Why Execution Determines VPP Maturity, Grid Trust, and Revenue

Building on the VPP Maturity Model introduced by EnergyHub

CONTENTS

IN THIS WHITE PAPER, YOU'LL LEARN:

- Why many VPPs underperform and are discounted despite strong forecasting and market access
- How VPP maturity has become a pricing and planning mechanism for utilities and grid operators
- Why scheduling capacity is not the same as operating a power plant in real time
- Why many DER-based VPPs cannot be treated as firm capacity or included in integrated resource plans (IRPs)
- Where OEM-led, firmware-first approaches break down for dynamic, grid-integrated control
- How execution-grade architectures enable VPPs to perform, earn, and scale like dependable grid resources

EXECUTIVE SUMMARY

Virtual Power Plants are widely viewed as one of the fastest and most cost-effective ways to add flexible capacity to the grid. Yet despite rapid growth in participation, most VPPs materially underperform their modeled potential.

Across markets, VPP portfolios often operate at approximately 50 percent of their modeled capability, driven by missed dispatches, partial participation, device coordination failures, and recovery effects. On top of that, grid operators routinely discount the value of VPP capacity because reliability, telemetry, and availability cannot be trusted at scale. When combined, these effects compound: assets earn less than they should and are paid less for what they do deliver.

At the same time, advances in forecasting and optimization intelligence are dramatically increasing the grid's ability to identify value. The grid increasingly knows what should be done and when. What remains missing is the ability to execute those decisions reliably at the device level.

This paper builds on the VPP Maturity Model introduced by EnergyHub and argues that reaching higher maturity levels, and therefore higher grid impact and revenue, requires an embedded execution layer that decouples intelligence from control while preserving OEM safety, certification, and device integrity.

This shift is also unfolding on an accelerated timeline. Grid operators are moving rapidly from pilot programs to enforceable performance requirements, and flexibility is becoming a resource that must be qualified, verified, and delivered with increasing rigor. For OEMs, becoming an eligible grid-integrated resource involves contractual frameworks, telemetry validation, and operational proving periods that take time to complete, often longer than anticipated. With 2026 now underway and grid flexibility expectations accelerating, OEMs that delay building execution-ready capability risk falling behind, even if their hardware is technically capable. The window to prepare is narrowing, and the decisions made now will determine who is positioned to lead as flexibility markets mature.

The VPP Maturity Model: Why Maturity Determines Grid Impact and Revenue

The EnergyHub VPP Maturity Model, introduced in EnergyHub's white paper Building Trustworthy Virtual Power Plants provides a clear, operator-centric framework for evaluating whether a VPP can be trusted as a grid resource.

In recent industry discussions, including EnergyHub's leadership commentary on VPP maturity, the gap between scheduling participation and operational performance has become increasingly explicit.

> **At its core is the Huels Test:** *If a grid operator cannot distinguish a VPP from a conventional power plant in operation, should it be treated as one?*

As VPPs progress through higher maturity levels, particularly Level 3 and Level 4, they demonstrate capabilities that directly affect grid confidence and economic value:

- Multi-hour, shaped dispatch instead of short, fixed events
- Multi-season or year-round availability
- Fast, accurate telemetry suitable for operational use
- Predictable adherence to schedules and real-time signals
- Increasing autonomy and reduced reliance on manual intervention

These capabilities are not theoretical. They determine which programs a VPP can participate in, how much capacity credit it receives, and how heavily its performance is discounted by planners and operators.

In short, maturity is not just a technical benchmark. It is a pricing mechanism.

As a result, many utilities are unable to include DER-based VPPs as firm capacity in integrated resource plans, not because the assets lack potential, but because their performance cannot yet be scheduled, verified, and relied on like conventional generation.

The Double Economic Penalty Facing VPPs Today

Most discussions of VPP underperformance focus on discounting by grid operators. That is only half the story.

In practice, many portfolios suffer from two simultaneous economic penalties:

1. **Underperformance vs. model:** Many VPPs operate at roughly 50 percent of expected capability due to coordination gaps, device availability issues, and non-deterministic control.
2. **Grid discounting:** Inconsistent availability, delayed telemetry, and uncertain response lead planners to derate VPP capacity relative to conventional resources.

Together, these effects are multiplicative:

- Modeled value is not realized
- Delivered value is discounted

This is why so much DER value remains stranded despite growing enrollment.

