Topic 3: Battery performance and durability

Presented by: USA, Canada, Recharge
Day 1, Agenda Item 5
EVE-12 meeting
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Outline

1. Defining battery durability
2. Factors influencing battery durability
3. Battery durability work:
    a) Private and standard associations
    b) Regulatory agencies
4. Next steps

Defining battery durability

- Full useful life standards
  - How will an electrified vehicle perform over its useful life?
  - How will the criteria pollutants and/or CO2 emissions change?
  - *CP's could define end of life performance criteria.*
- Customer satisfaction
  - Example: As a customer, the expectation is that the battery will last the full useful life of the vehicle or at least be comparable to the non-electric equivalent in its class
  - If regulations are technology forcing, do we understand the performance of electrified vehicles under all conditions.
- Other possible definitions:
  - Time taken to deplete the battery of one charge at certain operating conditions
  - Number of charge cycles until the end of useful life
  - Mean time between failure

Defining battery durability

- Recharge:
  - The definition of the battery performance and durability requires the understanding of the battery expected Service Life and End of Life criteria.
    - RECHARGE has been selected by the European Commission for a Pilot Study of the Batteries Product Environment Footprint : these definitions have been discussed recently.
  - **The expected service of the battery is the total energy delivered over the battery life (in Wh).**
    - It can be measured during a life cycle test of a battery
  - Recharge believes that a single “representative” testing of the various battery usage in EV application is impossible.
  - **The battery robustness and durability can be assessed in a “simple” testing**
  - These cycling tests need eventually to be consolidated with other adequate data from the battery manufacturer to assess the performance in different conditions.
  - The « battery life model » is needed for the BMS, and provide the information for all usage conditions.

Factors influencing battery durability

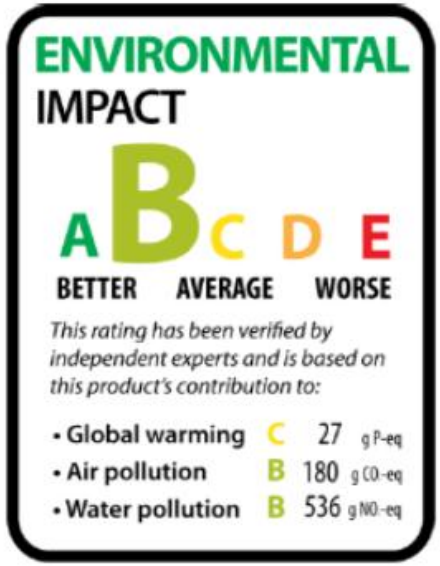
- DOC (top range of SOC used – bottom range of SOC used)
- Cell temperatures (= f(ambient temp, BMS, Thermal management system)
- Conditions of use and protection from elements (vibration, moisture, etc.)
- Discharge rate/pattern (i.e. duty cycle)
- Charge rate (i.e. SAE Level 1, 2 or 3, AC or DC)

Battery End of life criteria and CO2 emission

- ✓ **The battery minimum electrical performance (End of live criteria) depends on the Battery management system requirements.**

- ✓ **The battery smart management can change according Battery State of Health;**
  - **favorize the vehicle efficiency (i.e. while using more power from the battery),**
  - **enhance the battery life (i.e. while limiting the power).**

- ✓ **The CO2 emissions of an HEV is under the BMS (*) control, it cannot be directly linked to the battery performance or duration.**

