Connecting the digital thread across EV battery manufacturing

With AVEVA and Schneider Electric's Industrial Intelligent Platform

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A market in transition

State of the market

The Electric Vehicle Battery Manufacturing (EVBM) industry is navigating a critical transition. To date, manufacturing organizations have geared their business and operating models to optimize for production throughput, and capture market share as quickly as possible, and for a good reason. While EVs account for only **15%** of today's global passenger car sales emerging and converging research across key regions including the US, Europe, and Asia Pacific, estimates that we on track for EVs to represent approximately **60%** of passenger vehicle sales worldwide by the year 2030.

To meet the forecasted growth in demand, the EV battery market will require a steep ramp up of battery pack production. EV battery manufacturers will need more lithium, cobalt and many other materials than have historically been produced in such large quantities. They must also adopt battery manufacturing practices that optimize resource consumption, minimize waste, and support sustainable operations.

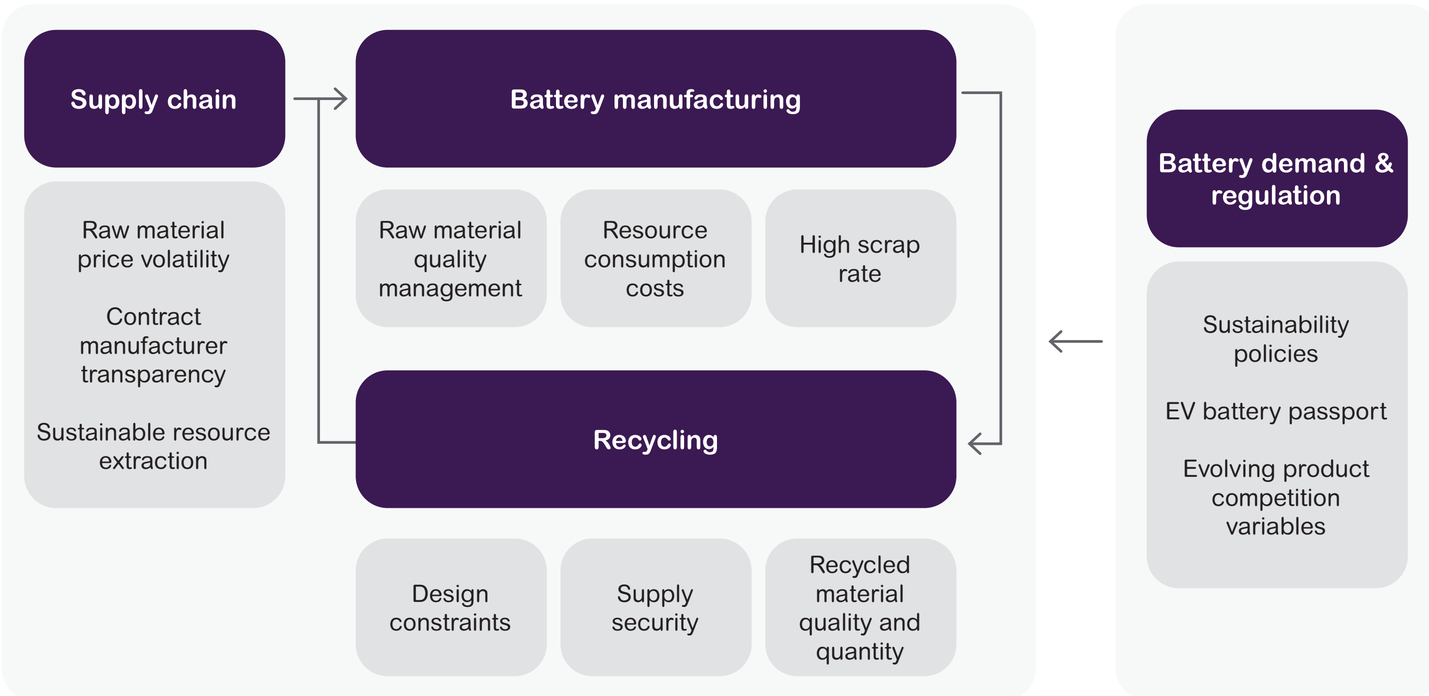
Compounding 'growth pain'

For EV battery manufacturing companies, ramping up production and creating economies of scale has, to date, created hidden costs. Commissioning gigafactories rapidly at scale creates hidden 'value leaks', enabled and fostered by the **inhibition of meaningful feedback loops** within the factory and across the value chain.