AI Improves Decisions Execution Determines Outcomes

Artificial intelligence is rapidly increasing the grid's intelligence density. In practice, this intelligence is delivered through machine-learning-driven forecasting models, algorithmic optimization engines, and other model-based analytics, rather than general-purpose AI systems.

These forecasting and optimization models can now anticipate load, pricing, weather, and congestion with growing accuracy and continuously evaluate how assets should be deployed across stacked value streams. In short, the grid is becoming far better at knowing what should be done and when.

But intelligence does not equal execution.

Many VPPs stop at scheduling capacity rather than operating assets in real time.

Even the most advanced decision models operate at regular intervals and depend on control systems that can respond deterministically, locally, and reliably. When execution infrastructure falls short, recommendations do not translate into outcomes. Missed dispatch windows, partial execution, and delayed responses erase the value identified by upstream intelligence.

As forecasting and optimization capabilities improve, expectations rise—and so does the cost of poor execution. In an increasingly model-driven grid, execution is what determines whether better decisions actually produce better results.

The Structural Mismatch Between OEM Software and Grid-Grade Execution

This execution gap exposes a deeper structural issue that is often left unstated.

The entities now expected to deliver grid-integrated VPP performance are hardware OEMs.

OEMs excel at building safe, certified, reliable devices. Their software stacks are designed for device operation, monitoring, and basic control. They are not designed to support:

- Deterministic, multi-DER orchestration across heterogeneous assets
- Continuous algorithmic evolution, including third-party or utility-owned intelligence
- Dynamic, market-specific logic with strict grid-operations latency and availability requirements

In effect, the grid is asking OEM software to solve problems it was never designed for—like forcing a square plug into a round socket. The result is fragile integrations, slow iteration, and systems that struggle to perform under real grid conditions.

Operationally, this mismatch shows up in how most VPPs behave today.

Legacy VPPs act more like booking agents—they reserve capacity on paper and pass schedules downstream, while expecting OEM software to handle real-time behavior. What's missing is an on-site plant manager—a system accountable for coordination, execution, and reliability under live grid conditions.

Expecting OEM firmware or product-level software to evolve into grid-grade execution platforms forces hardware companies into roles they were never structured to play, leading to persistent underperformance.

Why Separating Execution from Intelligence Matters

Reaching higher VPP maturity requires execution to be treated as infrastructure, not application logic.

That infrastructure must operate as the local energy management system (EMS), determining operational intent and coordinating dispatch across devices, while issuing control commands through standard interfaces (such as Modbus) that remain fully bounded by device firmware and safety constraints.

In this model, firmware continues to enforce device-level protection, certification, and hardware integrity, while the EMS layer provides the coordination and execution framework required for grid-grade operation.

Importantly, being the EMS does not mean owning or prescribing the control logic itself. Molecule's role is to provide the integration, orchestration, and execution layer that safely carries out dispatch decisions, while allowing third-party, OEM, utility, or AI-driven optimization logic to determine what those decisions should be.

> In practice, Molecule becomes essential wherever grid participation requires dynamic, real-time control rather than static schedules or best-effort dispatch—conditions under which firmware- or API-only approaches consistently break down.

This is formalized through Molecule's Adaptive Energy Response Automation (AERA), which allows control intelligence to originate from multiple sources while ensuring that execution remains deterministic, local, and secure.

Molecule Systems is embedded at this boundary, acting as the authoritative EMS across batteries, inverters, and flexible loads. Through local integrations, Molecule executes dispatch instructions in real time, operating entirely within firmware-defined limits, regardless of where the optimization logic resides.

