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Transition Super-Lab Action Plan

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Abstract

This deliverable is dedicated to the development of Action Plans for the subsequent stage for long-term implementation and establishment of their Transition Super-Labs (TSLs) by the four partner regions in the TRANSFORMER project (Emilia-Romagna, Lower Silesia, Ruhr Area and Western Macedonia). The document starts with an introduction section where the purpose and the structure of the deliverable are described. An emphasis is put on the challenging nature of the deliverable, which includes Action Plans for four very different regional Transition Super-Labs trying to align short-term designed actions with the goal of long-term implementation of these collaborative governance arrangements.

The central part of the document consists of the Action Plans of the four TRANSFORMER regions in alphabetical order. The Action Plans have the same basic structure, each of them built around three main blocks:

- The overall idea of the TSL
- Developing concrete actions through pilot use cases
- Recommendations for action

In the first part, project partners describe the vision for their region's Transition Super-Lab including the regional transition goal. They refer to the main goals and targets of the TSL and the topics addressed by the TSL. Here, they not only mention the specific topics considered through the project's pilot use cases, but also relevant topics across socio-technical regimes. Altogether, the purpose of this section is to share insights on the focus of the TSL in light of the development of a comprehensive Action Plan. Basically, it is built on the results of the previous deliverables of the Work Package 3 and the work done in the regions during the project's preparation and implementation phase.

In the second part, the regions demonstrate the potential implementation of concrete project ideas in the logic of the TSL approach. Here, they focus on specific topics through examples, which are pilot use cases, and they address each one of the pilot use cases individually. The partners from the TSL regions specify which are the goals and specific targets of the pilot use cases and highlight the connectivity among these different project ideas. They outline the actions needed to implement the Action Plan and the measures to put these actions into practice. Furthermore, they indicate the respective timelines for implementation including the different project phases and highlight the milestones. One of the central aspects of the Action Plan is about stakeholder identification and analysis, description of their roles and responsibilities. After referring to risk assessment and mitigation, the partners from the four TSLs focus on financing and funding options for the implementation of the pilot use cases. Finally, they share ideas for impact assessment and for monitoring and evaluation of these project ideas.

The third part of the Action Plans is dedicated to recommendations for action regarding the question on how to lay foundations for long-term implementation and establishment of the TSLs. This part of the Action Plans also focuses on a potential governance structure for the Transition Super-Labs that could be developed in a region in a continuous way over years. At the end of the document, the main conclusions and an outlook are presented.

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Project Partners

Organisation	Country	Abbreviation
RUHR-UNIVERSITAET BOCHUM	DE	RUB
RUPPRECHT CONSULT-FORSCHUNG & BERATUNG GMBH	DE	RC
BUSINESS METROPOLE RUHR GMBH	DE	BMR
REGIONE EMILIA ROMAGNA	IT	RER
FONDAZIONE ISTITUTO SUI TRASPORTI E LA LOGISTICA	IT	ITL
FIT CONSULTING SRL	IT	FIT
DOLNOSLASKI FUNDUSZ ROZWOJU sp. z o.o.	PL	DFR
UNIWERSYTET WARSZAWSKI	PL	Uni Warsaw
FUNDACJA DUMNI Z LUBINA	PL	Dumni z Lubina
ANKO DYTIKIS MAKEDONIAS A.E. - ANAPTYXIAKOS ORGANISMOS TOPIKIS AFTODIIKISIS	GR	ANKO
ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS	GR	CERTH
TWENTY COMMUNICATIONS SRO	SK	TWE
EUROPEAN NETWORK OF LIVING LABS IVZW	BE	ENoLL

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Table of Contents

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Table of Figures

Table of Tables

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List of Acronyms

Acronym	Meaning
AC	Alternating Current
BEB	Battery Electric Buses
BMR	Business Metropole Ruhr GmbH
CCS	Carbon Capture and Storage
CERTH-CPERI	CERTH - Chemical Process & Energy Resources Institute, department in Western Macedonia
CERTH-HIT	CERTH - Hellenic Institute of Transport
CLUBE	Cluster of Bioeconomy and Environment of Western Macedonia
CO2	Carbon dioxide
DC	Direct Current
DCE	Discrete Choice Experiment
DEDDIE	Hellenic Electricity Distribution Network Operator
DGR	Delibera Giunta Regionale
DIADYMA	Waste Management of Western Macedonia
DS	Data Space
EC	European Commission
EV	Electric Vehicles
ELSTAT	Hellenic Statistical Authority
EU	European Union
EUR	Euros
FCEB	Fuel Cell Electric Buses
FIAB	Federazione Italiana Ambiente e Bicicletta
GDP	Gross Domestic Product
GSE	Gestore Servizi Energetici
GHG	Green House Gas
GVA	Gross Value Added
GWI	Gas und Wärme-Institut Essen e.V.
H2	Hydrogen
HV	High Voltage
HyMR	Hydrogen Metropole Ruhr
KPI	Key Performance Indicators
KTEL PT	Local Buses Public Transport
kW	Kilowatt
LGOM	Legnicko-Głogowski Okręg Miedziowy
MG	Main Goals
MM	Mobility Management
Mt	Million tones
MoU	Memorandum of Understanding

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Acronym	Meaning
NECP	National Energy and Climate Plan
NGOs	Non-Governmental Organisations
NRW	North Rhine-Westphalia
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Cooperation and Development
PAIR	Piano Aria Integrato Regionale
PDCA	Plan-Do-Check-Act
PRIT	Piano Regionale Integrato Regionale
PT	Public Transport
PV	Photovoltaics
QH	Quadruple Helix
RACI	Responsible, Accountable, Consulted und Informed
RER	Regione Emilia-Romagna
RES	Renewable Energy Sources
RVR	Regionalverband Ruhr
SCM	Supply Chain Management
SMEs	Small and Medium-sized Enterprises
SMRs	Small Modular Reactors
SO	Specific Objectives
SpA	Società per Azioni
SrL	Società a responsabilità Limitata
STEM	Science, Technology, Engineering and Mathematics
SUMP	Sustainable Urban Mobility Plan
SWOT	Strengths, Weaknesses, Opportunities and Threats
T	Targets
TCO	Total cost of Ownership
TEMENUS	University of Western Macedonia Center for Research and Innovation
TJTP	Territorial Just Transition Plan
TSL	Transition Super Lab
TWh	Terawatt hour
UA Ruhr	University Alliance Ruhr
UAMR	University Alliance Metropolis Ruhr
VSEs	Very Small Enterprises
WP	Work Package

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1 Introduction

Within the framework of this deliverable, the four partner regions in the TRANSFORMER project (Emilia-Romagna, Lower Silesia, Ruhr Area and Western Macedonia) are developing the Action Plans for the subsequent stage for long-term implementation and establishment of their Transition Super-Labs (TSLs). At first sight, a quite clear mission, as developing an Action Plan is a common task in many European projects. Nevertheless, action plans for Transition Super-Labs, which is an entirely new concept, are being developed for the first time and there is no role model to follow. Furthermore, just as stated above, as the description of the Task 3.3 (Action Plan/programme (incl. financing and funding schemes for subsequent stage) development for Super-Labs) explicitly refers to the goal of "long-term implementation and establishment of the TSLs", the mission becomes even more ambitious: action plans are generally expected to be as concrete and precise as possible and usually address implementation of activities that will take place soon. The longer the way to go, the more difficult it is to design detailed measures and make the planning less abstract.

Basically, as the name is indicating, an action plan is supposed to be about planning actions, or more in detail, sub-actions, measures and activities to be implemented in a concrete place (for example, a country, a region, a city or a district) within a defined period of time. An action plan always explicitly refers to responsibilities to be assumed by actors and timelines to be respected among others, and therefore has to do with concrete projects.

In TRANSFORMER, such projects (or at least projects ideas) are the so-called pilot use cases, which were defined during the first six months of the project and described in the Deliverable 3.2: Definition of Transition Super-Lab use cases. As stated in the Deliverable 3.2: "Pilot use cases are the core of the Transition Super Labs in the four TRANSFORMER regions. They allow for an application of the TSL concept in practice. Designing and developing them together with regional stakeholders is the most practical part of the project. It is the first space where the TSL concept is tested, where project partners can learn to what extent the concept is accepted and what needs to be improved in the post-pilot phase." (Deliverable 3.2, p. 9)

Hence, on the one hand, a TRANSFORMER Action Plan needs to be built around the pilot use cases of the four Transition Super-Labs. On the other hand, we assume that a TSL is more than the sum of its pilot use cases. Pilot use cases are important examples from different thematic areas that can operate as enablers of a potential TSL development. However, to respond to the variety and the complexity of a TSL and to address the challenge of its long-term implementation and establishment, it is necessary to ensure connectivity to other relevant thematic areas and to elaborate (or at least to reflect) on a potential governance structure that could be developed in a region in a continuous way over years.

An intensive exchange among the project partners involved in the task and the respective deliverable was necessary to find the most appropriate approach to the challenge of designing and developing Action Plans for the four Transition Super-Labs. It was important to align the work of the WP3 with the WP2,

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particularly regarding the Deliverable 3.3 and the Deliverable 2.3. Furthermore, for Action Plan development, the work done previously for the Deliverables 3.1 (Recommendations for Transition Super-Lab coalition building, empowerment of vulnerable and marginalised groups, and vision process) and 3.2 (Definition of Transition Super-Lab use cases) was crucial, as the Action Plans represent a consequent continuation of the TSL pilot development initiated through those fundamental deliverables.

Based on the discussions described above, the partners have agreed on a deliverable structure that covers the variety of the different aspects of the task, considering both concrete actions to be implemented in near future and reflections on the long-term establishment of Transition Super-Labs.

The deliverable is structured in the following way:

- Four TRANSFORMER partner regions present their Action Plans in alphabetical order.
- The Action Plans consist of three main parts:
    - The overall idea of the TSL
    - Developing concrete actions through pilot use cases
    - Recommendations for action

In the first part, project partners describe the vision for their region's Transition Super-Lab including the regional transition goal. They refer to the main goals and targets of the TSL and the topics addressed by the TSL. Here, they not only mention the specific topics considered through the project's pilot use cases, but also relevant topics across socio-technical regimes. Altogether, the purpose of this section is to share insights on the focus of the TSL in light of the development of a comprehensive Action Plan. Basically, it is built on the results of the previous deliverables and even the work done in the regions during the project's preparation and implementation phase.

In the second part, the regions demonstrate the potential implementation of concrete project ideas in the logic of the TSL approach. Here, they focus on specific topics through examples, which are pilot use cases, and they address each one of the pilot use cases individually. The partners from the TSL regions specify which are the goals and specific targets of the pilot use cases and highlight the connectivity among these different project ideas. They outline the actions needed to implement the Action Plan and the measures to put these actions into practice. Furthermore, they indicate the respective timelines for implementation including the different project phases and highlight the milestones. Certainly, one of the central aspects of the Action Plan is about stakeholder identification and analysis, description of their roles and responsibilities. After referring to risk assessment and mitigation, the partners from the four TSLs focus on financing and funding options for the implementation of the pilot use cases. Finally, they share ideas for impact assessment and for monitoring and evaluation of these project ideas.

The third part of the Action Plans is dedicated to recommendations for action regarding the question on how to lay foundations for long-term implementation and establishment of the TSLs. This part of the Action Plans also focuses on a potential governance structure for the Transition Super-Labs that could be developed in a region in a continuous way over years.

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Of course, all TSL regions have developed their Action Plans according to the same structure, which is described above. Nevertheless, there are several important differences among the regions which have a direct effect on the development of the Action Plans. These differences already became evident during the initial phase of the project when the Deliverables 3.1 and 3.2 were developed. In the course of the development of the Deliverable 3.3 even more important differences could be clearly identified. Certainly, they have to do with the different political and administrative nature of the regions involved in the TRANSFORMER project, the room for manoeuvre, political power, access to decision-making processes and resources. Moreover, the differences can be explained by the variety of topics and especially the emphasis on different priorities of the partner regions. For example, some of them are confronted with the necessity of finding and introducing solutions within a relatively short timeline (partially, even starting implementation during the project's lifetime), while others are developing Action Plans with a more long-term perspective in mind. Correspondingly, some Action Plans are more concrete than others and are presenting detailed information regarding immediate actions. Therefore, this deliverable cannot be perceived and read as a typical template where each project partner just fills in the information required to respond to standardised questions (although, a basic common structure is definitely essential for the quality of the deliverable) but reflects the important differences among the four TSLs which need to be taken into account for the purpose of development of realistic Action Plans, especially regarding the fact that they will be implemented by regional stakeholders.

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2 The Action Plan for the Emilia-Romagna TSL

2.1 The overall idea of the Emilia-Romagna TSL

Vision of the TSL and the regional transition goal

The Emilia-Romagna Region is a highly productive region, home to some world-famous industrial districts and crossed by many transportation networks. These industrial districts can, however, also represent key challenges to decarbonisation. The region is oriented towards reducing CO_2 emissions, improving the circular economy and promoting climate neutrality. Several regional plans aim at reaching a sustainable future and improving air quality (e.g. transport, energy, air quality and waste plans). The Region has promoted the development of **SUMP (Sustainable Urban Mobility Plan)** at local level and with the 2030 Agenda has put in place a regional strategy for sustainable development[1] and a law for the development of energy communities[2].

The **Pact for Work and Climate**[3] and the **2020-2025 Regional Government Programme** [4]are the basis of the Regional Strategy 2030 Agenda, confirming the Emilia-Romagna objective to generate new quality jobs, accompanying Emilia-Romagna in the ecological and digital transition to reduce the economic, social, environmental and territorial disparities and achieve full gender equality.

Connected to this, the Region has also created an **Organizational Hub for Climate Change in the Emilia-Romagna Region (*Presidio Organizzativo per il Cambiamento Climatico della Regione Emilia-Romagna*)** and developed the project **"Path to Carbon Neutrality before 2050".** The project aims to identify, sector by sector, the best policies and actions to implement in order to reach the climate neutrality by 2050 by setting intermediate objectives and targets in line with the above-mentioned strategies. Moreover, the region has launched an integrated and multidisciplinary approach that aims to improve air quality: the **PAIR 2030**[5] (Regional Integrated Plan for air quality). The plan specifically involves the municipalities of Emilia-Romagna region that are located in the Eastern and Western Po Valley and in the agglomeration of the city of Bologna.

However, in order to reach the decarbonisation, there is a need for further cooperative processes of communication, sharing and information exchange between the different Quadruple Helix stakeholders and all the above-mentioned initiatives should be enhanced and interlinked.

[1] Regional Strategy 2030 Agenda for Sustainable Development: https://www.regione.emilia-romagna.it/agenda2030

[2] Legge regionale n. 5/2022: Promozione e sostegno delle comunità energetiche rinnovabili e degli autoconsumatori di energia rinnovabile che agiscono collettivamente'' available at: https://demetra.regione.emilia-romagna.it/al/articolo?urn=er:assemblealegislativa:legge:2022;5?

[3] Pact for Work and Climate: ese-patto-per-il-lavoro-17x24cm_en_web.pdf (regione.emilia-romagna.it)

[4] Programma di mandato della Giunta 2020-2025: https://www.regione.emilia-romagna.it/presidente/programma-di-governo/programmadimandato20202025.pdf/@@download/file/13_Mandato_A4_web_singole.pdf

[5] PAIR 2030: PAIR 2030 — Ambiente (regione.emilia-romagna.it)

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In this framework and context, Emilia-Romagna has developed a TSL Action Plan focused on the mobility sector.

The scope of the Action Plan

The general scope of the Action Plan is to develop **mid-term and long-term concrete actions involving all the stakeholders of the quadruple helix framework to enhance their collaboration to improve sustainable mobility at regional level with the final aim of accelerating the transformation towards climate neutrality.** The transport and mobility sectors are responsible for very high levels of greenhouse gas emissions. Transport causes about a quarter of the EU's total greenhouse gas emissions and generates air pollution, noise pollution and habitat fragmentation[6]. In Emilia-Romagna region the transport sector as a whole (including also air, water, rail, etc.) contributes approximately 32% to total regional PM10 emissions and 68% to total regional NOx emissions[7]. Therefore, the region's transition to climate neutrality cannot be successful without putting in place strong actions towards sustainable mobility. Moreover, acting on the mobility sector could enhance significant transformations in other sectors. For instance, the improvement of sustainable mobility can boost tourism, city attractiveness and citizens' wellbeing, but also the industrial and education sector by promoting homework and home-school sustainable commuting solutions. The main limitations of its implementation are the availability of financing resources and the fact that Emilia-Romagna Region public authority is a complex institution composed of different departments/directorates, each one specialised on a specific topic (e.g., public transport and sustainable mobility; energy and green economy; environment; agriculture, etc.) that, sometimes, do not communicate with each other and do not directly involve citizens and civil society.

Regional transition goal: Main goals, objectives and targets

The main goals, objectives and targets of Emilia-Romagna TSL Action Plan are the following:

1. **Improving and increasing the involvement of the municipalities of the Region**, in particular the ones that are part of the PAIR, in the decision-making process at regional level for the development of policies;
2. **Improving and increasing citizens and third sector associations interest and engagement in community affairs and in the decision-making process** thanks to the implementation participatory initiatives. Participatory initiatives revolve around creating debate and constructive dialogue among citizens with the aim of arriving at a mutually agreed choice of priorities. These priorities are then meant to be included by the municipal administrations in their preliminary budget. These initiatives should be enhanced and coordinated at regional level;
3. **Improving the cooperation among the different departments/directorates of Emilia-Romagna Region Authority** as sustainable mobility is a cross-sectorial theme that is addressed by more than

[6] EEA Report 2/2022Decarbonising road transport — the role of vehicles, fuels and transport demand (https://www.eea.europa.eu/publications/transport-and-environment-report-2021)

[7] ARPAE Emilia-Romagna (2018). Rapporto ambientale del PRIT-2025 dell'Emilia-Romagna (https://mobilita.regione.emilia-romagna.it/pianificazione/prit-piano-regionale-integrato-dei-trasporti/prit-2025-elaborati-tecnici)

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one department and not only by the department of public transport and sustainable mobility (e.g. energy and green economy; environment; agriculture, etc.).

Topics

The topics addressed by Emilia-Romagna TSL Action Plan are all specific aspects of sustainable mobility in order to reduce traffic congestion, improve liveability and the air quality by reducing CO_2 emissions.

Emilia-Romagna general topics

Emilia-Romagna TSL identified the following general topics:

1. **Cycling:** In Emilia-Romagna there are more than 8,000 km of road routes, cycle paths and dirt tracks for bikes and mountain-bikes distributed in all the nine provinces of the regional territory. Emilia-Romagna is the crossing land of four big national tourist cycling routes that interconnect with the great European tracks (Eurovelo), confirming the cultural, and the touristic value of cycle tourism. Three of these routes also cross the entire Emilia-Romagna: the Vento Route, the Ciclovia del Sole and the Ciclovia Adriatica.
2. **Mobility management policies:** "Mobility management" (MM) means "management of mobility demand". It consists of a set of measures aimed at improving the mobility of people, vehicles and goods in urban areas and using actions that safeguard and enhance the environment through innovative solutions with low environmental impact. Emilia-Romagna Region works on two levels: on the one hand it promotes MM policies in cooperation with all the municipalities, and on the other it applies MM policies on its employees. As an entity, the Region moves thousands of employees every day, but also visitors and suppliers whose movements have repercussions in terms of congestion, air and noise pollution: hence the decision to work, with the tools available to the mobility manager, to understand and therefore to reduce the overall impact that the regional offices produces through the mobility it generates in the territory with all its activities. To this end, the Region has approved the Corporate Mobility Plan[8], which includes actions to improve accessibility to regional offices and incentives for collaborators aimed at reducing the need to use private cars.
3. **Electric mobility:** Electric mobility is a more sustainable alternative to the use of traditional vehicles and manufacturers offer both electric, hybrid and plug-in car models (with more significant electric mileage than traditional hybrids). Considering that it is very common to travel short journeys in the city and that the average regional travel is within 12,7 km/day[9], electric cars can represent a valid alternative to traditional vehicles, also because the models currently on sale have ranges of up to 200 km.

[8] DGR Num. 2305 del 22/12/2023 (https://servizissiir.regione.emilia-romagna.it/deliberegiunta/servlet/AdapterHTTP?action_name=ACTIONRICERCADELIBERE&operation=leggi&cod_protocollo=GPG/2023/2352&ENTE=1)

[9] Audimob Report: https://www.isfort.it/ricerca/audimob/

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Emilia-Romagna specific topics and relevant topics across the regimes

In the context of the above-mentioned topics Emilia-Romagna TSL decided to focus on the following specific themes:

1. Development of a regional cycling mobility cartography and network, new cycling guidelines and modal share analysis;

2. Promotion of mobility coordination management activities to be carried out together with the Area Mobility Managers and company mobility managers, to favour actions and projects concerning sustainable home-work and home-school mobility, also paying attention to problems related to passengers with restricted mobility transport;

3. Creation of a centralized database and network at regional level including all data on Electric Vehicles charging stations.

The topics developed in Emilia-Romagna TSL have also impact and interconnections with other important sectors:

Tourism sector: promoting cycle tourism at regional and inter-regional level by constructing a network of cycle paths, bike parks and bike hotels. Promotion of charging points at tourist attractions.

Industrial/productive sector: mobility management policies and actions contribute to reduce and/or improving the quality of the commuting home-work travel time by, in this way, improving the employee comfort and productivity.

Educational sector: mobility management policies and actions contribute to reduce and/or improving the quality of the commuting home-school travel time by, in this way, improving the students and their families' comfort and education.

Health sector: the health sector in Emilia-Romagna can benefit from sustainable mobility through improved air quality, enhanced access to healthcare, promotion of physical activity, reduced stress, efficient emergency services, cost savings, a healthier environment, and better support for healthcare workers.

2.2 Developing concrete actions through pilot use cases

In the logic of the TSL approach, Emilia-Romagna develops concrete actions through three use cases linked to the specific topics explained in the section above. The use cases are the following and for each use case specific objectives have been set:

Pilot Use Case 1: Development of a regional cycling mobility cartography and network, new cyclability guidelines and modal shift survey

The goal of this use case is twofold:

1. **Regional cycling system guidelines update [10].** The region's cycling guidelines, (published in 2019 and co-designed by RER, local authorities and cycling associations), provide a

[10] DGR n.691 01/05/2019. Linee guida per il sistema regionale della ciclabilità (https://mobilita.regione.emilia-romagna.it/mobility-sostenibile/mobilita-ciclistica/la-regione-per-la-mobilita-ciclistica)

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framework for the development of a comprehensive cycling network that is safe, accessible, and attractive to cyclists of all ages and abilities. The Emilia-Romagna cycling guidelines have already had a positive impact on cycling in the region. The guidelines have also helped to raise awareness of the benefits of cycling, and have encouraged more people to choose the bicycle for their everyday transportation needs. In 2024 the objective of Emilia-Romagna TSL is to update the guidelines to improve and standardize cycle mobility guidelines and cartography at regional level including accessibility and safety features. The innovative and experimental character of this use case is the ambition to systemically transform the planning criteria for the whole road infrastructure that can lead to safe and low-speed streets that encourage the use of bicycles. The main aim is to create a new infrastructural system with more liveable streets that promotes the modal shift of the daily commute from car to bicycle. In parallel, the Region is conducting an analysis of the modal share, a crucial step in determining which types of policies need to be implemented to address transportation needs. Given that this data is often difficult to obtain, the Region is considering organizing a survey to gather comprehensive and up-to-date information on how people are commuting. This will provide valuable insights into current transportation patterns, enabling more effective planning and policy-making.

2. **Establishment of a permanent working group on Emilia-Romagna regional cycle cartography and cycle mobility initiatives with provinces, municipalities and civil society.** The objective is in line with the Emilia-Romagna Regional Law on Cyclability[11] In 2017 a regional working group was established in Emilia-Romagna with the aim of promoting the use of bicycles in the region. This group is composed of representatives from local governments, businesses, and advocacy groups. It meets regularly to discuss issues related to cycling, such as infrastructure, safety, and tourism. The working group has been established but it has not yet developed concrete actions and it has not involved citizens. For this reason, Emilia-Romagna TSL aims to improve the operation and the concrete actions of the already existing working group by also involving citizens.

Pilot Use Case 2: Promotion of mobility management coordination activities to be carried out together with the area mobility managers and company mobility managers

The final goal of this use case is to realize a **permanent working group on Emilia-Romagna Mobility Management with municipalities, companies and university involving Area, Company and University Mobility Managers**. This is in line with the national guidelines for drafting and implementing Home-Work Travel Plan and the objective of the Pilot Use Case 1. Emilia-Romagna TSL aims to implement a permanent working group on mobility management in order to coordinate all the activities at regional level involving all Quadruple Helix stakeholders' groups. The aim is to establish a permanent dialogue in order to reduce the use of private transport by giving employees useful information and creating a culture of sustainable mobility.

[11] Regional Law No. 10 of 2017 available at https://demetra.regione.emilia-romagna.it/al/articolo?urn=er:assemblealegislativa:legge:2017;10

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Pilot Use Case 3: Creation of a centralized database and network at the regional level including all data on electric vehicle (EV) charging stations

The goal of this use case is twofold:

1. **Establishment of a permanent working group on electric vehicles mobility to increase collaboration between municipalities, national energy manager (GSE: Gestore Servizi Energetici), Electric Vehicles charging stations companies, university and civil society**: in line with the Emilia-Romagna Regional Law on Cyclability[12] and the objective of the Pilot Use Case n. 1, Emilia-Romagna TSL aims to implement a permanent working group on electric mobility in order to coordinate all the activities at regional and national level involving all Quadruple Helix stakeholders' groups and supporting the development of an Electric Vehicles charging points regional network development;
2. **Electric Vehicles charging points regional network development, also in rural areas and for touristic attractions:** the development of a comprehensive network of electric vehicle (EV) charging points across the region, including in rural areas and near tourist attractions, is crucial for several reasons. First and foremost, it aims to alleviate "range anxiety," ensuring that EV users can travel throughout the region without the constant concern of running out of power. By strategically placing charging stations in both urban and rural locations, the region creates a reliable infrastructure that supports electric vehicle adoption. Moreover, expanding the charging network to include touristic attractions can serve as a significant boost to local economies. By encouraging EV owners to visit these sites, the region not only promotes sustainable tourism but also drives increased foot traffic to businesses and attractions.

Connectivity to other pilot use cases

Pilot Use Cases 1 and 2 are strictly connected as cycle mobility is one of the sustainable modes of transport that is encouraged by mobility management policies in order to create a new infrastructural system with liveable streets that promotes the modal shift of the daily commute from car to bicycle. Pilot Use Case 3 is more linked to Pilot Use Case 2 as it promotes the use of electric cars among citizens and companies for the commuting.

Actions, sub-actions and measures as parts of the pilot use case implementation

To achieve the objectives outlined above, specific actions and measures have been established for each use case. The activities undertaken across all use cases follow a unified approach and are closely linked, as they all pertain to sustainable mobility. Some of them have already happened in due course of TRANSFORMER project as the preparation phase of the Action Plan started in November 2023. The first two use cases collaborate on certain initiatives, particularly in cycling and mobility management, as these are closely intertwined. The goal is to promote bicycle usage for commuting to work or school, thereby reducing reliance on cars.

[12] Ibid.

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Necessary actions to implement the Action Plan

Pilot Use Cases 1 & 2

- Periodical meetings with municipalities and companies (every 3 months) on cycling mobility and mobility management activities;
- Definition of standards and data collection needs in collaboration with local authorities, aimed at creating a map of cycle paths on a regional scale;
- Procurement to contract an external consultant for the regional cycling system guidelines update (the date has to be confirmed. Maybe it could take place also after the TRANSFORMER project closure);
- Procurement to contract an external company to implement the new modal shift survey (the date has to be confirmed. Maybe it could take place also after the project closure);
- Awareness campaign promoting bicycle use in urban areas seeking to highlight the benefits of cycling while providing essential safety information to cyclists. This campaign educates the public on the health, environmental, and economic advantages of choosing a bicycle over other forms of transportation. It also emphasizes the importance of safety by offering tips on proper bike maintenance, road safety practices, and the correct use of safety gear such as helmets and reflective clothing. The campaign concludes with a call to action, encouraging employees to consider cycling as their daily mode of transportation. By doing so, individuals can contribute to a collective effort that can lead to a significant increase in cycling infrastructure, greater investments in bike-related projects, and the creation of jobs within the cycling industry.
- TRANSITIONCAMP workshop in collaboration with Emilia-Romagna Region, ITL Foundation and Municipality of Reggio Emilia. On 10th May 2024 a workshop on sustainable mobility and city logistics initiatives and policies at local, regional, national and European level was organized in Reggio Emilia, one of the Emilia-Romagna main city that promotes sustainable mobility and cycling culture. The workshop aimed to raise awareness and promote dialogue among citizens, government institutions, local authorities, and professionals on innovative urban initiatives related to sustainable mobility and freight transport to accelerate the transition. During this workshop aspects of TRANSFORMER project and of Emilia-Romagna Action Plan were presented, discussed and validated by key stakeholders and additional elements related to the implementation of the TSL's operation were examined;
- Collection of ideas and feedback through surveys and other engagement activities on the establishment of a permanent working group on cycle mobility and mobility management involving all Quadruple Helix stakeholders;
- Benchmarking against other European regions to identify best practices and areas for improvement, given the similarities in challenges faced across the continent;
- Co-definition and establishment of the permanent working group (structure, responsibilities and capacities needed) on cycle mobility and mobility management.

