ENERGY RESEARCH ACCELERATOR

At the forefront of energy transformation

Thermal Energy Storage for Heat, Cold, Power & Mobility

Yulong Ding

Birmingham Centre for Energy Storage
University of Birmingham

Edgbaston Park Hotel, University of Birmingham
23 January 2020

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Birmingham Centre for Energy Storage (BCES)

- **BCES consists of BCCES and BCTES – a distributed centre across the university campus**

BCES was established with substantial support from UK EPSRC under the Eight Great Technologies (£12.5M) and UK BEIS under Energy Research Accelerator (ERA, £60M)

- **BCES initially focuses on:**
  - Novel TES Materials & Advanced Manufacturing Technology
  - TES Components/Devices
  - TES Systems Integration, Optimisation and the Big Data including Cyber Security
  - Energy Storage Economics & Policy
  - TES Applications

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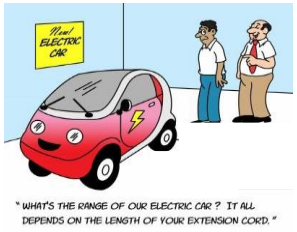
Birmingham Centre for Energy Storage (BCES)

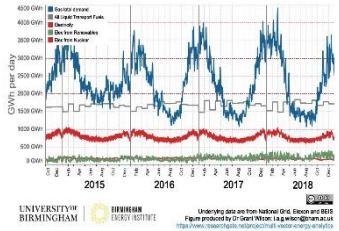
- **BCES has grown significantly since 2013 and BCES research themes have increased**

Cold Chain Technologies

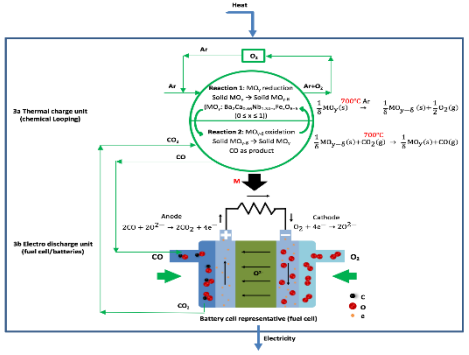


- Electrical batteries + **Thermal Batteries**;
- Electrical and thermal charge in **energy charging station;**
- Air conditioning in energy charging station;
- **Range increase** by up to 30-40%;
- **COP increase** by >2-3 times;
- Use of **AI & Telecommunication**

