

Aachen, 06.10.2026
Christoph Wellmann M.Sc.
Lead Software Architect FEV GenAISys
Chair of
Mechatronics in Mobile Propulsion

Prepared for

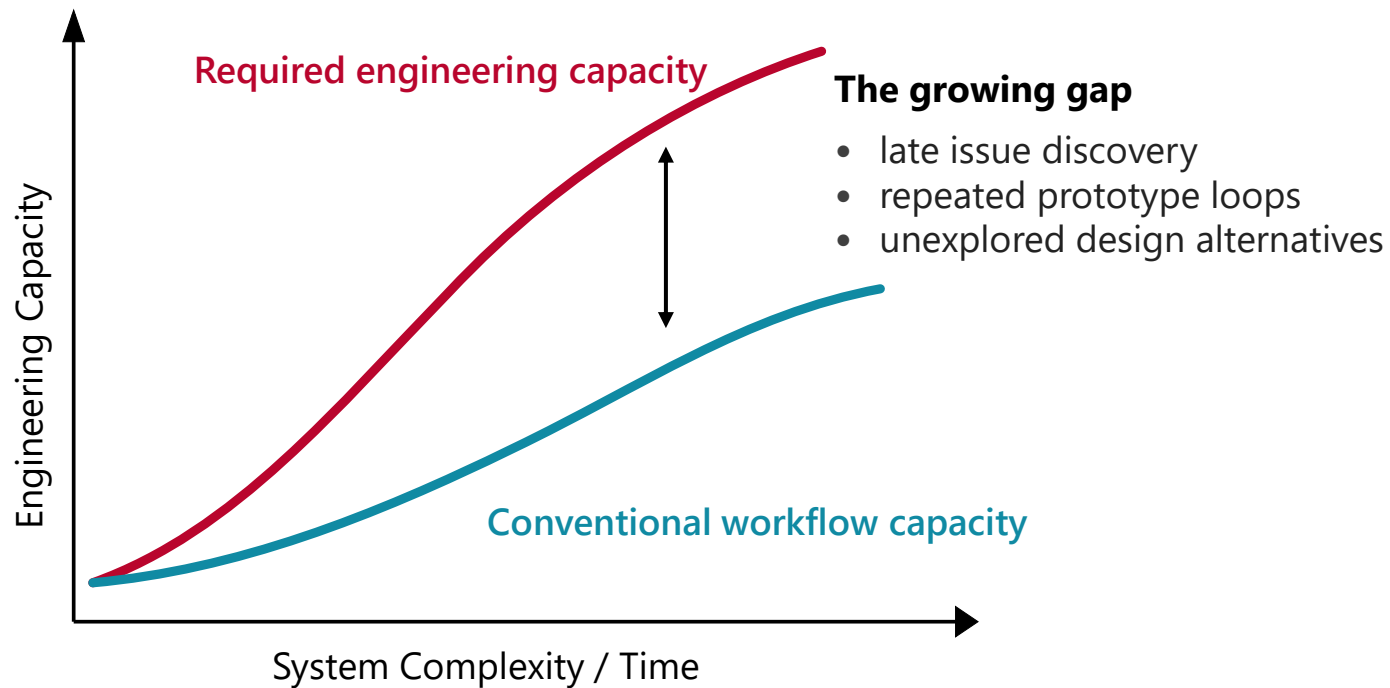
**Aachen Automotive
Colloquium**



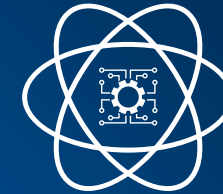
FEV GenAISys: A Multi Objective AI-Integrated Platform for Use-Case Driven Virtual BEV Concept Development



Why Conventional Vehicle Development No Longer Scales



The Challenge



The design space is growing faster than conventional workflows can explore it.

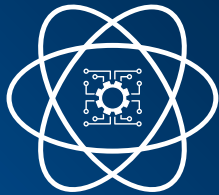
More feature combinations
More architecture alternatives
More coupled parameters

**Better design decisions.
In weeks, not months.**

Better vehicle concepts in weeks, not months. AI-powered engineering with FEV GenAISys.



The Challenge



The design space is growing faster than conventional workflows can explore it.

More feature combinations
More architecture alternatives
More coupled parameters

**Better design decisions.
In weeks, not months.**

The Innovation



**Generate architecture candidates.
Optimize design and control together.**

Multi-agent AI

Generate and refine architecture candidates

Bayesian optimization

Explore architecture and design parameters

Model predictive control

Optimize control actions for each design

The Value



Better design decisions

Compare alternatives against your targets.



Faster concept development

Automate exploration and optimization.



Reuse engineering knowledge

Build on existing models and design libraries.



Evidence before commitment

Evaluate concept performance through simulation.

FEV GenAISys – The Problem Statement

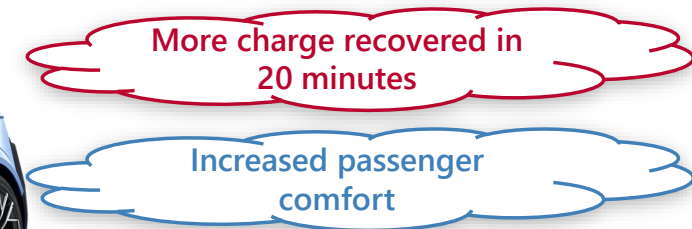
Translating Stakeholder Intent Into Executable Engineering Evidence



EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



Reference Vehicle



Selected Concept

	Lap Time 7:45.59* (7:48.25†) min
	Energy 21.2* (20.40†) kWh/100 km
	Charge 10–80% 18* (18.82†) min
	Cabin TTC — (464 / 0 / 211‡) s
	Aging — (0.138% modeled‡)
	Thermal — (3.31 scored‡)
	Violation — (0 °C‡)
* Public IONIQ 5 N KPIs	
† Default RB Virtual Vehicle Design at 23°C	
‡ –10 / 23 / 35 °C; Aging/Thermal Sum	

- Scenario 1 Nürburgring (NBR): 20 – 20 – 20
- Scenario 2: WLTC



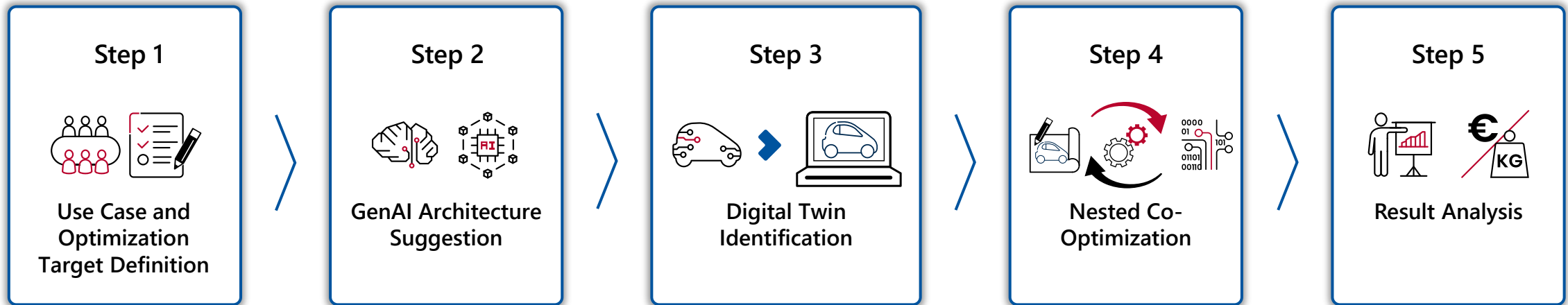
Abbreviations: RB – Rule-Based / NBR – Nürburgring / TTC – Time-to-Comfort / Aging – Modeled Damage (%) / Thermal – Unitless Proximity to Limits

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A Multi Objective AI-Integrated Platform for Virtual Concept Development



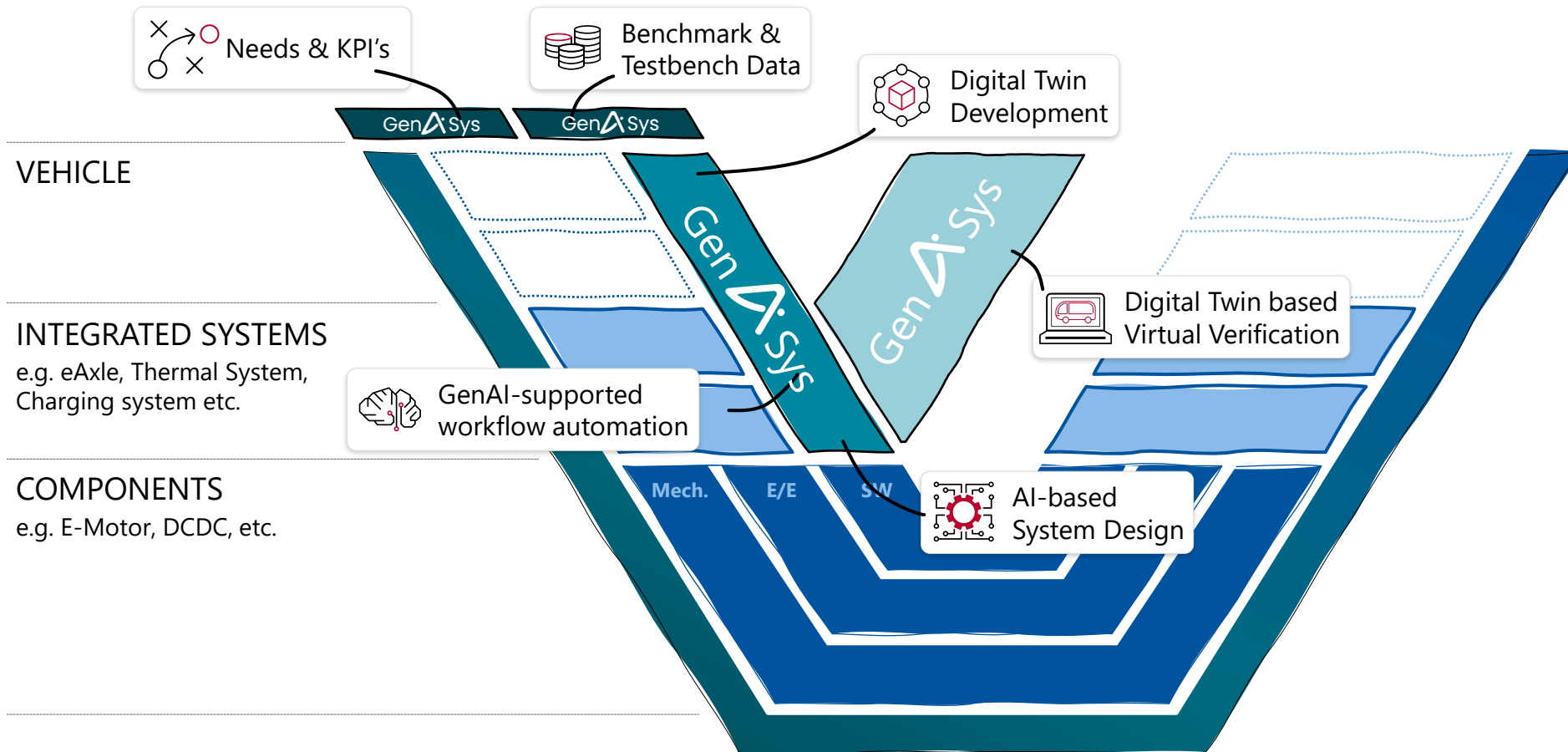
Scalable Generative AI & Bayesian Optimization for Comprehensive Resolution of Multi-Objective Design and Control Challenges

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Workflows that embed into traditional automotive development processes



AI-SUPPORTED DESIGN AND VIRTUAL VERIFICATION ACROSS VEHICLE, SYSTEM AND COMPONENT LEVELS

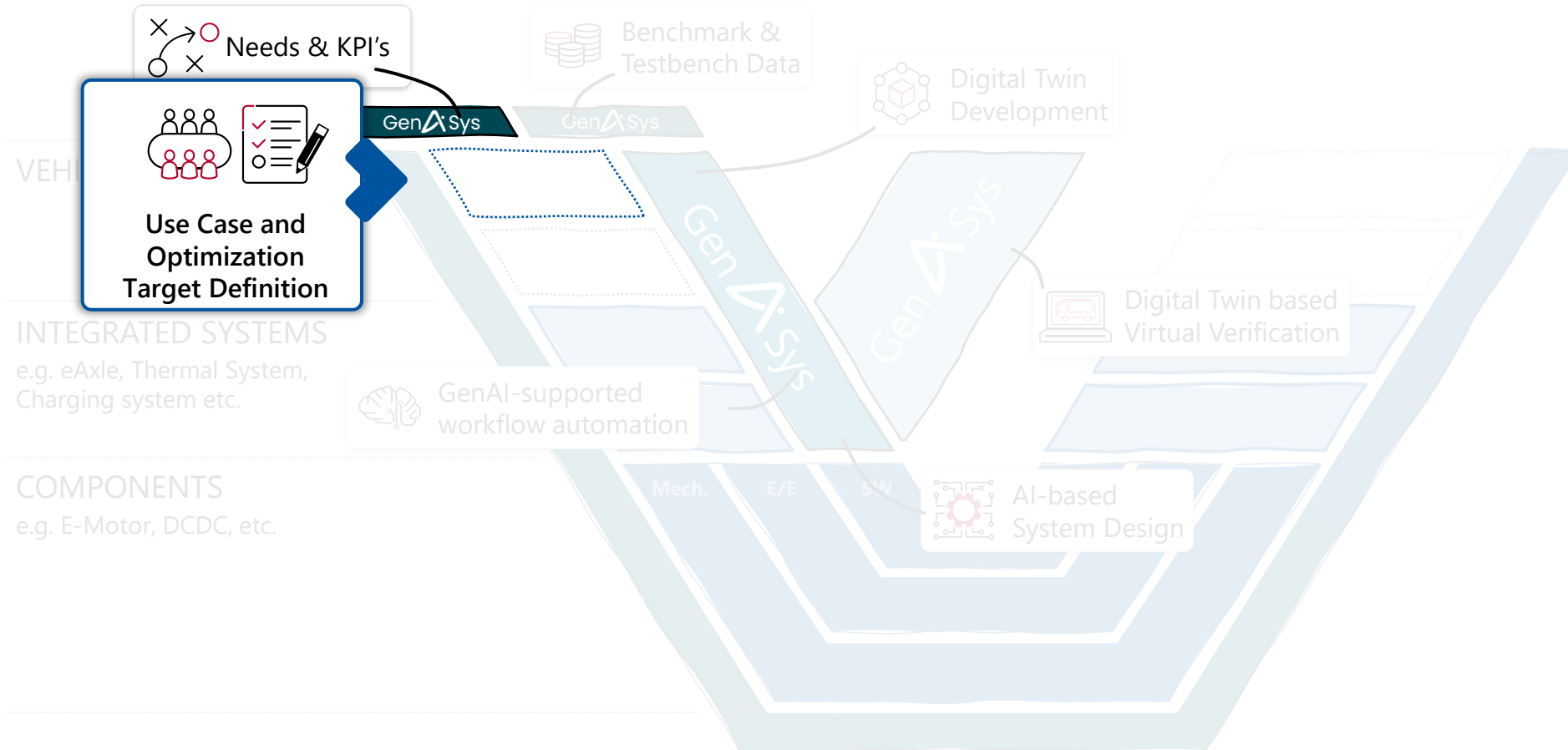


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Step 1: Use Case and Optimization Target Definition