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Pilot Use Case 3

- Collection of ideas and feedback through surveys and civic imagination activities on the establishment of a permanent working group on electric mobility involving all Quadruple Helix stakeholders;
- Benchmarking against other European regions to identify best practices and areas for improvement, given the similarities in challenges faced across the continent;
- Co-definition and establishment of the permanent working group on electric mobility;
- Creation of a centralized database at regional level including all data on electric vehicle (EV) charging stations (e.g. Charging stations ID, Typology (AC – DC), maximum power output per socket (kW);
- Cooperation with the tourism department area to promote the car charging point network near the tourism attractions.

Necessary measures to develop the actions

Pilot Use Case 1, 2 and 3

In order to implement the actions Emilia-Romagna TSL will develop the following specific measures that will keep the community active and help each stakeholder to understand what they can benefit from collaboration and what the others expect from them:

- Surveys to collect opinions and inputs by all stakeholders. Ad hoc survey prepared according to the targeted stakeholders in order to collect their opinions and inputs on the specific topics;
- B2match tool – TRANSITIONCAMP to promote and facilitate the events/workshops;
- Implementation of shared boards applications in order to engage the stakeholders in the ideation, rapid prototyping and simple experiments. The online collaborative whiteboarding platforms enable distributed teams to work effectively together, from brainstorming with digital sticky notes to planning and managing agile workflows;
- Organization of workshops and conferences:
    - International webinar on electric mobility organized by The Climate Group “Powering Remote Areas: Strategies for Securing Investments in Charging Infrastructure” on 17th January 2024. This webinar examined how to secure investment and reliable maintenance for charging infrastructure in remote areas. Emilia-Romagna public authority presented Emilia-Romagna policies on electric mobility (use case 3);
    - Workshop with Emilia-Romagna municipalities that have over 30,000 inhabitants and MOTUS-E (the first association in Italy composed by industrial operators, automotive companies, academic world and opinion movements with aim of creating a system and accelerate the change towards electric mobility) to share MOTUS-E “Handbook for the creation of a network of EV charging stations for public use” on 24th January 2024 (Pilot Use Case 3);
    - Conference on sustainable mobility policies in the region on 20th March 2024. This conference had the aim to inspire and guide regional leaders as they work towards creating a more sustainable future. By focusing on the practical implementation of

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mobility policies, the conference aims to drive tangible changes that can serve as a model for other regions;

- Event/workshop "Mobility and logistics of the Future" on 11th April 2024 at Basilica di San Domenico, Bologna to share with different stakeholders' visions and ideas on the future development of transport mobility and logistics. This workshop was implemented for both Pilot Use Cases 1 and 2;
- Workshop "Changing cities: innovative actions for the sustainable mobility of people and goods" with QH stakeholders on sustainable mobility and city logistics in Reggio Emilia (TRANSITIONCAMP event). The workshop took place on 10th May. This workshop was implemented for both Pilot Use Cases 1 and 2;
- Evaluation reports on the implemented events/workshops;
- Awareness campaigns.

Links between the different pilot use cases

Pilot Use Case 1 will be the basis for the other 2 use cases since Emilia-Romagna Region has already established a law on cyclability (Law No. 10 of 2017) that adopted a participatory and collaborative approach by implementing a regional working group composed of representatives from local governments, businesses, and advocacy groups.

Project phases (timeline) and milestones

Project phases (timeline)

The Action Plan for all use cases is divided in 3 main phases:

Preparation phase (from Nov/Dec 2023 to May 2024): analysis of the context, on the existing initiatives and discussion with all QH stakeholders in order to have a clear idea of the as-is situation of each use case, the stakeholders' engagement plan and how Emilia-Romagna TSL would like to reach the defined objectives.

Implementation and monitoring phase (from June 2024 to June 2025): at the beginning of this phase, it is important to start co-defining the permanent working group that will be implemented and to start with the periodical meetings (at least every 3 months). The implementation phase also includes a monitoring phase in parallel as it is important to monitor simultaneously each step taken, if it works and, if not, how it can be changed and adapted to the actual situation by applying the Plan-Do-Check-Act (PDCA) cycle explained in Monitoring and Evaluation session below. The PDCA cycle, also known as the Deming Cycle or Plan-Do-Check-Act, is a four-step iterative management method used for continuous improvement of processes and products.

Validation and replicability phase (from July 2025 to December 2025): during this period the results of each use case will be validated and the guidelines for replication in other Italian and European regions will be set.

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Pilot Use Case 1&2 – milestones

1. 18th December 2023: Meeting on cycle cartography with Bologna Città Metropolitana;
2. November – December 2023: Meetings with municipalities to design new projects on sustainable mobility;
3. 10th May 2024: Workshop with QH stakeholders on sustainable mobility and city logistics initiatives in Reggio Emilia (TRANSITIONCAMP event);
4. End of October 2024: Co-definition and establishment of the permanent working group on cycle mobility and mobility management;
5. End of December 2024: Update and approval of the regional cycling system guidelines.

Pilot Use Case 3

1. 24th January 2024: Workshop with Emilia-Romagna municipalities with over 30,000 inhabitants and MOTUS-E (the first association in Italy composed by industrial operators, automotive companies, academic world and opinion movements with aim of creating a system and accelerate the change towards electric mobility, and maybe University of Bologna) to share with MOTUS-E "Handbook for the creation of a network of EV charging stations for public use";
2. End of October 2024: Co-definition and establishment of the permanent working group on electric mobility;
3. Creation of a centralized database at regional level including all data on electric vehicle (EV) charging stations in cooperation with GSE (the national energy manager)

Stakeholder identification and analysis

Stakeholders from the Quadruple Helix

Stakeholder management and engagement plan

A stakeholders' engagement plan will be set with the support of the TRANSITIONCAMP and the Matchmaking platform (https://www.b2match.com/e/transformer-project/components/34158). The platform, developed within TRANSFORMER project, puts together stakeholders from different sectors and allows to share knowledge and insights on the different topics connected with the Transition Super-Labs (TSL). It also helps to organize a TRANSITIONCAMP, an open day event, bringing together all the identified stakeholders of the Transition Super-Lab (TSL) in a collaborative setting. The primary purpose of the stakeholder engagement plan is to facilitate effective communication and foster a common understanding among the various parties involved. The main objectives are to a) foster collaboration and communication with key stakeholders, b) ensure transparency and inclusivity in decision-making processes, c) gather input and feedback from stakeholders to inform activities design and implementation, and d) build support and commitment for the activities among stakeholders.

Emilia-Romagna Region Public Authority will ensure and consolidate the involvement of stakeholders through Institute for Transport and Logistics Foundation and the Municipalities of the Region that have

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more direct contact, dialogue and proximity with the territory. Emilia-Romagna Region will adopt policies encouraging the municipalities to implement local initiatives according to the needs of local stakeholders.

The idea is to start with events/workshops connected to the use cases where all QH stakeholders can take part. The aims of these events are to inform all participants on the initiatives currently in place on different levels (European, national, regional and local) and how they can influence and benefit from each other. They will also be an open space for dialogue and exchange where each participant can realise the potential added value of the inter-organisational encounters and continue with their regular participation.

Various stakeholders across mobility and energy sectors can play crucial roles in the successful implementation of Pilot Use Cases 1, 2 and 3. Some of the relevant potential partners include:

- CONFINDUSTRIA Emilia-Romagna (the main organization at regional level representing industrial companies in Emilia-Romagna): https://www.confind.emr.it/en/who-we-are-what-we-do. They can support in the harmonization of the regional plans and contribute to their implementation.
- CONFCOMMERCIO Emilia-Romagna (the most important association of Commerce, Tourism and Services in the region): https://www.confcommercio-er.it/. They can promote the coordination between enterprises and policy makers in the energy sector.
- UNIONCAMERE Emilia-Romagna (The Regional Union of Chambers of Commerce of Emilia-Romagna). It is the association of the Chambers of Commerce of the territory: https://www.ucer.camcom.it/. They can promote the coordination between enterprises and policy makers in the energy sector.
- Hera (multi-utility company that operates in the following fields: waste (management and treatment), water (aqueduct, sewerage, and purification) and energy (distribution and sales of electricity, gas and energy services), but they also offer public lighting and telecommunications, always following a business model that focuses on creating shared value for all our stakeholders: https://www.gruppohera.it/. They can implement activities towards the transition to climate neutrality.
- Iren (multi-utility company that operates in the following business areas: electricity (production, distribution and sale), district heating (production, distribution and sale), gas (distribution and sale), integrated water service management, environmental services (waste collection and disposal), integrated solutions for energy efficiency of public and private bodies and services for the local authorities: https://www.gruppoiren.it/. They can implement activities towards the transition to climate neutrality.
- Electric Vehicles Charging and infrastructure companies operating in Emilia-Romagna (Iren Mercato SpA, Enermia srl, Hera Comm SpA, BE Charge srl, Enel X Mobility srl). They can build the infrastructures and promote the usage of electric vehicles.
- GSE (Gestore Servizi Energetici): The Gestore dei Servizi Energetici (GSE) is an Italian public economic entity operating in the energy sector, primarily aimed at promoting and incentivizing renewable energy production and energy efficiency projects. The GSE manages various financial support mechanisms, such as incentives and contributions for renewable energy production, and provides technical assistance and consultancy for sustainable energy projects. They will contribute

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to the EV charging points regional network implementation and they will be part of the permanent working group of use case 3.

- Legambiente Emilia-Romagna (Legambiente is the most prominent and widespread environmental association in Italy. The main headquarters are in Rome and Milan. In Emilia-Romagna there is one of the 20 regional coordination offices: https://www.legambiente.emiliaromagna.it/associazione/). They promote initiatives and educational activities to protect the environment.
- Salvaiciclisti Bologna (association of urban cyclists that promotes a city where the most vulnerable road users, who every day choose sustainable mobility, are protected, encouraged and valued: https://salvaiciclisti.bologna.it/). They support in the promotion of the use of bicycle and cycle tourism in order to protect the environment.
- Cluster GreenTECH (association of public and private bodies: companies, research centres and training institutions that share skills) https://greentech.clust-er.it/en/. They contribute to the innovation of project solutions and results, involving also private companies and entities. They will be part of the TSL Daily Working Group.
- FIAB (Federazione Italiana Ambiente e Bicicletta: Italian Federation Environment and Bicycle. It is an environmental organization that promotes the daily use of the bicycle and cycle tourism to protect the environment and fight the climate crisis) https://fiabitalia.it/. They contribute to the promotion of the use of bicycle and cycle tourism in order to protect the environment.
- University of Bologna (UNIBO) and University of Modena and Reggio Emilia (UNIMORE). They can support the research to facilitate the transition towards climate neutrality and they will be part of the reflexive monitoring board of the TSL.
- Organizational Hub for Climate Change in the Emilia-Romagna Region that serves as the central point for coordinating climate action, promoting best practices, and ensuring that the region's approach to climate change. It will be part of the reflexive monitoring board of the TSL.
- Emilia-Romagna Municipalities with more than 30,000 inhabitants. They will be part of the TSL Daily Working Group, implementing the activities at local level.

Communication Plan

A communication plan is necessary to ensure the correct application of the Action Plan and the achievement of the planned results by enabling the stakeholders to participate increasing their motivation. The communication of the activities will be ensured by Emilia-Romagna Region existing tools: online internal platform, weekly newsletter and social networks containing all the information on the progresses of each use case, including also a forum and a chat where the stakeholders can communicate between each other, a matchmaking platform adapted to the TSL approach (https://www.b2match.com/e/transformer-project/components/34158), and an external communication agency will support the stakeholders' communication. The communication plan will also include a document reporting the ways and forms of cooperation between the stakeholders involved in the permanent working group.

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Stakeholders' roles and responsibilities

The TSL will be coordinated by a **TSL Management Team**, a team responsible for overseeing and coordinating the whole TSL process. This team will account for the transition requirements and opportunities across the entire region, along with the unique aspects of the specific pilot use cases. It is not mandatory for this team to include the same stakeholders involved in the pilot use cases. The pilot use cases will have a governance structure tailored to each specific project, which can differ greatly from the overall TSL governance, depending on the project's complexity and scale. However, each pilot use case will have at least one designated organization or individual (the pilot use coordinator/manager) responsible for coordinating with the TSL management team.

The TSL management team will consist of two different groups/roles:

- **TSL Coordinator**
- **TSL Daily working group**

Emilia-Romagna Region Public Authority will be at the head of the TSL Coordinator group and perform the following tasks:

- control of TSL actions (milestones & tasks), and resources;
- TSL stakeholders' engagement and management;
- TSL decision making (partially depending on pilot use case decisions).

The **TSL Coordinator group** will be composed by a representative of each Directorate of Emilia-Romagna Region Authority (Territorial and environmental care, Sustainable Mobility, Transport and Logistics, Tourism, Productive activities).

Moreover, the TSL management team will consider the transition needs and potentials of the whole region, analysed in TRANSFORMER Deliverable 2.3 "Regional SWOT analyses as feasibility studies to be used as evidence base in decision-making for Action Plan development", supported by the **Reflexive monitoring board** who monitors whether actions are in line with regional transition goals, oversees TSL processes, and provides guidance to the TSL management team on transition-related matters, as well as on coordination and management issues. In Emilia-Romagna Region this role will be played by "Presidio Organizzativo Cambiamento Climatico della Regione Emilia-Romagna" (Organizational Hub for Climate Change in the Emilia-Romagna Region), that serves as the central point for coordinating climate action, promoting best practices, and ensuring that the region's approach to climate change is comprehensive and effective, and by the University of Bologna.

The **TSL Daily working group** will be composed by Emilia-Romagna municipalities with more than 30,000 inhabitants that are also part of PAIR (Regional Integrated Plan for air quality) together with ITL Foundation and The Energy and Sustainable development Clust-ER GREENTECH, an association of public and private bodies: companies, research centres and training institutions that share skills, ideas and resources to support the innovation and sustainable growth of the sector.

The TSL Daily Working group will also involve citizens and third sector associations adopting different methodologies, such as the **participatory assembly**, promoting the collective ownership of decisions and to ensure that diverse voices and perspectives are considered in shaping policies, plans, or other outcomes

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and the **participatory budgeting**, a democratic process in which community members directly participate in deciding how a portion of a public budget of the municipal government is allocated or spent.

The TSL Coordinator Group will assign the tasks to the TSL Daily working group and identify a leader for each use case which is in charge of coordinating the daily activities, choose specialists, if needed, and report to the Coordinator group in order to give a feedback on the activities and exchange ideas for the future implementation, taking corrective actions when necessary. ITL Foundation will work as an intermediator between the TSL Coordinator Group and the TSL Daily working group as it has concretely contributed to the Emilia-Romagna TSL creation and has good connections with all the actors of the regional territory working with the transport and logistics sector, thanks to the several projects implemented at local level. The idea is to transfer this knowledge also to other local entities specialized in other sectors that can contribute to speed up the transition towards climate neutrality.

Ways and forms of cooperation

The stakeholders will collaborate through cross sectorial synergies for co-creating and implementing innovative actions/incentives to achieve climate neutrality. The concrete co-creation potential will be the continuous exchange of ideas between key stakeholders' institutions, focused on policies and regulations, and actors operating in daily activities.

The ways and forms of cooperation will be defined by the TSL Management Team and described within the communication plan.

Risk Assessment and Mitigation

The **potential risks** and challenges that could arise during the Action Plan implementation are the following:

- difficulty in involving the QH stakeholders in the permanent working group;
- lack of collaboration among the different stakeholders due to the different interests and needs;
- unwillingness to share data and difficulty in finding reliable data;
- difficulty in finding funding/financing options and opportunities;
- negative reaction of citizens to measures that could have a negative impact on car traffic (e.g. rededication of roads to cyclists, speed limits, reduction of parking spaces);
- political risks related to changes in decision makers and knowledge transfer.

The above-mentioned risks will be addressed through the following **mitigation measures**:

- organization of workshops/events with all Quadruple Helix stakeholders to inform them on the specific topics and initiatives, exchange synergies and to get to know each other to understand better their own interests/needs and the importance of collaboration;
- creation of a value proposition for each stakeholder group and adoption of conflict resolution mechanisms;
- development of specific funded project proposals together with private and public stakeholders;
- constant communication with the stakeholders using the communication tools identified in the communication plan;

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- focus on the technical aspects of the strategy from the outset, minimizing the impact of political shifts.

Financing and funding options

Use case 1:

€9,000,000 funding for citizens residents in Emilia-Romagna Region for electric bikes and cargo bikes purchase (National funds: Italian Ministry);

€40,000,000 funding for municipalities to build cycle paths (National funds: Italian Ministry).

Use case 2:

€3,000,000 (part of €40,000,000 funding for municipalities above) funding for companies to promote mobility management activities (national funds).

Use case 3:

€4,000,000 Funding for EV charging points Impact assessment

Moreover, other potential financing and funding options could be Regional funds by Emilia-Region Public Authority and EU funded projects implemented by ITL and RER (e.g. Interreg Programme).

Impact assessment

To evaluate the effectiveness and success of the pilot use cases, a series of Key Performance Indicators (KPIs) have been established. These KPIs are designed to measure various aspects of the impact each pilot use case has on the region, from improvements in modal share to satisfaction levels of involved stakeholders. The KPIs provide a comprehensive framework to monitor progress and ensure the pilot use cases are meeting their intended goals.

Pilot Use Case 1

- Modal share improvement linked to bicycles from 5% (current data) to 20% at regional level (through surveys and flows monitoring) in 10 years;
- Number of municipalities involved (all the 22 municipalities with over 30,000 inhabitants);
- Number of citizens and companies involved by municipalities in the co-creation activities (at least 50 citizens and 5 municipalities);
- Level of satisfaction and perception of contribution to the decision-making process of the involved actors (4 out of 5 on a 5-Point Likert scale).

Pilot Use Case 2

- Mobility manager nomination for all companies with more than 100 employees;
- Reduce commuting travel time (to less than 40 minutes);
- Increase remote working to reduce congestion and delays of 20% in 10 years;
- 20% reduction of the use of the car in favour of the bicycle through the adoption of mobility management plans within 10 years;

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- Number of municipalities involved (all the 22 municipalities with over 30,000 inhabitants);
- Number of citizens and companies involved by municipalities in the co-creation activities (at least 50 citizens and 5 municipalities);
- Level of satisfaction and perception of contribution to the decision-making process of the involved actors (4 out of 5 on a 5-Point Likert scale).

Pilot Use Case 3

- EV charging points regional network development;
- Increase of EV charging points in rural areas; (+1.000 charging points by 2025 compared to 2019)
- Number of municipalities involved (at least 50 citizens and 5 municipalities);
- Number of citizens and companies involved by municipalities in the co-creation activities (at least 50 citizens and 5 municipalities);
- Level of satisfaction and perception of contribution to the decision-making process of the involved actors (4 out of 5 on a 5-Point Likert scale).

Monitoring and Evaluation

Monitoring and evaluating plan's progress

The plan's progress will be monitored and evaluated through the PDCA (Plan-Do-Check-Act) methodology. The PDCA (Plan-Do-Check-Act) cycle: a four-step model for carrying out change. Just as a circle has no end, the PDCA cycle should be repeated again and again for continuous improvement.

Figure 1: PDCA

The effectiveness of the PDCA methodology will be ensured through the following steps:

1) Plan (P): set clear objectives and measurable KPIs and plan comprehensively, identifying risks and establishing clear actions.

2) Do (D): Execute the initiatives outlined in the Action Plan working with various stakeholders, allocating resources, and coordinating efforts across different departments or organizations.

3) Monitor (M): a) Monitor progress regularly against KPIs and objectives established in the planning phase through data collection, surveys, and trends analysis; b) evaluation of the effectiveness of

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the actions: determine whether the actions taken are producing the desired results and identify any areas where performance is falling short or where unexpected challenges have arisen.

4) Act (A): Take corrective actions promptly and continuously improve based on feedback from stakeholders at each phase. If performance is not meeting expectations, identify the root causes of the issues and take corrective measures. This could involve adjusting strategies, reallocating resources, or revising objectives.

This methodology was chosen for the Transition Super Lab's Action Plan because it supports a disciplined, data-driven, and flexible approach to continuous improvement, leading to more effective and sustainable outcomes. The cyclical nature of PDCA allows for adjustments and adaptations as new information and results become available. This flexibility is crucial for the Transition Super Lab, which may face evolving challenges and opportunities in its efforts to achieve its goals.

2.3 Recommendations for action

The long-term implementation and establishment of the Transition Super Lab (TSL) in Emilia-Romagna should proceed through specific steps, engaging key stakeholders from the regional ecosystem at the initial stage. To begin with, the Regional Authority should assume the role of coordinator, head of TSL Coordinator group (as explained in sub-chapter *Stakeholders' roles and responsibilities*) leading the creation of a cross-sectorial TSL to serve as a regional governance mechanism and to help drive the local ecosystem towards climate neutrality.

The TSL Coordinator Group will be composed by one representative of each Regional General Directorate that can contribute to the achievement of climate neutrality at regional level by 2050. The Organizational Hub for Climate Change in the Emilia-Romagna Region (Presidio Organizzativo per il Cambiamento Climatico della Regione Emilia-Romagna) should play a crucial role by supporting the TSL in terms of planning and funding its operation as it already coordinates the Regional Forum of Climate Change, which is a permanent space for dialogue with local administrations and productive sectors to discuss and coordinate mitigation and adaptation policies at the local level. Moreover, it informs citizens about adaptation and mitigation issues so that they can contribute to the development of increasingly resilient communities.

With this collaborative structure in place, partnerships between the stakeholders mentioned above, along with others from the quadruple helix and various sectors, including the academic sector (University of Bologna and University of Modena and Reggio Emilia) should facilitate the co-creation and development of both small- and large-scale projects, ensuring they are designed and matured for funding with climate neutrality in mind, while also considering their scalability and transferability.

As explained above, the Organizational Hub for Climate Change in the Emilia-Romagna Region and the Universities should be part of the Reflexive monitoring board, the group that ensures activities align with regional transition goals, supervises TSL operations, and offers advice to the TSL management team on transition-related topics, including coordination and management challenges.

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This governance structure is very effective for the long-term implementation and establishment of the TSL, in line with Emilia-Romagna TSL vision and objectives illustrated in chapter “The overall idea of the Emilia-Romagna TSL”. The TSL Action Plan should be an iterative and adaptable approach that will be further refined and redesigned also beyond the lifespan of the TRANSFORMER project thanks to continuous communication, experimentation, monitoring, and iterative improvements.

To support a successful transition, a series of key actions and recommendations have been identified for stakeholders in the Emilia-Romagna region and other similar regions. These recommendations are designed to promote a coherent and effective strategy for advancing climate neutrality and cross-sectoral collaboration:

1. Top-Down Vision Setting: The regional authority of Emilia-Romagna should initiate a top-down approach by establishing a clear vision for the Transition Super Lab (TSL). Once this vision is defined, the primary stakeholders should be identified and engaged to confirm or refine a shared perspective.

2. Staged Stakeholder Engagement: Engaging all stakeholders simultaneously isn't feasible; instead, you can approach them in phases based on their interest, position, and influence. This approach enables focused engagement and customized communication. It's crucial to articulate requests clearly to stakeholders and provide them with unambiguous feedback.

3. Maintain Regular Contact with Stakeholders: Establishing regular communication with stakeholders is crucial for sustaining momentum and fostering collaboration. It is important to keep in mind that not all stakeholders can offer feedback simultaneously, so it is necessary to wait for the right moment. It's also essential to stay flexible and avoid tying deliverables to a single stakeholder's input.

4. Cross-Departmental Collaboration: Greater collaboration among all regional departments is key to enabling cross-sector transitions. This united approach allows departments to support each other as they pursue the common objective of climate neutrality. It's crucial to appoint a coordinator acknowledged by all participants to oversee the process. Ideally, these collaborative activities should be formally integrated into the organization's work plan, ensuring that the outcomes are tied to official deliverables and the roles are clearly defined.

5. Iterative Development of Pilot Use Cases: Define pilot use cases by collecting feedback from all stakeholders, using a bottom-up approach. The coordinator should continuously monitor this process to ensure that it remains iterative and responsive to changing needs.

6. Engagement with Major Municipalities: Large municipalities are key stakeholders due to their direct contact with local communities and their ability to understand technical issues. They can play a central role in involving civil society through participatory budgeting and citizen assemblies, while also coordinating with other similar municipalities to accelerate the transition (such as through the 100 EU Mission cities).

7. Addressing Political Risks: Political elections represent a significant risk to the transition process. To mitigate this risk, focus on the technical aspects of the strategy from the outset, minimizing the impact of political shifts. Political risk is especially significant in sectors like transport and energy. A robust strategy should also account for potential disruptions and maintain flexibility.

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8. Increased Training and Information Dissemination: Organize more training and informative events on transition-related topics for stakeholders in the quadruple helix model (government, academia, industry, and civil society). Academic institutions can play a crucial role in these efforts.

9. Simplify Processes: The transition process should be simplified, ensuring that stakeholders understand their roles without being overwhelmed. This approach facilitates broader participation.

10. Use Benchmarking for Improvement: Benchmarking against other European regions can help identify best practices and areas for improvement, given the similarities in challenges faced across the continent.

11. Long-Term Civil Society Involvement: Involving civil society requires a long-term commitment and ongoing engagement. Consistency in outreach and activities is key to building trust and fostering meaningful participation.

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3 The Action Plan for the Lower Silesia TSL

3.1 The overall idea of the Lower Silesia TSL

Vision of the TSL and the regional transition goal

The LGOM (Legnicko-Głogowski Okręg Miedziowy) – Legnica-Głogów Copper District, also known as the Copper Valley – is a region located in Lower Silesia, Poland, with its main administrative centre in Legnica. The region's identity is closely tied to its primary natural and economic resource, copper. With a rich history of copper mining, the Copper Valley emerged as a pivotal mining centre in Europe, fostering the development of cities like Legnica, Lubin, Głogów, and Polkowice. Extensive copper mining and production in the region is managed primarily by KGHM Polska Miedź, one of the world's largest copper and silver producers. Copper mining began in the 1950s, with rapid industrial development in the mid-20th century. The area includes large mines like Lubin, Polkowice-Sieroszowice, and Rudna. Although it faces environmental challenges, the mining industry shapes the region's culture and infrastructure. Looking ahead, there is a focus on sustainable practices and economic diversification, making LGOM a crucial industrial hub in Poland.

While the Copper Valley has played a crucial role in the Polish copper industry, it is imperative to address environmental concerns associated with mining activities. The extraction and processing of copper have historically posed challenges to the region's ecosystems and air quality. To ensure the sustainable development of the Copper Valley, environmental conservation measures must be prioritized.

One of the pressing issues is the need for a substantial reduction in carbon dioxide emissions. The mining and metallurgical processes inherent to copper production contribute significantly to greenhouse gas emissions, notably carbon dioxide. Acknowledging this environmental impact, there is a growing imperative to implement measures that mitigate these emissions and promote a more sustainable industry.

Within the framework of the Copper Valley, the Industrial-Energy Basin, covering several neighbouring counties, hast to actively engage in environmentally responsible practices. Balancing economic interests with ecological considerations is crucial for the well-being of present and future generations.

Increased industrial activities in the region generate significant transportation needs for its residents. Tens of thousands of workers in the mining and industrial sectors commute to their workplaces daily, typically using private vehicles with combustion engines. Therefore, the development of transportation infrastructure and the promotion of alternative, more environmentally friendly forms of travel become extremely important for ensuring the comfort and quality of life of residents, while also contributing to reducing the negative impact of industry on the environment.

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While the Copper Valley remains a vital hub for the Polish copper industry, it is imperative to shift focus towards sustainable practices, emphasizing environmental conservation and, notably, the urgent need for a substantial reduction in carbon dioxide emissions.

In conclusion, recognizing the environmental challenges in the region, Lower Silesian TSL have embraced a mission that prioritizes the complete reduction of carbon dioxide emissions in the area. By undertaking the ambitious goal of achieving carbon neutrality, TSL aim to lead the way in demonstrating that economic prosperity and environmental stewardship can coexist harmoniously. This mission will involve continuous innovation, investment in green technologies, and collaboration with local communities and stakeholders to create a model for responsible and sustainable practices.

Main goals, objectives and targets

1. A systemic shift away from the dominant use of private cars in the region towards carbon free public transport

2. Formation of public opinion and decisions at higher levels regarding energy sources – promotion of green energy sources

Topics

Lower Silesian general topics

- Transport - Developing efficient and sustainable transportation means in the Copper Belt region is crucial for several reasons: First and foremost, it aligns with global efforts to combat climate change by reducing CO_2 emissions. Improving public transportation can significantly contribute to minimizing the use of individual vehicles, ultimately decreasing greenhouse gas emissions. Furthermore, enhancing alternative transportation methods can lead to improved air quality, public health, and overall quality of life for the region's residents.
- Energy - Transitioning from traditional fossil fuel-based energy sources to renewable and more sustainable alternatives is a crucial step toward a greener future. Photovoltaic farms, wind turbines, and hydrogen applications represent innovative and low-emission energy sources, alleviating pressure on the natural environment. Additionally, by increasing public awareness about the benefits of renewable energy sources, the project can contribute to fostering a more environmentally conscious community, influencing individuals to make more sustainable choices in their daily lives. It's worth noting that by developing new technologies in the energy sector, the region can become a leader in the field, attracting investments and creating new job opportunities.
- Public awareness - Raising public awareness plays a vital role in the success of environmental initiatives. Various methods, including education campaigns, community outreach programs, and social media, are employed to inform the public about environmental issues, conservation practices, and the significance of sustainable living. Involving the public in environmental awareness cultivates a sense of responsibility and promotes eco-friendly behaviours like recycling, reducing energy consumption, and supporting environmentally conscious policies and businesses.

