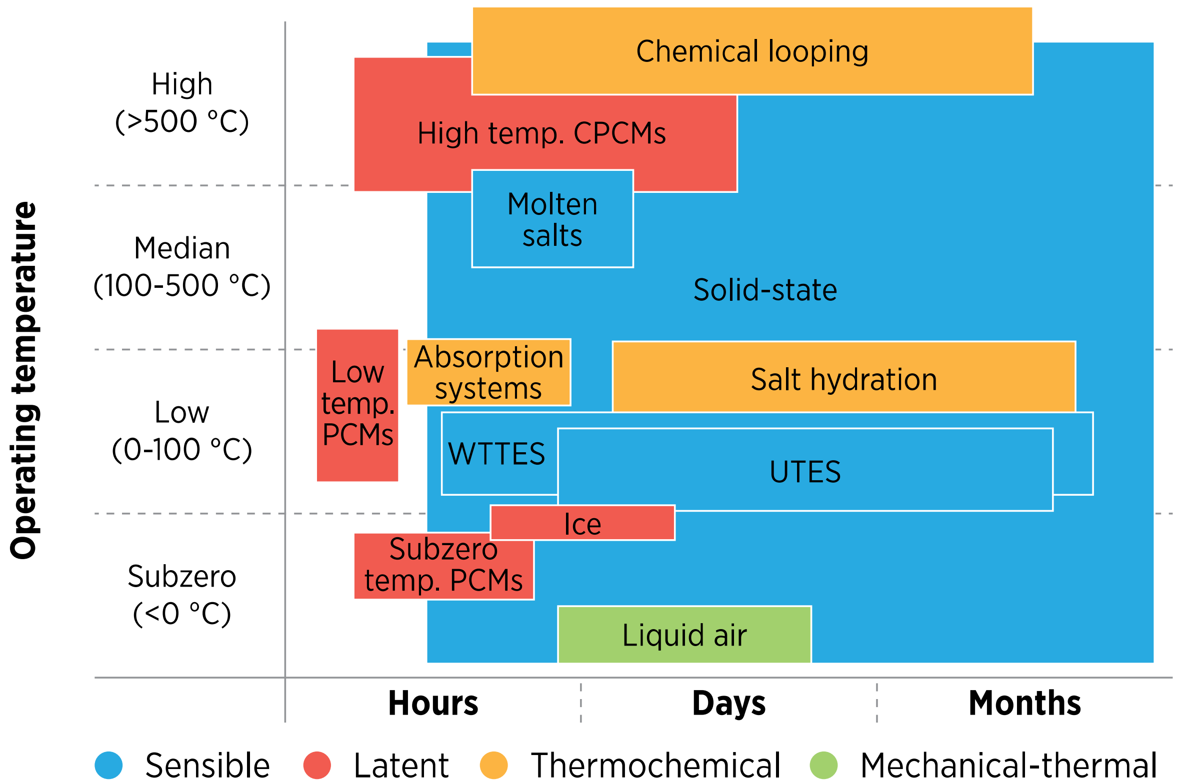
Examples of TES applications



PCM - phase change material

WTTES - water tank TES

CPCM - composite PCM

UTES - underground TES

IRENA (2020) Innovation outlook: Thermal energy storage

Thermal energy storage (TES) based solution – TES integration for forging process applications

