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# Integration of energy storage in power systems

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SuperStore meeting @ Imperial College London
14th July 2016

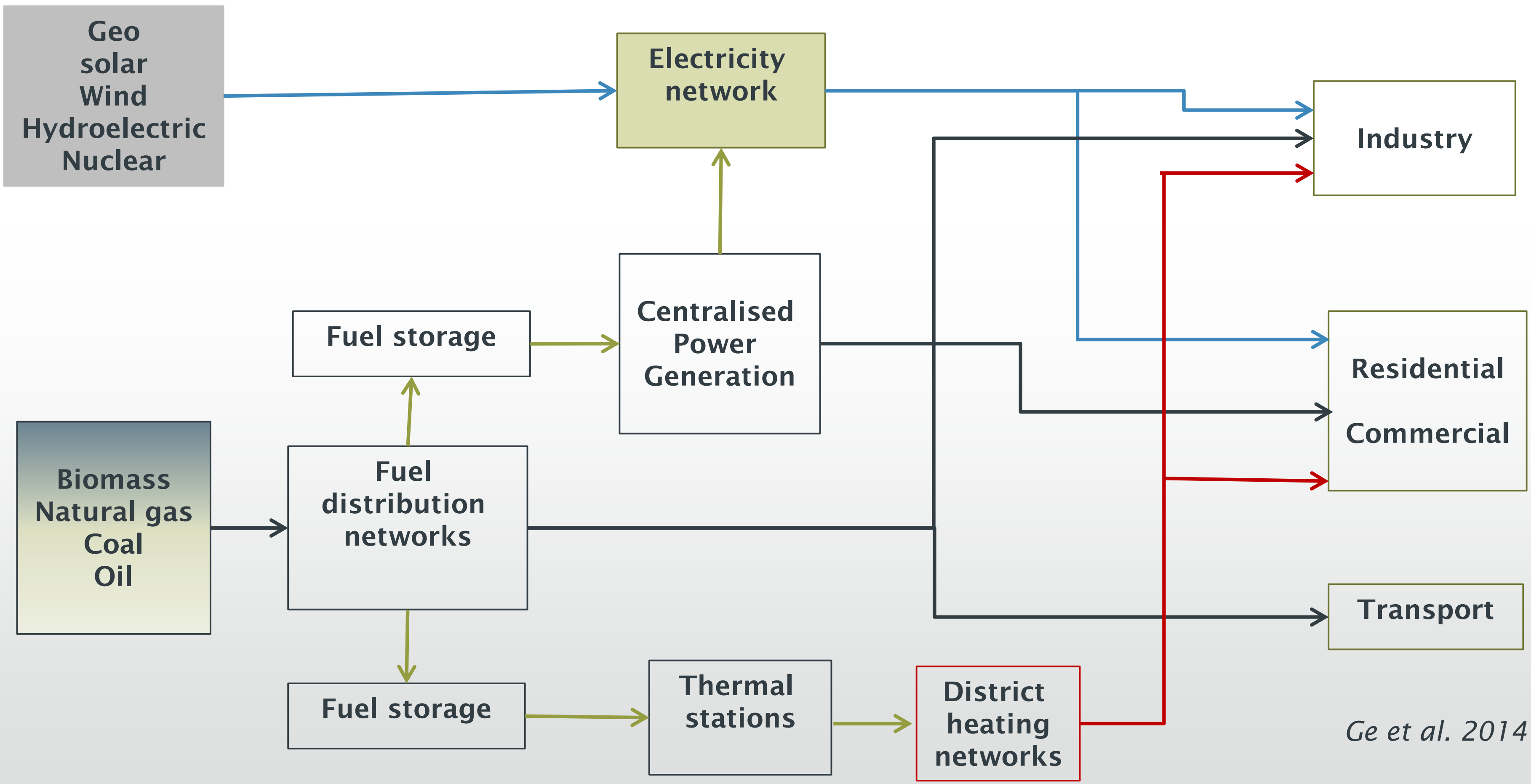
# Why is energy storage important?