Within the factory, battery scrap rates are ranging between 6% and 15%, and typically identified late within the battery aging process. The cost of delay between identifying batches of inadequate quality batteries and adjusting production variable parameters can be significant. Challenges understanding which production variables are most critical (coating density, electrode separation, cutting speed, folding variations, electrode deposition etc.), how they should be adjusted, and under which circumstances, also contributes to avoidable resource overconsumption.

Across the full value chain, input material quality variability impacts manufacturing parameters, lack of commodity differentiation, and volatility in supply chain resilience. Impacts from managing a moving target of process variables and supply scheduling starts at manufacturing quality volatility and spans to demand fulfillment challenges. In addition, securing a sufficient quantity and quality of recycled materials is another challenge that manufacturers must consider.

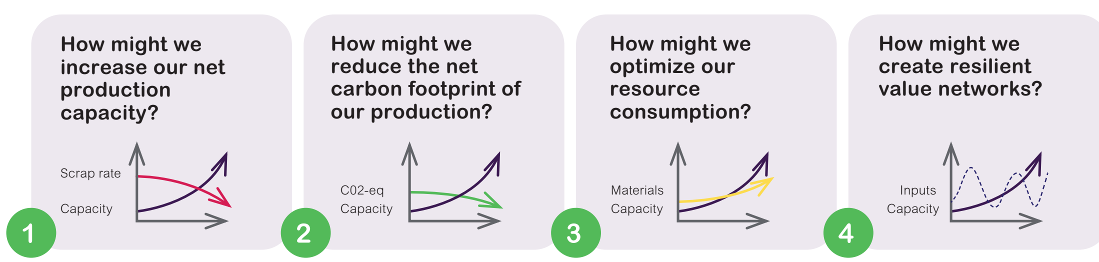
Global regulatory bodies are enforcing sustainability focused initiatives, including the EU's framework for the ecodesign of sustainable products. The design of a battery passport pioneered by the Global Battery Alliance is underway, whereby EV batteries are to be accompanied by a digital file, including the battery's carbon footprint, supply chain due diligence, materials and composition, circularity and resource efficiency, performance and durability. China launched the Chinese digital battery passport initiative following the same philosophy.



Strategic framing

Articulating the path forward

EV Battery Manufacturing organizations are asking key questions to optimize within the factory and across the value network, while simultaneously preparing for battery manufacturing sustainability to become a product feature, and differentiator via the battery passport regulation.



Continuing to drive an increase in production capacity to meet demand and maintain upward pressure on market share, while eroding the performance and quality debt accumulated through rapid multi-site production growth requires deliberate, coordinated action. Ensuring that the chosen approach and associated initiatives contribute passively to adjacent and sequential strategic priorities can 'grease the wheels' of organizational change. Examples of principles from consideration based on our experience are below.

Enabling innovation at the edge
32% of Chief Transformation Officers believe they have the agility to make decisions with sufficient speed.

Laying the AI data foundation
Harmonizing and contextualizing data and breaking down silos between systems enabling AI to unlock potentially transformative uses.

Delivering contextual insight experiences
95% of executives believe that future digital platforms need to offer *unified* experiences.

Modular, simplified architecture
Mitigate bespoke integration points and drive application agility to mitigate technical debt.

Cross-value chain communication
Prioritize hardware and software agnostic solutions to mitigate the cost of technology ringfencing.

