High Performance Power Electronics Integrations

Intermediate Exploitation Report

Deliverable Number	D7.4
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Lead Beneficiary	IESTA
Deliverable Type	R – Document, Report
Dissemination Level	PU (Public)
Actual Delivery Date	2024-04-30 (Month 18)
Pages	36
Document Version & Status	V2.0 | Final

Project Acronym	HiPE
Project Title	High Performance Power Electronics Integrations
Project ID	101056760
Project Coordinator	VIRTUAL VEHICLE Research Center (ViF) Bernhard Brandstätter (bernhard.brandstaetter@v2c2.at)

Funded by the European Union

HiPE has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101056760.

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Change History

Version	Date	Name/Organisation	Description
V0.1	2024-04-01	J. Weidenauer, IESTA	Structure, First content
V1.0	2024-04-17	J. Weidenauer, IESTA	Including content, Finished version ready for review
V2.0	2024-04-30	J. Weidenauer, IESTA	Reviewed version ready for submitting
	2024-04-30	M. Ćustić, ViF	Formal review and deliverable release

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1. Executive Summary

Main goal of this report is, to give a first overview of the exploitation and standardisation activities.

For exploitation activities, first the Key Exploitable Results (KERs) set in the HiPE Grant Agreement were collected and the partners were asked to validate them. Second, a first exploitation survey was done. The results of both will be shown in this deliverable.

On the standardisation side as a first step all HiPE relevant regulations and standards were collected, which are also listed in this deliverable.

Keywords: Exploitation, Standardisation, Report

2. Introduction and Scope

This chapter gives an overview of the aim of the exploitation activities and the target audience of HiPE as well as provides information who contributed to this deliverable and how it is connected to other activities in the project. To get an overview of the WP7 objectives and other relevant information about exploitation and standardisation, please refer to “D7.9 – Plan for Dissemination, Communication and Exploitation”.

2.1 Purpose and Target Group

The main goal of the exploitation activities in HiPE is to leverage the knowledge, technologies, and innovations generated through the project for various purposes such as commercialisation, social benefit, or further research.

The standardisation activities of HiPE are done to have an overview of which regulations and standards are needed for the project and to find first approaches and ideas how to standardise HiPE innovations and technologies for the international market

The exploitation **target audience** includes:

- **Scientific communities**: Especially in the domain of e-vehicle PE and inverters.
- **R&D project ecosystem**: R&D projects related to the HiPE project, e.g., by similar targets, technology, or interests including the E-VOLVE Cluster.
- **Technology users**: Companies developing BEV PE and inverters as well as Tier-I and OEM using the developed components, systems and tools within their own products.
- **Technology providers**: Companies and institutions developing tools and methods for BEV PE and inverters.
- **European Commission**: Main stakeholder of the project, responsible for set-up of R&D projects in line with the project call.
- **Private and commercial customers** of e-vehicles benefitting from higher efficiency and range and lower costs. Lower costs will increase affordability of e-mobility.
- **General Public**: Public community, interested in important project impact on public sector, especially lower CO_2 and other emissions from road transport.
- **Standardisation organisations**: Organisations which are creating international technical standards for BEV PE and inverters.

2.2 Contributions of Partners

The partners provided their input to the Key Exploitable Results (KERs), to HiPE applying regulations and standards as well as to the exploitation survey, which was conducted. The main structure and methodology were provided by the HiPE partner IESTA.

Table 2-1: Partner contribution

Chapter	Partner	Contribution
1 - 4	IESTA	Structure and content
3.1	All partners	KERs and Exploitation survey results
3.2	All partners	List of Standards

2.3 Relation to other activities in the Project

The following WPs have activities within the exploitation strategy:

- WP1: Is intended as an organisational component when planning and performing exploitation activities, as well as for risk management.
- WP7: Mainly responsible for dissemination and communication as well as exploitation activities.
- WP2 – WP6: Provide material and information for exploitation and standardisation (e.g., new plans for exploiting in HiPE developed innovations, new regulations/standards that are applying to the innovations or work process)

3. Description of Work so far

This chapter gives an overview of the exploitation and standardisation activities done so far.

3.1 Exploitation

This sub-chapter provides a first overview of exploitation results, such as the updated KERs – here as well called “Exploitation Objects” – and the first exploitation survey.

3.1.1 Key Exploitable Results/Exploitation Objects (KERs)

The following table (Table 3-1) gives an Overview of the exploitation objects set in the Grant Agreement, as well as additional information such as “Exploiting Partner”, “KER Category”, “Level of KER Implementation” and “Comments”.

- **Exploiting Partner**: HiPE partners exploiting the KERs
- **Key Exploitable Result (KER)**: KERs already set in the Grant Agreement that partners need to exploit
- **KER Category**: Shows if the KER is technical, economical or legal (e.g. patents). Or done in the field of research or testing.
- **Level of KER Implementation**: To see on which level the KER is implemented. Possible are vehicle level, system level and component level.
- **Comments**: Additional comments from the partners to the specific KER

Table 3-1: Key Exploitable Results (KERs)

Exploiting Partner	Key Exploitable Results according to GA	KER Category	Level of KER implementation	Comments
VIF	Advanced **power module cooling systems**	Technical	Component Level	None
	Integrated double-side pin-fin cooling concept	Technical	Component Level	None
	Immersion/impingement/two-phase cooling **concepts**	Technical	Component Level	None
	Digital sensor integration **in the power module for** enhanced ThMgt	Technical	System Level	None
	Model predictive and AI-based thermal control systems	Technical	Component Level	None
AVL	**Digital twins and self-adapting CDTs** of WBG-based electric drives for automotive powertrains	Technical	Component Level	None
Ford Otosan	New scalable, modular and integrated **SiC-based electric drive family** (50-250 kW, 400V-1200V)	Technical	Component Level	None