DEFINE WHAT THE CONCEPT MUST ACHIEVE AND WHICH TRADE-OFFS ARE ACCEPTABLE

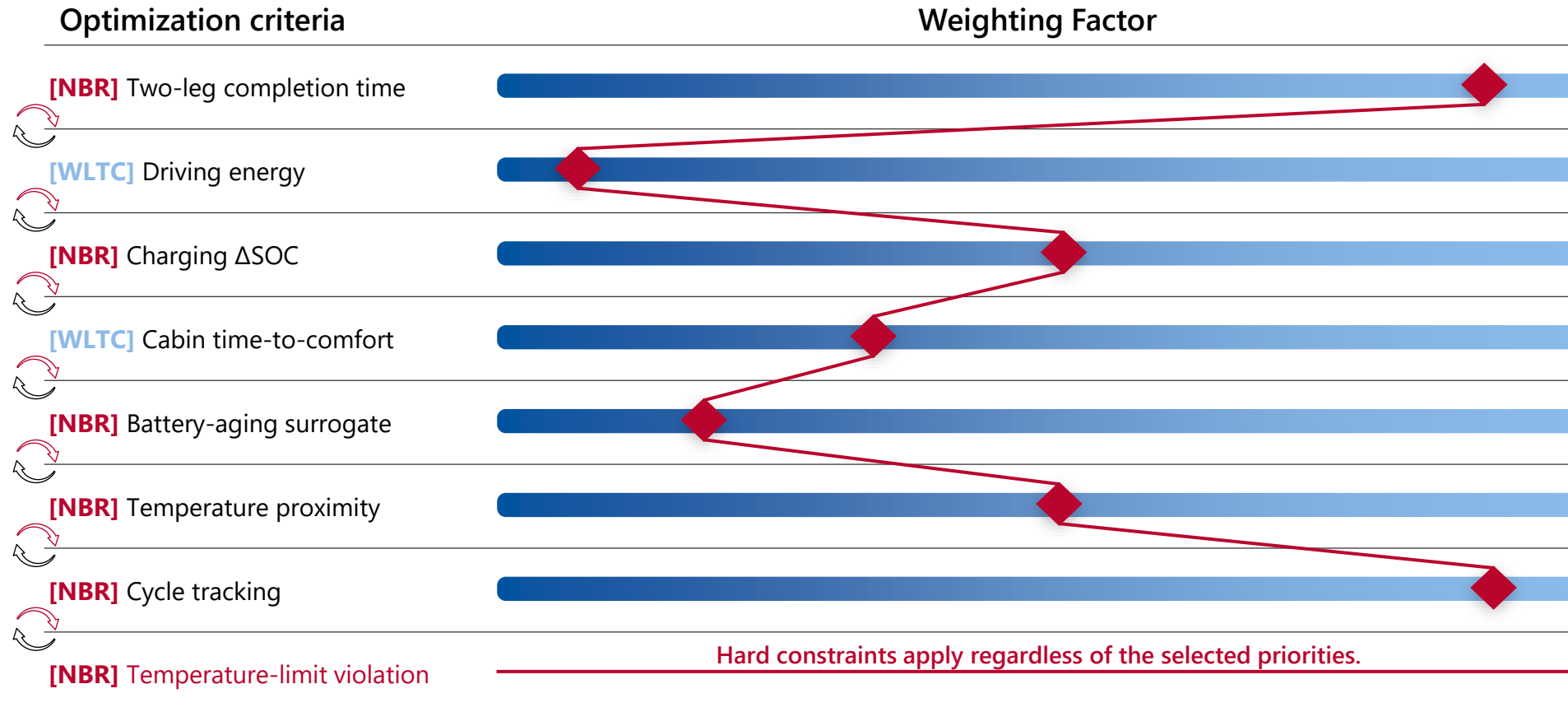


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Step 1: Use Case and Optimization Target Definition



TRADE-OFF FOR MULTI OBJECTIVE OPTIMIZATION – PERFORMANCE-FOCUSED PRIORITIES – ILLUSTRATIVE WEIGHTING PROFILE



Aging (%): $\sum_{ambients} \int_{drive-charge-drive} (r_{calender} + r_{cycling} + r_{cold\ charge}) dt$. Literature-informed *surrogate damage*, not measured battery capacity loss.

Thermal (unitless): $\sum_{ambients} \sum_{component\ groups} mean_{components,time}[B(d)]$, where d is temperature distance from the centre of each component's allowed range, divided by its half-range. $B(d)$ rises sharply near a limit and penalizes exceedance; **lower is better**.

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Optimization criteria	Weighting Factor
[NBR] Two-leg completion time	~10
[WLTC] Driving energy	~90
[NBR] Charging Δ SOC	~50
[WLTC] Cabin time-to-comfort	~50
[NBR] Battery-aging surrogate	~90
[NBR] Temperature proximity	~50
[NBR] Cycle tracking	~10
[NBR] Temperature-limit violation	~10

Hard constraints apply regardless of the selected priorities.



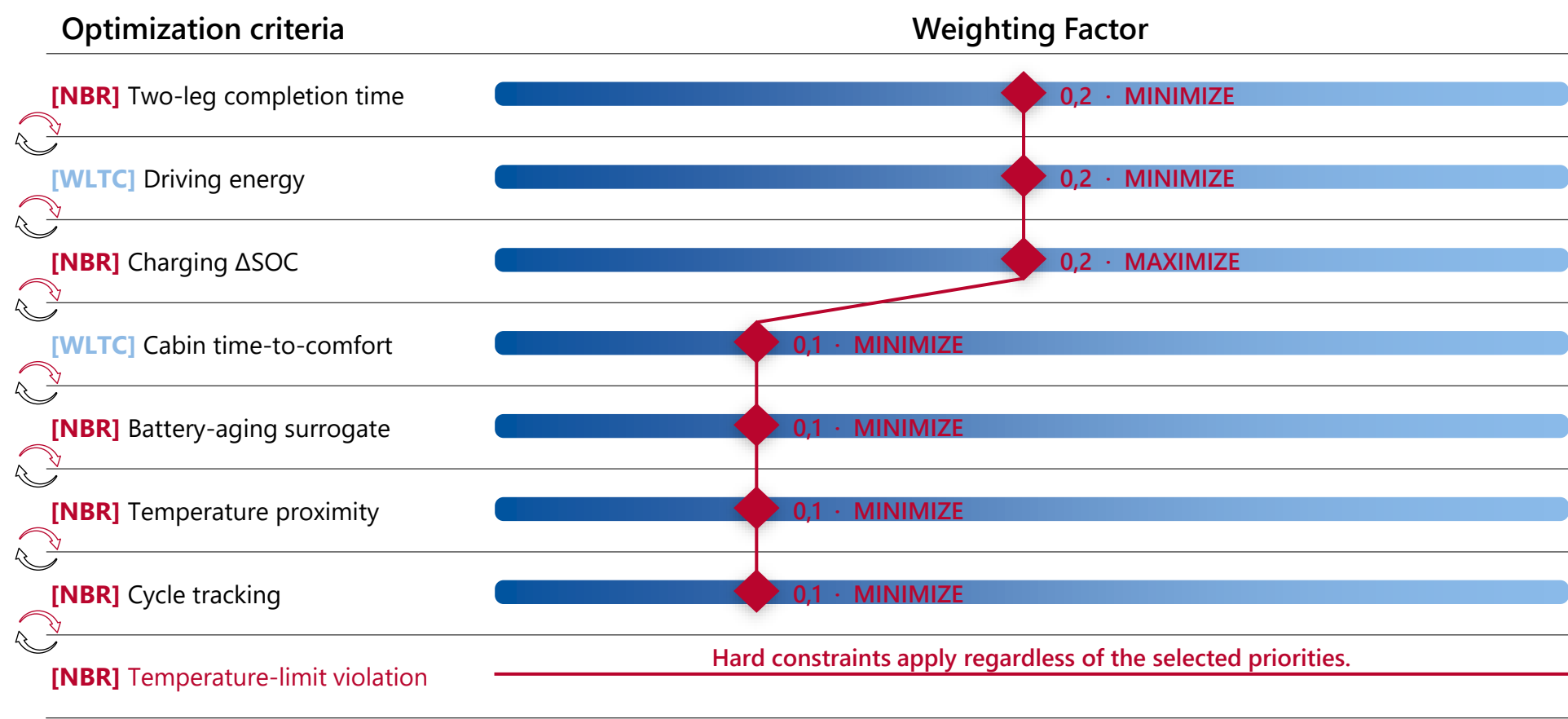
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in Mobile
Propulsion

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Step 1: Use Case and Optimization Target Definition



THE STUDY’S PRIORITIES DEFINE THE SELECTED CONCEPT – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



Aging (%): $\sum_{ambients} \int_{drive-charge-drive} (r_{calender} + r_{cycling} + r_{cold\ charge}) dt$. Literature-informed *surrogate damage*, not measured battery capacity loss.

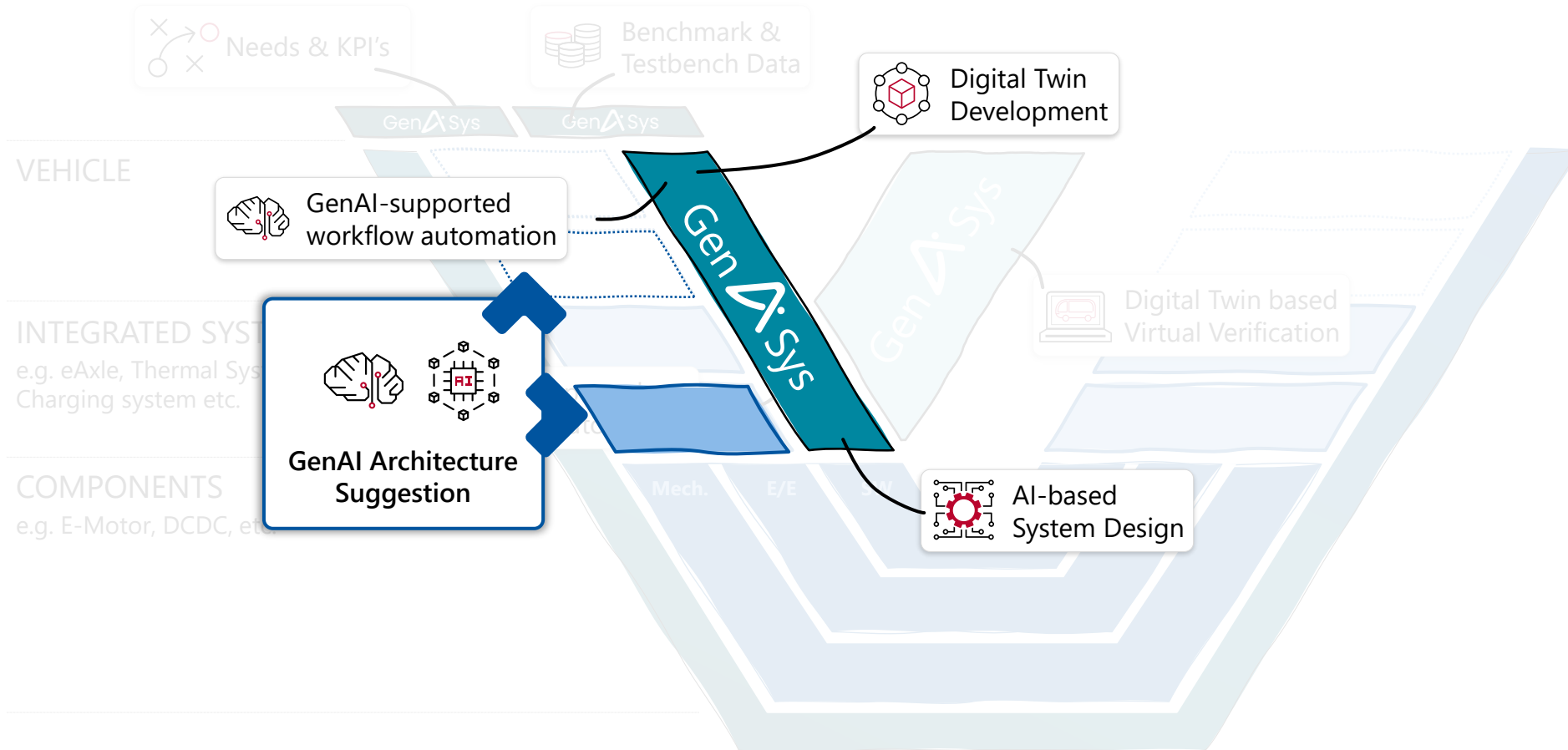
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Step 2: GenAI Multi-Agent Architecture Generation



TRANSLATE SELECTED FEATURES AND ENGINEERING REQUIREMENTS INTO ARCHITECTURE CANDIDATES

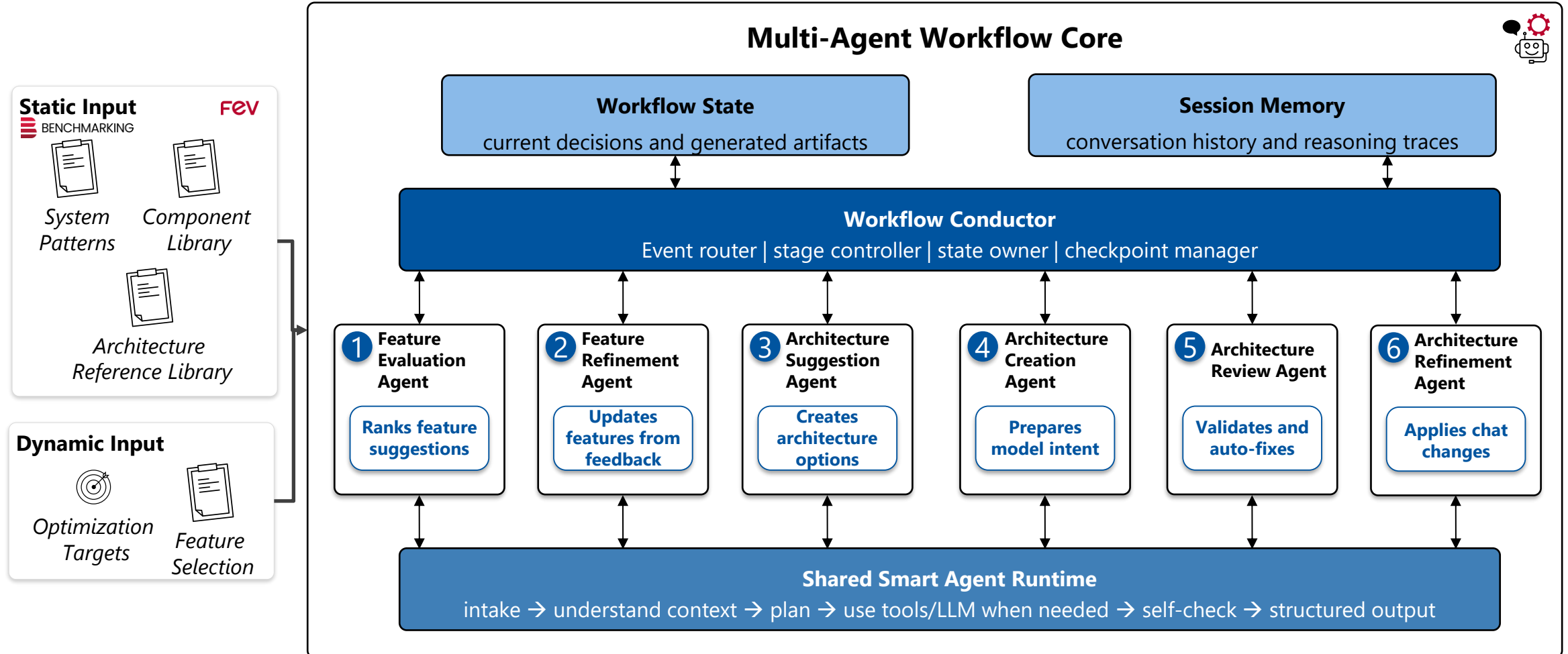


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Step 2: GenAI Multi-Agent Architecture Generation



ENGINEERING REQUIREMENTS BECOME SIMULATION-READY ARCHITECTURE CANDIDATES



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Step 2: GenAI Multi-Agent Architecture Generation



FROM STAKEHOLDER INTENT TO ARCHITECTURE LOGIC – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 System Selection

Selectable system

Thermal Management System ▼

Thermal management for battery, powertrain and cabin

2 Mandatory Features

Battery Cooling

EDU Cooling

Cabin Air Conditioning

Ambient Heat Exchange Stack

Circulation & Expansion

Automatically selected: 5 / 5

3 Optional Features

EDU Coolant Circuit

Chiller Coupling

Multi Loop Segmentation

Single Loop

Dual Chiller

Series Chiller

Oil Circuit for EDU

Twin Radiators

Battery Heater

ICCU Cooling

DCDC Cooling

Cold Soak Kit

Hot Soak Kit

User-selectable: 13 optional features

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Step 2: GenAI Multi-Agent Architecture Generation