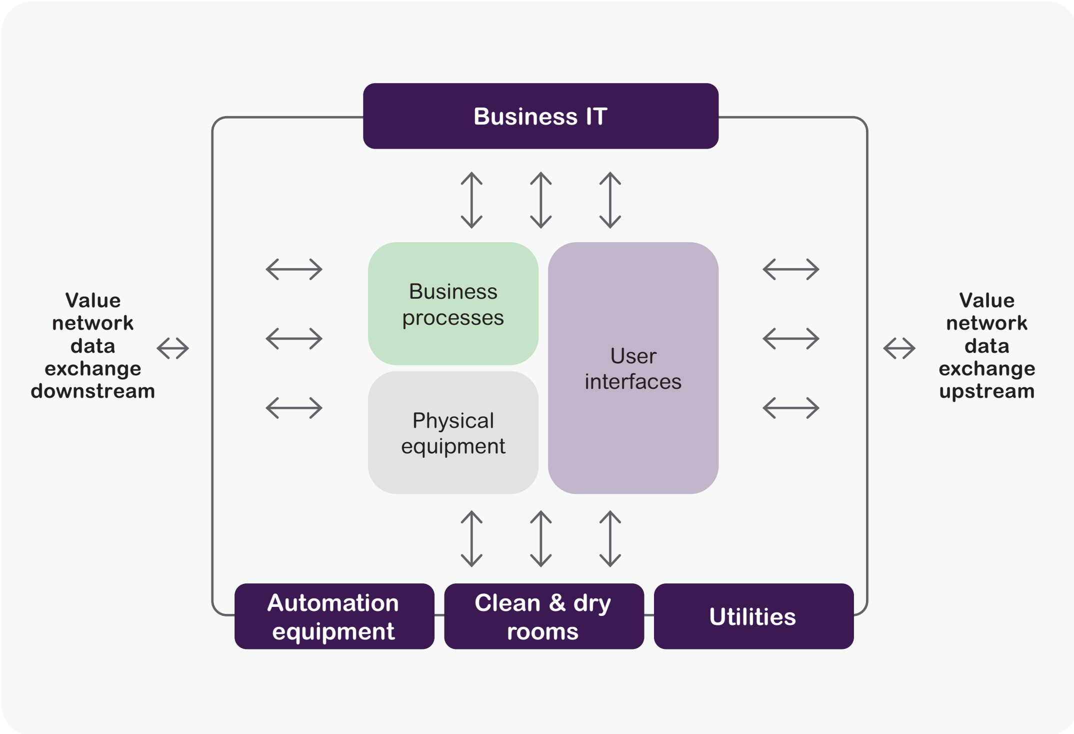
Cross-site scalability
Ensure the 'digital thread' can extend to all corners of manufacturing, with models scalable across greenfield and brownfield sites.

The pace of change across the engineering technology and operational technology landscape is rapid and has created new opportunities for EV battery manufacturing organizations to synthesize a digital thread across the value network, feeding and contextualizing asset and process digital twins to operate with agility and efficiency.

Generating and leveraging data across the manufacturing process and value chain can form a fit-for-purpose digital thread, which forms the basis of digital transformation. An effective digital thread provides the foundation for manufacturing execution and cross-value chain visibility, control, optimization, and collaboration – and the ability to address the four key challenges framed previously.

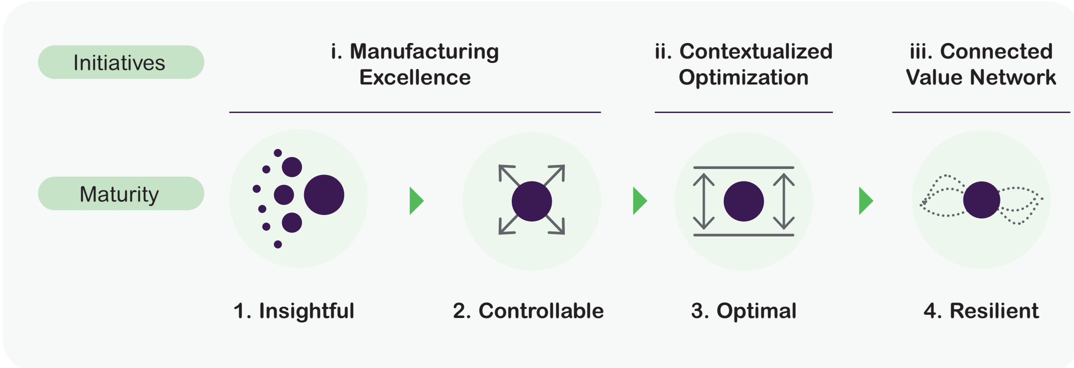
Data collected from production line sensors is integrated into a common framework for data storage, processing, and management. **This data is primarily leveraged across two types of models, asset models and process models – which together in shared context form the digital thread.**

Asset models provide representation of factory equipment and machinery, including mechanical and electrical models. Key use-cases typically include overall equipment effectiveness (utilization, uptime, yield), condition based and predictive maintenance, energy consumption, and emission management. **Process models** describe sections of the battery manufacturing process, including all relevant variables requiring optimization to produce the appropriate quality product, and associated flows describing the creation of products.