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In Poland, as well as in other regions, public opinion often resists changes in specific behaviours. Hence, it is essential to inform and raise awareness among residents in a manner that resonates with them.

Lower Silesian specific topics

1. Energy sources: The energy landscape in Lower Silesia is undergoing a significant shift due to the urgent need for sustainable energy solutions. Here are the key points:

- **Solar Power and Wind Power**: These renewable energy sources are being considered to reduce dependency on fossil fuels. Despite existing legislation and restrictive regulations such as the 10H rule for wind farms, there is potential for significant development if public and policy support can be garnered.
- **Coal and Lignite**: Lower Silesia has vast lignite deposits, which have been brought back into consideration due to the energy crisis sparked by the war in Ukraine. However, coal and lignite mining face public opposition due to health and environmental concerns.
- **Nuclear Energy**: Nuclear power generation is not taking place in the Polish energy sector, but recently KGHM is exploring the deployment of small modular reactors (SMRs) to meet the region's electricity demands. However, nuclear energy remains controversial among the public.

2. Trains: The region's train network is mostly electrified, providing a low-emission transport option. The new rail link being developed in the LGOM area will connect Lubin, Polkowice, and Głogów. This initiative aims to reduce car usage by offering a convenient and reliable alternative for daily commutes, particularly for those employed in the mining and economic zones. Integrating train services with bus routes to ensure seamless travel is a key focus to maximize public transport use.

3. Buses: The project proposes expanding bus services to connect areas not served by the railway. These buses will run on electric power and, potentially, hydrogen in the future. The buses will be scheduled to align with train timetables, ensuring efficient and convenient transfers. This strategy aims to reduce transport exclusion and cut down on private car usage, thereby lowering CO2 emissions.

4. Public opinion surveys: Public opinion surveys play a crucial role in the project, particularly through methods like the Discrete Choice Experiment (DCE). These surveys are designed to capture the preferences and opinions of local residents regarding energy sources and transportation solutions. The insights gained from these surveys will guide decision-making and ensure that proposed solutions align with public expectations and needs. Engaging the public from the outset helps in creating accepted and effective policies.

5. Spatial planning: Effective spatial planning is essential to optimize the placement of transport infrastructure and energy projects. This involves identifying the best routes for bus and train services, as well as suitable locations for renewable energy installations. Spatial planning must consider current land use, environmental impact, and future growth to ensure sustainable development. Involving experts and stakeholders in this process helps in creating well-integrated and functional urban and rural landscapes.

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6. Influencing decision-makers: The project aims to influence decision-makers by providing data-driven insights and public opinions collected through surveys. By involving local authorities, businesses, and NGOs in discussions and planning, the project seeks to align regional policies with sustainable development goals. Presenting well-researched and community-supported proposals to decision-makers can lead to more informed and effective policy changes. Engaging with key stakeholders ensures that the implemented solutions have broad support and are feasible within the regional context.

Lower Silesian relevant topics across the regimes

1. Energy Regime
   a) Renewable Energy Integration: The push towards solar power and wind power is critical. Solar and wind power are seen as key components in reducing the region's reliance on fossil fuels.
   b) Transition from Fossil Fuels: The region faces significant challenges in transitioning from coal and lignite to cleaner energy sources. Despite the economic importance of these fossil fuels, their environmental and health impacts necessitate a shift. The war in Ukraine and the resulting energy crisis have revived interest in local lignite deposits, but there is strong public opposition to further exploitation.

2. Transport Regime
   a) Electrified Train Network: Lower Silesia's train network, which is largely electrified, is a cornerstone of the region's low-emission transport strategy. The new rail link connecting Lubin, Polkowice, and Głogów aims to provide a reliable alternative to private car use, supporting the daily commutes of workers in the mining and economic zones.
   b) Expanded Bus Services: The introduction of electric and potentially hydrogen-powered buses to connect areas without railway access is a major focus. These bus services will be synchronized with train schedules to ensure efficient travel, reducing the reliance on private cars and mitigating transport exclusion.
   c) Public Transport Accessibility: Enhancing the accessibility and convenience of public transport is essential. This involves not only expanding the network but also ensuring that the services meet the needs of residents, particularly those in rural or underserved areas.

3. Governance and Public Participation
   a) Public Opinion and Engagement: Conducting public opinion surveys is vital for capturing the preferences and concerns of residents regarding energy and transport policies. This approach ensures that the voices of the community are heard and considered in the decision-making process.
   b) Collaborative Decision-Making: Involving local authorities, NGOs, businesses, academics and the public in planning and decision-making processes fosters a collaborative environment. This approach helps align regional policies with the sustainable development goals and ensures broader acceptance of proposed solutions.

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c) Influencing Policy: Providing data-driven insights and public opinion feedback to policymakers aims to influence regional energy and transport policies. The goal is to ensure that decision-makers adopt strategies that are both sustainable and supported by the community.

4. Spatial Planning and Infrastructure
   a) Integrated Spatial Planning: Effective and integrated spatial planning is crucial for optimizing the location of transport and energy infrastructure. This involves careful analysis to identify the best routes and sites that minimize environmental impact and enhance functionality.
   b) Sustainable Infrastructure Development: Building infrastructure that supports sustainable energy and transport solutions is a priority. This includes developing renewable energy installations, electrified train lines, and green bus networks that together form a cohesive and low-carbon regional infrastructure.

3.2 Developing concrete actions through pilot use cases

Goals and objectives

Goals and specific objectives of the pilot use case(s).

Pilot Use Case 1: Convenient transport connections for the benefit of the environment

The case involves developing new public transport links, particularly bus-rail connections, to reduce reliance on private cars and decrease carbon emissions. The initiative aims to find optimal routes, calculate potential CO_2 emission reductions, and involve local communities in the decision-making process. The effect of this use case in the future could be a systemic change in everyday transport, influencing residents to choose more environmentally friendly options.

Goal:
Increase the efficiency and sustainability of public transportation in the Copper Valley region.

Objectives:
Including the voice of the region's residents affected by transport exclusion in the process leading to the development of a new public transport network. Delineation of optimal bus-train connections in LGOM counties.

Measures:

- Performing of transport analysis
- Surveying a representative group of about 400 respondents
- Announcing the results to decision-makers
- Dissemination of achievements to the public, stakeholders and decision-makers in order to achieve systemic change

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Pilot Use Case 2: Develop a framework for integrating public participation methods in energy-related decision-making

The case aims to integrate public participation methods in energy-related decision-making through a Discrete Choice Experiment (DCE). The focus is on understanding citizens' preferences regarding energy sources and policies. The results are expected to inform policymakers and stakeholders, potentially leading to a systemic change in energy-related decision-making processes in the region and beyond.

Goal:

- Change in attitude and acceptance of zero-emission energy sources by residents of the Copper Valley region.

Objectives:

- Conduct surveys on energy preferences among the population and gather 500 responses.
- Promote the adoption of zero-emission energy sources in the Copper Valley region.
- Apply survey results to modify the local energy mix and present results to key decision-makers through e.g. relevant events and publications by the end of the year 2024.

Measures:

- Successful campaign in local media
- Surveying an adequate number of respondents
- Successful campaign in local media
- Creating a suitable report and drawing conclusions leading to an appropriate strategy
- Announcing the results to decision-makers

Connectivity to other pilot use cases

Air pollution

Addressing air pollution in the Lower Silesia region is imperative to safeguard public health and the environment. The area's industrial activities, coupled with transportation emissions, contribute significantly to air quality degradation. Implementing measures to reduce pollution, such as promoting cleaner technologies and energy sources, greener ways of transport and enhancing emissions controls, is essential to mitigate the adverse effects on residents' well-being and environmental sustainability. Additionally, fostering public awareness and engagement in sustainable practices can play a pivotal role in ensuring cleaner air for current and future generations in Lower Silesia.

Mining areas

Supporting the positive transformation of mining areas into environmentally conscious landscapes is crucial for sustainable development. These regions often bear the scars of past industrial activities, with degraded ecosystems and polluted landscapes. However, through strategic interventions and innovative approaches, we can facilitate their transition into vibrant, eco-friendly spaces. Promoting sustainable land use practices, such as agroforestry, regenerative agriculture, and renewable energy development, can contribute to both environmental conservation and economic revitalization. By harnessing natural resources responsibly and fostering green industries, former mining regions can become hubs of innovation and sustainable growth.

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Engagement with local communities and stakeholders is paramount in this process, ensuring that their voices are heard, and their needs are addressed. Empowering communities through education, capacity-building, and participatory decision-making can foster a sense of ownership and stewardship over their natural environment.

In essence, by prioritizing environmental considerations and embracing holistic, community-driven approaches, we can catalyse the positive transformation of mining areas into sustainable, resilient landscapes that benefit both people and the planet.

Actions, sub-actions and measures as parts of the pilot use case implementation

Necessary actions to implement the Action Plan

USE CASE 1.:

Action 1.1: Design and Distribute Surveys
Sub-action 1.1.1: Develop a comprehensive survey tool to capture transport preferences, needs, and current travel patterns of residents.
Measure 1.1.1.1: Include questions on preferred modes of transport, number of transfers, distance, cost to using public transport.
Sub-action 1.1.2: Distribute surveys through online platforms
Measure 1.1.2.1: Ensure a representative sample by targeting diverse demographics and geographical areas within the region.

Action 1.2: Analyse Survey Data
Sub-action 1.2.1: Compile the collected data for analysis.
Measure 1.2.1.1: Use statistical tools to identify key trends and insights regarding transport preferences.
Sub-action 1.2.2: Create a detailed report

Action 2.1: Conduct Transport Analysis
Sub-action 2.1.1: Utilize survey data to map current transport usage and identify underserved areas.
Measure 2.1.1.1: Analyse transport patterns and gaps.
Sub-action 2.1.1: Propose specific routes and service improvements based on analysis findings.
Measure 2.1.2.1: Consider factors such as cost, environmental impact, and potential ridership.

Action 3.1: Develop and Finalize Route Network Plan
Sub-action 3.1.1: Integrate validated suggestions into a comprehensive route network plan.
Measure 3.1.1.1: Ensure the plan addresses key transport needs and maximizes accessibility and efficiency.

Action 3.2: Seek Approval from Local Authorities
Sub-action 3.2.1: Present the final route network plan to local government bodies and stakeholders for approval.

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Measure 3.2.1.1: Organize formal presentation and meeting to discuss the plan's benefits and address any concerns.

USE CASE 2.:

Action 4.1: Design and Conduct Energy Preference Surveys
Sub-action 4.1.1: Develop survey questions focused on energy sources, costs, and attitudes towards various energy options.
Measure 4.1.1.1: Include questions on nuclear, coal, lignite, wind, and solar
Sub-action 4.1.2: Distribute surveys to a representative sample of the population.

Action 4.2: Analyse Survey Results
Sub-action 4.2.1: Compile and process survey data for analysis.
Measure 4.2.1.1: Identify key trends and preferences regarding energy sources.
Sub-action 4.2.2: Prepare a comprehensive report detailing the findings.
Measure 4.2.2.1: Highlight public sentiment towards each energy option and potential areas of concern.

Action 5.1: Present Survey Results to Key Decision-Makers
Sub-action 5.1.1: Organize meetings with local government officials and other stakeholders.
Measure 5.1.1.1: Present detailed findings and discuss their implications for the region's energy policy.
Sub-action 5.1.2: Provide actionable recommendations based on survey data.
Measure 5.1.2.1: Propose adjustments to the local energy mix to align with public preferences and sustainability goals.

Action 5.2: Conduct Workshops and Information Campaign
Sub-action 5.2.1: Develop educational campaign to inform the public about proposed energy changes.
Measure 5.2.1.1: Use various channels to reach a wide audience.

Action 5.3: Implement Changes Based on Survey Results

Links between the different pilot use cases

Both will take place on the same site and will be able to work together to realise the TSL vision. By raising awareness of energy sources among the population, more environmentally conscious decisions, such as the choice of mode of transport, are simultaneously promoted.

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Project phases (timeline) and milestones

Project phases according to the time plan

Pilot Use Case 1.

- Transport analysis ready: This marks the completion of initial data gathering and analysis necessary for planning the transportation project. It involves studying various factors such as demographics, transportation needs, existing infrastructure, and potential challenges.
- Connectivity Plan ready: After the analysis phase, a comprehensive connectivity plan is developed. This plan outlines how different modes of transportation, such as buses and trains, will integrate to provide efficient and seamless service. It includes routes, schedules, stops, and infrastructure requirements.
- Events/Meetings with decision makers: Engagement with key stakeholders, including local authorities and stakeholders' representatives, is crucial for gaining support and addressing any concerns. We will use this opportunity to present the connectivity plan, gather feedback, and secure necessary approvals and partnerships before the end of our project.
- First Planned Bus Service: This milestone marks the implementation of the first bus service according to the connectivity plan. It could involve launching a new route or improving an existing one to better align with the overall transportation strategy. This will require time and decisions that may extend beyond the TRANSFORMER project, however, by providing our research and guidelines, we can influence the process of shaping connections.
- Opening of Train Route and Synchronization with Bus Service: Once the train route is ready for operation, it is officially opened to the public. This milestone also involves ensuring synchronization between the train schedule and the planned bus service to optimize intermodal connectivity and passenger convenience.

Pilot Use Case 2.

- The first phase, Research and Analysis, involves designing comprehensive survey tools to capture residents' preferences regarding various energy sources such as solar, wind, lignite, and nuclear energy. These surveys are distributed through a representative sample. Following the distribution, the collected survey data undergoes cleaning to ensure accuracy and reliability for analysis. The data is then analysed to identify trends and preferences, and a detailed report summarizing the findings and insights is prepared.
- In the second phase, Presentation of Results to Decision-Makers, stakeholder engagement meeting is organized. It will include local government officials and other key stakeholders. During these sessions, the findings from the energy preferences survey are presented, and their implications for regional energy policy are discussed. Actionable recommendations based on the survey data are developed and presented to adjust the local energy mix in alignment with public preferences and sustainability goals.
- The third phase, Media Campaign, involves developing and launching a media campaign to inform the public about the survey results and the proposed changes in the energy mix. Various channels are utilized to reach a broad audience.

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- The final phase, Implementation and Monitoring, includes working with local authorities to incorporate public preferences into the regional energy policy and beginning the implementation of changes to transition towards preferred energy sources.

Project milestones to implement the plan

Milestones for Implementing Pilot Use Case 1

Transport Analysis Ready: This milestone marks the completion of the initial data gathering and analysis necessary for planning the transportation project. It involves studying various factors such as demographics, transportation needs, existing infrastructure, and potential challenges.

Connectivity Plan Ready: Following the analysis phase, a comprehensive connectivity plan is developed. This plan outlines how different modes of transportation, such as buses and trains, will integrate to provide efficient and seamless service. It includes routes, schedules, stops, and infrastructure requirements.

Event with Decision Makers: Engagement with key stakeholders, including local authorities and stakeholders' representatives, is crucial for gaining support and addressing any concerns. This milestone involves presenting the connectivity plan, gathering feedback, and securing necessary approvals and partnerships.

Milestones for Implementing Pilot Use Case 2

Research and Analysis Completion: This milestone involves the design and distribution of comprehensive survey tools to capture residents' preferences regarding energy sources. It includes the completion of data collection, cleaning, and the preparation of a detailed report summarizing the findings and insights.

Presentation of Results to Decision-Makers: This milestone marks the organization of stakeholder engagement meeting with local government officials and other key stakeholders. The findings from the energy preferences survey are presented, and actionable recommendations are developed.

Media Campaign: This milestone involves the development and launch of a media campaign to inform the public about the survey results and proposed changes in the energy mix.

Stakeholder identification and analysis

Stakeholders from the Quadruple Helix

Stakeholder management and engagement plan

- Among stakeholders, TSL has been building a coalition focused on our case from the very beginning. Based on the needs of the region, stakeholders were selected with whom we then developed a vision and resulting use cases (see D3.1). We were able to involve stakeholders

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representing all Quadruple helix groups. TSL strive to maintain continuous engagement and address every concern that we receive.

Communication Plan

- Based on the research and analysis, Lower Silesian TSL is developing and launching a major promotional campaign in the region to communicate the objectives of our activities to a wider audience. Within the TSL, we communicate on a regular basis. In addition, our plan is to communicate with decision-makers in the region, mainly representatives of local authorities. This one will be done by contacting through our stakeholders, who will help us reach the right people.

Stakeholders' roles and responsibilities

- TSL Management Team coordinates all activities, other stakeholders support and publicise them through their channels and provide an extensive network of contacts.
- Roles will be assigned depending on the area in which each partner operates. Local government officials will promote the concept in their respective areas. Business stakeholders ensure that their actions will be aimed at achieving the project's goals. Academic and society TSL representatives will be responsible for conducting research and disseminating it within society.
- Stakeholders outside the project are placed in the role of Consultants or Informed based on RACI matrix. Project partners assume the roles of Responsible and Accountable.

Ways and forms of cooperation

- TSL's concrete co-creation potential lies in actively engaging stakeholders to contribute their expertise and insights. By integrating scientific knowledge with practitioners' experiences and inviting them to challenge and shape our defined goals and activities, we can harness a diverse range of perspectives. Additionally, gathering their ideas and addressing their doubts could lead to the implementation of methods such as rapid prototyping and ad hoc experiments. This collaborative approach will not only enhance the attractiveness of our TSL among stakeholders but also foster a sense of ownership and belongingness, ultimately leading to more effective and sustainable outcomes.

Risk Assessment and Mitigation

Risk Assessment for Use Case 1

Risk Analysis:

1. Data Collection Risks: Incomplete or inaccurate data from local government units may lead to incorrect route planning and scheduling.
Mitigation Strategy: Implement robust data verification processes, cross-referencing information from multiple sources, and engaging in active communication with local authorities to ensure data accuracy.

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2. Survey Risks: Low response rates to surveys conducted among the population could result in insufficient information about travel patterns and preferences.
Mitigation Strategy: Offer incentives for completing surveys and ensure clear communication about the purpose and benefits of participation.

3. Community Engagement Risk: Lack of awareness or interest in the new transport system could result in poor adoption and utilization.
Mitigation strategy: Implement comprehensive community engagement programs to inform residents about the benefits of the public transport system. Conduct awareness campaign through local media to address concerns and build community support.

4. Political Risks: Changes in local government or political priorities could lead to a lack of support.
Mitigation Strategy: Secure commitments from multiple stakeholders and create a coalition of support that includes all the stakeholders from quadruple helix to ensure continuity despite political changes.

5. Financial Risks: Insufficient funding for the development and promotion of new connections.
Mitigation Strategy: Seek multiple funding sources, including government grants, private investments, and public-private partnerships.

Risk Assessment for Use Case 2

Risk Analysis:

1. Limited Public Engagement: Risk of limited public participation in energy-related decision-making processes due to a lack of interest, information, or perceived complexity.
Mitigation Strategy: Develop tailored public engagement programs to cater to different demographics and interests within the community. Utilize various channels to ensure diverse and inclusive participation.

2. Communication Challenges: Anticipated challenges in effectively communicating complex energy-related information to the public, leading to misunderstandings or misconceptions.
Mitigation Strategy: Implement clear and accessible communication strategies to simplify complex energy-related information. Utilize visual aids, plain language, and interactive formats to enhance understanding and encourage informed participation.

3. Political Risks: Changes in local government policies or priorities could affect the commitment to sustainable energy initiatives.
Mitigation Strategy: Engage with multiple levels of government and secure endorsements from a wide range of stakeholders to build a resilient support network.

4. Financial Risks: Limited funding or financial resources to support the implementation of preferred energy sources.

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Mitigation Strategy: Identify and apply for various funding opportunities, including government grants, European Union funds, and private investments.

5. Behavioural Risks: Residents may resist adopting new energy sources due to scepticism or a preference for traditional energy sources.
Mitigation Strategy: Conduct educational campaign to raise awareness about the benefits of sustainable energy. Highlight successful case studies and provide clear information on cost savings, environmental impact, and long-term benefits.

Financing and funding options

External source of financing and fundings

The initiative will actively explore regional funding options available for projects promoting sustainable transport and energy transition. A dedicated team will conduct thorough research to identify potential funding sources provided by regional bodies, government programs, or environmental agencies. Grant opportunities from national and international organizations supporting eco-friendly projects will be investigated, with applications prepared and submitted as deemed appropriate. Regular updates on funding exploration progress will be communicated to stakeholders through newsletters, stakeholder meetings, and online platforms.

Potential financing and funding options from the stakeholders' organisations

While the establishment of a common fund created by TSL members is under consideration, detailed discussions and negotiations will be initiated with key stakeholders, including local authorities, businesses, and non-governmental organizations. Interested organizations will be approached to gauge their willingness to contribute financially to the common fund, emphasizing the collective benefits and positive impact on the community. A transparent and equitable contribution model will be developed, taking into account the financial capacities of each participating organization. Continuous engagement and communication with stakeholders will be maintained to ensure ongoing interest and commitment, even as the decision on the establishment of the common fund remains contingent on the collective agreement and financial commitments from stakeholders.

Impact assessment

Relevant indicators

Direct

- **Community Engagement**

Indicator: Level of participation and satisfaction of local communities in decision-making processes related to transportation (Use Case 1) and energy transition (Use Case 2). Number of community ideas and initiatives discussed/tested. Diversity of participation (demographics/community groups).

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Indirect

- **Reduction in Carbon Emissions**

Indicator: Quantification of CO_2 emission reductions resulting from decreased reliance on private cars (Use Case 1) and transition to cleaner energy sources (Use Case 2).

- **Mode Shift in Transportation**

Indicator: Percentage increase in the use of public transport, particularly bus-rail connections (Use Case 1), compared to private car usage.

- **Infrastructure Development**

Indicator: Number of new public transport links established (Use Case 1) and implementation of renewable energy projects or infrastructure improvements (Use Case 2).

- **Policy Impact**

Indicator: Adoption of policies informed by citizen preferences regarding energy sources and policies (Use Case 2), as evidenced by changes in regulations or incentives.

- **Economic Benefits**

Indicator: Cost savings for commuters due to reduced reliance on private cars (Use Case 1) and potential economic growth resulting from investment in renewable energy projects (Use Case 2).

- **Environmental Quality**

Indicator: Improvement in air quality and reduction in pollution levels resulting from decreased carbon emissions (Use Case 1) and adoption of cleaner energy sources (Use Case 2).

- **Long-Term Sustainability**

Indicator: Maintenance of the green alternative transportation system over time (Use Case 1) and sustained transition to renewable energy sources in the LGOM region (Use Case 2).

Monitoring and Evaluation

Monitoring and evaluating plan's progress

The TSL is actively engaged in monitoring and evaluating the progress of its use cases to ensure their successful implementation. Milestones for each use case have been established. These milestones serve as significant stages of progress toward the overall objectives.

Data collection methods are carefully implemented to track progress using both quantitative metrics such as numerical measurements and qualitative data such as stakeholder feedback.

Stakeholder engagement is a priority throughout the monitoring and evaluation process. The TSL actively seeks feedback from stakeholders, recognizing their vital role in assessing progress and making necessary adjustments. Open communication channels are maintained to ensure stakeholders are informed and involved in decision-making.

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Few meetings were conducted to discuss progress, identify challenges, and develop strategies for overcoming obstacles. These meetings involve key members of the project team and relevant stakeholders, providing an opportunity to review data, assess performance, and make informed decisions.

By consulting our actions and their results on an ongoing basis, we have an overall view of the feasibility of the sentences we have imposed on ourselves.

Criteria for success and a plan for adjustments

Use Case 1.: The success of the plan will be measured against predetermined benchmarks in private car usage within the specified timeframe. If the desired results are not met, a comprehensive review will be conducted to identify the challenges. Adjustments may include optimizing bus routes, revising schedules, or intensifying awareness campaigns to enhance public acceptance. Continuous feedback loops will be established, allowing for real-time adjustments. Regular reviews will identify areas for improvement and ensure adaptability to changing circumstances.

Use Case 2.: Success will be measured by increased levels of public participation, informed decision-making, and positive perceptions of the energy transition. If the plan falls short of its objectives, adjustments may involve revisiting communication strategies, enhancing outreach efforts, or modifying engagement platforms based on feedback. The plan will incorporate flexibility to adapt to changing circumstances, with a commitment to refining public participation methods and communication approaches based on ongoing evaluations.

3.3 Recommendations for action

Laying foundations for long-term implementation and establishment of the TSLs:

1. Embedding results from pilot use cases and case studies in the overall Action Plan
   - Data Integration: Collating and synthesizing data and insights gathered from pilot use cases and case studies into a centralized repository. This repository serves as a knowledge hub, containing information on successful strategies, lessons learned, best practices, and challenges encountered during implementation.
   - Analysis and Reflection: Conducting a comprehensive analysis of the findings to extract key insights and implications for the broader context of the TSL's objectives. This analysis involves identifying patterns, trends, and correlations within the data to inform strategic decision-making.
   - Identification of Transferable Practices: Identifying practices, methodologies, and approaches from pilot use cases and case studies that are transferable to other contexts or sectors within the region. These transferable practices serve as building blocks for scaling up successful interventions and informing the development of new initiatives.
   - Incorporation into Action Plan: Integrating the findings and recommendations derived from pilot use cases and case studies directly into the Action Plan. This integration ensures that the Action Plan is grounded in evidence-based practices and informed by real-world experiences, enhancing its credibility and effectiveness.

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2. Checking against the vision and the objectives of the TSL presented in the chapter “The overall idea of the Lower Silesia TSL” – Alignment

- Stakeholder Consultation: Engaging stakeholders, including local communities, businesses, government agencies, and academic institutions, in the alignment review process. Soliciting feedback and input from stakeholders ensures that diverse perspectives are considered and that proposed actions resonate with the needs and priorities of the target audience.
- Adaptation and Adjustment: Making adaptations and adjustments to the Action Plan as needed based on the results of the alignment review. If discrepancies or deviations are identified, corrective measures are taken to realign proposed actions with the vision and objectives of the TSL, ensuring that the Action Plan remains focused and effective.

3. Elaborating on recommendations for action

- Stakeholder Engagement and Collaboration: Foster ongoing engagement and collaboration among stakeholders, including local communities, businesses, and academic institutions. Creating platforms for dialogue, knowledge sharing, and joint decision-making enhances buy-in, fosters ownership, and ensures the sustainability of initiatives.
- Establishing a Management Group for the TSL: Form a dedicated management group comprising experienced professionals from relevant fields such as transportation, energy, finance, and project management. Assign clear roles and responsibilities to each member of the management group, ensuring effective coordination and decision-making. Hold regular meetings to review progress, address challenges, and make strategic decisions regarding the implementation of use cases.
- Policies: Advocate for supportive policies and regulatory frameworks at local, regional, and national levels to create an enabling environment for sustainable development initiatives. Engage with policymakers, advocate for evidence-based decision-making, and mobilize public support to influence policy changes that align with the TSL's objectives.
- Resource Mobilization and Funding: Explore diverse funding sources and financing mechanisms to sustain TSL activities over the long term. This may include securing grants, attracting private investments, and leveraging public-private partnerships to fund projects and initiatives. Prioritize resource mobilization efforts based on the strategic priorities outlined in the Action Plan.
- Scaling Up and Replication: Identify successful interventions from pilot use cases that have demonstrated scalability and replicability potential. Develop strategies for scaling up these initiatives to broader geographical areas or replicating them in similar contexts to maximize their impact and reach.
- Including an analysis of key risk factors: Conduct a comprehensive analysis of key risk factors associated with each action, considering potential challenges such as political instability, financial constraints, and stakeholder resistance. Identify mitigation strategies to address these risks and ensure successful implementation.
- Provide detailed action description: Develop detailed plans for each activity, outlining specific steps and resource requirements. Break down larger initiatives into manageable tasks to facilitate effective execution and monitoring of progress. By putting actions into detail, the team can ensure clarity, accountability, and alignment with overall objectives.

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4 The Action Plan for the Ruhr Area TSL

4.1 The overall idea of the Ruhr Area TSL

The topic of hydrogen (H2) has recently gained enormous importance not only among experts but also among decision-makers in politics and industry. This is reflected, among other things, by the publication of specific hydrogen strategies and roadmaps in the EU, Germany, and North Rhine-Westphalia with ambitious targets for hydrogen production, infrastructure and application in the various sectors. In addition, significant activities on the corporate side have already been implemented or at least announced. It can be deduced from this that hydrogen – becoming increasingly green – is indispensable for achieving climate neutrality in 2050 in all sectors of industry, transport, energy, and heat. Green hydrogen is a key building block on the road to climate neutrality. It can function as an energy carrier, but also as a storage medium for electricity, as a raw material for industrial processes or even as an emission-free fuel.

The Ruhr Area (located in the Federal State of North Rhine-Westphalia) has decades of experience in the production, distribution and use of hydrogen, especially in the (petro)chemical industry. Germany's longest industrial hydrogen pipeline (240 km) also connects chemical sites in the Ruhr with the Rhineland region. The conversion of this previously emission-laden grey hydrogen to green sources is complemented by a wide range of new production and application possibilities for hydrogen. The steel industry, mobility, generation at former power plant sites and the supply of neighbourhoods are particularly worthy of mention.

