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# SHIFT to Direct Current

## Deliverable D 5.1 Innovation and Exploitation Plan

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## **Disclaimer**

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## Executive Summary

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This document presents the first version of the Innovation and Exploitation Plan for the Shift2DC project, funded by the European Union's Horizon Europe program. The project aims to develop and implement Direct Current (DC) technologies to enhance energy efficiency, sustainability, and reliability across various sectors, including datacentres, buildings, industries, and ports.

The primary objectives of this deliverable are to define the Innovation Management Process of the project, to identify and engage stakeholders both inside and outside the consortium, to monitor market evolution and adapt, to establish and track Innovation Key Performance Indicators (KPIs) and developing develop Exploitation strategies.

The methodologies employed in the Shift2DC project are designed to ensure a comprehensive and effective approach to innovation and exploitation:

- **Innovation Management Process (IMP):** This process ensures that innovation activities are aligned with the project's goals and are carried out efficiently and effectively.
- **Stakeholder Identification and Engagement:** Identifying and engaging relevant stakeholders both inside and outside the consortium.
- **Market and Technology Monitoring:** Continuously observing market trends, technological advancements, and regulatory changes. This monitoring helps identify opportunities and threats, allowing the project to adapt its strategies accordingly.
- **Intellectual Property (IP) Management:** Developing an IP management strategy to protect the intellectual property generated within the project.
- **Innovation Metrics and KPIs:** Defining KPIs to measure the success of the innovation activities. The project adopts the *KTH Innovation Readiness Level™* framework.
- **Exploitation Methodology:** Identifying and assessing significant results, developing exploitation strategies, and creating detailed implementation plans. This includes commercialization, further research, standardization, dissemination, and communication strategies.
- **Risk Management:** Implementing a risk management framework to identify, assess, and mitigate risks associated with the innovation activities. This includes regular risk assessments and the development of contingency plans.

The document outlines the development of 26 technological solutions, each addressing specific challenges and offering unique benefits. Key benefits include increased efficiency, cost savings, sustainability, scalability, and improved reliability. The project has also defined KPIs to measure the success of innovation activities, adopting the *KTH Innovation Readiness Level™* framework. Preliminary assessments indicate ambitious objectives for the project's duration, with significant progress expected in areas such as customer readiness, technology readiness, and business model readiness.

The first version of the Innovation and Exploitation Plan sets a solid foundation for the Shift2DC project, ensuring that innovative DC technologies are effectively brought to market and adopted by relevant stakeholders. The plan outlines clear objectives, methodologies, and strategies to achieve these goals, with a focus on continuous improvement and adaptation. Future updates will refine the plan based on ongoing assessments and feedback, ensuring that the project remains aligned with its strategic goals and maximizes its impact on the market.

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## Acronym

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AC	Alternating Current
ASIC	Application-specific Integrated Circuit
AI	Artificial Intelligence
BRL	Business Model Readiness Level
CPX	Clusters Proxy
CRL	Customer Readiness Level
CRL	Customer Readiness Level
DC	Direct Current
DERs	Distributed Energy Resources
PhD	Doctor of Philosophy
EVs	Electric Vehicles
EMS	Energy Management System
FRL	Funding Readiness Level
IMP	Innovation Management Process
IP	Intellectual Property
IPRL	IPR Readiness Level
KERs	Key Exploitable Results
KPIs	Key Performance Indicators
LVAC	Low-voltage Alternating Current
LVDC	Low-voltage Direct Current
MSc	Master of Science
MVDC	Medium-voltage Direct Current
PDU	Power Distribution Unit
PCB	Printed Circuit Board
R&D	Research and Development
SSCBs	Semiconductor Circuit Breakers
SWOT	Strengths, Weaknesses, Opportunities and Threats
TMRL	Team Readiness Level
TRL	Technology Readiness Level
TRL	Technology Readiness Level
IPR	The Intellectual Property Rights
UPS	Uninterruptable Power Source
USB-C	Universal Serial Bus Type C
UCs	Use-Cases
V2X	Vehicle-to-Everything
VPD	Vertical Power Delivery
WP	Work Package

# 1 Introduction

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## 1.1 Scope and Objectives

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The Shift2DC project, funded by the European Union's Horizon Europe program, aims to develop and implement innovative DC technologies to enhance energy efficiency, sustainability, and reliability across various sectors, including datacentres, buildings, industries, and ports. This deliverable, the first version of the Innovation and Exploitation Plan, outlines the strategic approach to innovation within the project. The primary objectives of this plan are to ensure that the developed DC technologies are effectively brought to market, adopted by relevant stakeholders, and generate significant impact.

The specific objectives of the Innovation and Exploitation Plan are:

- **Define the Innovation Management Process:** Establish a structured approach to managing the development and implementation of new ideas and technologies.
- **Identify and Engage Stakeholders:** Engage with key stakeholders, both inside and outside the consortium, to gather feedback, validate results, and foster collaboration.
- **Monitor Market Evolution and Adapt:** Continuously observe market trends, technological advancements, and regulatory changes to adapt the project's strategies as needed.
- **Establish Innovation KPIs:** Define and track Key Performance Indicators (KPIs) to measure the success of the project's innovation activities and ensure alignment with strategic goals.
- **Managing and collating the Exploitation Plans of the Partners:** Identifying and assessing significant results, developing exploitation strategies, and creating detailed implementation plans. This includes commercialization, further research, standardization, dissemination, and communication strategies.

By addressing these objectives, the Innovation and Exploitation Plan aims to foster a culture of innovation within the project, drive the development of solutions, and ultimately contribute to the project's overall success. This document will serve as a living guide, evolving as needed to adapt to new challenges and opportunities, ensuring that Shift2DC innovation efforts are both strategic and impactful.

## 1.2 Structure

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The document is structured to provide a comprehensive overview of the Innovation and Exploitation Plan for the Shift2DC project. It is organized into the following sections:

- **Innovation Plan and Strategy:** This section details the strategic approach to innovation, including the motivation and objectives, the innovation management process, the benefits and challenges of the technologies, market and project benchmarking, and the definition and importance of innovation KPIs.
- **Exploitation Plan:** This section presents the methodology for exploiting the project's results, including the identification and assessment of results, exploitation strategies, implementation plans, intellectual property management, market analysis, risk management, and monitoring and evaluation. It also includes short exploitation plans for each of the 26 technological solutions.

By following this structure, the document provides a clear and detailed roadmap for the innovation and exploitation activities within the Shift2DC project.

### 1.3 Relationship with other deliverables

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This deliverable is the first one published under Shift2DC Work Package (WP) 5: “Innovation, Exploitation and Harmonization”, laying the foundations for the work being developed in this WP, which will run until the end of the project. The final version of this deliverable will be *D5.2 – Innovation and Exploitation Plan- Updated* due M36.

The activities in this Task will also contribute to other sister Tasks and Deliverables, such as *D5.3 – Standardization and Harmonization activities* due M40, and *D5.5 – DC Roadmap and Business models* due M42.

Also given the relationship with Stakeholder Engagement and Dissemination activities, which will be developed in *WP6 - Knowledge transfer and Dissemination*, there will also be a relationship with deliverable *D6.1 - Dissemination and Communication Plan* and its updated version D6.2.

## 2 Innovation Plan and Strategy

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The Innovation Plan for the Shift2DC project is intended to ensure that the innovative technologies and solutions developed within the project are effectively brought to market, adopted by relevant stakeholders, and/or generate significant impact. This plan outlines the strategic approach to innovation, focusing on the commercialization, dissemination, and exploitation of project outcomes. Additionally, an innovation management process will be established to ensure proper interrelation and coherence between the research challenges, the exploitation of results, and validation by potential users.

In the first version of the document, a preliminary version of the Innovation Plan and Strategy will be presented. As it will be detailed later in the Innovation Management Process, the Innovation Plan will be revisited, iterated and refined throughout the Task duration.

The Innovation Plan aims to achieve the following key objectives:

1. Define the Innovation Management Process
2. Identify and Engage Stakeholders
3. Monitor Market Evolution and Adapt
4. Establish Innovation KPIs for the Project.

By addressing these objectives, the Innovation Plan aims to foster a culture of innovation within the project, drive the development of solutions, and ultimately contribute to the project's overall success. This document will serve as a living guide, evolving as needed to adapt to new challenges and opportunities, and ensuring that Shift2DC innovation efforts are both strategic and impactful.

### 2.1 Motivation and Objectives

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The primary motivation behind this Innovation Plan is to bridge the gap between research and market implementation and impact. While the Shift2DC project aims to develop cutting-edge DC technologies, the Innovation Plan ensures that these innovations do not remain confined to research labs but are translated into practical, market-ready solutions. **This involves addressing market needs, overcoming adoption barriers, and creating value for stakeholders.**

Innovation withing European projects, such as this one, requires an understanding of both the technical and market needs and problems, in order to succeed.

As a first approach, the main objectives and end goals of the Shift2DC Innovation Plan and Strategy should be:

- **Commercialization of Technologies:** Develop strategies to bring the innovative DC technologies and solutions to market. This includes identifying potential market segments, creating business models, and establishing partnerships with industry players. This can be done in cooperation with other related Tasks in the Project.
- **Market Adoption and Scaling:** Promote the adoption of DC technologies by end-users, including data centres, buildings, industries, and ports. This involves demonstrating the benefits of DC systems, providing training and support, and creating incentives for adoption.
- **Intellectual Property Management:** Protect the intellectual property generated within the project through patents, trademarks, and copyrights. This ensures that the innovations are safeguarded and can be commercially exploited. The intellectual property rights (IPR)

generation will be tracked over the duration of the project and the guidelines of the IPR-Helpdesk<sup>1</sup> will be followed.

- Stakeholder Engagement and Collaboration: Engage with key stakeholders, including technology providers, utilities, alliances, sister projects, regulatory bodies, and end-users, to foster collaboration and support for the adoption of DC technologies.
- Regulatory and Standardization Advocacy: Work with regulatory bodies and standardization organizations to address barriers to the adoption of DC technologies. This includes advocating for changes in regulations and standards that facilitate the integration of DC systems.
- Knowledge Transfer and Dissemination: Ensure that the knowledge generated within the project is effectively disseminated to stakeholders and the broader community. This includes organizing workshops, publishing research findings, and fostering collaborations with other projects and initiatives.

Engagement, communication, and Dissemination activities are managed in a specific Work Package (WP6), in line with the best practices in project management. Therefore, there should be a very good collaboration between both WPs, in order to the Innovation and Exploitation Plan and Management Process to keep track of the activities and ensure fulfilment of the objectives.

## 2.2 Innovation Management Process (IMP)

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In this section, the Shift2DC IMP is described.

An innovation management process is a structured approach to managing the development and implementation of new ideas, products, or processes [1]. It ensures that innovation activities are aligned with the project's goals and are carried out efficiently and effectively. This process is crucial for transforming creative ideas into tangible outcomes that can provide competitive advantages and meet market needs.

The Shift2DC innovation management process should be robust enough to ensure proper interrelation and coherence between research challenges, exploitation of results, and validation by potential users. This process will identify relevant stakeholders, both inside and outside the consortium, and continuously observe market evolution, defining strategies for the project to adapt if necessary.