Real-time data from operational technology (from the factory floor), engineering technology (3D models and associated data) and information technology (from business systems) converge to generate insights that inform key business capabilities and complex decision making across business units. The effective connection and contextualization of data to form insights, managing critical asset and process variable parameters, optimizing based on internal factors, and ultimately external factors, are the requirements necessary to respond to the conditions facing EV battery manufacturing organizations today.

Progressing towards a fit-for-purpose digitally enabled manufacturing solution involves transitioning across the maturity levels below. Initiatives relating to each maturity level are noted respectively and form the focus of the following topics.



Manufacturing Excellence

Decoupling process and parameter inconsistency, and manufacturing scale

Giga-scale EV battery production has been effective at reducing production cost and capturing market share – at the expense of operational variability and divergence while scaling.

A combination of logistical challenges in moving materials, analogue decision making, manual bottlenecks in planning and scheduling, and limited factory communication infrastructure has impeded decision making and manufacturing management. The 'cost of delay' between production and quality issues (often impacting energy density and cycle life parameters) being identified, and rectified can be amplified through scaling.

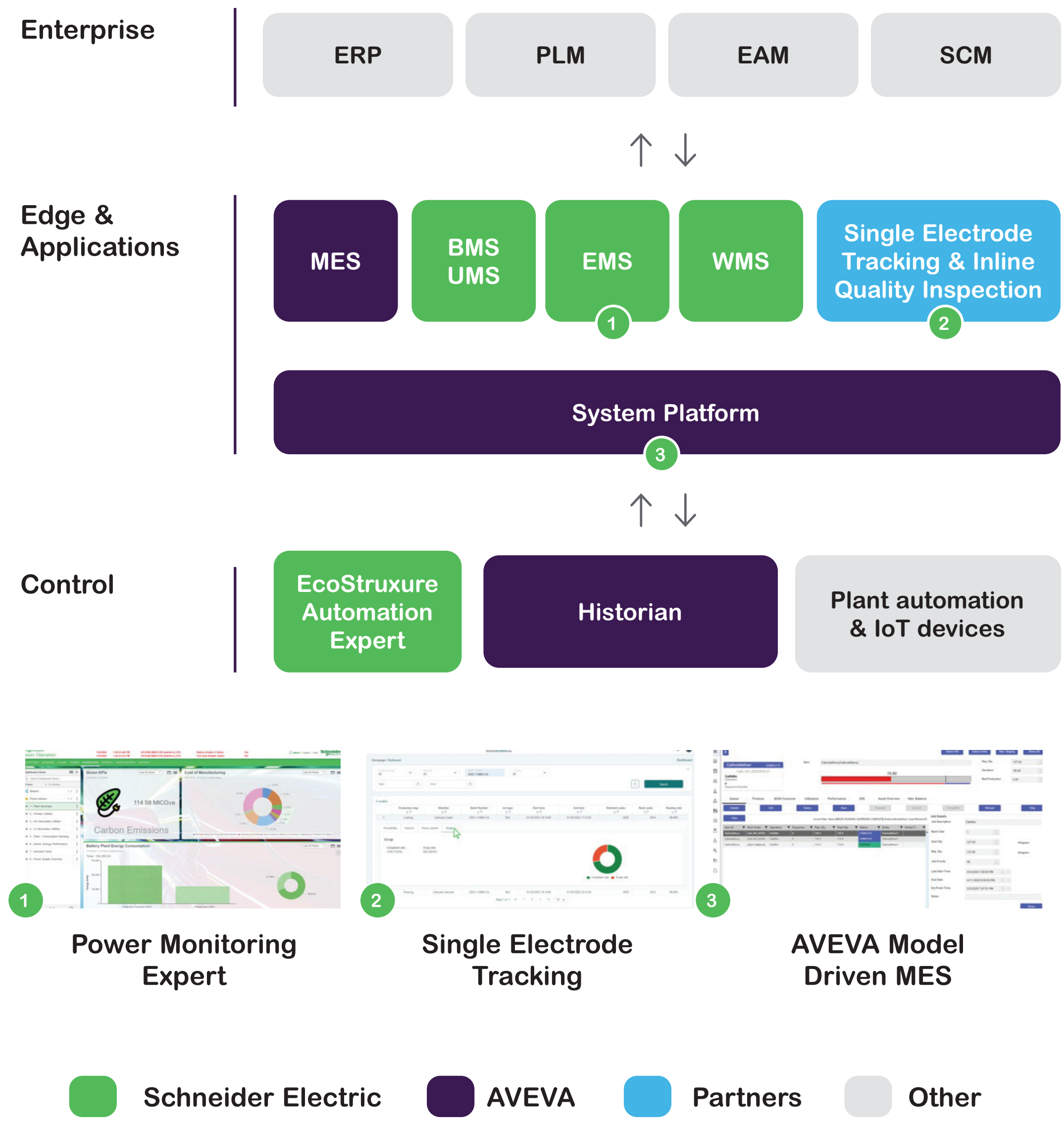
Model driven manufacturing execution system capabilities enable standardization and scalability across quality management, throughput, asset performance, inventory, planning and scheduling – and track and trace.