1. Balance between the energy supply and the energy demand

2. Due to decreasing resources of fossil fuels large scale solar and wind farms are required → Intermittency of wind and solar energy is a drawback

Small and fast scale energy storage installations are not that profitable

# The power grid without Energy and Thermal Storage




*Ge et al. 2014*

# The power grid with Energy and Thermal Storage

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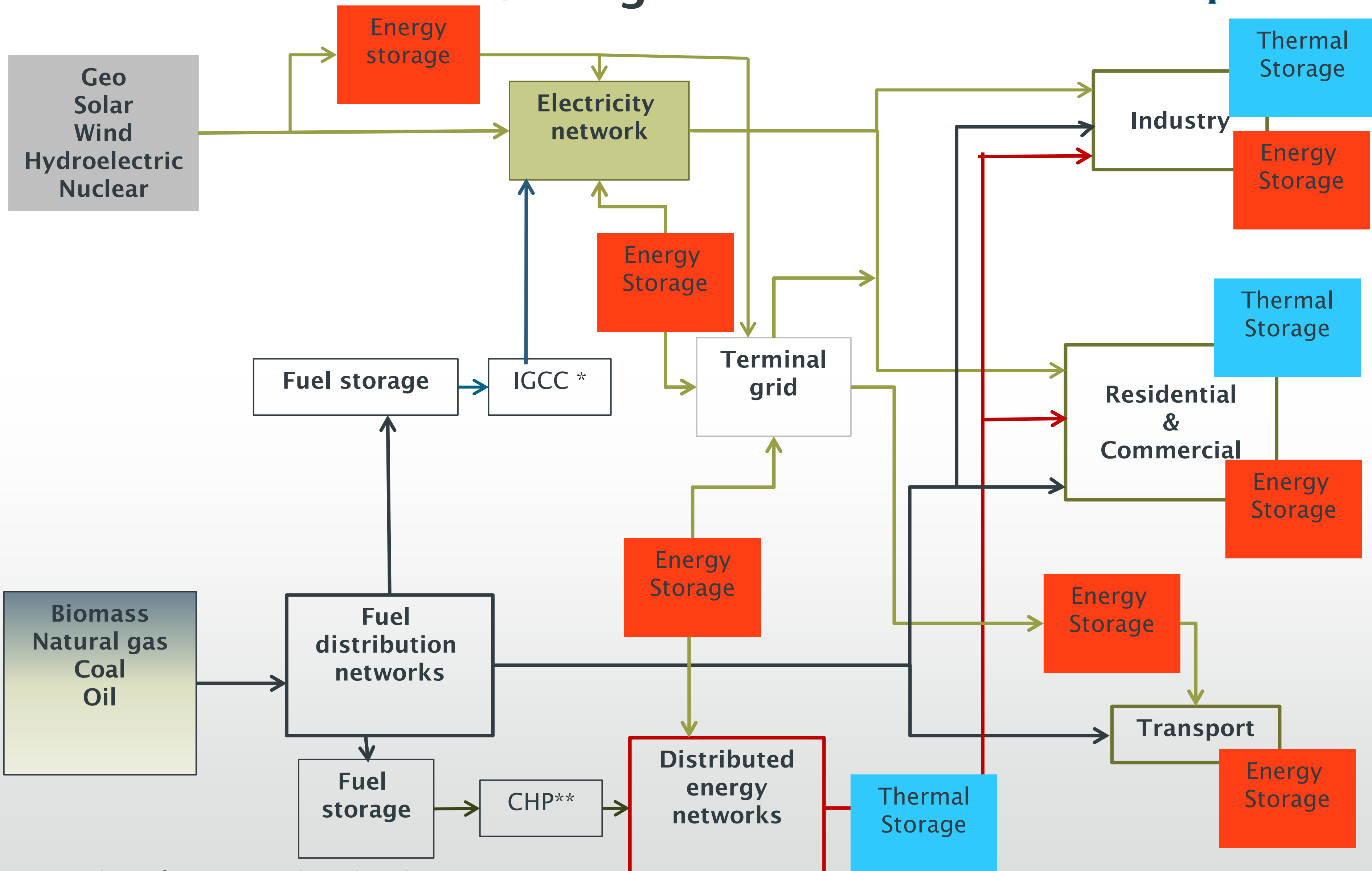


*integrated gasification combined cycle
**combined heat power

## Network connections of proposed and deployed storage in the UK (DNO and DECC demonstrators- December 2014) "A good practice guide on electrical Energy storage"