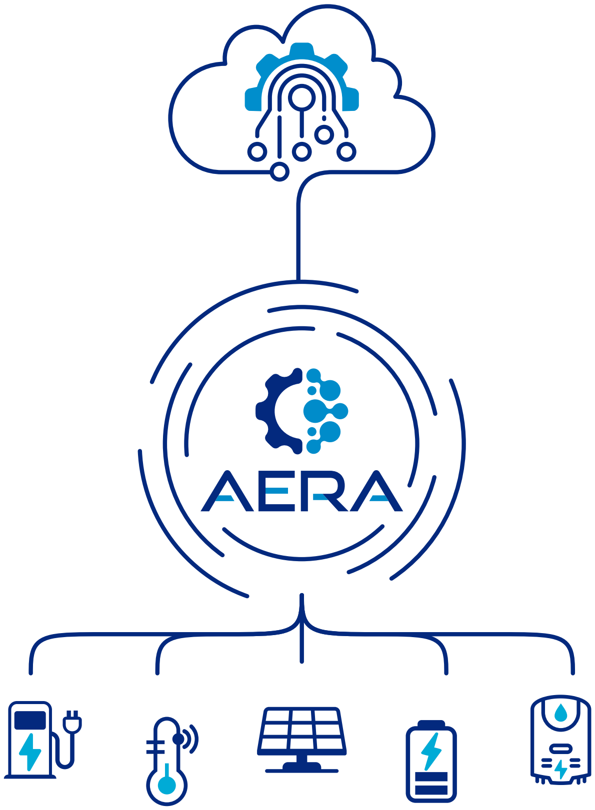
This separation is what enables higher-maturity behavior in practice, without forcing OEMs, utilities, or partners to surrender control over their intelligence models or decision frameworks.

AERA: The Execution Architecture for High-Maturity VPPs

This execution model is formalized through Molecule's Adaptive Energy Response Automation (AERA).

AERA is built on a simple principle:
Intelligence can come from anywhere.
Execution has to be reliable.

Under AERA, control intelligence and execution are intentionally decoupled. Optimization logic may be utility-owned, OEM-owned, third-party, or machine-learning-driven, and may operate at different levels of abstraction. Some logic specifies device-level actions, while other logic communicates higher-level outcomes or constraints that need to be satisfied.
This enables intention-based operation, simplifying grid coordination by allowing operators or orchestration systems to specify what needs to be achieved rather than how individual devices should behave.



Molecule's edge-resident intelligence, automation, and orchestration capabilities absorb that complexity, translating high-level intent into coordinated, device-level actions based on available resources, user-defined constraints, and real-time conditions.

In practice, this abstraction is critical to higher VPP maturity. As described in the EnergyHub maturity framework, grid operators require resources that can reliably meet schedules, sustain shaped load profiles, and respond predictably over multi-hour windows. Intention-based execution allows those requirements to be met without forcing grid-side systems to manage or even understand behind-the-meter device complexity.

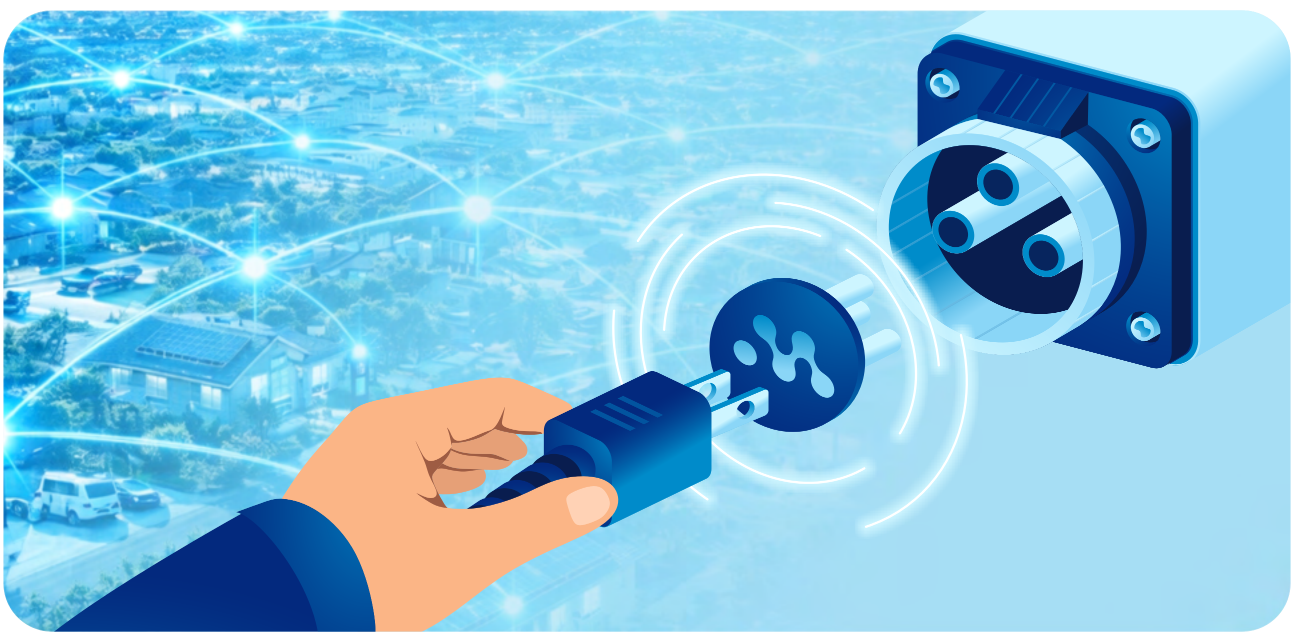
Under AERA:

