Electric Vehicle Battery Reuse & Recycling Opportunities

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ICT Evening Seminar

Meriden

25th February 2020

VALUABLE

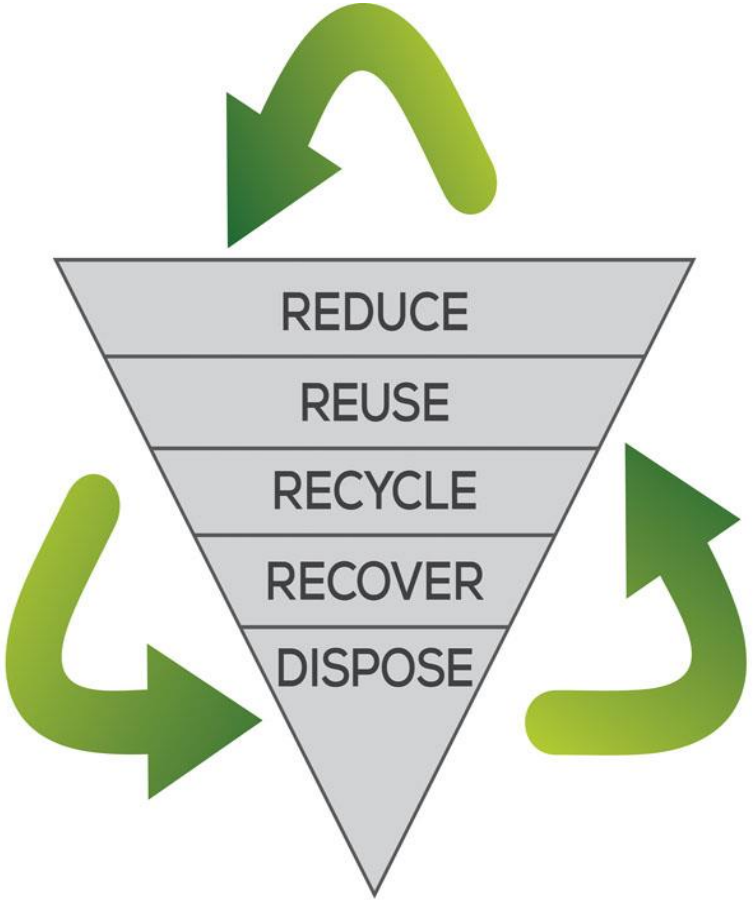
Why Recycle Electric Vehicle Batteries?

- ELV batteries gradually lose capacity – thereby reducing the vehicle range
- Typically replaced when capacity drops to below ~70 - 80% of original
- Expected to be after around 8 to 10 years of use (depending on a number of factors)
- The first generation of vehicle batteries are reaching end of life now
- Volumes are set to grow rapidly
- Huge demand on raw materials
- Repair, Reuse, Recycle
- It makes sense in the context of the circular economy

Recycle or Reuse?

Battery Specific Options

- Reduce – extend the service life
- Reuse in secondary applications
- Recycle to recover raw materials



Ideally, Reuse then Recycle

Electric Vehicle Batteries

- Batteries contain lithium and cobalt
- Various other valuable components and materials
- Battery management system
- High power circuit boards