	New **integrated WBG-based OBC and HV/LV DC/DC converter concepts**	Technical	Component Level	None
	Advanced **power module cooling systems**	Technical	Component Level	None
	Model predictive and AI-based thermal control systems	Technical	Component Level	None
Fraunhofer ENAS	**Digital twins and self-adapting CDTs** of WBG-based electric drives for automotive powertrains	Research	Component Level	None
	"Closed-loop" RUL control for SiC-based inverter systems	Research	Component Level	None
I&M	Integrated fault-tolerant **GaN-based drives for and chassis actuator**	Technical	Component Level	None
IESTA	Develop Links further with electric vehicle industry and provide support in new research areas of sustainable urban mobility solutions	Research	Vehicle Level	None
	Extend the knowledge base on advanced electric vehicle control and simulation methods & architectures	Research	System Level	None
	Establish world-leading testing and control system development capabilities	Research	System Level	None
Marelli	New scalable, modular and integrated **SiC-based electric drive family** (50-250 kW, 400V-1200V)	Technical	Component Level	MAR only working on UC2
	New **EMI filter** concepts	Technical	Component Level	Not promising for MAR
	New passive discharge circuits	Technical	Component Level	Not promising for MAR
	Stray inductance reduction methods	Technical	Component Level	Not promising for MAR
	Advanced **power module cooling systems**	Technical	Component Level	Not promising for MAR

	Integrated double-side pin-fin cooling concept	Technical	Component Level	Not feasible for MAR
	Immersion/impingement/two-phase cooling concepts	Technical	Component Level	Not feasible for MAR
	Digital twins and self-adapting CDTs of WBG-based electric drives for automotive powertrains	Technical	Vehicle Level	CDT not feasible for MAR
TU Illmenau	Methodology for testing high-performance powertrain and chassis actuators with novel power electronics	Testing	System Level	None
Tenneco	Integrated fault-tolerant **GaN-based drives for and chassis actuator**	Technical	System Level	None
UTIA	Development **new concept HMI** for multi-speed gearbox	Research	Vehicle Level	None
Skoda	Innovative multi-speed gearbox for EV	Technical	Vehicle Level	None
Nexperia	Digital sensor integration **in the power module for** enhanced ThMgt	Technical	System Level	None
University of Surrey	Digital twins and self-adapting CDTs **of WBG-based electric drives for automotive powertrains**	Research	Vehicle Level	None
	"Closed-loop" RUL control **for SiC-based inverter systems**	Research	Vehicle Level	None
	Integrated fault-tolerant **GaN-based drives for and chassis actuator**	Research	Vehicle Level	None

The listed KERs will be continuously updated over the project's lifetime.

3.1.2 Exploitation Survey

The first Exploitation Survey carried out in HiPE is based on HORIZON Results Booster Surveys from other projects but is not the official HORIZON Results Booster Survey. This is due to the fact that the application for the HORIZON Results Booster will be made in the course of April 2024, at the latest in early May. The application will be made together with the E-VOLVE Cluster. However, the application is slightly delayed because the HORIZON Results Booster has requested the Description of Action from the applying project. In accordance with the Consortium Agreements and internal project rules, the application has been suspended until a solution is found. An update on the HORIZON Results Booster Services will be provided in the next reporting period and in the following D&C&E Deliverables.

3.1.2.1 Survey Structure

As already mentioned, the questionnaire is based on HORIZON Results Booster exploitation questionnaires from other projects, adapted to HiPE needs.

The **first part** is related to Contact Details and GDPR related questions (see chapter 3.1.2.2). The **second part** includes the Products and Services – Questionnaire, which is sub-structured in the following parts (see chapter 3.1.2.2):

- General questions
- Questions for service / product deployment
- Questions for academia and further research

3.1.2.2 Survey Questions

The **first part** including Contact Details and GDPR related questions have in total five questions:

- **Q1 About you**: Contains “Name of the Organisation”, “Name” of the person who fills the questionnaire, “E-Mail” of the person who fills the questionnaire, “Contact telephone number” of the person who fills the questionnaire
- **Q2 Your role in the HiPE project**: Possible to select was “Project Manager”, “Developer”, “Business”, “Marketing”, “Sales Manager”, “Consultant” and, “Other – please specify”
- **Q3 Your external stakeholder groups (name three most important stakeholders)**: Possible to select was “Vehicle manufacturer”, “SMEs”, “Tier2 supplier”, “Private customers”, “Authority”, “University and Research Institutes”, and “Other – please specify”.
- **Q4 I am aware of how the data I provide in this survey will be used by the project and its members**: Possible to select was “Yes” or “No”
- **Q5 I understand I can withdraw my consent regarding my participation in the project and my data at any time and without specific reasons and without my legal rights being affected. Such withdrawal shall be given as simply as I gave my consent. I understand I will not be penalised for withdrawing my consent nor will I be questioned on the reasons of such withdrawal:** Possible to select was “Yes” or “No”.

The **second part** goes into details about the partners products and services of HiPE.

- The sub-part **“General questions”** had the following questions (see Table 3-2).

Table 3-2: Survey Questions - General part

General questions	
Interest	*Describe your interest in being part of the HiPE project*
Expectation	*Describe briefly your expectation regarding HiPE – project **and** business expectation*
Role	*Describe the role of your organisation in HiPE*
Innovation & Result	*What is the current state-of-the-art of your product/service?*

	What is the innovation you bring to the project, what does your solution do better compared to the state-of-the-art, what are the benefits considering what your user/customer wants, how does your solution solve his/her problem better than alternative solutions?
Business Cases	*Describe in a few lines how your solution will generate benefits (result and/or solution i.e. product, service, process optimization, standard, course, policy recommendation, publication, etc.).*
Sustainability	*Which effects do you expect for sustainability considerations, e.g. CO_2-emissons and other emissions, noise?*
Recommendation	*What did you learn from the project so far and development of the product/service? Where do you see the barriers? Do you have recommendations on how to overcome these barriers? (e.g. policy recommendations, standards)*

- The sub-part **"Questions for service / product deployment"** includes the questions which can be seen in Table 3-3.

Table 3-3: Survey Questions - Service / product deployment part

Questions for service/ product deployment	
Product/ Service Development	*What kind of product are you going to develop?* *What kind of service are you offering?* *Examples: manufacturing of a new product, provision of a service, training, technology transfer, license agreement, contract research, publications, standards, etc.* *How the product/ service will be put in use (made available to "customers" to generate an impact).*
"Market" – *Target market*	*Describe the market in which your product/service will be used/can "compete", answering the following questions:* - *Which stakeholders are involved?* - *Do you plan on partnering with SME's/ start-ups?* - *How will you further finance the development of your product/service?* - *How will you promote your product/service?*
"Market" - Competitors	*Who are your "competitors" (note: they are the ones offering "alternative solutions")?* *What are your strengths and opportunities within the market?*
Go to Market - Timing	*What is the time to market?*