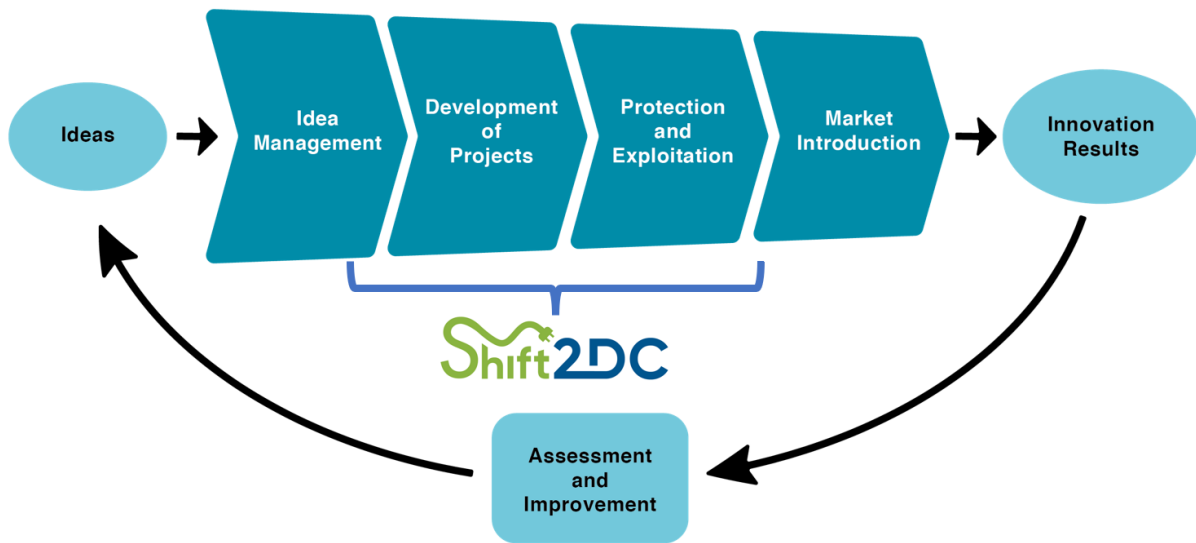
One of the first Shift2DC IMP tasks was nominating the Innovation Manager of the Project. The Innovation Manager will lead the strategy and progress status of the project innovation potential.

The Shift2DC IMP is also a high-level plan of the activities to manage innovation throughout the project. Once again, since this is the first version of the document, the IMP can be revised and adjusted as necessary. In fact, the plan for the revision and iteration of all the Innovation and Exploitation Plan will be included in the project IMP, detailed next.

The Shift2DC Innovation Management Process is based on an adaptation of the methodology defined in CEN/TS 16555 -1:2013 [2], whose main steps are identified in the Figure 2.1, together with Shift2DC scope.

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<sup>1</sup> [www.iprhelphdesk.org](http://www.iprhelphdesk.org)



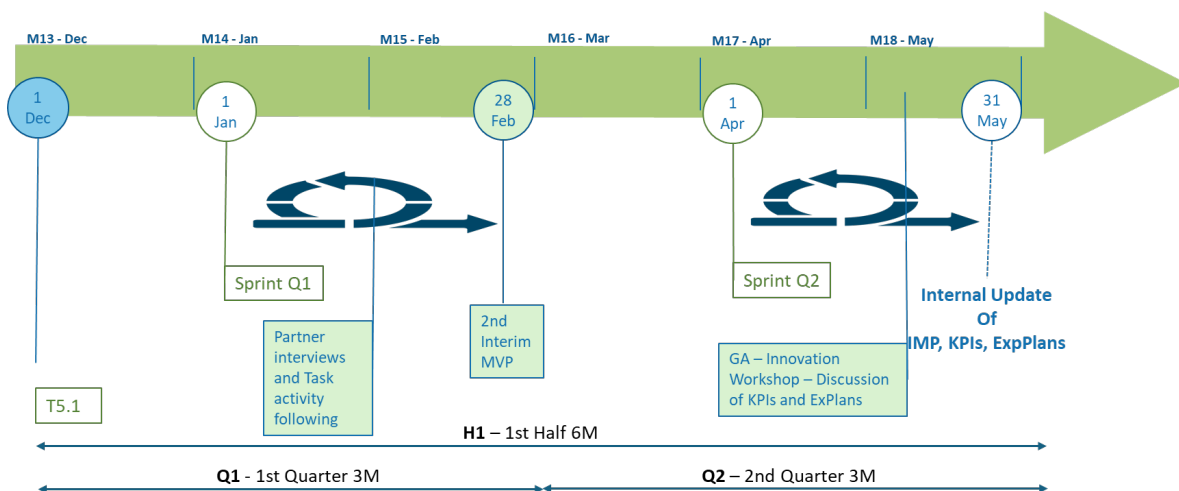
**Figure 2.1 – General Innovation Management Process and Shift2DC scope**

Being a mid-high Technology Readiness Level (TRL) project, Shift2DC is primarily on the middle stages of the innovation management process, but with some elements of market introduction, such as gathering user feedback, developing business models and engaging with potential users and stakeholders.

The entire duration of *Task T5.1 - Innovation and Exploitation Plan* (30 months) has been divided into five six-month periods to facilitate regular updates to the Project Innovation and Exploitation Plan. While formal deliverables are scheduled only at M6 and M30, updates during the intervening periods will be conducted internally within the project team.

In each six-month period, there will be 2 Innovation and Exploitation “sprints”, separated by retrospective and planning periods.

In Figure 2.2, an example of the T5.1 IMP planning for the period M13-M18 can be seen, together with the main internal Milestones.



**Figure 2.2 – Shift2DC IMP 6-month cycle**

Inside each sprint, the relevant activities pertaining to the Innovation Management Process will be conducted, with the objective of keeping the Shift2DC Innovation and Exploitation Plan updated throughout the project. A general representation of the possible sprint management activities can be seen in Figure 2.3.

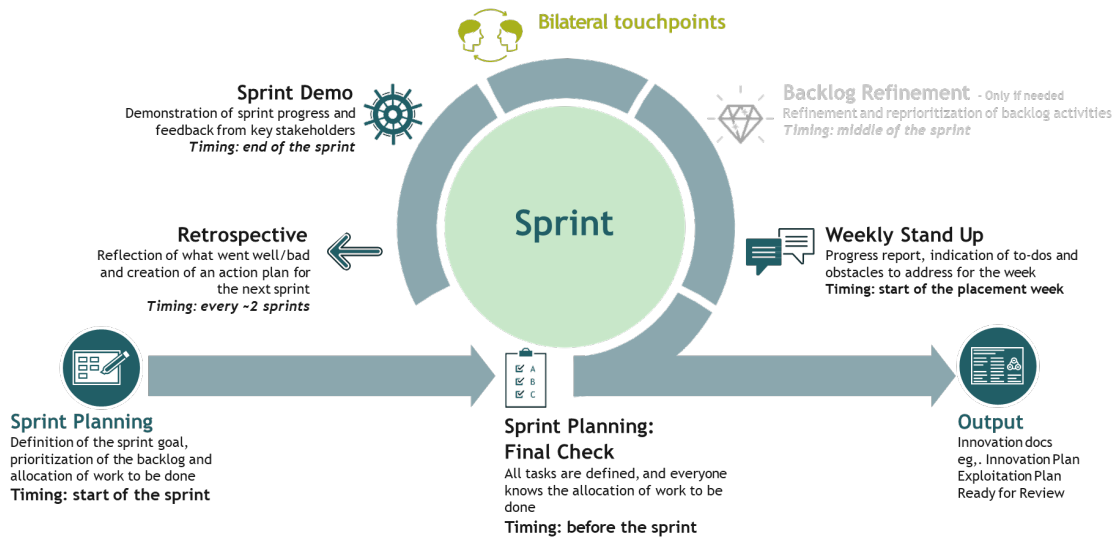


Figure 2.3 – Shift2DC IMP Sprint general view

In Figure 2.4, a more thorough description of the proposed possible activities that can happen during each sprint, including goals, duration and frequency, participants, and agenda. Following this plan is key to manage Shift2DC Innovation and Exploitation efficiently and to ensure the objectives of the respective Innovation and Exploitation Plans.

	Design + Implementation				
	Sprint Planning	Weekly stand-up	Backlog refinement <sup>1</sup>	Sprint Demo (a.k.a regular meeting)	Retrospective (GA or interim Workshop)
<b>Goal</b>	Clarification and alignment of the sprint goal	Team alignment and focus for the Week	Adapt to obstacles by refining the backlog	Stakeholder view of milestones	Concrete action plan for the next sprint
<b>Time &amp; freq.</b>	• 2h - 3h before the beginning and 1h at the beginning of each sprint.	• 15 min weekly (at the beginning of the week)	• 1 - 2h once per sprint	• 1h at the end of each sprint	• 30m - 1h at the end of each sprint
<b>Participants</b>	• Innovation Manager • T5.1 Team	• Innovation Manager • EDP NEW team	• Innovation Manager • WP5 leader • Coordination	• Innovation Manager • T5.1 Team • WP5 Leader • All partners (Optional) • External Experts (Optional)	• Innovation Manager • T5.1 Team • WP5 Leader • Scientific Committee
<b>Agenda</b>	• End-game of the sprint • Backlog and task allocation • Risks and obstacles	• Weekly achievements • To-dos for the Week • Obstacles	• Revisiting Current Activities • Prioritization and refinement of activities	• Goal Recap • Achievements & feedback • High-level goals for the next sprint	• Review of the sprint backlog • Action Plan

1. Backlog refinement should be done only if necessary

Figure 2.4 – Shift2DC IMP Sprint activity list and details

By the end of M30, all cycles will be completed, and the final Shift2DC Innovation and Exploitation plan deliverable will be finalized, and published.

The results of this Task will then feed on to the Task *T5.4 - DC Roadmap and Business Opportunities*, that will carry on the Innovation and Exploitation works, fulfilling specific objectives regarding DC technology Roadmap and new Business Models.

## 2.3 Technology, Benefits and Challenges

The Shift2DC project encompasses a wide range of innovative technologies and solutions aimed at enhancing the efficiency, sustainability, and reliability of DC systems. Each technology addresses specific challenges and offers unique benefits, contributing to the overall goals of the project.

At the time of the writing of this document, there are 26 different foreseen DC Technological Solutions to be developed in Shift2DC.

In Table 2.1, a first summary of the 26 Technological Solutions is presented.