Control and optimization intelligence may be provided by utilities, OEMs, or third-party systems

Dispatch and optimization logic can be updated continuously, with execution adapting in real time to changing inputs and intent

Execution operates deterministically and locally, enforcing device constraints and safety boundaries

By separating intent and control intelligence from execution, AERA allows forecasting, optimization, and other model-driven systems to evolve rapidly while preserving device safety, cybersecurity, and regulatory integrity. Think of AERA as an execution adapter—absorbing the mismatch between grid-level intent and device-level behavior so VPPs behave like dependable grid resources operated in real time, rather than capacity that is merely scheduled in advance.

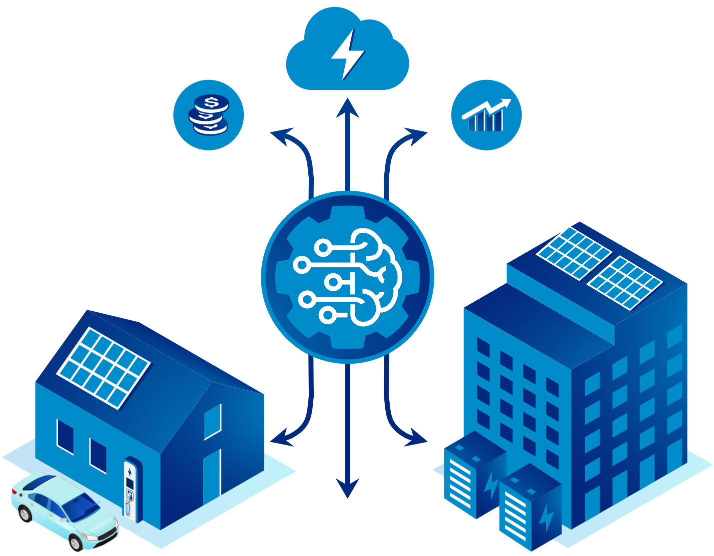


Turning Maturity into Money: DividendVPP as a Production-Grade Example

Execution infrastructure only matters if it delivers measurable economic results. This is where advanced forecasting and model-driven optimization intelligence must be able to inform execution without introducing fragility, latency, or control risk.

DividendVPP is an end-to-end VPP service offering designed explicitly to do exactly that. It combines forecasting and optimization intelligence with Molecule's embedded execution layer to move beyond best-efforts market access and into repeatable, high-maturity performance. In practice, this shift enables fleets to generate up to 2–4× higher earnings compared to traditional, OEM-managed or access-only VPP approaches. Actual results vary by market design, asset mix, and program eligibility.

Within DividendVPP, Lightsmith Energy provides the forecasting, optimization, and value-stack intelligence that determines when, where, and how assets should participate across programs and markets. These models continuously evaluate pricing, load, weather, and grid conditions to identify the highest-value opportunities available to a portfolio and prioritize participation across stacked incentives.



Molecule Systems provides the execution layer that turns that intelligence into action. Molecule assumes authoritative site- and fleet-level control, pre-positions assets ahead of events, shapes dispatch across multi-hour windows, and dynamically allocates energy across stacked opportunities as conditions change. Execution occurs deterministically and locally, independent of which optimization or control intelligence system provides the signal.

Together, DividendVPP delivers a production-grade VPP capability that includes:

- Forecast and optimization informed dispatch decisions
- Pre-event readiness and shaped dispatch execution
- Multi-hour, multi-season participation
- Dynamic allocation across stacked value streams
- Revenue-grade attribution, settlement, and reporting

The earnings uplift achieved under DividendVPP is not the result of a single program or incentive. It is the outcome of higher-maturity operation: assets perform closer to their modeled capability, participate across more value streams, and sustain longer-duration dispatch. This is how higher VPP maturity translates into higher realized revenue, not just theoretical value.

OEM Validation:
EG4's Approach to Execution and VPP Readiness

EG4 Electronics provides a strong example of how leading OEMs are approaching the next phase of grid-integrated energy management and VPP participation.

