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NEXT-generation physics and data-based Battery Management Systems for optimised battery utilisation

NEXTBMS - Deliverable report

D4.1 - Upscaling and sizing methodology for different battery pack voltage level

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Project summary

NEXTBMS will develop an advanced battery management systems (BMS) built on fundamental knowledge and experience with the physicochemical processes of lithium-ion batteries, which will enable the significant enhance of current modelling approaches, including the readiness for upcoming lithium (Li) battery material developments. These modelling approaches will be further improved by optimising sensors and measurement techniques to meet modelling needs (and optimising models based on physical sensor data) and the physical cell configurations to form a framework that supports improving the battery state prediction and -control. By solving these challenges, NEXTBMS will ensure that the next generation of BMSs will enable higher performance, safety, and longer lifetime of the battery cells for an overall optimal utilisation of the battery system.

Publishable summary

This deliverable has presented two-fold activities: (a) Task 4.1: battery pack upscaling and sizing using an optimization framework built on a model-based vehicle simulation platform and stationary load profile, and (b) Task 4.2: virtual testing of the upscaled battery pack through a physical e-axle setup.

Regarding point (a), this deliverable presents a comprehensive battery pack upscaling and sizing methodology for both passenger-car and stationary energy applications, developed in a MATLAB/Simulink simulation environment. The process begins by extracting the power and current demands from various application-centric profiles to the battery pack. Using this information, an optimization strategy is formed to identify the optimal battery pack configuration—including cell chemistry selection, cell-to-cell variation and series/parallel topology—to meet OEM operational requirements. A multi-objective genetic algorithm (NSGA-II) is employed to efficiently explore the design space and determine optimal pack configurations. For stationary applications, real-field grid-service power profiles are used to derive the optimal battery pack configuration.

Regarding point (b), to virtually validate the optimized battery pack configurations, the simulation environment is complemented by VUB's Open Vehicle Powertrain Platform (OVPP), a physical e-axle platform capable of reproducing OEM-specific (TOFAS) battery pack behavior. This setup enables verification of the optimized pack against real-life vehicle dynamics, ensuring that the design satisfies performance requirements not only in simulation but also within a HiL testing environment.

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Abbreviations & Definitions

Abbreviation	Explanation
ANO	Anode
BMS	Battery Management System
CAT	Cathode
EVs	Electric vehicles
FMI	Functional Mock-up Interface
FMU	Functional Mock-up Unit
HiL	Hardware in Loop
Li	Lithium
MC	Monto- Carlo
Np	Number of cells in parallel
Ns	Number of cells in series
PB	Physics-Based model
Phi_s_ SEP_ANO	Anode potential at the separator
Phi_s_CAT_SEP	Cathode potential at the separator
SEP	Separator
SoC	State of Charge
SoH	State of health
SOTA	State-of-the-art
WLTP	Worldwide Harmonised Light Vehicle Test Procedure

1 Introduction

This document presents: (a) an optimal battery pack sizing methodology applicable to passenger-car and stationary use cases, and (b) a virtual pack testing approach.

Optimal Pack sizing methodology:
A multi-objective-based optimization method is adopted for battery upscaling (module-pack) that considered cell-to-cell variations and minimize cost whilst maximizing range and satisfying all general specifications and constraints, including mass, volume, and other relevant limits. VUB leads the development of the module (12S1P, 48 V) to optimal pack sizing based on these specifications. TOFAS and EDF provides system-level requirements, respectively for automotive and grid applications. The needed cell models in FMU format are contributed by UL.

Virtual pack testing:
The upscaled battery pack configuration is evaluated using the WLTP driving cycle and validated against vehicle test conducted by TOFAS. Upon receiving the test data from TOFAS, VUB sets up and calibrates the Open Vehicle Powertrain Platform (OVPP) to closely represent the response of the TOFAS EV Doblo under WLTP driving cycles. Based on the results of the optimal battery pack sizing and considering the NEXTBMS battery module (12S1P , 12 cells in series , one in parallel), a configuration of 84S2P, comprising a total of 168 cells, "a series string comprises 7 × 12S1P modules (84S), and two strings in parallel form an 84S2P pack with 168 cells total. This battery pack configuration is chosen for further analysis. This battery pack, with a total energy capacity of 36.5 kWh (useable energy of 27.88 kWh), is assessed to determine the extent to which it satisfies the design constraints of the TOFAS use case, including the nominal voltage window, weight, and space limitations.

The other sections of this deliverable are structured as follows: Section 2 describes the version of a physics-based battery cell model in FMU format; Section 3 presents the use-case requirements and specifications; Section 4 introduces the battery pack upscaling framework; Section 5 describes the optimization method and the corresponding results ; Section 6 illustrates the virtual test execution and the obtained test results; Section 7 provides a summary.

2 FMU- based battery cell model

Battery cell models can be developed in various simulation environments, such as MATLAB/Simulink, Python, or Modelica. When these platforms support the FMI standard, the models can be exported as Functional Mock-up Units (FMUs), enabling tool-independent deployment. In this form, the FMU can be integrated into different simulation frameworks and used for co-simulation with other subsystems, as in our application, including the BMS, thermal management, vehicle dynamics, and grid dynamics. Figure 1 shows the physics-based model of the battery cell implemented as an FMU with I/O interfaces.

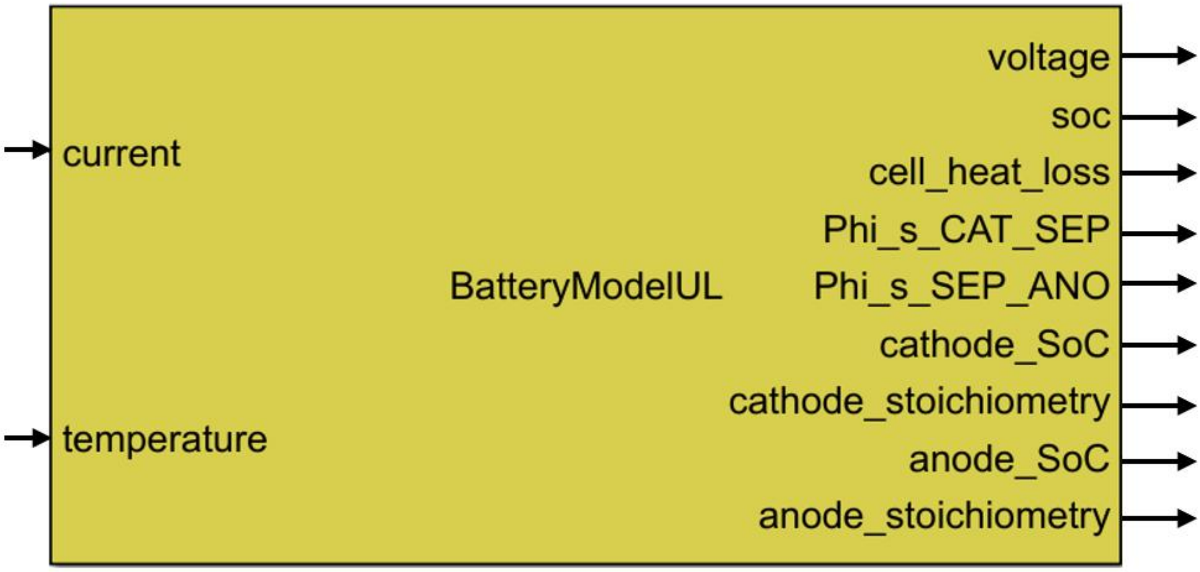

Figure 1: Battey cell FMU model.

