Thermal Energy Storage for Heat, Cold, Power & Mobility

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Birmingham Centre for Energy Storage
University of Birmingham
Edgbaston Park Hotel, University of Birmingham
23 January 2020
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

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 consists of BCCES and BCTES – a distributed centre across the university campus
Birmingham Centre for Energy Storage (BCES)

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

**Cold Chain Technologies**

**Thermal Storage based EVs**

**Energy + Data**

- 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

**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

Apparent energy efficiency for conversion & transmission ~49.6%

• The efficiency is very very low also indeed in the whole world!
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)

<table>
<thead>
<tr>
<th>Seasons / Total</th>
<th>Electricity</th>
<th>Gas - heating</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer, GWh/day</td>
<td>~600</td>
<td>~350</td>
<td>~1650</td>
</tr>
<tr>
<td>Winter, GWh/day</td>
<td>~1000</td>
<td>~3500</td>
<td>~1650</td>
</tr>
<tr>
<td>Total</td>
<td>~336 TWh/year</td>
<td>~300 TWh/year</td>
<td>~600 TWh/year</td>
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<th>Seasons / Total</th>
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<tbody>
<tr>
<td>Summer, GW</td>
<td>~20-40</td>
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<tr>
<td>Winter, GW</td>
<td>~30-50</td>
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</tbody>
</table>
Why Thermal Energy Storage?

Electrification of transport – pure EVs

Electrification route
Overall efficiency = 0.4 x 0.8 x 0.8 = 25.6%

- 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

Energy Sources
Electricity
Energy Storage
Electricity for Pure EVs

~60% Heat
~20% Heat
~20% Heat
~40%
~80%
~80%

~40%
~80%
~80%

~60% Heat
~20% Heat
~20% Heat
~40%
~80%
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Why Thermal Energy Storage?

Hydrogen for transport via hydrogen fuel cells

Hydrogen Route
Over efficiency = 0.4x0.5x0.7x0.5 = 7%

- 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
Our Technologies – Thermal Energy Storage for Renewable Heating

Composite PCM based TES materials formulation, manufacture & scale-up

System integration and applications of composite PCM based devices

- 6M / 36MWh high-voltage (10kV) discarded wind power for space heating
- 25kW/100kWh cold storage based on CO₂
- 200kW/2MWh heat and electrical storage

Industrial scale, Xinjiang, China 2016

Three 2019 IChemE Global Awards - Energy, Research Project and Outstanding Achievement Awards
Invented cryogenic engines and liquid air energy storage technologies some 15 years ago and led the initial technology developments.

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

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

Significant reduced start-stop frequency

20% weight reduction, energy consumption reduction by ~18%, significant improvement of customers experience due to reduced stop-start frequency
Our Technologies – Thermal Energy Storage for Cold Chain Transport

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

2018: First generation technology trialed for 36,000km
2019: Second generation technology commercial operation (50 vehicles)
2019: Planning and build of rail cold chain routes

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

Generation I: 2016-2018
Generation II: 2018-2019

Our Technologies – Thermal Energy Storage for Cold Chain Transport

2019年IChemE Global Award: Highly Commended for the Energy Award
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At the forefront of energy transformation