A flexibly integrated solution for gas compression and industrial thermal processing decarbonisation

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1. Background

➢ Gas Compression and Industrial Thermal Processing

Gas Compression (GC) and Industrial Thermal Processing (ITP) are two major and often co-located CO2 emission hot-spots within industrial clusters (ICs), contributing >5MT CO_2/year to UK emissions. Both GC and ITP processes in ICs are highly energy-intensive and inefficient. Industrial air compression alone consumes ~10% (~30 TWh) of the UK electricity supply and between ~10-30% in many other countries [1]; up to 90% of the electrical input for GC is dissipated as waste heat [2]. Concurrently, the ITP across major UK industrial sites (6 ICs being main ones) creates ~48 TWh/year waste heat [3].

➢ Decarbonization of GC and ITP

Research into efficiency enhancement of GC and ITP systems has been largely done separately, including through the UK and US air compression, energy storage (thermal energy storage, compressed air energy storage and liquid air energy storage), and waste heat utilisation communities. However, little has been done by these communities to properly integrate waste heat synergistically from the GC with ITP and other heat users.

Reference: [1] EUROPEAN COMMISSION. EUROPEAN COMMISSION Reference Document on Best Available Techniques for Energy Efficiency. 2009. [2] Saidur R, Rahim NA, Hasanuzzaman M. A review on compressed-air energy use and energy savings. Renew Sustain Energy Rev 2010;14:1135–53. [3] DECC. The potential for recovering and using surplus heat from industry.

2. Objectives and Innovative aspects

➢ Measurable objectives

System optimization & data collection/analysis

1. Optimize the integrated GC and ITP system configuration through thermodynamic analysis & Analyse the techno-economic and life-cycle performance of the integrated GC and ITP system.
2. Map and match the waste heat supply with the local heat demand in SWIC, BCIC and TIC considering temperature grade and spatial and temporal distributions, and develop transportation strategies to minimise CO2 emissions.

Demonstration#1
Build and test an integrated GC demonstrator to validate the proposed integrated GC and ITP system.

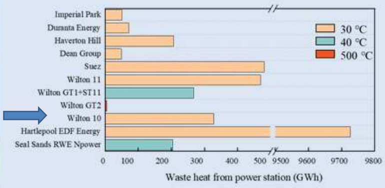
Demonstration#2
Demonstrate MESH, including material formulation and manufacture, modelling & design, testing and demonstration; in collaboration with Project No.42 led by SU.

➢ Novelties

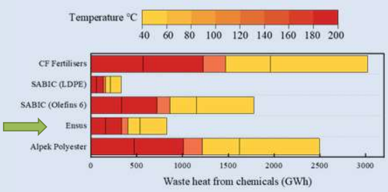
The major novelties lie in the innovative system configuration with compressors sized according to average loads, and peaks managed by gas storage, and dynamic mapping and matching of ICs waste heat supply and heat demand around IC regions, considering energy grade and their spatial and temporary distributions.

3. Demand-supply mapping for waste heat

➢ Waste heat from power stations and other industries in TIC



Waste heat quantity and temperature grades of power stations:
Most of waste heat has a temperature of 30°C. There are two locations where waste heat can be generated at 40°C and only a small portion of the waste heat can reach 500°C.

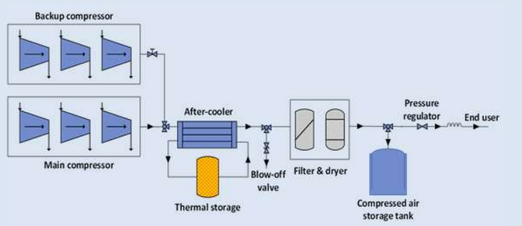


Waste heat quantity and temperature grades of five chemical plants:
The temperature of waste heat can range from 50°C to 200°C.

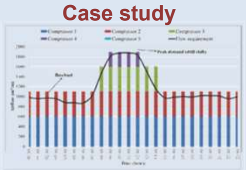
➢ Residential heat demand distribution in TIC

Simplified estimation of residential energy demand (gas) within Tees Valley:
Stockton-on-Tees has the highest heat demand due to the largest population.

4. Waste heat recovery (from gas compression)



Case study

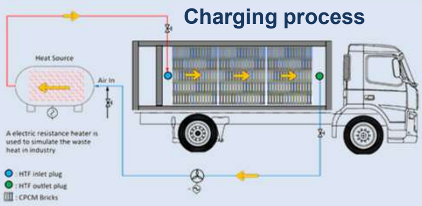


Configuration	Energy efficiency	Annual operation cost
Conventional	1.61%	56.8k GPB
Newly proposed (sized at average loads)	35.28%	52.2k GPB
Newly proposed (sized at peak loads)	35.28%	35.5k GPB

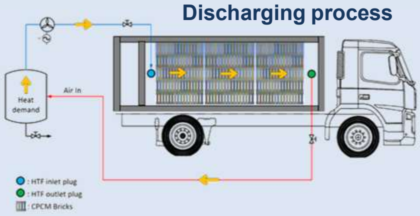
- ➢ The capacity/size of the main compressor is optimised with peak load managed by gas storage.
- ➢ A thermal storage is integrated for compression heat recovery.

5. Waste heat storage and distribution (via MESH)

Charging process



Discharging process



Mobile Energy Stored as Heat (MESH)

Develop and demonstrate MESH at ~250 MJ scale (main tasks):

- Material (CPCM) formulation and manufacturing
- CPCM box modelling /optimisation
- Device/system design
- Experiment and demonstration

Charging & discharging of MESH:

- MESH charging: industrial waste heat/cold, off-peak electricity, and renewable energy
- MESH transportation and distribution: road, rail, marine, etc.
- MESH discharging: domestic heating and cooling

IDRIC Partner and Stakeholder Forum, 06-09 June, Edinburgh

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