**Table 2.1: Shift2DC Technological Solutions**

Type	Solution number	Responsible Partner(s)	Solution Name and Description
Business Models	SOL1	RWTH	<p><b><u>Pre-qualification of DC Solutions Procedure</u></b>            A medium and low voltage DC testbed for components, systems and operation strategies will be further developed and is open to the whole consortium for early testing and pre-qualification of equipment for the demo sites. The testbed will feature Power-Hardware-in-the-Loop as well as Control-Hardware-in-the-Loop using real time simulations of power electronics (Digital Twins).</p>
	SOL2	EDF	<p><b><u>Participation in Grid and System Services</u></b>            DC microgrid allows local control of production and consumption assets, and this independently from upstream Alternating Current (AC) grid. Thus, it is possible to provide grid services at common coupling point such as power consumption curtailment, reactive power injection or consumption, contribution to frequency regulation...            These services require coordination between the main AC/DC converter and the Energy Management System (EMS) controlling the DC microgrid. The latter will guarantee an acceptable operation of the DC microgrid while supporting the AC grid.</p>
	SOL3	INESC	<p><b><u>Energy Hubs Management</u></b>            Energy hubs are becoming important infrastructures in the context of energy transition. New business models will be proposed in Shift2DC project promoting the concept of ports as energy hubs.</p>

<b>Technologies</b>	<b>SOL4</b>	<b>NEXNS</b>	<p><b><u>Smart and sustainable DC cables</u></b></p> <p>A cable system optimized for DC applications using the most recent existing sustainable raw materials. The electrical characterisation of insulating materials under DC stress will be carried out by testing. Compared to existing cables, the cable to be prototyped in the project includes an innovative design embedding power and data (data will be an enabler for supervision system). This will participate to reduce de cable quantity inside the building by merging power and supervision communication.</p> <p>The new cable design will use materials with a lower environmental impact and more easily recyclable.</p> <p>The prototype will include new features to support the grid. The cable system will optimize the need of the network to maintain its resilience and reliability.</p> <p>This new specific design allows a significant reduction in the costs of the installation as well as fewer human resources in their installation. The prototype will follow the standards which are relevant for LVDC solutions.</p>
	<b>SOL5</b>	<b>TALT</b>	<p><b><u>Micro Solar DC Systems</u></b></p> <p>The <i>FlexiVerte</i><sup>®</sup> technology allows a faster and simpler integration of PV systems in the DC grids. The system is based on a universal software-defined DC/DC converter with advanced control functions optimizing the photovoltaic (PV) generation. It will allow integration of any typical PV module types or distributed integration of low-voltage batteries. As a result, single stock keeping unit could be used to implement different functions and, consequently, simplify and accelerate deployment of residential DC systems.</p>
	<b>SOL6</b>	<b>W&amp;W</b>	<p><b><u>High Density V2X DC Stations</u></b></p> <p>Bidirectional DC charging stations will be developed allowing the direct integration in DC systems. A new DC/DC converter will be developed allowing a high efficiency energy exchange</p>
	<b>SOL7</b>	<b>SCHND</b>	<p><b><u>LVAC-LVDC Interlink Converter</u></b></p> <p>Bidirectional interface between Low-voltage Alternating Current (LVAC) and Low-voltage Direct Current (LVDC) networks. The system will include innovative droop power flow control functions.</p>
	<b>SOL8</b>	<b>SCHND</b>	<p><b><u>Static Protection System</u></b></p> <p>New control algorithms in static protection systems to be used in LVDC grids will be developed and tested. Protections will be designed to limit risks of overcurrent, electric shocks, overvoltage thermal effects and arcs. Several technologies will be considered and the most promising will be adopted.</p>
	<b>SOL9</b>	<b>HIRO</b>	<p><b><u>Vertical Power Delivery (VPD) Solution</u></b></p> <p>VPD architecture allows a significant reduction of copper loss on Printed Circuit Board (PCB) from the power converter to the Application-specific Integrated Circuit (ASIC), which is specifically relevant for the future of datacenters in which high performing Clusters Proxy (CPX) continue to become bigger and draw more power.</p>

	SOL10	EATON	<p><b><u>Semiconductor-Based Protection</u></b> Semiconductor circuit breakers (SSCBs) enable design of robust and resilient DC grids. In the scope of the project, SSCBs will be utilized whether standalone or in a combination with common protection technologies (e.g., mechanical breakers) to define and test protection architecture of LVDC grids.</p>
	SOL11	EATON	<p><b><u>Pre-Charging Units for DC Circuit Breakers</u></b> Connecting loads with input capacitors to a DC grid is usually accompanied with high capacitive inrush currents. Pre-charging units ensure safe bi-directional pre-charging of DC loads with input DC-link and reduction of inrush currents which may lead to nuisance tripping of the upstream protection device. In the core of this technology is a bidirectional DC-DC converter that enables pre-charge/discharge of the DC grid capacitances. The pre-charging units are applicable in combination with hybrid and solid-state circuit breaker.</p>
	SOL12	PHNIX	<p><b><u>DC Measurement Device</u></b> Control systems need to rely on exact and reproducible measurement of DC currents and voltages, also in case of retrofit installations in legacy grid infrastructure. With respect to this, independent measurements are required to serve essential and accurate data on the DC currents and voltages within the system. The proposed solution will provide a wide range measurement up to 1000 A DC and 1500 V DC to support all DC grid operation schemes possible within the LVDC domain. A digital interface will provide the essential measurement data to DC grid controllers.</p>
	SOL13	TECN	<p><b><u>Fast-response Control Technologies for the Power Electronics</u></b> Fast-response component-level control techniques that endow power-electronics interfaced Distributed Energy Resources (DERs) with the required flexibility to participate in the voltage control of the DC grid. DC grid-forming/grid-supporting control approaches, that combine state-of-the-art droop controllers with innovative techniques such as capacitive emulation to enhance the dynamic response and/or adaptive dead-bands to improve the steady state voltage regulation and prioritize what DERs contribute to the voltage control, will be developed. These control techniques will be implemented into different DC DERs, including some type of loads. Thus, they will enable some loads to become active nodes in the grid that contribute to the voltage regulation.</p>
	SOL14	W&W	<p><b><u>DC/DC Converter - Smart Power Distribution Unit</u></b> Smart Power Distribution Unit (PDU) by adding a (non-isolated) DC/DC converter that allows the PDU to control the energy flow between power sources and loads and potentially different voltages. For instance, two battery sets of different technology or state-of-charge can be connected and managed through a smart-PDU.</p>
	SOL15	BACH	<p><b><u>Multisocket-Smart Power Distribution Unit</u></b> This PDU, also called rack PDU, will be developed to be used in datacentres since existing rack PDUs are only available for AC applications. The DC rack PDU that will be developed in Shift2DC project will enable secure and reliable distribution of the DC grid</p>

			power to the associated IT equipment in a secure and reliable fashion. It will measure important power parameters, which will enable a comparison in efficiency of DC solutions over existing AC solution.
	SOL16	BACH	<p><b><u>Plug &amp; Play Infrastructure for DC-based Office</u></b></p> <p>A new type of plug &amp; play infrastructure solution that uses DC-based technologies such as Universal Serial Bus type C (USB-C) and battery storage in the office environment in particular. The solution is also to be tested and further developed in the context of smart buildings to primarily use renewable energy for the workplaces, conference- and meeting rooms.</p>
	SOL17	EDF/ EATON	<p><b><u>Sharing Voltage Control Approach</u></b></p> <p>Voltage sharing approach adapts the coefficients of the droop curves of the individual DC DERs that participate in the active voltage control. In one potential realization it accepts the active power and bus voltage references for each DER of the considered DC grid from the EMS and determines new values of the droop coefficients following device-level and system-level constraints and predefined objective (e.g., minimize the deviation from the provided voltage/power references).</p>
	SOL18	JJC	<p><b><u>Passive Thermosyphon Cooling System for High Density Data Centres</u></b></p> <p>New passive cooling system based on gravity-driven flow of liquid and vapor (loop thermosyphon) will connect to all compute boards to cool them and transport the heat to the top of the rack (without any cooling power consumption) where the heat will then be transferred by a condenser to the hot water network to reuse the waste heat or disperse to environment when no heat demand.</p>
	SOL19	PHNPS	<p><b><u>Modular rack mounted Battery Energy Storage System (BESS)</u></b></p> <p>Modular rack mounted BESS will be proposed for industry applications. The system needs high flexibility in power as well as in the dimension of energy storage since DC grids in industrial applications need to be quickly adaptable. The BESS needs to provide quick exchange of power or energy modules in case of any defect in order to quickly support the manufacturing processes within the factory. A plug-and-play concept needs to be supported, not to lose valuable time and pause the manufacturing.</p>
	SOL20	PHNKG	<p><b><u>DC-Connectors</u></b></p> <p>Connector concepts and contact systems will be proposed and tested. Connectors with breaking capacity are dependent on inductive or capacitive loads, as these have a direct influence on the separation arc. Therefore, characteristics from actual DC grids are measured since standards do not provide detailed information by now. The danger of arcing faults in demonstrator systems during disconnection under load and their effects on connector systems are to be evaluated. In this way, hazards for users can be ruled out and the reliability and service life of the components can be ensured.</p>
Tools	SOL21	EATON	<p><b><u>EMS tool for AC/DC Hybrid Systems</u></b></p> <p>An “White box” EMS allowing the management and control of hybrid AC and DC grids. This EMS will be to include new control functions namely the ones that will be developed in the Shift2DC project.</p>

	SOL22	TALT	<p><b><u>Partial Power Processing</u></b>          Partial power processing is a novel niche solution for DC microgrids. It enables DC/DC conversion with considerably better efficiency (&gt;99%) and power density than that of conventional full-power converters. It is especially promising for Uninterruptable Power Source (UPS) integration in DC datacentres as well as for rack-level power management.</p>
	SOL23	EDF/ Circe	<p><b><u>DC Solutions Design tool</u></b>          This tool allows to evaluate different DC architectures, compared to conventional AC radial networks. This comparison will cover the following aspects:</p> <ul style="list-style-type: none"> <li>• Electrical sizing: power flow calculations will be iterated to solve electrotechnical constraints (voltage drops, over current, energy losses...). It will give the basic design of the DC grid with a preliminary sizing of cables, converters, ...)</li> <li>• Economic calculation including the following costs: initial capital costs, operation &amp; maintenance costs (especially when maintaining the main AC/DC converter and the measures that guarantee continuous power supply in critical loads), replacement costs.</li> </ul>
	SOL24	EDF/ NEW	<p><b><u>DC Solutions Simulation tool using Digital Twins</u></b>          This tool serves as a framework for a feasibility assessment of the control and protection strategies. It is particularly relevant for technical and economic feasibility studies and the assessment of novel algorithms/methodologies in hybrid AC/ DC of full DC grids. The digital twin tool will comprise simulation models of the DC components as well as DC grids developed in demos T4.1 to T4.4 and would enable closed-loop simulations when control, management and protection algorithms are considered/activated. It also enables a benchmark study and comparative analysis and complexity scalability for the evaluation of different scenarios. As such, the state-of-the-art control and protection solutions could for example be compared with the novel/adaptive strategies proposed in this project (e.g.: adaptive voltage sharing concept).</p>
	SOL25	SCHND	<p><b><u>Protection DC System Design tool</u></b>          This tool allows the design of protection systems for DC grids. The tool should consider different technologies such as semiconductor breakers, hybrid semiconductor breakers, mechanical breakers and fuses. Another important aspect to be considered is the selectivity between protection and the coordination of AC/DC protection system.</p>
	SOL26	RWTH/ TECN	<p><b><u>Small-signal Stability including analysis of Multi-vendor Interoperability</u></b>          Software tool to perform small-signal stability analysis based on the state-space representation and/or impedance-based modelling, complemented by investigations of an Artificial Intelligence (AI)-based approach. Methodologies to assess the stability of multi-terminal Medium-voltage Direct Current (MVDC) systems and required protection concepts will also be developed. Further control design specifications that allow a <i>plug&amp;play</i> integration of converters into</p>

			MVDC grid systems will be given. The tool will include a methodology aiming to assure the interoperability between multi-vendor protection systems.
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The general benefits, challenges, barriers and opportunities of DC technology were presented in detail in the deliverables D1.1 [3] and D1.2 [4] of the project. Nevertheless, a summary is presented below, focused on the 26 project Solutions and on feeding the Innovation and Exploitation Strategy.

Benefits:

- **Increased Efficiency:** DC systems can significantly reduce energy losses associated with AC/DC conversion, leading to higher overall efficiency.
- **Cost Savings:** Lower installation and operational costs due to reduced infrastructure requirements and improved energy efficiency.
- **Sustainability:** Enhanced integration of renewable energy sources, such as solar and wind, which are inherently DC, leading to a reduced environmental footprint.
- **Scalability:** Solutions are designed to be scalable and adaptable to various applications, from small residential systems to large industrial and port installations.
- **Improved Reliability:** Advanced protection and control systems enhance the reliability and resilience of DC grids, reducing the risk of outages and improving system stability.

