

Integration of energy storage in power systems

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SuperStore meeting @ Imperial College London

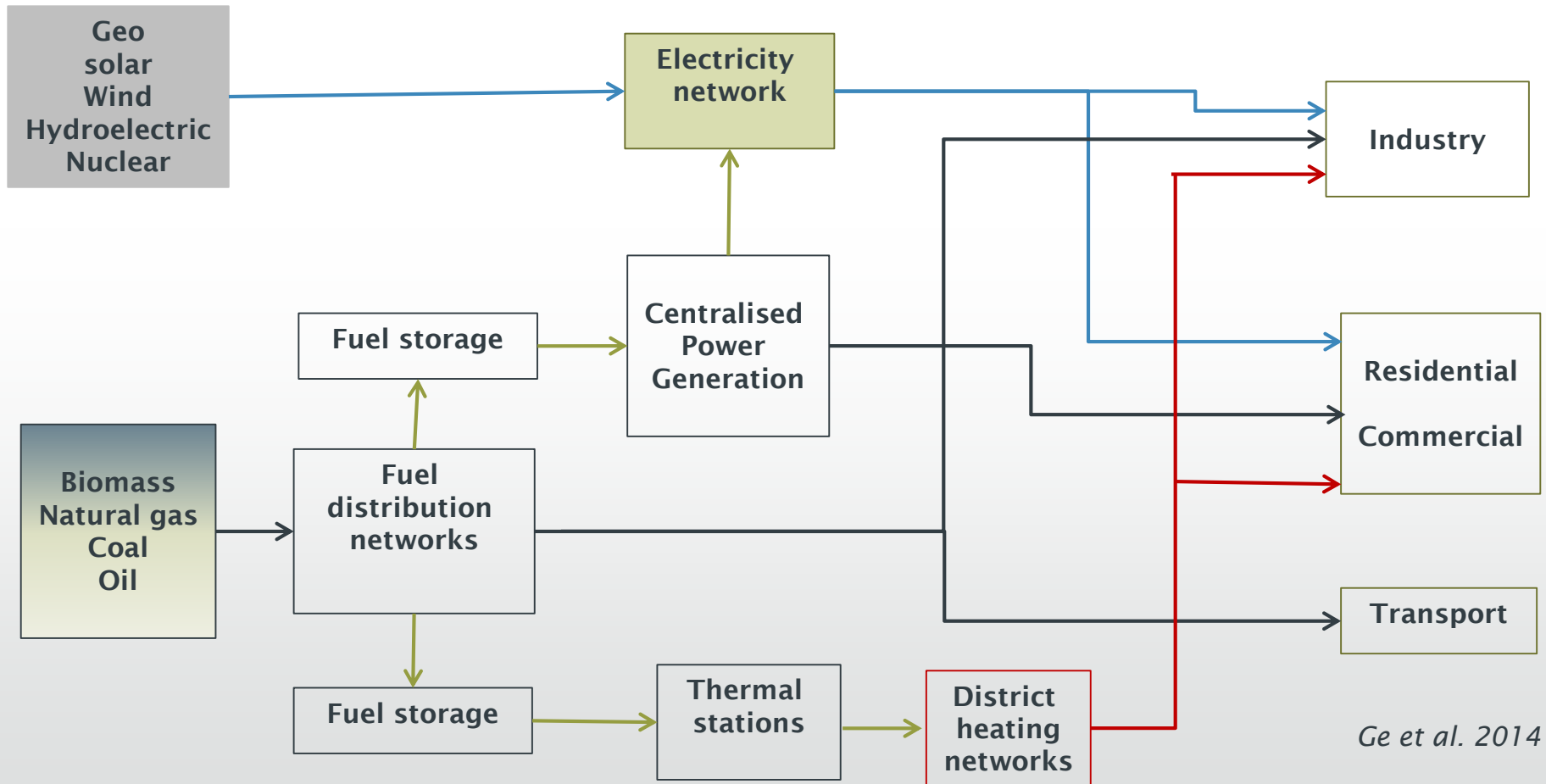
14th July 2016

Why is energy storage important?