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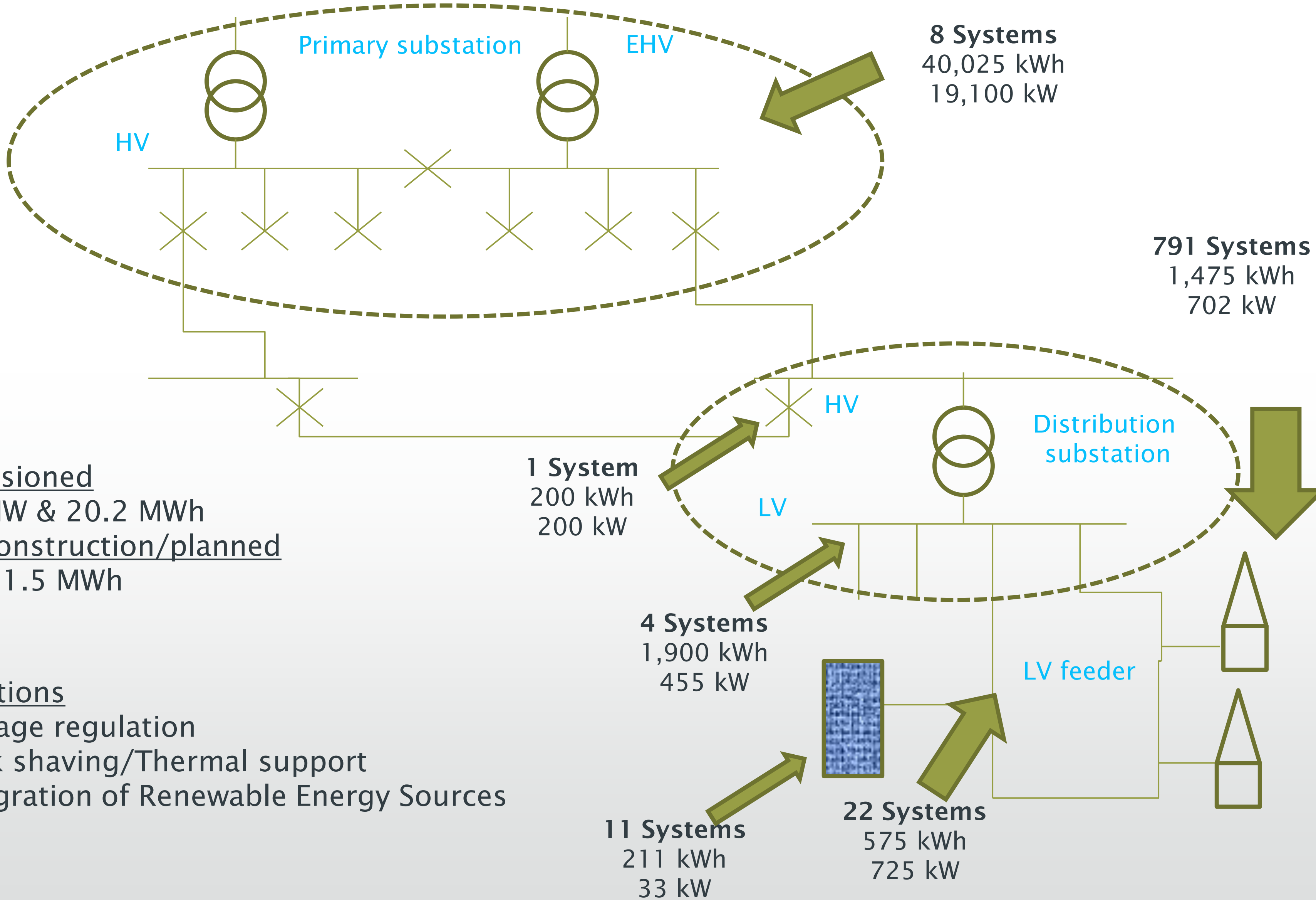
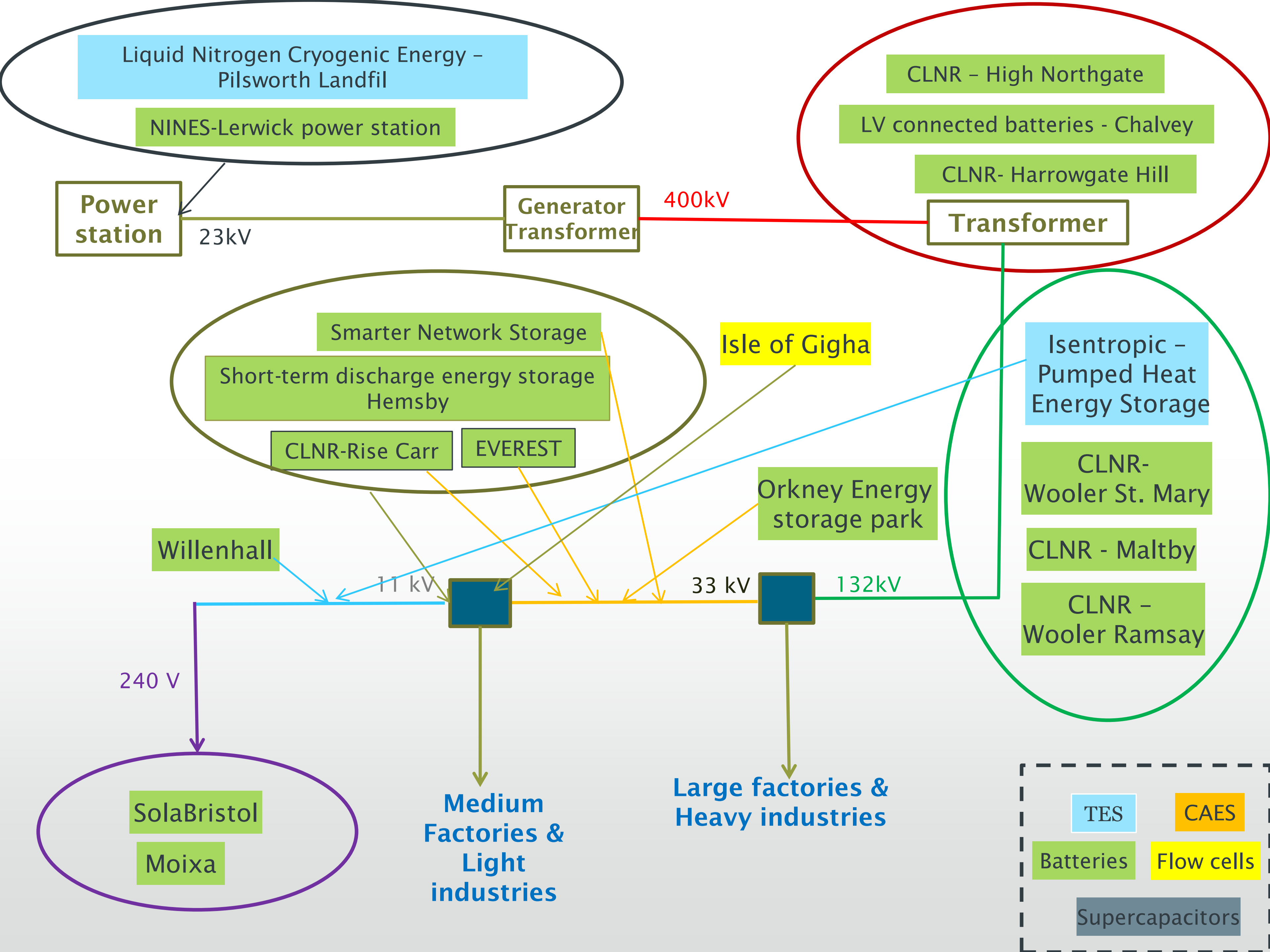