FROM STAKEHOLDER INTENT TO ARCHITECTURE LOGIC – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 System Selection

Selectable system

Thermal Management System ▼

Thermal management for
battery, powertrain and cabin

2 Mandatory Features

- Battery Cooling ☒
- EDU Cooling ☒
- Cabin Air Conditioning ☒
- Ambient Heat Exchange Stack ☒
- Circulation & Expansion ☒

Automatically selected: 5 / 5

3 Optional Features

- EDU Coolant Circuit ☐
- Chiller Coupling ☒
- Multi Loop Segmentation ☒
- Single Loop ☐
- Dual Chiller ☐
- Series Chiller ☐
- Oil Circuit for EDU ☒
- Twin Radiators ☒
- Battery Heater ☒
- ICCU Cooling ☒
- DCDC Cooling ☐
- Cold Soak Kit ☐
- Hot Soak Kit ☐

User-selectable: 13 optional features

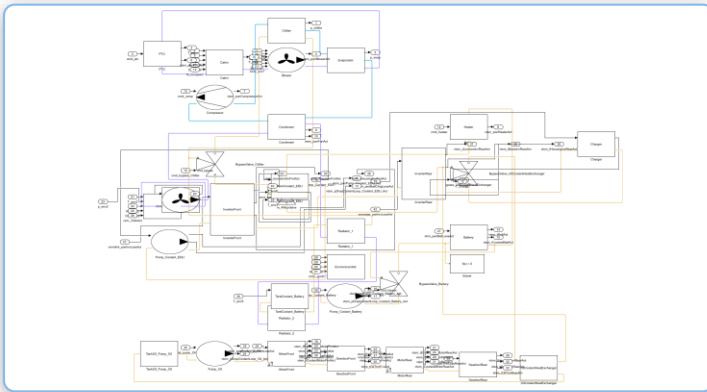
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Step 2: GenAI Multi-Agent Architecture Generation



THREE QUALIFIED EXECUTION ARCHITECTURES – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

Layout 1 / Battery + Chiller Routing

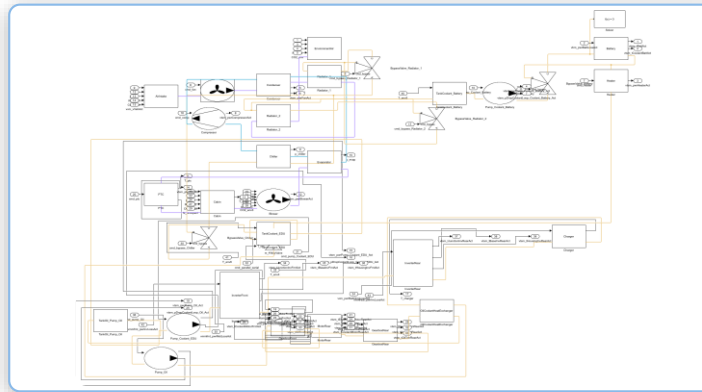


**Battery + chiller bypass;
Selectable oil-coolant HX coupling**

Strength: Selective battery conditioning and EDU oil coupling

Trade-off: Both radiators remain inline

Layout 2 / Radiator Staging

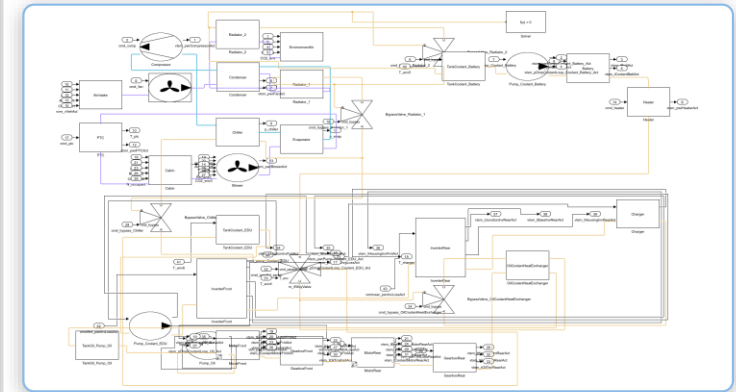


**Battery + chiller + twin-radiator
bypasses; Oil HX inline**

Strength: Independent radiator staging for track and charge

Trade-off: Four bypass commands increase calibration effort

Layout 3 / Selective Oil Coupling



**Chiller + radiator + oil-HX bypasses;
Battery inline**

Strength: Selectable EDU oil coupling and radiator staging

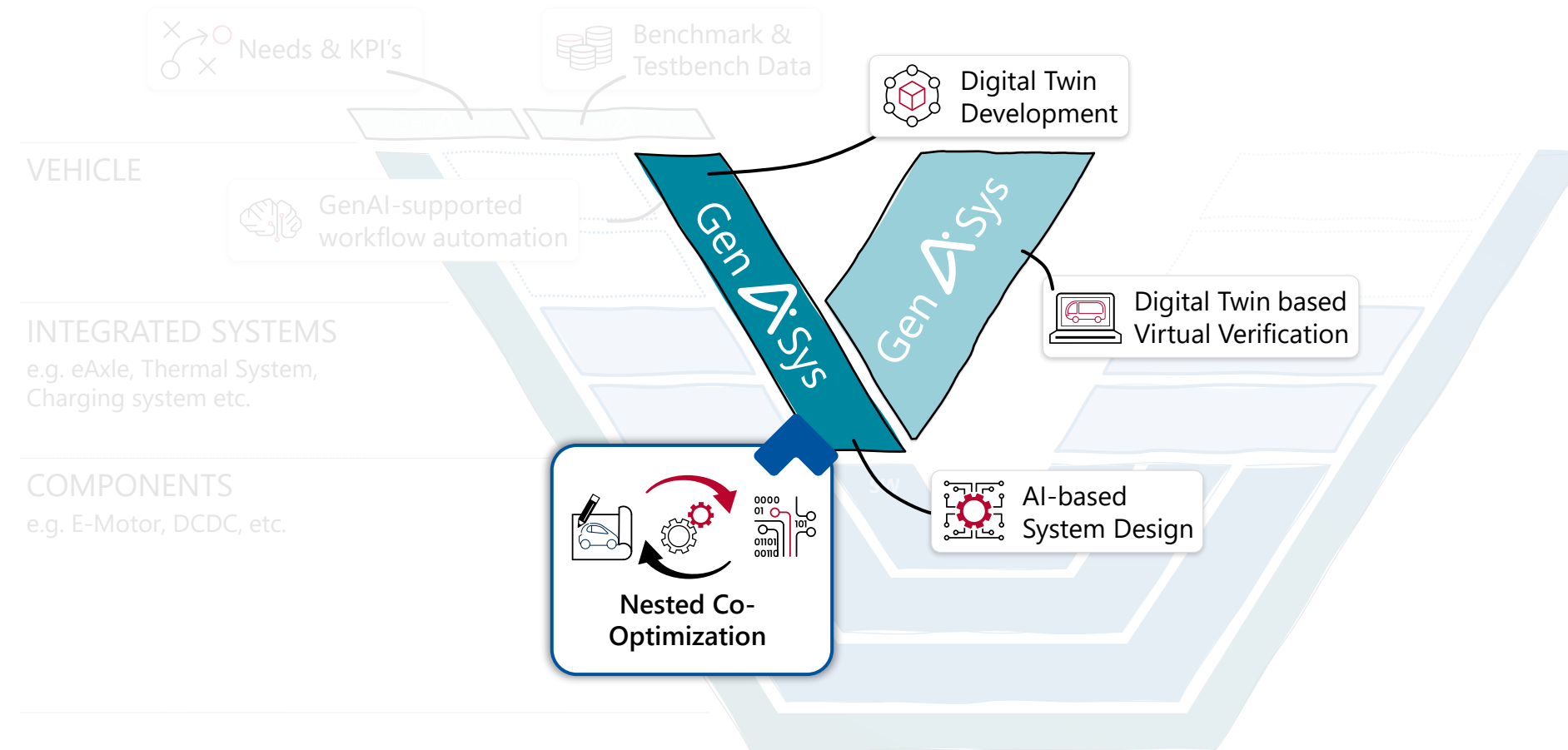
Trade-off: Battery remains inline; Four bypass commands

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Step 4: The Innovation: Nested Co-Optimization



JOINT DESIGN-CONTROL OPTIMIZATION

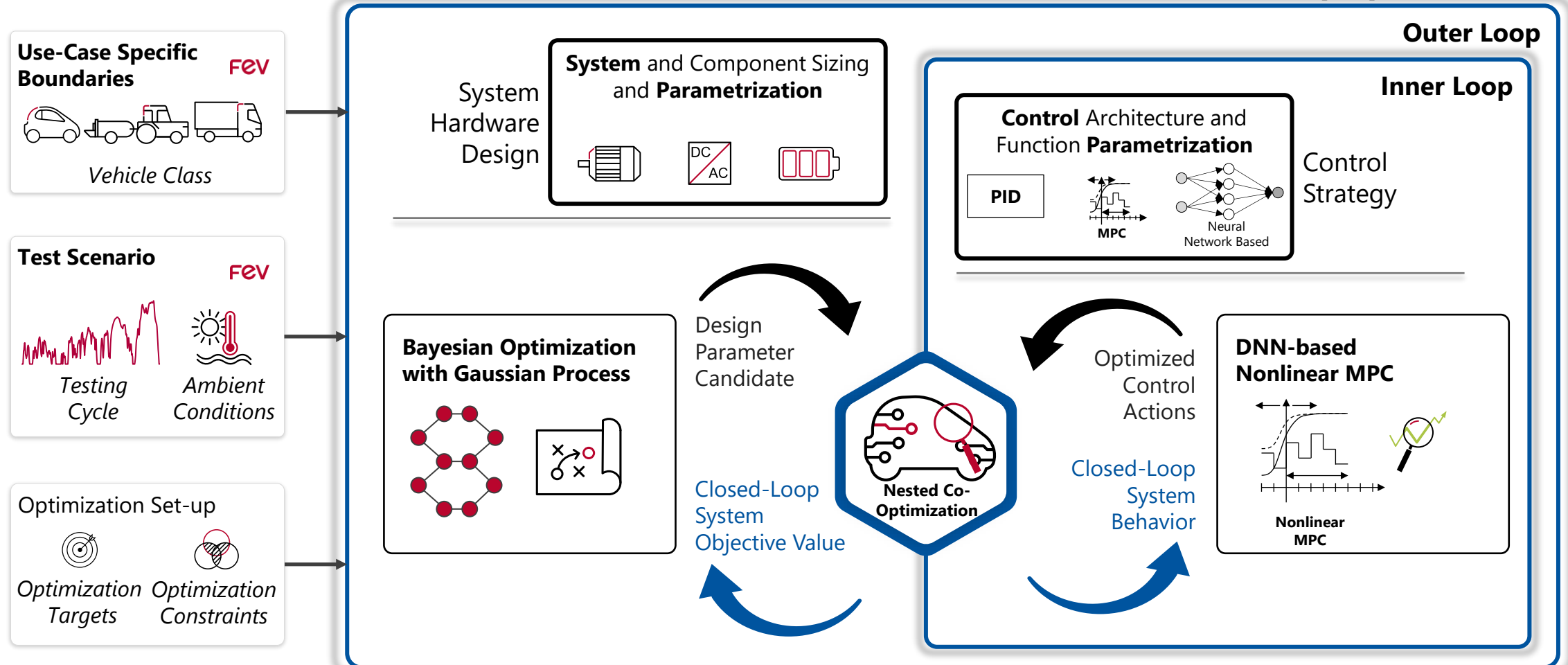


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Step 4: The Innovation: Nested Co-Optimization



AI-BASED OPTIMIZER IN A NESTED CO-OPTIMIZATION FASHION, SPANNING DESIGN AND CONTROL SPACE [1-2]



[1] Christoph Wellmann et al., Electric machine co-optimization for EV drive technology development: Integrating Bayesian optimization and nonlinear model predictive control, eTransportation, 2025, <https://doi.org/10.1016/j.etrans.2024.100392>

[2] Christoph Wellmann et al., Machine-learning integrated multi-domain co-optimization for electrified heavy duty fleets, eTransportation, <https://doi.org/10.1016/j.etrans.2025.100511>

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Step 4: The Innovation: Nested Co-Optimization



DEFINING THE COMPLETE DESIGN AND CONTROL SEARCH SPACE – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 Design Parameters

Electric Parameters	Thermal Parameters
Battery cells in parallel	TMS Architecture
Electromagnetic Parameters	Battery-pump displacement
Front motor axial scaling	EDU-pump displacement
Front motor radial scaling	Oil-pump displacement
Rear motor axial scaling	Battery-heater scale
Rear motor radial scaling	Compressor-flow scale
Mechanical Parameters	Cabin PTC heater scale
Front gear ratio	Cabin blower-flow scale
Rear gear ratio	Cooling fan-flow scale
	Radiator length

2 MPC Controls

Control
Battery pump command
Battery-heater command
Compressor command
Cabin blower command
Cabin PTC heater command
Cooling fan command

3 Optimization Settings

100 evaluations
Stall 50
$\Delta \geq 0.01$
12 parallel workers

GenAISys searches 17 design powertrain system parameters across the **electromagnetic, mechanical and thermal domain** together with six bounded thermal-control commands

Abbreviations: EDU – Electric Drive Unit / PTC – Positive Temperature Coefficient (Electric Heater) / TMS – Thermal Management System

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Step 4: The Innovation: Nested Co-Optimization



DEFINING THE COMPLETE DESIGN AND CONTROL SEARCH SPACE – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 Design Parameters

Electric Parameters
Battery cells in parallel → 3p
Electromagnetic Parameters
Front axial scale
Front radial scale
Rear axial scale
Rear radial scale
Mechanical Parameters
Front gear ratio
Rear gear ratio

Thermal Parameters
TMS Architecture → 3
Battery pump disp.
EDU pump disp.
Oil pump disp.
Battery-heater scale
Compressor-flow scale
PTC heater scale
Blower-flow scale
Fan flow
Length (both radiators)

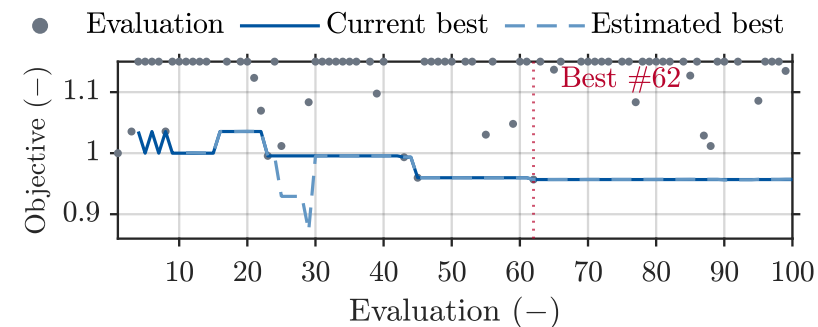
2 MPC Controls

Control
Battery pump command
Battery-heater command
Compressor command
Cabin blower command
Cabin PTC heater command
Cooling fan command
Decreased Dimensions
Neutral Dimensions
Increased Dimensions

3 Optimization Settings

100 evaluations
Stall 50
$\Delta \geq 0.01$
12 parallel workers

4 BO Training Process



Larger motors with lower gear ratios **balance performance and energy use**.
The 3p battery is paired with **smaller battery-conditioning** and ambient-cooling hardware.