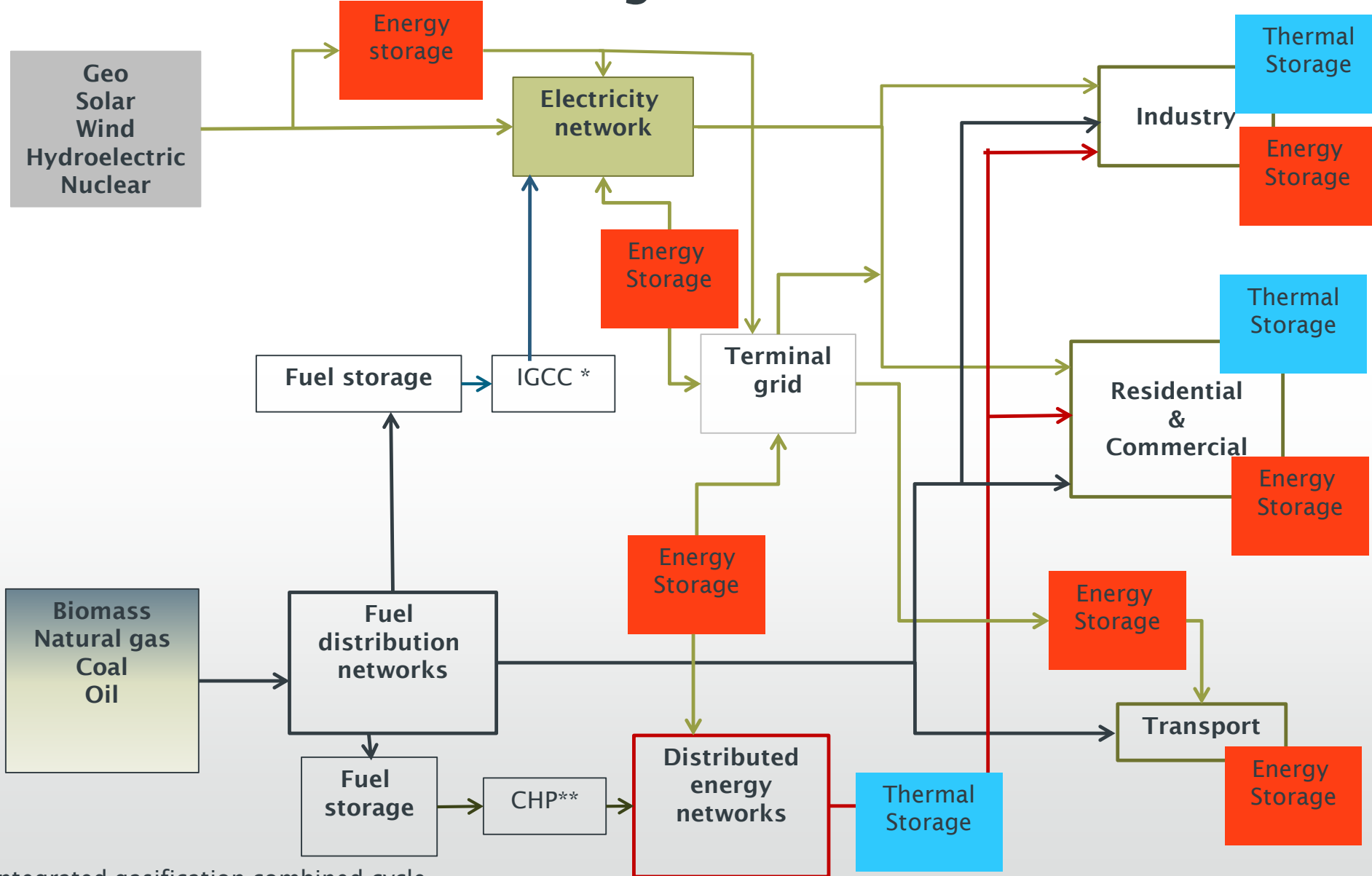
1. Balance between the energy supply and the energy demand
2. Due to decreasing resources of fossil fuels large scale solar and wind farms are required → Intermittency of wind and solar energy is a drawback