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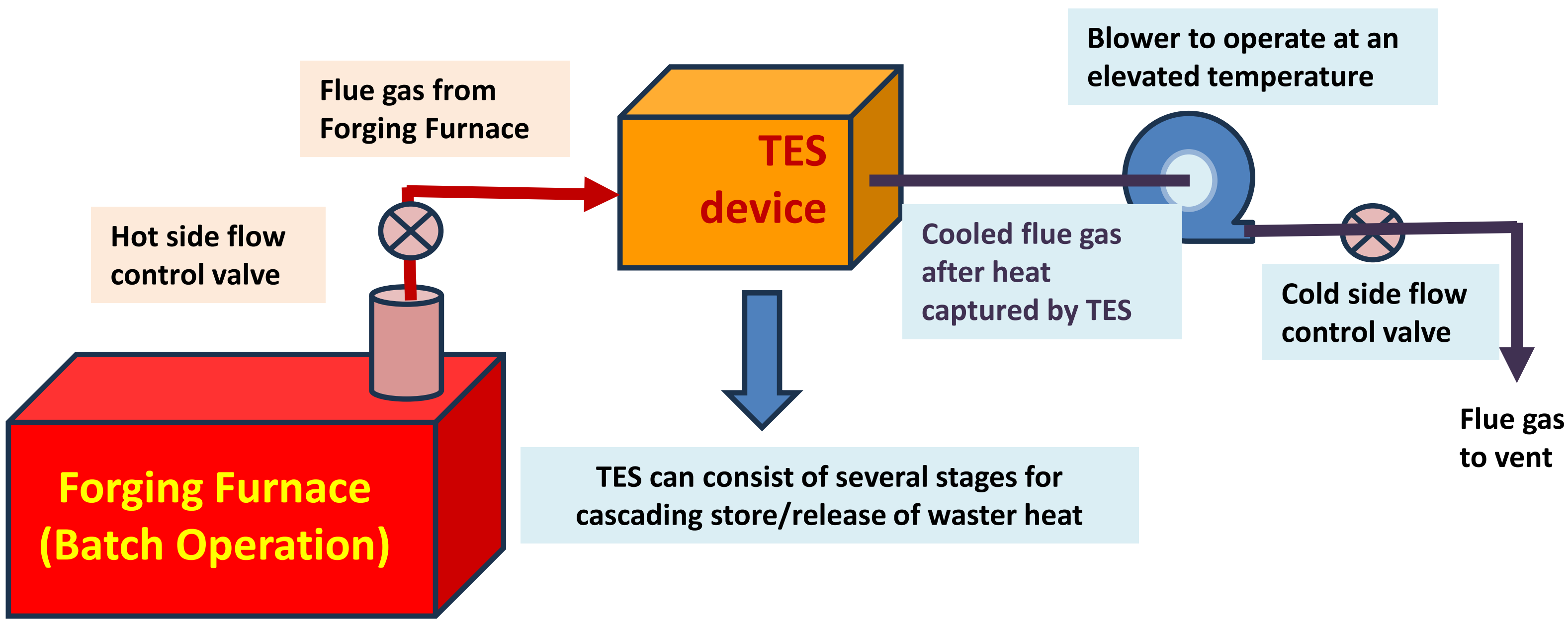
The principle of integrating TES with a forging furnace



The waste heat capturing / charging / storing process

Thermal energy storage (TES) based solution – TES integration for forging process applications

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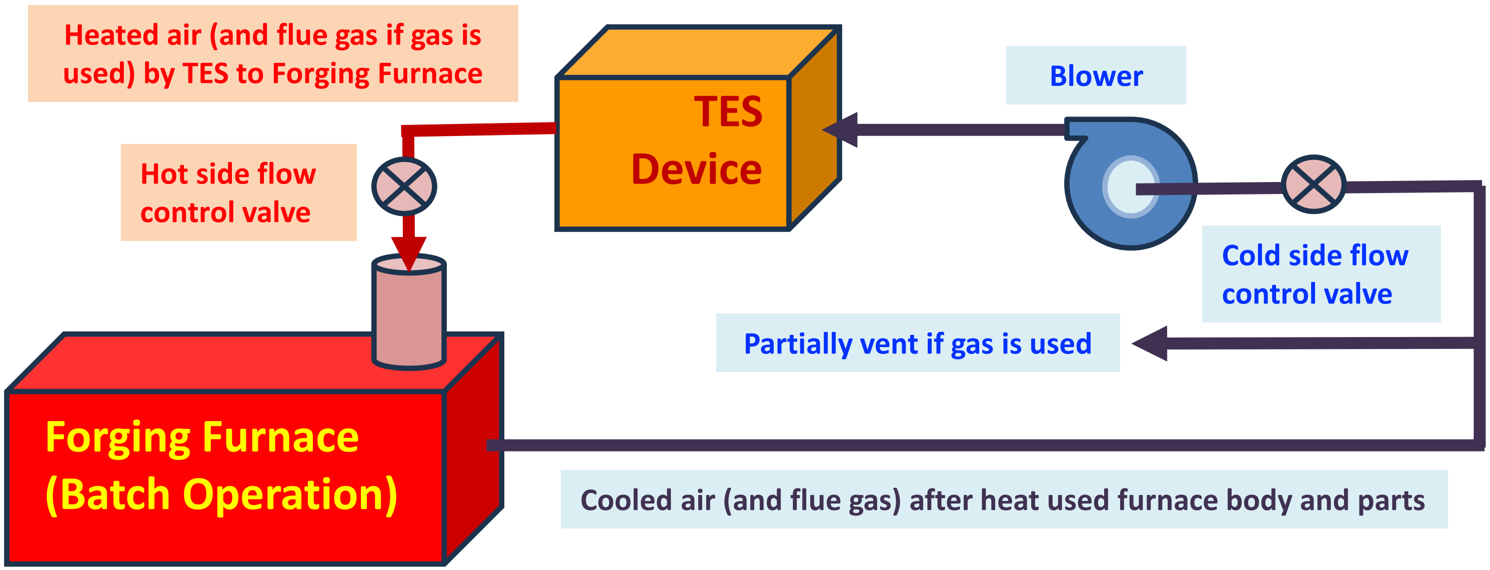
The principle of integrating TES with a forging furnace