In parallel, leveraging a 'system of systems' approach and combining data across the ecosystem, including dispatching and logistics systems, energy (via an Energy Management System, EMS), utilities (via a Utilities Management System, UMS, for electrolyte, compressor, and vacuum management), building systems (via a Building Management System, BMS, for humidity, particles, and pressure management), and a warehouse management system (WMS) is paramount to building a contextualized and orchestrated system, ensuring a consistent business outcome.

Capability intent

Enterprise	Source of truth and master interface for order requirements
Edge & Applications	Dynamically bridging the gap between an order being submitted at the enterprise layer, and the control/automation layer executing the order to achieve manufacturing and sustainability KPIs, in a standardized and scalable way.
Control	Agnostic control and automation, integrated with the MES layer

AVEVA and Schneider Electric portfolio overlay



Business case considerations

What is the accuracy of quality tracking, and what is the impact of quality tracking on scrap rate, and staff productivity?

What is the accuracy of OEE for critical equipment, and what is the impact of OEE tracking and reporting on staff productivity?

What is the cost of measuring and reporting the energy consumption of equipment?

How are production losses accounted for, and how are insights leveraged to reduce wastage?

What is the cost of maintaining desired inventory levels, and when deviation occurs, what is the operational impact?

What is the productivity impact of planning and scheduling, and what is the benefit of improving On-Time-In-Full (OTIF) orders?

What is the opportunity cost of siloed asset performance, quality management, and operations management models between sites?

What is the cost (across scrap rate, energy consumption, and throughput) of limited standardization and consistency when scaling?

Contextualized optimization

Optimizing the manufacturing process, with cross-system context.

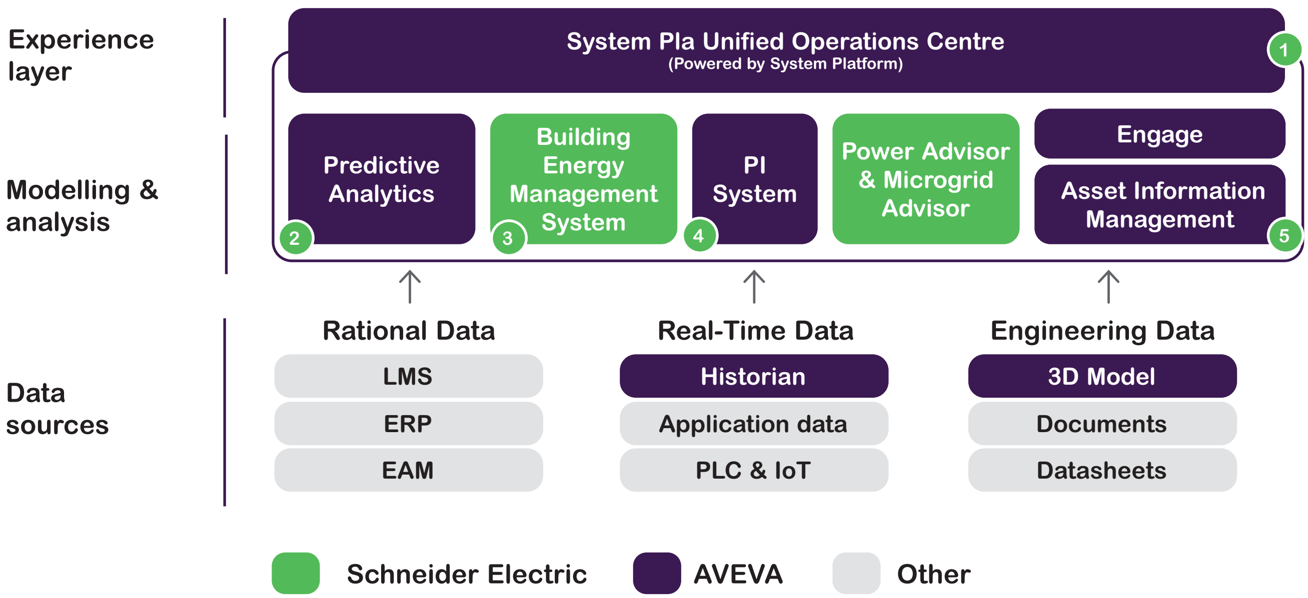
Fragmented manufacturing optimization solutions, typically originating due to rapid production growth, often requires bespoke integration and/or manual effort by staff. Examples include leveraging real-time production data for process simulation and asset performance predictive analytics, and linking insights with the context necessary for resulting asset maintenance activities.