The battery cell model developed in NEXTBMS is a physics-based model delivered as an outcome of Task 2.1 via UL. The key advantage of such physics-based model results from the mapping of the electrochemical processes in battery cells, the material properties and the geometrical parameters of the cell to the model topology, the corresponding governing equations and their parameters, which improves the physicochemical consistency of the applied models. Therefore, the electrochemical models enable modelling of coupled intra-cell phenomena in much greater detail, for example transport of charged species, electric potentials, electrochemical reactions, heat generation and degradation. Current and cell temperature are used as input parameters, whereas initial cell voltage serves as a parameter to set the lithiation levels of cathode and anode to appropriate levels. Besides the typical battery model outputs (prediction of terminal voltage, state of charge (SoC), and cell heat loss), the main results of the electrochemical model are spatially resolved concentration fields of Li/Li^{+} and spatially resolved solid and liquid phase potentials (denoted with Phi_s on the figure above). The model will be used as a virtual sensor for electrode potential to prevent undesired side reactions such as Li-plating, cathode and electrolyte degradation.

2.1 Battery cell specifications

The battery cell used in the NEXTBMS project is a prismatic cell with the specifications and characteristics listed below in Table 1. The calibration and parameterisation of the battery model are carried out for this cell.

Table 1: Battery cell specification

Parameter	L148N58A
Form Factor	Prismatic
Nominal Voltage [V]	3.75
Voltage Range [V]	2.2-4.35
Capacity[Ah]	58
Energy[Wh]	217.5
DCIR[mΩ]	0.6~0.8
Continuous C-rate[-]	2
Mass[g]	926±20
Dimensions[mm]	W=148.24±0.15, T= 26.66±0.15, H=105.9±0.2

3 Use case preparations

Virtual battery upscaling (project Task 4.1) is conducted for two use cases, specifically:(a) an automotive use case and (b) a stationary use case. While virtual pack testing (Task 4.2), however, has been carried out only for the automotive use case. In the following sections, the specifications for these two use cases are elaborated.

3.1 Requirements and Specification of the Automotive Use case

As one of the primary objectives of this deliverable is system-level validation across multiple application scenarios, this subsection sets out the detailed requirements and specifications for the automotive use case. This use case has been defined based on bilateral discussions with the NEXTBMS OEM - TOFAS. Table 2 shows a few generic parameters that are being used in the battery pack sizing activity.

Table 2: Specification of the automotive use case.

Parameters	Values
Motor power	100 [kW]
Battery power	29.3 [kWh]
Battery Pack Voltage	280-400 [V]
Range	Up to 140 [km]
Top Speed	130 [km/h]

3.2 Requirements and Specification of the Stationary Use case

The second use case focuses on a stationary battery energy storage power plant integrated into a microgrid located in one of the French territories. The installation is intended to improve grid stability by delivering both primary and secondary frequency control services. The system specifications are listed in Table 3, and have been defined based on bilateral discussions with the NEXTBMS grid service provider - EDF.

Table 3: Specification of the stationary use-case.

Parameters	Units	Nominal Value	Remark
Energy	[kWh]	1600	
Continuous Power	[kW]	1600	
Charge Peak Power @ minimum SoC	[kW]	3200	Minimum SoC value = 0%
Charge Peak Power @ Maximum SoC	[kW]	528	Maximum SoC value = 100%
Battery Pack Maximum Voltage	[V]	940V	
Pack Nominal Voltage	[V]	700V	
Pack minimum Voltage	[V]	480V	
Maximum Current	[A]	5000A	

4 Battery pack upscaling framework

In this section, the battery cell-module-pack upscaling methodology for both use cases have been discussed. The same workflow is used across both use cases. And the upscaling framework is developed in MATLAB/Simulink environment.

4.1 Battery cell-module-pack upscaling and sizing methodology

The upscaling activities are performed using NEXBMS battery cell and module configuration 12S1P (12 cells in series, one parallel string), with a nominal voltage of 48 V to satisfy the power requirements of the two use cases as described in Table 2 and Table 3. This deliverable proposes a metaheuristic, multi-objective optimization method, called, Non-sorted Genetic Algorithm (NSGA-II) for battery cell–module–pack upscaling that incorporates both system-level requirements and constraints.

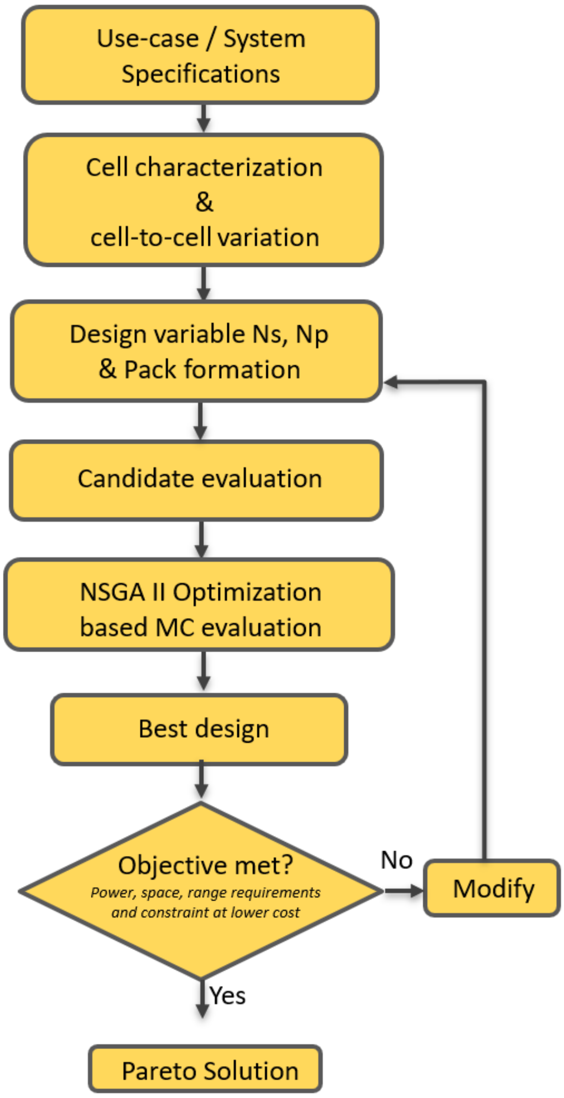

Figure 2: Battery cell-module-pack upscaling workflow.