Abbreviations: EDU – Electric Drive Unit / PTC – Positive Temperature Coefficient (Electric Heater) / TMS – Thermal Management System

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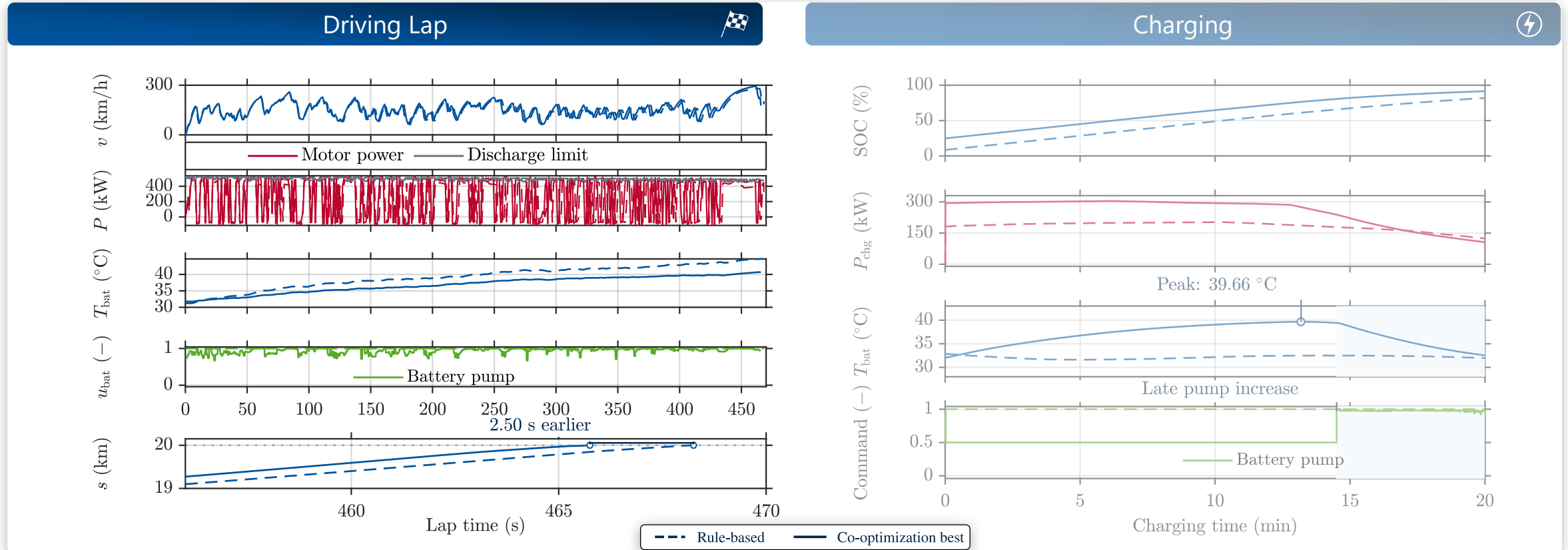
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Step 4: The Innovation: Nested Co-Optimization



DRIVING AND CHARGING PERFORMANCE EVALUATION IN NBR SCENARIO – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



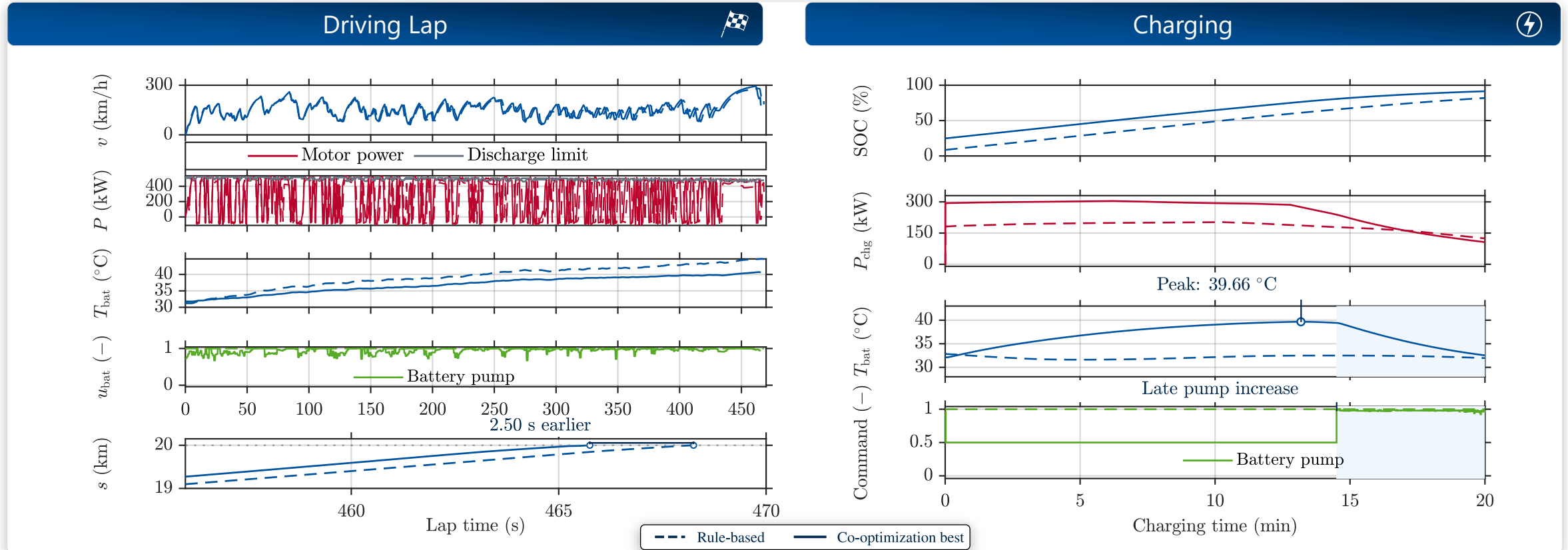
A cooler driving battery accompanies a **2.50 s faster lap**.

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Step 4: The Innovation: Nested Co-Optimization



DRIVING AND CHARGING PERFORMANCE EVALUATION IN NBR SCENARIO – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



A cooler driving battery accompanies a **2.50 s faster lap**.
During charging, higher energy input adds heat before the **late battery-pump increase**.

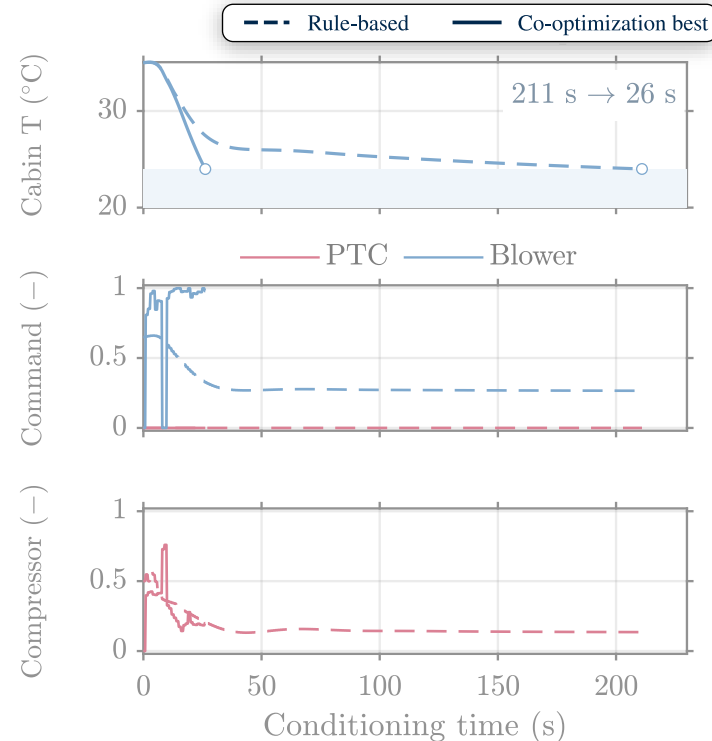
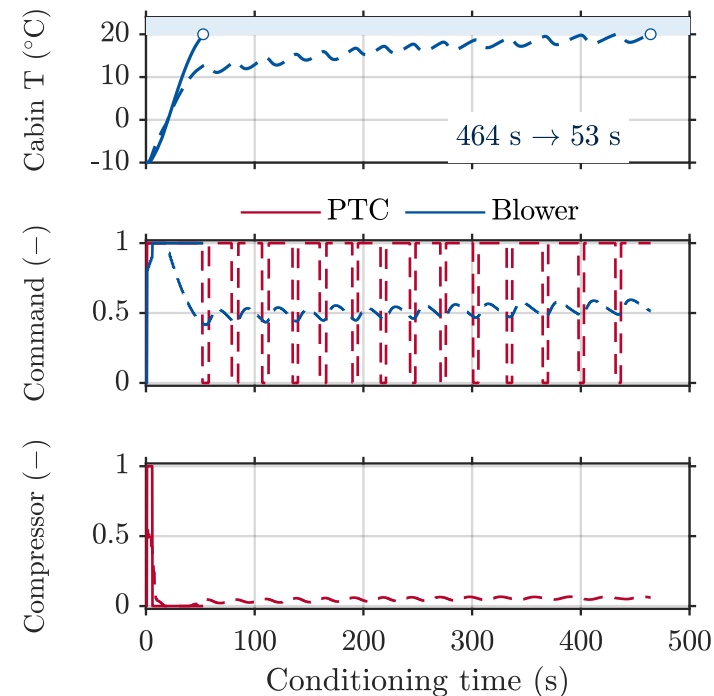
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Step 4: The Innovation: Nested Co-Optimization

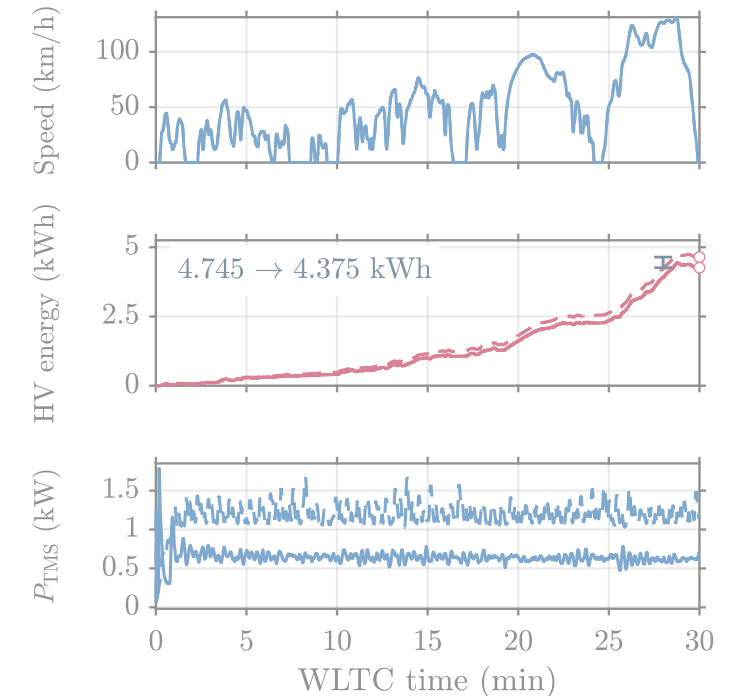


COMFORT AND EFFICIENCY EVALUATION IN WLTC SCENARIO – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

Cabin Time-to-Comfort: Cold / Hot



WLTC Battery Energy: 23 °C



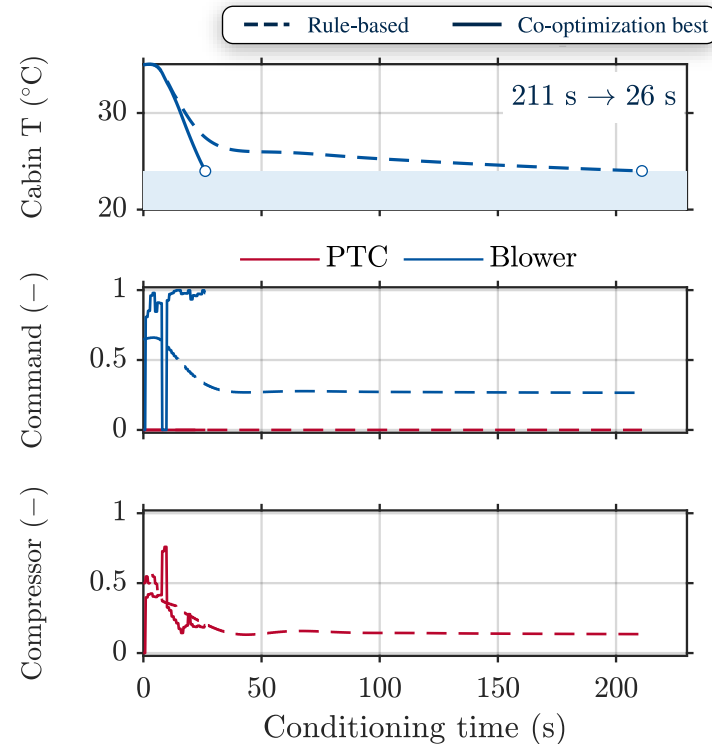
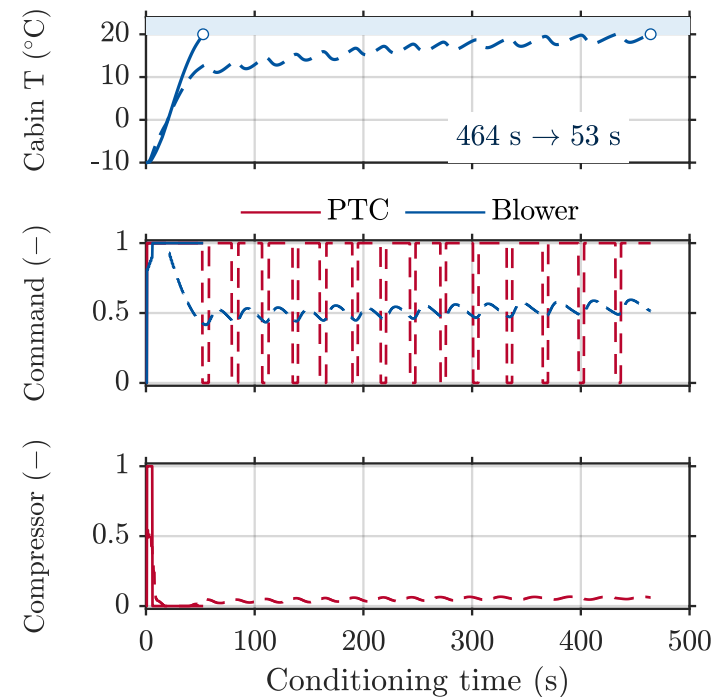
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Step 4: The Innovation: Nested Co-Optimization