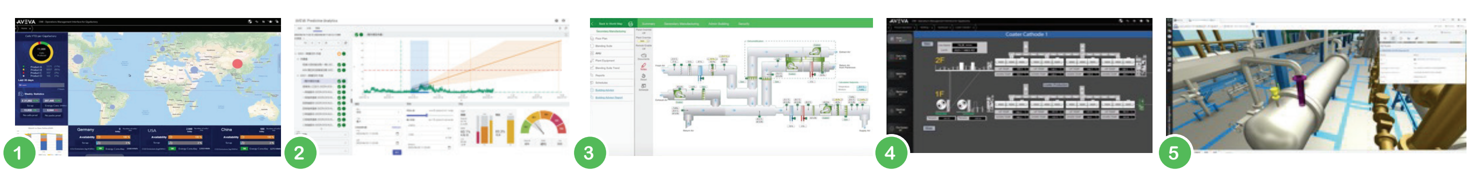
Ensuring that asset knowledge and production context, relating to both within and between operations and engineering data, is retained throughout the stages which inform decision making de-risks and promotes effective optimization and action.

Capability intent

Experience layer	Ability to display asset and process centric information across applications dynamically, for cross functional decision making.
Modelling & analysis	Applications with knowledge (such as asset hierarchies, calculations, and standards) built in for business users to rely upon, all connected by a common information standard.
Data sources	Relational data, real-time data, and engineering data, including 3D models of the facility, and plant.

AVEVA and Schneider Electric portfolio overlay





Business case considerations

- What is the total cost of delay from manufacturing issue identification through to triage, solution identification, and actioning?
- How can additional return on investment be measured by connecting engineering and operations data context with existing applications?
- What is the benefit of an operator adopting a ‘business’ driven approach, as opposed to ‘process’ driven?
- What are the hidden costs of optimizing one dimension of a production line, without visibility of the impact across other KPIs?
- How much time is spent searching for real-time operations or engineering digital twin data across the organization?
- How might predictive energy consumption forecasts based on asset health, throughput and performance influence decarbonization initiatives?
- What is the reduction in line downtime resulting from predictive plant condition insights and automatically generated prescriptive maintenance activities?
- How can you empower the operator by having an agnostic and system of systems approach?

Connected Value Network

Continuous digital thread across the value network with AI optimization

Key variables impacting throughput, cost and quality are often out of reach – either existing outside the walls of the organization in the value network or hidden in the veracity and volume of collected manufacturing data (in particular where sensitive parameters within mixing, calendaring, and laser cutting are involved).