Many players – large companies and SMEs as well as research institutes and municipalities – are already active in the field of hydrogen in the above-mentioned areas. Many new players can still be additionally involved in the hydrogen value chain ("hydrogen ecosystem") and network with each other. This concerns both the side of the operators and users of hydrogen technology as well as the manufacturers of plants and systems and the suppliers of components.

The conversion of energy systems and production processes to hydrogen, therefore, requires a large number of investments and innovations along the entire value chain, from the production of hydrogen to transport, storage and application. This transformation, which has already begun, cannot be accomplished by individual players. Therefore, numerous companies (alliances) and regional initiatives have set out to bring hydrogen applications to fruition. In the Ruhr Area, in particular, a high density of exciting initiatives and networks has developed.

A special regional feature of the region is that the state government in the Federal State of North Rhine-Westphalia has been conducting a large-scale and multidimensional stakeholder dialogue called the "Ruhr Conference" since 2018. In this multi-stage and complex process, stakeholders from all parts of society were involved and the participation of individuals was also possible. In five different fields of action, 75

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project ideas of various types and sizes were developed. One of the fields of action is "Safe energy - healthy environment" and hydrogen is named as a key technology for the region.

One of the main goals of the regional authorities in the Ruhr Area is to position the region as a hydrogen model region in Germany and in Europe.

It can be assumed that the development of the hydrogen network cannot take place simultaneously and uniformly in Germany. Rather, it can be assumed that there will be different development phases. Competition between the individual regions must be avoided. It should be noted that there can and probably will be strong regional differences. A timely use of hydrogen could therefore occur particularly in areas with a strong chemical and/or steel industry – such as the Ruhr Area – as this is plausible for structural and economic reasons. The hydrogen ramp-up could be driven or "trialled" by using it in selected regions. Areas with a high level of renewable energy production should also potentially be included.

As a model region for hydrogen, the Ruhr Area offers favourable conditions and high potential, particularly in terms of its business and infrastructure as well as its geographical location and the associated integration into national and international hydrogen structures, which can only be found in a few areas in Germany to this extent.

- Relevance of local and supra-regional co-operations
- National synergy effect by linking hydrogen-producing regions with hydrogen-utilising regions
- Ruhr Area as an "agglomeration point" for hydrogen in Germany and Europe

A model region for hydrogen would focus on:

- Testing the (economic) implementation of a hydrogen economy in reality
- Increasing social acceptance of hydrogen as an energy carrier
- Interaction between the production, transport, storage and use of hydrogen
- Analysing technological, economic, ecological and social issues in the context of hydrogen
- In addition, it should focus on co-creating, testing and increasing social acceptability.

In this context, a hydrogen model region could be understood as a large-scale demonstration project for hydrogen as an energy carrier.

As an energy-intensive business location, the Ruhr Area can also serve as a model region for other regions with a similar profile. The knowledge and experience gained in the Ruhr Area as a model region for hydrogen can thus be applied to the challenges and specific problems of comparable regions in the form of tried and tested solutions. The Ruhr Area should be actively and sustainably presented as a hydrogen model region. The basis for this is provided by the fundamental requirements as a hydrogen model region that have already been discussed and presented, as well as the general performance profile of the Ruhr Area. To this end, measures must be taken to increase the visibility and perception of the Ruhr Area as a

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national and international hydrogen hotspot. Existing hydrogen activities can be presented as anchor points and pilot projects for this purpose. The Ruhr Area can also position itself as a pioneer in the development and expansion of hydrogen technologies, infrastructures and measures.

In order to develop and to establish the Ruhr Area as a hydrogen model region in Germany and in Europe, several central aspects need to be considered, also particularly in light of the development of the region as a Transition Super-Lab to accelerate the transition to climate neutrality:

- Targeted expansion and development of the hydrogen infrastructure
- Matching hydrogen supply and demand
- Establishment of a hydrogen ecosystem

a) Targeted expansion and development of the hydrogen infrastructure

The availability of hydrogen and the development of a hydrogen infrastructure can be supported and promoted through the promotion of production, transport and storage infrastructure. The development of hydrogen infrastructure and the ramp-up of hydrogen use therefore require robust and reliable funding instruments as well as risk protection for the pre-financing of network operators by the state (protection against amortisation risks). For the sustainable development and expansion of the hydrogen landscape, the existing subsidy structures must be expanded and possible barriers to access removed. At this point, it is strongly recommended that further infrastructural links and consolidation with national and international hydrogen structures, including the Netherlands, Belgium and Norway, should be sought. This requires political support and corresponding funding measures at state, federal and EU level.

- Support measures for the development of electrolyser capacities and the expansion of hydrogen infrastructures
- Support for large companies and major projects in the field of hydrogen applications and structures
- Targeted support for small and medium-sized enterprises (SMEs) and start-ups in the field of hydrogen and in supplier areas/technologies, including support for capital expenditure on longer-term assets

As only limited volumes of hydrogen are available in the Ruhr Area and in Germany in the short to medium term, both in terms of in-house production and imports, an alternative solution should be considered (for detailed description, see Deliverable 2.3).

b) Matching hydrogen supply and demand

Currently, it is not possible to derive any reliable and secure patterns for both the supply of and demand for hydrogen. This makes it extremely difficult for the actors involved to foresee a corresponding development path, and there are corresponding uncertainties. Solutions must also be sought at regional level. One approach could be regional platforms, for example in the form of "hydrogen marketplaces", which bundle the regional demand for hydrogen and either harmonise it with the available supply or document the necessary demand volume and pass on corresponding signals to the markets. To this end,

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it is recommended that active networking of the supply and demand levels be promoted at regional level. Well-networked regional players could be utilised for this purpose, for example regional municipal utilities could take on a central networking function. In addition, the use of digital instruments and platforms is recommended for the (supra-)regional exchange of information.

- Regional bundling of hydrogen demand
- Establishment of hydrogen marketplaces
- Activation and networking of regional players, including regional municipal utilities

c) Establishment of a hydrogen ecosystem

In addition to the technical and infrastructural development of the Ruhr Area as a hydrogen model region, the establishment of a corresponding ecosystem is advisable. To this end, the relevant stakeholders (regional/national/international), favourable network structures and qualified workers must be addressed in particular. Here, it is essential to highlight the role of Hydrogen Metropole Ruhr, Ruhr Area's coordination unit for hydrogen run by BMR and the Ruhr Regional Association. For the development of a Transition Super-Lab, it can function as an orchestrator who constantly communicates and activates the actors.

For the market ramp-up, large companies as potential buyers of large quantities of hydrogen are important addressees for the establishment of demand patterns, but the potential of small and medium-sized enterprises (SMEs) must also be included in medium to long-term planning and development lines in order to promote the long-term and broad-based ramp-up of hydrogen structures.

- Involvement and networking of regional, national and international stakeholders
- More active approach and involvement of SMEs and municipal units
- Staggered and context-related implementation strategies for small and large-scale projects
- Mix of instruments at political level (top-down and bottom-up)
- Promotion of synergy effects between existing regional networks
- Promotion of national and international networking
- Recruitment and training of "hydrogen experts" (including a wide range of professions)

The vision development process is a summary of numerous discussions that took place over the course of several years before the beginning of the project. These discussions were carried out within working groups as well as within involved dialogues with energy suppliers, among other parties. The resulting vision emerged from a lengthy and inclusive process of collective engagement. It can be summarised as follows: Ruhr Area aims to be one the greenest industrial regions in Europe. The principles of sustainability and resource efficiency are strengths of the Ruhr Area, and they will be the strategies against climate change. Hydrogen will be one of the key energies of the future in the economy and society. The goal is to transform the infrastructure and industry of the region in an inclusive, collaborative and innovative way so that the use of hydrogen, together with other renewable energies, significantly contributes to climate neutrality.

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Several reports on the development of the field of hydrogen in the Ruhr Area, recently commissioned by BMR, confirm that there are different scenarios or transformation paths for the hydrogen market ramp-up. These differ greatly in the various areas of application and time horizons. They range from the "champagne of the energy transition", in which hydrogen is outlined as an expensive energy carrier for special areas, to the near-term substitution of all-natural gas. The prioritisation of different areas of application, such as material use or energy use in the heat market or industry, also plays a decisive role (for a critical discussion, see Deliverable 2.3). Currently, however, the market ramp-up is taking concrete shape, as the energy-intensive steel and chemical industries need to decarbonise and move away from natural gas as quickly as possible. This pressure to act has led to the establishment of a hydrogen nucleus, which in the medium term, will also serve as the backbone of the market ramp-up in other areas of application. In terms of the availability of hydrogen, facts are being created in the region, opening up the opportunity to realise further activities in this area economically. The conditions in the Ruhr Area are very good, for example, due to the port triangle of Antwerp, Rotterdam and Duisburg as well as the connection to the GetH2 pipeline network, so that the first significant hydrogen imports will take place as early as 2024. There is now momentum to create a nucleus of the hydrogen economy for Europe and to outline transformation paths for the energy transition in various areas.

4.2 Developing concrete actions through pilot use cases

In the following, three pilot use cases from the Ruhr Area, designed in the previous phase of the project, are analysed for the purpose of Action Plan development. The analysis together with the corresponding estimations is taken from a study conducted by EE Energy Engineers GmbH. This consulting company from the Ruhr Area, specialised in the topic of hydrogen among other things, was commissioned by Business Metropole Ruhr GmbH to support Action Plan development through its expertise. The study can be made available on demand.

Goals and objectives

Pilot Use Case 1

Expansion of Water Canals into a ‘Hydrogen Canals (Network)’: This pilot use case delves into extending water canal systems into a comprehensive ‘hydrogen canal network,’ exploring the potential of hydrogen distribution and the distribution of its derivatives. The idea of the Hydrogen River is to make the existing shipping routes a second pillar of the hydrogen infrastructure alongside the pipeline infrastructure. The Hydrogen Canals pilot use case embodies a dual opportunity: rapid and efficient hydrogen supply to larger regions than feasible via pipeline expansion and the strengthening of climate-friendly hydrogen technology for inland waterways.

Pilot Use Case 2

Hydrogen System Cockpit: This pilot endeavours to construct a hydrogen system cockpit, geared towards monitoring and optimizing hydrogen systems while fostering seamless integration with other energy frameworks, thereby maximizing systemic synergies. It is a model with which the future hydrogen-based

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energy supply can be simulated and thus optimised by making generation, distribution and consumption more flexible.

Pilot Use Case 3

Hydrogen's Role in Municipal Heat Planning with hydrogen: Focused on investigating potential applications of hydrogen as an energy carrier within municipal heat planning, this case aims to further unravel its viability in local settings. The idea of the Project is to find intelligent energy solutions at the neighbourhood level in close cooperation with municipalities, public utilities and housing associations.

Actions, sub-actions and measures as parts of the pilot use case implementation

Pilot Use Case 1

Costs

Price per Hydrogen: Conduct a comprehensive analysis of the cost structure involved in producing hydrogen from ammonia. This includes factors like the cost of ammonia, electricity, equipment, labour, maintenance, and distribution. Calculating the cost per unit of hydrogen produced will be decisive in determining competitiveness against alternative hydrogen production methods. There are currently no certain cost estimations due to levels of high volatility and energy cost fluctuations.

Infrastructure Costs: Detailed assessment of the expenses associated with establishing and upgrading infrastructure, such as ammonia crackers, long-distance transport infrastructure, storage facilities, and hydrogen fuelling stations for vessels. An analysis of capital and respective associated costs like interest is essential. At present, there are not enough ships that have a corresponding dangerous goods class.

Operational Costs: Estimation of ongoing operational expenses, encompassing labour, maintenance, utilities, and logistics. Determining the ongoing costs to maintain and operate the entire value chain is crucial for projecting profitability. Furthermore, the currently high levels of interest rate on the high initial investment are influencing operating (+ financing) costs.

Technical feasibility

There are different aspects on the technical side which needs to be considered. The technology value chain consists of ammonia cargo ships, the transshipment hub, ammonia crackers, hydrogen-transporting cargo ships, ammonia boilers, et cetera.

Since the choice of derivatives boiled down to ammonia, other relevant technical parts can be inspected. Ammonia cargo ships are already widely used and known. Thus, it does not inflict a relevant implication on the technical feasibility (however, the availability of ships is strongly limited). The technologies which are not yet available on a large scale on the market are ammonia crackers and ammonia boilers. But there are some projects testing and further developing them.

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Infrastructure

In the context of the Hydrogen canals project, infrastructure plays a pivotal role in enabling the seamless transportation and distribution of hydrogen and its derivatives along the waterways. The project necessitates the development of robust infrastructure, encompassing storage facilities, loading docks, pipelines, and transportation vessels tailored to the unique requirements of ammonia and hydrogen logistics. Key considerations include the retrofitting of existing port facilities to accommodate the handling and storage of hydrogen, as well as the establishment of dedicated hubs along the canal network to facilitate efficient distribution. Moreover, the design and construction of specialized ships capable of transporting hydrogen and ammonia safely and efficiently are relevant to the success of the project. Collaboration between public and private stakeholders is essential to ensure the timely development and implementation of the requisite infrastructure, laying the foundation for a sustainable hydrogen economy centred around the canal network.

Regulation

Regulation plays a critical role in shaping the operational framework and ensuring the safety, reliability, and compliance of the Hydrogen canals project. Given the novel nature of hydrogen transportation and distribution via inland waterways, regulatory frameworks must be adapted to address the unique challenges and considerations associated with this mode of transport. This encompasses a range of regulatory aspects, especially safety standards, environmental regulations, permits, and licensing requirements governing the handling, storage, and transportation of hydrogen and ammonia (the regulatory framework for ammonia is ahead of the one needed for hydrogen as it is already a very common resource in the chemical industry especially for fertilizer production). Additionally, regulatory oversight is necessary to safeguard against potential hazards, mitigate risks, and ensure the protection of public health and the environment. Close collaboration between regulatory authorities, industry stakeholders, and relevant experts is essential to develop comprehensive regulatory frameworks that foster innovation, ensure operational integrity, and promote the responsible deployment of hydrogen infrastructure along the canal network.

Plot Use Case 2

Costs

Infrastructure Costs: The deployment of a hydrogen system cockpit involves initial infrastructure investments for the necessary technological setup, including sensors, data integration systems, and modelling tools. These costs need to be carefully estimated and balanced against the long-term benefits.

Operational Costs: Continuous operation and maintenance costs, including software updates, data management, and personnel training, should be factored in. Regular updates and adaptations are crucial for the system's efficiency and relevance.

Price per User: Determining the cost structure for users accessing the hydrogen system cockpit is essential. This could be a subscription-based model, and the pricing strategy should consider affordability for various stakeholders, including smaller businesses and municipalities.

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Technical feasibility

Integration of Existing Infrastructures: Successfully integrating existing gas, electricity, and heat pipelines with planned hydrogen infrastructures requires advanced technological expertise. Collaboration with experienced partners (especially, H2 suppliers, distributors, consumers (in terms of companies), and technology providers) is crucial for technical success.

Data Synchronization: Ensuring accurate data synchronization involves deploying advanced modelling tools and data management systems. The Gas and Heat Institute Essen's technological capabilities play a pivotal role in achieving this synchronization. The more pressing factor is the availability of data provided by energy companies and synchronization of that data on a timely basis to be able to draw conclusions.

Infrastructure

Aspects concerning the infrastructure of this project involve designing, simulating, and managing a comprehensive network of hydrogen production, storage, distribution, and utilization facilities, as well as integrating various hardware and software components to enable seamless data collection, processing, and analysis. Key considerations include selecting appropriate technologies and equipment for measuring. By leveraging advanced sensing, monitoring, and control systems, the project can enhance situational awareness, fault detection, and system resilience, thereby minimizing downtime, disruptions, and risks. Furthermore, by fostering collaboration with industry partners, research institutions, and government agencies, the project can drive innovation, knowledge sharing, and best practices in infrastructure development and management, accelerating the transition to a hydrogen-based economy.

Regulation

Adherence to Evolving Regulations: Staying abreast of evolving regulations in the energy sector is crucial. The project's technological systems should be adaptable to comply with changing regulatory frameworks to avoid legal challenges.

Cybersecurity Measures: Implementing robust cybersecurity measures is non-negotiable due to the sensitive nature of the data involved. Ensuring data integrity, confidentiality, and protection against cyber threats is a fundamental technical requirement.

Expansion to Other Regions: Assessing the technical feasibility of expanding the hydrogen system cockpit to other regions involves understanding the scalability of the technology, adaptability to diverse infrastructures, and potential modifications needed for different contexts.

Data

Data regarding hydrogen demand and supply plays a pivotal role in the success of the hydrogen system cockpit project, serving as the foundation for informed decision-making, performance optimization, and continuous improvement. However, ensuring data security, integrity, and privacy are paramount considerations to safeguard sensitive information, prevent unauthorized access, and mitigate cybersecurity risks. Implementing robust encryption, authentication, and access control mechanisms can help protect data confidentiality and integrity, while regular audits and vulnerability assessments can identify and address potential vulnerabilities and threats. Moreover, maintaining data quality and consistency is essential to ensuring the accuracy, reliability, and relevance of insights derived from data

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analysis and modelling. By adhering to standardized data formats, protocols, and validation procedures, the project can enhance data interoperability, comparability, and usability across different stakeholders and systems. While resistance to sharing data may arise due to concerns about confidentiality, competition, or regulatory compliance, fostering a culture of transparency, collaboration, and trust can foster positive outcomes by facilitating knowledge sharing, innovation, and collective problem-solving. Ultimately, by leveraging accurate and actionable data, the project can drive operational efficiency, cost-effectiveness, and sustainability across the hydrogen value chain, unlocking new opportunities for growth and impact.

Pilot Use Case 3

Costs

Infrastructure Costs: The adaptation of existing natural gas infrastructure and the installation of hydrogen-compatible technology involves significant initial costs. However, opportunities are minimizing expenses by utilizing pre-existing gas pipeline routes and fostering collaboration with utility providers.

Operational Costs: Operating and maintaining the hydrogen infrastructure, along with cargo transportation, requires substantial resources. Nevertheless, opportunities arise in optimizing operations through efficient logistics and automation, thereby reducing manpower costs.

Price per User: Potential limitations exist in the adoption of hydrogen-based heating if the pricing is perceived as higher. Strategic opportunities involve implementing customized pricing models and positioning hydrogen as an important, sustainable energy carrier to address user concerns.

Cost Comparison to Alternatives: Emphasizing the long-term benefits of hydrogen and exploring government incentives can enhance competitiveness.

Technical feasibility

From a technical perspective, the feasibility of municipal heat planning hinges on the development and integration of reliable and efficient hydrogen-based heating technologies. This involves selecting appropriate equipment, such as hydrogen boilers or fuel cell heating systems, and ensuring compatibility with existing heat distribution networks.

One of the key technical aspects is the seamless integration of hydrogen heating with existing infrastructure. This involves adapting or replacing current heating systems, ensuring compatibility with residential structures, and modifying distribution networks. The challenge lies in minimizing disruptions during the transition while maximizing efficiency.

Ensuring that appliances, especially boilers, can efficiently and safely operate using hydrogen is crucial. This involves technological upgrades or replacements to accommodate hydrogen combustion characteristics. It also necessitates extensive testing and certification processes to meet safety standards and regulations.

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The technical feasibility is closely tied to a reliable source of hydrogen. The project needs to explore various production methods, including local electrolysis or importing hydrogen, and establish a robust supply chain. The efficiency of these processes, considering energy losses and environmental impact, is a critical technical consideration.

Efficient storage of hydrogen is a technical challenge. This involves exploring different storage options, such as advanced materials for on-site storage, to ensure a consistent and reliable supply. The choice of storage solution will impact the overall effectiveness and feasibility of the hydrogen heating system.

Modifying or creating distribution networks for hydrogen poses technical challenges. The existing natural gas infrastructure might need adjustments, or entirely new pipelines for hydrogen may be required. The technical aspects involve materials compatibility, pressure requirements, and safety measures to avoid leaks or accidents.

Technical feasibility also encompasses hydrogen production methods, storage solutions, and safety measures to mitigate potential risks associated with hydrogen handling and combustion. By leveraging advancements in hydrogen technology and adopting best practices in system design and operation, municipalities can overcome technical challenges and achieve robust and resilient heating solutions.

Infrastructure

Infrastructure plays a pivotal role in enabling municipal heat planning with hydrogen by providing the necessary physical framework for hydrogen production, distribution, and utilization. This includes establishing hydrogen sourcing resources, such as hydrogen production facilities like electrolysers, to generate green hydrogen from renewable energy sources. Infrastructure also encompasses storage facilities, such as tanks or underground caverns, to store surplus hydrogen and ensure supply reliability. Additionally, distribution networks, including pipelines or tanker trucks, are essential for transporting hydrogen to end-users, such as residential buildings or industrial facilities. By investing in robust and interconnected infrastructure, municipalities can unlock the full potential of hydrogen-based heating and achieve sustainable heat supply for their communities.

Implementing robust monitoring and control systems is essential for the technical success of the project. This includes real-time monitoring of hydrogen production, distribution, and consumption. The system should also have adaptive controls to optimize efficiency and respond to varying demand patterns.

Regulation

Navigating and complying with existing regulations and safety standards is a technical necessity. The project must ensure that the hydrogen heating systems adhere to all relevant laws and regulations, covering aspects like appliance safety, storage, and distribution of hydrogen, and emissions standards.

In conclusion, considering the diversity of residential structures, the project's technical feasibility could benefit from hybrid heating systems. Combining hydrogen with other renewable energy sources or traditional heating methods provides flexibility. The technical challenge is to design systems that seamlessly switch between sources based on demand and availability.

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Project phases (timeline) and milestones

Pilot Use Case 1

In the conception phase, the project's foundation is laid. This involves identifying the appropriate project and project lead(s), assembling a project team with diverse expertise, and ensuring alignment with policy and authorities. Additionally, the project concept is developed, and a pre-feasibility study is conducted to assess its viability. The estimated duration for this stage is one year.

During the planning stage, proper preparation is undertaken. This phase will be the longest and can take between 3-4 years. A detailed feasibility study is conducted to evaluate technical, financial, and environmental aspects, while additional stakeholders are integrated to garner support and input. Funding is sought from various sources, pre-engineering of initial projects is conducted, and necessary permits are obtained from authorities. Planning is finalized, and technical equipment is procured to prepare for the construction phase. The optimum process is outlined here if all steps are implemented smoothly. Of course, this process can also take longer (e.g., due to legal appeals from stakeholders).

Construction marks the physical realization of the project. Executing the construction phase involves implementing the approved plans and specifications, while ensuring compliance with regulatory requirements and securing necessary approvals from authorities at various stages. The duration is approximately two years.

Finally, during the commissioning phase, the project undergoes testing and acceptance. Operational testing is conducted to verify functionality, followed by acceptance tests to ensure compliance with requirements and specifications.

Upon successful completion of these tests, regular operation of the project commences, marking the culmination of the project's journey from conception to realization. This stage can be completed after approximately one year.

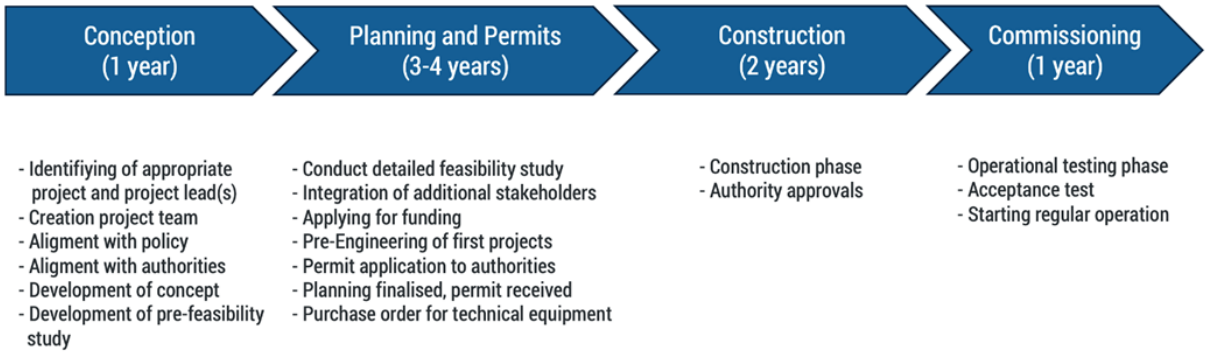

Figure 2: Project phases of the Pilot Use Case 1

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Pilot Use Case 2

The project commenced with the finalization of its concept and the identification of initial project partners, while concurrently pursuing funding from the state government of North Rhine-Westphalia. This can take up to six months. In Phase 1, the project focused on establishing the hydrogen (H2) grid and planning for its expansion, including integration with the methane (CH4) grid and accommodating inputs and outputs from the chemical sector. This phase takes about one year. While phases 2 and 3 each take about two years. Phase 2 saw the introduction of additional modelling elements, such as reallocations within the CH4 grid and planning for entries and exits from industrial sectors, alongside the gradual incorporation of public transport and other transportation modes. Finally, Phase 3 involved further detailing of the modelling aspects, refining network infrastructure, identifying specific entry and exit points, and planning storage facilities to ensure efficient operation of the hydrogen grid.

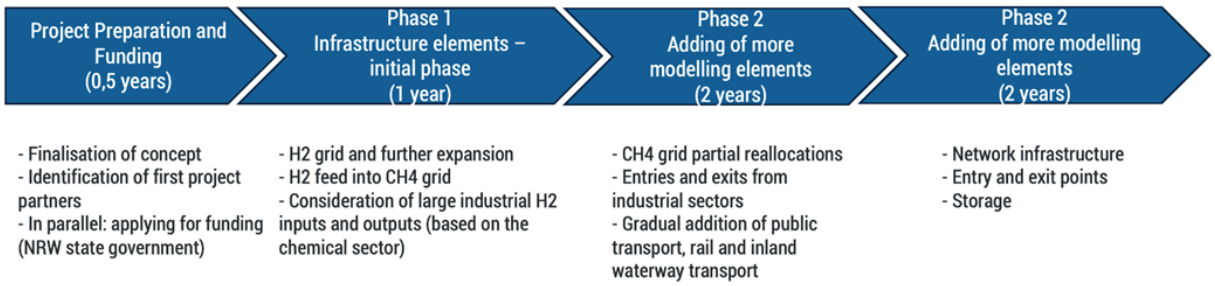

Figure 3: Project phases of the Pilot Use Case 2

Pilot Use Case 3

The project begins with the conception phase, which involves identifying the appropriate project and project leads, creating a project team, developing the project concept, conducting a pre-feasibility study, and establishing contact with local authorities. This can take up to six months.

In the planning and permits phase, a detailed feasibility study is conducted to assess project feasibility, additional stakeholders are integrated to gather support, pre-engineering work is undertaken, and permit applications are submitted to authorities. Once planning is finalized, purchase orders for technical equipment are issued. The estimated duration of this phase is two and a half years. During the construction phase, the project progresses with physical construction work, while obtaining necessary approvals from authorities. The third phase is expected to be completed after six months.

Finally, in the commissioning phase, operational testing is conducted to ensure functionality, followed by acceptance tests to verify compliance with requirements. Upon successful completion of these tests, regular operation of the project commences. This stage can be completed after approximately half a year.

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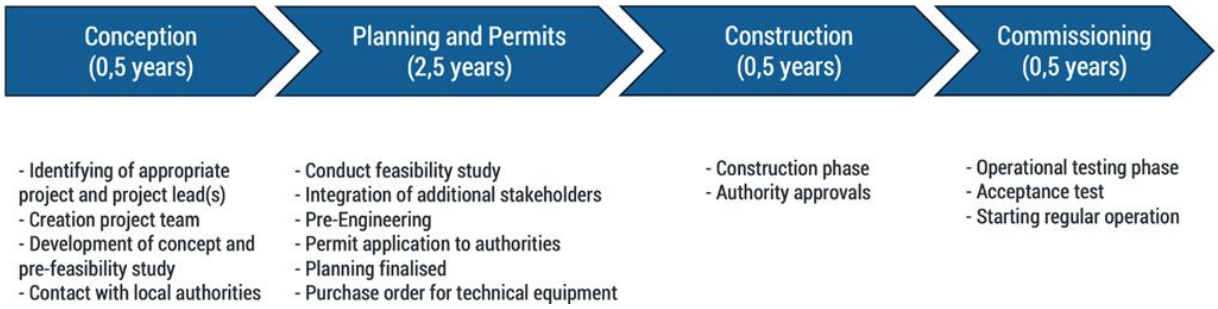

Figure 4: Project phases of the Pilot Use Case 3

Stakeholder identification and analysis

Identification and analysis of stakeholders is a continuous task. This coalition-building for a Transition Super-Lab is a dynamic process that never ends as long as a TSL exists. Here, it is essential to highlight the role of Hydrogen Metropole Ruhr, Ruhr Area's coordination unit for hydrogen run by BMR and the Ruhr Regional Association. For the development of a Transition Super-Lab, it can function as an orchestrator who constantly communicates and activates the actors.