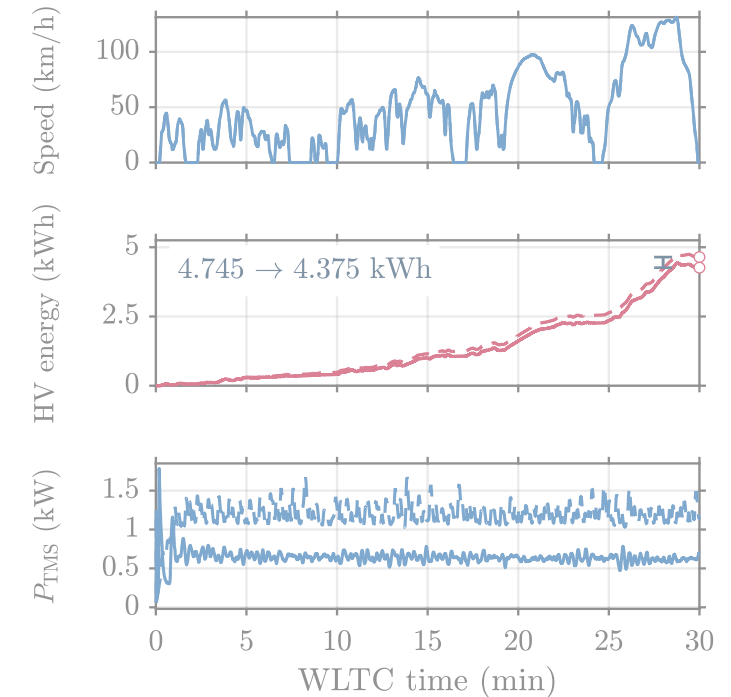


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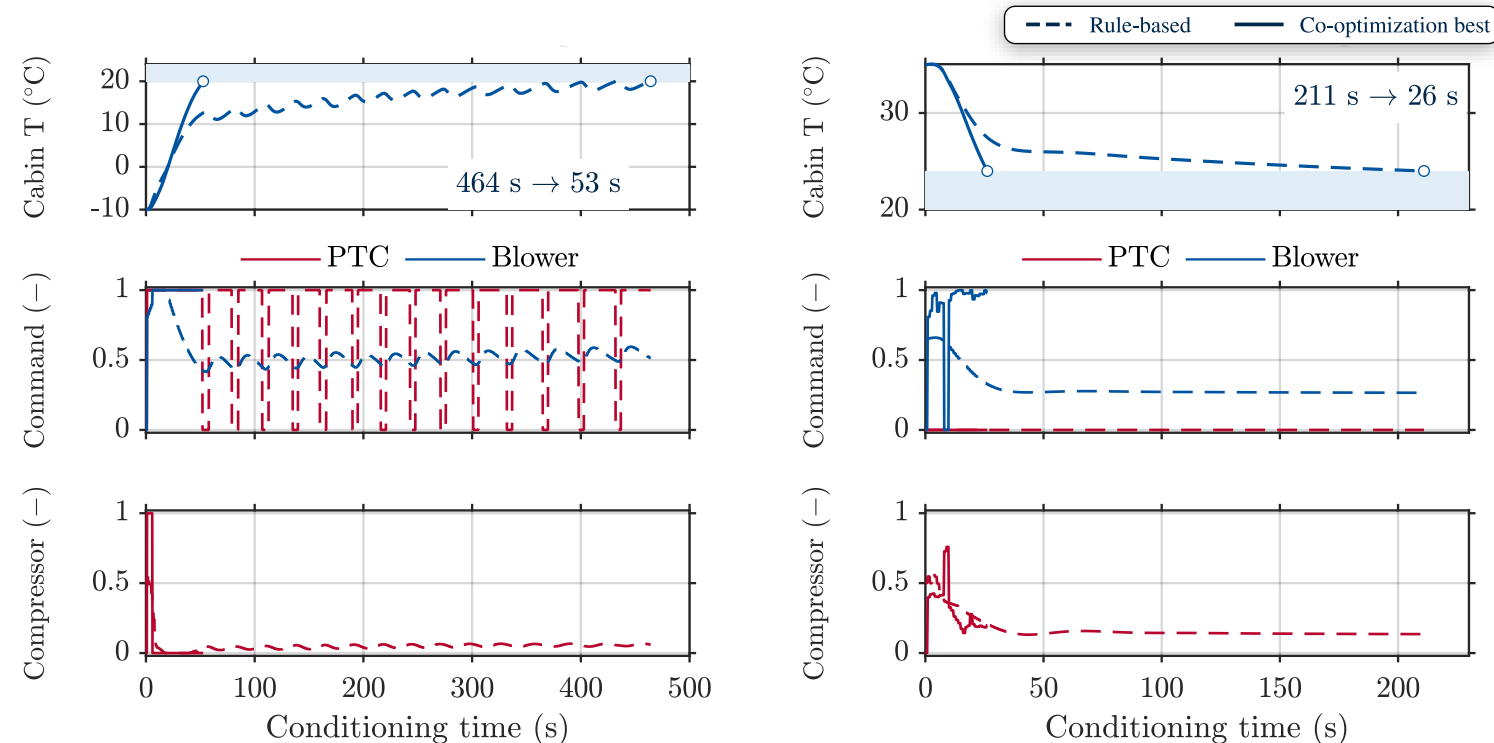
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Step 4: The Innovation: Nested Co-Optimization

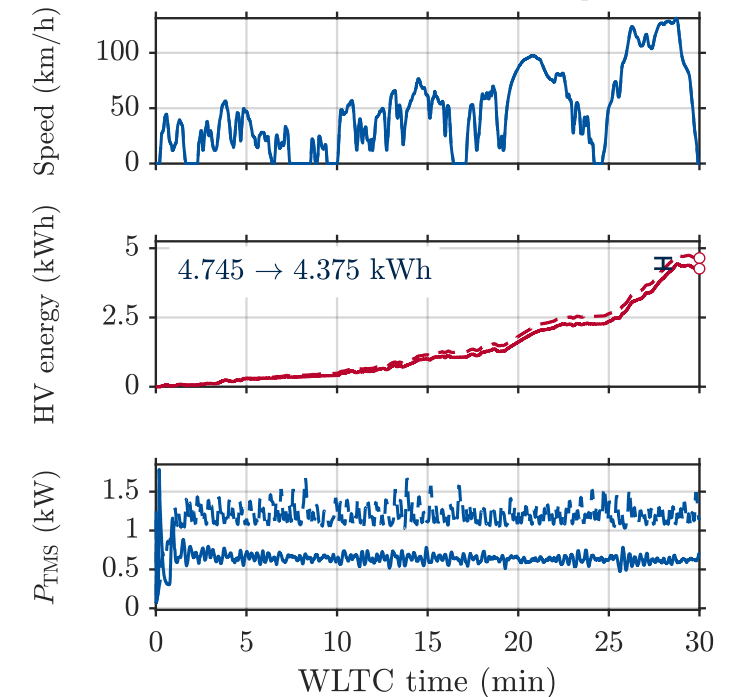


COMFORT AND EFFICIENCY EVALUATION IN WLTC SCENARIO – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

Cabin Time-to-Comfort: Cold / Hot



WLTC Battery Energy: 23 °C



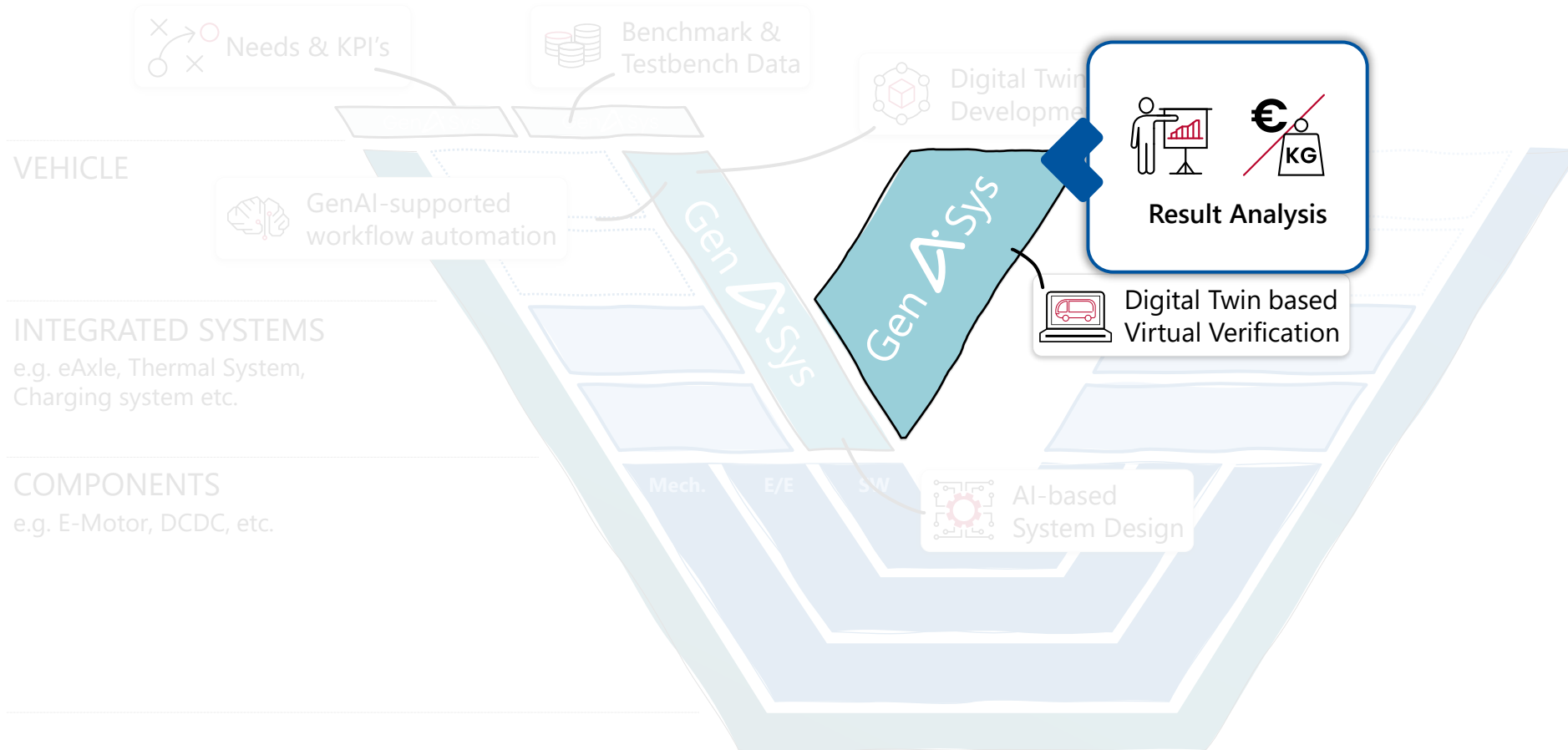
Co-optimization reaches first **cabin comfort sooner** and **lowers warm-WLTC battery energy**, alongside a lower simulated total TMS load.

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Step 5: Optimization Result Analysis



COMPARE BENEFITS, TRADE-OFFS AND CONSTRAINT COMPLIANCE

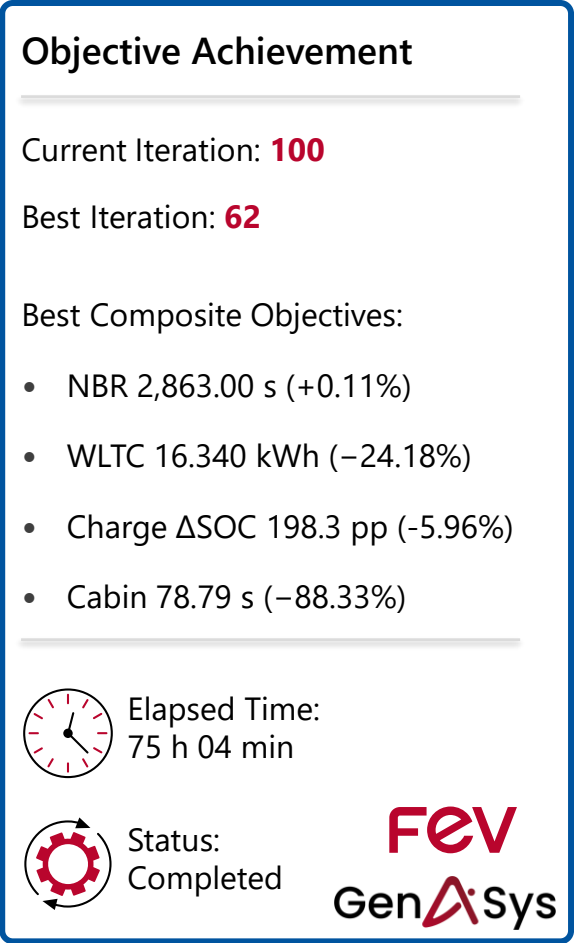
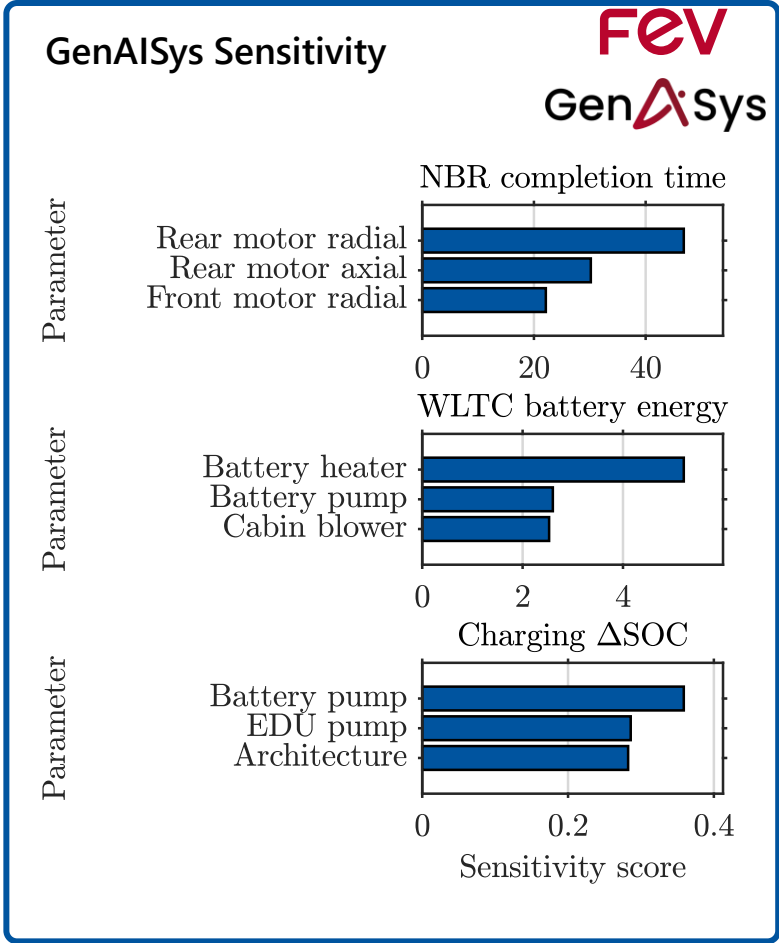
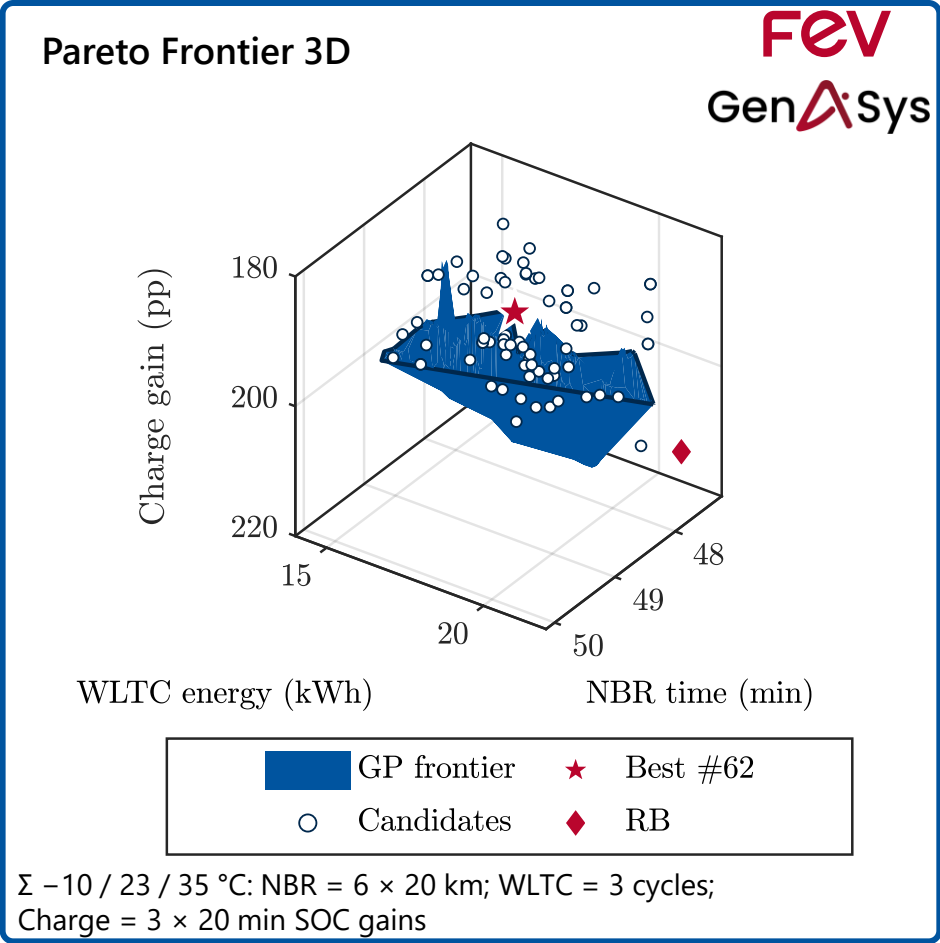


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Step 5: Optimization Result Analysis