Challenges:

- **Technical Barriers:** Developing control algorithms, protection systems, and design tools specific to DC systems requires significant research and innovation.
- **Regulatory and Standardization Issues:** The lack of existing regulations and standards for DC technologies poses a challenge to their widespread adoption. Engaging with regulatory bodies and advocating for necessary changes is crucial.
- **Market Adoption:** Overcoming market resistance and promoting the benefits of DC systems to potential users and stakeholders is essential for successful commercialization.
- **Interoperability:** Ensuring compatibility between different DC technologies and systems is critical for seamless integration and operation.

## 2.4 Market and Project Benchmarking

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The Shift2DC project aims to position itself as a reference project in the development and implementation of DC technologies, targeting a wide range of sectors and stakeholders. By leveraging the strengths of its diverse consortium, the project seeks to create a significant impact on the market and drive the adoption of DC systems.

The Shift2DC project will continuously benchmark itself against other leading initiatives and projects in the field of DC technologies. By comparing its objectives, methodologies, and outcomes with those of similar projects, Shift2DC aims to identify best practices, avoid potential pitfalls, and ensure that its innovations are at the forefront of technological advancements. This benchmarking process will involve regular reviews of external documents, participation in relevant conferences and workshops, and collaboration with other research and development initiatives. By staying informed about the

latest trends and developments, Shift2DC can adapt its strategies to remain competitive and maximize its impact on the market.

Based on a preliminary assessment, Shift2DC should position itself as an Innovator, Collaborator and Influencer, in order to succeed:

- **Innovator:** The Shift2DC project is at the forefront of demonstrating the feasibility and benefits of DC systems. By implementing real-world demonstrators, the project showcases the practical applications and advantages of DC technology.
- **Collaborator:** The project brings together a diverse consortium of partners, including research institutions, industry players, and utilities. This collaborative approach ensures a comprehensive and multidisciplinary perspective on the development and implementation of DC technologies.
- **Influencer:** By engaging with alliances, regulatory bodies and standardization organizations, the Shift2DC project aims to shape the regulatory and standardization landscape for DC technologies. This influence is crucial for creating a favourable environment for the adoption of DC systems.

A typical Market and Project Benchmarking should also identify Target audiences, Relevant Stakeholders, Competitors, and Market Opportunities [5].

#### 2.4.1 Target Audience

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The Target Audience for Shift2DC is mainly the one defined by the call for proposals that the project addressed, although through the duration of the project, other Targets can and should be identified:

- **Data Centres:** Operators and developers of data centres looking to improve energy efficiency, reduce operational costs, and enhance system reliability.
- **Buildings:** Commercial and residential building managers seeking sustainable energy solutions that integrate renewable energy sources and improve energy management.
- **Industries:** Manufacturers and industrial operators aiming to enhance efficiency, reliability, and flexibility in their energy systems.
- **Ports:** Port authorities and operators interested in electrification, renewable energy integration, and improving the sustainability of port operations.

#### 2.4.2 Relevant Stakeholders

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A preliminary assessment of Relevant Stakeholders, external to the project, was also conducted. It is relevant to conclude that among the Shift2DC consortium, most of these types of Stakeholders are already represented, reinforcing the idea of a strong consortium, able to provide the expected results. The identified Relevant Stakeholders are:

- **Technology Providers:** Companies developing DC components, devices, and systems, including manufacturers of cables, converters, protection systems, and energy management tools.
- **Utilities:** Energy providers and grid operators responsible for managing the integration of DC technologies into existing and future energy systems.
- **Regulatory Bodies:** Organizations responsible for setting standards and regulations for DC systems, including national and international standardization bodies.

- Research Institutions: Universities and research centres conducting studies and developing new technologies related to DC systems.
- End Users: Businesses and individuals adopting DC solutions for their operations, including data centres, buildings, industries, and ports.

### 2.4.3 Competitors

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The term “Competitors” should be interpreted broadly at high-level, when discussing DC technologies and general and Shift2DC in particular. The preliminary so-called Competitors can be identified as:

- Traditional AC Systems: Existing AC infrastructure and technologies that dominate the market. These systems are well-established and have a significant market presence, posing a challenge to the adoption of DC technologies.
- Emerging alternative DC Technologies: Other projects and companies developing similar DC solutions. These competitors may offer alternative approaches and technologies that address similar challenges.

### 2.4.4 Market Opportunities

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The Market Opportunities for the Shift2DC Technological Solutions are closely related to the general DC benefits (and were also thoroughly described in the Deliverable D1.1 of the project [3]), but also with a focus on the four specific areas addressed by the project:

- Energy Efficiency: The growing demand for energy-efficient solutions presents a significant market opportunity for DC technologies. By reducing energy losses and improving overall efficiency, DC systems can meet the needs of energy-conscious consumers and businesses.
- Renewable Energy Integration: The increasing adoption of renewable energy sources, such as solar and wind, which are inherently DC, creates a favourable environment for the implementation of DC systems. DC technologies can facilitate the seamless integration of these renewable sources into the grid.
- Electrification of Transportation: The shift towards Electric Vehicles (EVs) and the need for efficient charging infrastructure present a substantial market opportunity for DC technologies. High-density Vehicle-to-Everything (V2X) DC stations can enhance the flexibility and efficiency of EV charging networks.
- Sustainable Building Solutions: The demand for sustainable and energy-efficient building solutions is on the rise. DC systems can provide significant benefits in terms of energy management, integration of renewable energy sources, and overall sustainability.
- Industrial Applications: Industries are continually seeking ways to improve efficiency, reliability, and flexibility in their energy systems. DC technologies can address these needs by offering robust and scalable solutions tailored to industrial applications.
- Port Electrification: Ports are increasingly looking to electrify their operations to reduce emissions and improve sustainability. DC systems can support the electrification of port infrastructure, including the integration of renewable energy sources and energy storage systems.
- Datacentres: The datacentre market is poised for significant growth, driven by the increasing demand for data-intensive applications. These applications require substantial computational power and, consequently, large amounts of energy. DC technologies offer a compelling

solution for datacentres by improving energy efficiency, reducing power conversion losses, and lowering operational costs.

## 2.5 Innovation Key Performance Indicators

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KPIs, in general, are measurable values that demonstrate how effectively an organization is achieving its key business objectives. KPIs are used to evaluate success at reaching targets across various levels of an organization. They provide a focus for strategic and operational improvement, create an analytical basis for decision-making, and help focus attention on what matters most.

For the Shift2DC project, Innovation KPIs will be specifically tailored to measure the success of the project's innovation activities, technological developments, and market impact. These KPIs will help ensure that the project stays on track to achieve its goals and can adapt strategies as needed.

### 2.5.1 Importance and Definition of the Innovation KPIs

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Innovation KPIs are crucial for the Shift2DC project as they provide a clear framework for measuring the success of the project's innovation activities. These KPIs help ensure that the project remains focused on its objectives, identifies areas for improvement, and adapts strategies based on real-time data and feedback. By defining and tracking innovation KPIs, the project can:

- **Ensure Alignment with Objectives:** KPIs help align the project's activities with its strategic goals, ensuring that all efforts contribute to the desired outcomes.
- **Facilitate Decision-Making:** By providing measurable data, KPIs support informed decision-making and help prioritize actions that will have the most significant impact.
- **Monitor Progress:** Regular tracking of KPIs allows the project to monitor progress towards its goals, identify any deviations, and take corrective actions as needed.
- **Enhance Accountability:** KPIs create accountability by clearly defining what needs to be achieved and who is responsible for achieving it.
- **Drive Continuous Improvement:** By identifying areas where performance can be improved, KPIs encourage continuous innovation and optimization of processes and technologies.
- **Demonstrate Impact:** KPIs provide tangible evidence of the project's impact, which is essential for securing support from stakeholders, including funding bodies, regulatory agencies, and industry partners.

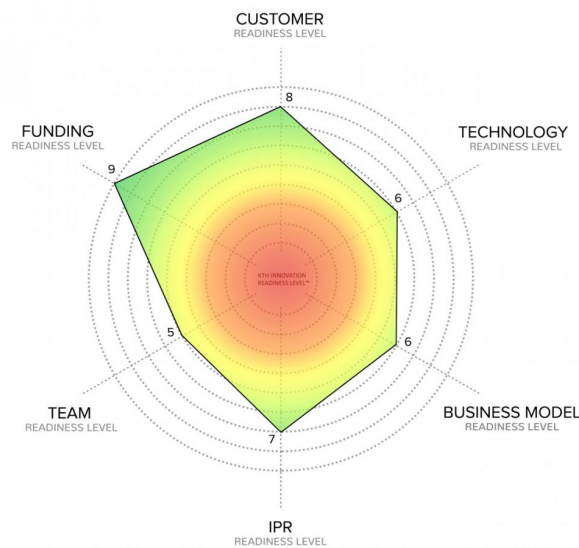
In the Shift2DC Project first Innovation and Exploitation Workshop which took place in the beginning of Task T5.1, it was proposed to, and accepted by the consortium, instead of the adoption of general Innovation KPIs, the adoption of a fully developed trademark open-source solution: *KTH Innovation Readiness Level™* [6].

*KTH Innovation Readiness Level™* is a method, visual tool, and resource library guiding the development from early-stage idea to innovation on the market. The *KTH Innovation Readiness Level™* is a complete framework for guiding idea development and assessing idea status across key dimensions. It provides structure and support for idea owners as well as coaches and managers.

The model assesses the idea development on a scale from 1 to 9 in six key areas of innovation development. For each area, clear definitions of the different levels are given as well as milestones and activities that are needed to reach each level.

The model was built on and developed from the *Technology Readiness Level* produced by NASA [7]. However, the *KTH Innovation Readiness Level™* includes five additional important areas that are crucial for successful innovation development, such as Customer or Funding Readiness.

The model is a highly useful tool to measure progress and status. The model is supplied via access to an online open-source resource library where all descriptions and documents can be found, under the Creative Commons-license: *Attribution-Non Commercial-ShareAlike 4.0 International* (CC BY-NC-SA 4.0).



**Figure 2.5 – KTH Innovation Readiness Level™ - the six Innovation Levels or KPIs**

As presented in the above Figure 2.5, there are six KPIs, in this case six Innovation Readiness Levels:

- Customer Readiness Level (CRL) – confirm customer need and interest.
- Technology Readiness Level (TRL) – develop and test the technology, product, service, or concept.
- Business Model Readiness Level (BRL) – establish that the concept can be financially, environmentally, and socially viable and feasible.
- IPR Readiness Level (IPRL) – clarify the legal and IP situation and secure relevant IP protection.
- Team Readiness Level (TMRL) – secure the right competencies and align the team.
- Funding Readiness Level (FRL) – secure the necessary funding to take the idea to the market.

For each Readiness Level, there are nine pre-defined levels where several criteria need to be met to reach each level. The scales will be presented in the next section.

Two further important Innovation KPIs could be added to this list:

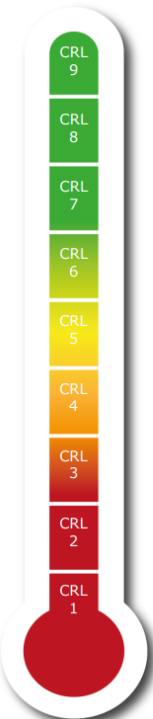
- Dissemination and Knowledge Transfer
- User and Stakeholder Engagement

Nevertheless, these KPIs are being tracked in a specific Work Package (WP6), so their assessment will be presented in the respective activities and deliverables. Nevertheless, the Innovation Manager will also keep track of these KPIs during the IMP activities.