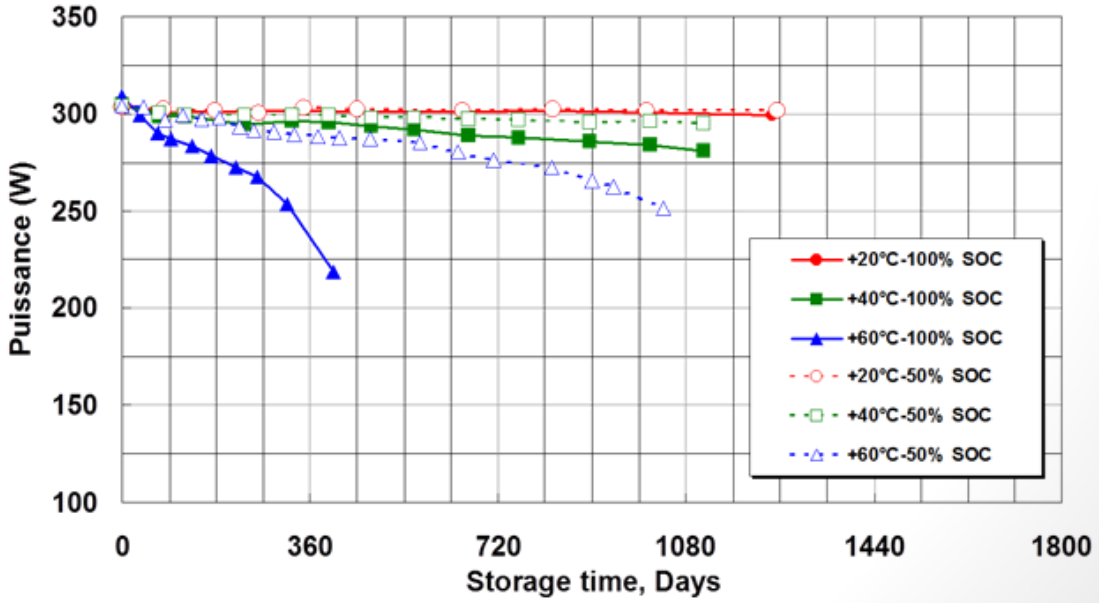


(*) dual power management between the ICE and the Battery.

Factors influencing battery durability

Example, Recharge: Battery performance sensitivity to SOC and temperature

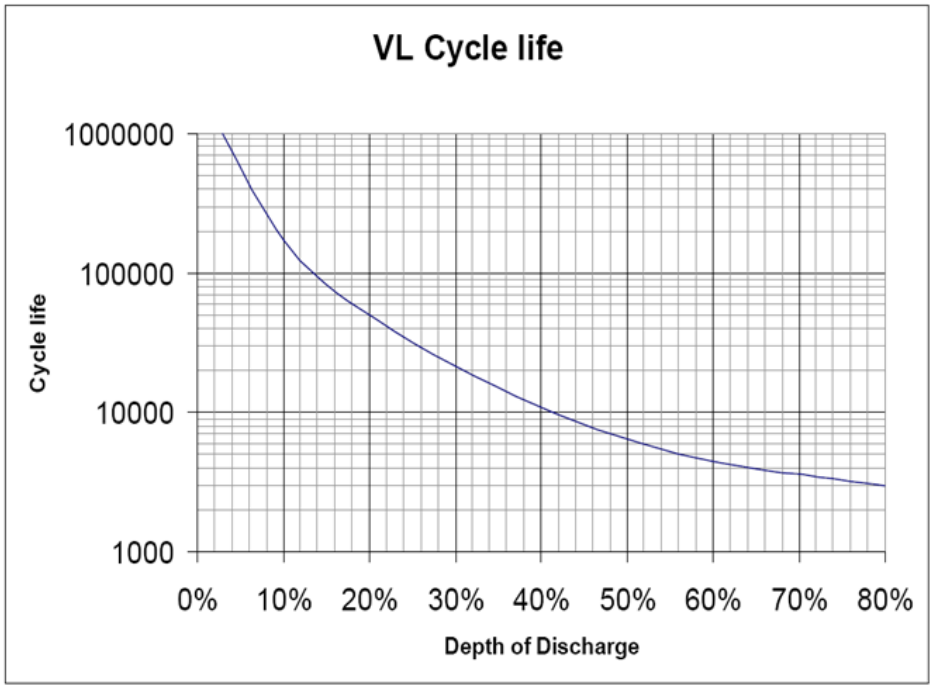
- Typical Li-Cobalt battery behavior: impact of the storage temperature and different state of charge (SOC).
- Compared to the result at 20°C, the life duration at 60°C is divided by 3.