These include, in particular, driving-range requirements (usable energy), acceleration-time targets (peak power), DC-bus voltage window, allowable SOC window, thermal limits (maximum cell temperature and ΔT), space and packaging constraints, mass constraints, cost targets, lifetime requirements (cycle and calendar life), safety and compliance requirements, cell-to-cell variation (capacity and impedance dispersion), and end-of-life reliability margins. The workflow of the upscaling phase of the battery pack sizing is illustrated in Figure 2.

As shown in the Figure 2, the overall workflow consists of six main steps: (a) first, the system specification defines the high-level vehicle and pack requirements (b) second, the cell characterisation and cell-to-cell variation step loads the OCV–SOC curve (see Figure 3), selects the cell model and nominal parameters, and specifies statistical spreads in R_0(Equation 2), capacity(Equation 3), initial SOC(Equation 4), UA (Equation 5) and path resistance that will be used later in the Monte-Carlo analysis. To be more specific, unavoidable differences between cells mainly in internal (ohmic) resistance and capacity lead to uneven heating and/or non-uniform performance at pack level, which can prevent the pack from supplying the required power. In series strings, capacity mismatch is the main cause of energy loss, while combined variations in capacity and resistance limit the available power. In parallel branches, resistance differences create current imbalance: some cells are under-used whole others are over-stressed, especially near end-of-discharge, which increases the risk of deep-discharge and reduces lifetime. In this simulation, following previous work on intra-pack heterogeneity [1,2], these cell-to-cell variations are modelled as Gaussian perturbations around nominal values and then clipped to physically realistic bounds (Equation 1); (c) the third step is the pack formation and Ns/Np design-space step, uses the pack geometry to determine which combinations of series and parallel cells are physically feasible and to set the bounds for Ns and Np; (d) after that, a candidate evaluation step takes any given (Ns, Np), computes nominal and usable energy, range, mass and voltages, applies fast analytic constraints, and, if those are passed, runs a Monte-Carlo transient simulation to estimate the pass probability under cell-to-cell variation; (e) next, the multi-objective optimisation (NSGA-II or grid sweep) explores the Ns/Np design space, repeatedly using this approach to search for designs that minimise cost, maximise range and satisfy the robustness constraint; and (f) finally, the best designs are selected based on the Pareto front.

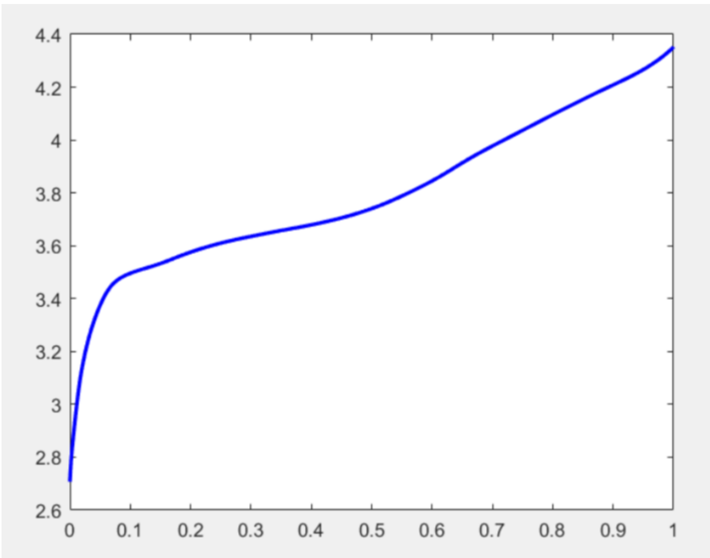

Figure 3: NEXT-BMS battery cell OCV curve

Clipping function

Equation 1

$$clip = (x; a, b) = min(max(x, a), b)$$

Internal resistance

Equation 2

$$R_0^{(i,j)} = clip\left(R_{0,nom}[1 + \sigma_R \mathcal{N}(0,1)]; 0.5R_{0,nom}, 2R_{0,nom}\right)$$

Capacity

Equation 3

$$Q^{(i,j)} = clip\left(Q_{nom}\left[1 + \sigma_Q \mathcal{N}(0,1)\right]; 0.7Q_{nom}, 1.3Q_{nom}\right)$$

Initial SoC

Equation 4

$$SoC^{(i,j)} = clip(\bar{s} + \sigma_{SoC} \mathcal{N}(0,1); 0, 1)$$

Cooling /thermal

Equation 5

$$UA^{(i,j)} = clip(UA_{base}[1 + \sigma_{UA} \mathcal{N}(0,1)]; 0.2UA_{base}, 5UA_{base})$$

i (series index) and j (parallel index) denote a cell's position in the $S \times P$. The symbol σdenotes the fractional standard deviation, and $\mathcal{N}(0,1)$ is a standard normal variate (mean 0, standard deviation 1). $\bar{s}$ denotes the mean state of charge (SoC). Q_{nom} is the nominal cell capacity, used as the mean for capacity sampling.

4.2 Vehicle simulation platform

Figure 4 shows the MATLAB/Simulink interface of the virtual simulation platform representing the automotive use case. The platform is integrated with the FMU of the PB cell model, developed for the NEXTBMS battery cell by UL as part of WP2 [3]. As illustrated in Figure 4 the DC current from the vehicle model is used as an input to the battery model. The vehicle model used in this activity is a feed-forward vehicle model comprising three main subsystems:

- Traction system, including the inverter, motor, and gearbox;
- Auxiliary system, including the auxiliary DC–DC converter and the heating, ventilation, and air-conditioning (HVAC) system; and
- Control system, which tracks the speed reference and implements the energy management and thermal management strategies.

The main objective of this simulation is to analyse the interaction between the vehicle powertrain and the battery pack. In this setup, the vehicle powertrain model computes the dynamic battery current demand based on the driving cycle, while the coupled battery pack model—obtained by upscaling the PB battery cell model to the module and pack levels—supplies the corresponding DC bus voltage and state evolution (state of charge and temperature) under different driving-cycle scenarios.