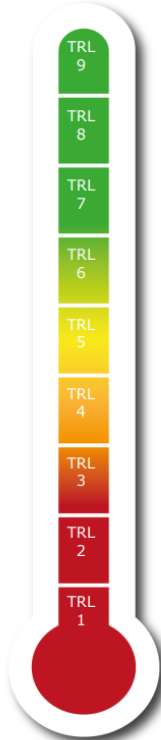
## 2.5.2 KPIs scales, assessment mechanisms and first preliminary assessment

As mentioned before, the KTH Innovation Readiness Level™ has six scales with nine levels each. For each scale, a certain level is attained if all the written requirements for that level are achieved by the project/solution. Their detailed description is presented in the Table 2.2: *KTH Innovation Readiness Level™ scales and levels definitions*.

**Table 2.2: KTH Innovation Readiness Level™ scales and levels definitions**

Innovation Readiness Levels Categories	Level Description
<p><b>Customer Readiness Level – CRL</b></p>  <p>CRL 9: Widespread product sales that scale.</p> <p>CRL 8: First products sold and increased structured sales efforts.</p> <p>CRL 7: Customers in extended product testing or first test sales</p> <p>CRL 6: Benefits of the product confirmed through partnerships or first customer testing.</p> <p>CRL 5: Established interest for product and relations with target customers.</p> <p>CRL 4: Confirmed problem/needs from several customers or users</p> <p>CRL 3: First market feedback established.</p> <p>CRL 2: Identified specific needs in market.</p> <p>CRL 1: Hypothesizing on possible needs in market.</p>	<p><b>9</b></p> <ul style="list-style-type: none"> <li>- Widespread product deployment, sales to several customers in a repeatable and scalable way.</li> <li>- Customer creation- company focuses on execution with growth of sales and efforts to build user/customer demand etc.</li> </ul> <p><b>8</b></p> <ul style="list-style-type: none"> <li>- Customer qualifications are complete and initial products are sold to a few customers.</li> <li>- Payment willingness confirmed from sufficient % of customers (product-market fit validated).</li> <li>- The real buyers/economic decision makers are identified.</li> <li>- Business development and sales mature and adapt to support larger scale sales efforts (e.g. clear sales process/organization, CRM systems etc)</li> </ul> <p><b>7</b></p> <ul style="list-style-type: none"> <li>- Customer agreements in place- first sales and/or test sales of product versions take place (customer validation to show initial product-market fit).</li> <li>- Customers and relevant stakeholders engaged in product qualifications/extended testing.</li> <li>- Ramp up of business development and sales efforts according to sales process and roadmap.</li> </ul> <p><b>6</b></p> <ul style="list-style-type: none"> <li>- Testing of product by customers/users where the value and benefits of the product is confirmed (validated problem-solution fit).</li> <li>- Partnerships formed with key stakeholders in value chain (e.g. partners, pilot customers).</li> <li>- Initiated structured business development/sales activities. First sales process/roadmap defined</li> </ul> <p><b>5</b></p> <ul style="list-style-type: none"> <li>- General interest from customers/users for the product where the possible product/solution (core features) is confirmed to solve customers' problems (i.e. initial problem-solution fit)</li> <li>- Existing contacts strengthened and/or more contacts established with additional customers. Deeper understanding of the market is achieved. Target customers are identified</li> <li>- Established relationships with potential target customers, users or partners e.g. providing input on requirements and initial prototypes (e.g. resulting in updated product hypothesis).</li> <li>- Defined who the target customers/segments are to be focused on as entry/first customers.</li> </ul> <p><b>4</b></p> <ul style="list-style-type: none"> <li>- Contacts and feedback are established with several possible customers/users. Numbers are typically limited but depend on B2B/B2C and market structure (e.g. 5-10 in B2B, if market is concentrated 2-5 market leading customers, in B2C higher e.g. 10-20).</li> <li>- The problem and need (and its importance) is confirmed from multiple customers/users</li> <li>- Customer segmentation in place, knowledge of customers/users has increased level of details</li> <li>- A primary product hypothesis is defined, possibly based on feedback.</li> </ul> <p><b>3</b></p> <ul style="list-style-type: none"> <li>- Initiated customer discovery with feedback from primary market research i.e. direct contacts e.g. a few possible users/customers or persons with industry/market knowledge (experts)</li> <li>- A more developed understanding of possible customers and possible customer segments</li> <li>- A more clear problem hypotheses</li> </ul> <p><b>2</b></p> <ul style="list-style-type: none"> <li>- Some market research is performed, typically derived from secondary sources.</li> <li>- Brief familiarity with the market, possible customers and their problems/needs.</li> <li>- There is a more clear and more specific problem/need description</li> <li>- Product/solution ideas may exist, but are not clear and typically speculative and unvalidated</li> </ul> <p><b>1</b></p> <ul style="list-style-type: none"> <li>- Thinking (yourself) that a possible need/problem or opportunity might exist in a market.</li> <li>- No clear hypotheses on who customers are and what problems are etc. If hypothesis exist they are unclear, speculative and there is no proof or analysis to support assumptions.</li> <li>- Limited or non-existing knowledge of the market and customers/users (who they are etc)</li> </ul>

## Technology Readiness Level – TRL



TRL 9	Actual Technology system proven in operational environment
TRL 8	Actual Technology system completed and qualified through test and demonstration
TRL 7	Technology prototype demonstration in an operational environment
TRL 6	Technology demonstration in a relevant environment
TRL 5	Technology validation in relevant environment
TRL 4	Technology validation in laboratory
TRL 3	Analytical and experimental proof-of-concept of critical function and/or characteristics
TRL 2	Technology concept and/or application formulated
TRL 1	Basic principles observed

- 1
  - Published research that identifies the principles that underlie this technology. Scientific research begins to be translated into applied research and development.
  - Software: development of basic use, basic properties of software architecture, mathematical formulations, and general algorithms.
  - Example: studies of basic properties e.g. tensile strength as a function of temperature for a new material
- 2
  - Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, no proof or detailed analysis to support the assumptions.
  - Software: analytic studies, studies on synthetic data, small code units
  - Example: observation of high critical temperature superconductivity, potential applications of the new material in instruments (e.g. telescope sensors) defined.
- 3
  - Active R&D is initiated. Analytical studies and laboratory-based studies to physically validate that analytical predictions are correct. Laboratory tests are performed to measure parameters of interest and comparison to analytical predictions for critical subsystems.
  - Software: limited functionality environments to validate critical properties/analytical predictions using non-integrated software components and partially representative data.
  - Example: super-cooled hydrogen as a propellant where the concept-enabling temperature/pressure for the fluid was achieved in a lab. Software algorithms run on a surrogate processor in lab environment.
- 4
  - Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared with the eventual system. System concepts considered and results from testing laboratory scale breadboard(s). Only limited and initial information about the end product function.
  - Software: module and/or subsystem validation in a laboratory environment (i.e. software prototype development environment). Basic software components are integrated to establish that they will work together. Architecture development initiated (e.g. interoperability, reliability).
  - Example: demo of a 'fuzzy logic' approach to avionics by testing algorithms in a partially computer-based, partially bench-top components to demo in a controls lab using simulated vehicle inputs.
- 5
  - Basic technological components integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Fidelity of breadboard technology increases significantly.
  - Integrated components provide a representation of a system/subsystem for determining concept feasibility and to develop technical data. Lab use to validate the technical principles of interest.
  - Software: Module and/or subsystem validation in relevant environment. Ready to start integration with existing system, conforms to target environment/interfaces. System software architecture established and all components and elements affecting the operation of the critical software element.
  - Examples: a new type of solar photovoltaic material promising higher efficiencies would at this level be used in an actual fabricated solar array that would be integrated with power supplies, supporting structure, etc., and tested in a thermal vacuum chamber with solar simulation capability.
- 6
  - Representative model or prototype system, tested in a relevant environment. Represents a major step up and requires evidence of performance on full-scale, realistic problems.
  - For software: level at which the engineering feasibility of a software is demonstrated. This level extends to laboratory prototype implementations on full-scale realistic problems in which the software technology is partially integrated with existing hardware/software systems.
  - Examples: testing a prototype in a high-fidelity lab environment or simulated operational environment.
- 7
  - Prototype near or at planned operational system. Requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space). Normally only performed when the technology and/or subsystem is mission critical and relatively high risk.
  - Critical technological properties are measured against requirements in an operational environment.
  - Readiness in an operational environment requires evidence of the acceptable performance under operational factors, including, for example for a software system loading, user interaction, security etc.
- 8
  - Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development
  - Software fully integrated with operational hardware and software systems, development documentation is complete. All functionality tested in simulated and operational scenarios.
- 9
  - Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation
  - Software: readily repeatable and reusable. The software based on the technology is fully integrated with operational hardware/software systems. All software documentation verified. Successful operational experience. Sustaining software engineering support in place.

