

Market Diffusion of Second-life Electric Vehicle Batteries: Barriers and Enablers



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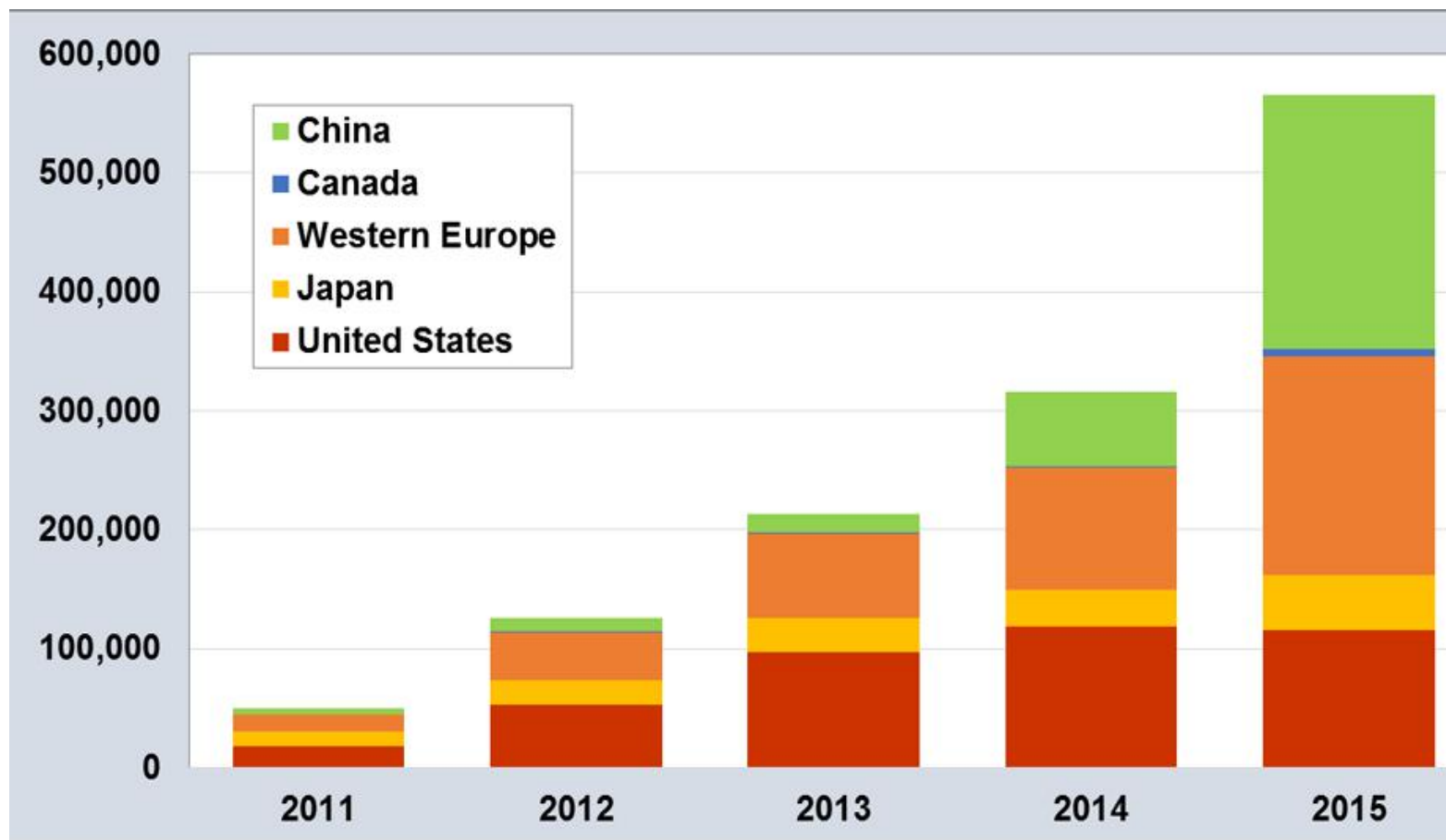
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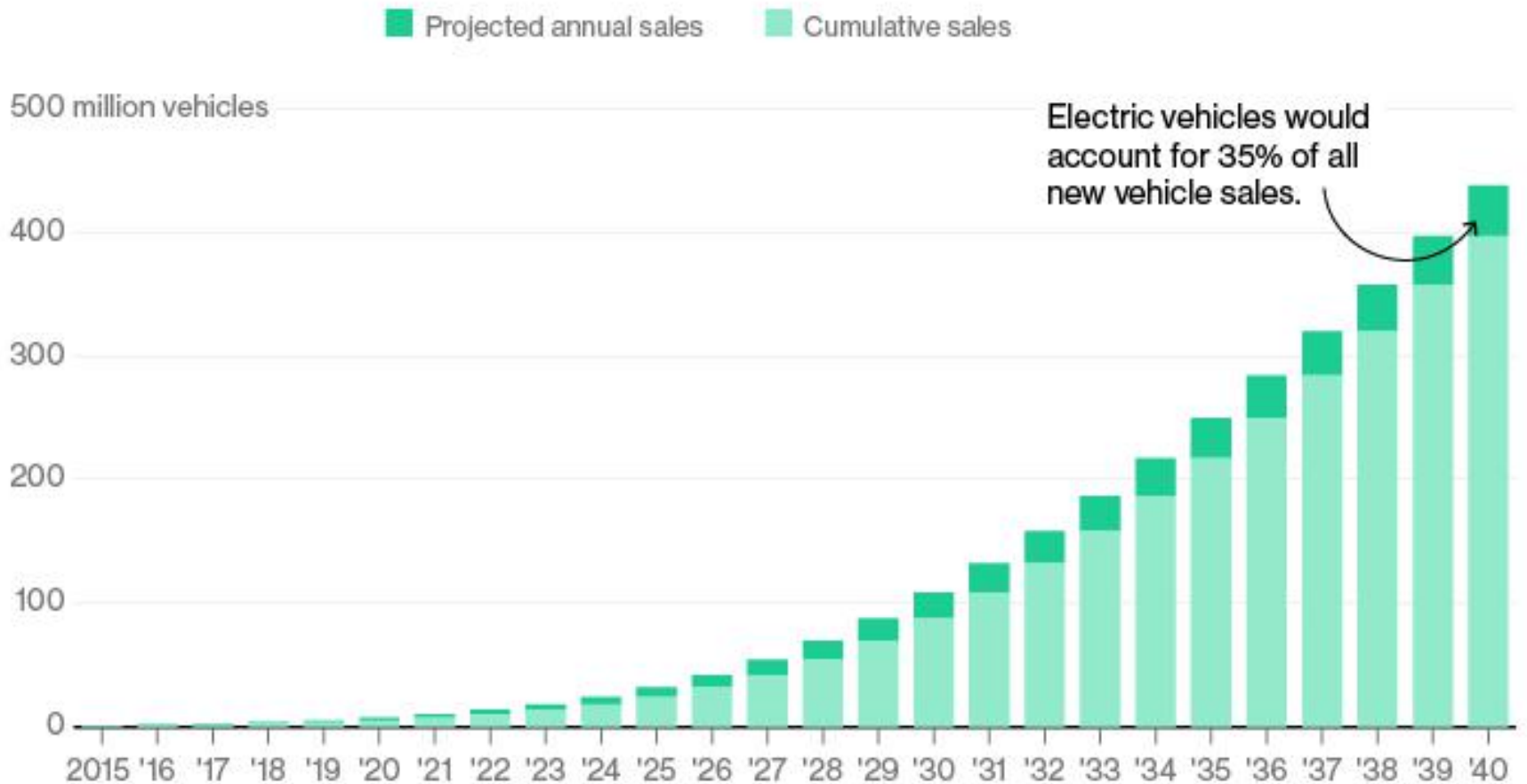
19-22 June 2016