The waste heat release / discharge / utilisation process at the next heating cycle

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- **Waste Heat Recovery (WHR) feasibility studies**

- **Somers Forge**

A large open die forger of steel and titanium alloys for the aerospace & defence industries. £25M turnover, 140 employees, 15,000 tonnes output from circa 40 gas-fired furnaces

- **Mettis Aerospace Group**

A large closed die forger of ferrous and non-ferrous alloys for the aerospace & defence industries. £100M+ turnover, 500 employees, 4,000 tonnes output, 47 gas-fired furnaces (+ electric furnaces)

Examples of UK efforts to decarbonise forging industry – Mettis Aerospace Group (closed die)

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Mettis Aerospace Group -

Investigated both high temp gas-fired furnaces and low temp electric furnaces

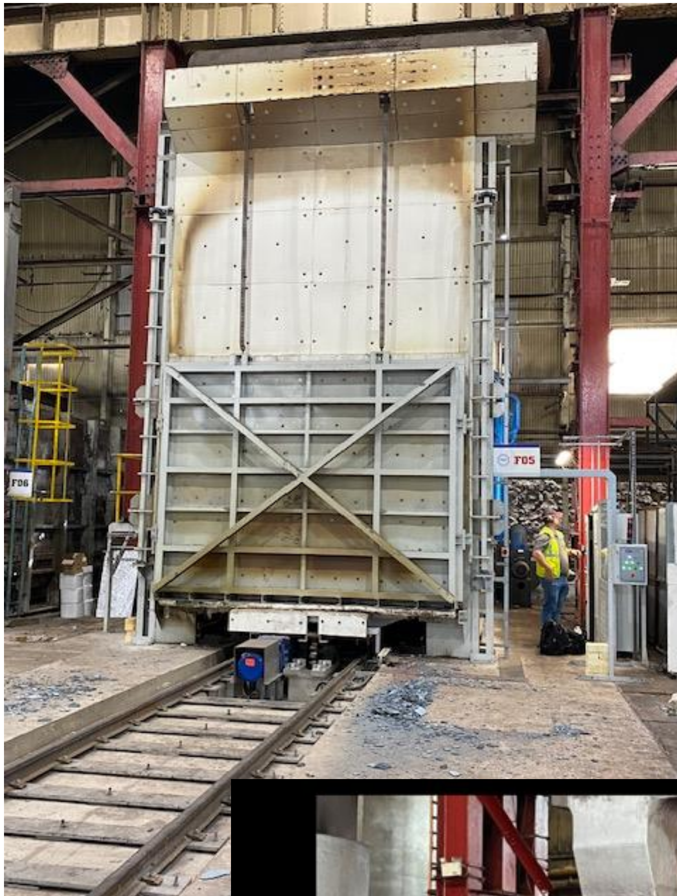
Electric ovens have little recoverable waste heat so do not offer feasible WHR options

Most high temps operate at 940 DegC and offer good potential for WHR.
Adjacent gas ovens are used to pre-heat dies

With continuous shifts there is potential to capture waste heat and use this to provide heat at 400 DegC for die ovens

Challenge – small batch runs with frequent load/unload provide variable waste heat temperature so lower temp cPCM required

Examples of UK efforts to decarbonise forging industry – Somers Forge (open die)



Somers Forge

In the large forge there are 10 bogie gas-fired furnaces operating up to 1350 DegC.

With 40Gwh gas consumed there is a large potential for WHR with up to 50% that could be captured.

The vision is to capture WHR during the day and use this to pre-heat for the next shift - energy saving, decarbonisation, operational efficiency benefits

Challenge – sizing the WHR unit to fit space & maximise benefit, with sensible payback.

Time for Q & A?

Thank you

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