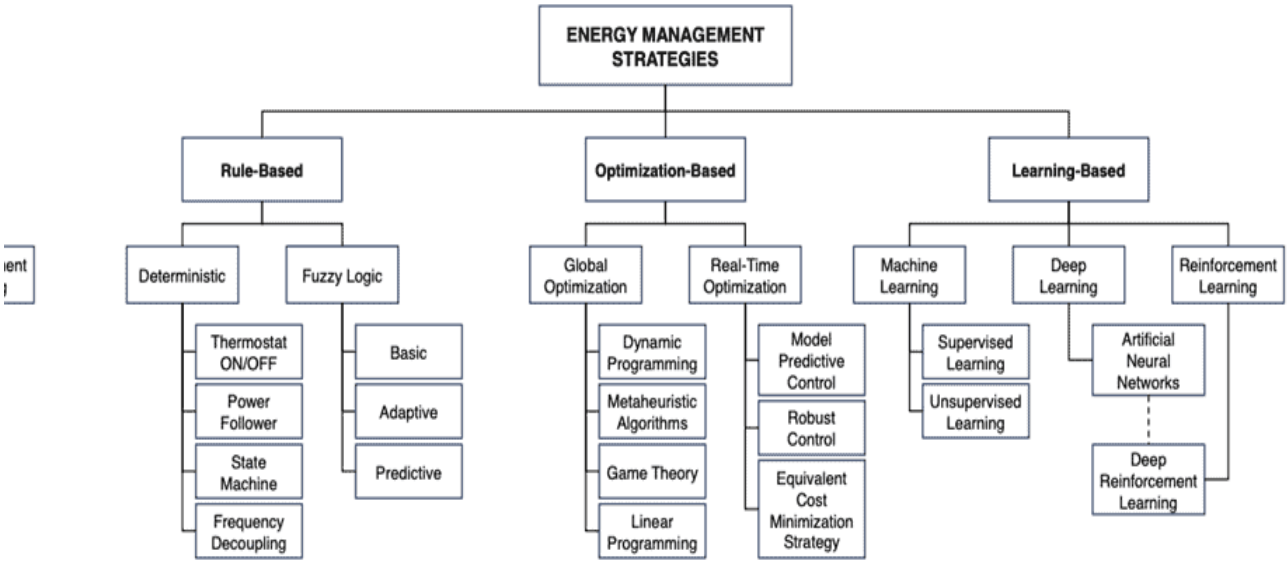

Why the Latest EMS Research Strongly Reinforces the Strategic Value of Hybrid Technology

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(Based on Gómez-Barroso et al., 2025) Picture: From Scientific Study Report,

Europe’s climate ambitions hinge on fast, credible, and socially acceptable emission reductions. While electrification remains the long-term anchor of transport strategy, the scientific question is becoming increasingly urgent: *Which technologies deliver the greatest real-world impact in the critical years before 2030?*

A comprehensive review published in *Energies* (2025) delivers a clear and evidence-driven message: **hybrid vehicles — especially those equipped with advanced energy-management systems (EMS) — offer substantial, scalable, and still-growing efficiency gains**. Far from being a mature or static technology, hybrids are shown to be *improving rapidly*due to advancements in control algorithms, machine learning, and powertrain coordination.

This new scientific evidence directly strengthens the political case for hybrid

technology.

1. The Study Shows Why Hybrids Achieve High Real-World Efficiency

The paper provides one of the most detailed analyses to date of how hybrid vehicles manage energy flow between combustion engines, electric motors, batteries, and regenerative braking. It highlights:

- The **vast efficiency potential** unlocked through intelligent torque blending, SoC (State of Charge) control, and adaptive operating modes.
- The ability of hybrid systems to maintain the combustion engine **near its optimal efficiency zone**, something conventional ICEs almost never achieve.
- The important role of regenerative braking, which the review identifies as a *major contributor* to real-world efficiency gains.

The authors emphasise that **hybrids are uniquely capable of responding to real driving conditions**—traffic, gradients, accelerations—thanks to their flexible powertrain configuration.

For policymakers, this matters because Europe increasingly evaluates progress based on **real-world emissions**, not solely on laboratory cycles.

2. The Study Highlights That Hybrid EMS Technologies Are Advancing Quickly

The review categorises EMS strategies into three families — rule-based, optimisation-based, and learning-based — and shows how each contributes to rising efficiency:

Rule-Based EMS (RBS)

- State machines, fuzzy logic, and heuristic rules offer robust, low-cost real-time performance.
- Many current production hybrids rely on this family.

Optimisation-Based EMS (OBS)

- Dynamic Programming (DP) and ECMS provide the *theoretical optimum* for fuel consumption.
- These strategies are already influencing new hybrid generations as

computation becomes cheaper.

Learning-Based EMS (LBS)

- Reinforcement Learning, deep neural networks, and predictive controllers can anticipate driver behaviour, traffic, and terrain.
- The review identifies these as *key future enablers* of major additional efficiency gains.

The scientific takeaway is unambiguous: **hybrids have not reached their efficiency limit — they are accelerating toward it.**

This directly strengthens their political relevance: a technology that continues to improve is a technology worth integrating into policy.

3. The Study Demonstrates That Hybrids Multiply the Impact of Clean Energy

Another central finding is the way hybrids amplify the usefulness of renewable electricity and low-carbon fuels:

- The EMS can prioritise electric propulsion when renewable electricity is abundant.
- Intelligent blending reduces the amount of fuel needed per kilometre, **increasing the climate benefit of every litre of biofuel or synthetic fuel**.
- The battery enables flexible strategies such as load-shifting, engine downsizing, and peak-efficiency operation.

This synergistic effect is politically powerful:
Hybrids make every clean unit of energy go further.

4. Why These Scientific Findings Strengthen the Political Case for Hybrids

A) Hybrids offer immediate and large-scale emission reductions

The study confirms that modern EMS can significantly lower emissions from day one.
In a decade where timing matters more than theory, hybrids provide results now — independent of charging access, grid constraints, or supply-chain limitations.

B) Hybrids enhance fairness and social acceptance

Because EMS improvements translate directly into fuel savings:

- Hybrids reduce operating costs for households,
- extend the lifespan of existing powertrain infrastructure,
- and create an affordable path for consumers unable to switch to full EVs.

This aligns with political realities: climate policy that fails on affordability fails altogether.

C) The research confirms strong compatibility with Europe's energy transition

The study shows that hybrid EMS algorithms can adapt dynamically to:

- renewable electricity availability,
- low-carbon fuels,
- varying driving conditions,
- and grid flexibility.

This adaptability makes hybrids **a stabilising technology** during Europe's transition rather than a competing one.

D) Hybrids support Europe's industrial and technological strengths

EMS improvement relies heavily on domains where European engineering excels:

- control theory,
- software integration,
- AI-driven optimisation,
- power electronics,
- system-level efficiency design.

The study reinforces that hybrids are a field in which Europe can lead, not follow.

5. Conclusion: The Study Confirms That Hybrids Are a Strategic Necessity

The *Energies* 2025 review supplies a scientifically rigorous foundation for what the Hybrid Alliance has long argued:

- **Hybrids deliver high, proven real-world efficiency today.**
- **Their performance improves as EMS technology evolves.**
- **They multiply the climate value of clean fuels and renewable electricity.**
- **They support social acceptance, affordability, and industrial resilience.**

As Europe moves toward a more pragmatic and technology-diverse decarbonisation strategy, this study provides essential evidence:
hybrid technology is not a temporary bridge — it is a core pillar of a balanced, credible, and effective climate transition.

Read more: https://www.mdpi.com/1996-1073/18/1/10