Global plug-in EV sales



Source: Data compiled by Argonne National Laboratory, Argonne, IL, February 2016.

EV sales forecast

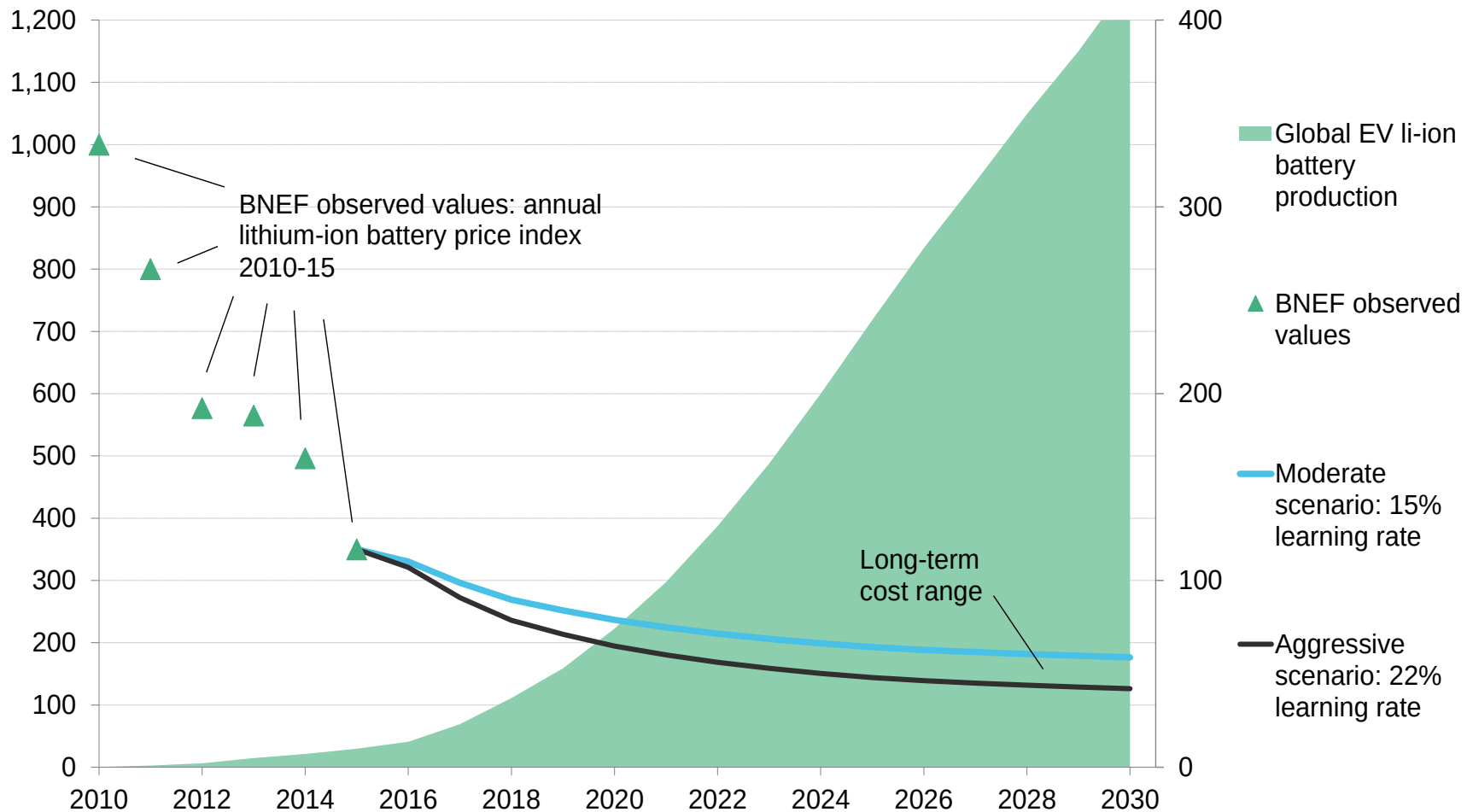


Sources: Data compiled by Bloomberg New Energy Finance, Marklines



Source: Bloomberg New Energy Finance (BNEF)

EV Li-ion battery cost outlook 2010-2030



Source: Bloomberg New Energy Finance (BNEF)

Battery reuse: a potential way to improve the value of EV offering

- **End-of-life traction battery:** battery reaches its end-of-life in vehicles when capacity drops to 70-80% of initial level
- **Second-life battery:** battery no longer suitable for vehicular usage can be used in energy storage applications

Battery reuse – extending the total lifetime of EV batteries:

- alternative revenue stream and image promotion for OEMs;
- reduction in energy consumption and environmental impact by postponing battery recycling;
- reduction in resource and energy consumption for new battery manufacturing
- cost reduction for energy storage – advancement of smart grid and renewable integration;
 - Energy bill reduction and electricity security for consumers

“Post-vehicle” applications of EV batteries

- **Utility scale**
 - Renewable integration and EV charging buffering for grid
 - Grid balancing
- **Commercial & Industrial**
 - Peak demand reduction
 - Back-up power
- **Residential**
 - Peak demand reduction
 - Energy management
 - Back-up power



“Post-vehicle” applications of EV batteries

- **Mobile**

- Low-speed EV traction
e.g. sight-seeing buses
- Mobile charger
- Starter battery for conventional vehicles



Research Design

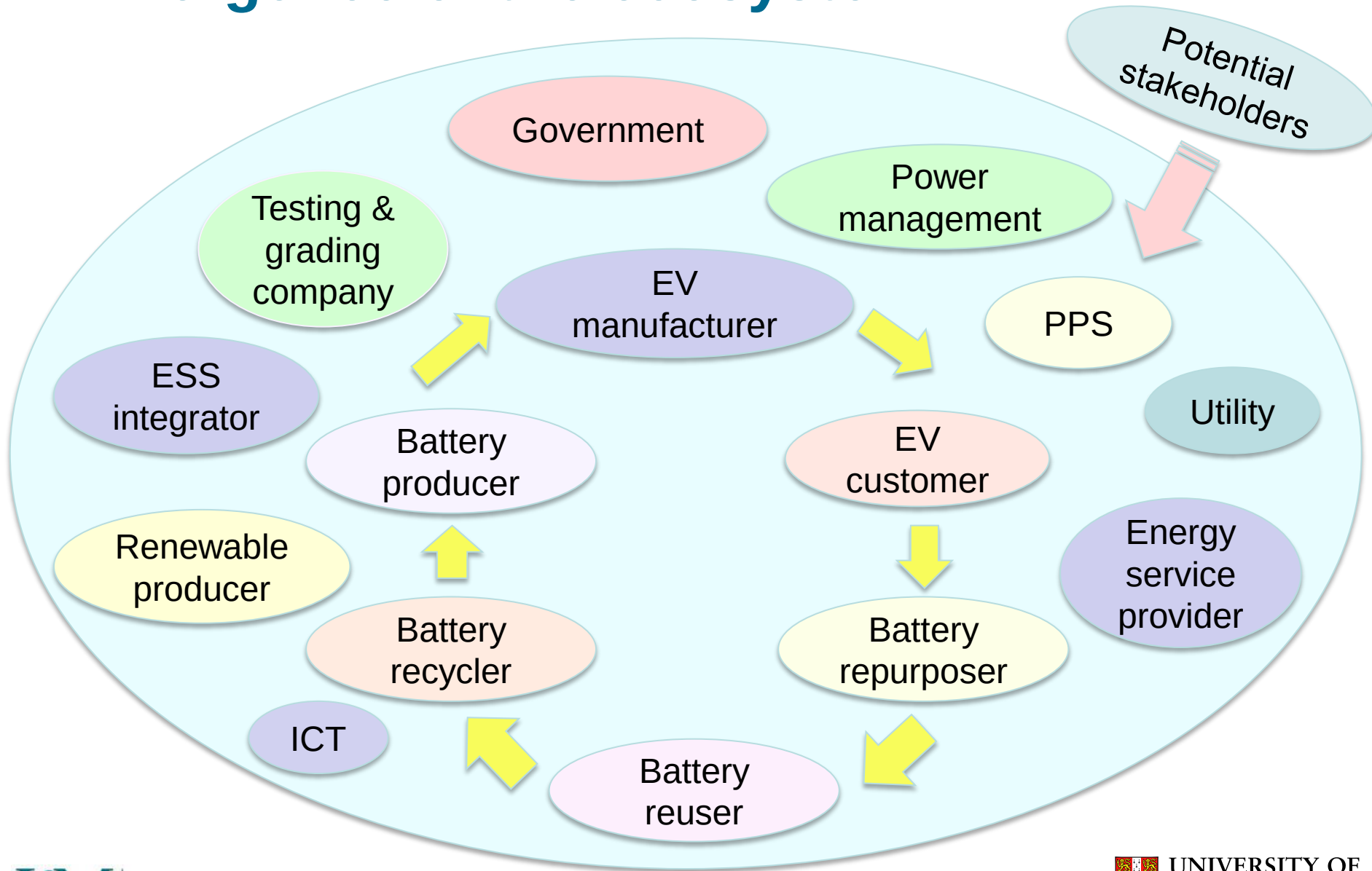
Objective: Understanding the factors influencing the market development of second-life batteries and their implications for the ecosystem emergence