THE RESULT ANALYSIS TRADE-OFF AND OBJECTIVE ACHIEVEMENT– EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



FEV GenAISys – The Problem Statement

Translating Stakeholder Intent Into Executable Engineering Evidence



EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



	Lap Time 7:45.59* (7:48.25†) min
	Energy 21.2* (20.40†) kWh/100 km
	Charge 10–80% 18* (18.82†) min
	Cabin TTC — (464 / 0 / 211‡) s
	Aging — (0.138% modeled‡)
	Thermal — (3.31 scored‡)
	Violation — (0 °C‡)
* Public IONIQ 5 N KPIs	
† Default RB Virtual Vehicle Design at 23°C	
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- Scenario 1 Nürburgring (NBR): 20 – 20 – 20
- Scenario 2: WLTC



Abbreviations: RB – Rule-Based / NBR – Nürburgring / TTC – Time-to-Comfort / Aging – Modeled Damage (%) / Thermal – Unitless Proximity to Limits

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FEV GenAISys – The Result

Translating Stakeholder Intent Into Executable Engineering Evidence



THE SELECTED CONCEPT MAKES BENEFITS AND TRADE-OFFS EXPLICIT - EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

Faster repeated track performance

Lower standardized driving energy

Reference Vehicle



More charge recovered in 20 minutes

Comfort and thermal robustness

Selected Concept

	Lap Time 7:45.59* (7:48.25†) min
	Energy 21.2* (20.40†) kWh/100 km
	Charge 10–80% 18* (18.82†) min
	Cabin TTC — (464 / 0 / 211‡) s
	Aging — (0.138% modeled‡)
	Thermal — (3.31 scored‡)
	Violation — (0 °C‡)
* Public IONIQ 5 N KPIs	
† Default RB Virtual Vehicle Design at 23°C	
‡ –10 / 23 / 35 °C; Aging/Thermal Sum	

■ Scenario 1 Nürburgring (NBR): 20 – 20 – 20

■ Scenario 2: WLTC



	Lap Time 7:45.75 min (–0.5%)
	Energy 18.75 kWh/100 km (–7.8%)
	Charge 10–80% ≈18.96 min (+0.8%)
	Cabin TTC 53 / 0 / 26 s (–88.3%)
	Aging 0.0837% modeled (–39.2%)
	Thermal 3.654 scored (+10.3%)
	Hard violation 0 °C (unchanged)

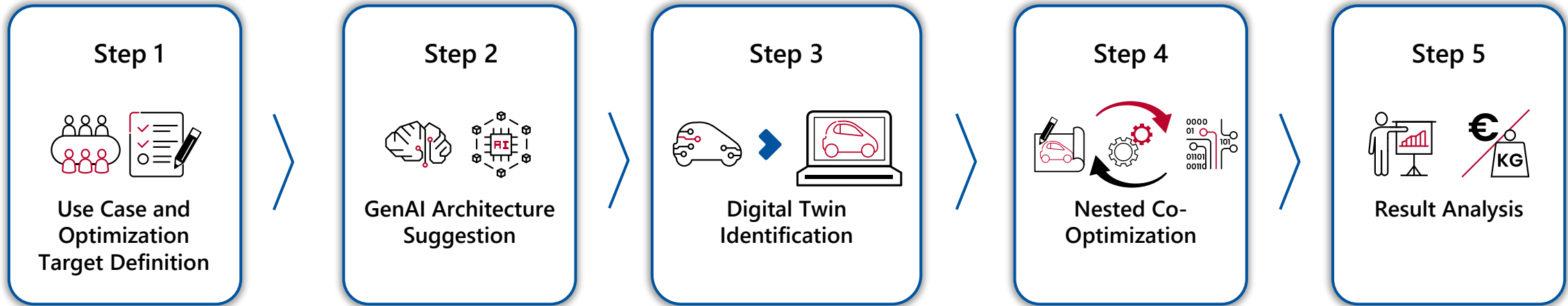
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FEV GenAISys

Better Vehicle Concepts in Weeks, Not Months



FEV GENAISYS COMBINES ARCHITECTURE GENERATION WITH JOINT DESIGN-CONTROL OPTIMIZATION TO SUPPORT CONCEPT DECISIONS



Scalable Generative AI & Bayesian Optimization for Comprehensive Resolution of Multi-Objective Design and Control Challenges

The Advantages

- Explore architecture, design and control together
- Effective concept workflows in less time at less cost
- Clear engineering trade-offs before decisions

The Outlook

- Broader FEV engineering knowledge and data
- AutoML for predictive model development
- Agentic CAD and 3D packaging

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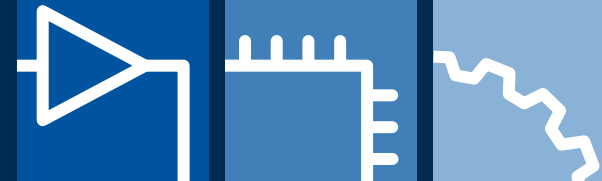
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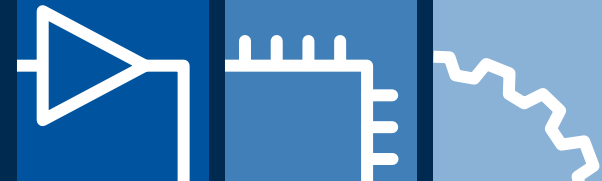
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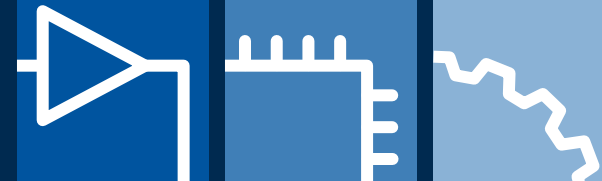
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Univ.-Prof. Dr.-Ing. Jakob Andert

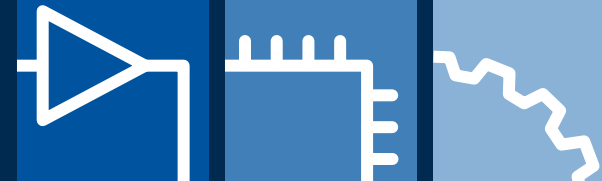
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**Thank you for your
attention!**

Questions?



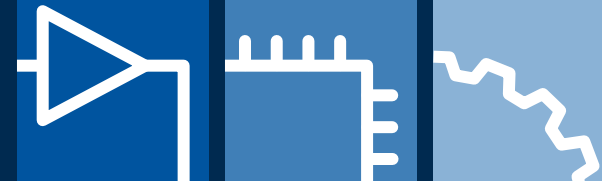
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Chair of Mechatronics in Mobile Propulsion



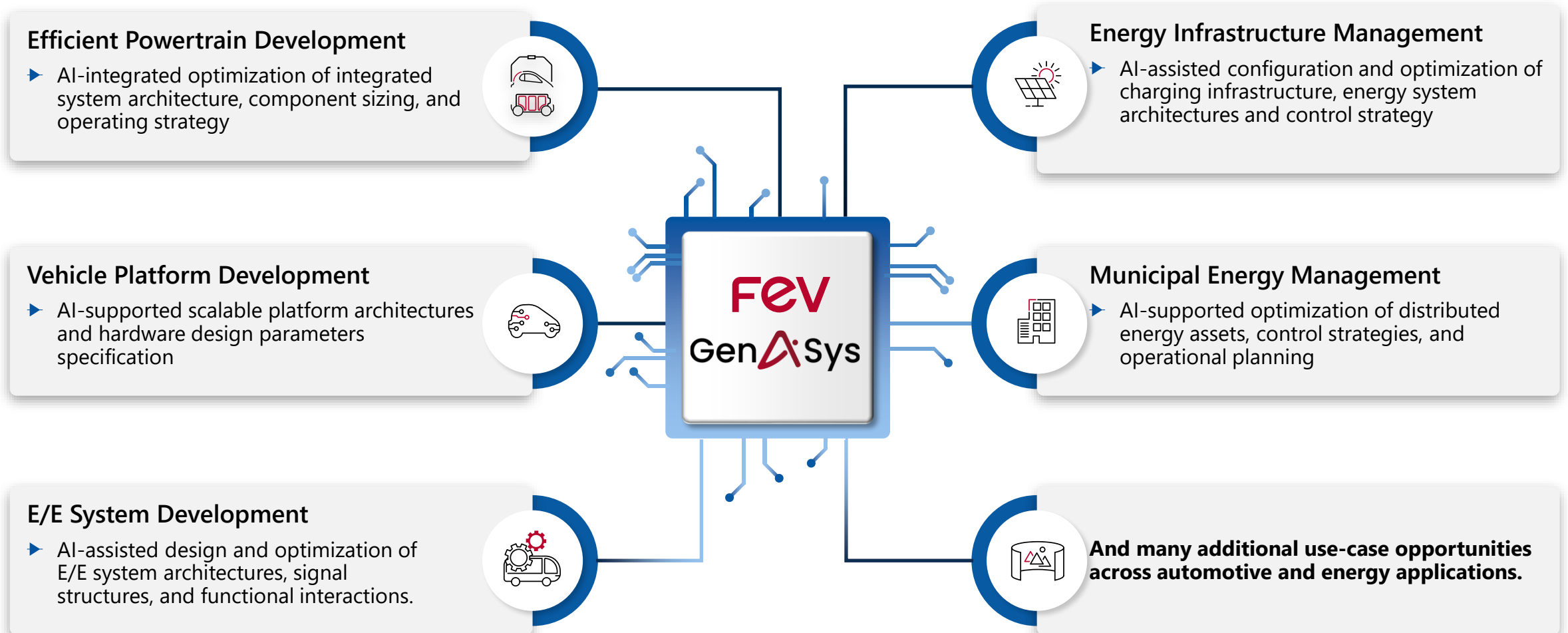
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FEV GenAISys Scalability Across Use Cases



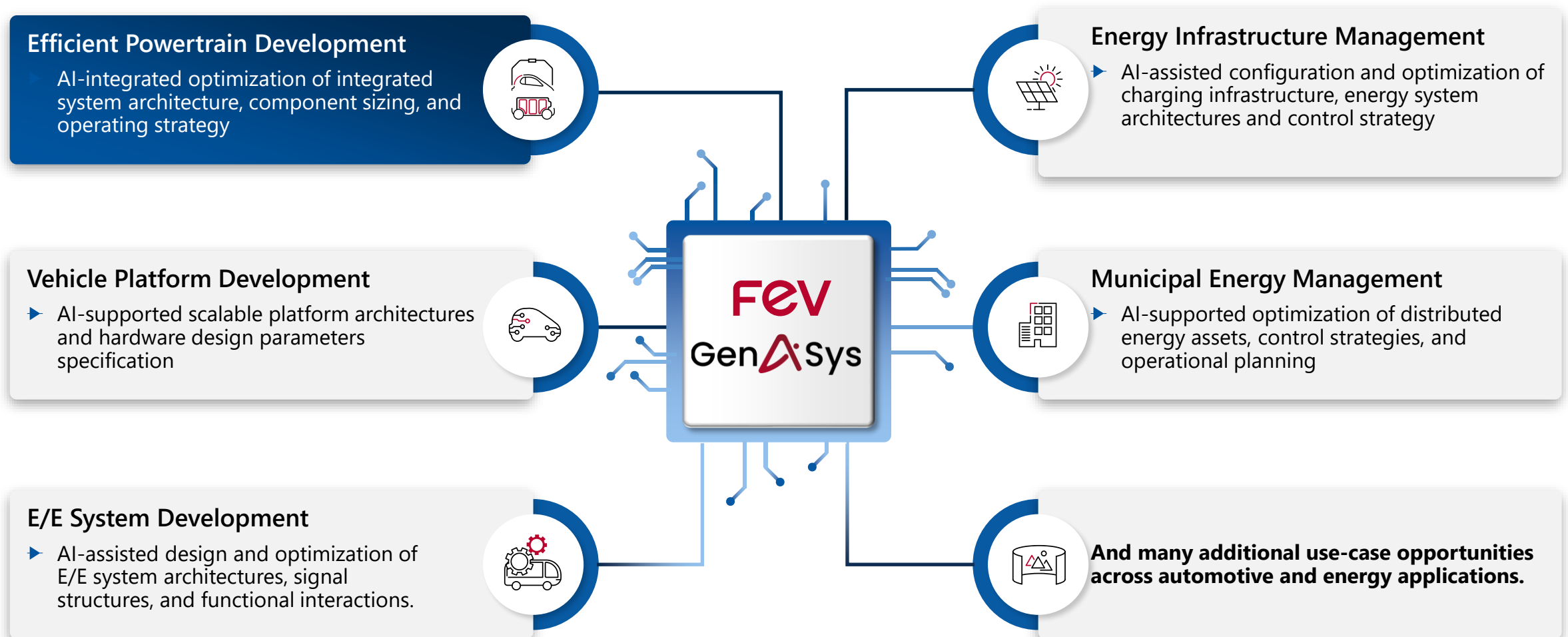
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Scalability Across Use Cases



E/E: Electrical and Electronic, Patents: DE102026109811A1, DE102025126037A1

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FEV GenAISys

Step 2: GenAI Multi-Agent Architecture Generation



FROM STAKEHOLDER INTENT TO ARCHITECTURE LOGIC – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 Selected Features

MANDATORY

- Battery Cooling ☒
- EDU Cooling ☒
- Cabin Air Conditioning ☒
- Ambient Heat Exchange Stack ☒
- Circulation & Expansion ☒

USE-CASE OPTIONAL

- Oil Circuit for EDU ☒
- Battery Heater ☒
- ICCU Cooling ☒
- Chiller Coupling ☒
- Multi Loop Segmentation ☒
- Twin Radiators ☒

2 User-Specific System Definition

"20 km Nürburgring drive ... **fixed 20-minute DC-charge stop** ... second 20 km Nürburgring drive" at "**-10, 23, and 35 degC**" with an "55 percent SOC" ambient-soaked start.

"lower completion time, energy, comfort time, aging damage, tracking error, and thermal exposure are better" ... "**higher charging delta SOC is better**" ... "**any positive temperature-limit violation is infeasible.**"

"Charging is fixed-time with **no terminal SOC target**" and remains component-map limited; demand-activated N Grin Boost keeps its "**10-second window and 10-second reuse lockout.**"

"**produce three materially different, simulation-relevant topologies**" by **varying only defensible, library-supported choices.**

3 Architecture Engine Translation

COLD START "Battery Heater ... for cold-start battery conditioning at **-10°C**; supports fast charging performance in cold ambient."

TRACK + HOT "Twin Radiators ... increased heat rejection capacity for high-performance track driving and **35°C** hot ambient."

CHARGE "ICCU Cooling ... integrating charger into coolant loop for the **fixed 20-minute charging phase.**"

CONTROL "Multi Loop Segmentation ... independent battery and EDU coolant circuits for specialized thermal control."