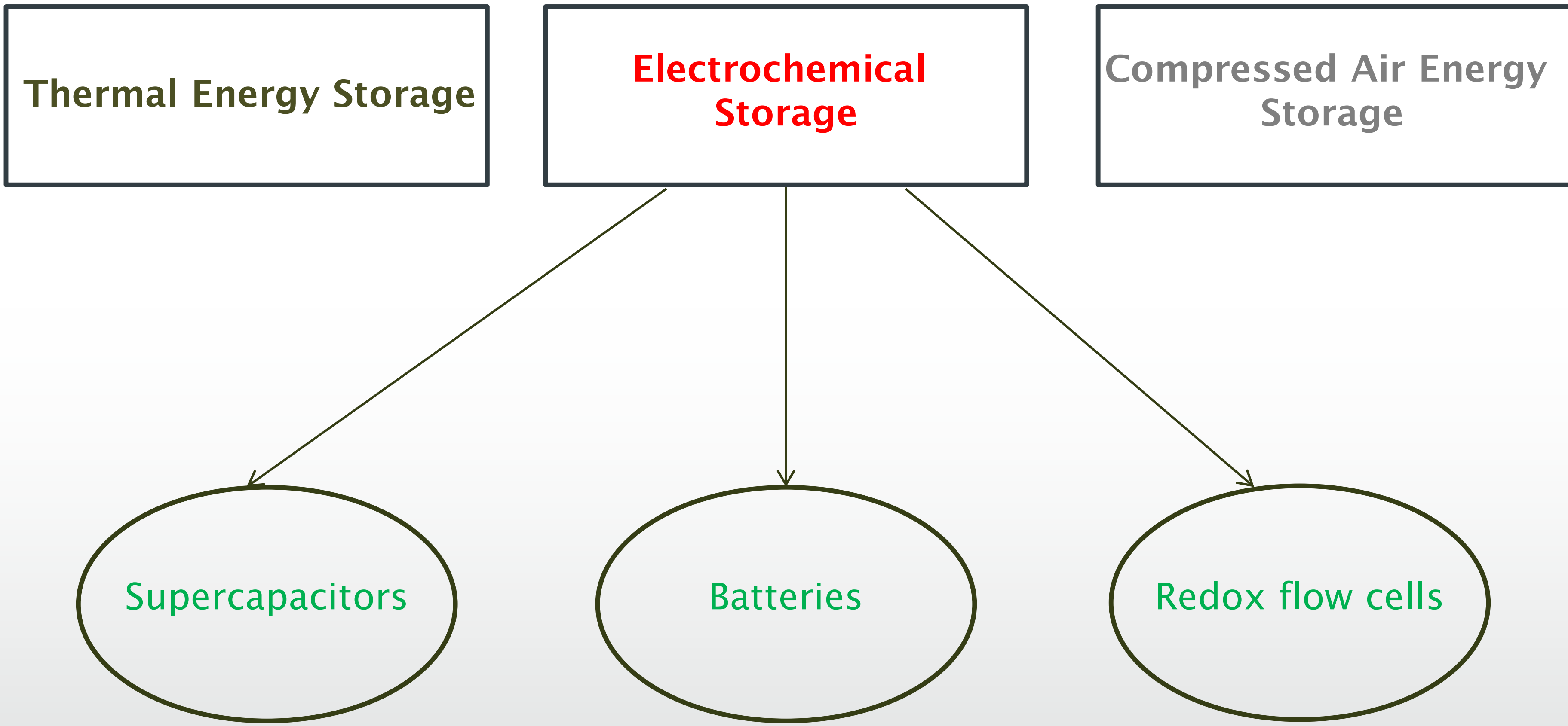

<u>Commissioned</u>
12.45 MW & 20.2 MWh
<u>Under construction/planned</u>
3 MW & 1.5 MWh

<u>Applications</u>

- Voltage regulation
- Peak shaving/Thermal support
- Integration of Renewable Energy Sources


Liquid Nitrogen Cryogenic Energy – Pilsworth Landfil
NINES-Lerwick power station
Power station
23kV
Generator Transformer
400kV
CLNR – High Northgate
LV connected batteries - Chalvey
CLNR- Harrowgate Hill
Transformer
Smarter Network Storage
Short-term discharge energy storage Hemsby
CLNR-Rise Carr
EVEREST
Isle of Gigha
Isentropic – Pumped Heat Energy Storage
CLNR- Wooler St. Mary
CLNR - Maltby
CLNR – Wooler Ramsay
Orkney Energy storage park
Willenhall
11 kV
33 kV
132kV
240 V
SolaBristol
Moixa
Medium Factories & Light industries
Large factories & Heavy industries
TES
CAES
Batteries
Flow cells
Supercapacitors