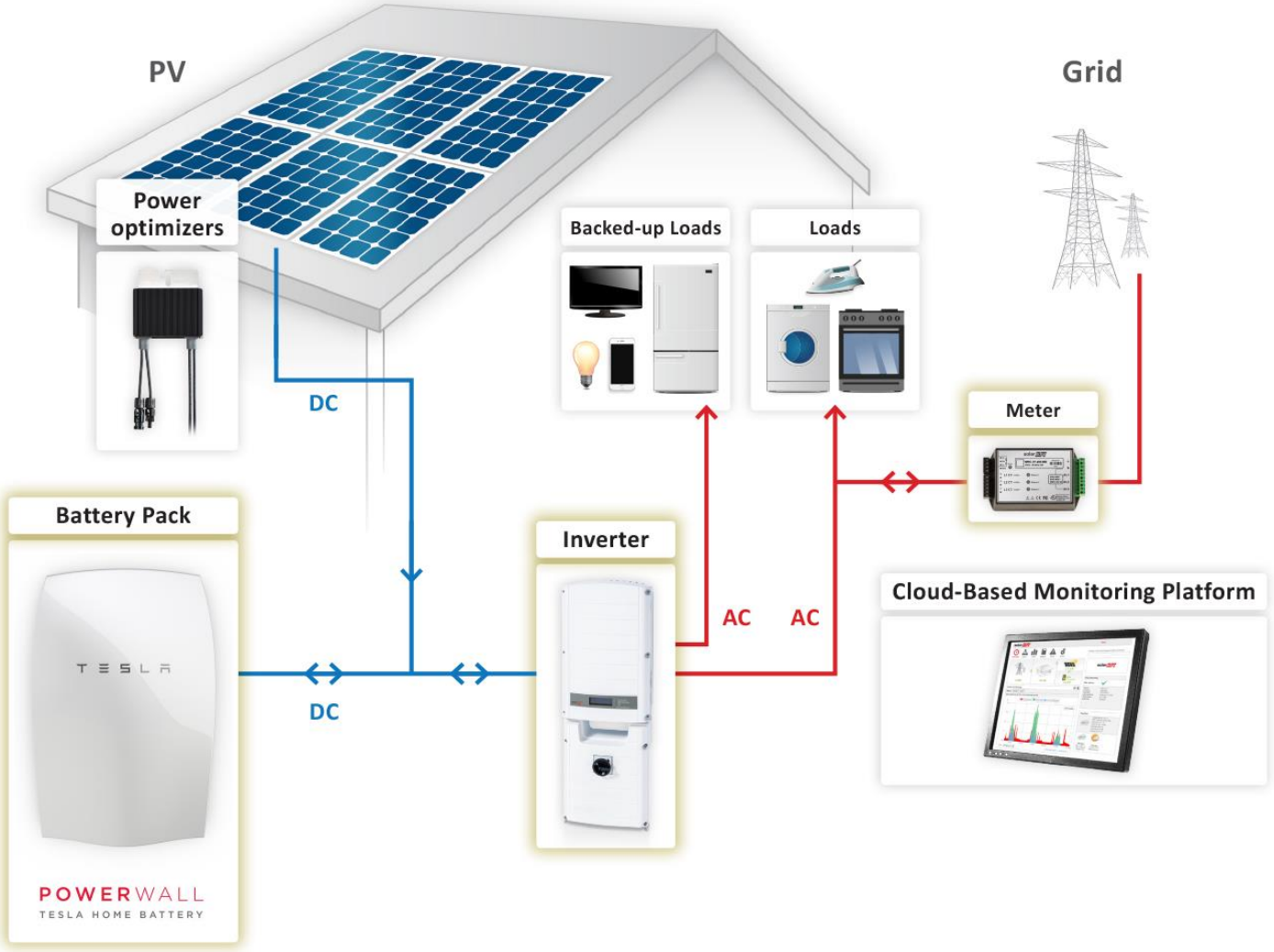
Rapidly Growing End of Life Battery Capacity