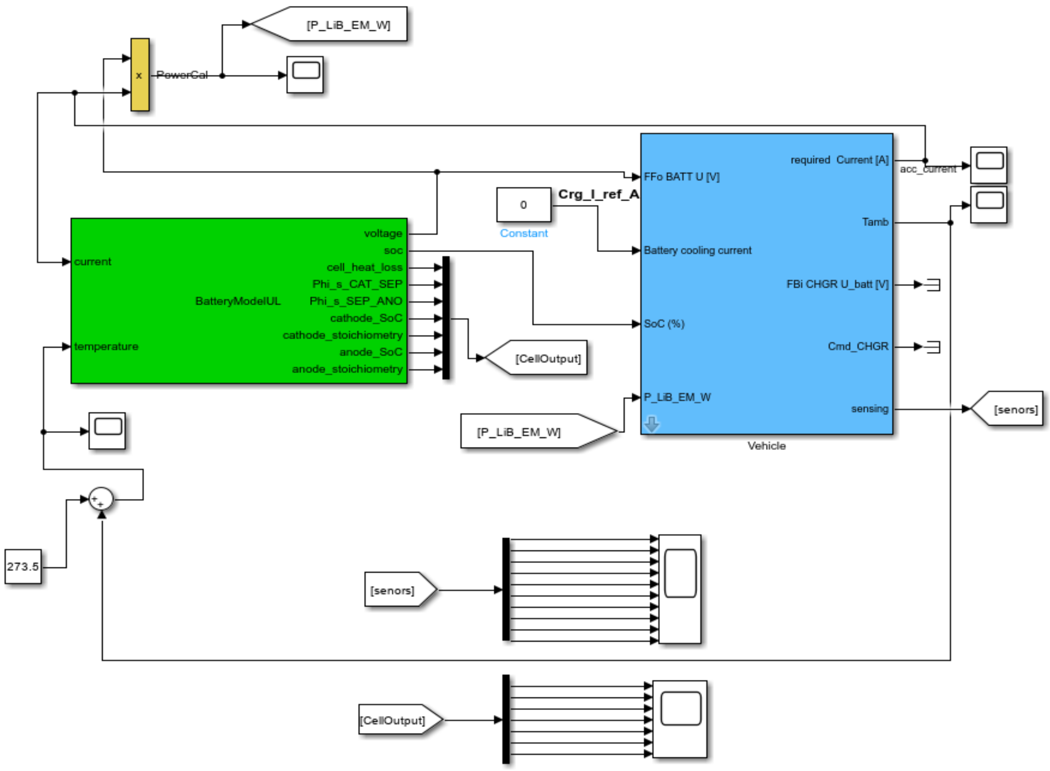

Figure 4: Simulink model of the vehicle powertrain integrated with the battery pack.

4.3 Stationary load profile simulation

As discussed earlier for stationary use case, the battery system is configured as a grid-support device, the main objective is to stabilise the grid by providing primary and secondary frequency control (frequency regulation) services. Figure 5 depicts the power demand profile of this stationary use case. According to this graph the battery usually operates at relatively low power, with small charge and discharge variations around zero. From time to time, short high-power peaks occur: positive peaks (up to about 600 kW) when the battery delivers power, and negative peaks (down to about –300 kW) when the battery is being charged.

Figure 5: The load profile of EDF use case for month time period.

5 Optimal Pack configuration for use cases

5.1 Objective functions and problem formulation

The optimization algorithms developed in the NEXTBMS project as part of T4.1, aim to minimize cost and maximize range, while satisfying all general specifications and constraints, including mass, volume, and other relevant limits. Hence, in this case the objective functions and constrains for this pack configuration are listed as below:

Design Variables: N_s, N_p
Objectives functions:
$f_1(x) = cost(x)$
$f_2(x) = -range(x)$

Used constrains :

g_1=g_top_abs	Absolute worst-case pack voltage below HW max
g_2=g_top_ocv	Usable-top OCV below pack max
g_3=g_bottom_ocv	OCV at SOC floor above pack min
g_4=g_footprint	satisfying the given footprint
g_5=g_mass	Pack mass ≤ mass limit
g_6=g_energy	Nominal energy ≥ target
g_7=g_range	Usable-energy range ≥ required km
g_8=g_under_pack	Under-load pack voltage ≥ min limit
g_9=g_under_cell	Under-load cell voltage ≥ cell min
g_{10}=g_pf	MC transient pass probability ≥ required value
g_{11}=g_max_par	Parallel stacks fit in height

This sizing methodology first loads a measured OCV–SOC curve for the cell and defines all pack- and cell-level specifications, including voltage limits, energy and range targets, mass and pack formation constraints, cell cost and mass, and a 1D thermal model through the cell thickness. It also incorporates realistic effects such as temperature-dependent resistance, self-discharge, cell-to-cell variation in capacity and resistance, and cooling variation via a heat-transfer coefficient.
For every candidate (N_s, N_p), the approach computes key performance metrics: nominal energy, usable energy (considering SOC window, temperature derates, aging, rate capability, and manufacturing tolerance), resulting driving range for a given energy consumption, total pack mass, and pack cost. It performs voltage checks at the top and bottom of the SOC window (both at OCV and under load) and enforces geometric constraints derived from the vehicle footprint, maximum pack height, and deck configuration. To capture transient behaviour, a Monte-Carlo (MC) transient simulation is run over a defined power profile (peak and continuous power) to estimate the probability that voltage, current, SOC, and temperature limits are respected; this probability is used as an additional robustness constraint.
On top of this physical and constraint model, an NSGA-II multi-objective optimization (implemented with an open-source framework “pymoo”) is applied over integer values of (N_s, N_p). The objectives are to minimize pack cost and maximize driving range (implemented as minimization of the negative of range), subject to all electrical, thermal, packaging, mass, energy, range, and robustness constraints. The optimizer produces a Pareto front in cost–range space, from which the best (N_s, N_p) design options can be selected.

5.2 Optimization results

As illustrated in Figure 6 and Figure 7, the sizing framework generates a set of pareto-optimal solutions by evaluating the trade-offs between the primary objectives “increased driving range at lower cost” while satisfying system specifications such as the nominal voltage window, weight limits, and space constraints. The optimal solution refers to the 89S2P configuration (89 cells in series and two parallel strings), providing the best trade-off between range, cost, and mass. The detailed specification of the selected battery pack can be found in Table 4.