Business Readiness Level – BRL	
BRL 9	Business model is final and is scaling with growing recurring revenues that results in a profitable and sustainable business
BRL 8	Sales and metrics show business model holds and can scale Business model is fine-tuned to explore more revenue options
BRL 7	Product/market fit and customers payment willingness demonstrated Attractive revenue vs cost projections (validated by data and sales)
BRL 6	Full business model incl. pricing verified on customers (by test sales)
BRL 5	Parts of business model tested on market and canvas updated First version of revenue model incl. pricing hypotheses Verified competitive position/uniqueness through market feedback
BRL 4	First version of full business model in canvas (incl. revenues/costs) First projections to show economic viability and market potential
BRL 3	Draft of business model in canvas (excl. revenues/costs) Described market potential and complete competitive overview
BRL 2	First possible business concept described (e.g. NABC) Identified overall market and some competitors/alternatives
BRL 1	Hypothesizing on possible business concept Little knowledge or insight into market and competition
BRL 9	<ul style="list-style-type: none"> <li>- Business model is final and business is scaling with growing and recurring revenues.</li> <li>- The business scales by growing in new markets, new geographies, new segments etc.</li> <li>- There is a working business which is profitable and sustainable over time.</li> </ul>
BRL 8	<ul style="list-style-type: none"> <li>- Sales and other metrics show the business model holds and is profitable e.g. customer acquisition is not costing too much.</li> <li>- The business model shows it can scale (potentially globally). Sales channels and supply chain are fully in place.</li> <li>- Business model is set but is continuously fine-tuned to explore more revenue options.</li> </ul>
BRL 7	<ul style="list-style-type: none"> <li>- There is product/market fit meaning you can demonstrate significant customer interest and use of products and sales where customers show clear payment willingness.</li> <li>- Attractive revenue vs cost projections (being validated by sales and data) implying a sustainable/ attractive business could be built.</li> <li>- Preparations for scaling business with suppliers, sales channels etc (incl. agreements).</li> </ul>
BRL 6	<ul style="list-style-type: none"> <li>- A complete business model incl. the pricing is tested vs. customers by test sales or similar.</li> <li>- The revenue model incl. pricing is updated and refined based on customer feedback.</li> <li>- First more complete projections on revenue/costs (profit and loss projections or similar) with more details and well-grounded assumptions/data (e.g. 1-3 years horizon)</li> </ul>
BRL 5	<ul style="list-style-type: none"> <li>- The business model (at least parts of it) is tested against customers for verifying hypotheses.</li> <li>- The business model is updated and refined to new version based on customer feedback</li> <li>- There is a first version of a more detailed revenue model incl. pricing hypotheses (what revenue streams are there, from what, when, how and what prices are possible?)</li> <li>- The competitive position and differentiation is verified by market feedback.</li> </ul>
BRL 4	<ul style="list-style-type: none"> <li>- There is a full business model in canvas format incl. details on possible revenues/costs.</li> <li>- First economic projections with numbers to show the market potential and economic viability (bottom-up calculations based on projections/guesstimates on volumes, prices etc)</li> <li>- Assessed feasible Share Of Market based on e.g. barriers to entry incl. competition</li> <li>- Made a competitive analysis on your position and uniqueness/differentiation vs them.</li> </ul>
BRL 3	<ul style="list-style-type: none"> <li>- There is draft of the business model in a canvas format (business model canvas/lean canvas) but typically without the revenues/cost parts and details of these.</li> <li>- The market description is getting more highly resolved with more specific market applications and segments being identified. Target applications identified.</li> <li>- The market potential and the market size is quantified with TAM and SAM- Segmented/Served Available/Addressable Market (everyone you have decided/can reach)</li> <li>- A more complete competitor overview with direct/indirect competitors and alternatives</li> </ul>
BRL 2	<ul style="list-style-type: none"> <li>- Described the proposed business concept in some structured form e.g. NABC</li> <li>- One or several markets or applications are identified and described on overall level e.g. user numbers, TAM- Total Available or Addressable Market (everyone you wish to reach)</li> <li>- Some competitors and/or alternatives are identified and listed</li> </ul>
BRL 1	<ul style="list-style-type: none"> <li>- Vague and unspecific description of the potential business idea or business concept</li> <li>- Little insight into the market and its potential/size-hypothesizing on possible applications</li> <li>- Little knowledge or insight into competition and alternative solutions</li> </ul>
IPR Readiness Level – IPRL	
IPRL 9	Strong IPR support and protection for business. Patent granted in relevant countries and maintained in force
IPRL 8	IPR strategy and IP management fully implemented. More complete assessment of freedom-to-operate.
IPRL 7	All relevant IPR filed (e.g. additional patents). Patent entry into national/regional phase.
IPRL 6	IPR/patent strategy implemented and supporting business. Positive response on filed applications Initial assessment of freedom-to-operate (or landscape)
IPRL 5	Draft of IPR/patent strategy in place to use IPR for business. Filed first complete patent application (or other IP registrations)
IPRL 4	Confirmed if protection possible and for what (e.g. patentability). Decided why to protect certain IPR (business relevance).
IPRL 3	Detailed description of possible key IPR (e.g. invention or code) Initial search of technical field and existing IPR.
IPRL 2	Identified different forms of possible IPR that you have. Ownership is clarified and you clearly own/control IPR.
IPRL 1	Hypothesizing on possible IPR you might have (such as patents, software, copyright, designs, trade secrets etc.)
IPRL 9	<ul style="list-style-type: none"> <li>- Strong IPR support and protection for business, for example using various other forms of registered IPR (trademarks, designs etc) or for example using agreements, trade secrets etc.</li> <li>- Patent granted and maintained in several countries relevant for business</li> <li>- Patent is in force/valid with no invalidation procedures</li> </ul>
IPRL 8	<ul style="list-style-type: none"> <li>- IPR strategy is fully implemented and managed. IPR is proactively used to support business, for example all IPR related agreements are professionally managed and new IP is managed.</li> <li>- First patent is granted with relevant scope for business</li> <li>- No oppositions encountered for patent grant</li> <li>- More complete assessment of freedom-to-operate</li> </ul>
IPRL 7	<ul style="list-style-type: none"> <li>- Other forms of relevant IPR might be registered such as trademarks, designs.</li> <li>- Entry into national phase (US, EU, JP etc.)</li> <li>- Complementary or additional new patents might be filed</li> </ul>
IPRL 6	<ul style="list-style-type: none"> <li>- More full IPR strategy in place that is validated by professional and that really links to and supports business strategy.</li> <li>- Patent strategy in place-identifying possible additional patents, country strategy, claim changes.</li> <li>- Positive response on applications from authorities and analysis of response performed.</li> <li>- If no positive response: analysis is performed together with professional with strong arguments and strategy for prosecution.</li> </ul>
IPRL 5	<ul style="list-style-type: none"> <li>- Initial assessment of freedom-to-operate (e.g. competitor based, narrowed product scope etc.) or landscaping. Overall purpose to get knowledge on the field, key IPR, players and activity.</li> <li>- Draft IPR strategy- first analysis (preferably by professional) on how different IPR can be used to protect and be of value for the business.</li> <li>- Patent strategy- professional analysis on what/how to patent and how to improve/build value of patent application (e.g. supporting data, new/additional details to be filed etc.)</li> <li>- Basic agreements in place to ascertain control of IPR (e.g. assignments, ownership copyright)</li> <li>- First complete patent application (or other IPR registration) filed in cooperation with professional</li> </ul>
IPRL 4	<ul style="list-style-type: none"> <li>- Confirmed novelty and patentability through searches/analysis by professional</li> <li>- Confirmed possibilities for protecting other forms of IPR</li> <li>- Possibly filed "provisional" patent application i.e. not professionally drafted and complete</li> <li>- Analyzed (ideally with professional) the key IPR and what the priorities should be for what to protect (e.g. patent). Decided on alternative forms of protection if patents are not suitable.</li> </ul>
IPRL 3	<ul style="list-style-type: none"> <li>- Considered what forms of IPR are key and could/should be protected ( e.g. through patents)</li> <li>- Sufficiently detailed description of possible IPR and patentable inventions (invention disclosure)</li> <li>- Made own searches/analysis of publications, state-of- the art solutions etc.</li> <li>- Possibly initial searches by professional to find prior art within patent databases</li> </ul>
IPRL 2	<ul style="list-style-type: none"> <li>- Mapped different forms of IPR that exist or could emanate during development</li> <li>- Specific ideas for patenting exist, but are not well described and defined.</li> <li>- Agreements related to IPR are identified and ownership is clarified. IPR is verified to be under your ownership or control. Inventors are clarified. Knowledge of applicable IP policies etc.</li> </ul>
IPRL 1	<ul style="list-style-type: none"> <li>- Hypothesizing results or ideas might contain possible patents or some other form of IPR</li> <li>- Some ideas on IPR e.g. for patenting may exist, but are speculative and uniqueness etc. not clear.</li> <li>- Vague description and documentation of the possible IPR</li> <li>- Limited knowledge or unclearities regarding relevant legal agreements (ownership, use-rights etc.)</li> <li>- Limited or non-existing knowledge of the technical field, state-of-the art, publications etc</li> </ul>

Team Readiness Level – TMRL	
	<p>High performing, well-structured team and organization that is maintained and performs over time.</p>
	<p>Management and CEO in place. Professional use of board/advisors. Activated plan and recruitment for building long term team.</p>
	<p>Team and culture is fully in place and proactively developed. Updated plan for building necessary team on longer term.</p>
	<p>Complementary, diverse and committed team with all necessary competencies/resources incl. both business and tech.</p>
	<p>Initial founding team with main needed competencies. Team agrees on ownership and roles and has aligned goals</p>
	<p>A champion is present. Several needed competencies in place. Initiated plan for recruiting or securing additional key resources.</p>
	<p>A few of necessary competencies/resources are present. Defined needed competencies/resources (and plan for finding).</p>
	<p>Insight and first idea on necessary competencies or external resources (e.g. partners).</p>
	<p>Little insight into the need for a team (typically an individual) Lack of necessary competencies/resources.</p>

Funding Readiness Level – FRL	
	<p>Investment obtained. Additional investment needs and options continuously considered.</p>
	<p>There is corporate order and structure enabling investment. Term sheet discussions with interested investor(s).</p>
	<p>Team presents a solid investment case incl. status and plans. Discussions with potential investors on-going around an offer.</p>
	<p>Improved investor presentation in place incl. business/ financials. Decided on seeking private investors and initial contacts taken</p>
	<p>Investor oriented presentation and supporting material tested. Applied for and secured additional larger funding (soft or other).</p>
	<p>Good pitch and short presentation of the business in place. Plan in place with different funding options over time.</p>
	<p>Well described business concept and initial verification plan. First small soft funding secured.</p>
	<p>Description of business concept (e.g. NABC). Defined funding needs and funding options for initial milestones.</p>
	<p>Initial business idea with vague description. No clear view on funding needs and funding options.</p>

A first preliminary assessment of the Shift2DC Innovation KPIs was conducted during the first 6-month cycle of the Task.

Data was collected from several sources, including the project proposal, deliverables already published, and ongoing Tasks and meetings. This was enough to make the first assessment, and also equally important, to define the first Innovation KPI objectives. Future assessments will be performed according to the Project IMP, at least once for every 6-month cycle.

Since there are 26 different Technology Solutions in the project involving different partners, business proximities and TRLs, 26 different assessments could be done, but this would be very difficult to analyse for the target audience of this deliverable. Accordingly, this detailed analysis was done internally, but in this case only one assessment will be presented, corresponding to an average of all the solutions statuses. This is expected to show the progress of Shift2DC in a much more integrated and intuitive manner.

The results of the first preliminary assessment of the Shift2DC Innovation KPIs is presented in the Figure 2.1.

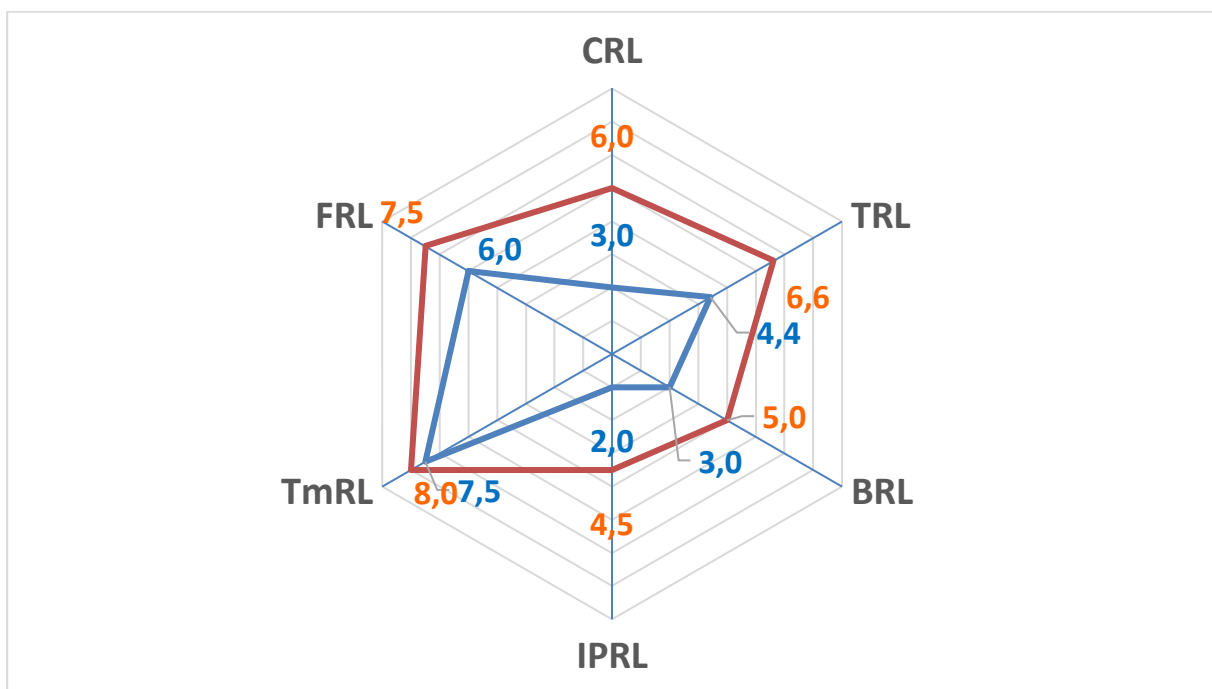


Figure 2.6 – Shift2DC first Innovation KPI assessment using *KTH Innovation Readiness Level™*

Analysing these first preliminary KPI assessment results, several insights and conclusions can be made:

- The preliminary KPI objectives for the end of the Shift2DC are ambitious, in line with the main TRL objective that was specified in the Project proposal. IPRL and BRL are the lowest ones, but future work will be conducted in order to assess if it is realistic to increase these objectives.
- With the exception of FRL and TMRL, which are already high at the beginning of the Shift2DC project due mainly to the strong consortium and partners, there is a very long road ahead in the remaining 2.5 years of the Project, to attain the specified objectives.