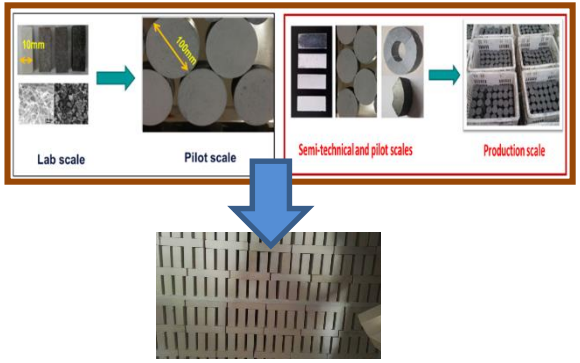
Thermal Storage based EVs



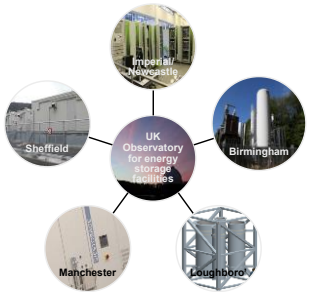
Energy + Data



Thermo/Chemical/Electrochem/Electrical Conversion & Storage



Advanced Manufacturing Technologies

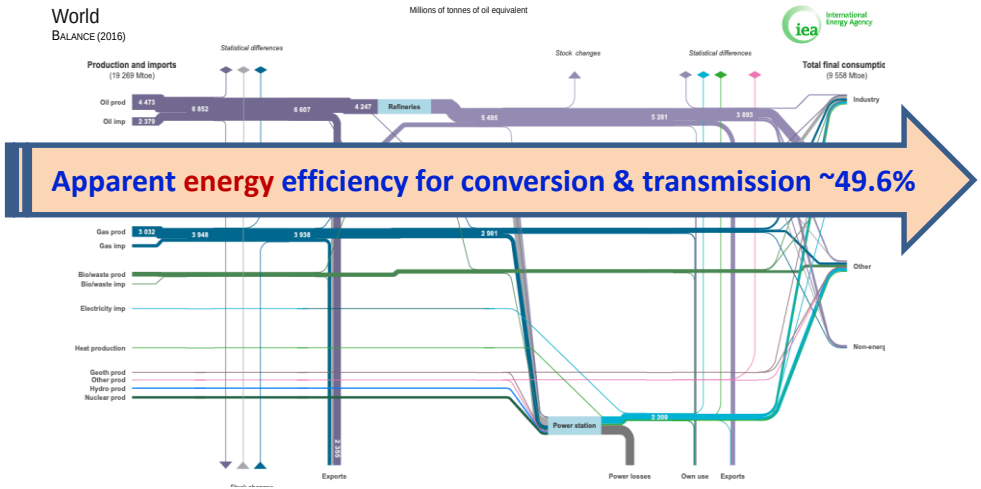


Energy systems and policy analysis

Why Thermal Energy Storage?

The World Energy Flow Chart 2016

Energy Production & Import
19269 MTOE



Final Energy Consumption
9558 MTOE

- **The efficiency is very very low also indeed in the whole world!**

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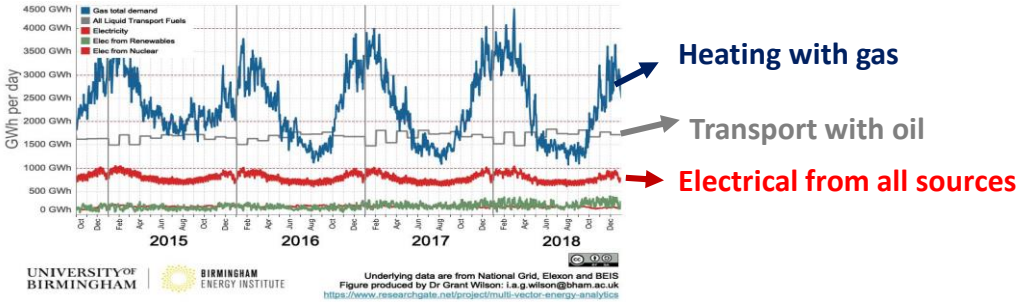
Why Thermal Energy Storage?

Energy system ≠ electrical power system; challenges related to thermal energy >> that related to electrical power system & transport

Take the UK as an example: energy consumption as a function of time (energy)



Seasons / Total	Electricity	Gas - heating	Transport
Summer, GWh/day	~600	~400	~1650
Winter, GWh/day	~1000	~3500	~1650
Total	~336 TWh/year	~600 TWh/year	~600 TWh/year

Thermal Energy is the main challenge!

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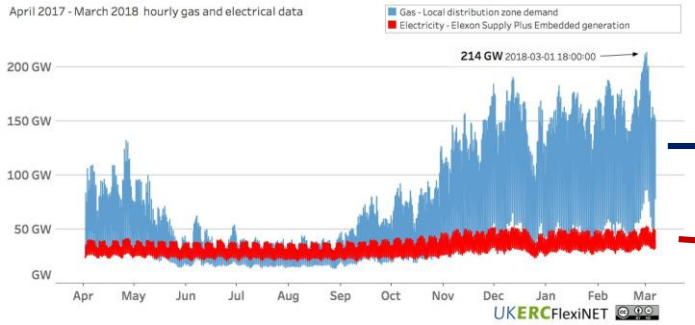
Why Thermal Energy Storage?