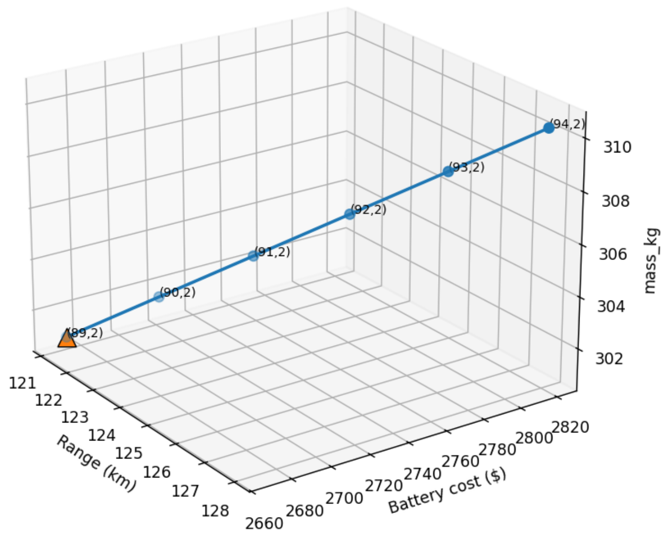

Figure 6: Pareto front graph for the automotive use cases

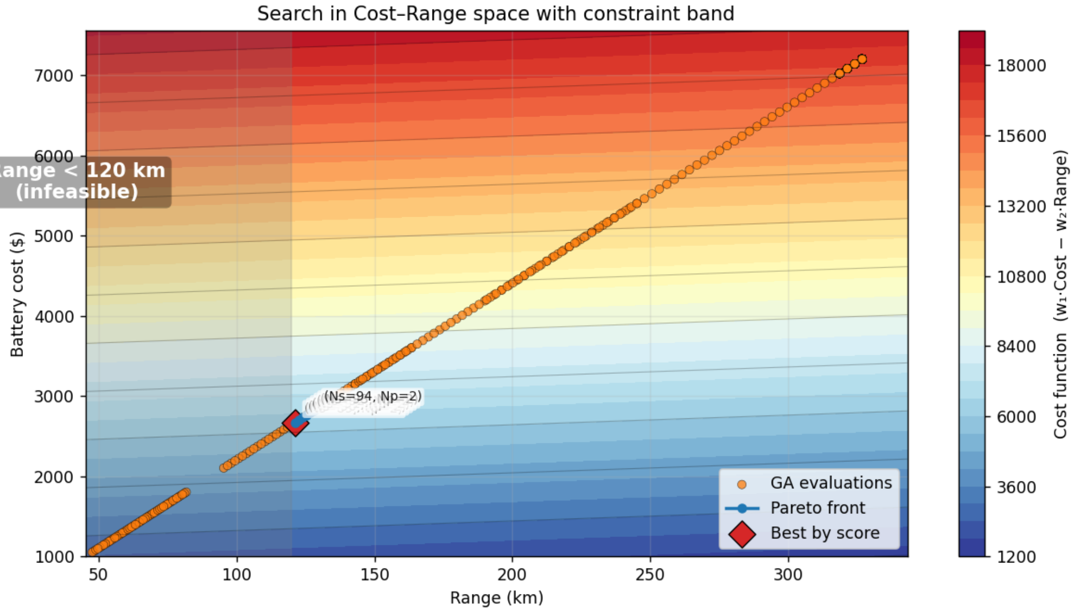

Figure 7: Cost–range trade-off with GA evaluations, Pareto front, and best feasible design.

Table 4: Optimization results for the automotive use-case.

Parameters	Optimal Pack configuration	TOFAS Pack Value
Proposed Ns, Np	89S2P	96S2P
Useable Energy	27.88 [kWh]	29.3 [kWh]
Range	120 [km]	140 [Km]
Pack Max. Voltage	374.6 [V]	400 [V]
Pack Min. Voltage	311 [V]	280 [V]
Pack weight	301 [kg]	314 [kg]

5.3 Optimization results for the stationary application

Figure 8 shows the Pareto-optimal solutions given the general system specifications discussed in Section 3.2, the battery cell characteristics listed in Table 1, and the provided power profile with current-related specifications (e.g., a slow-dynamics C-rate). The best possible solution, aimed at maximizing usable energy and minimizing mass, with the configuration of the185S49P, is indicated on the Pareto front by a triangle marker. The specification of the selected battery pack is presented in Table 5.

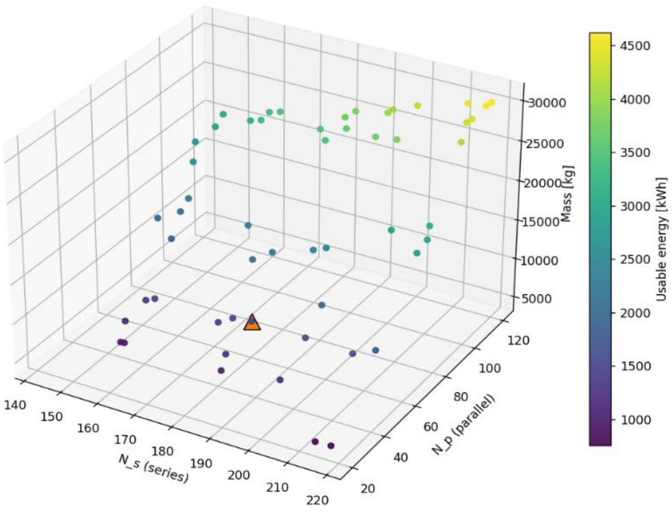

Figure 8: Pareto fonts for the stationary use case

Table 5: Optimal pack config for the stationary use case.

Parameters	Optimal Battery Pack configuration
Ns, Np	185S49P
Mass	10492.7 [kg]
Useable energy	1602.1 [kWh]
Min Voltage	627.9 [V]
Max Voltage	795.2 [V]

6 System level validation for automotive use case

Once the optimal configuration of the battery pack is achieved, as part of Task 4.2 virtual pack-level testing is being executed for automotive use case.

6.1 Work methodology: virtual test approach

The workflow comprises two phases: (i) system-level virtual testing and data generation, and (ii) correlation with test data. To assess the performance of the optimal battery pack, virtual vehicle-level tests are performed. These virtual tests are required because the same battery cell (different NMC chemistry and size) used in the NEXTBMS project is not available in the TOFAS vehicle. Consequently, the objective is to evaluate whether the optimal battery pack—configured based on TOFAS specifications and requirements—meets the performance targets of the automotive (TOFAS) use case. The details of the test procedures and driving scenarios are explained in this subsection. Figure 9 illustrates the workflow of the virtual powertrain platform used to integrate the virtual NEXTBMS battery pack model into the simulation loop. This setup enables the virtual assessment of the integration and performance of the selected optimal battery pack for the TOFAS EV Doblo use case.

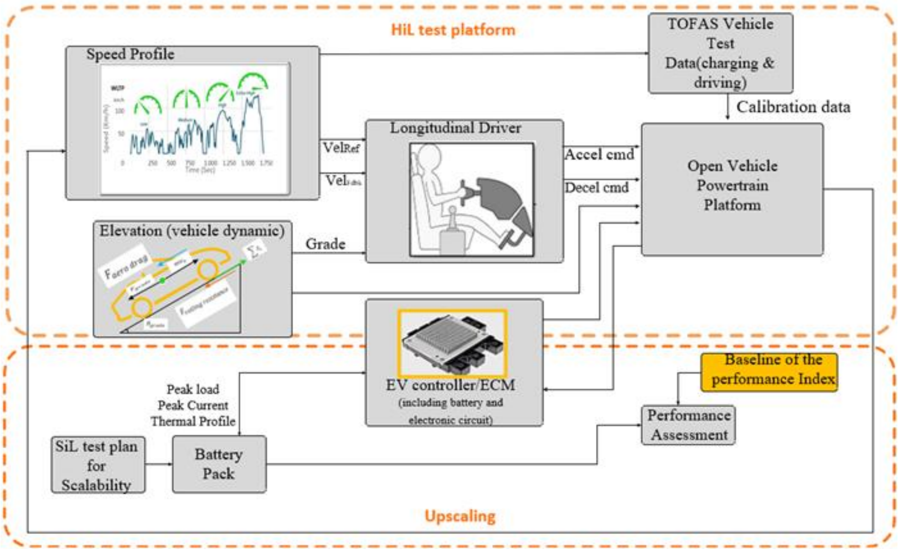

Figure 9: Virtual test workflow comprises physical e-axle setup (i.e., OVPP) and battery pack model in-the-loop.