Small and fast scale energy storage installations are not that profitable

The power grid without Energy and Thermal Storage



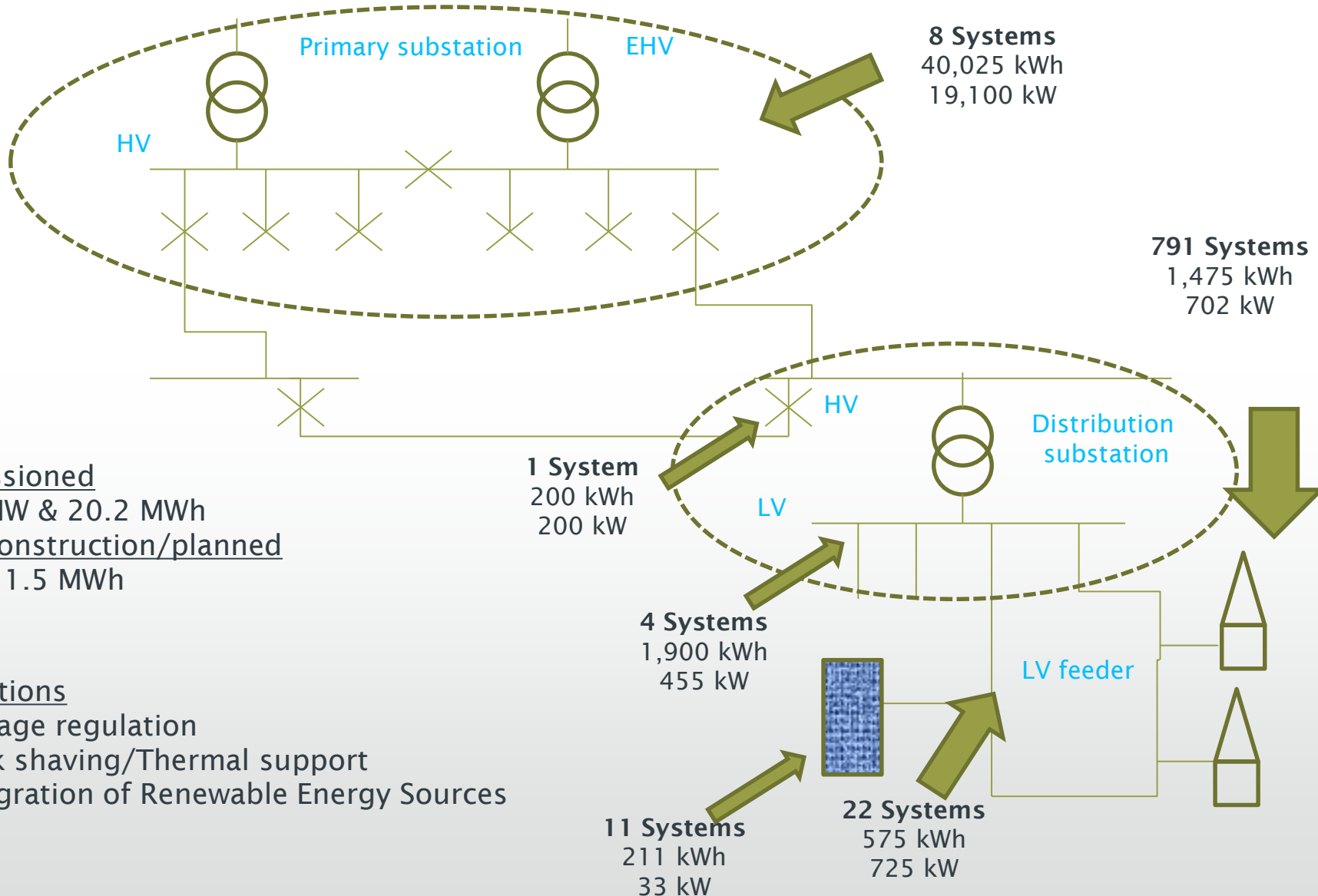
The power grid with Energy and Thermal Storage