# The *Supergen* technologies



# Large-scale applications

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Thermal Energy Storage

Electrochemical Storage

Compressed Air Energy Storage

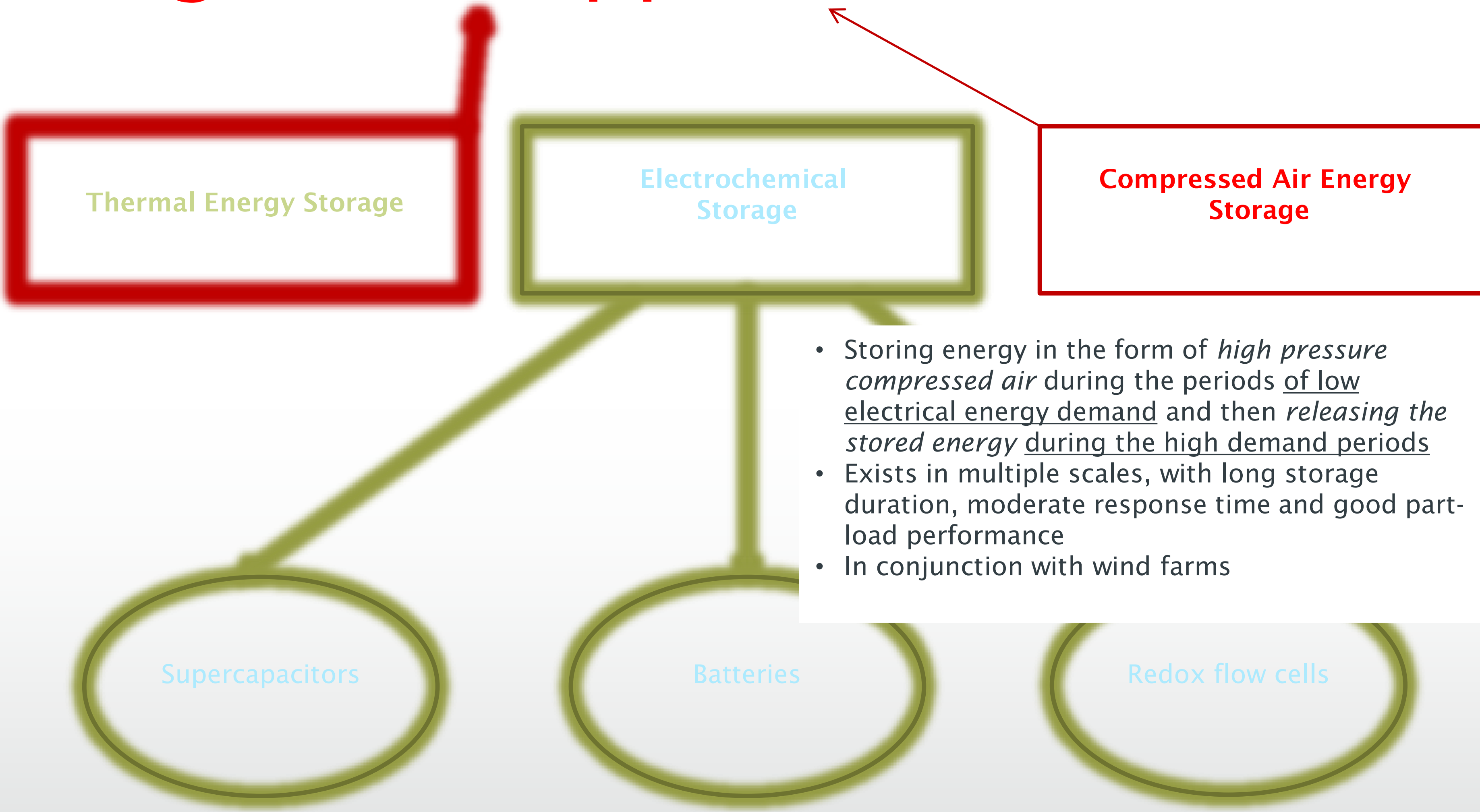
- *Heating a storage medium*
so the *thermal energy*
in the system can be *used at a later time*
- Ability to provide GWhs in minutes
- Utilisation of waste heat
- Can be used in conjunction with
  - fossil fuel fired power plants,
  - nuclear power plants,
  - large scale solar thermal power generation,
  - cryogenic energy storage,
  - CAES &
  - pumped thermal energy storage.