6.2 Virtual test execution & validation

This section presents the virtual validation of the upscaled battery configuration and assesses whether it satisfies the requirements of the TOFAS use case. More specifically, the optimized upscaled battery module, based on the characterization of the NEXTBMS battery module, has been validated within VUB's OVPP using a physical e-axle configured to represent the TOFAS-EV use case. To be more specific VUB received vehicle test data from TOFAS. Upon the dataset the VUB OVPP are setup/ calibrated to closely represent the response of the TOFAS EV Doblo under WLTP driving cycle conditions. The vehicle test data of the TOFAS EV Doblo for WLTP driving cycles is shown in Figure 10.

The battery module of the NEXTBMS project consists of a 12S1P configuration (12 cells connected in series). Based on the results of the optimal battery pack sizing and considering the NEXTBMS battery module, a configuration of 84S2P, comprising a total of 168 cells, is selected for further analysis. This battery pack, with a total energy capacity of 36.5 kWh, is assessed to determine the extent to which it can meet/satisfy the design constraints of the TOFAS use case including the nominal voltage window, weight and space limitation.

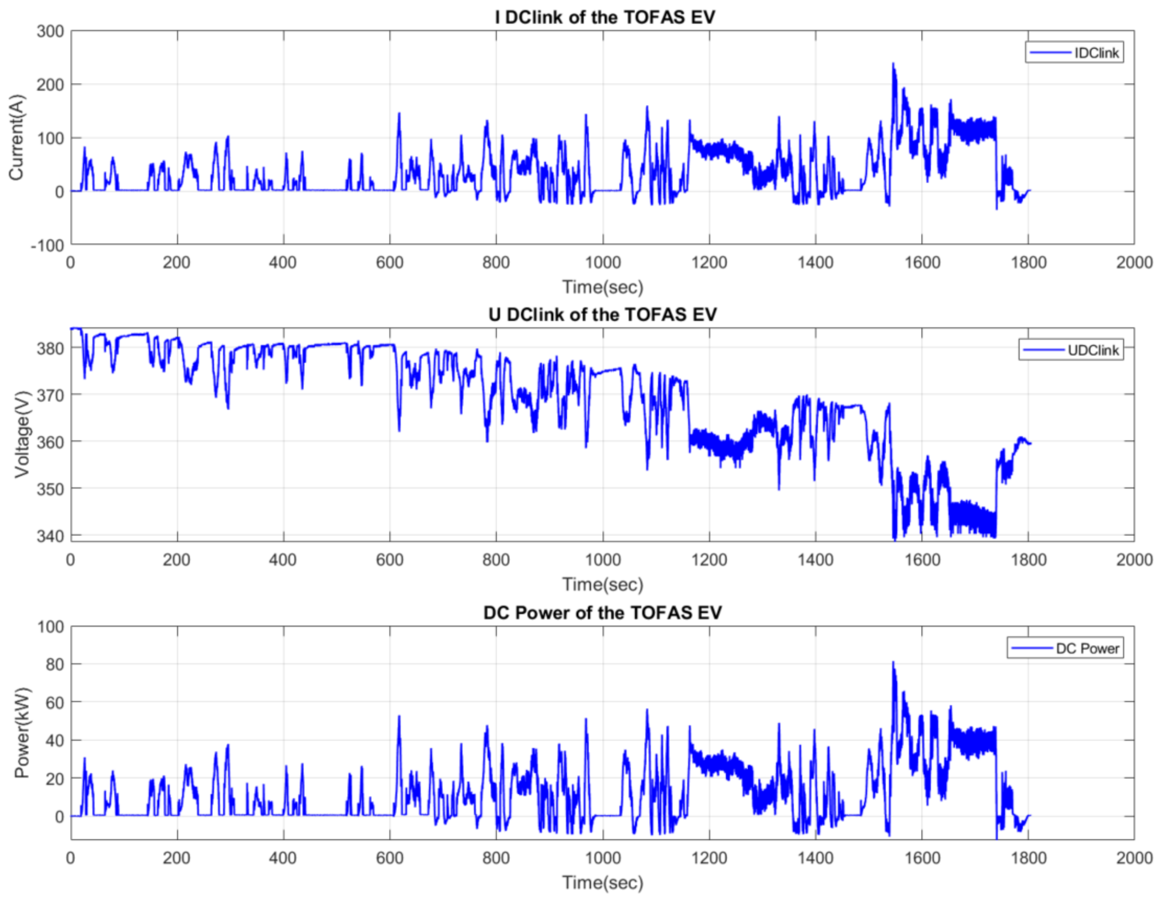

Figure 10: The test data from the TOFAS EV Doblo

The evaluation results indicate that, with this configuration and having an acceleration time of 12 s, the vehicle can achieve a driving range of 113 km over the WLTC Class 3b driving cycle. This difference arises because the efficiency of the OVPP system does not fully match that of the TOFAS EV powertrain. Figure 11 compares the current profile of the VUB OVPP system, which virtually reproduces the TOFAS EV use case, with the measured current profile obtained from TOFAS EV test data. The results (see Figure 10 to Figure 12) show that the virtual model closely follows and accurately tracks the current profile observed in the TOFAS EV use case. The result of the battery pack is shown in Figure 13 illustrating the battery pack's voltage and SoC behavior during the WLTC Class 3b driving cycle. The voltage profile exhibits fluctuations in response to the driving cycle's varying current demand, while the SoC curve shows a steady decline, indicating progressive battery discharge throughout the cycle. Since the physics-based model is still under development, state-of-health (SoH) estimation cannot yet be performed using the model. Figure 14 compares the pack-level SoC of the upscaled battery configuration with that of the TOFAS battery pack, demonstrating that the proposed battery upscaling framework is able to accurately reproduce the pack-level response.