Pilot Use Case 1

For a project as complex and multifaceted as the Hydrogen Canals initiative, various stakeholders across different sectors can play crucial roles in its successful implementation. Some of the relevant potential partners include:

- Energy Companies and Utilities: Established energy companies with expertise in power generation, distribution, and infrastructure development are vital partners. They can contribute resources, technical know-how, and infrastructure support required for hydrogen production, storage, and distribution. Moreover, they might be interested in decarbonizing their heating business operations. Companies might be Iqony, Evonik, RWE, E.ON and Uniper.
- Port Authorities and Logistics Providers: Port authorities and logistics firms are essential partners for facilitating the import, storage, and transportation of ammonium, hydrogen, and derivative products. They can contribute expertise in port operations, vessel handling, and supply chain logistics. Relevant companies might be Duisport and Rhine Waterways and Shipping Authority or the Rhein-Lippe-Hafen Wesel. However, smaller ports are also important for the distribution or construction of decentralised systems, like Gelsenkirchen (Klimahafen), Dortmund or Hamm.
- Government Agencies and Regulatory Bodies: Collaboration with governmental bodies at local, regional, and national levels is essential for regulatory compliance, securing permits, navigating legal frameworks, and accessing potential funding or policy support. For example, Federal Ministry of Transportation, the Ministry of Economic Affairs of NRW, or the relevant regional governments which are responsible for permits (Bezirksregierungen).
- Industrial and Commercial Consumers: Partnerships with industries relying on hydrogen or its derivatives, such as the steel, cement, chemical, or shipping industries, are crucial. They serve as potential consumers and users of the hydrogen produced, driving demand and contributing to project sustainability. If they are in areas which are not soon to be connected by a pipeline, they may become strong driving efforts for this project. Like chemical industry (Evonik, DGW, Arsol

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etc.), metal processing industry (ZinQ, CD Wälzholz) or other industries like cement, glass/ceramic, food.

- Environmental and Community Organizations: Engaging environmental groups, community organizations, and advocacy groups is vital for ensuring social acceptance, addressing environmental concerns, and fostering a positive relationship with local communities affected by the project. For example, Nabu, BUND or Scientist for Future.

Engaging these potential partners in collaborative efforts aligned with their expertise, interests, and contributions will be crucial for creating a robust ecosystem necessary for the successful implementation and long-term sustainability of the Hydrogen Canals project.

Agreements

- Project Partners: Identifying and engaging key stakeholders across industries, governments, and local communities. Building alliances and agreements to ensure support, resource sharing, and aligned objectives throughout the project lifecycle.
- Key Players: Recognizing entities critical for successful implementation, including regulatory bodies, port authorities, energy companies, technology providers, and research institutions. Establishing collaboration and support from these stakeholders is pivotal for overcoming challenges.
- Necessary Stakeholders: Engaging with a broad range of stakeholders, including local communities, environmental groups, academia, and relevant interest groups. Gaining their support, addressing concerns, and ensuring inclusivity in project planning and execution is vital for social acceptance.
- Stakeholder commitment: Aligning diverse stakeholders' interests and securing commitments is challenging.

Pilot Use Case 2

Organizational Structure: Clearly defining the organizational structure is crucial. Identifying the entity responsible for operating and maintaining the hydrogen system cockpit, as well as its relationship with stakeholders, is vital for long-term sustainability. The Gas and Heat Institute Essen (GWI), as the first operator of this platform, can be an interim solution at the beginning. Continuation through a co-operative model.

Consumer and Owner Identification: Understanding who the primary consumers and owners of the system will be is essential. This involves clarifying whether municipalities, energy companies, or a consortium of stakeholders take on the ownership role. As already mentioned, a co-operative model is proposed here. Companies that are partners supply data and can also retrieve it.

Project Partners: Identifying key project partners, including H2 suppliers, distributors, consumers, and technology providers, is essential. Building strong collaborations ensures data accuracy, reliability, and the overall success of the system. Potential partners could be MAN, Iqony, Westnetz and Thyssengas.

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Necessary Agreements: Establishing clear agreements, contracts, and protocols for data sharing, system integration, and collaboration among stakeholders is vital for the project's smooth operation. In order to put this system into practice, a first collaboration with one or few municipalities are to be expected. Possible partners here could be the regional municipal utilities, Westnetz, Open Grid Europe or Thyssengas.

Desirable Regions/Areas: Identifying regions or areas with high hydrogen demand and supportive (already existing) infrastructure is essential. Possible areas could be Essen and Herne.

Agreements

In the context of the hydrogen system cockpit project, establishing agreements among key stakeholders is crucial to ensuring the successful development, deployment, and operation of the system. These agreements may encompass various aspects, including project governance, data sharing protocols, intellectual property rights, and liability frameworks. By engaging with a diverse range of stakeholders, including utility companies, industry partners, research institutions, and municipal authorities, the project can facilitate collaborative processes, build consensus, and mitigate potential conflicts of interest. Moreover, by formalizing agreements through legal contracts, memoranda of understanding, or consortium agreements, the project can provide clarity, transparency, and accountability, ensuring that all parties are aligned with common objectives and responsibilities. Furthermore, by fostering a culture of trust, reciprocity, and mutual respect, the project can cultivate long-term partnerships and alliances, enabling sustained cooperation and collective action to address complex challenges and seize emerging opportunities in the hydrogen sector.

Pilot Use Case 3

In the context of municipal heat planning with hydrogen, the business model revolves around establishing a sustainable framework that ensures the effective deployment of hydrogen-based heating solutions while optimizing economic feasibility. This entails identifying key stakeholders, including municipalities, energy providers, and private investors, and defining their roles and responsibilities within the project. The business model should also incorporate revenue streams, such as heat sales and energy services, to cover infrastructure costs and ensure long-term financial sustainability. As aforementioned, key application possibilities for hydrogen-based heat planning are residential areas with relatively low efficiency heating which are adjacent to business parks with companies interested in using hydrogen for their processes (e.g. high-temperature heating). Possible partners here include housing associations (Vonovia). However, industrial and commercial areas also offer great potential. Further potential can be identified through the H2-Raum initiative as a partner. In addition, the regional municipal utilities, Westnetz and OGE. The company Wilo can serve as a model and share its experience.

Agreements

Identifying suitable partners and balancing stakeholder interests can be complex. Formalizing agreements and incentivizing collaboration create opportunities to align diverse stakeholder interests.

Identifying areas with high hydrogen demand and community acceptance is a complex task. Opportunities arise through extensive market research, collaboration with local authorities (as operator of new and innovative business parks) and housing associations, and alignment with regional energy goals.

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Risk Assessment and Mitigation

Pilot Use Case 1

Strengths:

1. Proven Waterway Network: Leveraging the existing Rhine-Herne Canal and adjacent waterways provides a robust and well-established network for inland shipping, offering reliability and accessibility for transporting hydrogen.
2. Modularity and Non-Pipeline Infrastructure: The Hydrogen Canals concept, by utilizing waterways, offers a modular approach and is not dependent on extensive pipeline infrastructure. This modularity allows flexibility in reaching areas without pipeline connections.
3. Decarbonization of Inland Shipping: The project aligns with broader sustainability goals by contributing to the decarbonization of inland shipping, addressing environmental concerns associated with traditional shipping methods.
4. Hydrogen as a Transportable Energy Carrier: The use of ammonia as a hydrogen carrier allows for efficient transportation and storage, enabling the distribution of hydrogen to areas without direct pipeline access. It could substitute the traditional transport of coal und with that secure energy security and economic development. Integration of the non-operational ports alongside the Ruhr canals.
5. Industrial Collaboration: Collaboration with energy companies operating coal-fired power plants along the canals presents an opportunity for partnerships, leveraging existing infrastructure and knowledge.

Weaknesses:

1. Initial Investment: The establishment of the Hydrogen Canals infrastructure, including ammonia crackers and related facilities, requires significant upfront investment, potentially posing financial challenges.
2. Transport capacity: At the present time, there are not enough ships with a corresponding hazard classification.
3. Technology Maturity: While ammonia as a hydrogen carrier shows promise, the technology is still evolving, and there might be uncertainties regarding the efficiency and scalability of ammonia crackers.
4. Dependency on Ammonia Imports: The project's reliance on ammonia imports, especially from regions like North Africa and the Middle East, may expose it to geopolitical and supply chain risks. The availability of other import regions such as North and South America, the Far East Asia and Australia should be examined.
5. Limited Hydrogen Use Cases: The project's success relies on the identification and development of diverse hydrogen use cases, and the absence of such applications may limit its overall impact.

Opportunities:

1. Economic Transformation: The Hydrogen Canals Project has the potential to stimulate economic growth and job creation, particularly in regions associated with the development and operation of the project.
2. High Efficiency: Operating and other costs have the potential to decrease due to economies of scale and advancements in productivity and production.
3. Utilisation of disused areas: 60-70 sites of former colliery harbours lie fallow and could be reactivated. The advantage is that they still have the legal use of a harbour.

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4. Ammonia Industry Growth: The project could stimulate the growth of the ammonia industry, creating opportunities for related businesses and fostering innovation in ammonia-related technologies.
5. Hydrogen Infrastructure Expansion: Success in the Hydrogen Canals Project could pave the way for the expansion of hydrogen infrastructure in other regions, contributing to a broader hydrogen economy. On the other hand, this project offers the opportunity to expand relatively short-term compared to the big pipeline projects. There are industrial companies that want to start hydrogen business at short term and cannot wait for hydrogen pipelines. Therefore, the faster availability of an industrial scale of Hydrogen for local companies in energy intensive areas is a big advantage of this approach.
6. Collaboration: Opportunities exist in fostering collaborations among various stakeholders, exploring innovative revenue streams, and aligning business models with sustainable practices for long-term feasibility.
7. Policy Support: Favourable government policies supporting renewable energy and hydrogen initiatives could provide regulatory backing and financial incentives for the project's development.

Threats:
1. Financing: Due to perceived risks and uncertainty, securing initial investments may be challenging. Competing Technologies: Advancements in alternative hydrogen transportation technologies, such as pipelines or advanced storage methods, may pose competition to the Hydrogen Canals Project.
2. Geopolitical Instability: Political and geopolitical uncertainties in regions supplying ammonia could disrupt the import chain, affecting the reliability of the project
3. Public Perception and Acceptance: Public resistance or concerns about the safety and environmental impact of ammonia and hydrogen transport might impede the social acceptance of the project.
4. Regulatory Challenges: Evolving and potentially stringent regulations related to ammonia and hydrogen transport and storage could pose compliance challenges. E.g. the usage of Ammonia as ship fuel is not regulated by now.

In summary, the strengths of this project are significant due to the existing infrastructure of canals in the Ruhr Area, the associated power plant locations, and the desired energy transition. The opportunities arising from the implementation of this project are also positive, given the economic factor (maintenance and creation of jobs) and the political will to utilize renewable energies. While the weaknesses and dangers of this project should not be overlooked, they are largely manageable, as some factors already apply to fossil fuels today. However, there are other transportation options competing with this project, as well as unclear framework conditions.

Pilot Use Case 2

Strengths:
1. Technological Expertise: The project leverages the technical proficiency of the Gas and Heat Institute Essen (GWI), ensuring a robust foundation for the hydrogen system cockpit.
2. Collaborative Network: The involvement of diverse stakeholders, including H2 suppliers, distributors, consumers, project developers, and authorities, establishes a collaborative network, fostering comprehensive data exchange.

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3. Transformation Potential for the Ruhr Metropolis: The Ruhr Area is the perfect starting point: existing energy infrastructure power, heat and hydrogen, high energy demand of several industries on a well-defined area in Central Europe. The transformation potential to other European regions is enormous.
4. Flexible Integration and modular structure: The hydrogen system cockpit demonstrates flexibility by integrating data on H2 quantities from various sources, including suppliers, distributors, and consumers, providing a holistic view of the hydrogen landscape. Also the timeline of the project is accounting for variable levels of the dynamic energy system to be displayed and modelled.

Weaknesses:
1. Dependency on Stakeholder Participation: The success of the system cockpit relies heavily on the active participation of H2 suppliers, distributors, and consumers. Insufficient collaboration may compromise data accuracy and system optimization. Currently, the project is lacking the willingness of possible partners to provide (edited) data which can be fused into the system cockpit and/or support financially.
2. Technological Risks: As the project involves the integration of existing infrastructures with planned hydrogen infrastructures, technical challenges and uncertainties may arise, potentially delaying the project timeline.
3. Current lack of public funding: Public funding is the key to starting concrete activities, which can be supported by an own contribution from industrial and commercial partners. Future funding from the NRW state government is not unlikely.

Opportunities:
1. Market Expansion: The hydrogen system cockpit can be expanded to other regions beyond the Ruhr Area, offering an opportunity to create a scalable model for nationwide or even international applications.
2. Public Engagement: Involving residents in the project can lead to increased public awareness and acceptance of hydrogen technologies. Public support is crucial for the successful implementation of large-scale energy projects.

Threats:
1. Regulatory Challenges: Evolving regulations and policies in the energy sector may pose challenges, requiring the project to adapt swiftly to comply with changing frameworks.
2. Security Concerns: As the project involves sensitive data related to hydrogen quantities and distribution, ensuring robust cybersecurity measures is crucial to prevent data breaches and potential misuse.

In conclusion, the hydrogen system cockpit project demonstrates significant strengths in its technological foundation. However, potential weaknesses and threats need careful mitigation strategies, and the project holds promising opportunities for market expansion, public engagement and all aforementioned benefits. Regular monitoring and adaptation to the evolving landscape will be critical for sustained success.

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Pilot Use Case 3

Strengths:

1. There is a synergy effect if there is a commercial area with hydrogen production or utilisation in the vicinity of residential areas. Either the waste heat can be fed into the local heating network, or the hydrogen can be used in the hot springs in the neighbourhood.
2. Technological Advancements: Integration of advanced technologies, such as condensing boilers, fuel cells and CHP plants capable of utilizing hydrogen, showcases a strong technological foundation.
3. Real-world Testing: Involvement or exchange in significant pilot projects like H2HoWi and H2Linnich, along with participation in the SmartQuart project, provides practical testing grounds and opportunities for innovation.
4. Collaborative Approach: The inclusive collaboration with housing societies, municipalities, business development agencies, residents, tenant associations, business park operators and utilities fosters a holistic and community-driven perspective.
5. Regional Energy Production: Decentralised hydrogen production could be a door opener to first green business parks and create economic advantages

Weaknesses:

1. Economic Feasibility: The economic feasibility of transitioning entire neighbourhoods consisting of commercial areas and adjacent residential buildings to hydrogen-based heating solutions would be very challenging, especially considering initial infrastructure investments.
2. Adaptability of Existing Infrastructure: The adaptability of local natural gas infrastructure to incorporate hydrogen poses potential challenges and requires careful cooperation with the infrastructure providers.

Opportunities:

1. Market Expansion: Successful implementation of the project could open new markets for hydrogen-based heating solutions, contributing to the broader transition to sustainable energy systems. Furthermore, it can support decarbonisation of the heating sector if close to industrial areas.
2. Policy Support: Evolving political discussions and support for sustainable heating solutions present an opportunity for favourable policies and incentives.

Threats:

1. Competing Technologies: The emergence of alternative technologies in the heating market may pose a threat to the adoption of hydrogen-based solutions.
2. Public Perception: Overcoming potential scepticism or resistance from the public regarding the use of hydrogen for heating is crucial for project success.

In conclusion, regarding the ‘municipal heat planning’ project, it can be said that there are already pilot projects underway, building knowledge and experiences that can be leveraged. Utilizing commercial areas as anchors and providing heating to surrounding buildings is a significant advantage. However, competition with other technologies or sectors poses a risk to this project, as does the willingness of citizens to transition their systems. Therefore, transparency and political frameworks must be established.

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For all pilot use cases presented here, must be stated that regarding the very initial state of idea development it is hardly possible to develop any strategies to mitigate these risks already now. The current state of risk assessment relies on a basic SWOT analysis outlined above and a deeper analysis implying processing of a whole variety of technical and economic data would be needed to identify more concrete risks and corresponding risk mitigation strategies.

Financing and funding options

Pilot Use Case 1

Existing Funding Sources: Identifying available grants, subsidies, venture capital, private funding, or public-private partnership opportunities for sustainable energy projects. Exploring sources of financing to cover high initial capital expenditures and ongoing operational costs.

Required Government Schemes: Advocating for specific funding schemes, tax incentives, or policy reforms tailored to support large-scale hydrogen infrastructure projects. Lobbying for supportive regulatory frameworks and financial incentives to attract private sector investment. Dedicated funding for large-scale hydrogen projects (i.e. funding of CAPEX and OPEX of hydrogen production; EU Hydrogen Bank, IPCEI, Carbon Contracts for Difference) is limited.

Pilot Use Case 2

Exploring existing and potential government initiatives, grants, and funding programs for energy transition projects is crucial. Aligning with these initiatives can significantly support the project's economic feasibility. Furthermore, attracting investment from energy companies, technology providers, and other stakeholders such as municipalities can further support to finance the cockpit. A funding support could be granted by the NRW state within the programs progres.nrw-Innovation or progres.nrw-Klimaschutztechnik.

Pilot Use Case 3

There are several possibly applicable programs that should be further investigated. Such programs are the following: Guideline for federal funding for efficient heating networks (BEW) from the Bafa, Municipal guideline, Federal subsidy for efficient buildings (BEG), Climate protection campaign for companies Module C – Energy supply (loan), Federal subsidy for energy and resource efficiency in the economy: Module 2 Process heat from renewable energies (grant). More funding on national level is available from the Ministry of Economic Affairs (e.g. Reallabore) or on the States level (e.g. progress.nrw-Klimaschutztechnik in North-Rhine Westphalia).

Although, dependence on government initiatives may expose the project to political changes. However, developing a strong business case aligned with government goals and engaging in proactive dialogues presents opportunities for sustainable funding.

For the Pilot Use Cases 1 and 3, there is no ownership yet, and, therefore, it is too yearly to reflect on potential financing and funding options from the stakeholder’s organisations. Self-financing is partially

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possible on a small scale in case of System Cockpit, but that would not be so much part of a Pilot Use Case development strategy.

Impact assessment

Pilot Use Case 1

Climate effects

Climate Protection

In the context of the Hydrogen canals project, climate protection emerges as a central theme, with the overarching goal of reducing greenhouse gas emissions and advancing towards a more sustainable energy landscape. By facilitating the transportation and distribution of hydrogen and its derivatives via inland waterways, the project aims to contribute to the decarbonization of key industrial sectors, such as manufacturing and transportation by opening up new areas at an early stage, thereby mitigating the adverse impacts of traditional fossil fuel-based systems on the climate. Hydrogen, particularly when produced from renewable sources through processes like electrolysis, offers a promising avenue for achieving carbon neutrality by serving as a clean energy carrier with zero emissions at the point of use. Furthermore, the utilization of ammonia as a hydrogen carrier presents additional opportunities for emissions reduction, as ammonia can be produced using renewable energy sources and serve as a versatile fuel for power generation, heating, transportation and of course by cracking up to produce hydrogen. Through strategic infrastructure development and strategic partnerships, the Hydrogen canals project seeks to accelerate the transition to a low-carbon economy, driving innovation, fostering sustainable growth, and safeguarding the planet for future generations.

Environmental implications

The handling with ammonia entails various environmental implications that warrant careful consideration and proactive mitigation measures to ensure the preservation and enhancement of ecological integrity along the canal network. As the project involves the transportation and distribution of hydrogen and ammonia, potential environmental risks associated with spills, leaks, or accidental releases must be effectively managed through stringent safety protocols, monitoring systems, and emergency response mechanisms. Additionally, the construction and operation of infrastructure, such as storage facilities, loading docks, and transportation vessels, may entail habitat disruption (if newly built), alteration of water quality, and disturbance to local ecosystems, necessitating environmental impact assessments and adherence to regulatory guidelines to minimize adverse effects. Furthermore, the project's success hinges on the sustainable sourcing and production of hydrogen and ammonia, with a focus on renewable energy sources and environmentally responsible practices to mitigate the carbon footprint and ecological footprint associated with fuel production and supply chains. By integrating environmental considerations into all phases of planning, implementation, and operation, the Hydrogen canals project can strive to achieve a harmonious balance between economic development and environmental stewardship, paving the way for a greener, more sustainable future.

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Local values

Local Value Creation

The Hydrogen canals project has the potential to foster significant local value creation by generating employment opportunities, stimulating economic growth, and enhancing regional competitiveness. Through the development of infrastructure along inland waterways for the transportation and distribution of hydrogen and ammonia, the project can catalyse investment in port facilities, logistics hubs, and related industries, thereby creating jobs in construction, engineering, manufacturing, and logistics sectors. Additionally, the establishment of hydrogen production facilities (e.g. ammonia crackers) and associated supply chains can spur innovation and position the region as a hub for clean energy technology development.

Social Impact

By facilitating the adoption of clean energy technologies and reducing emissions from industrial processes and transportation, the project can contribute to improved air quality, public health, and overall well-being for residents in surrounding communities. Moreover, the creation of job opportunities and investment in workforce development initiatives can empower local residents, particularly those in underserved or marginalized communities, by providing pathways to meaningful employment, skills training, and career advancement. Additionally, by engaging with stakeholders through inclusive planning processes, community outreach initiatives, and participatory decision-making forums, the project can foster a sense of ownership, pride, and solidarity among residents, strengthening social cohesion and building trust between public and private sector actors.

Public Awareness and Engagement

Effective public awareness and engagement strategies can positively impact the success of the Hydrogen canals project, ensuring transparency, accountability, and public support throughout all stages of planning, implementation, and operation. By leveraging various communication channels, including public meetings, workshops, social media, and educational campaigns, the project can disseminate accurate information, raise awareness about the benefits and risks associated with hydrogen and ammonia transportation, and solicit feedback from diverse stakeholders, including residents, businesses, advocacy groups, and government agencies. Moreover, by fostering partnerships with local universities, and community organizations, the project can promote STEM education, environmental literacy, and civic engagement, empowering citizens to become active participants in shaping the future of their communities. By incorporating public input into decision-making processes and addressing concerns in a timely and transparent manner, the project has the opportunity to build trust, credibility, and social license to operate, laying the foundation for long-term success and sustainability.

Scalability

The scalability of the Hydrogen canals project represents a determinant of its long-term feasibility and impact. By demonstrating the technical feasibility, economic feasibility, and environmental sustainability of hydrogen and ammonia transportation via inland waterways, the project can serve as a replicable model for other regions facing similar challenges and opportunities. Moreover, by fostering collaboration

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and knowledge sharing among stakeholders, exchanging best practices, and identifying common standards and regulations, the project can accelerate the diffusion of innovation and the scaling of clean energy infrastructure and technologies across different geographic contexts.

Pilot Use Case 2

Climate effects

Climate Protection

The hydrogen system cockpit project holds significant potential to contribute to climate protection by facilitating the transition to cleaner and more sustainable energy systems. By promoting the use of green hydrogen derived from renewable sources such as wind, solar, and hydroelectric power, the project can help reduce greenhouse gas emissions and mitigate climate change impacts. Through advanced monitoring, modelling, and optimization capabilities, the system cockpit enables stakeholders to assess the environmental footprint of hydrogen production, distribution, and utilization, identifying opportunities to minimize carbon emissions and enhance energy efficiency.

Environmental implications

While the hydrogen system cockpit project offers promising benefits for climate protection and energy transition, the underlying hydrogen system poses environmental implications that must be carefully considered and managed. The production of hydrogen, particularly from fossil fuels or through processes with high carbon intensity, may generate emissions of pollutants and greenhouse gases, contributing to air and water pollution, and exacerbating environmental degradation. Additionally, the construction and operation of hydrogen infrastructure, such as electrolysis plants, pipelines, and storage facilities, could entail land use changes, habitat disruption, and ecosystem impacts, necessitating comprehensive environmental assessments and mitigation measures.

Local values

Local value creation

The hydrogen system cockpit project has the potential to generate value through partnerships with local businesses, research institutions, and government agencies, the project can stimulate investment in renewable energy infrastructure, manufacturing, and technology development, driving growth and prosperity in the region. Moreover, by leveraging local resources, expertise, and supply chains, the project can enhance resilience, self-sufficiency, and competitiveness, fostering a vibrant and sustainable socio-economic ecosystem.

Social impact

The hydrogen system cockpit project holds the potential to generate positive social impacts. By prioritizing stakeholder involvement, consultation, and collaboration, the project can ensure that diverse voices, needs, and perspectives are taken into account in decision-making processes, enhancing social acceptance and legitimacy. Moreover, by supporting access to clean and affordable energy services, such as hydrogen-based transportation and heating, the project can improve quality of life, public health, and well-being.

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Public awareness / engagement

Effective public (and municipal) awareness and engagement are essential pillars of the hydrogen system cockpit project, enabling stakeholders to understand, support, and participate in the energy transition towards hydrogen-based solutions. By disseminating accurate, accessible, and compelling information about the project's objectives, benefits, and challenges, the project can raise awareness and build trust and confidence in hydrogen technologies and initiatives.

Scalability

Scalability is a critical consideration for the hydrogen system cockpit project, as it seeks to model and simulate effective practices. By designing flexible, modular, and interoperable solutions, the project can adapt to different contexts, needs, and conditions, facilitating replication and scaling across diverse regions and sectors. By fostering collaboration, partnerships, and networks at local, regional, and international levels, the project can leverage collective expertise, resources, and efforts to achieve greater impact and sustainability outcomes, advancing the transition to a hydrogen-powered future.

Pilot Use Case 3

Climate effects

Climate Protection

The municipal heat planning project promotes advanced climate protection efforts by the adoption of renewable and low-carbon heating solutions. By integrating sustainable energy sources such as hydrogen into municipal heating systems, the project can reduce reliance on fossil fuels and mitigate greenhouse gas emissions, contributing to local and global climate goals. Through strategic planning, policy support, and technology deployment, the project can facilitate the transition to climate-resilient and carbon-neutral heating infrastructure, aligning with international commitments such as the Paris Agreement. By fostering collaboration between local governments, utilities, business parks, and communities, the project can drive innovation and knowledge exchange, accelerating the adoption of climate-smart heating solutions and fostering a culture of environmental stewardship and sustainability.

Environmental implications

While the municipal heat planning project offers promising benefits for climate protection, it also entails environmental implications that must be carefully addressed and managed. Hydrogen infrastructure, including storage facilities and distribution networks, may have environmental impacts related to land use, resource consumption, and potential hazards associated with hydrogen handling and transportation. By integrating environmental considerations into planning, the project can minimize negative impacts and promote sustainable and regenerative practices in municipal heat supply.

Local values

Local value creation

The municipal heat planning project has the potential to generate value for local communities and economies by fostering innovation, job creation, and economic development opportunities. By investing in renewable energy infrastructure, energy efficiency retrofits, and district heating networks, the project

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can stimulate local demand for clean energy technologies and services, driving growth in related industries and supply chains. Through partnerships with local businesses, contractors, and workforce development agencies, the project can create employment opportunities and skill-building programs, empowering residents to participate in the green economy. Moreover, by leveraging local resources, expertise, and community assets, the project can enhance resilience, self-sufficiency, and prosperity, fostering a vibrant and sustainable socio-economic ecosystem.

Social impact

The municipal heat planning project holds the potential to generate positive social impacts by improving access to affordable, reliable, and clean heating services for residents and communities. By upgrading heating infrastructure and implementing energy efficiency measures, the project can reduce energy costs, alleviate energy poverty, and enhance indoor comfort.

Public awareness / engagement

Effective public awareness and engagement are essential components of the municipal heat planning project, enabling stakeholders to understand, support, and participate in the transition to sustainable heating solutions. By communicating the benefits, challenges, and opportunities of renewable heating technologies through targeted outreach campaigns, educational materials, and community events, the project can raise awareness and build public support for climate-smart heating initiatives. Moreover, by providing opportunities for hands-on experiences, demonstrations, and pilot projects, the project can empower citizens to become active agents of change, inspiring broader adoption of sustainable heating practices and behaviours.

Scalability

Scalability is a key consideration for the municipal heat planning project, as it seeks to develop and implement effective models and strategies that can be replicated and scaled across different regions but similar contexts. By documenting best practices, lessons learned, and success stories, the project can create a knowledge base and resource repository to support replication and scaling efforts.

Monitoring and Evaluation

Realistically spoken, the Action Plan development is still at such an abstract level that it is difficult to talk about monitoring and evaluation already now. It is just too early to discuss concrete measures to monitor and evaluate the progress of the Action Plan. The pilot use cases presented above require a long-term perspective, probably going beyond the common approach to an action plan that is widely known from many funded projects. The possible governance structure for the Ruhr Area TSL with a TSL Management Team described in the following chapter could be important not only for implementation but also for monitoring and evaluation issues. It could develop and apply a systematic approach to this task.

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4.3 Recommendations for action

The Ruhr Area is one of the biggest metropolitan regions in the European Union. Nevertheless, despite its size, it is not a region in the sense of an administrative unit, and it is not categorised as a NUTS region.

The administrative management of the region is extremely complex. The cities and districts in the Ruhr Area are part of three of the five governmental districts in the Federal State of North Rhine-Westphalia (Düsseldorf, Arnsberg and Münster). At the same time, the state has devolved regional planning to the Ruhr Regional Association. This structure makes administrative processes more difficult because it regularly requires a high level of coordination between the actors involved. Additionally, the cities and districts of the Ruhr Area have always claimed strong autonomy for themselves, in which elements of intermunicipal rivalry have been clearly evident.

The Ruhr Area's regional identity is mainly rooted in its historical and cultural context. In the past, several projects helped to strengthen the identity between the cities and districts as part of one region and to support structural change in the region. In this respect, the International Building Exhibition Emscher Park was a programme for structural change in the Ruhr Area from 1989 to 1999 in order to show new concepts for social, cultural and ecologic renewal. In particular, formats like the ecological restoration of the Emscher river system, the preservation of the industrial heritage as a regional cultural asset and the creation of public parks helped the region to cope with structural change and to strengthen its identity as one region for the inhabitants.