- CRL is the KPI with the largest improvement margin, followed approximately equally by IPRL, BRL and TRL.

These insights will be very useful for the next cycle of the Shift2DC IMP, helping in defining the activities and action targets that have the most priority, in order to fulfil the specified objectives.

## 3 Exploitation Plan

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In this section, a first version of the Shift2DC Exploitation Plan is presented, as well as all the guidelines, strategy and planning for the development of its definitive version to be presented in the final version of this deliverable.

An Exploitation Plan is a strategic document that outlines how the results of a project, particularly those that are considered Key Exploitable Results (KERs), will be utilized, disseminated, and brought to market or otherwise used to achieve the project's objectives [8]. It is a crucial component in research and innovation projects, such as Shift2DC, ensuring that the outcomes of the project are effectively used to generate impact and value. The Exploitation Plan will be mostly focused on a timeframe 1 to 2 years after the project ending, and made of plans for concrete actions, which should be attainable without significant dependence on external factors, although it will be factored in the analysis.

The management and update of this Exploitation Plan will also follow the Shift2DC Innovation Management Process, being updated in 6-month cycles.

### 3.1 Methodology

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The key elements of an Exploitation Plan are:

1. **Identification of Results:** The plan starts with identifying all the significant results of the project, especially those that have potential for exploitation. These results can include new technologies, products, services, methodologies, or scientific discoveries.
2. **Assessment of Results:** Each identified result is assessed for its potential impact, marketability, and feasibility. This involves analysing the strengths, weaknesses, opportunities, and threats (SWOT) analysis related to each result.
3. **Exploitation Strategies:** The plan outlines specific strategies for how each result will be exploited. This can include:
  - a. **Commercialization:** Plans for bringing a product or service to market, including intellectual property management, licensing, and business development.
  - b. **Further Research and Development:** Identifying opportunities for further research to enhance the result or develop it into a more mature product.
  - c. **Standardization:** Efforts to integrate the result into industry standards or regulatory frameworks.
  - d. **Dissemination and Communication:** Strategies for sharing the result with relevant stakeholders, including academic publications, conferences, workshops, and public engagement.
4. **Implementation Plan:** The Exploitation Plan includes a detailed implementation plan, specifying the actions, timelines, responsibilities, and resources required to exploit each result. This ensures that there is a clear roadmap for turning the project's results into tangible benefits.
5. **Intellectual Property Management:** The plan addresses how IP generated by the project will be managed, protected, and utilized. This includes patenting, licensing agreements, and other IP-related activities.

6. Market Analysis: The plan includes an analysis of the market potential for the project's results, identifying target markets, potential customers, competitors, and market trends.
7. Risk Management: The plan identifies potential risks associated with the exploitation of the results and outlines strategies to mitigate these risks.

Monitoring and Evaluation: The plan includes mechanisms for monitoring the progress of exploitation activities and evaluating their success. This helps in making necessary adjustments to the strategy and ensuring that the exploitation efforts are on track.

A template was developed during the first sprint of the first 6-month cycle of the Shift2DC, see screenshot in the following Figure 3.1.

Exploitation plan Sol24			
Exploitable result	Topic	Done (SEE DETAILED EXPLANATION OF QUESTIONS BELOW TABLE)	Planning to do
DC Solutions Design tool	1. Product/outcome concept	Concept is well defined. This solution will achieve a preliminary DC design tool for several C&I use cases. The tool will be able to perform power flow calculations/ equipment sizing. It will also assess economic costs, energy savings and reliability. The solution is a software tool based on excel, python and pandapower.	
	1.2 Components		
	1.3 Uniqueness	Novelty lies in enabling power flow calculations for a DC grid with equipment sizing combined with benefits assessment.	
	2. Market		
	2.2 Target user	Future user of DC installations, Researchers, Engineering companies (EPC)	
	2.3 Competitors	Direct Energy (DCIDE tool)	
	2.4 Market Study	This tool can be widely used all across the value chain.	
	3. Validation	Scientific Literature studies & EDF experience	
	3.1 Prototype	A prototype has been coded for power flow calculations.	
	4. IPR strategy (link with WP7)	The tool will be developed from scratch based on open source data and tools.	
	4.1 IPR strategy evolution	NA	
	4.2. Feasibility to Operate (FTO)		TBD
	5. Legal compliancy	The tool will adhere to industry standards and regulations for DC grids.	
6. Value capture / business model (link with WP5)	The value lies in the tool's ability to design DC installation and assess DC integration benefits. This will help future DC users and installation owners make informed decisions and promote DC in the right use cases. <b>Business Model:</b> The tool will be open source.		
6.1 Inspiration	TBD		
7. Market launch	The tool is in a development stage with prototypes based on simulations. Market launch will coincide with the completion of these demonstrations, after validating the algorithms and methodologies. This would likely be when the final results are published likely by	Algorithms validation by simulation and by field feedback (from demos).	
8. Internal commitment	The team responsible for the global execution of this work within EDF is the R&D team from the Department of Power Systems and Energy Markets (SYSTEME). Management and board of directors are aware of the project, and the topic has been highlighted as highly relevant. Partners from SHIFT2DC project are contributing to several subtasks.	Each SHIFT2DC partner will be leading one or several subtask to ensure a general engagement.	
9. Dependencies	The success of the tool depends on the models and data provided by partners, specifically regarding cables and converters. Additionally, it relies on the effective integration of control algorithms for the DC grid, such as sharing droop control. The accuracy of the calculated KPIs will be heavily influenced by the assumptions and approximations used in the models, given that some technologies are not yet available on the market. This makes it challenging for partners to provide complete technical and economic data, so initial simulations may need to rely on values from existing literature.	Final adjustments during implementation.	
10. Importance of Shift2DC	The tool is closely tied to the Shift2DC project, which focuses on developing DC grids for various applications, including buildings, ports, data centers, and industrial settings. The success of Shift2DC directly affects the tool's applicability and usefulness, as it aims to support the implementation of these DC solutions across multiple sectors.		
11. Dissemination (link with WP6)	Presentation of findings at industry conferences or journals (specific conferences to be determined).		
12. Demonstrator connection	The tool is deeply connected to the four demonstrators, as the KPIs calculated by this tool will be essential for assessing the technical and environmental impacts of the proposed DC solutions during the demonstrations.		
13. Risk assessment	Details on the risk assessment map tab	A continuous and active strategy regarding risk assessment	

Figure 3.1 – Screenshot of the template to be used in collecting Exploitation Plans

This template was circulated, and some answers were collected during the second sprint of the first cycle. Nevertheless, the first 6-month cycle was proven not long enough to collect all the specified data for all 26 Technological Solutions and other Exploitable Results. The final part of the second sprint was focused on brainstorming with and priming all partners to be aligned with the Shift2DC Innovation and Exploitation Plan, while ensuring to have at least a one-paragrapher Exploitation Plan for each of the Solutions and other Exploitable Results identified so far. It will be presented in the next section.

### 3.2 Technological Solutions Exploitation Plans

In the following subsections, a very short Exploitation Plan is presented for each of the Shift2DC 26 Technology Solutions and Other Exploitable Results identified at the beginning of the Innovation and Exploitation Task of the Project.

### 3.2.1 SOL1

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Shift2DC Technical Solution 1 is named **“Pre-qualification of DC Solutions Procedure”**.

The responsible partner for SOL1 is **RWTH**. Expected TRL advancement in the project is 3 to 6.

The preliminary Exploitation Plan for SOL1 is: **Methods identified as suitable for testing of DC equipment in the living lab during this project, can be applied to other DC products in the future.**

### 3.2.2 SOL2

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Shift2DC Technical Solution 2 is named **“Participation in Grid and System Services”**.

The responsible partner for SOL2 is **EDF**. Expected TRL advancement in the project is 5 to 7.

The preliminary Exploitation Plan for SOL2 is: **KPIs’ evaluation for Use-Cases (UCs) will encourage developing grid services by sharing results and helping evolve regulatory framework.**

### 3.2.3 SOL3

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Shift2DC Technical Solution 3 is named **“Energy Hubs Management”**.

The responsible partner for SOL3 is **INESC**. Expected TRL advancement in the project is 3 to 6.

The preliminary Exploitation Plan for SOL3 is: **The concept will be explored for research purposes and to design suitable business models to be applied in other contexts.**

### 3.2.4 SOL4

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Shift2DC Technical Solution 4 is named **“Smart and Sustainable DC Cables”**.

The responsible partner for SOL4 is **NEXNS**. Expected TRL advancement in the project is 4 to 7.

The preliminary Exploitation Plan for SOL4 is: **The cables will be included in the NEXANS catalogue in a medium-term increasing the commercial offer.**

### 3.2.5 SOL5

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Shift2DC Technical Solution 5 is named **“Micro Solar DC Systems”**.

The responsible partner for SOL5 is **TALT**.

The preliminary Exploitation Plan for SOL5 is: **TALT is discussing a cooperation with Infineon Technologies Austria – world-leading provider of power electronic components to exploit the ideas. Continuous showcasing at TALT premises for teaching and applied research.**

### 3.2.6 SOL6

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Shift2DC Technical Solution 6 is named “**High Density V2X DC Stations**”.

The responsible partner for SOL6 is **W&W**. Expected TRL advancement in the project is 5 to 7.

The preliminary Exploitation Plan for SOL6 is: **The solution will be part of the offer of W&W creating a new market compatible with DC grids. It will be CurrentOS and OCDA compliant and not dependent on EV brand.**

### 3.2.7 SOL7

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Shift2DC Technical Solution 7 is named “**LVAC-LVDC Interlink Converter**”.

The responsible partner for SOL7 is **SCHND**. Expected TRL advancement in the project is 6 to 7.

The preliminary Exploitation Plan for SOL7 is: **The products are already in development and new control functions will be included in the solutions. It is expected that the new functions can be integrated in the SCHND offer in a short-term.**

### 3.2.8 SOL8

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Shift2DC Technical Solution 8 is named “**Static Protection System**”.

The responsible partner for SOL8 is **SCHND**. Expected TRL advancement in the project is 5 to 7.

The preliminary Exploitation Plan for SOL8 is: **The products are already in development and new control functions will be included in the solutions. It is expected that the new functions can be integrated in the SCHND offer in a short-term.**

### 3.2.9 SOL9

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Shift2DC Technical Solution 9 is named “**Vertical Power Delivery solution**”.

The responsible partner for SOL9 is **HIRO**. Expected TRL advancement in the project is 5 to 7.

The preliminary Exploitation Plan for SOL9 could not be retrieved from HIRO in time for this deliverable. Nevertheless, it is easy to deduce that **the VPD solution will increase overall datacentres efficiency and power. Being a datacentre developer, HIRO will benefit directly of this technology to increase its competitiveness in the market.**

### 3.2.10 SOL10

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Shift2DC Technical Solution 10 is named “**Semiconductor-Based Protection**”.