*integrated gasification combined cycle

**combined heat power

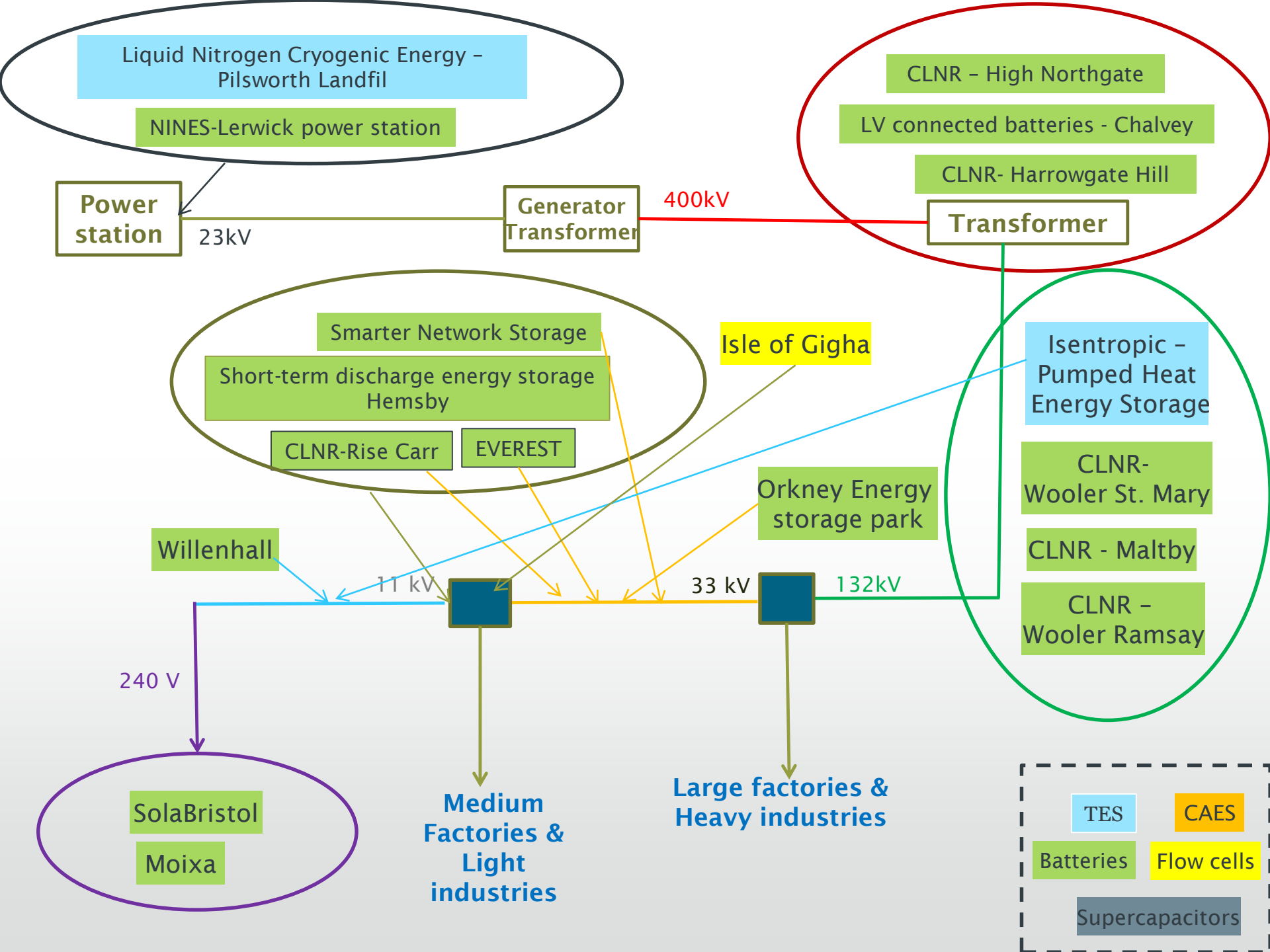
**Network connections of proposed and deployed storage in the UK
(DNO and DECC demonstrators- December 2014)
“A good practice guide on electrical Energy storage”**



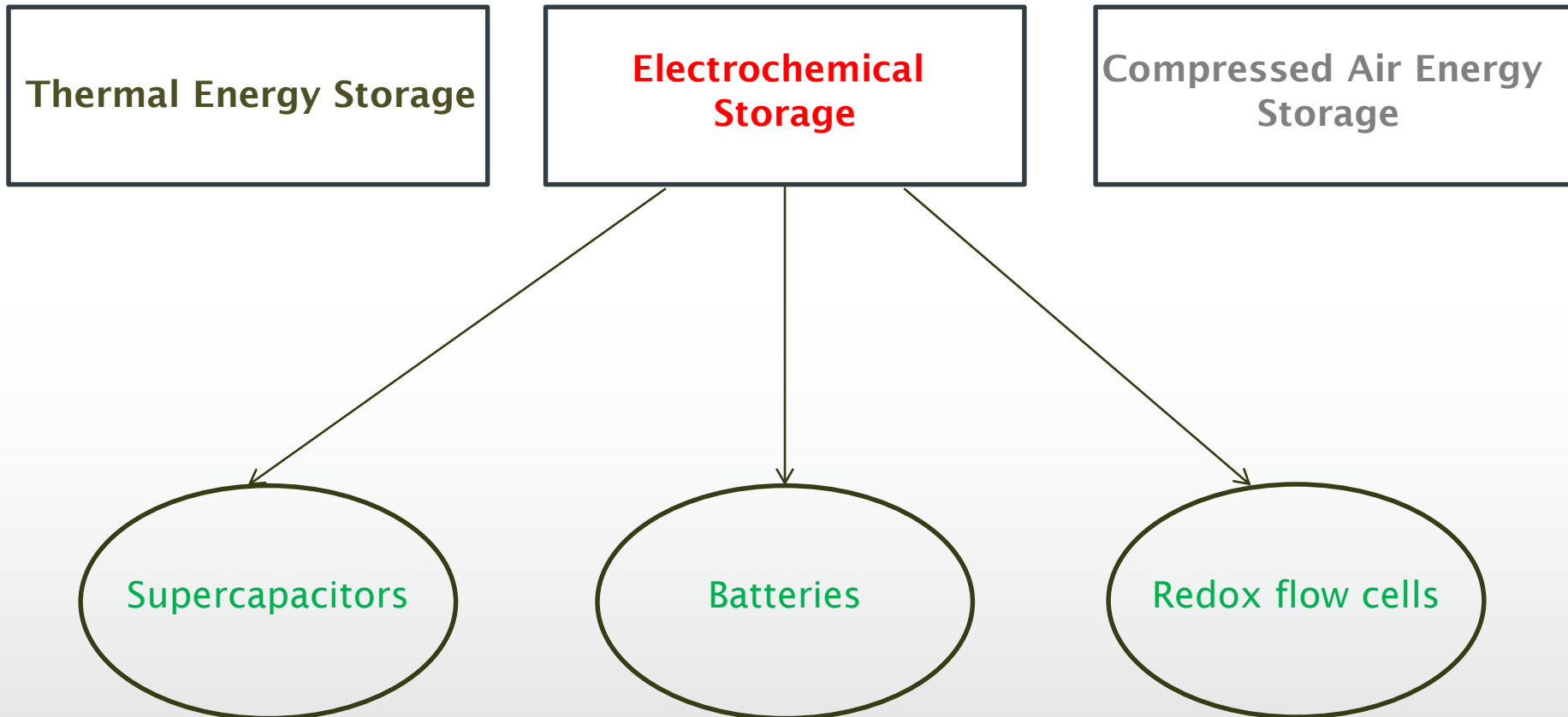
Commissioned
12.45 MW & 20.2 MWh
Under construction/planned
3 MW & 1.5 MWh