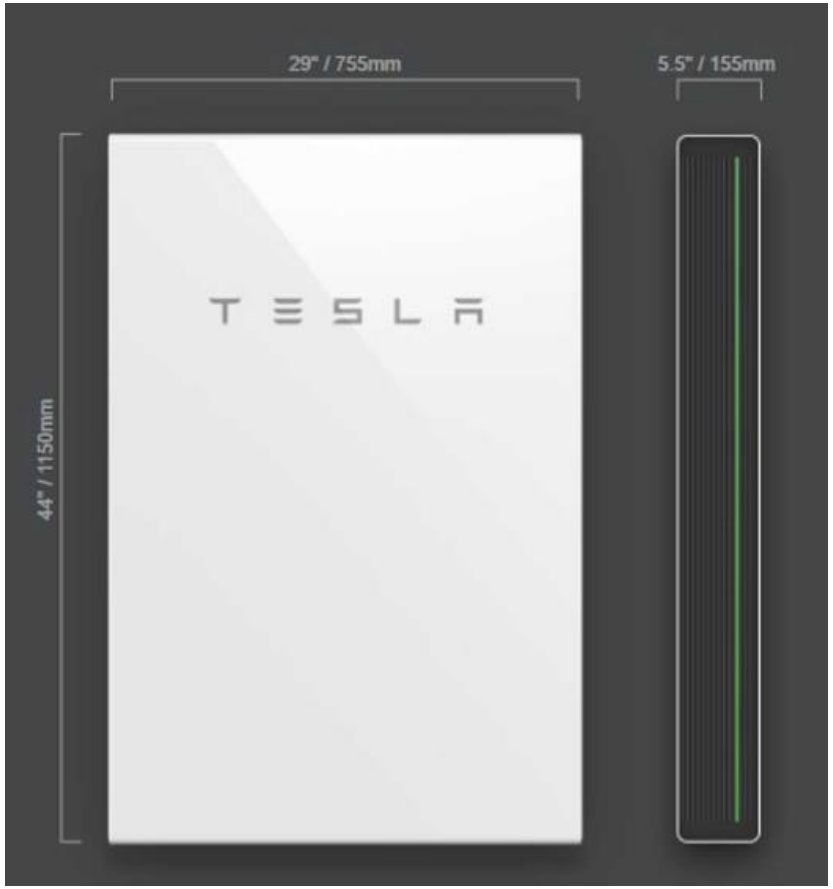
- The number of end of life vehicle batteries will grow rapidly;
  - 55,000 in 2018 to 3.4 million by 2025 and 6.0 million by 2030

Year	Capacity (GWh/year)
2020	16.7
2021	31.4
2022	54.4
2023	85.6
2024	127.2
2025	186.5

- This represents around 275 GigaWatt hours of capacity

Home Energy Storage by Re-Using ELV Batteries





Tesla Powerwall2; 13.5 kWh, 7.0 kW max

Home Energy Storage by Re-Using ELV Batteries

The Powervault range of home storage batteries are made in Britain by UK company, Powervault Ltd.

Powervault products are sophisticated and have been designed to take advantage of future developments in how we use electricity in the home. The Powervault battery range allows you to:

1 Store excess solar electricity for later use

2 Store cheap, off-peak electricity for later use

3 Power devices in your home

4 Charge your electric car

5 Receive an income via GridFLEX

6 Do away with a separate solar inverter

7 Make use of smart tariffs to save money

But does it stack up economically for the average user?