	Note: It doesn't have to be within a year after HiPE. If the product/service still needs development, etc., it is valid to give a greater number.
Success Factors	*Describe your expected and measurable success factors (i.e. environmental, use of product/service, financial, market development, acceptance)*
Value Chain	*Will the product/service enhance/complement your current operation, or will you enter new fields of business?*
Enablers	*For the development of your product/service, what are the pre-conditions, key enablers to short-term and long-term developments, is policy support still needed?* *If yes, then how?*
Disruptors/Challenges	*What are the barriers, challenges, and financial and organizational issues you are facing during the development and implementation of your product/service?*

- The sub-part **"Questions for academia & further research"** include the following questions that are presented in

Table 3-4: Survey Questions – Academia & further research part

Academia & further research	
Funding	*Will you apply for further funding from a new research project or consultancy tender?* *☐ Yes ☐ No* *Do you already know which? - please specify.*
Research	*Will HiPE deliver input to research led teaching for students?* *☐ Yes ☐ No* *Will HiPE be part of PhDs and/ or student projects?* *☐ Yes ☐ No*
Consulting	*Are you going to offer your learnings for networking with industry partners or administrations?* *☐ Yes ☐ No* *Do you already have industry partner for "HiPE consulting"?*

3.1.2.3 Exploitation Survey Results

After receiving the survey, the partners were asked to fill it out and send it back to IESTA. Unfortunately, only seven of the 13 HiPE partners provided a filled-out version of the survey although all partners were reminded several times over the course of four months to provide input.

For this reason, the following results are only based on the input given by those seven HiPE partners.

3.1.2.3.1 First part – Contact Details and GDPR related question results

This part will start with the second question because the first question only includes personal data such as name, e-mail, phone number, etc.

Q2: Your role in the HiPE project

For this question it was possible to select more than one answer, which means that – for example – one partner can be a project manager and a consultant on the same time. The result can be seen in the following Figure 3-1. It shows that most of the partners are project managers and developers. Whereas no one is working in the business, marketing and sales department.

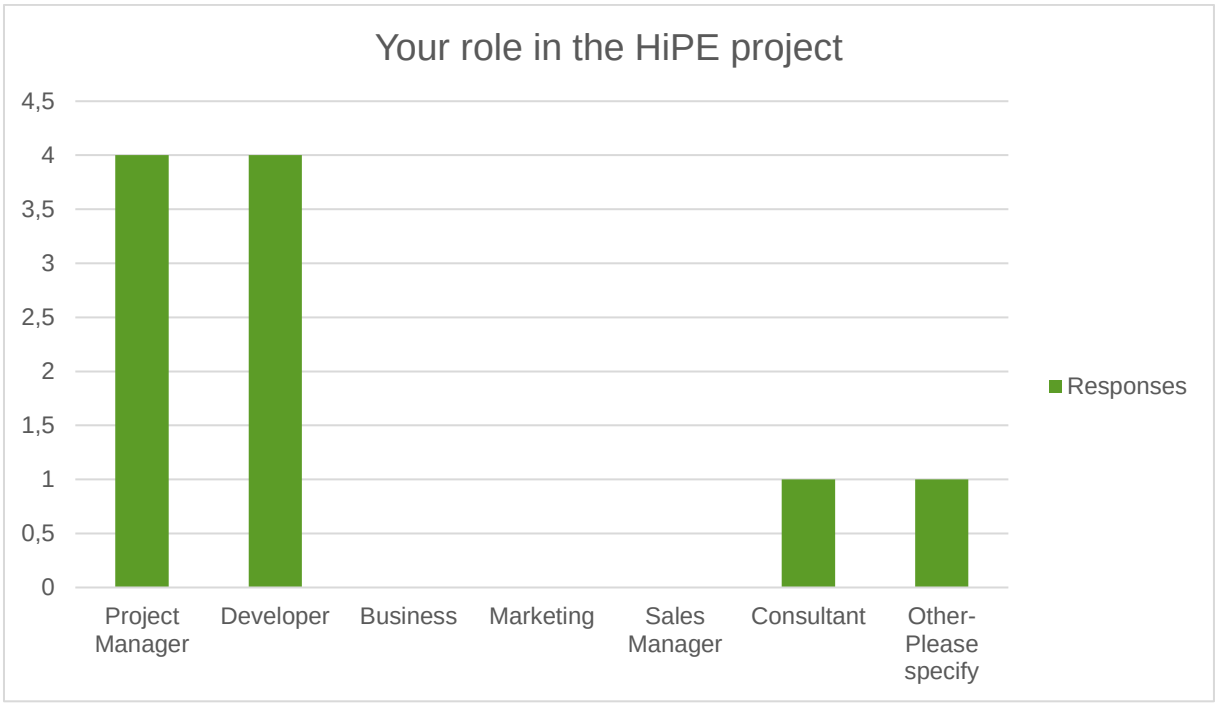

Figure 3-1: Survey result - Your role in the HiPE project

Q3: Your external stakeholder groups

Here it was possible to choose up to three different stakeholder categories. The result can be seen in Figure 3-2 on the next page. Main external stakeholders are vehicle manufacturers as well as university and research institutes, whereas private customers do not play a role at all.