Therefore, there is no political power (at least directly) for the Ruhr Area as a region, and lack of financial autonomy makes it difficult to develop large-scale projects. Against this background, there is no mandate for setting up an agency for the region's green transformation, such as Transition Super-Lab. In addition, the financial room for manoeuvre is not only limited because of the dependency on the Federal State's financial policy but also due to the fact that many of the region's municipalities are suffering from high debts that they have accumulated during the tough decades of structural transformation.

The main official organisation that represents the Ruhr Area is the Ruhr Regional Association (in German: Regionalverband Ruhr, its abbreviation is RVR). It was founded 1920 as the Ruhr Coal District Settlement Association (in German: Siedlungsverband Ruhr). The following description summarises the essence of RVR: "The focus of the statutory duties of the RVR is the well-being of the Ruhr Area: the Association acts as a networker, coordinator, initiator, service provider and project promoter for the Ruhr Area in all relevant regional fields of activity. The tasks and activities of the Association are governed by the RVR Act. The RVR is responsible for regional planning in the Ruhr Area and is the owner of major infrastructure projects."[13]

[13] Regionalverband Ruhr (RVR) 2024: https://www.rvr.ruhr/en/en/daten-fakten/rvr

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Altogether, while the region has explicitly formulated its claim to become the greenest industrial region in the world, the framework conditions are specific and not necessarily very favourable. However, this does not mean that developing a TSL for the Ruhr Area would be an impossible task, but the political, administrative and financial context need to be taken into account before starting any idea development for long-term implementation of such a regional living lab.

Of course, in basic terms this context was clear before TRANSFORMER, but it was through an intensive exchange with other TSL regions that the need for different approaches for development of Transition Super-Labs would become evident. Learning in certain aspects is always possible among regions and it should not be underestimated. For example, regions (and regional authorities as well as other stakeholders) can always learn from each other how to approach different stakeholder groups or to apply (new) co-creation methods. But as soon as the political dimension and administrative context of creating and establishing a TSL is concerned, learning opportunities through exchange with others become scarcer. This aspect highlights one of the most important differences between a common living lab and a Transition Super-Lab. While the former are largely driven by science and civil society, the latter are much more dependent on the part of the quadruple helix which is the state if they are supposed to achieve impact on regional scale.

For the Ruhr Area, there is no role model to follow. The region needs to develop its own approach to a Transition Super-Lab. Some important constraints for this task have been already presented above. To complete and balance the picture, it is also important to mention the key competences of the region, especially regarding the role of the Ruhr Regional Association (RVR) and one of its subsidies Business Metropole Ruhr (BMR), a TRANSFORMER project partner. While RVR is responsible for regional planning in the Ruhr Area, both RVR and BMR have a lot of experience in governance issues as well as project development and implementation. These competencies could be extremely important for developing a regional TSL.

A TSL is a collaborative governance approach and therefore it is a regional asset if achieving results through governance mechanisms rather than common top-down structures is one of the region's key features. This pronounced culture of dialogue, negotiation, convincing, coordination and networking represents an excellent opportunity for the region to develop a TSL in its true sense.

At the same time, with the experience of decades of designing and implementing projects, the region knows how to develop concrete initiatives to shape structural transformation. This also applies explicitly to projects that demonstrated the region's capacity for experimentation and innovation and helped make the Ruhr Area a region of green technologies. More than just a project but an entire programme, the International Building Exhibition Emscher Park, which had a notable impact on the region, has been already mentioned.

A more recent initiative, although not implemented at such a large scale yet, is the InnovationCity Ruhr, the first project in the world to comprehensively renovate an industrially characterised urban district in

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terms of energy efficiency. The aim of the overall project is to promote climate-friendly urban redevelopment while at the same time safeguarding Bottrop, one of Ruhr Area's municipalities, as an industrial location. Specifically, CO_2 emissions are to be reduced by 50% and the quality of life improved. InnovationCity Ruhr was designed as a model for the regeneration of the entire Ruhr Area, as well as other industrial metropolises around the world.

This initiative basically indicates that there is potential for developing a TSL for the Ruhr Area. There is openness to experimentation and innovation, mutual learning and replication, there is organisation and project management capacity, cross-sectoral collaboration is functioning. Last but not least, accelerating the shift to climate neutrality is definitely a high priority topic. At the same time, the initiative shows that there is high dependency on external funding (e.g., Federal State and EU). The region needs to enhance its capacity in acquiring external funding. This is a difficult task per se, and it becomes even more challenging when the region is de facto disadvantaged because of already existing strict financial limits. For example, often municipalities do not apply for funding due to lack of financial resources that would be necessary to manage the excess when funding is not 100% and they need to contribute a certain percentage.

Based on the numerous discussions in the course of Action Plan development, but also previous debates dedicated to the idea of a TSL pilot for the Ruhr Area, some recommendations for action can be summarised.

First, the region needs to establish a unit with a clear responsibility for developing and coordinating a Transition Super-Lab. Such a demanding work cannot be done just as one of many tasks by the same group of people but requires a staff explicitly in charge of such an initiative. Ideally, it represents not only a mix of different organisations but also a collaboration across the quadruple helix or at least parts of it. In TRANSFORMER, we refer to it as the **TSL Management Team**. For example, there could be a basic team consisting of several employees and extended through funded projects according to specific needs. In the Ruhr Area, there are already several examples of such teams, units or hubs dedicated to different topics. It is important not to create redundancies but to address the need for developing a collaborative governance arrangement allowing for the region's faster green transition. The team would focus on prioritisation of co-creation processes and mechanisms for new solutions and put an emphasis on involvement of civil society organisations and citizens in these processes. The type of team described here does not exist yet in the Ruhr Area.

Second, such a unit or team needs to be both supported and monitored by an advisory board, which should be influential, but not exclusive. In TRANSFORMER, we call it the **Reflexive Monitoring Board**. Here, representation of all parts of the quadruple helix should be a condition. The Ruhr Area has a long tradition of cross-sectoral collaboration and social networks throughout different parts of the society. Furthermore, rooted in the region's long trajectory of structural transformation from heavy industries to a knowledge-based and service economy, awareness of the significance of ecological sustainability seems to be relatively high among the region's elites. Hence, convincing influential players to join the Reflexive

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Monitoring Board should not be a big challenge per se. More challenging would be the balancing of power. Concretely, the principles of a Transition Super-Lab as an inclusive, open, co-creative and unconventional collaborative arrangement must be applied and defended in practice, beyond the theoretical discourse. Here, the TSL Management Team requires strong leadership, people able to conduct tough negotiations with powerful representatives of the Reflexive Monitoring Board.

Third, experimentation for impact should be established as one of the core principles of the TSL. As mentioned above, the Ruhr Area has often demonstrated its openness to experimentation. Nevertheless, in times of budgetary restrictions and increasing pressure for pragmatic solutions, experimentation might not be always an obvious option. The right to experiment, of course, not for the sake of experimentation but with the purpose of accelerating the shift to climate neutrality should be undisputed.

Fourth, a TSL for the Ruhr Area should be guided by the principles of the innovation paradigm of the 21st century where social innovations are as important for achieving the goal of climate neutrality as technological innovations. In the Ruhr Area, there is a very strong focus on development and introduction of new technologies as well as infrastructural issues. For example, it can be clearly observed in the whole debate around introduction, distribution and application of (green) hydrogen in the region. There is a danger of easily overlooking the potential of social innovations, both in terms of new social practices and innovations with an explicit social value creation. It is difficult to imagine how the shift to climate neutrality could be accelerated without changes in social practices and without initiatives which put an explicit focus on social impact.

Fifth, a TSL for the Ruhr Area should consider the approach of developing several subregional units in parallel. The Ruhr Area is not just a large region in terms of its geographical extension and especially population but also a very diverse and polycentric region. For example, the so-called Hellweg Axis with the region's bigger municipalities, such as Dortmund, Bochum, Essen and Duisburg has experienced a profound structural transformation towards a knowledge-based economy and is characterised by a high density of research institutions. The north and the south of the region are more industrial. A more targeted approach by a regional TSL with subregional orientation could help achieve more impact. However, this approach would be more complex and more expensive. It would be more feasible to establish a regional TSL first and in case of its success analyse how a more subregional focus could be put in practice.

While it is not possible yet to make any concrete or even binding declarations regarding the institutional support for the Transition Super-Lab in the Ruhr Area, it is still important to mention institutions or organisations that could play a key role in the development and long-term implementation of the TSL.

Business Metropole Ruhr, the region's economic development agency, has made the Ruhr Area familiar with the TSL idea through its participation in the TRANSFORMER project. As the regional economic development agency of the Ruhr Area, BMR is closely connected to the economic development agencies of the cities and districts, working together on topics such as the marketing of commercial estates, the

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development of international projects or the support for start-ups and other innovation activities. Consequently, an effective governance structure for the Ruhr Area has emerged over years, enabling the coordination of joint initiatives. These reliable and non-hierarchical links between regional stakeholders are crucial for successful collaborations.

On the one hand, BMR is more than just a conventional economic development agency. For example, it has established Greentech.Ruhr, the region's network for green economy with a variety of members from the different parts of the society. BMR's commitment to the challenge of the Ruhr Area's green transition definitely goes beyond mere business topics, and participation in TRANSFORMER confirms this perspective. On the other hand, BMR still has a well-defined mission to support the region's municipalities in their economic development efforts, and therefore, BMR, on its own would not be able to cover the variety of aspects and topics that a TSL is expected to cover.

Nevertheless, BMR could play an important role in the regional coalition that would manage the TSL. Another core player in such a coalition could be the Ruhr Regional Association (RVR), which is also strongly dedicated to the region's green transition. With BMR as RVR's subsidy responsible for economic development and RVR covering a wide range of topics, there would be a solid ground for a TSL supported from the public sector with strong ties to a very diverse landscape of the region's municipalities. In fact, with Hydrogen Metropole Ruhr (HyMR), there is already a very good example of institutionalised collaboration between BMR and RVR aiming to support the process of the region's green transition.

HyMR was founded at the end of 2021 by resolution of the Ruhr Regional Association's assembly and is intended to make the region's diverse hydrogen activities visible and provide coordinating support in realising the market ramp-up of the hydrogen economy. With this project office, the RVR and BMR are supporting the Ruhr Area in becoming a leading transfer region and an anchor point for the development of a nationwide hydrogen economy, thereby making a significant contribution to climate protection. Through the cooperation between BMR and RVR, it is intended to utilise synergy effects and harmonise economic interests with the implementation of climate protection goals.

The primary aim of HyMR is to provide the best possible framework conditions for the market ramp-up of the hydrogen economy. This requires the targeted development and marketing of existing potential and strategic communication from a single source. This should trigger impulses for optimising the infrastructure as well as private sector investment.

Concrete tasks of Hydrogen Metrople Ruhr as the region's hydrogen coordination unit already include or could include in the future:

- Support for the region's Hydrogen Roadmap Ruhr.
- Development of the network/mapping of stakeholders and activities.
- Development of joint approaches for innovations – project and product-based – in the individual areas of the value chain in the hydrogen ecosystem.

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- Offering consulting services for project development and funding measures: Identification of funding sources, preparation of funding applications and business plans.
- Establishment of overarching collaborations across the entire value chain in the hydrogen ecosystem; initial linking of H2 production and application.
- Preparation of an "H2 enabler" as an intermediary between all players – producers and consumers, infrastructure operators, manufacturers and suppliers, as well as research and development – in the hydrogen ecosystem based on the activities already launched (including HyExperts) with a special focus on SMEs and start-ups in the Ruhr Area.

Of course, Hydrogen Metropole Ruhr is not a Transition Super-Lab, and its experience cannot be directly applied to establish a regional living lab, but there are definitely several important aspects, which demonstrate that this type of coalition can be considered as a potential foundation for a collaborative governance arrangement to accelerate the shift to climate neutrality.

To create a Transition Super-Lab for the Ruhr Area, such a coalition should include more partners responsible for its establishment and long-term development. Particularly, the Initiativkreis Ruhr and the UA Ruhr should be mentioned here.

The Initiativkreis Ruhr is an association in which more than 70 business enterprises and institutions have joined forces. The association aims to promote economic development and structural change in the Ruhr Area and supports projects in the fields of business, education and culture. The companies represented in the Initiativkreis come from sectors such as energy, chemicals, services, trade, logistics and management consultancy. The activities are managed by the subsidiary Initiativkreis Ruhr GmbH.

The Initiativkreis Ruhr is an unincorporated association based in Essen. The purpose of the Initiativkreis is to promote corporate social responsibility in practice. Only an executive representative of the respective company or organisation can become a member of the association as a Personal Member. The General Assembly decides on the admission of new members. The bodies of the Association are the General Assembly and the Moderators. The bodies of the Association and their members work on an honorary basis. The General Assembly elects a Moderator and a Co-Moderator from the ranks of the Personal Members for a two-year term, who, as members of the Association's Executive Board, manage the Business Alliance on an honorary basis for two years. All operational activities are carried out by Initiativkreis Ruhr GmbH and its subsidiaries and associated companies. Initiativkreis Ruhr GmbH is a limited company based in Essen, all of whose shares are held by the Initiativkreis Ruhr association.

InnovationCity Ruhr, mentioned above, can be classified as one of the outstanding projects initiated by the Initiativkreis Ruhr. Another particularly innovative and promising project is Urban Future Ruhr, currently developed in the City of Duisburg. It is a flagship project of the Initiativkreis Ruhr. With the aim of improving the quality of life of local people, the Initiativkreis Ruhr wants to work with the City of Duisburg to tackle the challenges of the neighbourhood and simultaneously focus on the fields of action ‘Education & Social Affairs’, ‘Housing & Public Space’ and ‘Mobility’. Duisburg-Hochfeld is to become a

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blueprint for the region over the next ten years with scientific support and the involvement of existing stakeholders. The project is also to be developed step by step into a platform for partner companies and other sponsors to join in. This example indicates that Initiativkreis Ruhr has the potential to significantly contribute to a regional Transition Super-Lab.

The University Alliance Ruhr (UA Ruhr) was founded in 2007 as the University Alliance Metropolis Ruhr (UAMR). It is a strategic alliance of the University of Duisburg-Essen, the Ruhr University Bochum and the Technical University of Dortmund. The first joint metropolitan research competence centre was established in 2017. The three universities in the alliance cooperate wherever it makes sense to do so in order to become more efficient by pooling their expertise and strengths. By expanding compatible profile areas at the individual partner universities as well as through diverse cross-university cooperation in the areas of research, teaching and administration, the UA Ruhr is constantly being further developed with the aim of establishing the Ruhr Area as an excellent location in the national and international science and study landscape.

Furthermore, the UA Ruhr jointly promotes knowledge transfer, innovation and business start-ups, thereby contributing to structural change in the Ruhr Area. The University Alliance stands for the transformation of the Ruhr Area from an industrial region to a knowledge region. By promoting science-based start-ups, networking between research and industry and providing further training for skilled workers, we are strengthening the Ruhr Area for the challenges and transformation processes of the 21st century. Through these competences, the UA Ruhr could also make an important contribution to a Transition Super-Lab in the Ruhr Area.

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5 The Action Plan for the Western Macedonia TSL

5.1 The overall idea of the Western Macedonia TSL

Vision of the TSL and the regional transition goal

To create a common understanding of the vision of the Western Macedonia TSL, a brief overview the de-lignitisation process in the region as well as its effects on different sectors such as economy and employment is provided in the following sub-chapters.

The complete de-lignitisation as the case of Greece

Greece ratified the Kyoto Protocol in 2002 and the Paris Agreement in 2016. The National Energy and Climate Plan (NECP), the main tool for national policy-making over the next 10 years, was ratified in 12nd/2019 by decision of Government Council[14] and reflects the increased climate ambition & the national target set at the UN Climate Conference of 9th/2019: complete de-lignitisation of Greece by 2028 with a drastic reduction and complete removal of lignite from the electricity mix (including heat), on the basis of an organised plan for the withdrawal of lignite-fired power plants, decarbonising the islands by 2029.

In parallel, Greece has developed the 2050 long-term strategy, with decarbonisation scenarios. In the two scenarios compatible with keeping global temperature increase below 1.5 °C, the country aims to achieve a 95% reduction in its net emissions compared to 1990. Many lignite-fired plants have already been withdrawn. In 2011, the production of Public Power Corporation's plants was 27.4 TWh and in 2019 10.42 TWh, reduction of 62%. In 2020, lignite-fired energy production was 5.7 TWh compared to 8.1 TWh foreseen in the NECP for the same year, reduced by 30%[15].

The transition of the Region of W. Macedonia to a climate-neutral economy and its affects

The transition process towards the EU's 2030 targets in the Region of Western Macedonia (also in Megalopolis) foresees that all lignite plants will be withdrawn by 2025, with the exception of one (Ptolemaida V in Western Macedonia) which will be withdrawn by 2028, being in line with the EU and national target for the transition to a climate-neutral economy. However, this transition entails the cessation and/or limitation of activities and related industries and, due to the importance of lignite extraction and the generation of energy from its incineration for Western Macedonia, it has adverse social and economic consequences for the whole region.

[14] Government Council of Economic Policy (2019) Ratification of the National Energy and Climate Plan (NECP), Government Gazette, Series II, No 4893 [In Greek], Available at: https://www.elinyae.gr/sites/default/files/2020-02/4893b_2019.pdf

[15] Hellenic Ministry of Environment and Energy (2021). 2021 TJTP Territorial Just Transition Plan- TJTP Western Macedonia

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The region consists of four Regional Units. The main place in its production system, have the Regional Units of Kozani & Florina, where 71% of the 266.16 thousand inhabitants of Western Macedonia live, the 80% of regional GDP is generated and is found the largest share of employment (67.7% of the 87.10 thousand employees).[16] Therefore, any impact on the production system of these two Regional Units affects the overall economy of Western Macedonia.

Unemployment in the Region of Western Macedonia has already been the largest in 2017 (29.1%) among the remaining regions of Greece and NUTS2 of the Coal Regions in Transition. In fact, the unemployment rate has remained higher over time than in the country[17]. This is an indication of the structural weaknesses of the region's economy.

Over the last 10 years, the population of the region has been steadily declining (from 287,000), cumulatively close to 10%[18]. This change reflects on the existing workforce, which should be exploited in the sectorial restructuring and transition phase of the region.

According to the OECD[19], Western Macedonia has (strong) specialisation (Location Quotient=6.36[20]) in lignite mining and power generation, supplying energy for 10 years throughout the country. Specialisation in the non-mining areas is considered as weak or moderate. The region therefore has monoculture, making its economy highly dependent on lignite. De-lignitisation will directly and indirectly affect the whole region.

In addition, wages in the mining and electricity sector are still high, although they have decreased significantly in recent years. The average annual income of someone involved in mining decreased from EUR 31,149 in 2008 to EUR 18,652 in 2018. In the electricity sector, the average annual wage decreased from EUR 41,603 in 2008 to EUR 30,758 in 2018[21]. These wages are significantly higher than wages in the rest of the economy and maintain a large part of the region's consumption and jobs. As a result of the de-

[16] Hellenic Ministry of Environment and Energy (2021). 2021 TJTP Territorial Just Transition Plan- TJTP Western Macedonia

[17] World Bank, (2020). A Road Map for a Managed Transition of Coal-Dependent Regions in Western Macedonia (English). Washington, D.C.: World Bank Group. Available at: http://documents.worldbank.org/curated/en/103611593562422573/A-Road-Map-for-a-Managed-Transition-of-Coal-Dependent-Regions-in-Western-Macedonia

[18] Hellenic Ministry of Environment and Energy (2021). 2021 TJTP Territorial Just Transition Plan- TJTP Western Macedonia

[19] OECD (2020), REGIONAL POLICY FOR GREECE POST-2020 REGIONAL PROFILES, Available at: https://www.espa.gr/el/Documents/2127/Regional_profiles_gr.pdf

[20] Location Quotient is the ratio that allow an area's distribution of employment to be compared to a reference area's distribution. So, here it means that the share of employment in mining and power generation in Western Macedonia is 6.36 times higher than in the rest of Greece.

[21] Hellenic Statistical Authority. Labor Cost Surveys, Available at: https://ec.europa.eu/eurostat/cache/metadata/EN/lcs_r2_esqrs_el.htm

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lignitisation for the 2019 base year, it is estimated that a total of around 12,000 workers (directly, indirectly and induced) will be affected throughout the region.

Finally, in relation to the impact on the economy, it is estimated that the total loss of gross value added (GVA) at country level from the changeover to EUR 1,580 million by 2029. In Western Macedonia the total GVA loss is estimated at more than EUR 1 billion by 2029 (compared to 2019), or 26% of Western Macedonia's GDP in 2019 (~ EUR 4 billion)[22]. Therefore, in terms of GDP, there will also be a major direct impact on Western Macedonia.

The scope of the Action Plan

The Action Plan's scope is to enhance the **Vision of the Western Macedonia TSL** ***for the diversification of the economy through climate neutral energy production and*** the **Regional Transition Goal**, for ***Just transition, providing support to those affected by the social, employment, economic and environmental impacts of the transition and subsequently find out ways to support the policymakers taking evidence-based decisions towards the Union's 2030 energy and climate goals and towards a climate neutral Union economy by 2050.***

Therefore, the **Action Plan aims** ***to accelerate a fair and inclusive transition focusing on energy and mobility, agriculture/food production and circular economy and drive the innovation in the area, with close collaboration with all relevant stakeholders and an emphasis in civil society engagement*****.**

Regional transition goal: Main goals, objectives and targets

The local context of Western Macedonia forms a set of main challenges that need to be addressed by the region in view of reaching a climate-neutral economy. These challenges are summarised in the following:

1. **Restructuring of the region's production system**

Lignite-fired activity created monoculture in the production system of the Region of Western Macedonia and limited positive spillover effects, leading the rest of the economy to be unable to absorb excess labour at this stage and to create sufficient jobs in the future.

2. **Support for human resources & communities affected by de-lignification**

The very high share of unemployment (19.5%) in the Region of Western Macedonia, highest in the country among all Greek Regions makes it necessary to take immediate action to train and retrain the unemployed and the existing workforce in sectors with absorption capacity and prospects in the region, which are relevant to the existing skills of workers affected by de-lignification.

[22] Hellenic Ministry of Environment and Energy (2021). 2021 TJTP Territorial Just Transition Plan- TJTP Western Macedonia

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3. **Mitigation of negative effects on the environment, health & safety from lignite mining/combustion and prevention of the creation of new pollution factors**

It is crucial to restore former lignite land and implement projects that ensure a shift towards a new production model, which will not give rise to other environmental problems (recycling of RES by-products, storage, etc.). The adaptation of land also seeks to promote the area's diverse natural environment (e.g. the development of green spaces, lakes, forests) and to create suitable infrastructure for attracting and developing new economic activities.

The above-mentioned challenges for the Region drive in the need of identification of **Main Goals (MG), Specific Objectives (SO) and their relevant Targets (T)** that will structure a more specific framework for the Action Plan. These MG, SO and T as described below are aligned with those that are foreseen in the **Territorial Just Transition Plan (TJTP) of Western Macedonia**[23]

But at the preliminary stage it is very important to identify the connection between the TJTP and the regional TSL of Western Macedonia. In practice, the cross-sectorial TSL and the ecosystem of the stakeholders that TSL will be consisted of, will address and elaborate on many fields of innovation in economic sectors of the Region, being a mechanism for speeding-up innovative growth in parallel with climate neutrality. At the same time, the TSL of Western Macedonia will support the financing coming from TJTP by providing data, tools and know-how to the stakeholders for the maturation and development of projects that will be endorsed by TJTP and other financial instruments. In other words, TSL will support TJTP by providing added value in its implementation. Nevertheless, despite the complementarity of TSL and TJTP, it is clear that the former is a technologically based ecosystem for co-creation of co-sectorial "quick wins" in Regional Transition policy implementation while the latter is the main umbrella of Regional Transition policy making and financing.

The main linkage of TSL and its contribution to the implementation of the TJTP in Western Macedonia will be this Action Plan and its updates in the future, under a wider framework that has to be specified. Specifically, **Strengthening & promotion of entrepreneurship (MG1)** is specified in two SOs. The first aims to *Strengthen the competitiveness of business* through targeting significant scale investments, entrepreneurship infrastructures and mechanisms along with start-up entrepreneurship and digital transformation of businesses, while the second *Interconnects entrepreneurship with research, innovation and advanced technologies*.

The **Energy transition (MG2)** has as Specific Objective to *Improve energy efficiency in affordable clean energy systems and infrastructures, including storage technologies*, targeting to energy efficiency along with clean and smart energy.

[23] Hellenic Ministry of Environment and Energy (2021). 2021 TJTP Territorial Just Transition Plan- TJTP Western Macedonia

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In Western Macedonia, **Land use readjustment (MG3)** is very crucial and is divided in three SOs. It refers, firstly, to the *Regeneration and reuse of lignite soils* via adaptation of land and installations in lignite fields, secondly to the *Green infrastructure and technical land use readjustment* targeting the upgrade of infrastructures and land and finally to the *Circular economy enhancement* aiming to circular economy and rational use of natural resources.

In order to achieve the former, **Fair labour transition (MG4)** has a key role. At the first stage it focuses on *Upgrade skills and requalify human resources*, by immediate response to the effects of de-lignitisation on the labour market/promotion & strengthening of employment and by skilling and re-skilling of human resources/adaptation of workers & enterprises. *Investments in training infrastructure* are another SO targeting to socio-economic inclusion / social care & welfare infrastructure and infrastructure for vocational education & training. Finally, to *Facilitate integration into the labour market* by familiarisation — awareness of social & economic fabric is also very important.

Finally, the **Attraction of integrated small-scale interventions (MG5)** is highlighted in order to *Improve the quality of life of residents* through integrated development interventions in urban & rural areas. Additionally, to *Diversify local economies* targeting to new complementary economic activities is another focus.

Topics

For **Strengthening & promotion of entrepreneurship** the general topics are the *Economic modernization and transformation* and the *Enhancement of competitiveness through the production and promotion of products/services of high added value,* focusing on four specific topics. **Research – Innovation – Advanced technologies** include the support for start-ups/existing innovative businesses, the creation of incubators/business accelerators and measures to contain/attract scientists. **Competitiveness & Digital transformation of enterprises** deals with establishing & supporting the competitiveness of VSBs & SMEs in all territorial sectors including the green & digital transformation of businesses. The specific topic of **Entrepreneurship infrastructures** focuses on upgrading existing ones, supporting also the creation of new organised spatial receptors of productive activities on rehabilitated land & facilities. **Large scale investments from non-SMEs** support their implementation to strengthen the energy pillar & vertically integrate the value chain, as well as to create other productive pillars and value chains beyond energy, to increase job creation.

The General Topics of **Energy transition** are the *Transition to a neutral climate economy* and the *Support of investments in clean production and use of energy.* Specifically, it refers to **Energy efficiency** providing support to households, public/municipal buildings & infrastructure, office & production unit buildings either through energy communities or individually and penetration of **Clean energy** by reduction of CO2 footprint and also promotion of energy autonomy utilising RES (i.e. installation of heat pumps for heating/cooling and/or RES electricity generation systems in line with the "REPowerEU" standards, actions to create charging/refuelling points for electro-mobility/clean fuel mobility, smart energy systems & networks, storage and electric mobility equipment, incorporation of smart solutions in energy systems

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for energy managements, energy storage systems and upgrade of networks in order to facilitate the increasing RES power).

The **Land use readjustment** of the Region is generally focused on *Rebirth, depollution and rehabilitation of degraded land and infrastructures, Enhancement of circular economy* and *Promotion of effective management of natural resources.* This framework is specified in three topics. **Reorientation of land and complexes in lignite fields** needs repurposing civil works (i.e. access facilitation infrastructure, networks & infrastructure of a public nature deemed necessary for the proper functioning of business parks & other investments/activities within the perimeter of the former lignite mines, etc.). **Circular economy** will support investments for reuse, repair & recycling of waste, in relation to emerging value chains and new productive investments. Finally, **Rational use of natural resources** refers to green infrastructure (such as: flood protection projects, terraces for cultivation, restoration, management & monitoring of biodiversity, natural resource efficiency infrastructure).

Fair labour transition has as General topics the *Confrontation of socio-economic impact of economy's transition in zero-pollution economy* and the *Adjustment of labour market in skills and jobs related to new productive activities.* For that, several specific topics are identified. **Instant interventions of employment and social inclusion** is facing unemployment through programmes of granting job positions in enterprises, consulting and training unemployed and ex-workers in businesses affected by de-lignitisation. Thus, **Support & promotion of employment** for people affected by de-lignitisation, at the risk of losing jobs or in unemployment, is necessary along with **Upgrade and reskilling of human resources** by cultivating new & upgrading existing skills of human resources (in areas of: RES, environmental restoration, waste management, industrial specialisations depending on new investments). **Adaptability of employees and businesses** is to be achieved by implementation of programmes for consulting development, in-job training and modernisation of systems for human resources management in enterprises with emphasis in digital skills and new technologies. **Socio-economic inclusion** is needed for vulnerable population groups with specialised advisory support and empowerment programmes at local level, strengthening also the relevant infrastructures for their socio-economic integration. Upgrading and modernising **Infrastructures for vocational education and training** and is also foreseen, along with **Infrastructures of social care and welfare** supporting also unemployed parents in the transition of their working life. Also, **Socio-economic awareness** includes lifelong learning programmes for the environment, the green economy, digital skills & entrepreneurship.