Factors influencing battery durability

Example, Recharge: Battery performance sensitivity to DOD

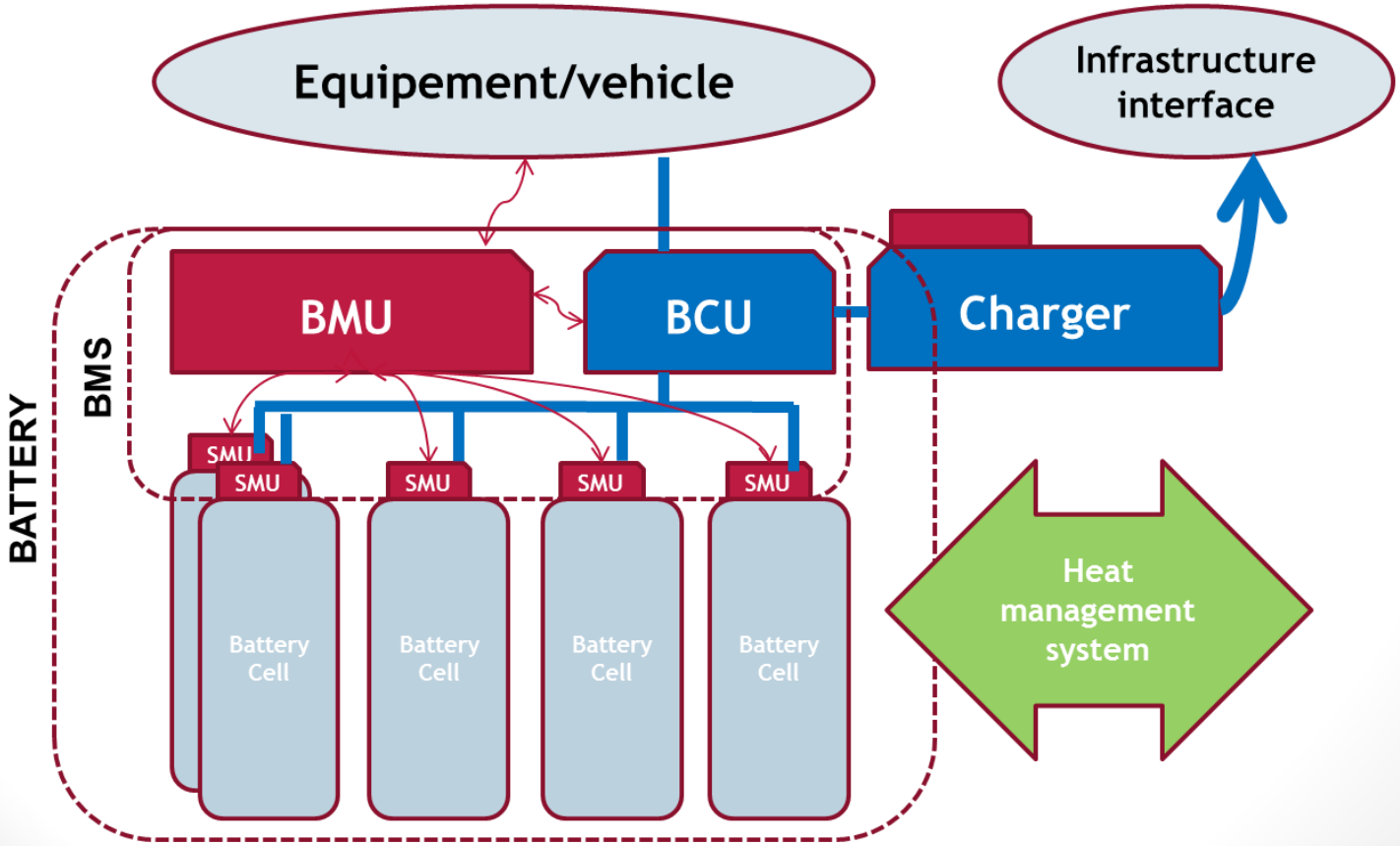
- The depth of discharge (DOD) has a large effect on the number of cycle
- total energy released at 3% DOD is 12 times larger than at 80% DOD



Factors influencing battery durability

Example, Recharge: Battery performance and EV battery design

BMS: battery management system
BMU: battery management unit (PCB)
SMU: safety management unit (PCB)
BCU: battery control unit (switches, contactors, cables..)