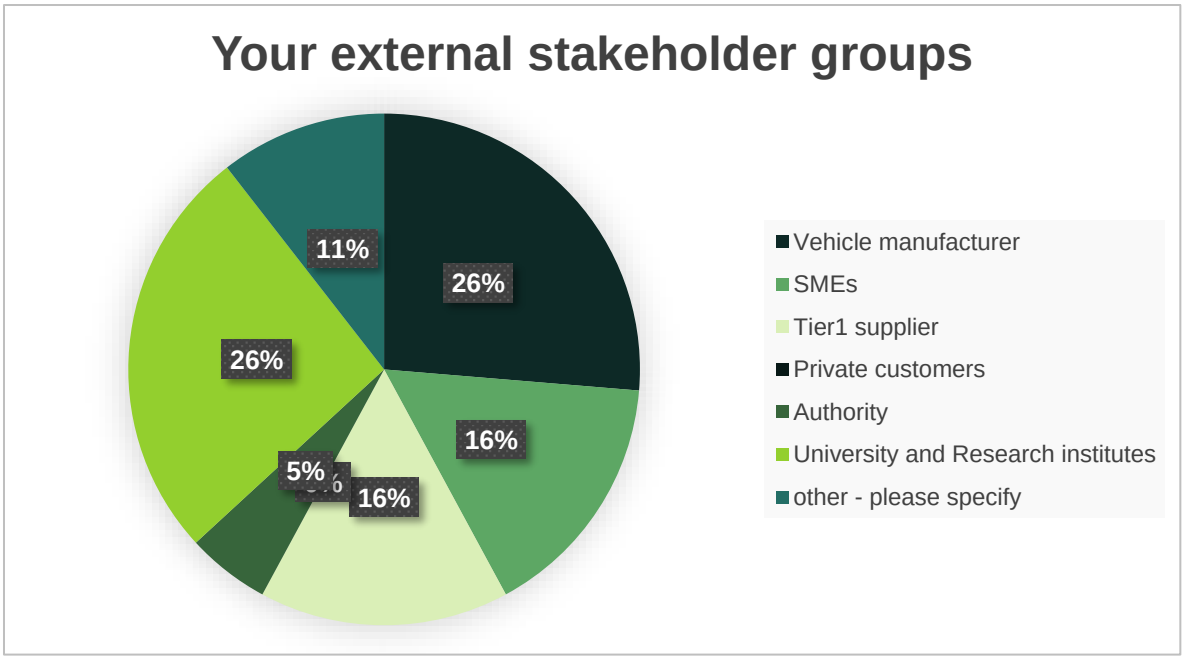

Figure 3-2: Survey result - Your external stakeholder groups

Q4: I am aware of how the data I provide in this survey will be used by the project and its members

All partners who provided input marked the YES possibility of this question.

Q5: I understand I can withdraw my consent regarding my participation in the project and my data at any time and without specific reasons and without my legal rights being affected. Such withdrawal shall be given as simply as I gave my consent. I understand I will not be penalised for withdrawing my consent nor will I be questioned on the reasons of such withdrawal.

All partners who provided input marked the YES possibility of this question.

3.1.2.3.2 Second part – HiPE products and services

Because this part includes questions which leads to very specific answers depending on the project partner, the answers cannot be presented in a generic way. This part includes the sub-parts “General questions”, “Questions for service / product deployment” and “Questions for academia & further research”.

Therefore, for each question a table with the partner specific answers is created (see Table 3-5 to Table 3-22). Due to space savings the headline of the following tables does not include the specific long and detailed survey questions but only the category. For the specific and detailed questions please refer to chapter 3.1.2.2.

Sub-part "General questions"

Table 3-5: Survey answer - General question - Interest

Interest	
Partner	**Survey Answer**
Ford Otosan	Ford Otosan's interest to be part of HiPE is to develop/design/optimize the following things: High Efficient PE converter design with WBG devices, PE Advanced Cooling Method and Development, Vehicle System Modelling and Optimization
I&M	Being part of an international consortium to enable the development of high-performance electronics for electric vehicles.
TU Ilmenau	Developing integrated control on chassis actuators and electric motors to improve vehicle dynamics and functional safety.
Tenneco	The interest of Tenneco is to build knowledge through innovative concept exploration and new partnership for collaboration. In this case it consists of a HV motor for levelling system with GaN-PE.
UTIA	UTIAS interest on being part in HiPE are research activities, partnerships, long-term cooperation, new knowledge/expertise and networking.
University of Surrey	Exploit HiPE innovations at the vehicle level such as optimisation and design of intelligent controllers for electric powertrains and actuators.
IESTA	The interest of IESTA being part of the HiPE project is to gain further experience in R&D project management, especially in mobility aspects as well as tool development, a positive image/relationship to/with other project partners and to have a well-developed and enhanced TCO, CEA and CBA calculation tool, that can be used outside of HiPE. Beside that IESTA is interested to provide HiPE their expertise in the field of dissemination, communication & exploitation.

Table 3-6: Survey answer - General question - Expectation

Expectation	
Partner	**Survey Answer**
Ford Otosan	Developing a high performance Power Electronics Converter by using innovative power electronics and thermal management design methods.
I&M	Being in contact with research institutes to improve our design capabilities on new technologies and find new commercial partners to develop ad hoc electronic solutions.

TU Ilmenau	Developing new control systems with corresponding chassis and powertrain actuators ready for operation with new power electronics, characterised by using GaN as semi-conductor technology.
Tenneco	The project expectation is to reach a functional prototype on the demo car and reach a technical readiness level to sell the product.
UTIA	Implementation of background for long-term cooperation, implementation of theoretical assumptions to the practice, integration of students to the research activities, solving technical / innovation / business challenges.
University of Surrey	Strengthen expertise in electric powertrain optimization, and advanced BEV control, establish further industrial collaborations on the HiPE topics, and pursue publicly funded initiatives.
IESTA	Expectations regarding HiPE: • Establishing and enhancing business and research network in the area of innovative and new mobility solutions • TCO and CBA tool enhancement covering new mobility requirements and innovations based on an already created tool in the course of other projects • Gain further knowledge in the course of dissemination, communication and exploitation especially with the HORIZON Results Booster Expectations regarding business: • Be able to use the developed TCO, CEA and CBA tool for further business and research projects on national and European level • Building up a guideline for a successful economic implementation of mobility innovations and products offering a business potential for IESTA regarding TCO and CBA calculations

Table 3-7: Survey answer - General question - Role

Role	
Partner	**Survey Answer**
Ford Otosan	Ford Otosan has two teams with the following tasks: **EPS Team:** Power Electronics Modelling HW & SW Development **EPEM Team:** PE Advanced Cooling Method Simulations and Development Vehicle System Modelling and Optimization
I&M	Our company is involved in the design of high-voltage power electronics for auxiliaries to be used in electric vehicles.

TU Ilmenau	Developer of control systems; Formulation and implementation of the strategy for testing chassis and power train systems with new power electronics.
Tenneco	Tenneco is end user, responsible of UC4.
UTIA	Development of control systems, Human Machine-Interface, simulation and prediction models. Testing of automated systems and signal processing. UTIA having been involved as technological partner.
University of Surrey	Associated partner
IESTA	IESTA is WP7 lead, responsible for the Cost Assessment (TCO, CBA and CEA) and supports other tasks when needed and asked.