Applications

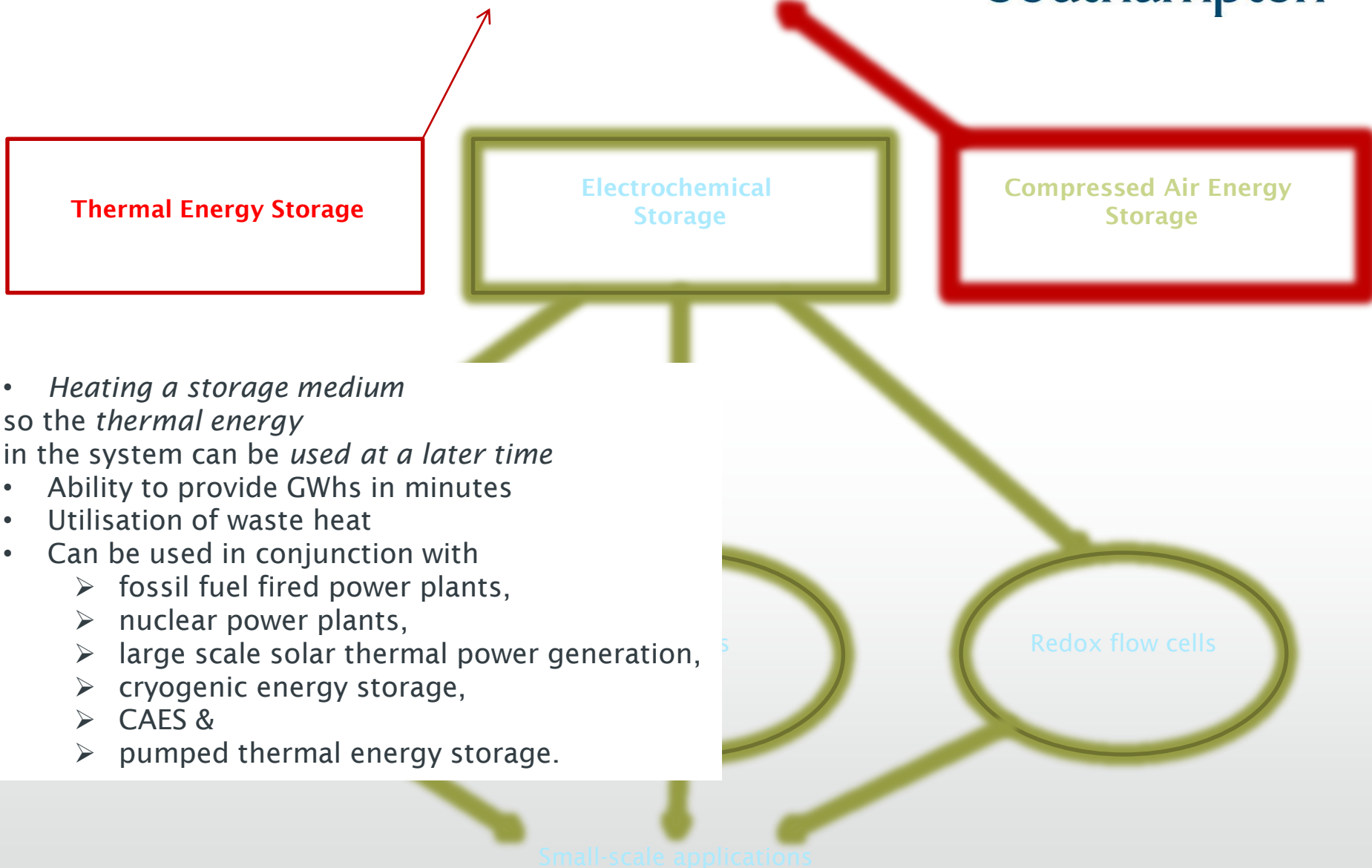
- Voltage regulation
- Peak shaving/Thermal support
- Integration of Renewable Energy Sources



