What are the EMS control algorithm published by main stream EMS supplier on sizing of BESS and PV with respect to on-site energy consumption at the design stage

This is a rich and technically nuanced topic. Here's a structured breakdown of the EMS control algorithms and sizing methodologies published or used by mainstream EMS suppliers for co-sizing BESS and PV relative to on-site energy consumption at the design stage.

Algorithmic Frameworks for PV+BESS Sizing

At the design stage, EMS vendors and researchers broadly use three algorithmic families to size BESS and PV in relation to on-site load profiles:

Rule-Based (RB) EMS Algorithms

The simplest and most commercially prevalent approach uses **threshold-based control rules** — predefined SOC bands, demand thresholds, and charge/discharge triggers. In these systems, the PV generation profile and load consumption data are used to derive the optimal threshold (e.g., peak demand target in kW), and BESS size is iterated until the threshold can be consistently maintained. Vendors like **Wattstor** and **Nor-Cal Controls** use SCADA-grade rule-based load shifting for C&I peak shaving. The limitation is they do not adaptively respond to price signals or forecast uncertainty.[1] [2] [3]

Optimization-Based Algorithms

For more rigorous co-sizing, **Mixed-Integer Linear Programming (MILP)** is the most widely adopted method among commercial and academic EMS developers. A **two-layer MILP framework** — published by Brunel University researchers — uses the following structure:[4]

- **Layer 1 (sizing):** Minimizes microgrid operation cost AND maximizes on-site PV self-consumption simultaneously, subject to BESS charge/discharge constraints, to derive the initial BESS capacity[4]
- **Layer 2 (validation):** Uses **Differential Evolution (DE)** heuristic algorithm to refine BESS size against system-level constraints including Virtual Energy Storage System (VESS) participation in demand response[4]

This two-layer approach is notable because it directly uses on-site load consumption and PV generation time-series as input — precisely the design-stage data you'd have from a load audit.

Genetic Algorithm (GA) and Heuristic Methods

Genetic Algorithms (GA) and **Firefly Algorithms** are well-published for sizing BESS in multi-site or multi-objective problems. A notable IEEE/DataCellar paper proposes a **two-level GA-based optimal sizing** framework:[5] [2] [6]

- **Upper level:** GA iterates PV array size and BESS energy/power capacity
- **Lower level:** Rule-based EMS simulates system operation over a full year of on-site consumption data, returning self-consumption rate, peak shaving performance, and LCOE as fitness function inputs

Stem's Athena AI platform (prominent in CAISO/ERCOT markets) uses ML-driven forecasting within optimization loops for revenue stacking, though specific sizing algorithms are proprietary.[3]

Key Sizing Criteria Used at Design Stage

The OSMOSE H2020 project (EU-funded) published a methodology framework for application-specific BESS design that defines the following performance indicators used as optimization targets:[7]

Criterion	Relevance to On-Site Consumption
Self-Consumption Rate (SCR)	% of PV generation consumed on-site
Self-Sufficiency Rate (SSR)	% of load demand met by PV+BESS
Peak Demand Reduction	Reduction of grid import peak (kW)
LCOE / NPV	Economic viability of the sized system
Loss of Power Supply Probability (LPSP)	Reliability metric for islanded/critical loads

Mainstream EMS Vendor Approaches

Vendor	Algorithm Type	Primary Sizing Use Case
Siemens (Xcelerator)	Optimization + DERMS	Utility/C&I, grid compliance [3]
Schneider Electric (EcoStruxure)	Rule-based + MPC	Building & industrial self-consumption
Eaton	Rule-based + EMS logic	PV self-consumption, surplus injection control [8]
Stem (Athena AI)	ML + stochastic optimization	Revenue stacking, ISO market optimization [3]
Fractal EMS	Rule-based + on-prem cloud	PV+Storage, CIP-compliant utility sites [3]
Elum Energy	Rule-based + deep logging	Hybrid PV/diesel/BESS microgrids [3]
Energy Toolbase (Acumen EMS)	Threshold + dispatch optimization	Demand charge management, DC clipping recapture [9]

Most major OEM vendors (Schneider, ABB, Siemens) do **not** publicly release their exact sizing algorithms — these are embedded in proprietary tools like **Schneider EcoDesign Tool**, **ABB Ability EMS**, and **Siemens SICAM**. Academic publications using MILP and GA are the most transparent and replicable references available.[5] [4]

Design-Stage Input Data Requirements

Regardless of algorithm, all published frameworks require the following on-site data as inputs:[10] [1] [4]

- **15-min or hourly load consumption profile** (at least 1 year)
- **PV generation profile** (simulated via irradiance data or measured)
- **Electricity tariff structure** (TOU, demand charges)
- **Target metric** (SCR, peak reduction %, NPV, or LCOE)
- **BESS chemistry constraints** (DoD, cycle life, round-trip efficiency)

The **deterministic simulation method** (simulate → evaluate KPI → resize → iterate) is the most common design-stage approach for C&I projects, while stochastic methods are used when load or solar uncertainty is high.[7]

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