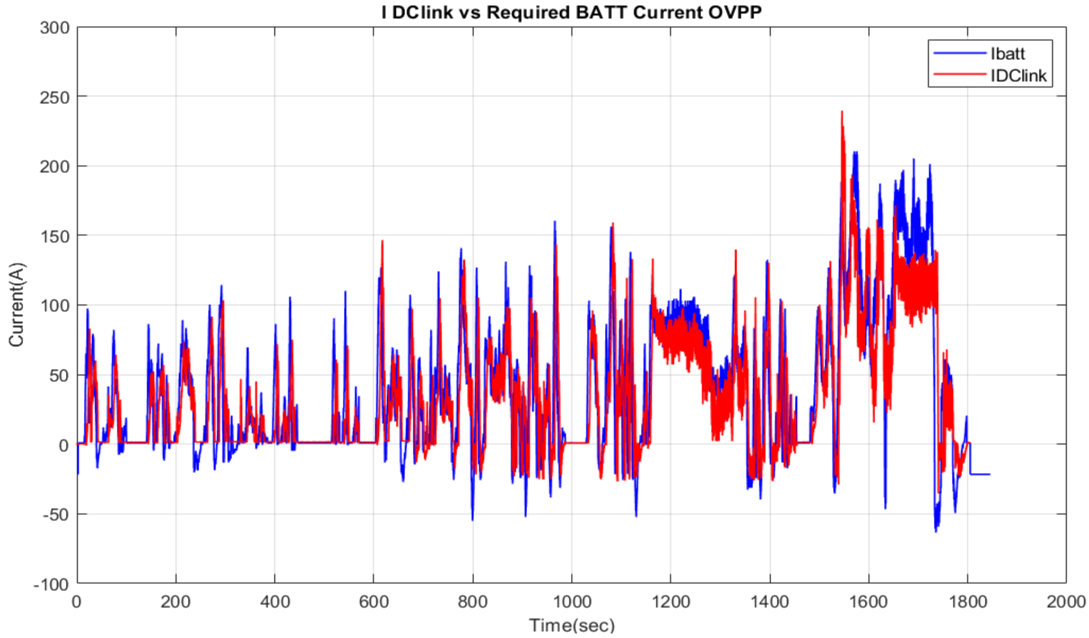

Figure 11: Current profile of OVPP and TOFAS EV use case

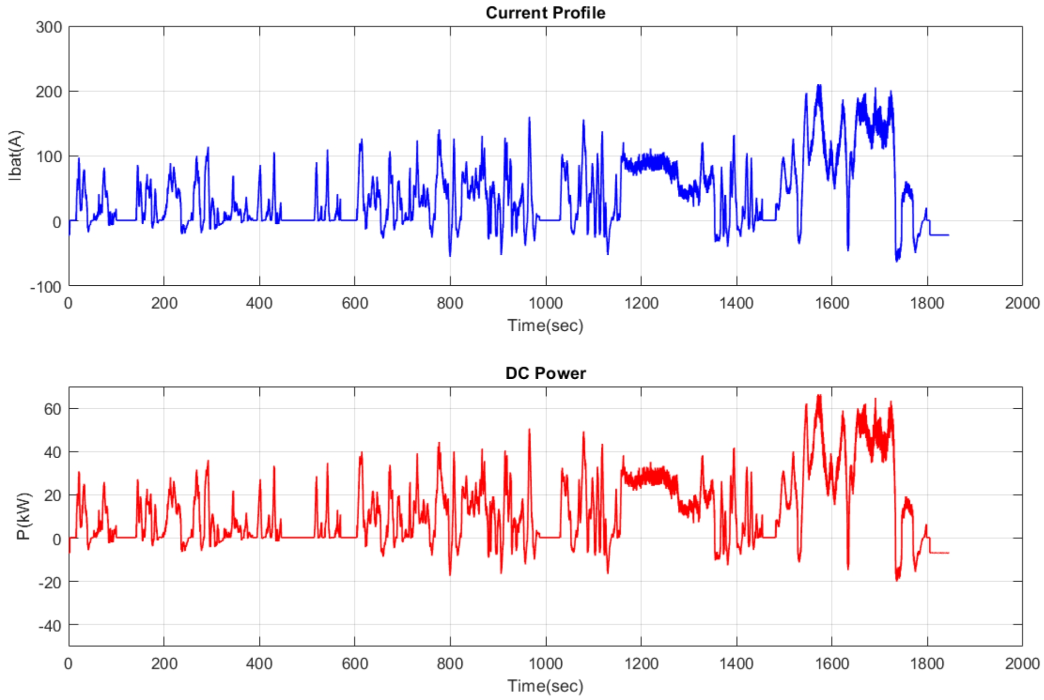

Figure 12: Current Profile and DC Power

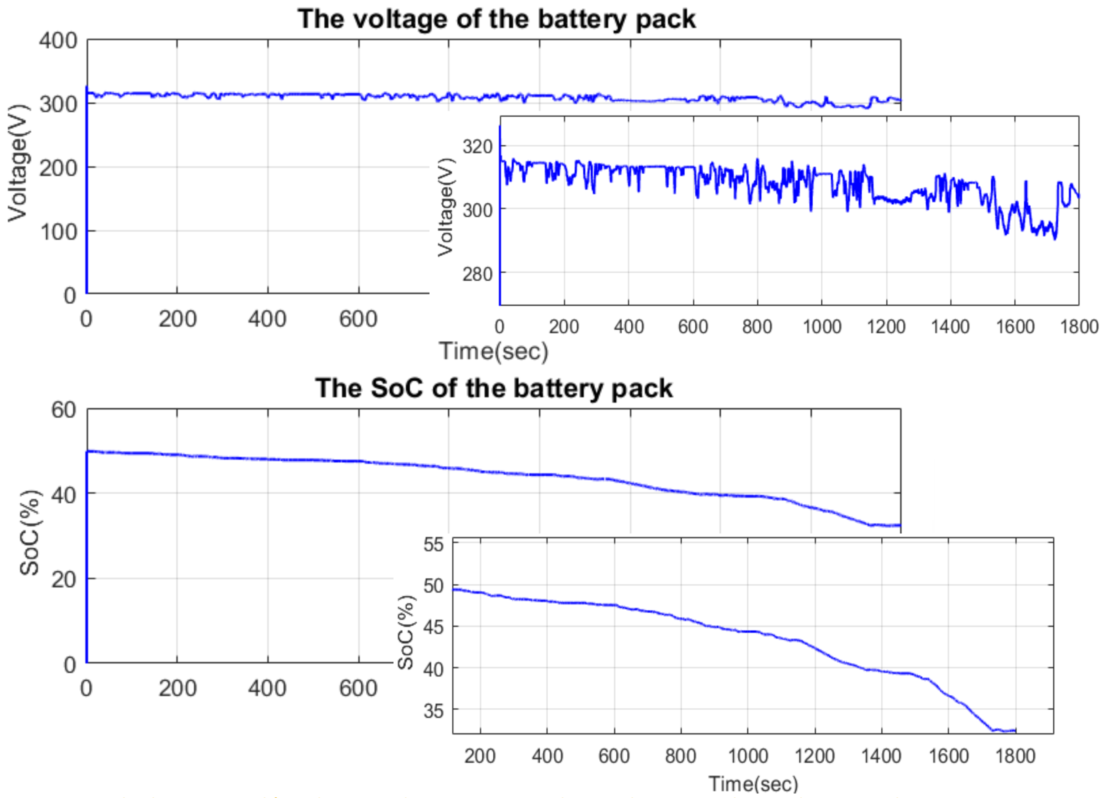

Figure 13: The battery pack's voltage and SoC over time during the WLTC-class 3 driving cycle.