The *Supergen* technologies

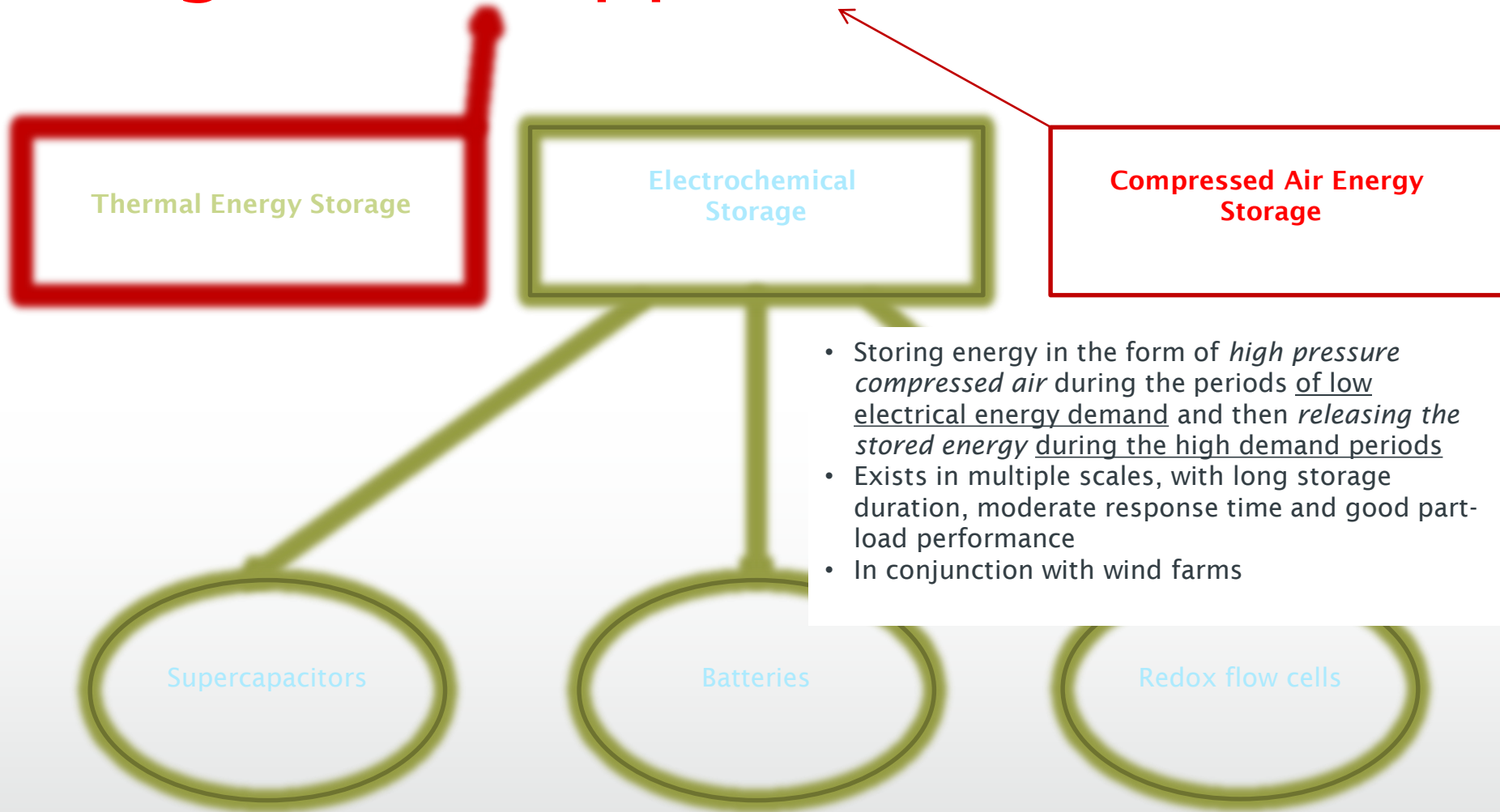


Large-scale applications



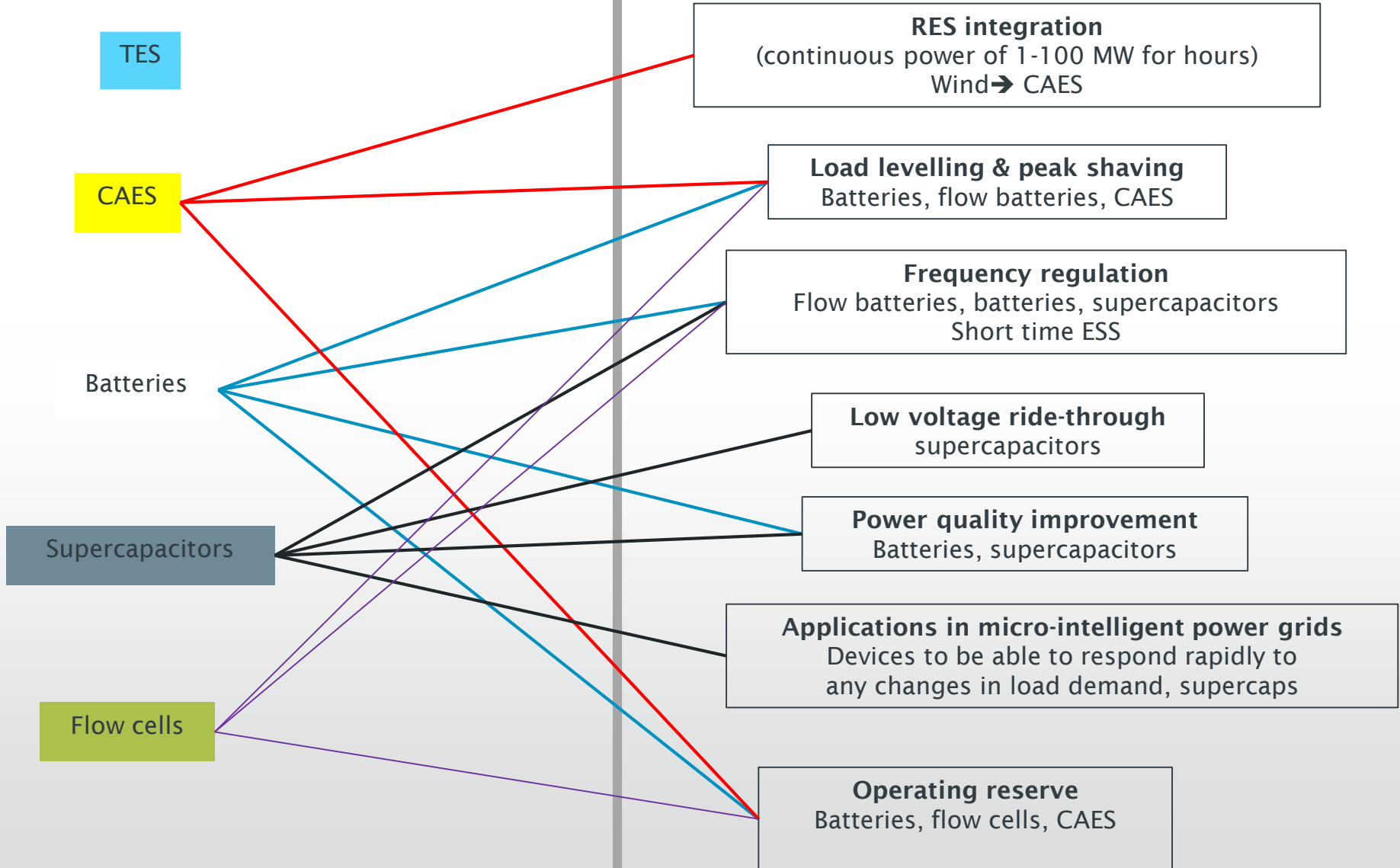
- Heating a storage medium so the thermal energy in the system can be used at a later time
- Ability to provide GWhs in minutes
- Utilisation of waste heat
- Can be used in conjunction with
 - fossil fuel fired power plants,
 - nuclear power plants,
 - large scale solar thermal power generation,
 - cryogenic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

Large-scale applications



EES technologies

Applications



Database containing the characteristics of different storage devices

Institution (Leader)	Imperial College (Nigel Brandon)		University of Cambridge (Clare Grey)		University of Oxford (Peter Bruce)		University of Oxford (Patrick Grant)		University of Birmingham (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