The responsible partner for SOL10 is **EATON**. Expected TRL advancement in the project is 6 to 7.

The preliminary Exploitation Plan for SOL10 is: **The solution presents higher current ratings than existing ones on the market. It will be demonstrated in the living lab and Industry Demo of SHIFT2DC. After that, the product will be developed for market launch.**

### 3.2.11 SOL11

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Shift2DC Technical Solution 11 is named **“Pre-Charging Units for DC Circuit Breakers”**.

The responsible partner for SOL11 is **EATON**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL11 is: **The solution presents the ability to reducing inrush currents, preventing nuisance tripping of upstream protection devices, and enabling safe bi-directional pre-charge/discharge of DC grid capacitances. It will be demonstrated in the living lab and Industry Demo of SHIFT2DC. After that, the product will be developed for market launch.**

### 3.2.12 SOL12

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Shift2DC Technical Solution 12 is named **“DC Measurement Device”**.

The responsible partner for SOL12 is **PHNIX**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL12 is: **In case of positive validation the prototype will be finalised to a commercial product for supporting all DC grids within the full voltage range of LVDC.**

### 3.2.13 SOL13

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Shift2DC Technical Solution 13 is named **“Fast-response Control Technologies for the Power Electronics”**.

The responsible partner for SOL13 is **TECN**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL13 is: **Tecnia will capture value of this research via four different paths: 1) Having projects with power electronics manufacturers that hire Tecnia to provide consultancy services 2) Via IP protection and selling of intellectual property rights to companies. 3) Via reutilization of results in upcoming research projects. 4) Contributing to power electronics community through the conceptualization, development and validation of new knowledge.**

### 3.2.14 SOL14

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Shift2DC Technical Solution 14 is named **“DC/DC Converter - Smart Power Distribution Unit”**.

The responsible partner for SOL14 is **W&W**. Expected TRL advancement in the project is 5 to 8.

The preliminary Exploitation Plan for SOL14 is: **The solution will be part of the offer of W&W creating a new market compatible with DC grids. It will enable the easy connection of DC equipment working at different voltage levels, e.g. PV and BESS.**

### 3.2.15 SOL15

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Shift2DC Technical Solution 15 is named **“Multisocket-Smart Power Distribution Unit”**.

The responsible partner for SOL15 is **BACH**. Expected TRL advancement in the project is 5 to 8.

The preliminary Exploitation Plan for SOL15 is: **Verified and tested DC PDU for final steps of industrialization to provide as an enabling product to the market for DC powered Data Centres.**

### 3.2.16 SOL16

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Shift2DC Technical Solution 16 is named **“Plug & Play Infrastructure for DC-based Office”**.

The responsible partner for SOL16 is **BACH**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL16 is: **The solution is also to be tested and further developed for smart buildings. The underlying technology can be integrated in the catalog of BACH market solutions.**

### 3.2.17 SOL17

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Shift2DC Technical Solution 17 is named **“Sharing Voltage Control Approach”**.

The responsible partners for SOL17 are **EDF and EATON**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL17 is: **Control strategies will help developing future stable DC grids that guarantees plug-and-play operation.**

### 3.2.18 SOL18

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Shift2DC Technical Solution 18 is named **“Passive Thermosyphon Cooling System for High Density Data Centers”**.

The responsible partner for SOL18 is **JJC**. Expected TRL advancement in the project is 5 to 8.

The preliminary Exploitation Plan for SOL18 is: **The solution of passive cooling system captures and delivers value through a multi-dimensional business model focused on financial returns, environmental impact, and industry influence. JJC generate value by providing an energy-efficient cooling solution for data centers and micro-edge facilities, meeting the rising demand for sustainable technology. Delivery occurs through direct sales, licensing, and demonstrator installations that validate the system’s effectiveness and support widespread adoption. In addition to revenue, we capture valuable operational data to drive further Research and Development (R&D) and maintain competitive advantages.**

### 3.2.19 SOL19

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Shift2DC Technical Solution 19 is named “**Modular Rack mounted BESS**”.

The responsible partner for SOL19 is **PHNPS**. Expected TRL advancement in the project is 5 to 7.

The preliminary Exploitation Plan for SOL19 is: **The focus for this solution is on the development of the BESS internal components, such as DC/DC power module, energy modules. These components will be included in PHNPS catalog and continue to be upgraded and developed.**

### 3.2.20 SOL20

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Shift2DC Technical Solution 20 is named “**DC-Connectors**”.

The responsible partner for SOL20 is **PHNKG**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL20 is: **In case of positive validation the prototype will be finalised to a commercial product for supporting all DC grids within the full voltage range of LVDC.**

### 3.2.21 SOL21

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Shift2DC Technical Solution 21 is named “**EMS tool for AC/DC Hybrid Systems**”.

The responsible partner for SOL21 is **EATON**. Expected TRL advancement in the project is 4 to 7.

The preliminary Exploitation Plan for SOL21 is: **The tool will be available to be used in different demonstration and research activities and in future research and industrial projects.**

### 3.2.22 SOL22

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Shift2DC Technical Solution 22 is named “**Partial Power Processing**”.

The responsible partner for SOL22 is **TALT**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL22 is: **TALT is discussing a cooperation with Infineon Technologies Austria AG – world-leading provider of power electronic components to exploit the ideas. Continuous showcasing at TALT premises for teaching and applied research. Dissemination through scientific papers, possible patenting and staff training.**

### 3.2.23 SOL23

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Shift2DC Technical Solution 23 is named “**DC Solutions Design tool**”.

The responsible partners for SOL23 are **EDF and CIRCE**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL23 is: **This tool will be shared with future users/designers of DC installations, researchers and engineering teams designing future DC projects.**

### 3.2.24 SOL24

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Shift2DC Technical Solution 24 is named **“DC Solutions Simulation Tool using Digital Twins”**.

The responsible partners for SOL24 are **EDF and NEW**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL24 is: **Considering the development of the simulation tool, NEW intends to apply this software for internal purposes and consultancy services.**

### 3.2.25 SOL25

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Shift2DC Technical Solution 25 is named **“Protection DC System design tool”**.

The responsible partner for SOL25 is **SCHND**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL25 is: **The solution will consist of a set of documents detailing the design and study methodology. Excel sheets may also be provided. Primarily designed for SHIFT2DC use cases, the knowledge will be available for future projects within the domain.**

### 3.2.26 SOL26

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Shift2DC Technical Solution 26 is named **“Small-signal Stability including analysis of Multi-vendor Interoperability”**.

The responsible partners for SOL26 are **RWTH and TECNALIA**. Expected TRL advancement in the project is 4 to 6.

The preliminary Exploitation Plan for SOL26 is: **This tool will be used for interoperability tests of protections that can be used for research purposes and for technical advice for companies.**

### 3.2.27 Knowledge/Other Exploitable Results

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Six Knowledge/Other Exploitable Results were identified so far. Their preliminary Exploitation Plans are presented in Table 3.1.

Table 3.1: Knowledge and Other Shift2DC Exploitable results Plans

Type	ER number	Responsible Partner(s)	Exploitable Result Name and Description
	ER1	NEW	<p><b><u>DC Challenges and opportunities</u></b>            The knowledge produced in the scope of Task 1.1 will be used to capacitate the human resources of NEW regarding the state-of-the-art of DC grids.</p>
	ER2	INESC	<p><b><u>DC simulation tools and algorithms</u></b>            The simulation tools that will be developed in the project will be re-used in the courses tough in IST - Universidade de Lisboa at Master of Science (MSc) and Doctor of Philosophy (PhD) level.</p>
	ER3	TECN	<p><b><u>LV Living Lab for testing solutions</u></b>            i) Use it as a showcase to make demos or show technological capabilities to our customers. ii) Open it to customers, so they can validate their products.</p>
	ER4	NEXNS	<p><b><u>Industrial DC grid demonstrator</u></b>            The DC industrial demonstrator will be used intensively to promote DC grids to all customers, visitors and public in general.</p>
	ER5	FRAUN	<p><b><u>DC data centre demonstration</u></b>            FRAUN will use the demo to showcase their knowledge in the design, dimensioning and implementation of DC.</p>
	ER6	INESC	<p><b><u>Data Exploitation</u></b>            Exploitation of the data generated in the project for replicability tests.</p>

## 4 Conclusions

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### 4.1 Summary

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This deliverable presents the first version of the Innovation and Exploitation Plan for the Shift2DC project. The plan outlines the strategic approach to innovation, focusing on the commercialization, dissemination, and exploitation of project outcomes. It aims to bridge the gap between research and market implementation, ensuring that the innovative DC technologies developed within the project are effectively brought to market and adopted by relevant stakeholders.

The document details the methodologies used, including the Innovation Management Process, stakeholder engagement, market and technology monitoring, and risk management. Additionally, it provides preliminary assessments of the project's KPIs and outlines short exploitation plans for each of the 26 technological solutions and other exploitable results.

### 4.2 Progress

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Significant progress has been made in the initial stages of the Shift2DC project's Innovation and Exploitation Task. Key achievements include:

- Establishment of the IMP: A structured approach has been defined, based on CEN/TS 16555-1:2013, to manage the development and implementation of new ideas and technologies.
- Stakeholder Engagement and Market Benchmarking: A methodology was described to identify relevant stakeholders, both within and outside the consortium, to ensure broad support and collaboration, and to continuously benchmark Shift2DC in the market.
- Development of Technological Solutions and their Exploitation Plans: Work has begun on the 26 technological solutions, with detailed descriptions and preliminary Exploitation Plans outlined in the document.
- Adoption of the *KTH Innovation Readiness Level™* Framework: This framework has been adopted to measure the progress and status of the project's innovation activities across six key areas.
- Preliminary Innovation KPI Assessments: Initial assessments of the project's Innovation KPIs have been conducted, providing valuable insights into the current status and setting ambitious objectives for the project's duration.

### 4.3 Main Challenges

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Despite the progress made, several challenges remain, that need to be addressed to ensure the successful implementation and exploitation of the project's outcomes, from which we highlight:

- Technical Barriers: The 26 Shift2DC Technological solutions involve developing control algorithms, protection systems, and design tools specific to DC systems, which requires significant research and innovation work in a tight timeframe.
- Coordination: Ensuring effective coordination and communication among all consortium partners can be complex, especially with diverse stakeholders involved. Adherence to the IMP procedures will be key to succeed.

- **KPI measurement and tracking:** Accurately measuring and tracking the progress of KPIs across different technological solutions and partners can be difficult. Clear protocols for data collection and reporting will be needed, to ensure accurate and consistent KPI tracking.
- **Sustainability and Scalability:** Ensuring that the developed solutions are sustainable and scalable for broader adoption.
- **Market fit:** Ensuring that the technological solutions are market-ready and meet the needs of potential users, while addressing any possible market barriers, such as regulatory and customer adoption.

#### 4.4 Next deliverables

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*WP5 - Innovation, Exploitation and Harmonization* will run until the end of the project. There will be a large 2-year gap without deliverable publication in this WP until the release of the Deliverable D5.2, which is the final version of this deliverable. The work developed in this task and presented in the final version of the deliverable will also fuel the following tasks and deliverables.

The deliverables to be published in WP5 are:

*D5.2 – Innovation and Exploitation Plan- Updated* due M36

*D5.3 – Standardization and Harmonization activities* due M40

*D5.4 – Cost Benefits Analysis of DC solutions* due M41

*D5.5 – DC Roadmap and Business models* due M42

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