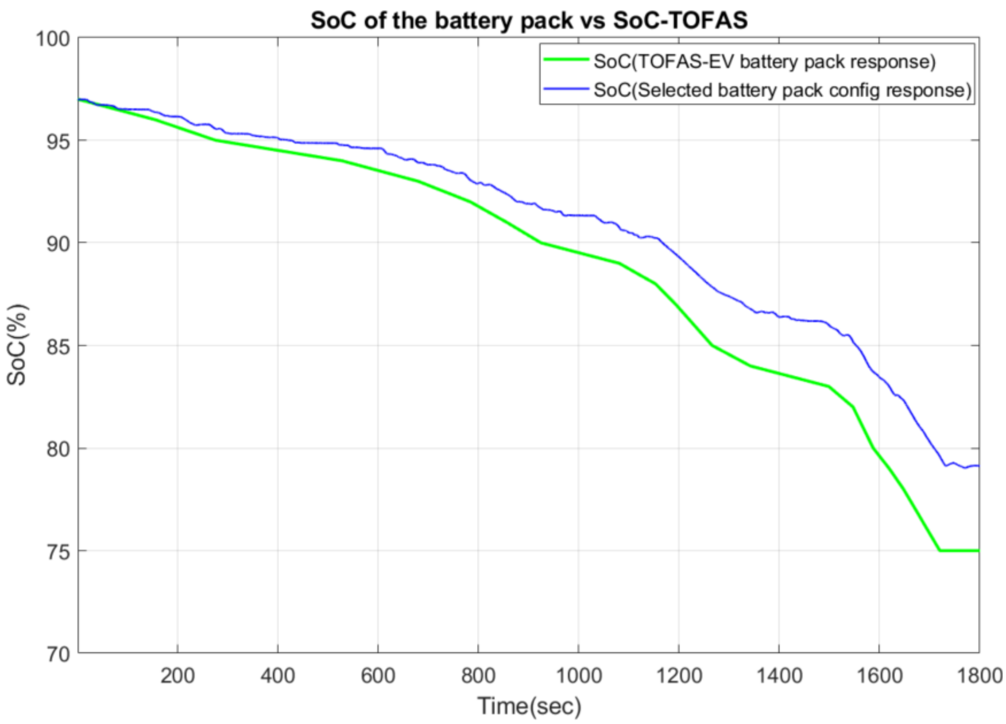

Figure 14: SoC comparison between TOFAS EV pack and selected pack configuration in maximum voltage value

7 Conclusion

The document introduces a comprehensive framework and simulation platform for battery-pack sizing, suitable for both automotive and stationary energy storage applications. It also defines the key specifications for two distinct use cases and includes validation results for one selected case.

In this deliverable, optimal battery-pack configurations were determined for two different applications: a light-duty electric vehicle (TOFAS EV Doblo) and a stationary energy storage for supporting grid stability. For each scenario, the framework scales from the cell to the module and finally to the pack level. Its simplicity and flexibility allow it to adapt to a broad range of operational conditions and design targets.

The final section of this deliverable presents the outcomes of a virtual performance test for the selected battery pack. Validation was performed using the OVPP, a detailed virtual model of the TOFAS EV Doblo. The evaluation confirms that the simulation achieved the expected performance results.

A sensitivity analysis will be conducted in the next phase of the project. Furthermore, this virtual testing framework will be used to generate representative real-vehicle responses for the HiL testing of the NEXTBMS battery pack in Task 4.3.

8 Risks and interconnections

8.1 Risks/problems encountered

No risks have been identified or anticipated.

8.2 Interconnections with other deliverables

The outputs from Deliverable D2.1 have been incorporated into this deliverable. And physics-based battery model from WP2 is used as input for pack upscaling activity. Besides, output of this sizing framework and virtual testing provide required module-level input profiles to TNO and EDF for executing the hardware-in-the-loop (HiL) testing of the NEXTBMS HW solution (outcome of WP3) as part of Task 4.3. Actually, deliverable D2.1 provides foundational data for the present work, and the outputs of this deliverable directly support the testing activities in Task 4.3 (deliverable D4.2).

9 Deviations from Annex 1

There was a delay of 1.5 months in the submission of the deliverable due to an unforeseen change in the schedule of using the VUB's Open Vehicle Powertrain Platform (OVPP) and its components' integration for NEXTBMS.
This delay was communicated to the project manager via email and subsequently accepted.
Further, there are no deviations from the description of this deliverable, as given in Annex 1 of the Grant Agreement.

10 References

1. Schaeffer, J., et al., *Gaussian process-based online health monitoring and fault analysis of lithium-ion battery systems from field data.* Cell Reports Physical Science, 2024. **5**(11).
2. An, F., et al., *Rate dependence of cell-to-cell variations of lithium-ion cells.* Scientific reports, 2016. **6**(1): p. 35051.
3. Feye Hoekstra, Hansjörg Kapeller, Dominik Dvorak, *Characterisation test results of physics-based cell models. Deliverable D2.1*

11 Acknowledgement

11.1 The consortium

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Partner short name	Partner Full Name
1	AIT	AIT Austrian Institute of Technology GmbH
2	TNO	Nederlandse organisatie foor toegepast natuurwetenschappelijk onderzoek TNO
3	UL	Univerza v Ljubljani
4	VUB	Vrije Universiteit Brussel
5	UNR	Uniresearch BV
6	AVL	AVL List GmbH
7	AVL-SFR	AVL Software and Functions GmbH
8	AVL-TR	AVL Arastirma ve Muhendislik Sanayi ve Ticaret Limited Sirketi
9	BOSCH	Robert Bosch GmbH
10	NXP-AT	NXP Semiconductors Austria GmbH & Co KG
10.1	NXP-NED	NXP Semiconductors Netherlands Bv
11	EDF	Electricite de France
12	TOFAS	TOFAS Turk Otomobil Fabrikasi Anonim Sirketi

11.2 Disclaimer/ Acknowledgment

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12 Appendix A - Quality Assurance Review Form

The following questions should be answered by all reviewers (WP Leader, reviewer, Project Coordinator) as part of the Quality Assurance procedure. Questions answered with NO should be motivated. The deliverable author will update the draft based on the comments. When all reviewers have answered all questions with YES, only then can the Deliverable be submitted to the EC.

NOTE: This Quality Assurance form will be removed from Deliverables with dissemination level "Public" before publication.

Question	Reviewer 1	Reviewer 2	Project Coordinator
	Bernhard Stanje (AVL)	Viral Vadaviya (AVL-SFR)	Hansjörg Kapeller (AIT)
1. Do you accept this Deliverable as it is?	**Yes**	**Yes**	**Yes**
2. Is the Deliverable complete? - **All required chapters?** - **Use of relevant templates?**	**Yes**	**Yes**	**Yes**
3. Does the Deliverable correspond to the DoA? - **All relevant actions preformed and reported?**	**Yes**	**Yes**	**Yes**
4. Is the Deliverable in line with the PILATUS objectives? - **WP objectives** - **Task Objectives**	**Yes**	**Yes**	**Yes**
5. Is the technical quality sufficient? - **Inputs and assumptions correct/clear?** - **Data, calculations, and motivations correct/clear?** - **Outputs and conclusions correct/clear?**	**Yes**	**Yes**	**Yes**
6. Is created and potential IP identified and are protection measures in place?	**Yes**	**Yes**	**Yes**
7. Is the Risk Procedure followed and reported?	**Yes**	**Yes**	**Yes**
8. Is the reporting quality sufficient? - **Clear language** - **Clear argumentation** - **Consistency** - **Structure**	**Yes**	**Yes**	**Yes**