

# INTEGRATED ENERGY SYSTEM DESIGN: CO-OPTIMIZATION FOR GRID-FRIENDLY COMMUNITIES AND INDUSTRIAL SITES

Andreas BRAUN<sup>1</sup>, Paul SCHIFFBAENKER<sup>2</sup>, Richard SCHAUPERL<sup>3</sup>, Erik LUZNIK<sup>4</sup>, Bernhard STOECKL<sup>5</sup>

## Abstract

Fluctuating renewable generation and rising electrification are challenging today's energy technology and business models: grid stability becomes harder to guarantee, while investors and operators struggle to predict revenues and risks. At the same time, innovative concepts such as energy communities, fleet depots, or industrial campuses are hard to realize as their business models require complex decisions on sizing and operation of interconnected assets such as PV, storage, electrolysis, or bidirectional charging. Current practice often treats these elements in isolation – ignoring dynamic interrelations that are critical for resilience and profitability. Lifecycle aspects such as service and replacement planning further complicate total cost of ownership (TCO) calculations.

Our contribution closes this gap with a systematic approach: first, integrated energy systems of production and consumption are modeled in all relevant aspects, enabling decision-grade simulation. This foundation supports multi-objective optimization for KPIs such as TCO, LCOE, CO<sub>2</sub>, and grid-friendliness. Technologically, the method ensures right-sizing and optimal operational strategies by virtually interconnecting generation, storage, grid interfaces, and charging under realistic conditions – hourly resolution, weather and tariff data, day-ahead forecasts, and uncertainty quantification. Grid-integration constraints and flexibility requirements can be embedded early in the system specification and configuration process, ensuring technical feasibility and resilient profitability – just when investors need this confidence.

From a business perspective, the approach delivers procurement-ready layouts, trustworthy KPI corridors, and staged development paths for municipalities, utilities, and industrial operators. For investors and funding authorities, it provides transparency on risk bands and flexibility value, improving bankability and accelerating approvals. In our presentation we demonstrate cost and carbon reduction while enhancing grid friendliness for three use-case archetypes: energy communities, fleet depots, and industrial campuses. Modular delivery paths (consulting and software) enable easy entry, quick decisions, and scalable roll-outs from pilots to portfolios. Our contribution establishes a common decision framework for all stakeholders – technical planners, business strategists, and investors – creating a shared basis for resilient, scalable energy projects.

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<sup>1</sup> AVL List GmbH, Österreich

<sup>2</sup> AVL Deutschland GmbH