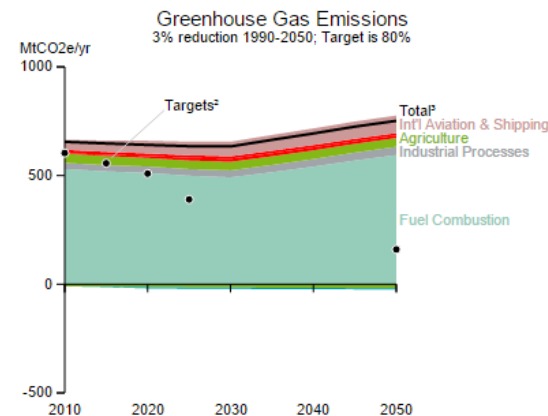
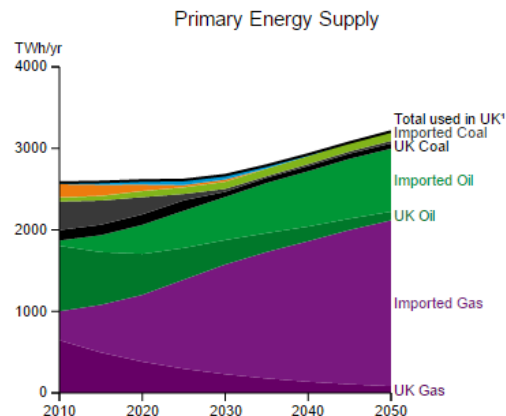
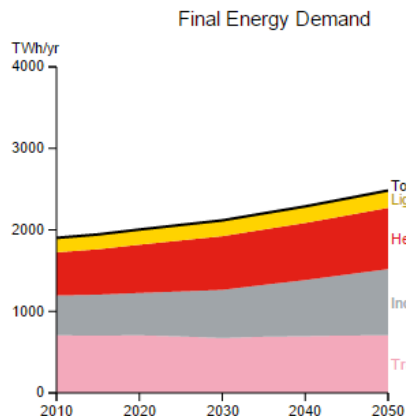
OR

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

2050 Energy Calculator

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

The UK 2050 Calculator Energy Electricity Security Flows Map Story Costs Air Share Docs Examples



- Domestic transport behaviour ? 1 2 3 4
- Shift to zero emission transport ? 1 2 3 4
- Choice of zero-emission technology ? A B C D
- Domestic freight ? 1 2 3 4
- International aviation ? 1 2 3 4
- International shipping ? 1 2 3 4
- Average temperature of homes ? 1 2 3 4
- Home insulation ? 1 2 3 4
- Home heating electrification ? A B C D
- Home heating that isn't electric ? A B C D
- Home lighting & appliances ? 1 2 3 4
- Electrification of home cooking ? A B
- Growth in industry ? A B C
- Energy intensity of industry ? 1 2 3
- Commercial demand for heating and cooling ? 1 2 3 4
- Commercial heating electrification ? A B C D
- Commercial heating that isn't electric ? A B C D
- Commercial lighting & appliances ? 1 2 3 4
- Electrification of commercial cooking ? A B

- Nuclear power stations ? 1 2 3 4
- CCS power stations ? 1 2 3 4
- Choice of CCS power station fuel ? A B C D
- Offshore wind ? 1 2 3 4
- Onshore wind ? 1 2 3 4
- Wave ? 1 2 3 4
- Tidal Stream ? 1 2 3 4
- Tidal Range ? 1 2 3 4
- Biomass power stations ? 1 2 3 4
- Solar panels for electricity ? 1 2 3 4
- Solar panels for hot water ? 1 2 3 4
- Geothermal electricity ? 1 2 3 4
- Hydroelectric power stations ? 1 2 3 4
- Small-scale wind ? 1 2 3 4
- Electricity imports ? 1 2 3 4
- Land dedicated to bioenergy ? 1 2 3 4
- Livestock and their management ? 1 2 3 4
- Volume of waste and recycling ? A B C D
- Marine algae ? 1 2 3 4
- Type of fuels from biomass ? A B C D
- Bioenergy imports ? 1 2 3 4

- Geosequestration ? 1 2 3 4
- Storage, demand shifting & interconnection ? 1 2 3 4

Notes

- ? Question marks take you to one page descriptions of each choice
- 1 The least effort possible on this choice.
- 2 Viewed as ambitious, but reasonable by most experts.
- 3 Viewed as unlikely without significant change from the current system and/or significant technological breakthroughs
- 4 The upper end of what is thought to be physically plausible by the most optimistic observer.
- A-D A range of options where one alternative is not necessarily harder than another
- Total used in the UK¹ Primary energy supply is normally higher than final energy demand, because of the energy used to generate electricity.
- Targets² The targets up to 2027 exclude international aviation and shipping. They are also calculated as five year 'budgets', rather than the single year targets shown here.
- Total³ The total includes the reduction in emissions from carbon capture and storage and from growing new biomass to replace that used (the bioenergy credit).

All the assumptions and calculations are available in a spreadsheet. Download [Excel Version 3.6.1 \(Version history\)](#). The source code for this site is available under an open source licence from <http://github.com/decc/twenty-fifty>

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

Thank you for your attention