ECP 2025 Conference
The 4th International Electronic Conference on Processes
20–22 October 2025 | Online
MDPI

HEPV Re-evaluation Reveals Practical Limitations

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INTRODUCTION & AIM

Hybrid Electric-Pneumatic Vehicles (HEPV) have been proposed as energy-efficient alternatives for urban mobility, with claimed fuel savings of 30–45% (Peugeot, Tata trials). Preliminary simulation results (v3.0) suggesting such savings contained critical modeling errors: a double efficiency penalty in pneumatic discharge and a non-mass-based tank thermodynamics implementation (P·V^n instead of mass-based P = mRT/V). AIM: Present corrected validation results (v3.1-beta) and demonstrate the value of transparent error reporting in preventing wasted R&D investment. v3.1-beta (WLTP urban 400 s, dt=0.1 s) shows HEPV = 0.1969 kWh vs BEV = 0.1914 kWh (Δ = +2.90%), indicating a net energy penalty under the tested assumptions; full data and code available in the project repository.

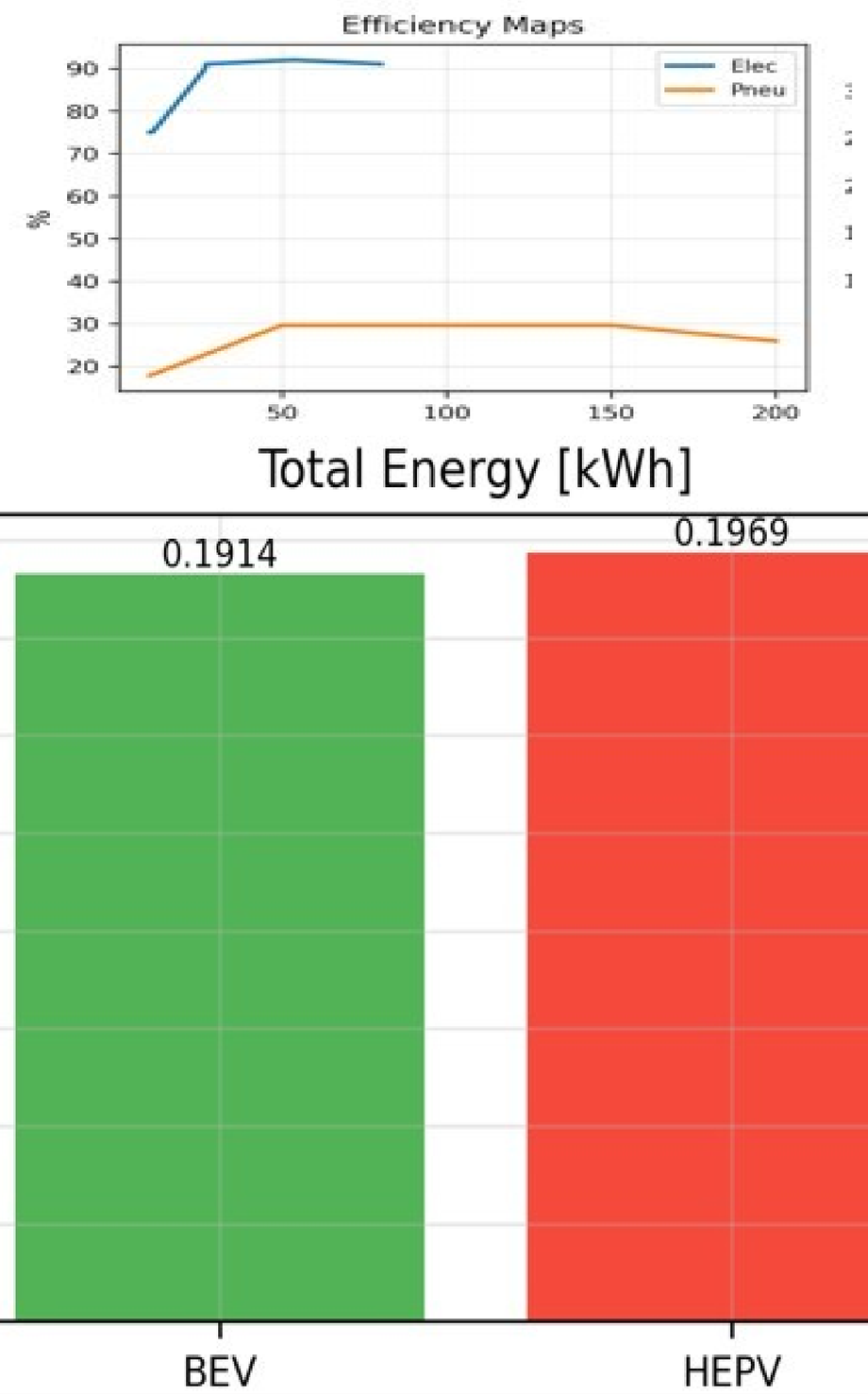
METHOD

Baseline (v3.0): two physics flaws identified — energy draw implemented as E = P/η² (double_η penalty) and tank thermodynamics omitted the mass term (used P·V^n). Corrected (v3.1_beta): tank thermodynamics updated to mass_based P = mRT/V; energy flow fixed to E = P/η; pressure_dependent expander efficiency map added. Simulation: 450 kg BEV vs 500 kg HEPV (≈+50 kg pneumatic hardware) on WLTP urban 400 s (dt = 0.1 s); pneumatic assist active 360/400 timesteps; battery capacity = X kWh. Result: v3.1_beta shows HEPV consumes +2.90% more cumulative traction energy than BEV (BEV = 0.1914 kWh, HEPV = 0.1969 kWh), overturning prior v3.0 savings claims.

One_line tag: v3.1_beta (WLTP urban 400 s): HEPV = 0.1969 kWh vs BEV = 0.1914 kWh; Δ = +2.90%.

RESULTS & DISCUSSION

HEPV → +2.9% cumulative traction energy vs BEV (WLTP urban 400 s). Main drivers: ~3× lower tank→wheel conversion efficiency (electric drivetrain ≈90% vs pneumatic chain ≈25%), ≈+50 kg additional storage mass, and negligible net battery relief from pneumatic assist. Conclusion: Under v3.1-beta validation and tested assumptions, air-hybrids are not competitive for urban duty.



FUTURE WORK / REFERENCES

Future Work
Hardware validation (tank + expander).
RL assist control.
TCO & sensitivity (mass, expander η).

Compact References (one_line each)
[1] Isbuga C. 2025. HEPV Re_evaluation. MDPI ECP. [2] MotorXP 2018. Tesla Model 3 motor report. [3] PSA 2014. Hybrid Air / MDI technical notes.

CONCLUSION

Validated model proves HEPV non-viable (+2.9 % penalty).
Negative result prevents future wasted R&D