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2nd Life battery energy storage for fast and rapid EV charging & wider applications.

6th April 2016

Battery research program - Swedish Energy Agency

Matthew Lumsden

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Agenda

1. Company overview
2. EVEREST project and E-STOR evolution
3. Product & service concept
4. R&D and commercial challenges
5. Knowledge gaps & research needs

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The Business

FTS
FUTURE TRANSPORT SYSTEMS

- Strategic and technical consultancy, project management and R&D services:
  - Typically our clients are large organisations in the automotive and energy sectors
  - Using a combination of internal investment, grant funding and client contracts we have developed the E-STOR energy storage systems

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- Commercialisation Co. for E-STOR and other developments:
  - A wholly owned subsidiary of FTS
  - Provides distributed energy storage operating services and sales via distributors
  - Market entry strategy focussing on providing storage to support EV rapid charging
  - First commercial product installation April 2016

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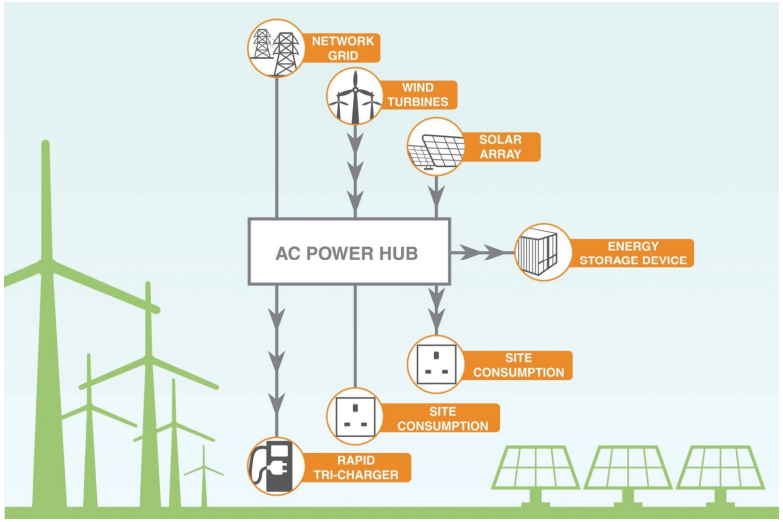
EVEREST technology demonstrator

Hypothesis:

- Mitigate the impact of an EV charging hub on the grid
- Design, build, install & operate a intelligent modular ESS
- Complimentary local network reinforcement
- Renewable generation integration



Solution:

- ~Multi channel 120 kWh 2nd life EV battery storage with bi-directional power electronics
- 15kW PV and wind installation
- Local and remote power management system

Results:

- Total storage & discharge of 11 MWH since April 2015
- Supporting local micro grid & charging hub
- Follow on OEM battery integration completed
- Duty cycle testing
- Commercialisation of technology – E-STOR