Research questions:

- What are the enablers and barriers for second-life EV batteries?
- What are the determining factors that influence the market development of second-life EV batteries?

Methodology: Exploratory qualitative case studies and semi-structured interviews with different stakeholders involving EV battery second use.

Emergence of the ecosystem



Case Studies and Findings

Case No.	Company/ Joint Venture	Region	Role of Stakeholder	Strategy & Capability
1	Company A	China	Battery & EV manufacturer	Collaboration with electricity suppliers; EV fleet (taxies and buses); technology leadership for batteries
2	Company B	Japan	EV manufacturer (OEM)	Establishing a B2U joint venture to support the EV programme; leadership for EV sales
3	Joint Venture C	Japan	B2U utility	Partnership with energy storage companies; support from OEM; expertise in B2U
4	Company D	California	Energy storage service provider	Niche market in low-cost mobile EV charging service for commercial utilities to avoid expensive construction project.

On-going B2U activities

- Pilot and demonstration projects investigating technical and economic viability of battery second-use in various energy storage applications;
- Partnerships between major stakeholders to seek potential market and customers;
- Small-scale commercial activities selling second-life battery products and/or services

Factors influencing the B2U market

Company A – battery & EV OEM

Large EV database & expertise in batteries;

Collaboration with utilities;
Customers' bias towards used batteries;

Regulatory support

Company B – EV manufacturer

Large EV database;
EV volume;
Robust battery engineering;
Competition from new batteries;
Electricity liberalization in Japan

Company C – B2U joint venture

Access to EV database and support from parent company;

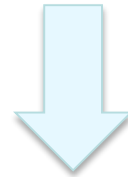
Battery repurposing cost and system cost;
Competition from new batteries

Company D – ESS service provider

Standardized products, pricing and contracts;
Inter-industrial collaboration;
Regulatory support

Prerequisite: large database to support battery performance testing, grading and prediction

Challenge: rapid decrease in new battery price, which could eliminate the cost advantage of second-life batteries



Inter-industrial
collaboration to
establish the
infrastructure &
standardized
platform

Innovative
business
models that
reduce the risks
in cost and
performance

Regulatory
supports that
create
favourable
market
environment

Determining factors for B2U

Standardized platform

- Standardized product
- Transparent pricing
- Standardized contract

Inter-industrial collaboration

- Establish infrastructure
- Create market mechanism

Regulatory support

- Regulate and guide the market
- Incentives for second-life batteries

Innovative business models are essential to reduce risks and maximize value, making second-life batteries more attractive

Role of OEMs – key player in the nascent stage of B2U ecosystem

- OEMs have the biggest motivation to develop B2U to support their EV programmes and improve the value of EV offering
- OEMs hold the key to battery design – reuse-friendly initial design
- OEMs determines the ownership strategies (selling, rental etc.) – the battery flow
- OEMs play an important role in enabling the determining factors to facilitate B2U

Recommendations

- Collaboration with battery manufacturers to avoid direct competition with new batteries
- Innovative business models to reduce risks on customers – collaborate with customers to co-create value
- Joint efforts from regulators, major OEMs and research institutes to establish standards and demonstrations and educate customers

Future Work

Limitations

- Limited EV market share – low volume of retired batteries currently and economic uncertainty in B2U
- Limitation in identifying all the key stakeholders in this emerging industry over a relatively short time period

Future research

- Deeper case studies with the existing stakeholders and identify potential key players in the B2U ecosystem – include the European market
- Exploring effective business models for EV battery reuse
- Insight into the interplay between battery reuse business models and the evolution of B2U ecosystem

Thank you!



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