Table 3-8: Survey answer - General question – Innovation & Result

Innovation & Result	
Partner	**Survey Answer**
Ford Otosan	Mainly, as Ford OTOSAN, our use case develops a combined product of HV-LV DC-DC and OBC converters with WBG devices. Firstly, this combination provides volume advantageous. Also, using WBG devices, Ford OTOSAN will exceed the power density and efficiency level of current products in the market. Current products mainly use silicon-based switching devices, which limits the frequency at which the circuit can operate. Higher frequency means smaller magnetic components thus, smaller volumes. Lastly, we aim to design a bidirectional OBC that enables the two-directional power flow between the BEV HV battery and AC utility or AC load. This will increase the usefulness of the vehicle itself.
I&M	At present there are not HV solutions for the drive of auxiliaries in EVs. Our contribution is to eliminating the need for DC/DC converter for auxiliaries supply by developing HV power electronic solutions. This approach will reduce car complexity, cost, improving efficiency and reliability overall.
TU Ilmenau	Current technologies on integrated chassis control are mainly concentrated on the improvement of vehicle stability. We would like to give more attention to combined functionality that covers energy efficiency operating safety and comfort. In addition, we would like to demonstrate an application of smart control methods within the context of integrated control. Further innovation element will relate to holistic

	testing procedure for validation and verification of integrated chassis control using shared XiL experiments.
Tenneco	SotA: The product is new on the market. Better compared to SotA: The product is energy efficient and cost attractive.
UTIA	The current state-of-the-art of UTIA outputs in the area of FEV is indeed progressive and incorporate AI aspects incl. data, signal or picture recognition e.g. augmented reality. Our benefit lies in development and testing new concepts of ground fully electric vehicles and their components with respect to real vehicle on the market – Skoda Enyaq. Another perspective can be found in bringing new ideas and theoretical assumptions into the practice.
University of Surrey	Current SotA: Model-based control of powertrains and vehicle dynamics. Innovation: Incorporate the features of HiPE innovations into the design of advanced vehicle control strategies and thus reduce the energy loss. The innovations include, for example, the digital twins and self-adapting compact digital twins of WBG-based electric drives for automotive powertrains, and the integrated fault-tolerant GaN-based drives for and chassis actuators.
IESTA	For WP7 there are no great innovations foreseen. For WP5 – the Cost Assessment - IESTA's innovation is a TCO, CEA and CBA tool, that was already used in other projects but is adapted to HiPE needs and will be enhanced to the previous versions. With that a better and more accurate calculations can be done.

Table 3-9: Survey answer - General question – Business Cases

Business Cases	
Partner	**Survey Answer**
Ford Otosan	The resulting power density will ease the electrical system because placing the components across the vehicle system is challenging. An increment in efficiency will result in a decrement in relative cost. More actual power will be transferred from the vehicle's HV and LV batteries when compared to off-the-shelf products at the same input power. This is better for a battery lifetime. The effect of these main features will increase after the prevalence of WBG devices. With prevalence, the WBG device cost decreases which will result in actual cost decrement with better performance.

I&M	The development of small high-voltage inverters for automotive application enables the direct connection of these components to the HV bus present in modern EV, reducing the need for extra electronics components (DC/DC) and hence reducing costs and complexity in these vehicles. Being part of this process provide us with a set of solutions that can be used directly or customized for the end customer.
TU Ilmenau	Publications, patent application, testing methodology for sharing with stakeholders.
Tenneco	Innovative product with efficient energy consumption, fitting the requirement for next generation EV's.
UTIA	Our solution serves as predevelopment phase for car maker Skoda Auto/Concern VW. Furthermore, our outputs integrate students of Skoda Academy and other scholars to marketplace incl. start-ups. Another positive aspect lies in development new technical standards e.g. ISO/IEC/JTC1/ Information technology, Subcommittee SC 7, Software and systems engineering.
University of Surrey	**High-quality peer-reviewed journal publications about advanced vehicle control that exploit and validate the HiPE innovations**: Focus on producing and disseminating research. This involves not only developing new knowledge but also ensuring its recognition and validation through peer-reviewed academic journals. **Enhance our research knowledge and capability:** Commit to continuously improving our research skills and knowledge base. This goal emphasizes the importance of staying at the forefront of advancements in vehicle control technologies and related fields. **Implement research-led teaching**: Integrate cutting-edge research findings and methodologies into our teaching curriculum. This approach ensures that students are educated with the most recent and relevant information, thereby preparing them for future challenges and innovations in the field.
IESTA	The business cases for IESTA are: • Further research projects on national and European level • Business support of the implementation of new mobility services and products • Business support for the optimization of already existing mobility services and products. • Lead of Dissemination, Communication & Exploitation activities

Table 3-10: Survey answer - General question - Sustainability

Sustainability	
Partner	**Survey Answer**
Ford Otosan	Power Consumption and Cost Reduction on Component Selection
I&M	The HV electrification of auxiliaries will directly impact on efficiency since requires one step less in power conversion. Moreover, the specific use case developed for HiPE (i.e., levelling system) will help the car adapting its height with respect to road condition, hence improving its drag coefficient and thus its energy consumption.
TU Ilmenau	It is expected that the proposed smart control will contribute to reducing energy consumption of electric vehicles.
Tenneco	The solution is proposing to change the level of the car. A low-level position on the highway will directly result in a lower power consumption of the vehicle (with better aerodynamic).
UTIA	Sustainability of emissions is supported within development predictive and simulation models e.g. suggestion vehicle speed profile for various forms of automated driving.
University of Surrey	Improving the efficiency of EVs will lead to reduced electricity usage. This, in turn, allows for the use of smaller batteries, decreasing the overall vehicle mass. A lighter vehicle further reduces energy consumption, ultimately contributing to a decrease in emissions. This cycle of efficiency improvement demonstrates how advancements in EV technology can have a significant, positive environmental impact.
IESTA	No direct influence on sustainability matters.

Table 3-11: Survey answer - General question - Recommendation

Recommendation	
Partner	**Survey Answer**
Ford Otosan	First Time Development
I&M	At present there are not small electric motors (in the range of 1÷5 kW) for HV applications (400÷600 V), hence it is not easy to develop a complete solution.
TU Ilmenau	None
Tenneco	The research and collaboration with partners allow to learn about the available technologies and limitations. One of the barriers is the selection of a HV motor for the lower power application. No recommendations at this stage as it is still under investigation.
UTIA	UTIA considers as highly motivated development of UC1 to increase vehicle range, top speed and vehicle dynamic for lower speed as is described in detail in D2.1. Indeed, attractive is the transmission from baseline Skoda Rapid to Skoda Enyaq. At the present stage of the project UTIA do not see any significant barriers.

University of Surrey	There is no immediate barrier at this stage.
IESTA	None

Sub-part "Questions for service / product deployment"

To do not miss the context of the answers sometimes the questions of the surveys are also included in the tables (especially if there are more than one question) beside the partners answers (see as example Ford Otosan in Table 3-12).