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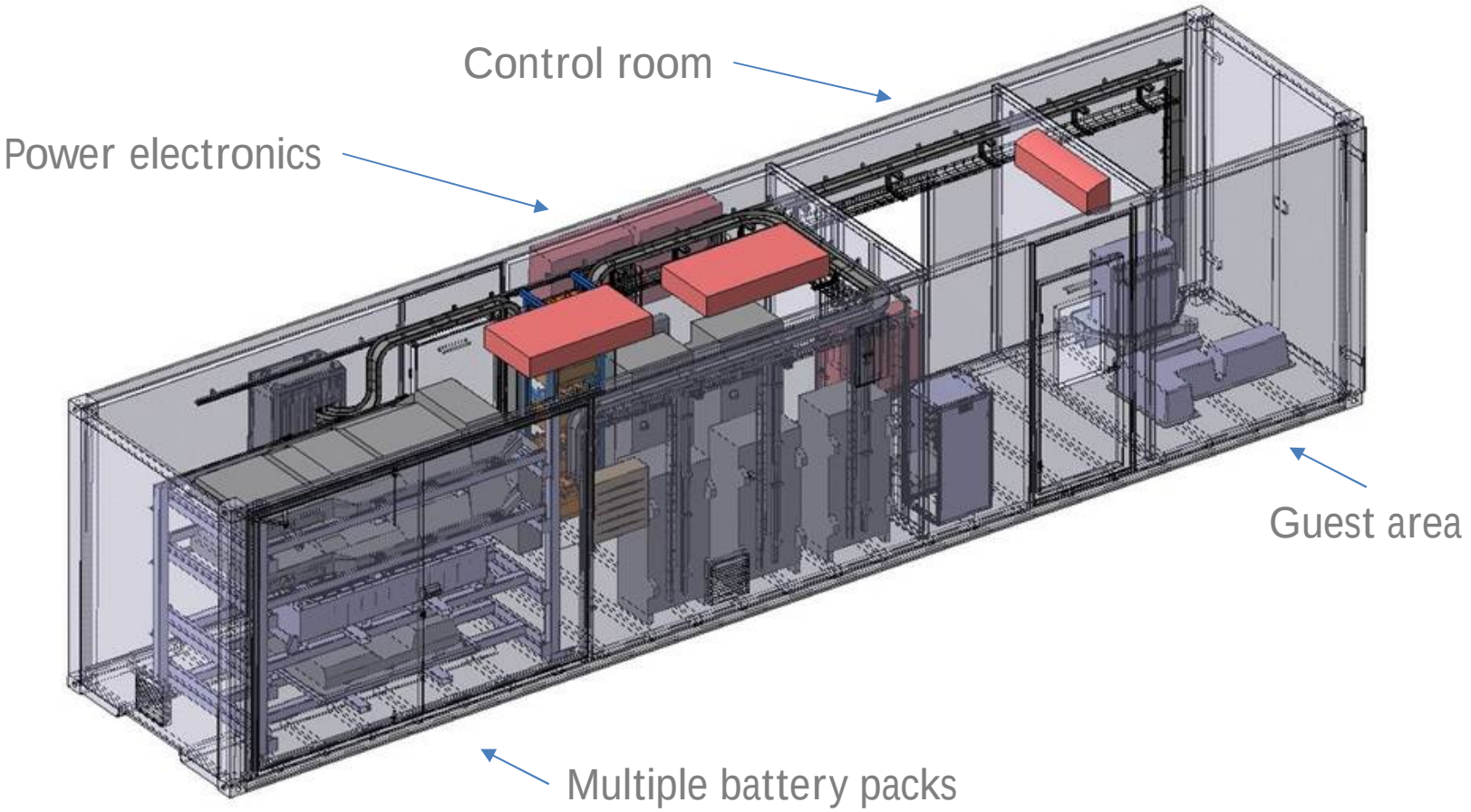
EVEREST R&D facility