Finally, **Attraction of integrated small-scale interventions** generally applies to the *Positive impact of green and digital transition to a zero-pollution economy.* The first relevant topic is the **Quality of life in urban areas** promoting two-pack tourism-culture & improving the quality of life of residents (i.e. restoration of archaeological or cultural sites within lignite mines to develop alternative economic activities, digital applications, promotion of sustainable mobility through soft traffic zones & roads, cycle paths, etc.) while the second is **Integrated development interventions & Smart communities (cities, villages)** by integrated territorial strategies concerning the implementation of complementary interventions.

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5.2 Developing concrete actions through pilot use cases

Goals and objectives

Goals and specific objectives of the pilot use case(s).

Pilot Use Case 1: Production, transfer and storage of PV energy and consumption in Ptolemaida KTEL Public Transport buses (Ptolemaida KTEL PT) buses electrification – PV energy and Pilot Use Case 2: Production, transfer and storage of H2 energy and consumption in Kozani KTEL Public Transport buses (Kozani KTEL PT) buses electrification – H2 energy

The goal of the Pilot Use Cases 1 and 2 is to achieve the energy transition towards climate neutrality by shifting to an energy model ''Produce and consume locally''. The objective is to improve energy efficiency, in affordable clean energy systems and infrastructures, including storage technologies.

This specific objective involves optimizing the overall energy utilization of the public transportation system. It emphasizes affordability in the adoption of clean energy systems, ensuring cost-effective solutions for PV installations, charging infrastructure, and energy storage.

For increasing the possibilities of achieving the specific objective it is necessary to seamlessly integrate clean energy infrastructures into existing systems. This includes incorporating PV panels into Ptolemaida's bus terminal and specified equipment for electrolysis within the terminal of Kozani, establishing efficient charging infrastructure, and integrating advanced yet affordable energy storage solutions to support the daily operations of the public transport system. The use of cutting-edge storage technologies, such as batteries, is also encouraged for improving energy efficiency by storing excess energy from PV and H2 sources and releasing it when needed, minimizing reliance on non-renewable sources.

Efficient energy transfer mechanisms are crucial to ensure that the energy generated from PV and H2 sources is effectively utilized. The use of smart charging technologies, the optimization of schedules, and minimization of losses during energy transfer can contribute towards this direction. To balance the intermittent nature of solar energy, the promotion of the use of storage technologies that will match energy supply and demand is critical ensuring a reliable power source for buses.

Additionally, the objective involves aspects of scalability and replicability, aiming to create a model that other public transportation systems of the region can adopt. It encourages continuous improvement and innovation, staying updated on advancements in clean energy technologies, and evolving infrastructure and systems to enhance energy efficiency in the public transportation sector. Overall, the objective aligns with broader sustainability goals and supports the transition to a more environmentally friendly and energy-efficient transportation system.

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Pilot Use Case 3: Application of CO2 capture/emission reduction technologies in farms & transfer, storage & reconsumption of CO2 in farms (link to the circular economy park)

This pilot use case aims to strengthen the competitiveness of agricultural businesses and promote the synergies between agriculture and circular economy sectors. The objectives are to enhance circular economy by interconnecting entrepreneurship with research and innovation through the application of emission reduction technologies such as carbon farming techniques.

Pilot farms link to Waste Management of Western Macedonia (DIADYMA) Circular Economy and Energy Park

According to the previously mentioned information, carbon farming is linked to DIADYMA Circular Economy Park in several ways.

DIADYMA operates a biomass power plant that generates electricity from locally sourced agricultural and forestry residues. This is a form of carbon farming, as the use of biomass feedstocks can result in carbon sequestration, especially if sustainable forestry practices are implemented to ensure that the biomass feedstocks are produced in a sustainable manner.

Furthermore, **carbon farming practices such as cover cropping and conservation tillage can be used to improve soil health, which is essential for the production of biomass feedstocks for the power plant**. By improving soil health, farmers can increase the carbon content of the soil, which can help to sequester carbon in the soil and reduce greenhouse gas emissions.

Additionally, **the use of carbon capture and storage (CCS) technology can be used to further reduce greenhouse gas emissions from the power plant**. CCS technology involves capturing carbon dioxide emissions from industrial processes and storing them underground or using them for industrial processes such as enhanced oil recovery or the production of synthetic fuels. This technology can be integrated into DIADYMA biomass power plant, further reducing its carbon footprint.

Finally, **DIADYMA's focus on waste management and recycling can also contribute to carbon farming**. By recycling waste materials such as plastics, metals, and glass, the park can reduce the need for virgin materials to be produced, which can result in lower greenhouse gas emissions. Additionally, the use of waste materials as feedstocks for industrial processes can also result in carbon sequestration.

Overall, DIADYMA Circular Economy and Energy Park and carbon farming are linked in several ways, and the integration of carbon farming practices into the park's operations can contribute to its overall goal of promoting sustainable economic development and reducing greenhouse gas emissions.

Pilot Use Case 4: Development of Kozani's Transition Super Lab (TSL) & Data Space (DS)

The goal of the Pilot Use Case 4 is to create regional leveraging mechanism of the cross-sectorial ecosystem to achieve the acceleration of the region's transition to climate neutrality through innovation and digitization.

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The objectives are:

- Ensuring its operation in accordance with EU Living Labs' standards and procedures, but also in accordance with the priority axes of the just transition defined by the Region of Western Macedonia
- Systematic development of a portfolio of innovative cross-sectorial solutions, while reshaping various systems such as transport, energy and agriculture among others
- Development of a roadmap of funding initiatives for the region that will align with the **TJTP of Western Macedonia**

Connectivity to other pilot use cases

Some of the initiatives that are already under discussion or planned in the region of Western Macedonia are described below.

Innovation Zone

An emblematic project mentioned in the TJTP is the creation of an Innovation Zone in Western Macedonia. Its purpose is to serve as a vehicle that promotes innovative entrepreneurship in the fields of clean energy and environmental technologies and act as a lever for the transformation of the economy of Western Macedonia in the post-lignite era. In particular, the main priorities of the Innovation Zone include spatial planning, infrastructure development, creation of innovation initiatives in the region (e.g. Technological Park, incubators, clusters) and coordinating initiatives that take place in the Innovation Zone, to promote technological applications and innovative entrepreneurship in the areas of clean energy and environmental technologies. The Transition Super Lab (Pilot Use Case 4) can be the hub where the actions and initiatives created in the Innovation Zone will be matured to emblematic projects through the development of cross sectorial synergies, the support of investors and the creation of value proposition for the stakeholders involved.

Innovation Hub for Hydrogen

A hydrogen technology park will be developed in order to rapidly promote the use of green hydrogen and favour the investment environment in Western Macedonia. The park will be complemented by a Center for Hydrogen Studies based at the University of Western Macedonia, a cluster of hydrogen companies based at CERTH facilities in Ptolemaida and an electronic platform of hydrogen technologies applications.

The Hydrogen Fuel Supply Station will initially serve two municipal heavy-duty vehicles-garbage trucks and two smaller vehicles for the transport of personnel and supplies of the H2 Hub operations, for research purposes with prospects for the development of hydrogen mobility applications. In addition, cooperation with the urban public transport of the municipalities of Eordaia and Kozani is foreseen, in terms of covering the fuel needs of the local buses with the produced green Hydrogen (link to Pilot Use Case 1 and 2).

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Initiative of the creation of the Institute for Energy Development and Transition to Post-Lignite Era of Western Macedonia

The University of Western Macedonia has created the Institute of Energy Development and Transition to Post-Lignite Era (one of the nine distinct Institutes within the University Center for Research and Innovation "TEMENUS"). The Institute's objectives are:

- The development of basic, applied, and interdisciplinary research in the fields of energy development, just transition policies, governance, and climate neutrality.
- The promotion of knowledge, the publication and promotion of research activities, and scientific and technological achievements in the fields of energy development and transition.
- The utilization of energy development and transition research findings for the benefit of the scientific community and local society.
- The young scientists' expertise in the fields of the green economy, climate change, and energy transition.
- The provision of services of documented scientific support and advisory actions in matters of energy development and transition to bodies in Western Macedonia, Greece, and abroad.
- The development of collaborations with relevant research organizations both nationally and internationally, as well as the promotion of cross border cooperation in the fields of energy management and just transition.
- Support for the implementation of the National Energy and Climate Plan (NECP) and the TJTP of Western Macedonia.
- Networks and synergies development at local, national and European level with bodies, institutions and organizations of civil society, in matters of energy development and transition.
- Organization of conferences, symposiums, workshops and meetings, related to issues of energy, environment and just transition.
- The undertaking of joint actions and initiatives with institutes, bodies, and centres of the same or related scientific field in Greece or abroad.

Actions, sub-actions and measures as parts of the pilot use case implementation

Necessary actions to implement the Action Plan

Pilot Use Cases 1 and 2

The actions foreseen for the implementation of the Action Plan of the use cases 1 and 2 are the following:

- Meetings with regional authority of Western Macedonia and Managing Authority of Just Transition Development Programme 2021-2027 for identifying potential funding sources (2028)
- Execution of study and installation of PV panels for own production of energy in Kozani and Ptolemaida KTEL PT facilities (2028)
- Agreement between Kozani and Ptolemaida KTEL PT and CERTH for supply of green H2 from Innovation Hub for Hydrogen (2028)
- Provision of the final funding – Support Scheme (2035, 2040)
- Design – Licensing of PV Park (2035, 2040)
- Agreement with producers - providers of Green H2 (2035, 2040)

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Pilot Use Case 3

Following a workshop organized with key stakeholders on June 7, 2023, and various follow up online meetings with DIADYMA, Proud Farm, Velventos DIMITRA Cooperative and Cluster of Bioeconomy and Environment (CLUBE) of Western Macedonia, the following three alternative scenarios were developed:

- Scenario 1 - Utilization of agricultural and livestock residues in the anaerobic digestion unit of DIADYMA.
- Scenario 2 - Utilization of agricultural residues by DIADYMA for compost and fertilizer production.
- Scenario 3 - Implementation of good practices for carbon sequestration, use and storage in agriculture and livestock production.

However, based on the feasibility studies of these scenarios, the 3rd scenario is selected for further elaboration. The selection is practically based on the exclusion of Scenarios 1 and 2 for the following reasons:

- Technical complexity of Scenarios 1 and 2.
- Lack of interest from stakeholders to engage in the Scenarios.
- Lack of critical mass of residues for feeding the processes.
- Cost and economic feasibility parameters which preclude their selection.

The following actions will be necessary to implement the Action Plan for the 3rd scenario of use case 3:

- Presentation of the Scenario at a Project (TRANSFORMER) and Stakeholders level
- Refining the various parameters of the Scenario, incl. the definition of the Measures/ Interventions that shall be prioritized
- Identification of potential funding sources for the implementation of the Scenario
- Promotion of applications for programmes/ projects which shall fund the implementation of the Scenario
- Launch of programmes
- Implementation of programmes

Pilot Use Case 4

The first action that is considered critical for the implementation of the Action Plan related to the development of a Transition Super Lab (TSL) and Data Space (DS) is reaching an agreement with the involved stakeholders on the institutional framework and the governance scheme of the Transition Super Lab as well as the use of data of the Data Space through the signing of a Memorandum of Understanding (MoU) among the Region of Western Macedonia, ANKO and CERTH, while it is foreseen to be signed by more stakeholders at a next stage.

The next actions include the definition of human and financial resources that are needed for the operation of the Transition Super Lab - Data Space and ensuring the necessary funding from the Region of Western Macedonia or other sources. As soon as the funding will be secured, the required personnel will be mobilised, and the necessary infrastructure and equipment will be set up.

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Necessary measures to develop the actions

Pilot Use Case 1 and 2

For developing the actions mentioned in the above section a cross sectorial transition path for transport and energy including specific measures for 2028, 2035 and 2040 is needed. The specific measures for each time horizon are listed below and where it is possible they are further supported with specific indicators included in the ''Project phases (timeline) and milestones'' and ''Impact Assessment'' subsections:

Transition path and measures of transport and energy for 2028

Transport

Encouraging citizens to use electric buses and increasing acceptance of new technologies

Need to have certified bus maintainers

Need for training of involved stakeholders (e.g. KTEL and drivers) for the correct use of electric buses and H2 buses

Cooperation between public transport authorities and private operators to improve service quality, innovation and funding.

Energy

Seeking know-how from energy communities or individuals contributing to PV energy production

Integrating digital technologies and smart grids to optimize energy distribution and consumption.

Growing interest in hydrogen, with an emphasis on green hydrogen production using renewable energy sources.

Transition path and measures of transport and energy for 2035

Transport

Restructuring of the bus line network

Change in the fleet mix and replacement of the largest number of large buses with minibuses

Development of flexible and on-demand public transport services to better meet the different needs of passengers.

Cooperation between public transport authorities and private operators to improve service quality, innovation and funding.

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Energy

Development of advanced energy storage technologies to support grid reliability and stability and address intermittency issues associated with renewables.

Cooperation with new investor-providers

Transition path and measures of transport and energy for 2045

Transport

Total fleet replacement to achieve zero emissions.

Cooperation between public transport authorities and private operators to improve service quality, innovation and funding.

Energy

Change in the energy mix (reduction of energy from fossil fuels and increase of energy from RES)

Cooperation with new investor-providers

Scalability and adaptation of new energy systems

Pilot Use Case 3

To identify good farming practices which are used globally and have large potential for the reduction of CO_2 emissions, a report and methodology produced by McKinsey & Company, titled "Agriculture and climate change- Reducing emissions through improved farming practices"[24] was used.

The report presents the key 25 measures to reduce on-farm emissions and organizes them into a marginal abatement cost curve. These measures have the potential for the reduction by 2050 of about 20 percent of total emissions from agriculture, forestry, and land-use, compared with business-as-usual emissions. Based on the discussions with the pilot use case's stakeholders and the region's context and tangible resources, the following measures were selected as potentially suitable and applicable for the Region of Western Macedonia categorized in Machinery, Livestock Farming and Agricultural Practices.

[24] McKinsey & Company, (2020), "Agriculture and climate change- Reducing emissions through improved farming practices" (available at https://www.mckinsey.com/industries/agriculture/our-insights/reducing-agriculture-emissions-through-improved-farming-practices)

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Table 1: Measures in Machinery, Livestock Farming and Agricultural Practices selected as potentially suitable and applicable for the Region of Western Macedonia

Category	Measure	Suitability/ Applicability in Region of Western Macedonia
Machinery	**Adopt zero-emissions on-farm machinery and equipment:** The largest amount of on-farm emissions abatement potential can be achieved by shifting from traditional fossil-fuel equipment and machinery—such as tractors, harvesters, and dryers—to their zero-emission counterparts.	A considerable fleet of 12,496 Double-axis tractors is documented in Western Macedonia Region, (2021, ELSTAT). An intervention of replacing, by 2050, the 20% of the conventional fossil-fuel equipment and machinery with electric ones is considered. Such replacement could be supported by particular state- sponsored incentives for farmers.
Good Livestock Farming Practices	**Employ greenhouse gas–focused genetic selection and breeding:** Genetic selection and breeding programs focused on ruminant animals' enteric fermentation could significantly reduce overall emissions by 2050. Leading experts assert that about 20 percent of a ruminant's methane emissions rate stems from genetics alone.	Good Livestock Farming Practices could be implemented in Western Macedonia The population of livestock involved is 7,365 cows, 289,318 sheep and 105,877 goats. An intervention in 20% of the population of livestock by 2050 is considered. The implementation of Good Livestock Farming Practices could be supported by particular state- sponsored incentives for farmers.
	Improve animal health monitoring and illness prevention: By improving the health of farm animals, farmers could improve productivity and reduce animal mortality due to disease. The ability to meet the world's projected animal protein demand with fewer, healthier animals could reduce emissions from enteric fermentation, manure left on pasture, and manure management.	
	Optimize the animal feed mix: Transitioning ruminants to higher-fat diets is widely applicable and recognized as effective in reducing enteric fermentation.	

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	Expand use of animal feed additives: Some feed additives have been shown to inhibit methane production in the rumen. Propionate precursors—a class of free acids or salts, such as sodium acrylate or sodium fumarate—will likely have widespread applicability, as their use has been shown to directly inhibit methane emissions from cattle without affecting animal growth.	
	Expand use of anaerobic manure digestion: Capturing and using methane through anaerobic digesters can significantly reduce GHG emissions from dairy cow and hog manure systems. Today, such digesters are primarily used to control for odour and pathogens, and as such their deployment is limited. There is significant scope, however, for expanded generation of biogas, which can be used on the farm or sold back to the grid (electricity or natural gas).	
	Expand use of feed-grain processing for improved digestibility: Mechanical processing, such as steam flaking, improves the starch digestibility of grain for large ruminants by reducing particle size, providing greater microbial access to substrate, reducing energy expenditures, and increasing overall feed intake.	
	Expand uptake of technologies that increase livestock production efficiencies: Increasing livestock production efficiency can reduce GHG emissions from animals bred for consumption. It is possible to increase efficiency through a wide range of measures including hormones, microbial additives (for example, probiotics), biosecurity, herd management and monitoring (including new digital tools), and vaccination.	

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Good Agricultural Practices	**Apply nitrification inhibitors on pasture:** Though the practice is nascent, direct application of nitrification inhibitors on pastureland has demonstrated significant reduction in nitrous oxide emissions from ruminant urine.	Agricultural Good Practices could be implemented in Western Macedonia. The total cultivated agricultural and fallow land in Western Macedonia is 193,134 hectares.
	Scale low- and no-tillage practices: Low- and no-tillage practices aim to reduce soil organic matter loss, limit erosion, and conserve water through alternatives to conventional tillage. When combined with deep placement of nitrogen, low- and no-tillage practices—such as shallow ploughing, fewer tillage passes, chisel coulter drilling, and zone tillage—reduce fuel usage and denitrification, in turn reducing emissions.	Intervention in 20% of hectares by 2050 is estimated. The implementation of Good Agricultural Practices could be supported by particular state- sponsored incentives for farmers.
	Expand adoption of controlled-release and stabilized fertilizers: Moving farmers away from traditional fertilizers and toward controlled-release fertilizers or stabilizers could deliver up to a 20 percent reduction in nitrous oxide emissions.	

Pilot Use Case 4

The application of methodologies and tools that support the development of cross sectorial synergies for implementing innovative actions towards achieving a common goal, quickly identifying real and current challenges and solving them will mobilise the local ecosystem ensuring the engagement of the necessary human resources (businesses, clusters, etc.).

Programs of capacity building, training and education (stakeholders, agencies, citizens) regarding sustainable practices will keep the stakeholders engaged and facilitate the replicability and scalability of the cross sectorial action co-created in the Transition Super Lab. Developing of a permanent Mechanism of Business Discovery will support the operation of the Transition Super Lab ensuring its long-term sustainability. For the support of the Data Space attracting data providers & collecting, processing, correlating and analysing cross-sector data is considered important. These activities will start in 2025 and take place in continuous basis following iterative processes rather than linear ones. For achieving this, some sub measures have been identified and illustrated in the Figure 5:

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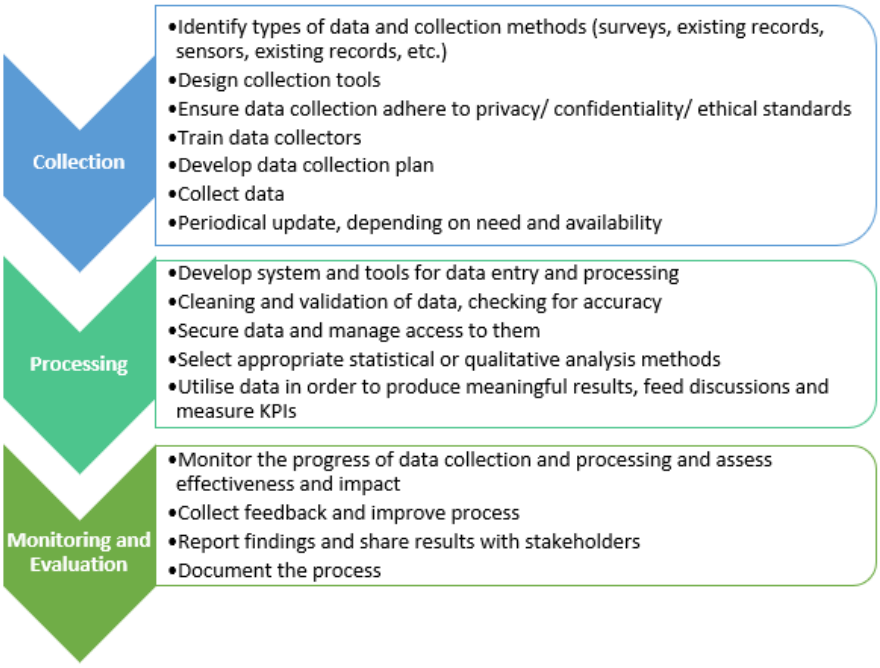

Figure 5: Sub measures for the development of a Data Space in Kozani's Transition Super Lab

Links between the different pilot use cases

The vision for Western Macedonia is the ''Diversification of the economy through climate neutral energy production''. The region's strong academic and business eco-system will lead this transition in which the mobility, agri-food sector and digital innovation will play a crucial role as the backbone of the new economic system. The Pilot Use Case 4 '' Development of Kozani's Transition Super Lab & Data Space is the link among the different pilot use cases as the data collected from Pilot Use Cases 1, 2 & 3 will be the first data of the region's data space.

Project phases (timeline) and milestones

Pilot Use Case 1 and 2

Based on the initial feasibility study performed for Pilot Use Cases 1 and 2, the total replacement of the conventional public transport fleet in Ptolemaida and Kozani with PV electric or H2 buses is considered impossible due to high purchase costs, non-existence of sufficient facilities and operational limitations. The project is separated in 3 phases-time horizons (2028, 2035 and 2040) following the strategy and goals set by the European Commission for emissions reduction for new heavy-duty vehicles by 45%, 65% and 90% by 2030, 2035 and 2045 respectively.

So, an initial replacement of about 10% that represents 2 buses of the conventional public transport fleet of each city is suggested by 2028 to test the reliability of the new solution and increase public acceptance. In 2035, it is estimated that there will be the ability to create sufficient infrastructure, market maturation

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and support schemes to replace and operate approximately 40% of the remaining conventional fleet in order to meet the European 65% CO2 reduction target. The replacement of the fleet is based on the ''age'' criterion of the vehicles. This means that the older vehicles with higher fuel consumption will be replaced first, and according to the feasibility study performed, 65% CO2 reduction is feasible when 40% of the fleet will be replaced. Final in the last phase of the project in 2040, the remaining conventional public transport fleet is planned to be replaced. For each of the above phases, the production and supply of PV energy and H2 to cover the fleet needs is also studied and the most suitable option based on the feasibility study is suggested.

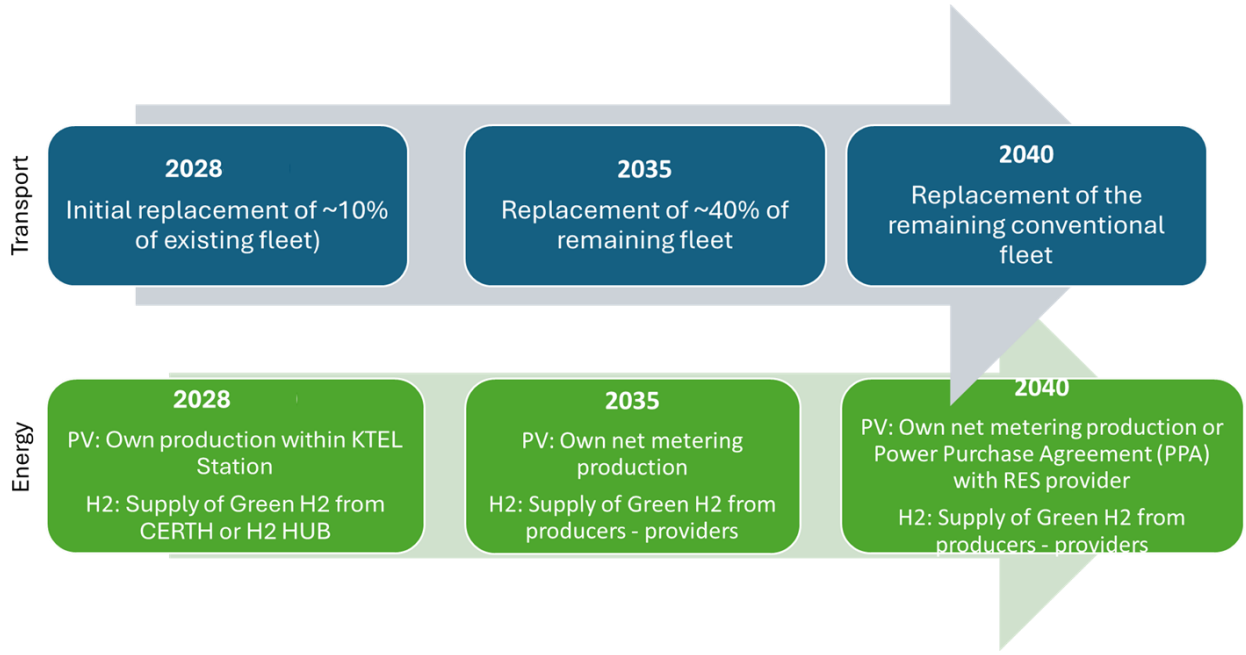

Figure 6: Timeline of Pilot Use Cases 1 and 2

Pilot Use Case 3

During the first phase of the project (2024) and after the presentation of the scenario at stakeholders´ level, the various parameters of the project should be refined and the measures/interventions that should be prioritised will be defined in Q2. For selecting the suitable measures and intervention to take place data related to labelling schemes and subsidies that have been implemented internationally, practices already in place by producers in region and interest in joining a good practice incentive program and agricultural land that can be exploited should be collected. In parallel, potential funding sources for the implementation of the scenario will be identified. In Q4 applications for programmes/ projects that can fund the implementation of the scenario will be developed and promoted. In the second phase during 2025, the launch of these programs is planned while their implementation is foreseen in the third phase (2026 and on).

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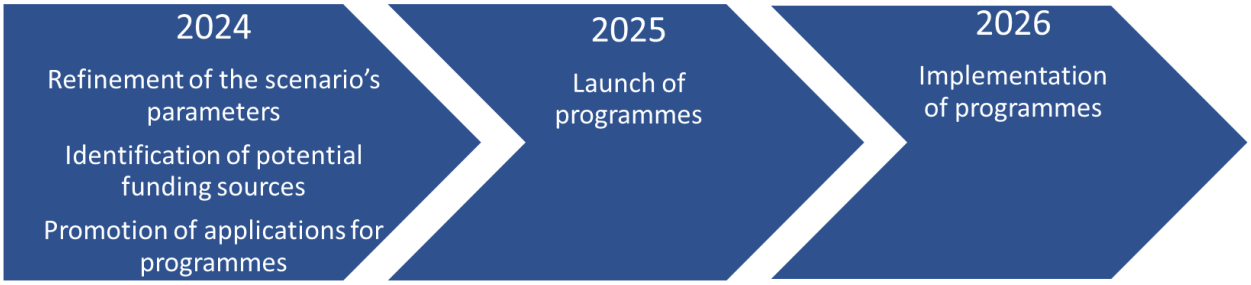

Figure 7: Timeline of Pilot Use Case 3

Pilot Use Case 4

For the development of the Transition Super Lab (TSL) and Data Space (DS) there are two phases; the preparatory phase and the implementation phase. During the preparatory phase in Q1 2024, a Memorandum of Understanding with the involved stakeholders that defines the institutional framework and the governance scheme of the Transition Living Lab as well as the process and the use of the data of the Data Space will be signed. In parallel, the resources (personnel and financial) needed for the operation of the TSL- DS will be defined. As soon as the funding sources will be secured (Q4 2024), the required personnel will be mobilised and the infrastructure and equipment will be created (Q1 2025), the implementation phase will start. The Transition Super Lab – Data Space will be established in Q2 2025.

From Q2 to Q4 2025 the development of cross sectorial synergies and initiatives along with the collection of the required datasets will take place. Provision of services to interested parties, dissemination and networking with potential clients and initiatives with similar and complementary scope will start in 2026 and continue during the next years. Also, as the Transition Super Lab will be mature by 2026, the participation since then in competitive projects (national and EU) pertinent to TSL- DS character will be feasible.