Table 3-12: Survey answer – Questions for service / product deployment – Product / service Development

Product / Service Development	
Partner	**Survey Answer**
Ford Otosan	*What kind of product are you going to develop?* Power Electronic Converter (OBC and DC/DC) *What kind of service are you offering?* Manufacturing of a new product, publications *How the product/ service will be put in use (made available to "customers" to generate an impact).* It will be used in our Heavy Commercial Vehicle Project
I&M	The development of a small HV power inverter for a levelling system is covering a segment of the market where no other integrated solutions are available. This development can be reused to different auxiliaries (i.e., heaters, air conditioning…).
TU Ilmenau	*What kind of product are you going to develop?* Controller (software) *What kind of service are you offering?* XiL testing as a service *How the product/ service will be put in use (made available to "customers" to generate an impact).* Implementation on eventual vehicle demonstrators, Test campaign with offering Open Research elements for inclusive design work.
Tenneco	*What kind of product are you going to develop?* Levelling system to change the ride height of vehicles.

	How the product/ service will be put in use (made available to "customers" to generate an impact). The product should reach a technology readiness in order to propose it to customers.
UTIA	We are going to support development and testing UC1 especially from the perspective of new concepts of machine-interface for multi gear box. Generally, our products serve for development and testing vehicle components, e.g. signal convertors for data/video transmission incl. improving and verification efficiency key parameters, optimisation vehicle dynamic and power consumption. From this point of view we are offering manufacturing embedded control components, processing data and vehicle network signals. Our products/services serve for specification “Lastenhefts” and demonstration use cases for expert community.
University of Surrey	*What kind of product are you going to develop?* Not directly applicable. Our main focus is on research collaborations. *What kind of service are you offering?* Our research will output high-quality publications in the area of control and optimisation of powertrains and vehicle dynamics, which can be further developed as technology transfer to OEMs, and/or as track record to attract future contract research. *How the product/ service will be put in use (made available to "customers" to generate an impact).* Our research outputs will be presented to the project advisory board, in technical conferences and in publications.
IESTA	*What kind of service are you offering?* Consulting Service for innovative Mobility solutions and innovations including TCO and CBA calculation tool as well as the expertise in the field of dissemination, communication and exploitation. *How the product/ service will be put in use (made available to "customers" to generate an impact).* Via marketing and further research activities.

Table 3-13: Survey answer – Questions for service / product deployment – "Market" – Target market

"Market" – Target market	
Partner	**Survey Answer**

Ford Otosan	*Describe the market in which your product/service will be used/can "compete", answering the following questions:*
	- *Which stakeholders are involved?*
	  ○ FO
	- *Do you plan on partnering with SME's/ start-ups?*
	  ○ No
	- *How will you further finance the development of your product/service?*
	  ○ Internally
	- *How will you promote your product/service?*
	  ○ Internally

I&M	The collaboration with Tenneco can lead to the development of a full system and hence a product for the market. The product will be advertised on both our website, international fairs, and social media.
TU Ilmenau	The target market for our product/service are suppliers and engineering service companies. Besides we plan on partnering with SMEs for developing chassis systems and components. Various strategies are currently being considered to further finance the development of our products/services. To promote our product/ service, we use participation in exhibitions and dissemination in various web channels.

Tenneco	*Describe the market in which your product/service will be used/can "compete", answering the following questions:*
	- *Which stakeholders are involved?*
	  Tier2 and OEM's
	- *Do you plan on partnering with SME's/ start-ups?*
	  No
	- *How will you further finance the development of your product/service?*
	  Internal funding or joined development.
	How will you promote your product/service?
	Presentation to customer

UTIA	Our products/services are used in vehicle market. We are partnering with various SME and large companies, e.g. TRENZ, SKODA AUTO etc. We are going to promote our outputs thanks to financial support of national /European projects.

University of Surrey	*Describe the market in which your product/service will be used/can "compete", answering the following questions:* - *Which stakeholders are involved?* Tier1 and OEMs - *Do you plan on partnering with SME's/ start-ups?* Yes, in the form of research collaborations. - *How will you further finance the development of your product/service?* Attraction of contract research grants *How will you promote your product/service?* Conferences and journal papers.
IESTA	Planned is to provide the service to different actors in the mobility industry. This can include public authorities, SMEs and OEMs. The service is primarily promoted and financed through already existing business and research networks of IESTA as well as future European and national R&D projects.

Table 3-14: Survey answer – Questions for service / product deployment – "Market" - Competitors

"Market" - Competitors	
Partner	**Survey Answer**
Ford Otosan	*Who are your "competitors" (note: they are the ones offering "alternative solutions")?* Tier1 *What are your strengths and opportunities within the market?* Heavy-Duty Vehicle Manufacturer and Having Current Customer Chain
I&M	Other companies might offer similar solutions (Continental, Pierburg, AVL), but at present we don't have information of devices as the one we are developing.
TU Ilmenau	*Who are your "competitors" (note: they are the ones offering "alternative solutions")?* Engineering service companies *What are your strengths and opportunities within the market?* Flexibility to benchmark different concepts within a short time, know how from previous collaborative projects, also with industry.
Tenneco	*Who are your "competitors" (note: they are the ones offering "alternative solutions")?* Many alternative existing

	What are your strengths and opportunities within the market? The other solutions are more complex, more expensive and request more power consumption.
UTIA	UTIA has strong competition in the fundamental and applied research in computer science, signal and image processing, pattern recognition, system science, and control theory. UTIA falls under the Czech Academy of Sciences that consists of 52 research organisations. This brings further positive aspects on the market.
University of Surrey	*Who are your "competitors" (note: they are the ones offering "alternative solutions")?* Other R&D units or institutes. *What are your strengths and opportunities within the market?* Continuous innovations demonstrated by means of track records in publications, research fundings, direct industrial collaborations.
IESTA	*Who are your "competitors" (note: they are the ones offering "alternative solutions")?* • Consulting companies • All companies providing as well dissemination, communication & exploitation and cost assessment expertise *What are your strengths and opportunities within the market?* IESTA is well known in the R&D Environment and its expertise is trusted and valued.

Table 3-15: Survey answer – Questions for service / product deployment – Go to Market - Timing

Go to Market - Timing	
Partner	**Survey Answer**
Ford Otosan	*What is the time to market?* 2028
I&M	By the end of the project we can have a fully operational solution (i.e., a couple of years) that will require some engineering step to be at a TRL sufficient to be commercialized.
TU Ilmenau	Within five years, in the case of no essential new trends on the market.
Tenneco	*What is the time to market?* In 5 years.
UTIA	Time to market is influenced by the situation on the market, readiness of stakeholders and legislative/political aspects.