Energy system ≠ electrical power system; challenges related to thermal energy >> that related to electrical power system & transport

Take the UK as an example: energy consumption as a function of time (power)



Heating with gas

Electrical from all sources

Seasons / Total	Electricity	Gas - Heating
Summer, GW	~20-40	~15-35
Winter, GW	~30-50	~100-210

Thermal Energy is the main challenge!

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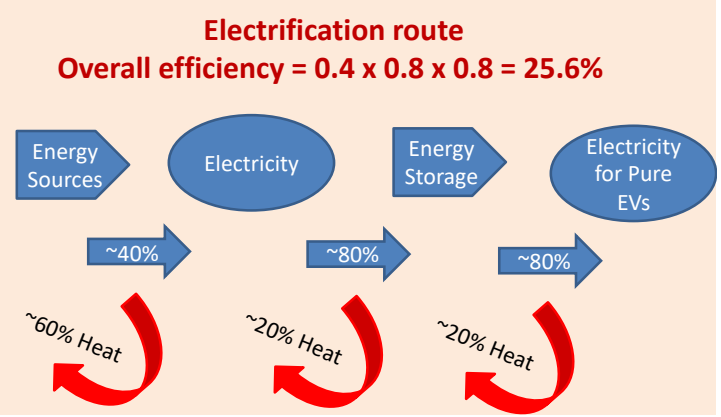
Why Thermal Energy Storage?

Electrification of transport – pure EVs



Heating consumes ~50% of battery power

Long range， heavy trucks and rail trains difficult

- **Average data taken from various sources including academic literature and US national lab and DOE reports**
- **The importance of thermal energy**

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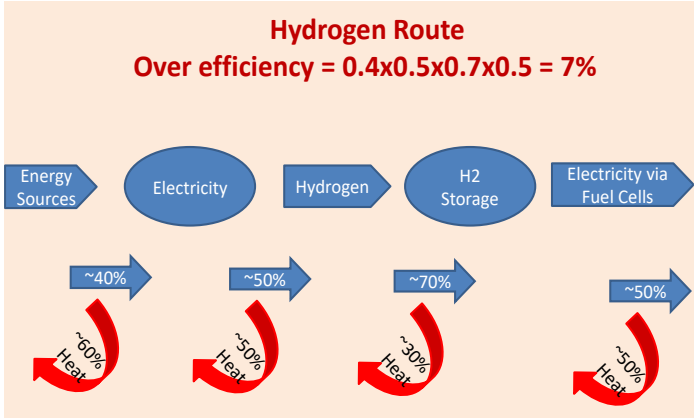
Why Thermal Energy Storage?

Hydrogen for transport via hydrogen fuel cells



Heating can be provided and possibly cooling by using heat

Long range easily achievable

- **Average data taken from various sources including academic literature and US national lab and DOE reports**
- **The importance of thermal energy**

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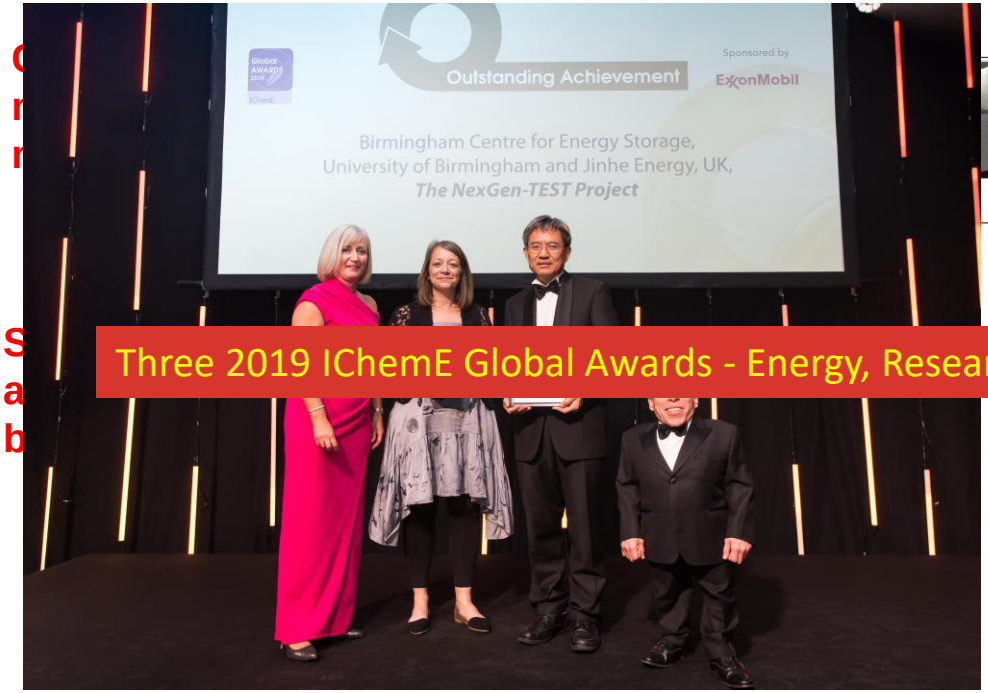
Our Technologies – Thermal Energy Storage for Renewable Heating



