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Challenges and Solutions to EU Battery Passport Regulation Compliance for Asian Economic Operators

- Regulatory, Architectural, and Cybersecurity Requirements for Digital Battery Passport Implementation -

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This paper examines the regulatory, architectural, and cybersecurity challenges confronting Asian economic operators in achieving compliance with the EU Digital Battery Passport (DBP) mandate under Regulation (EU) 2023/1542. The regulation requires that every industrial battery above 2 kWh, as well as all EV and light means of transport batteries placed on the European market from February 2027, must carry an interoperable electronic record encompassing both static supply chain data (material provenance, recycled content, product carbon footprint) and dynamic operational telemetry (State of Health, State of Charge, extreme event logging).

The paper identifies asymmetric compliance burdens across three major Asian markets. Chinese manufacturers, producing over 75% of global batteries, face challenges with Scope 3 carbon footprint disclosures from fragmented upstream suppliers and conflicting cross-border data transfer restrictions under PIPL and DSL, with no EU–China data adequacy framework in place. South Korean operators, heavily reliant on Chinese upstream materials (over 96% of precursor cathode materials), cannot finalize EU-mandated carbon footprint declarations without verified supplier data, and have launched a "K-Battery Passport" initiative. Japan has adopted a proactive government-led approach through METI's Ouranos Ecosystem, a cross-industry data-sharing infrastructure aimed at achieving Data Free Flow with Trust (DFFT).

To manage complex data requirements across international jurisdictions, the paper advocates for federated, decentralized data space architectures based on the IDS Reference Architecture Model (IDS-RAM), as implemented by Catena-X. These architectures enable organizations to retain control over proprietary datasets while sharing data through standardized connector nodes governed by machine-readable usage contracts. Semantic interoperability is achieved through the Asset Administration Shell (AAS) methodology (IEC 63278-1:2023), with seven AAS submodels developed specifically for the DBP. A successful Proof of Concept between Japan's IPA and Catena-X demonstrated bidirectional PCF data exchange across independent regional architectures.

For dynamic data synchronization, the paper compares MQTT and REST API telemetry protocols, concluding that MQTT's asynchronous publish-subscribe architecture is more suitable for fleet-scale deployment due to superior bandwidth efficiency and lower energy consumption. At the hardware level, the integration of dedicated Secure Elements (e.g., NXP NCJ37x cryptographic chips) on the Battery Management Unit provides hardware-based cryptographic signing, tamper-resistant local storage of passport parameters, and offline verification via NFC. The paper also addresses the need for standardized SoH estimation algorithms, proposing a hybrid edge/cloud computation model where local BMS performs high-frequency measurements and cloud infrastructure handles long-term historical analysis.

A two-phased implementation strategy is proposed: a Minimum Viable Product (MVP) for rapid 2027 compliance using basic data pipelines and static empirical algorithms, followed by evolution into a Smart Battery Passport (SBP) that transforms the regulatory requirement into a monetizable diagnostic service platform with predictive analytics and lifecycle management services. Findings from the GTD-E and SeBaPaD pilot projects at TNO validated the hybrid edge/cloud architecture and demonstrated end-to-end cryptographic data protection. The paper recommends that Asian operators adopt standardized open-source data exchange protocols, leverage federated networks such as Catena-X and Ouranos, and champion trust frameworks to ensure continued European market access while supporting the global transition toward a circular battery economy.

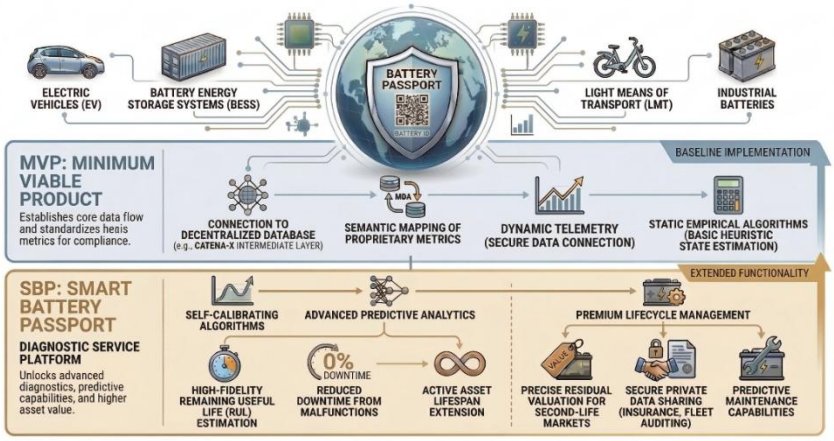

Fig.1 Battery Passport implementation from MVP to SBP.