Factors influencing battery durability

Example, Recharge: Battery performance and EV battery usage

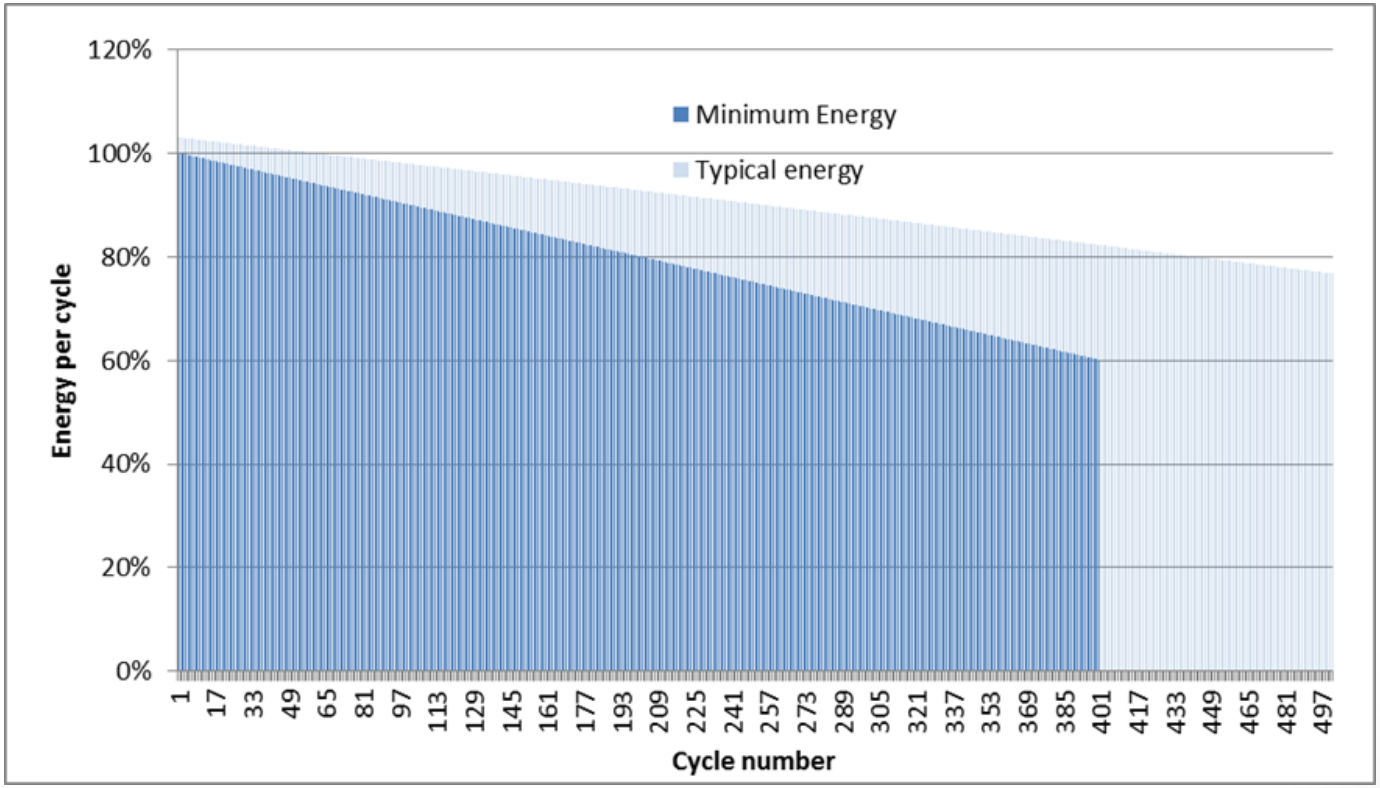
- Examples:
  - The weight of the battery in a « Renault twizzy » is much smaller (100 kg) than in a « Tesla » (350kg) and is not used with the same conditions
  - HEV, PHEV and EV batteries are used in a very different way (particularly about DOD range)
  - Thermal management systems: can be more expensive, but more efficient to protect the battery and enhance the battery life duration