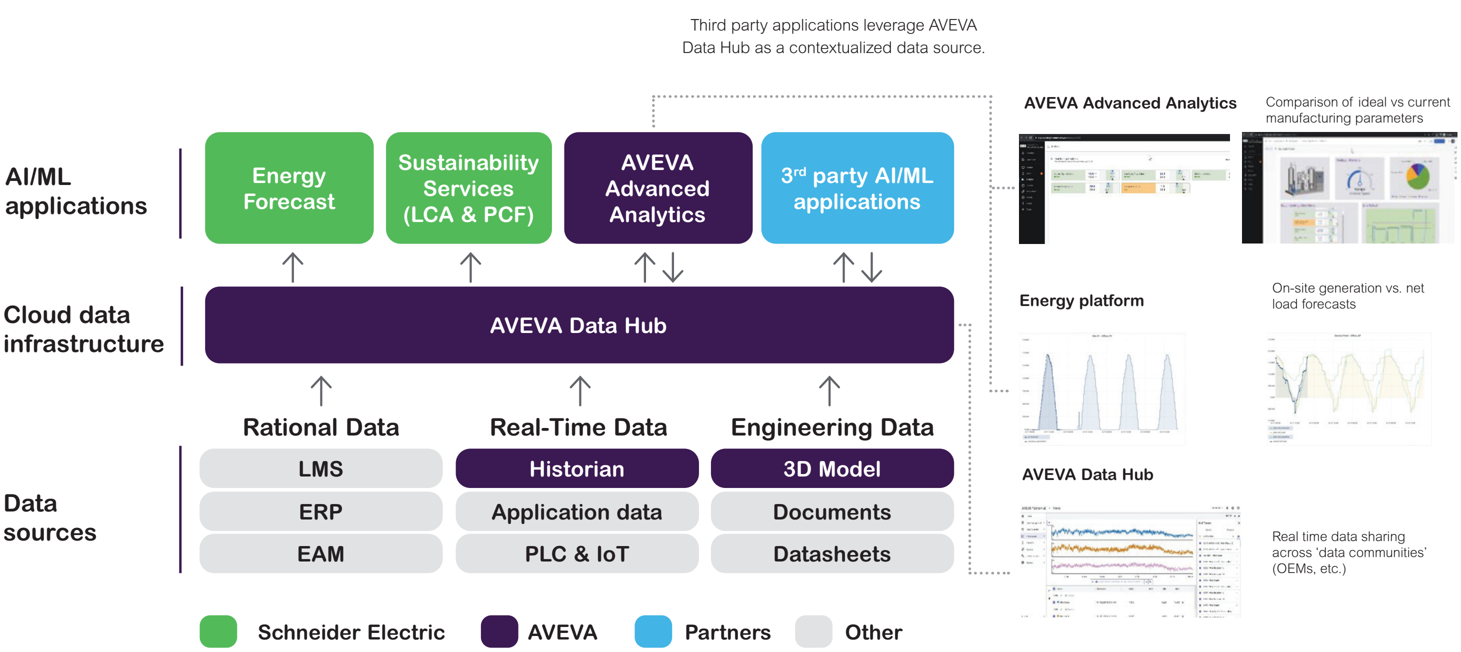
Autonomous manufacturing environments with continuous physical/digital data exchange, within and outside the enterprise, with intelligent parametric adaptation in response to forecast variable changes are currently considered the 'North Star' in Industry 4.0. Striving for the North Star has resulted in significant throughput, quality, and cost benefits for many manufacturing organizations – and this is predicted to amplify.

Upcoming changes to the legislative landscape, including the EU Battery Passport, require value network level sustainability insights per battery that are forecast to create competitive advantages for manufacturing organizations which provide competitive carbon economy metrics, spanning from raw materials through to battery packs.

Capability intent

AI/ML applications	Applications which leverage real-time data for AI/ML use-cases, whilst writing back to data infrastructure for shared insight leverage.
Cloud data infrastructure	Real-time and relational data infrastructure with asset context for cloud-based analytics and AI/ML applications from 3rd party providers, within the organization, and securely across the value network (external organizations).
Data sources	Relational data, real-time data, and engineering data, including 3D models of the facility, and plant.

AVEVA and Schneider Electric portfolio overlay



Business case considerations

- What are the optimal manufacturing production parameters to balance cost, throughput, quality, and carbon footprint, within and outside of the factory?
- Which factors (including raw material supply, site specific, and utility parameters) influence battery carbon footprint?
- How might complex cost, quality, throughput, and sustainability drivers be distilled when analyzing and innovating manufacturing approaches?
- How can I improve my energy procurement by leveraging advanced energy forecasting and control of Distributed Energy Resources?
- How do AI/ML insights deteriorate in value when lacking context, and including only within the factory walls?
- What is the benefit of sharing real-time data across divisions, equipment OEMs, component suppliers, and maintenance service providers?
- How might insights into plant performance variables inform availability contracts, maintenance services, and warranty obligations with OEMs?
- How can I move towards a circular value network by leveraging recycled materials?

Proposed path forward

EV battery manufacturing organizations globally are on a journey, transitioning from converting data to insights, driving automation, optimization, and connecting the digital thread across their value chain.

Engage and partner with Schneider Electric and AVEVA to understand the value that we can create for your organization across all stages of your facility lifecycle, manufacturing ramp-up, and digital maturity.