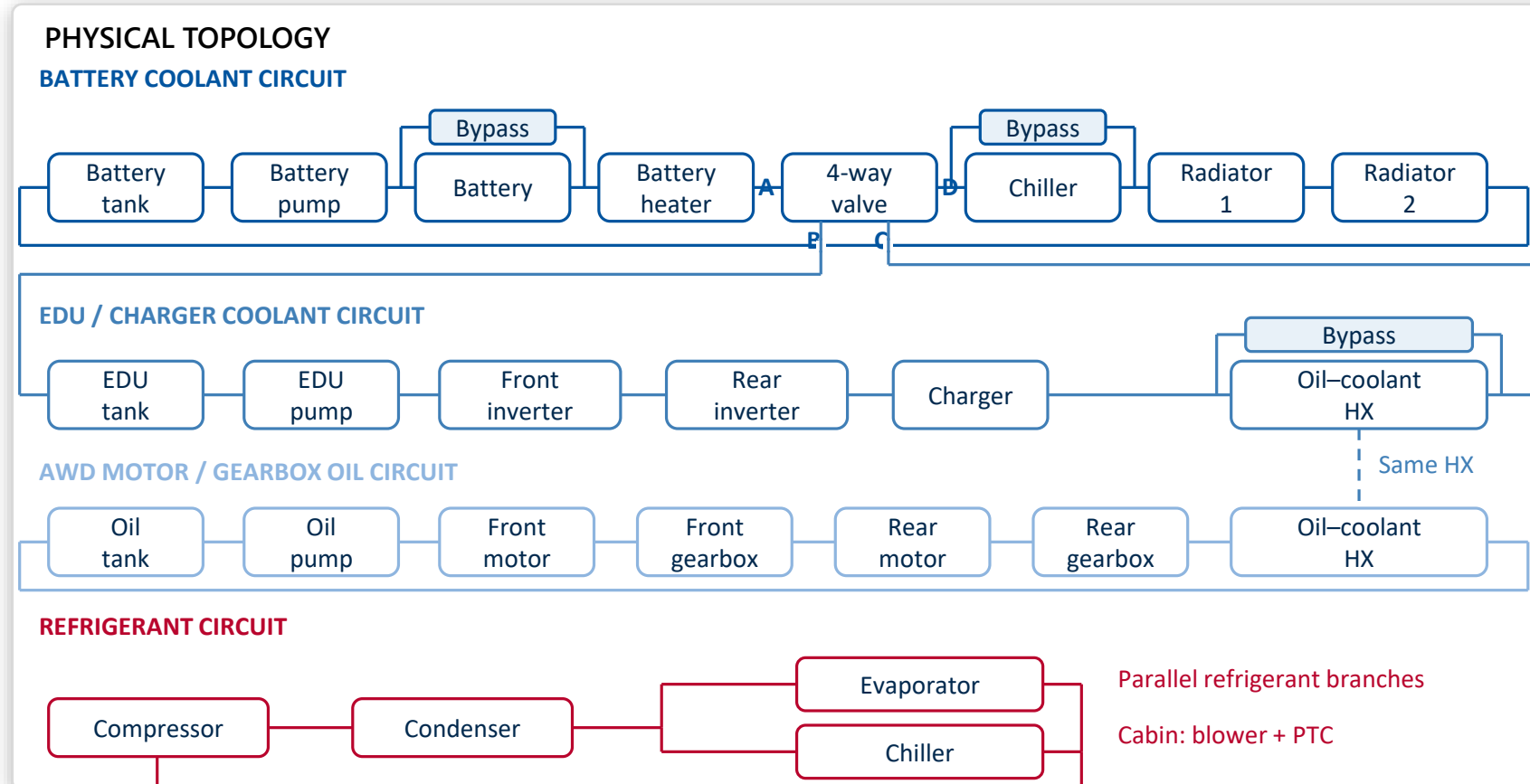
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Step 2: GenAI Multi-Agent Architecture Generation



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ARCHITECTURE 1 / 3 – BATTERY AND OIL-COUPLING BYPASSES – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5 N



SELECTIVE BATTERY ROUTING

ARCHITECTURE DIFFERENCE

Battery and chiller bypasses; oil-coolant HX bypass on the EDU coolant path. Both radiators remain inline.

BENEFIT

Selective battery conditioning and oil-to-coolant heat transfer; charger and both inverters remain cooled.

TRADE-OFF

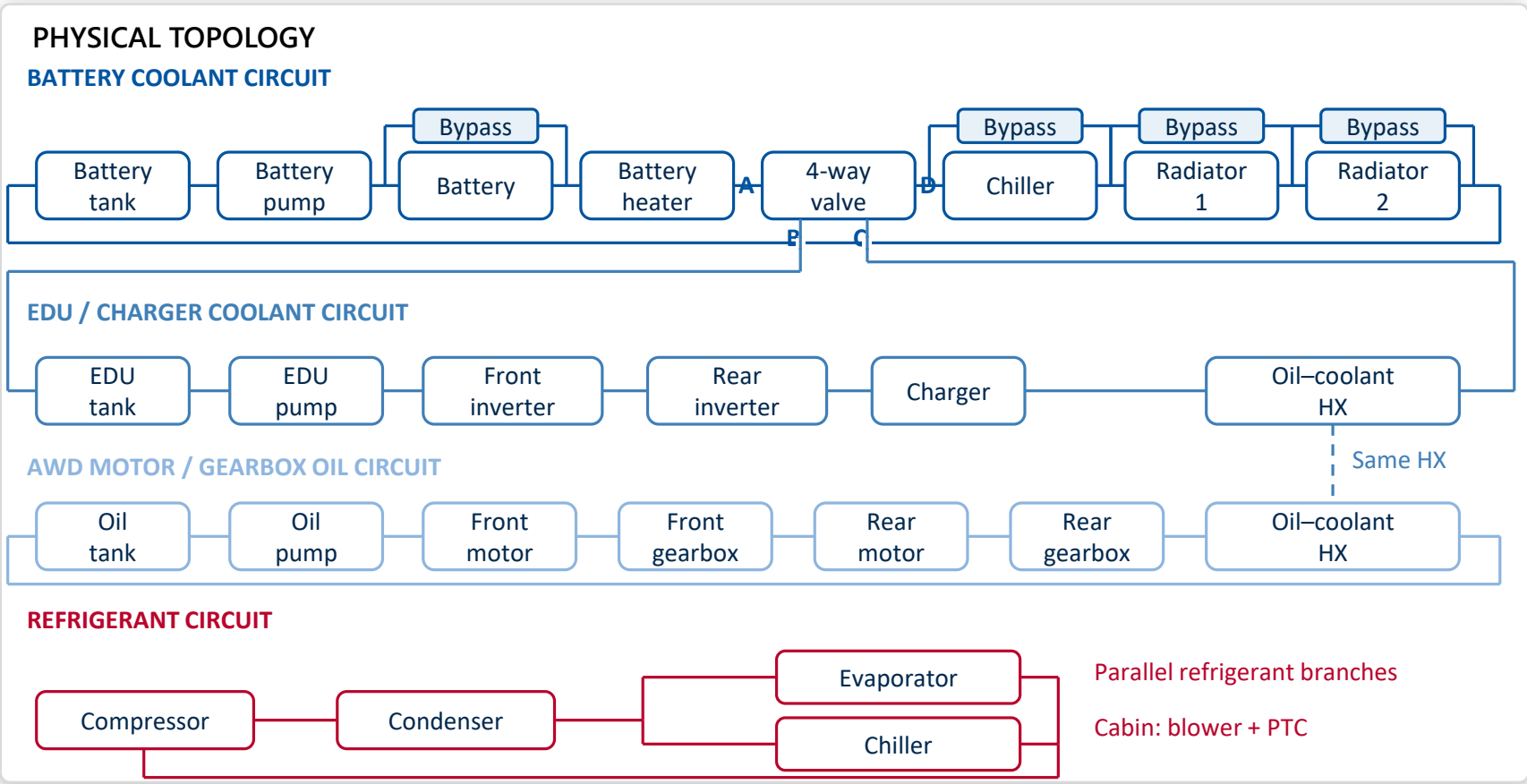
No separate radiator bypass, so ambient heat rejection is less configurable.

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Step 2: GenAI Multi-Agent Architecture Generation



ARCHITECTURE 2 / 3 – BATTERY AND TWIN-RADIATOR BYPASSES – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5 N



RADIATOR-STAGED ROUTING

ARCHITECTURE DIFFERENCE

Battery, chiller and both radiators each have bypasses. The oil-coolant HX remains inline on EDU coolant.

BENEFIT

Individual radiator staging broadens heat-rejection choices for hot driving and fixed-time charging.

TRADE-OFF

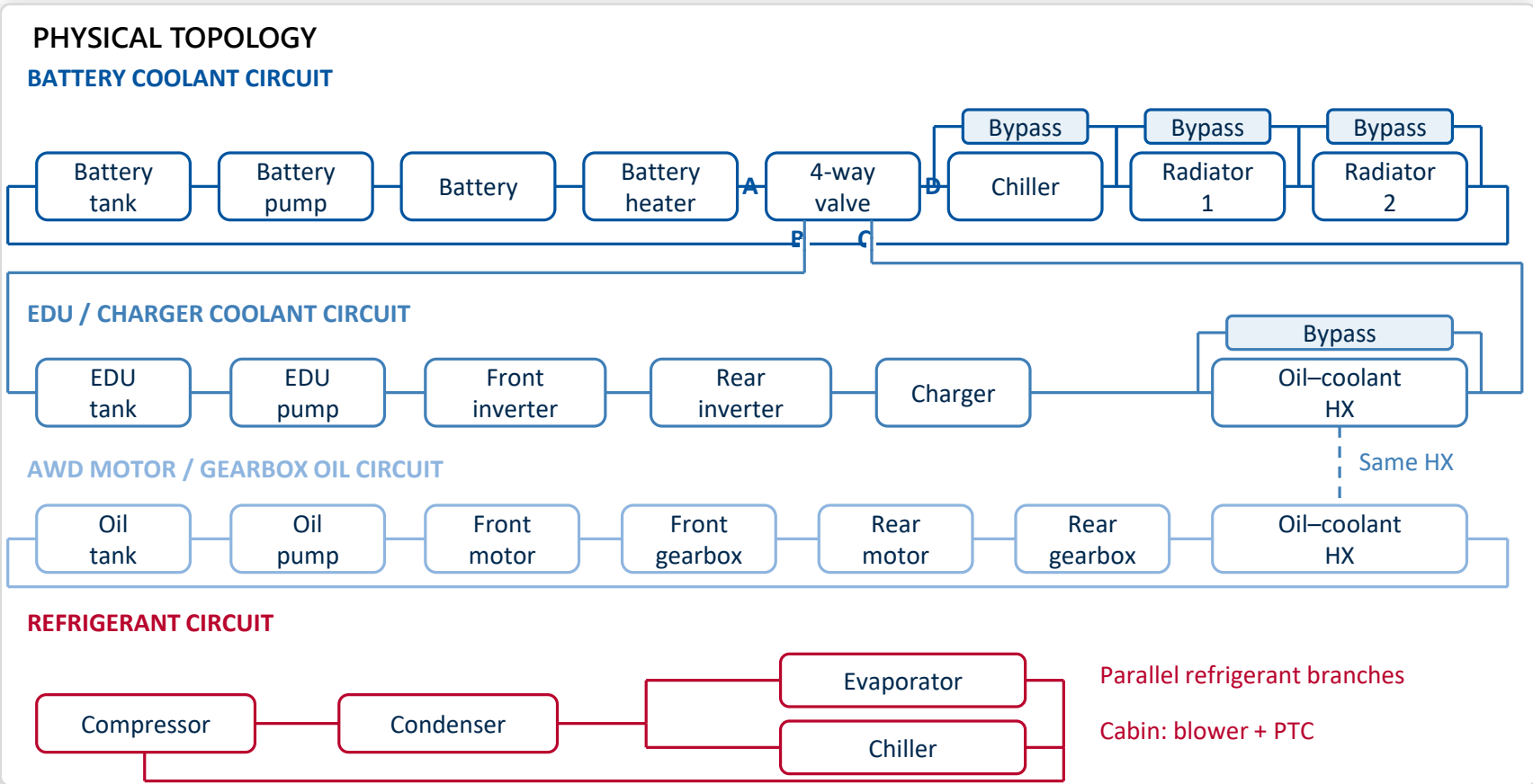
Four bypass commands add routing and calibration complexity.

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Step 2: GenAI Multi-Agent Architecture Generation



ARCHITECTURE 3 / 3 – RADIATOR AND OIL-HX BYPASSES – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5 N



SELECTIVE EDU OIL COUPLING

ARCHITECTURE DIFFERENCE

Chiller, both radiators and oil-coolant HX have bypasses; the battery stays inline. No EDU-string bypass.

BENEFIT

Selectable radiator and oil-coupling paths retain coolant flow through both inverters and charger.

TRADE-OFF

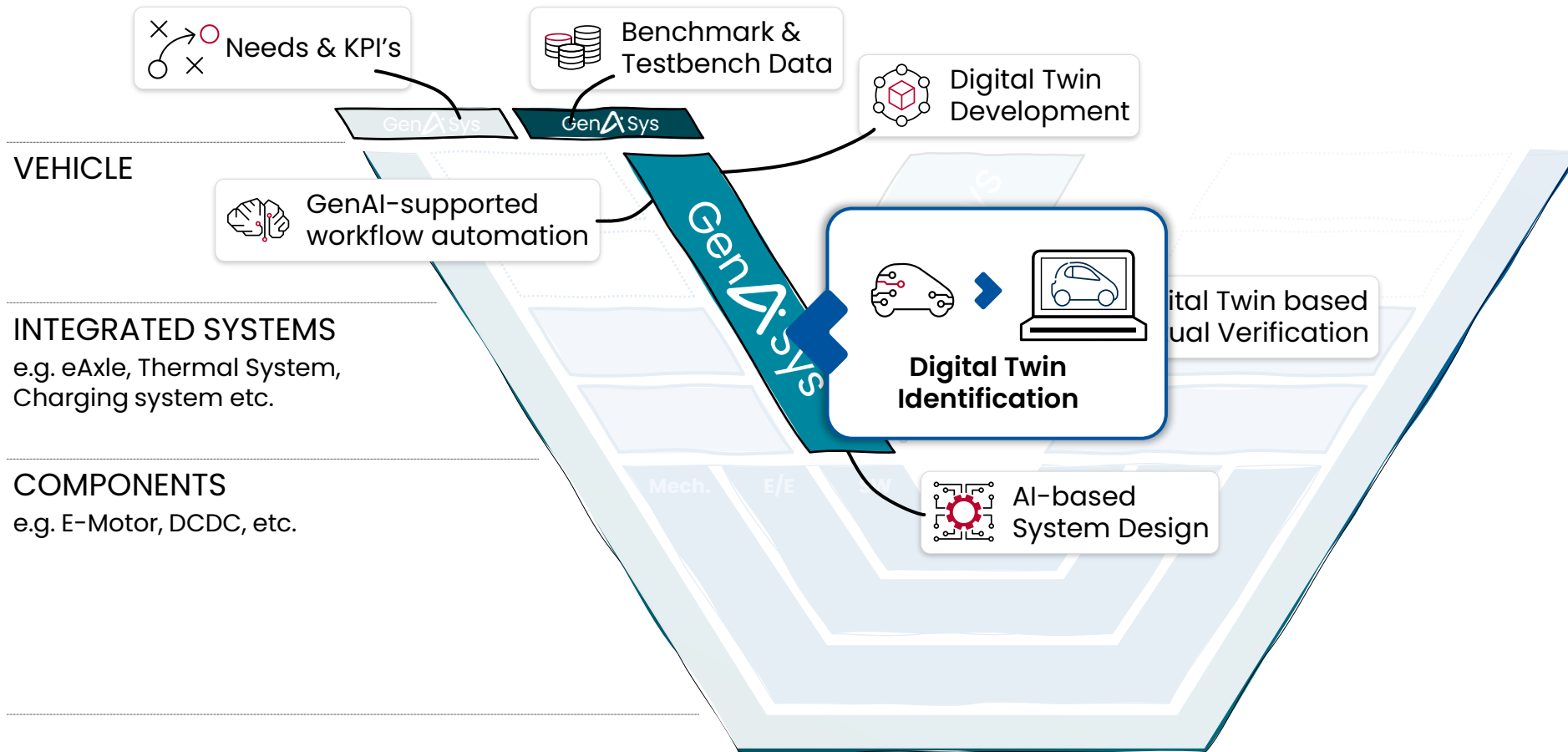
No dedicated battery bypass; four bypass controls require calibration.