Tesla prefers to recycle its used batteries

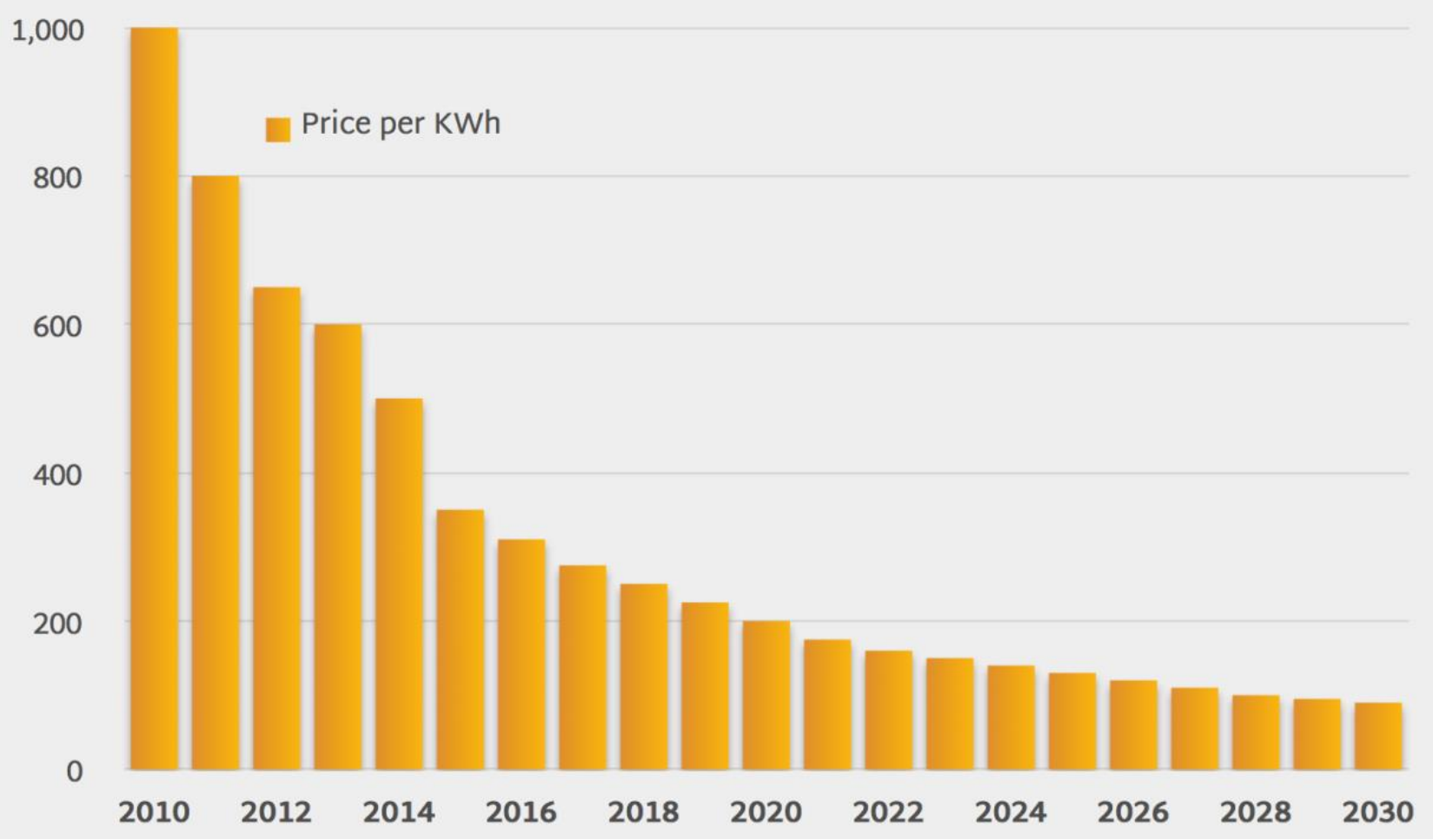
Benefits of Reusing ELV Batteries

- There should be significant benefits at a number of levels
- Significant socio-economic impacts; but both positive and negative
- Contributes to the circular economy with energy use
- Extends battery life, thereby reducing overall costs
- Encourages use of intermittent renewables i.e. wind and solar energy
- Creates employment opportunities
- Materials can ultimately be recycled anyway

Possible Negatives of Reusing ELV Batteries

- Transport costs – ELV batteries are big and very heavy
- Dismantling, testing, reassembly and certification all add to the cost
- There are many different types of battery chemistry and sizes etc
- Batteries ultimately need recycling anyway – more cost
- Battery performance is continually improving
- New battery costs are reducing
- Why not just use new batteries and simply recycle the old ones?