University of Surrey	Not applicable
IESTA	Directly after the project it would be possible to offer the service to the market.

Table 3-16: Survey answer – Questions for service / product deployment – Success Factors

Success Factors	
Partner	**Survey Answer**
Ford Otosan	*Describe your expected and measurable success factors (i.e. environmental, use of product/service, financial, market development, acceptance)* Financial, Product, and Acceptance
I&M	The design will be modular and scalable to enable wide range of application.
TU Ilmenau	Acceptance of developed technologies by industrial customers.
Tenneco	The system is energy efficient, simple in design, at a targeted low cost and will help to improve the EV's range.
UTIA	UTIA development products/testing services are used all over the national vehicle market e.g. Technical development Skoda Auto incl. subsidiaries like Digiteq Automotive.
University of Surrey	Impactful high-quality publications
IESTA	Successful public response to the HiPE project because of the dissemination activities (e.g. rising follower numbers in LinkedIn). Further involvement in national and European R&D projects, especially with the task Cost Assessment.

Table 3-17: Survey answer – Questions for service / product deployment – Value Chain

Value Chain	
Partner	**Survey Answer**
Ford Otosan	The know-how in this product can be used in power electronic converter design in charging stations. This results in different business opportunities.
I&M	This can put our company to operate in a new business sector.
TU Ilmenau	To be defined to the final stage of the project.
Tenneco	New field of business

UTIA	Current product/service enhancement may boost up entering new fields of business but it is influenced by strategic decision of Czech Academy of Sciences.
University of Surrey	It will enhance our current operation in research capability, knowledge and expertise.
IESTA	The service will enhance the image of IESTA in the R&D environment.

Table 3-18: Survey answer – Questions for service / product deployment – Enablers

Enablers	
Partner	**Survey Answer**
Ford Otosan	In-house sub-component development is a trend for almost every OEM. Therefore, this is a key-enablers for us. Our company already has this policy for different components, and OBC+DC-DC is one of them.
I&M	At present we miss electric motors in the kW range suitable for the various applications.
TU Ilmenau	To be defined to the final stage of the project.
Tenneco	The business plan (still under construction) should be attractive enough.
UTIA	Policy aspects are significant in various areas – green transport, urban air mobility, automated vehicles, wireless communication etc.
University of Surrey	Direct collaborations with industry.
IESTA	No specific enablers in HiPE

Table 3-19: Survey answer – Questions for service / product deployment – Disruptors/Challenges

Disruptors/Challenges	
Partner	**Survey Answer**
Ford Otosan	For our company, in-house component development is a new trend, similar to other OEMs. Therefore, defining the process and gathering the team have some barriers. Also, although individual know-how exists in the Team, building the organizational know-how is challenging. Besides these, the HiPE requirement (very high efficiency, using WBG, power density target, etc.) results in deep technical approaches for designing every part of the system/circuit
I&M	Not applicable
TU Ilmenau	Potential changes in existing regulations related to (i) vehicle safety and (ii) testing procedures on vehicle and on system levels.

Tenneco	There can be some technical challenges (speed, noise, spacing, implementation issues), or cost (the design is more complex than expected) then the product might be less attractive than expected.
UTIA	We are influenced by various barrier e.g. pandemic situation, military activities, migration of population etc.
University of Surrey	Not applicable
IESTA	No specific disruptors or challenges are foreseen.

Sub-part "Questions for academia & further research"

To do not miss the context of the answers the questions of the surveys are also included in the tables.

Table 3-20: Survey answer – Questions for academia & further research – Funding

Funding	
Partner	**Survey Answer**
Ford Otosan	*Will you apply for further funding from a new research project or consultancy tender?* ☐ Yes ☒ No
I&M	*Will you apply for further funding from a new research project or consultancy tender?* ☐ Yes ☒ No
TU Ilmenau	*Will you apply for further funding from a new research project or consultancy tender?* ☒ Yes ☐ No *Do you already know which? - please specify.* Horizon Europe, Several German national funding programs
Tenneco	*Will you apply for further funding from a new research project or consultancy tender?* ☐ Yes ☒ No
UTIA	*Will you apply for further funding from a new research project or consultancy tender?* ☒ Yes ☐ No *Do you already know which?* It is still open.
University of Surrey	*Will you apply for further funding from a new research project or consultancy tender?* ☒ Yes ☐ No
IESTA	*Will you apply for further funding from a new research project or consultancy tender?* ☒ Yes ☐ No *Do you already know which? - please specify.* On European and National level

Table 3-21: Survey answer – Questions for academia & further research – Research

Research	
Partner	**Survey Answer**
Ford Otosan	*Will HiPE deliver input to research led teaching for students?* ☐ Yes ☒ No *Will HiPE be part of PhDs and/ or student projects?* ☒ Yes ☐ No
I&M	*Will HiPE deliver input to research led teaching for students?* ☐ Yes ☒ No
TU Ilmenau	*Will HiPE deliver input to research led teaching for students?* ☒ Yes ☐ No *Will HiPE be part of PhDs and/ or student projects?* ☒ Yes ☐ No
Tenneco	*Will HiPE deliver input to research led teaching for students?* ☐ Yes ☒ No
UTIA	*Will HiPE deliver input to research led teaching for students?* ☒ Yes ☐ No *Will HiPE be part of PhDs and/ or student projects?* ☒ Yes ☐ No
University of Surrey	*Will HiPE deliver input to research led teaching for students?* ☒ Yes ☐ No *Will HiPE be part of PhDs and/ or student projects?* ☒ Yes ☐ No
IESTA	*Will HiPE deliver input to research led teaching for students?* ☒ Yes ☐ No *Will HiPE be part of PhDs and/ or student projects?* ☒ Yes ☐ No

Table 3-22: Survey answer – Questions for academia & further research – Consulting

Consulting	
Partner	**Survey Answer**
Ford Otosan	*Are you going to offer your learnings for networking with industry partners or administrations?* ☒ Yes ☐ No
I&M	No answer
TU Ilmenau	*Are you going to offer your learnings for networking with industry partners or administrations?* ☐ Yes ☒ No
Tenneco	*Are you going to offer your learnings for networking with industry partners or administrations?* ☐ Yes ☒ No

UTIA	*Are you going to offer your learnings for networking with industry partners or administrations?* ☒ Yes ☐ No *Do you already have industry partner for "HiPE consulting"?* It is still open.
University of Surrey	*Are you going to offer your learnings for networking with industry partners or administrations?* ☒ Yes ☐ No
IESTA	*Are you going to offer your learnings for networking with industry partners or administrations?* ☒ Yes ☐ No

3.2 Standardisation

Main goal of the standardisation activities is – as already mentioned – to find approaches and ideas how to standardise HiPE innovations and technologies for the international market.