EG4's collaboration with Molecule is driven by a clear recognition that market access and basic participation alone have not delivered the outcomes customers expect. As VPP programs have evolved, growing performance requirements, regional complexity, and utility expectations have made it increasingly difficult for firmware-centric, OEM-led approaches to adapt quickly or scale with confidence.

Rather than expanding OEM software scope beyond what is sustainable, EG4 chose to partner with Molecule to provide the execution and orchestration layer required for advanced energy management and grid readiness. In parallel, EG4 aligned with a VPP service model built on Molecule's execution platform, designed to translate execution-grade control into scalable market participation and long-term value creation as grid-flexibility programs mature.

Today, EG4 and Molecule are working together through implementation and onboarding, with a shared objective of enabling robust site-level energy management and a clear path toward higher-maturity, grid-integrated VPP capability consistent with the EnergyHub framework.

As EG4 describes it:

> “As we evaluate the VPP landscape, it's clear that real value is earned through trust. That trust is built by execution. Systems that perform reliably, adapt as programs evolve, and hold up under real grid conditions become utility-grade infrastructure, not ongoing pilots. Working with Molecule allows us to continue building great hardware while giving both grid operators and our customers the confidence, reliability, and long-term value they expect as these markets evolve.”
>
> — Clinton O'Neill, Grid Services Manager, EG4 Electronics

What EG4's approach illustrates is not a finished state, but a strategic one: OEMs that treat execution and VPP readiness as foundational capabilities, rather than afterthoughts, are better positioned to unlock the full economic potential of grid flexibility over time.

Conclusion: Execution Is the Gating Factor for VPP Performance

The grid is entering a decisive phase.

Forecasting and optimization intelligence is accelerating grid-level system awareness. Load growth from data centers, electrification, and industrial demand is pushing utilities and regulators to prioritize flexibility as a first-class grid resource. As a result, 2026 is shaping up to be a watershed year: grid operators are moving from experimentation to expectation, and flexibility is becoming something that must be sold, verified, and delivered, not merely promised.

What remains scarce is reliable execution.

Reaching higher VPP maturity levels and unlocking the grid impact and revenue they enable requires more than market access or scheduled capacity commitments. It requires infrastructure that can assume operational control, execute deterministically, and adapt continuously as programs, performance requirements, and markets evolve. That infrastructure must preserve OEM safety and certification boundaries while remaining independent of any single intelligence or optimization source.

This is precisely why DividendVPP was designed. DividendVPP exists to accelerate time to market for OEMs while maximizing revenue and earning potential. Instead of forcing OEMs to build and maintain complex, market-specific VPP infrastructure internally, turning VPP participation into a long-term cost center, DividendVPP provides an end-to-end, grid-integrated service model that allows flexibility to become a new revenue layer.

By combining third-party forecasting and optimization intelligence with Molecule's authoritative execution layer, DividendVPP enables OEM-led fleets to achieve up to 2–4× higher earnings than traditional, OEM-managed or market-access-only approaches. This performance uplift is not theoretical; it is the direct result of higher maturity operation, better preparedness, longer duration, and multi-program participation.

For OEMs, this is not just a technical challenge. It is a timing challenge.

Becoming an eligible grid-flexibility resource involves contractual frameworks, program qualification, telemetry validation, and operational proving periods. Even with the right architecture in place, launching effectively in a single market takes time. Scaling across multiple markets takes longer. OEMs that wait to address execution and service-model risk until programs are fully mature will find themselves perpetually behind the curve, eligible on paper, but late in practice.

The opportunity is clear. The clock is real.

Execution-ready platforms and end-to-end VPP service models allow OEMs to enter this next phase with confidence—delivering Level 3+ maturity out of the gates, accelerating market entry, and capturing value as flexibility markets expand. Those that do will be positioned not just to participate in the grid-flexibility economy but to lead it.

The future grid will not be constrained by insight. It will be constrained by who can execute—reliably, repeatedly, and at scale—when the grid needs it most.

About the Author

Adam Boucher is the Founder and CEO of Molecule Systems, where he works with OEMs, developers, and grid operators to turn distributed energy resources into reliable, grid-integrated assets. His work focuses on execution-grade energy management, VPP orchestration, and enabling higher-maturity grid flexibility at scale.

Feedback and discussion are welcome.

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This paper reflects ongoing work at Molecule Systems and with partners across the VPP and energy optimization ecosystem.