ELV Batteries – Cost per kWh



Source: Bloomberg New Energy Finance, World Economic Forum

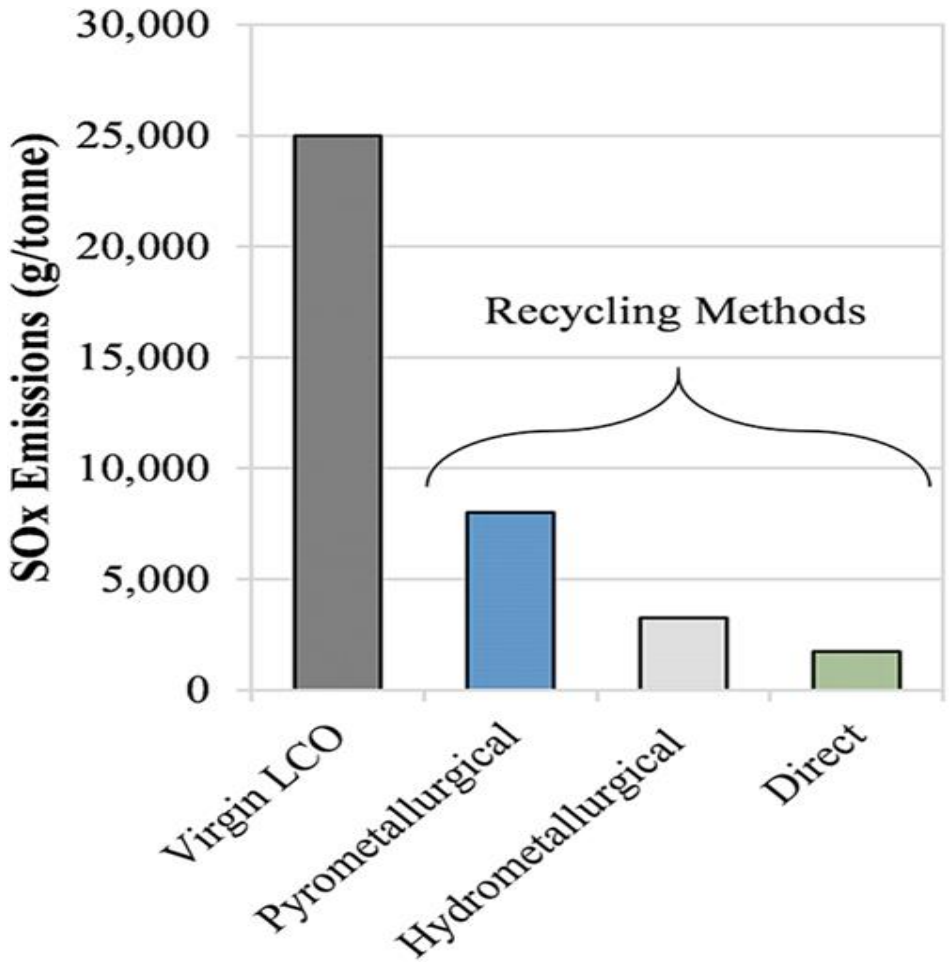
Societal Impacts – an Opportunity

- Balancing power availability
- Becoming more important as electricity generation from intermittent sources grows
- The solar industry is dependent on the cost-effective integration of appropriate energy storage systems
  - University of California have commissioned a commercial-scale assembly of used Nissan Leaf batteries to store energy from a local solar array

Societal Impacts – the Benefits

- Reduced levels of materials consigned to landfill
- Raw materials conserved and potentially available for reuse
- Helps prevent pollution by reducing mining and processing of virgin, raw materials
- Savings in energy
- Reduced greenhouse gas emissions and thus their contribution to climate change
- Creation of employment opportunities across the battery supply chain, including in the recycling and manufacturing industries
- Materials can be reused for making new products - sustainability

Societal Impacts – the Benefits



- Big reductions in energy use possible via recovery of metals
- Initial extraction from ores is very energy-intensive
- Cobalt, nickel, and copper are often produced from sulphide ores
- Results in significant SOx emissions

Source: Key issues for Li-ion battery recycling, Gaines L', et al, doi.org/10.1557/mre.2018.13

Societal Impacts – the Benefits

- Estimated employment opportunities in the collection, dismantling and recycling of batteries;

	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
	2030		2035		2040	
Collection + dismantling	2,094	2,618	4,673	5,841	9,684	12,105
Recycling	524	654	1,168	1,460	2,421	3,026
Total	**2, 618**	**3,272**	**5,841**	**7,302**	**12,105**	**15,131**

(But does not take into account any job losses that might occur in the primary extraction sector as a result of the key metals such as cobalt being increasingly recycled)

Summary - Li-ion battery Recycling and Reuse

- It clearly makes sense to recycle and reuse end of life vehicle batteries
- Both reuse in secondary applications and recycling have some merits
- Which is the best route is still to be determined
- It depends on a number of inter-related factors
- However, with the move to electric vehicles being accelerated by government policy it will be vitally important that the correct decisions are taken

As Always, Great British Engineering Led the Way

- The sadly missed, the **Enfield 8000**
- Total production of 120 cars (1973)
- A famous Anglo-Greek collaboration
  - powered by an 8 bhp (6 kW) electric motor
  - lead-acid batteries
  - top speed of ~48 mph
  - range of around ~40 miles

Electric Vehicle Battery Reuse & Recycling Opportunities

https://www.valuablebatteries.co.uk

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