In a first step, the regulations and standards relevant for HiPE were collected, as well as to which use case the regulation/standard applies and which partner is responsible for monitoring the specific regulation/standard in case of new versions or amendments (see Table 3-23 and Table 3-24).

It should be mentioned that these tables include a first collection of relevant regulations and standards, meaning that these lists are going to change over time as a living document available at the HiPE SharePoint. New Regulations/Standards will be added to the list and already mentioned ones might be removed in the course of the project. The final regulation and standard lists are going to be implemented in "D7.5 – Final Exploitation Report" at the end of the project.

Table 3-23: Overview of Regulations relevant for HiPE up until now

Regulation	Applies to which Use Case?	HiPE partner responsible for monitoring
Regulation No 0 of the Economic Commission for Europe of the United Nations [2018/780]	Use case 1, 2, 3, 4	IESTA
Regulation (EU) 2019/2144 – Type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users	Use case 1, 2, 3, 4	IESTA
Regulation No 155 – Uniform provisions concerning the approval of vehicles with regards to cybersecurity and cybersecurity management system [2021/387]	Use case 1, 2, 3, 4	UTIA

UN Regulation No 154 – Worldwide harmonized Light vehicles Test Procedure (WLTP)	Use case 1, 2, 3, 4	UoS

Table 3-24: Standards relevant for HiPE up until now

Standard	Applies to which Use Case?	HiPE partner responsible for monitoring
ISO 6469 (-1, -2, -3, -4): Electrically propelled road vehicles – Safety specifications	Use case 1, 2, 3, 4	IESTA
IEC 60664: Insulation coordination for equipment within low-voltage supply systems	Use case 1, 2, 3, 4	IESTA
IEC 60749-25:2003: Thermal Shock Test (TST)	Use case 1, 2, 3, 4	Fraunhofer ENAS
IEC 60749-34:2011: Lifetime testing: power cycling (PCsec)	Use case 1, 2, 3, 4	Fraunhofer ENAS
ISO 26262 - 1:2018: Road vehicles - Functional safety	Use case 3, 4	TU Illmenau
IEC 61851-1:2017: Electric vehicle conductive charging system	Use case 3	Ford OTOSAN
BS EN ISO 17409:2020: Electrically propelled road vehicles. Conductive power transfer. Safety requirements	Use case 3	Ford OTOSAN
IEC 60664-1:2020: Insulation coordination for equipment within low-voltage supply systems	Use case 3	Ford OTOSAN
ISO 16750-1:2023: Environmental conditions and testing for electrical and electronic equipment	Use case 3	Ford OTOSAN
AEC - Q100: Failure Mechanism Based Stress Test Qualification for Integrated Circuits	Use case 1, 2, 3, 4	Nexperia
AEC - Q101: Failure Mechanism Based Stress Test Qualification for Discrete Semiconductors	Use case 1, 2, 3, 4	Nexperia
AEC - Q006 Rev - A: Qualification Requirements for Components using Copper (Cu) Wire Interconnects	Use case 1, 2, 3, 4	Nexperia
EN 60191-4:2014/A1:2018-05: Mechanical standardization of semiconductor devices - Part 4: Coding system and classification into forms of package outlines for semiconductor device packages	Use case 1, 2, 3, 4	Nexperia

EN IEC 60191-1:2018-03: Mechanical standardization of semiconductor devices - Part 1: General rules for the preparation of outline drawings of discrete devices	Use case 1, 2, 3, 4	Nexperia
BS EN 60191-6-13:2016: Mechanical standardization of semiconductor devices - Part 6: Design guideline of open-top-type sockets for Fine-pitch Ball Grid Array (FBGA) and Fine-pitch Land Grid Array (FLGA)	Use case 1, 2, 3, 4	Nexperia
DKE682: Assembly and connection technology for electronic assemblies	Use case 1, 2, 3, 4	Nexperia
VDE-ITG 5.7: Platform for automotive semiconductors along the value chain	Use case 1, 2, 3, 4	Nexperia

Beside collecting all HiPE relevant regulations and standards, it is planned to discuss within the consortium how to standardise the developed HiPE innovations for the international market. This will be done in the upcoming months of the project.

4. Conclusion

In the first 18 months of the HiPE project several tasks were performed for exploitation and standardisation:

- Grant Agreement Key Exploitable Results were asked and updated
- First exploitation survey was done and presented
- First HiPE relevant regulations and standards were collected

The next steps will be to continuously update the KERs and the regulations and standards until the end of the project. The final findings will be presented in D7.5.

Besides that, a second exploitation survey is planned. This survey will be done in cooperation with the HORIZON Results Booster service. Risk here is, that partners are not willing to provide input. But to countermeasure this risk, an exploitation workshop is planned with the HiPE partners. The final results will be presented in D7.5.

5. Abbreviations

Term	Definition
AC	Air Conditioner
AI	Artificial Intelligence
BEV	Battery Electric Vehicle
CBA	Cost-Benefit-Analysis
CDTs	Compact digital twins
CEA	Cost-Effectiveness-Analysis
CO_2	Carbon Dioxide
Cu	Copper
EMI	Electro-magnetic Interference
EU	European Union
FBGA	Fine-pitch Ball Grid Array
FLGA	Fine-pitch Land Grid Array
GaN	Gallium Nitride
GDPR	General Data Protection Regulation
HiPE	High Performance Power Electronics Integrations
HMI	Human Machine Interface
HV	High Voltage
HW	Hardware
KERs	Key Exploitable Results
LV	Low Voltage
OBC	On-Board chargers
OEM	Original Equipment Manufacturer
PE	Power Electronics
PhD	Doctor of Philosophy (Philosophiae doctor)
PU	Public
R	Document, Report
R&D	Research and Development
RUL	Remaining useful life
SiC	Silicon Carbide
SME	Small and Medium Enterprises
SotA	State-of-the-Art
SW	Software
TCO	Total-Cost-of-Ownership
ThMgt	Thermal Management
TST	Thermal Shock Test
UC	Use Case

WBG	Wide Bandgap
WLTP	Worldwide Harmonised Light-Duty Vehicles Test Procedure
WP	Work Package