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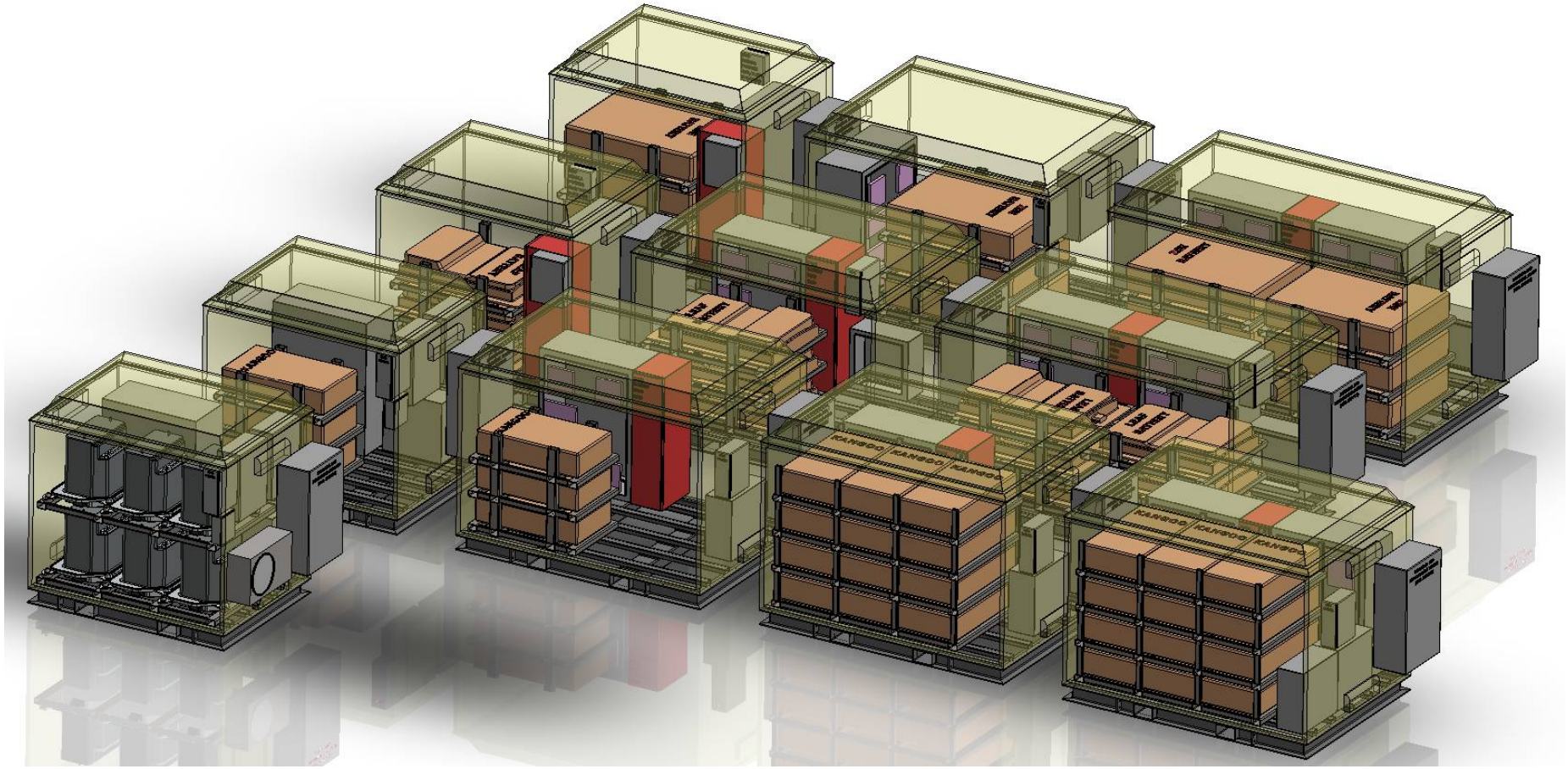
E-STOR Platform



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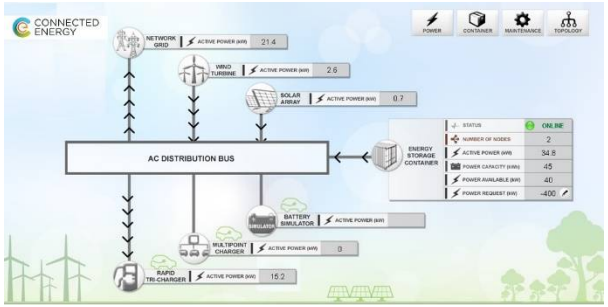
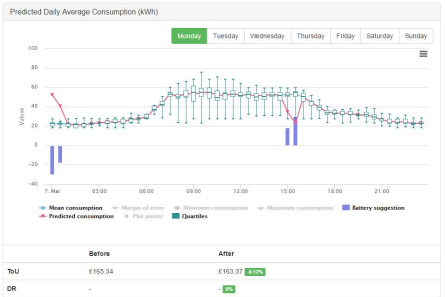
Product & service concept

- **E-STOR**
  - Scalable, modular ‘plug & play’ unit
  - Any EV battery subject to CAN programming and repackaging
  - General and niche application units
  - Minimise size & cost
- **Operating software**
  - EV rapid charger integration via OCPP
  - Scheduled and real time response
  - Site load, PV, EV charging optimisation
  - Optimised and aggregated charging
  - Managed EV charging
- **Procurement**
  - Capital purchase with finance options
  - Storage as a service





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R&D and commercial challenges

The storage sector is new – storage needs to be segmented

Distributed storage is new – its not yet straight forward, particularly I&C

The reuse of 2nd life batteries is new – industry is not set up for this

The reuse of 2nd life batteries in static applications is new – value optimisation will evolve

Storage related power electronics will evolve – need to understand trajectory

The market and regulatory environment is evolving – business models will evolve

The operation of distributed storage is new – effective operation requires knowledge of the above