Redox flow cells

Small-scale applications

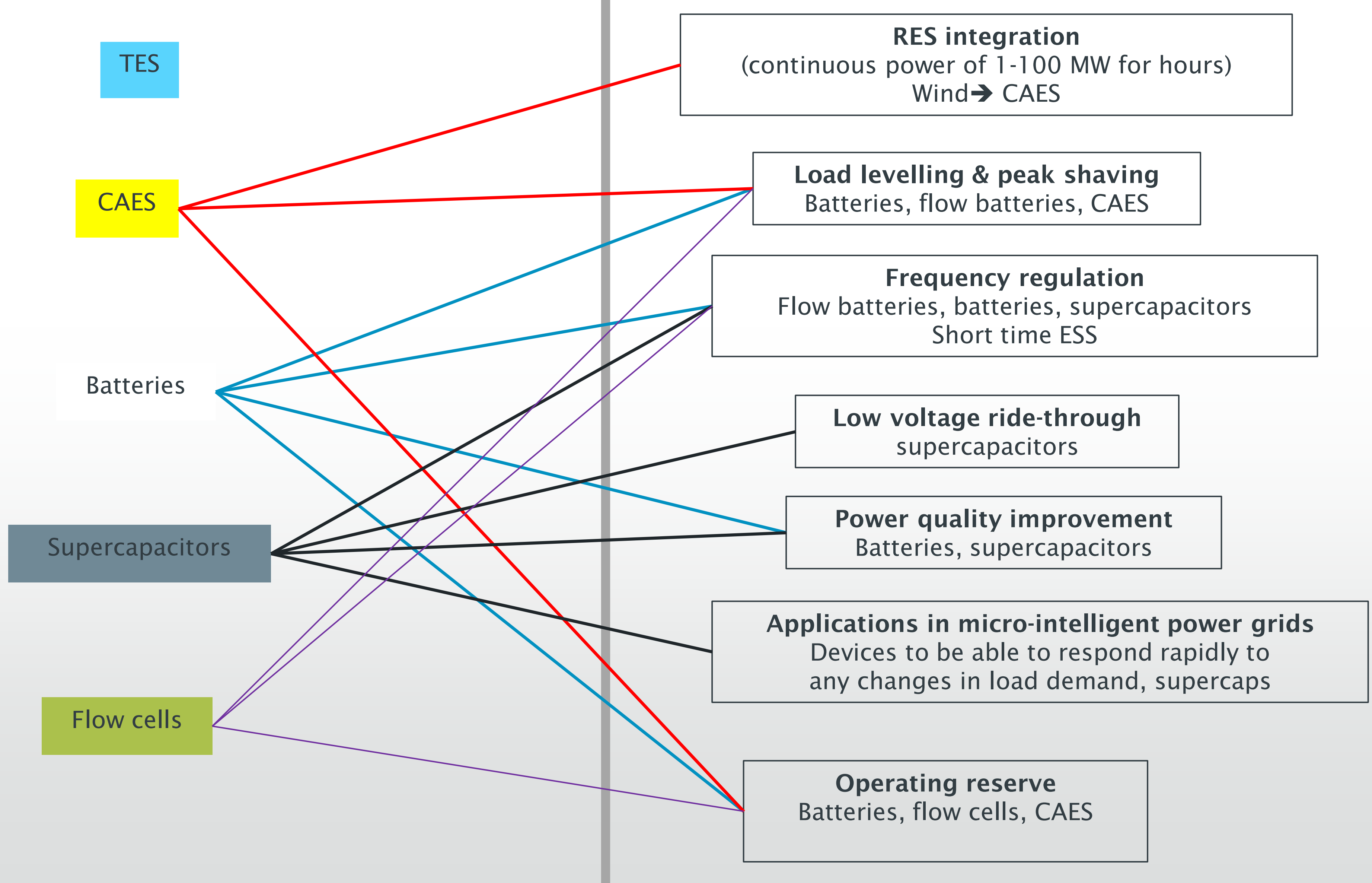
# Large-scale applications






- Storing energy in the form of *high pressure compressed air* during the periods of low electrical energy demand and then *releasing the stored energy* during the high demand periods
- Exists in multiple scales, with long storage duration, moderate response time and good part-load performance
- In conjunction with wind farms

## EES technologies | Applications



# Database containing the characteristics of different storage devices

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| Institution (Leader) | Imperial College (Nigel Brandon) | | University of Cambridge (Clare Grey) | | University of Oxford (Peter Bruce) | | University of Oxford (Patrick Grant) | | University of Birmigham (Yulong Ding) | | University of Warwick (Jihong Wang) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Work packages / Technology | WP1: Redox Flow Batteries | | WP2: Li- & Na-ion batteries | | WP3: Li-air battery | | WP4: Supercapacitors | | WP5: Thermal Energy Storage | | WP6: Compressed Air | |
| | Theoretical values* | Practical values | Theoretical values* for Li-ion batteries | Practical values | Theoretical values | Practical values | Theoretical values* | Practical values | Theoretical values* | Practical values | Theoretical values* (small CAES) | Practical values |
| Energy density (W h/L) | 16-60 | | 150-500 | | N/A | | 10-30 | | 80-500 | | higher than 6 | |
| Power density (W/L) | between <2 and <25 | | 1500-10000 | | N/A | | 10000+ | | N/A | | higher than 2 | |
| Specific energy (W h/kg) | 10-50 | | 75-200 | | N/A | | 0.05-15 | | 80-250 | | 140 at 300 bar | |
| Specific power (W/kg) | 45-166 | | 150-2000 | | N/A | | 500-10000 | | 10-30 | | n/a | |
| Power rating (W) | 0.004MW-3MW, possible 50 | | <8MW-<34MW | | N/A | | 0.001-0.3MW | | 0.-300MW | | 0.003MW-potentially 10MW | |
| Rated energy capacity (W h) | 0.05MWh -3.6MWH, potential up to 120 | | 0.004-10MWh | | N/A | | 500 | | N/A | | 0.002-0.01MWh | |
| Form and nature of output (e.g. 3.7V dc voltage) | DC | | | | N/A | | | | | | | |
| Response time | very fast | | milliseconds | | N/A | | milliseconds | | not rapid response | | seconds-minutes | |