Three 2019 IChemE Global Awards - Energy, Research Project and Outstanding Achievement Awards

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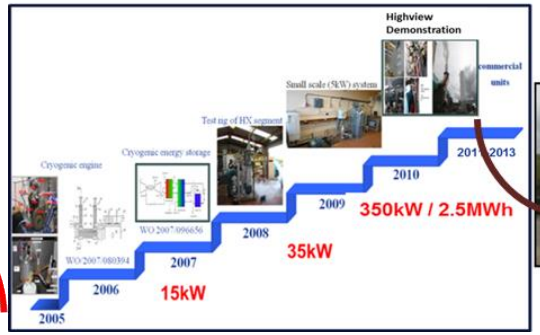
Our Technologies – Thermal Energy Storage for Heat, cold & Power

Invented cryogenic engines and liquid air energy storage technologies some 15 years ago and led the initial technology developments



5MW/15MWh Commercial Demonstration in Manchester (2015~2018)

2019: Announcement of designing and building 50MW/250MWh system – Europe's largest system non-pumped hydro system

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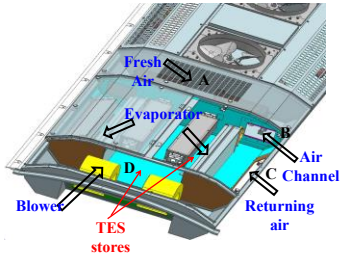
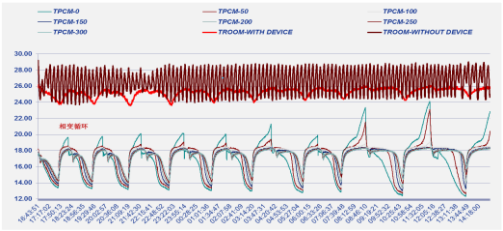
Our Technologies – Thermal Energy Storage for Rail Carriages

Invented TES based rail carriage air-conditioning technology and carried out initial technology validation and demonstration work





- Power: 44kW;
- Weight: ~1000kg

→

- TES device ~500kg;
- Heat transfer device ~300kg

= 200kg

Original AC | New AC | Weight reduction

Significant reduced start-stop frequency →

- Better customer experiences
- Better energy efficiency
- Lower maintenance cost
- Long life-span

20% weight reduction, energy consumption reduction by ~18%, significant improvement of customers experience due to reduced stop-start frequency

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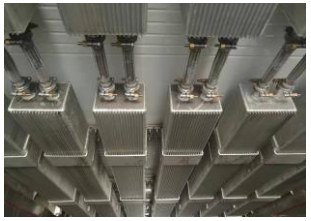
Our Technologies – Ther ain Transport

Invented TES based rail freight technology for cold chain transportation and demonstrated the technology



Generation II: 2018-2019

2018: First generation technology trialed
2019: Second generation technology cor
2019: Planning and build of rail cold cha

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