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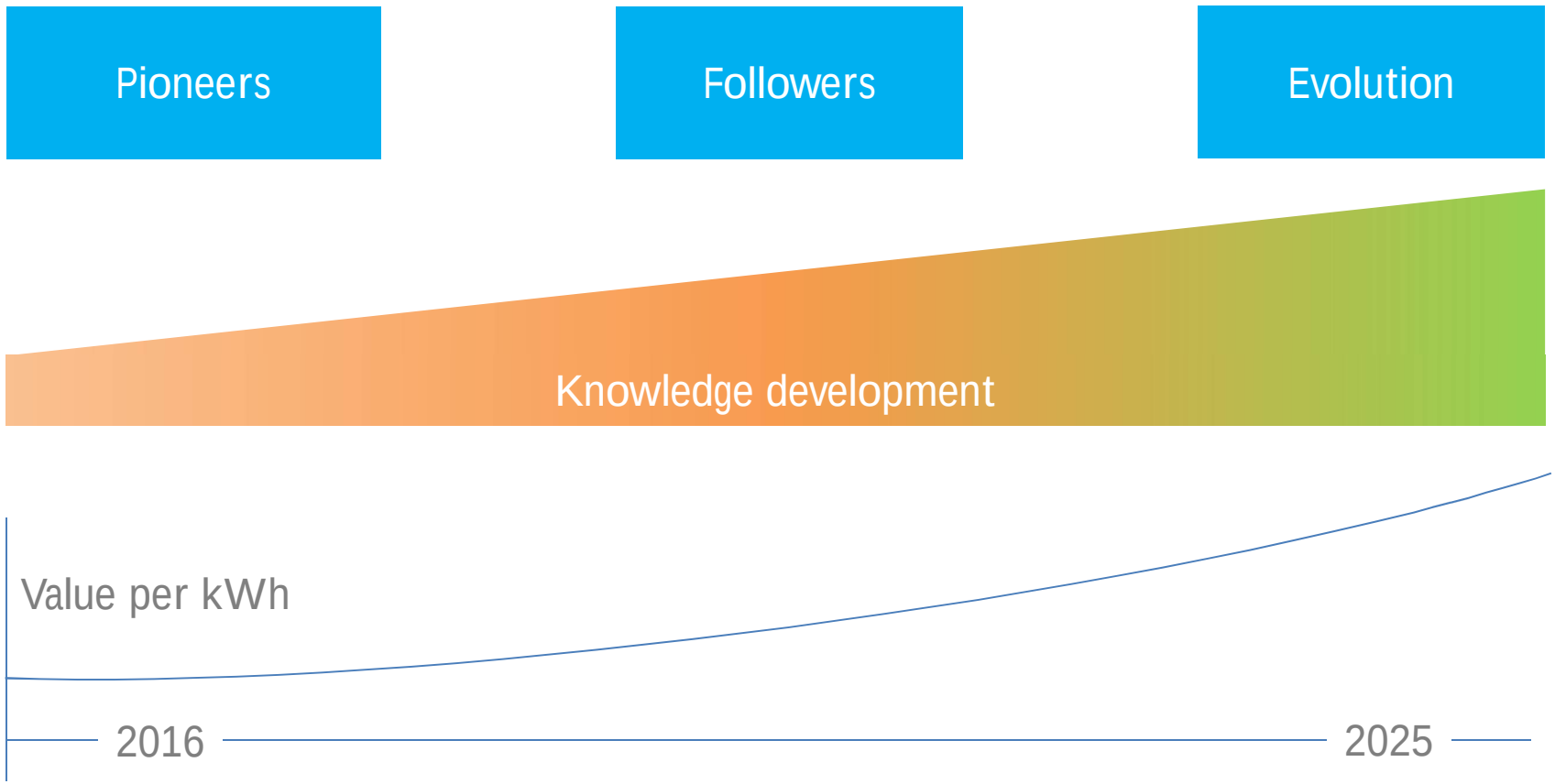
Solution development over time



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Knowledge gaps & research needs

- **Performance & degradation:**
  - Large scale, long term & independent 2nd life battery degradation testing project:
    - SoH
    - Duty cycles
    - Classification
    - Basis for control software development

- **Optimised power electronics:**
  - Current technology suitability assessment and future trends/direction:
    - Disruptive technologies on the way – when, cost and network acceptance?
    - Cost effective bi-directional battery charging systems for EV battery voltage range

- **Operating software:**
  - Development of complex models and algorithms to enable full asset(s) optimisation:
    - Balancing market opportunities with technology characteristics
    - Multi-stakeholder/customer satisfaction

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Thank you

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