Battery durability work: Private and standard associations

- Examples:
  - J1798 – Performance rating of battery modules
  - J2289 – Functional guidelines-EV Battery Pack
  - ISO 12405 – Abuse and Performance
  - IEC 62660 – Abuse and Performance
  - INL/EEL – Life, characterization, durability

Battery durability work: Private and standard associations

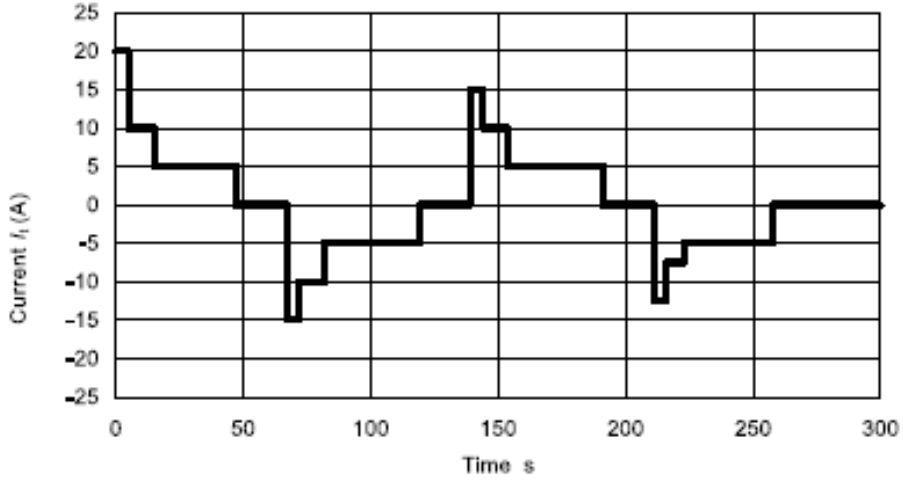
Example, Recharge: Energy per cycle using IEC 61960 cycle life testing standard as a reference



Battery durability work: Private and standard associations

Example, Recharge: Standards Cycling tests for EV

- More complex charge/discharge profile
- But still not a representation of the large variety of real life uses, thermal conditions in use, etc…
- Only provides the battery duration information in specific conditions.



IEC 62660 microcycle discharge rich profile for Battery EVE

Battery durability work: Regulatory agencies

Environment Canada:

- eTV and ERMS are anticipating a collaborative project starting this fiscal year

2) Range Degradation due to Mileage Accumulation

- Typical 5-door BEV available in North America
- Mileage Accumulation: Up to 100000km (testing every 15000km)
- Mix of DC Level 2 and Level 3 charging during accumulation
- Observation of real SOC% during testing
- Logging select CANbus signals during all accumulation
- In-Lab testing:
  - Ambient temperature: 35C, 25C & -18C (w/ and w/o cabin heat)
  - Duty Cycles: SAE J1634, SAE J1634 US06 MCT, NYCC, SC03
- Measurements: 1) Select CANbus signals, 2) Vehicle Energy draws
- Instrumentation:
  - CANbus Logger
  - High Precision Power Analyser and clamp-on probes
  - Chassis Dynamometer system
  - Thermocouples and Datalogger

Next steps

- Confirm that EVE should continue the investigation of battery durability.
- Establish a definition of battery durability
  - What criteria should be established for full useful life requirements?
- Identify all factors that effect battery durability
- Design an appropriate test program or methodology for evaluating battery durability (Design of Experiments?)
  - Where test cycles and procedures are considered, the WLTP will be the basis
- Perform testing and report results at future EVE and WLTP meetings.
  - Reference Part A of the new EVE mandate