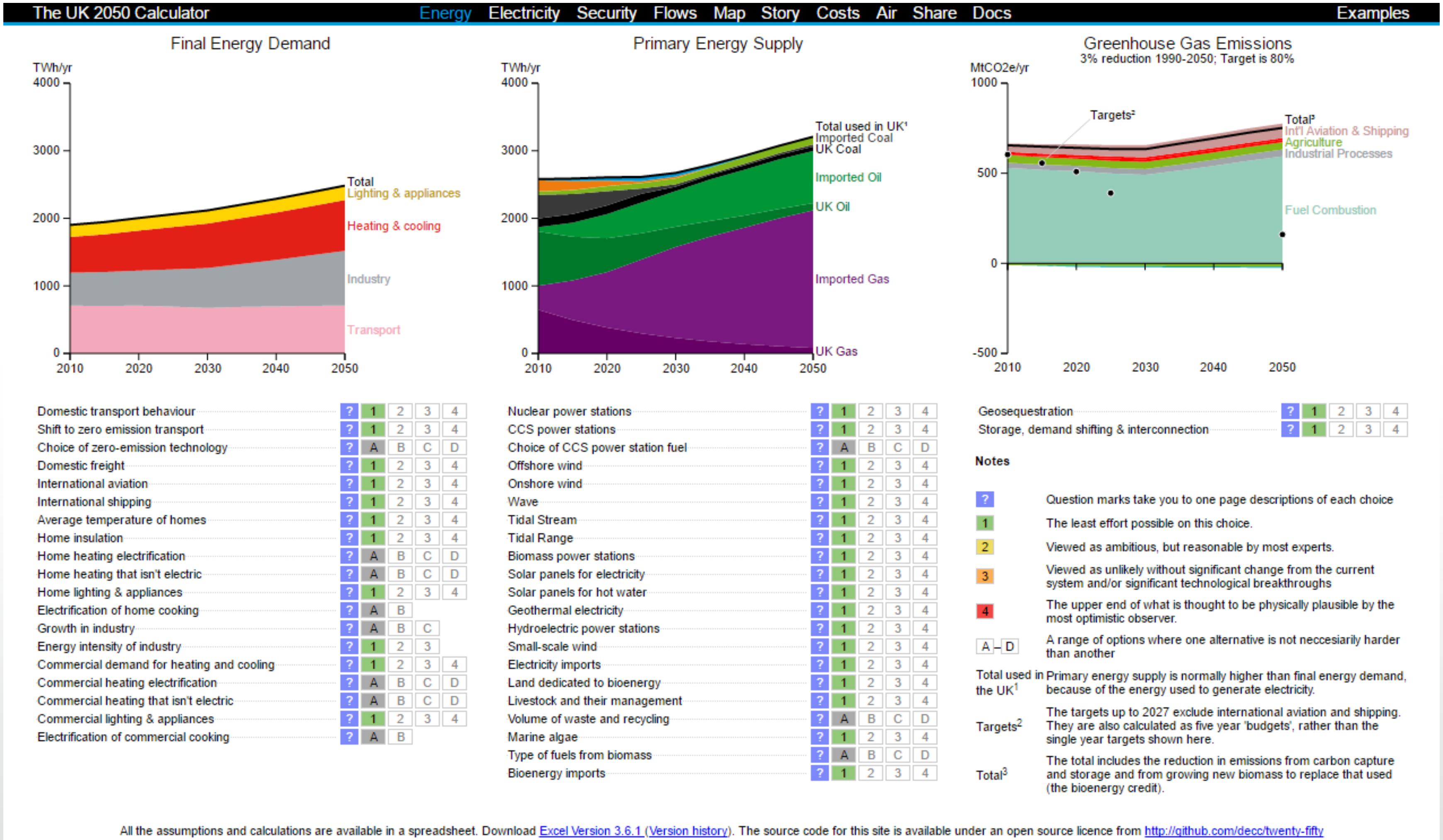
1. We are actively seeking devices to test/characterise for inclusion in this table

*or*

2. Please send Prof Andy Cruden (A.J.Cruden@soton.ac.uk) any updated results of your tests

# 2050 Energy Calculator

http://2050-calculator-tool.decc.gov.uk/#/home




- Future work: Consider how energy storage would influence 2050 energy calculator outcomes

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# Thank you for your attention