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Step 3: Digital Twin Setup & Identification



FEV GENAISYS UTILIZES AI-BASED METHODS AND DIGITAL TWIN SUPPORTED EVIDENCE ACROSS SYSTEM DEVELOPMENT

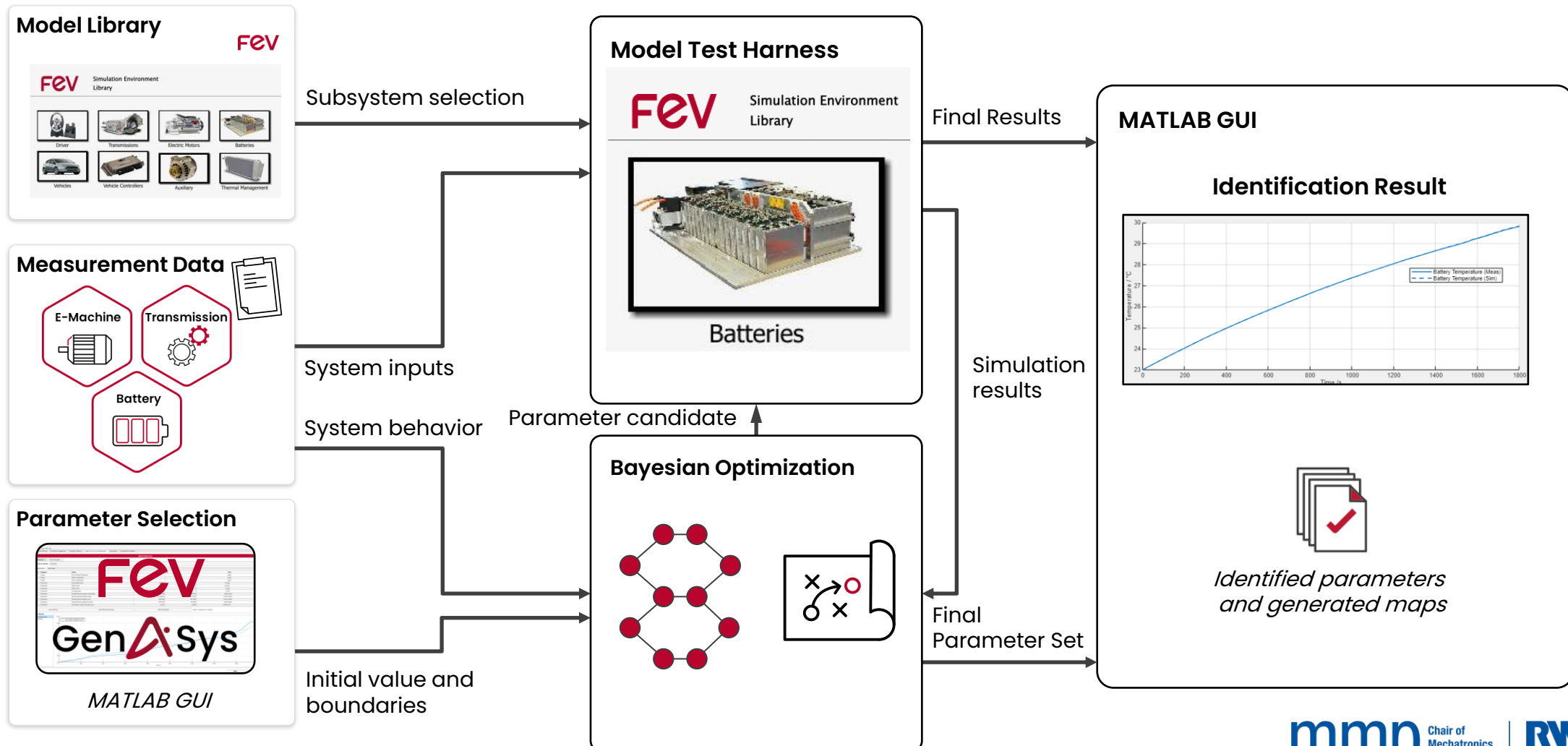


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Step 3: Digital Twin Setup & Identification



GENAISYS BAYESIAN OPTIMIZATION BASED DIGITAL TWIN PARAMETER IDENTIFICATION



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Step 4: The Innovation: Nested Co-Optimization



DEFINING THE COMPLETE DESIGN AND CONTROL SEARCH SPACE – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 Design Parameters – Defaults and Bounds

Parameter	Default	Min	Max	Parameter	Default	Min	Max
Architecture	2	1	3	EDU-pump displacement	0.030	0.020	0.050
Battery cells parallel	2	2	3	Oil-pump displacement	0.030	0.020	0.050
Front motor axial	1.00	0.80	1.20	Battery-heater scale	1.50	0.50	1.50
Front motor radial	1.00	0.80	1.20	Compressor-flow scale	1.00	0.50	1.50
Rear motor axial	1.00	0.80	1.20	PTC scale	1.00	0.50	1.50
Rear motor radial	1.00	0.80	1.20	Blower-flow scale	1.50	0.50	1.50
Front gear ratio	10.65	7.00	11.00	Fan flow	1.20	0.50	1.20
Rear gear ratio	10.65	7.00	11.00	Radiator length	0.80	0.40	0.80
Battery-pump displacement	0.050	0.020	0.050				

Pump displacement: l/rev; fan flow: m³/s; radiator length: m (same length for both radiators).

2 MPC Controls – Normalized Bounds

Control	Default	Min	Max
Battery pump command	0.00	0.00	1.00
Coolant heater command	0.00	0.00	1.00
Compressor command	0.00	0.00	1.00
Cabin blower command	0.00	0.00	1.00
PTC heater command	0.00	0.00	1.00
Cooling fan command	0.00	0.00	1.00

3 Optimization Settings

100 evaluations · Stall 50 · $\Delta \geq 0.01$ · 12 workers

GenAISys searches 17 design powertrain system parameters across the **electromagnetic, mechanical and thermal domain** together with six bounded thermal-control commands

FEV GenAISys

Step 4: The Innovation: Nested Co-Optimization



OPTIMAL SELECTED DESIGN VALUES FROM CANDIDATE #62 – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

1 Design Parameters – Defaults, Bounds and Selected Point

Parameter	Default	Min	Max	Opt.	Parameter	Default	Min	Max	Opt.
Architecture	2	1	3	3	EDU pump disp.	0.030	0.02	0.05	0.035
Battery cells parallel	2	2	3	3	Oil pump disp.	0.030	0.02	0.05	0.035
Front motor axial	1.00	0.8	1.2	1.054	Battery-heater scale	1.50	0.5	1.5	1.021
Front motor radial	1.00	0.8	1.2	1.005	Compressor-flow scale	1.00	0.5	1.5	1.453
Rear motor axial	1.00	0.8	1.2	1.106	PTC scale	1.00	0.5	1.5	1.298
Rear motor radial	1.00	0.8	1.2	1.051	Blower-flow scale	1.50	0.5	1.5	1.487
Front gear ratio	10.65	7	11	7.666	Fan flow	1.20	0.5	1.2	0.587
Rear gear ratio	10.65	7	11	7.269	Radiator length	0.80	0.4	0.8	0.681
Battery pump disp.	0.050	0.02	0.05	0.035					

Pump displacement: l/rev; fan flow: m³/s; radiator length: m (same length for both radiators).

2 MPC Controls – Normalized Bounds

Control	Default	Min	Max
Battery pump command	0.00	0.00	1.00
Coolant heater command	0.00	0.00	1.00
Compressor command	0.00	0.00	1.00
Cabin blower command	0.00	0.00	1.00
PTC heater command	0.00	0.00	1.00
Cooling fan command	0.00	0.00	1.00

3 Source

GenAISys completed 100-evaluation Co/Parallel run

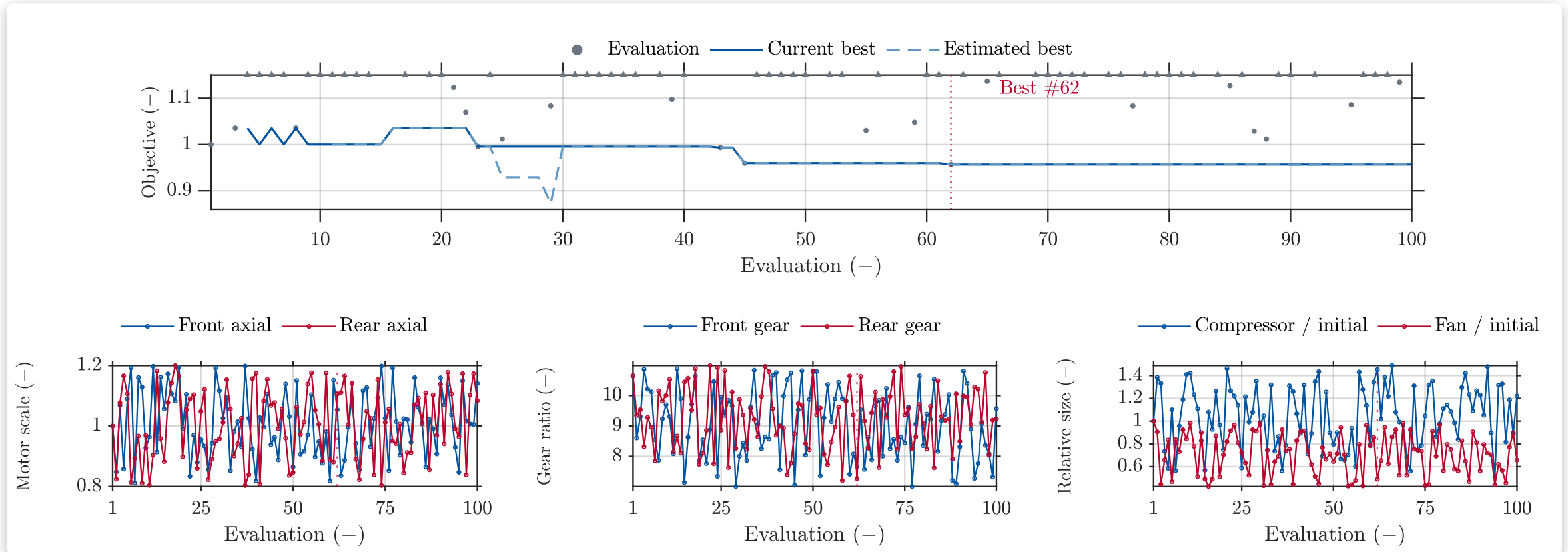
Candidate #62 selects Architecture 3 and a 3p battery, larger axial motor scales and lower gear ratios. The unchanged design-0 reference is retained for all parameter comparisons.

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Step 4: The Innovation: Nested Co-Optimization



OUTER LOOP TRAINING PROGRESS – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N



Bayesian optimization selected candidate #62 under the original combined objective. The plots show current/estimated minima, evaluated candidates and representative design-parameter trajectories.

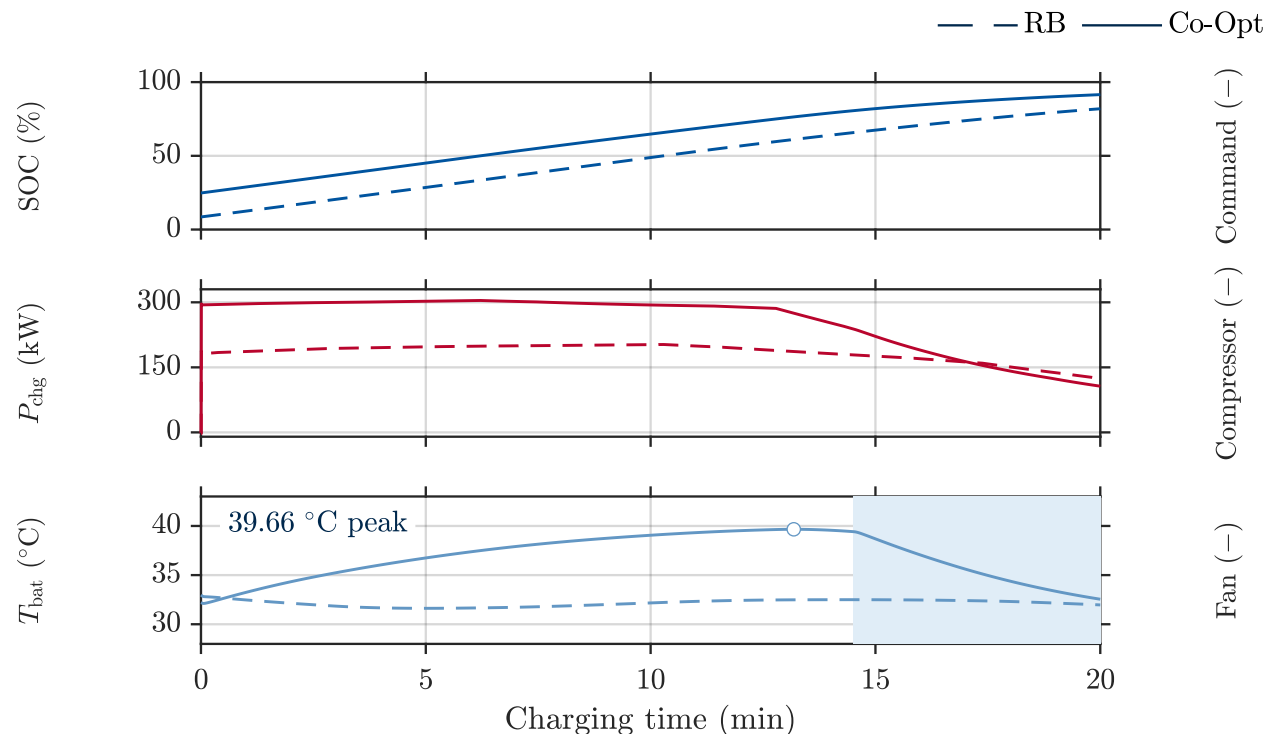
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Step 4: The Innovation: Nested Co-Optimization

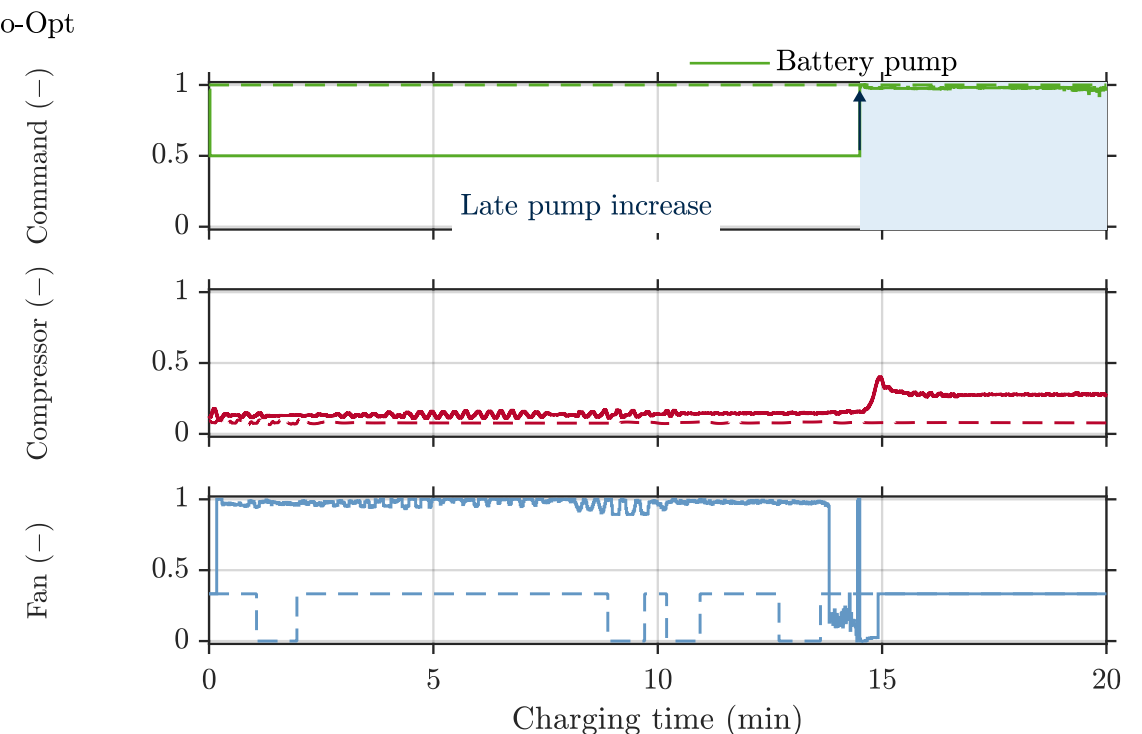


DRIVING AND CHARGING PERFORMANCE EVALUATION IN NBR SCENARIO – EXAMPLE USE-CASE: RE-IMAGINED IONIQ 5N

Charging



Cooling Actuators



Charging absorbs more energy but produces more battery heat. Separate actuator plots highlight the late pump increase and the subsequent decline from the 39.66 °C peak.