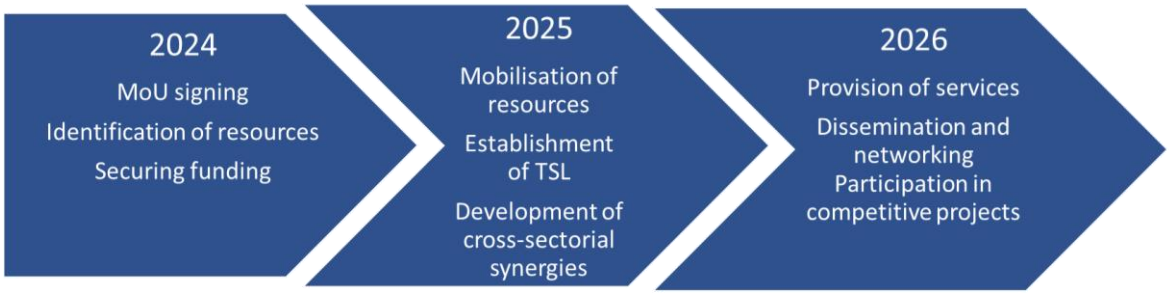

Figure 8: Timeline of Pilot Use Case 4

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Stakeholder identification and analysis

Stakeholders from the Quadruple Helix

Stakeholder management and engagement plan

Pilot Use Case 1 and 2:

Various stakeholders across mobility and energy sectors can play crucial roles in the successful implementation of use case 1 and 2. Some of the relevant potential partners include:

- Public Trasport providers (Kozani and Ptolemaida KTEL PT): key stakeholders and facilitators of the change related to the electrification of the public transport flee of Kozani and Ptolemaida
- University of Western Macedonia - Department of Mechanical Engineering: Contribution in optimization of multiple electric power storage solutions & buses based multimodal electrified modes operation in region's public transport
- CERTH-CPERI (Chemical Process & Energy Resources Institute, department in Western Macedonia): Host and manager of the Innovation Hub for Hydrogen
- Ministry of transport and mobility: Incorporation of transition initiatives in policy and programming documents and funds
- Region of Western Macedonia: Key player for ensuring the required funding
- Managing Authority of the Just Transition Development Programme 2021-2027: Key player for ensuring the required funding
- Hellenic Electricity Distribution Network Operator (DEDDIE): Distribution of multiple electric power storage solutions
- Union of Investors in Photovoltaics in Western Macedonia Region: Providers of Electric power, coming from PV
- The public as a stakeholder of high importance for the acceptance of new technologies especially in the public space.

Pilot Use Case 3:

Some of the relevant potential partners include:

- Farms and Rural Cooperative Producers Organisations: Beneficiary of CO2 capture & CO2 emission reduction technologies for green and fair agri-food supply chains (e.g., Proud Farm, AFOI MPISIRITSA S.A., Rural Cooperative Producers Organisation "Dimitra" etc)
- Waste Management of Western Macedonia (DIADYMA): Hosting enterprises and research units involved in CO2 capture & CO2 emission reduction technologies in the forthcoming Circular Economy Park of Western Macedonia
- Cluster of Bioeconomy and Environment of Western Macedonia (CLUBE): Clustering and support in Supply Chain Management (SCM) of a network of agri-food companies involved in CO2 capture & CO2 emission reduction technologies

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- University of Western Macedonia - Department of Agriculture: Contribution in CO2 capture & CO2 emission reduction technologies for green and fair agri-food supply chains
- Citizens: indirect beneficiaries

Pilot Use Case 4:

Some of the relevant potential partners include:

- ANKO: Leader of the collaborative governance of the Transition Super Lab
- Region of W. Macedonia: member of the collaborative governance of the Transition Super Lab
- Managing Authority of the Just Transition Development Programme 2021-2027: member of the collaborative governance of the Transition Super Lab
- CERTH-HIT: member of the collaborative governance of the Transition Super Lab. CERTH-HIT is a "neutral" (no benefit) technical coordinating partner with expertise in arguments creation for cross-sectorial initiatives for achieving transition to climate neutrality providing also "out of the box" knowledge and experience for creating value for all the stakeholders of the Transition Super Lab.
- Also, representatives of the quadruple helix (research/academy, public authorities, industry, citizens) as well as decision makers and veto players of different ecosystems (mobility, energy, agriculture, industry, cycling economy) will be part of the Transition Super Lab. (e.g. Cluster of Bioeconomy and Environment (CLUBE) of Western Macedonia, Technical Chamber of Greece - Department of Western Macedonia etc)

Communication Plan

A stakeholder communication plan is crucial to keep stakeholders informed through the Action Plan implementation and thus gain their support and engagement throughout the whole process. A detailed communication plan will be designed at a later stage by the leading team of the TSL including frequency and methods of communication.

It is important to identify the communication approach for different stakeholders. This means that it is necessary to identify the most effective communication channels for each stakeholder group (e.g. regular meetings (in-person or virtual), email updates, project management tools (e.g., Asana, Trello), collaboration platforms (e.g., Slack, Microsoft Teams), newsletters or progress reports, social media etc). The frequency of communication for each stakeholder group will be based on their level of involvement and information needs. It is also important to define key messages that need to be communicated at each stage of the project and ensure that communication is clear, concise, and tailored to the audience's needs and interests. Key messages could include milestones achieved, challenges encountered, upcoming deadlines, and changes in project scope or timeline.

By following the above principles and maintaining open lines of communication with stakeholders, team members, and relevant parties, the project implementation can proceed smoothly, fostering collaboration, accountability, and ultimately, project success.

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Stakeholders' roles and responsibilities

The responsibilities for each of the actions included in the Action Plan of each use case are presented in the following tables:

Pilot Use Case 1 and 2:

No	Action	Responsibility/involvement
1	Meetings with region of Western Macedonia and Managing Authority of Just Transition Development Programme 2021-2027 for identifying potential funding sources	ANKO, CERTH/HIT
2	Execution of study and installation of PV panels for own production of energy in KTEL PT facilities	KTEL PT
3	Agreement between KTEL PT and CERTH for supply of green H2 from Innovation Hub for Hydrogen	KTEL PT, CERTH
4	Provision of the final funding – Support Scheme	Regional Authority of Western Macedonia, Managing Authority of Just Transition Development Programme 2021-2027
5	Design – Licensing of PV Park	KTEL PT, Hellenic Electricity Distribution Network Operator (DEDDIE)
6	Agreement with producers - providers of Green H2	KTEL PT, producers - providers of Green H2

Pilot Use Case 3

No	Action	Responsibility/involvement
1	Presentation of the Scenario at a Project (TRANSFORMER) and Stakeholders level	ANKO and CERTH
2	Refining the various parameters of the Scenario, incl. the definition of the Measures/ Interventions that shall be prioritized	ANKO and CERTH
3	Identification of potential funding sources for the implementation of the Scenario	ANKO
4	Promotion of applications for programmes/ projects which shall fund the implementation of the Scenario	ANKO

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5	Launch of programmes	Region of Western Macedonia
6	Implementation of programmes	Applicants/ Farmers

Pilot Use Case 4:

No.	Action	Responsibility/ involvement
	Preparatory	
1	Agreement with Stakeholders on the institutional framework, governance, organization and use of data of the TSL- DS	ANKO, Regional Authority of Western Macedonia, CERTH/HIT, Managing Authority of Just Transition Development Programme 2021-2027
2	Definition of the resources (personnel and financial) needed for the operation of the TSL- DS	ANKO
3	Securing funding from the Region of W. Macedonia	ANKO
4	Mobilisation of resources, i.e. personnel, infrastructure and equipment	ANKO and Stakeholders
	Implementation	
5	Establishment of the TSL- DS	ANKO and Stakeholders involved
6	Development of TSL- DS datasets and services	ANKO and Stakeholders involved
7	Provision of services to interested parties. Dissemination and networking with potential clients and initiatives with similar and complementary scope	ANKO and Stakeholders involved
8	Participation in competitive projects (national and EU) pertinent to TSL- DS character	ANKO and Stakeholders involved

Ways and forms of cooperation

The stakeholders will collaborate through cross sectorial synergies for co-creating and implementing innovative actions/incentives to achieve climate neutrality. The ways and forms of cooperation will be described in the Memorandum of Understanding that the collaborative governance of the TSL will sign

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with the stakeholders of the various ecosystems (mobility, energy, agriculture, circular economy, industry) in a later stage.

Risk Assessment and Mitigation

Pilot Use Cases 1 & 2: According to the results of the feasibility studies of Pilot Use Case 1 and 2, zero emission mobility is feasible in the two case study cities of Kozani and Ptolemaida. From the economic point of view, the total cost of electrical buses seems almost equivalent with the conventional internal combustion diesel buses, travelling the same distances. From an environmental point, the transition to electric or hydrogen mobility would represent a great decrease in carbon dioxide emissions. In addition, if photovoltaic systems are implemented in situ to supply energy to electric vehicles or the hydrogen fuel is produced by RES, the reduction of CO2 emissions would be even more significant.

However, there are some **crucial aspects** to be considered in order to determine the most suitable solution of zero emission transportation system for Kozani and Ptolemaida, as follows:

1. **Battery Electric Buses (BEB) and Fuel Cell Electric Buses (FCEB) vehicles purchase price**

This depends on time, as BEB and FCEB prices are generally dropping, selected options of bus characteristics and charging / fuelling systems and the number of buses to be ordered. These can be supported though an accurate route profile and modelling and detailed techno-economic analysis.

2. **Transfer and storage system of PV energy and H2**

The transfer and storage of PV energy and H2 also play crucial roles in this system. The transfer of solar energy must be efficient to minimize losses during transmission from the point of generation to the point of use. Advanced infrastructure and technology are required to ensure that the energy remains viable for consumption in remote areas, such as the bus depots in Ptolemaida and Kozani. Storage solutions, particularly for hydrogen, demand careful attention to safety and efficiency. Hydrogen must be stored under high pressure or at very low temperatures, both of which require significant energy inputs and robust safety measures to prevent leaks or explosions, which could pose risks to the environment and local communities.

3. **Grant and Incentives provision**

At this early stage of market development, a grant and related incentives are needed to make most BEB and particular FCEB investments cost-effective. KTEL PT in Kozani and Ptolemaida should seek the largest grant possible, which will be determined by the Greek Government and the EC, or alternatively they should seek suitable project finance schemes. In addition, the taxation level on H2 fuel prices should be kept low, as it is a crucial factor for the viability of projects aiming to introduce zero-emission systems in public transport.

4. **Regulatory framework for the renewable H2 fuel production, storage and distribution system**

Currently, the regulatory and commercial landscape surrounding the production, storage, and distribution of renewable hydrogen for the transport sector is at early stages in Greece. Although the development of

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the regulatory framework of H2 fuel production, storage and distribution system is beyond TSL role and responsibilities, the European experience has been already described in the feasibility study of Pilot Use Case 2 and it will be examined at a later stage whether this experience from other (EU) countries can further accelerate development in Greece.

Consequently, critical parameters for planning the utilization of FCEBs in local public transport remain uncertain. However, it is noteworthy that the Western Macedonia Region is spearheading investments and research initiatives in renewable hydrogen production within Greece, so we anticipate rapid developments in this particular market quite soon.

Pilot Use Case 3: During the refining of parameters and measures/interventions, stakeholders may have differing opinions on the prioritization of measures or interventions, leading to delays in decision-making. This difficulty in achieving consensus and balancing competing interests may delay the process. However, by employing conflict resolution mechanisms and facilitating transparent and inclusive discussions, this delay can be avoided ensuring that all stakeholders have a voice in the decision-making process. Also, securing adequate funding may be challenging due to budget constraints or competition with other projects. For identifying the most suitable funding sources, the involved team will conduct thorough research to identify a diverse range of potential funding sources, including government grants, private investments, and international aid programs. During the promotion of applications for funding programs/projects, stakeholders may not be aware of available funding programs or how to navigate the application process effectively. This can reduce the likelihood of successful applications. To mitigate this risk, targeted outreach and communication strategies will be developed to raise awareness about available funding programs and provide guidance on the application process.

By proactively identifying and addressing these potential risks and challenges, project stakeholders can enhance the likelihood of successful Action Plan implementation and achieve their desired outcomes effectively.

Pilot Use Case 4: Overall, the creation of a Transition Super Lab in Kozani has the potential to contribute to the goal of climate neutrality and decarbonisation. However, there are some potential risks, such as political instability at local or national level that can lead to limited funding and infrastructure. The city of Kozani may face financial constraints that could limit its ability to fund the creation and operation of the Transition Super Lab. The city may also lack the necessary infrastructure, such as specialized equipment, to support the development of the Transition Super Lab. By leveraging the city's strengths, such as the strong political will that is confirmed by the fact that the Region of Western Macedonia has already announced the signing of a MoU for the establishment and the operation of the Transition Super Lab of Western Macedonia, abundant local resources and a skilled workforce but also examining collaboration with other cities and regions and spurring innovation and investment, the above-mentioned risks can be overcome. Also, contacts have been already done with the Managing Authority of the Just Transition Development Programme 2021-2027 for ensuring the required funding.

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Additionally, resistance from local stakeholders, who are reluctant of the benefits of transitioning to a low-carbon economy or who fear the potential economic impacts of such a transition could disrupt the development of the Transition Super Lab and hinder progress towards the goal of climate neutrality. Following continuous communication, experimentation, monitoring, and iterations in TSL operations, joint learning will take place increasing public and stakeholders' awareness and creating common understanding of the benefits of a Transition Super Lab.

Finally, there may be regulatory hurdles that could slow down the development and operation of the Transition Super Lab. By addressing region's weaknesses and threats and leveraging its strengths and opportunities, specific solutions for each of the regulatory issue that may arise will be provided and described in detail in the MoU that will be signed in the following months among the key stakeholders of the TSL of Western Macedonia. Thus, by addressing effectively the above challenges that may arise, the city of Kozani can maximize the potential impact of the Transition Super Lab towards achieving climate neutrality and decarbonisation.

Financing and funding options

As the Action Plan of the TSL in Western Macedonia is directly linked with the Just Transition Development Programme 2021-2027 of the Region, this will be the main financial instrument to focus in for all the use cases. But as the fields of the TSL are very wide, other sources of funding with lower (i.e. Regional Operational Plan of Western Macedonia 2021-2027) or higher (i.e Recovery and Resilience Facility / Recovery and Resilience Plan "Greece 2.0") financial opportunities will be examined for exploitation.

Pilot Use Cases 1 and 2

According to the technoeconomic analysis that has been performed in the feasibility studies the required funding for each of the time periods are shown in the tables below. Contacts have been already done with the Managing Authority of Just Transition Development Programme 2021-2027 for ensuring the required funding.

2028/2030	PV buses	H2 buses
Coverage average mileage (total 10% of PT fleet)	105,600 km / year for 16 years	
Capital cost:	1,048,000 €	1,300,000 €
PV plant Maintenance & operating cost– H2 cost:	60,473 €	749,609 €
Bus Batteries replacement cost- Fuel Cell + HV battery system replacement cost:	78,400 €	100,000 €
Bus Maintenance & Operation cost:	140,492 €	140,492 €

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Total:	1,327,365 €	2,290,101 €
Total Cost of Ownership- TCO (€/km)	**0.79**	**1.36**

2030	PV buses	H2 buses
Coverage average mileage (total 40% of remaining PT fleet)	422,400 km / year for 16 years	
Capital cost:	3,533,600 €	4,250,000 €
PV plant Maintenance & operating cost– H2 cost:	241,893 €	2,998,437 €
Bus Batteries replacement cost- Fuel Cell + HV battery system replacement cost:	268,800 €	320,000 €
Bus Maintenance & Operation cost:	561,966 €	561,966 €
Total:	4,606,259 €	8,130,403 €
TCO (€/km)	**0.68**	**1.20**

2040	PV buses	H2 buses
Coverage average mileage (total 50% of remaining PT fleet)	633,600 km / year for 16 years	
Capital cost:	3,533,600 €	5,650,000 €
PV plant Maintenance & operating cost– H2 cost:	302,366 €	4,047,890 €
Bus Batteries replacement cost- Fuel Cell + HV battery system replacement cost:	268,800 €	360,000 €
Bus Maintenance & Operation cost:	842,949 €	842,949 €

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Total:	4,947,716 €	10,900,840 €
TCO (€/km)	**0.49**	**1.08**

Pilot Use Case 3

Contacts have been already done with the Managing Authority of Just Transition Development Programme 2021-2027 for ensuring the required funding for the Implementation of Good Practices for Carbon Sequestration, Use and Storage in Agriculture and Livestock Production. The techno economic analysis of this use case will be performed in a later stage as soon as the required measures/initiatives to be implemented will be selected.

Pilot Use Case 4

To assess the financial viability of the TSL- DS, the following assumptions for its development are made:

1. The TLL- DS becomes an integral part of ANKO strategy and part of the time of selected personnel is used for its operation.
2. ANKO is by its Charter, and its design not allowed to charge for the provision of data, however added value services developed can be remunerated.
3. Participation in competitive projects (national and EU) pertinent to TSL- DS character is sought.
4. The main operators and stakeholders of the TSL- DS offer resources, data and information without charge.
5. Co- funding for its operation is sought from Operational Programmes of the Programme Period 2021-2027.
6. External expertise is used for the development of the TLL- DS services.

Based on a preliminary analysis shown in the table below, an amount in the order of **687,500€** would be required from the Region of Western Macedonia for funding the TSL- DS operation for the first 5 years.

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Income	**175,000**	**165,000**	**157,500**	**155,000**	**145,000**	**797,500**
Income from the provision of TSL- DS services	5,000	10,000	15.000	20.000	25.000	75.000
Income from participation in competitive projects (national and EU) pertinent to TSL- DS character	-	5,000	10.000	10.000	10.000	35.000
Income from regional funding of TSL- DS operation	170,000	150,000	132,500	125,000	110,000	687,500

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In the later stages, a more thorough economic study will be conducted to analyse how stakeholders' awareness of opportunity costs can enhance the TSL's decision-making process, leading to the identification and use of more sustainable solutions.

Impact assessment

Pilot Use Case 1 and 2

Both pilot use cases offer promising solutions for decarbonizing public transportation and promoting sustainability having positive impact in various fields.

Environmental Impact

The immediate environmental impact is notably positive, as it significantly reduces greenhouse gas emissions compared to conventional energy production methods that rely on burning fossil fuels. Additionally, solar energy production is associated with minimal water use and air pollution, enhancing its appeal as a sustainable energy solution. However, it's essential to consider the environmental and economic implications of manufacturing and disposing of solar panels, which include the use of rare earth elements and the challenge of recycling panel components.

Moreover, the consumption of PV energy and H2 in public transport buses introduces a transformative change in urban mobility. By utilizing clean energy sources, these buses significantly reduce carbon dioxide emissions and air pollutants, contributing to improved air quality and public health in Ptolemaida and Kozani. This shift also aligns with global efforts to combat climate change by reducing dependency on fossil fuels. Moreover, the adoption of green technologies in public transportation can foster public acceptance and increase awareness of sustainable practices among the local population.

Economic Feasibility

Economically, the investment in PV and H2 technologies for public transportation presents both challenges and opportunities. Initial capital costs for solar infrastructure, hydrogen production facilities, and retrofitting buses to run on hydrogen can be substantial. However, these investments are likely to pay off in the long term through reduced operational costs, as the price of solar energy and hydrogen is expected to become more competitive in comparison to fossil energy sources. Additionally, this initiative could stimulate local economies by creating jobs in the green energy sector and enhancing the technological expertise of the workforce.

Energy efficiency

PV panels convert sunlight into electricity with relatively high efficiency, contributing to the overall energy efficiency of the system while battery storage systems can efficiently store excess energy generated during daylight hours for later use, enhancing overall energy utilization. On the other hand, hydrogen fuel cells have high energy conversion efficiency, making them a promising alternative to traditional combustion engines. This combined with advances in hydrogen storage and transportation technologies are improving efficiency and safety.

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Societal impact

The implementation of renewable energy solutions like PV and H2 in the public transportation of Ptolemaida and Kozani will enhance the cities' images, showcasing the region's commitment to innovation and sustainability. This will increase the attractiveness of region in terms of new investments in public transport and thus lead to greater use of public transport. Additionally, reduced emissions from cleaner public transportation will lead to improved air quality, benefiting public health and well-being.

Below are listed some of the indicators identified at this stage for assessing the impact of pilot case 1 and 2:

- Share of RES and H2 in Public Transportation (for Pilot Use Case 1: 20% by 2030, 60% by 2035 and 100% by 2040, for Pilot Use Case 2: 11% by 2030, 60% by 2035 and 100% by 2040) Decrease in energy consumption of public transportation (incl. sub-indicators for fuel types) [MJ]: (for Pilot Use Case 1: decrease of 20% by 2030, decrease of 60% by 2035 and by 2045 both diesel & biodiesel fuel replaced totally by RES-PV / H2 fuel, for Pilot Use Case 1: decrease of 11% by 2030, decrease of 60% by 2035 and by 2045 both diesel & biodiesel fuel replaced totally by RES-PV / H2 fuel)
- Increase of energy efficiency per passenger-kilometre travelled. (MJ/p-km) (for Pilot Use Case 1: increase of 16% by 2030, of 43% by 2035 and of 66% by 2045. For Pilot Use Case 2: increase of 11% by 2030, of 46% by 2035 and of 70% by 2045
- Decrease of Greenhouse Gas (GHG) emissions [tn CO2eq and %] (for Pilot Use Case 1: decrease of 20% by 2030, of 60% by 2035 and of 100% by 2045. For Pilot Use Case 2: decrease of 11% by 2030, of 60% by 2035 and of 100% by 2045)
- Reduction of 20% in noise levels by 2045
- Decrease of operating cost (running and maintenance cost (€) (for Pilot Use Case 1: decrease of 12% (BEB) and 6% (FCEB) by 2030, of 40% (BEB) and 20% (FCEB) by 2035 and of 77% (BEB) and 42% (FCEB) by 2045. For Pilot Use Case 2: decrease of 7% (BEB) and 4% (FCEB) by 2030, of 41% (BEB) and 22% (FCEB) by 2035 and of 79% (BEB) and 45% (FCEB) by 2045)
- User satisfaction: increase of 20% of the users that are satisfied by the service (measured on a scale from 1 to 5)

Pilot Use Case 3

Carbon farming can provide numerous benefits to the environment, society, and the economy of Western Macedonia. By sequestering carbon in soil and vegetation, carbon farming can help reduce greenhouse gas emissions, mitigate climate change impacts, and improve soil health. Additionally, carbon farming practices, such as agroforestry, conservation tillage and cover cropping **can enhance biodiversity, improve water quality, and provide opportunities for sustainable agriculture and rural development.**

Carbon farming can also provide **economic benefits to farmers** by diversifying their income sources and improving the resilience of their farms to climate change impacts. Carbon credits and payments for ecosystem services can provide additional revenue streams for farmers, thus creating a new economic opportunity for rural communities.

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More particularly, implementing carbon farming practices in Kozani and the wider region of Western Macedonia can have several benefits at local and regional level. Some of the key benefits include:

- **Climate change mitigation:** Carbon farming practices can contribute to reducing greenhouse gas emissions and sequestering carbon in the soil and vegetation, thereby mitigating the effects of climate change. This can help to reduce the region's vulnerability to extreme weather events such as droughts and floods.
- **Improved soil health:** Many carbon farming practices, such as conservation tillage, cover cropping, and crop rotation, can improve soil health and fertility. This can result in higher crop yields, better water retention, and increased resilience to extreme weather conditions.
- **Biodiversity conservation:** Implementing carbon farming practices such as agroforestry, conservation tillage, and the restoration of degraded lands can create habitats for biodiversity, promote the return of native species, and increase the overall biodiversity of the region.
- **Economic benefits:** Carbon farming can create new economic opportunities for local farmers and landowners. By implementing carbon farming practices, farmers can potentially earn additional income by selling carbon credits or participating in carbon offset programs.
- **Improved air and water quality:** Carbon farming practices can also contribute to improving air and water quality. For example, planting trees and other vegetation can absorb pollutants from the air, while reducing the use of synthetic fertilizers and pesticides can prevent contamination of water resources.

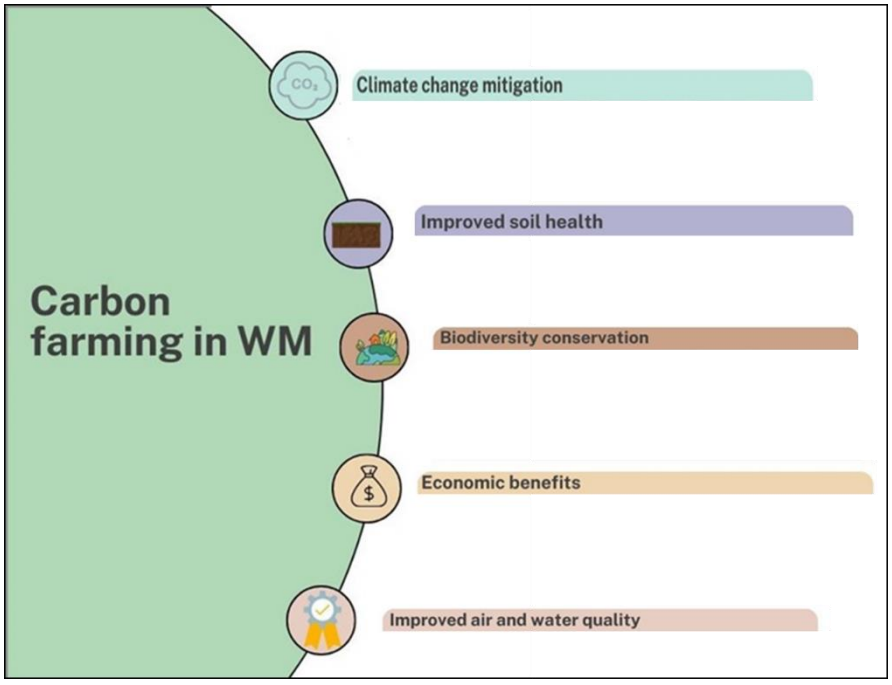

Figure 7: Key benefits of Pilot Use Case 3

Moreover, there is a strong link between carbon farming and circular economy farms. A circular economy farm is a farm that operates in a closed-loop system, where resources are conserved, and waste is

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minimized using regenerative practices. **Carbon farming practices are a key component of a circular economy farm, as they can help to sequester carbon in the soil and vegetation, reducing the amount of carbon released into the atmosphere**. By implementing carbon farming practices, such as cover cropping, conservation tillage, and agroforestry, farmers can also improve soil health, reduce erosion, and conserve water resources. This can result in higher crop yields, improved farm productivity, and reduced inputs of water, fertilizers, and pesticides.

Moreover, the carbon captured through carbon farming can be used to create value-added products, such as biochar, which can be used as a soil amendment to improve soil fertility and water retention. Biochar can also be used as a feedstock for renewable energy production, creating additional economic opportunities for farmers.

In circular economy farms, waste materials, such as crop residues, manure and food waste can also be used to create value-added products. For example, crop residues can be used as a feedstock for biofuel production, while manure can be used as a soil amendment to improve soil fertility.

Overall, the link between carbon farming and circular economy farms is clear, as both aim to reduce waste, conserve resources, and create value from waste materials. By implementing carbon farming practices in a circular economy farm, farmers can create a more sustainable and regenerative farm system, contributing to the overall goal of a more sustainable and resilient food system.

Some of the Key Performance Indicators (KPIs) that have been identified so far as they can contribute to the impact assessment of pilot 3 are the following:

- CO2 captured and used or stored from agriculture activities compared to emissions [30% by 2030]
- GHG emissions reduction of the farm's activity [Mt CO2eq and %]. The reduction depends on the applied measure by 2030. For machinery measures the expected reduction is 75% (0.029 MtCO2eq). For Livestock Farming measures the expected reduction ranges from 3-5% (0.002-0.004 MtCO2eq). For Agricultural Practices the expected reduction ranges from 10-20% (0.017-0.034 MtCO2eq).
- Cost Savings (€). The cost savings depend on the applied measure by 2030. For machinery measures the expected cost savings are more than 6M euro, for Livestock Farming measures the expected cost savings range from 5,000 to more than 400,000 euro and for Agricultural Practices the expected cost savings range from 300,000 to more than 1M euros.
- Innovative practices used [20% of the available cases in the Region of Western Macedonia to applied innovative practices by 2030]

Pilot Use Case 4:

The Transition Super Lab will offer several benefits, including innovation, stakeholder engagement, capacity building for sustainable innovation and policy impact. Transition Super labs can have a significant impact on policy by generating evidence and insights for policy development and implementation. By

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involving policymakers in transition living labs, cross sectorial solutions can be co-created, tested, and refined, leading to more effective and sustainable policies towards climate neutrality.

The development of the Transition Super Lab in Kozani will provide an opportunity for collaboration with other cities and regions that are also pursuing the goal of climate neutrality, which could enhance the impact of the initiative. It will also spur innovation in the region and attract new businesses and investment.

Additionally, the Transition Super Lab will contribute to the achievement of climate neutrality through:

- Facilitating the development and implementation of cross-sectorial solutions through the collaboration of actors from different sectors.
- Supporting local community engagement and empowerment.
- Identifying the key challenges to achieve climate neutrality and developing strategies and solutions to address these challenges.
- Enhancing the monitoring and evaluation of the transition to climate neutrality through the collection and analysis of cross-sectorial data to identify areas where additional efforts are needed, support decision making and create value proposition for all the stakeholders of the different ecosystems (mobility, energy, agriculture, circular economy, industry).
- Decision support through informed decisions on how to allocate resources and prioritize actions to achieve climate neutrality.

Monitoring and Evaluation

Monitoring and evaluating plan's progress

A robust monitoring and reporting system to track the progress and outcomes of the Action Plan of each use case will be established. This system will include the collection of the required data from the pilot use cases to calculate the relevant indicators and metrics as identified in the impact assessment. The collected insights may be shared with stakeholders, decision-makers, and the public to ensure transparency and accountability. The monitoring results may serve to showcase achievements and guide decision-making by identifying areas for enhancement and necessary adjustments to the Action Plans.

Criteria for success and a plan for adjustments

The achievement of the objectives and the expected impact as described in the previous actions are the criteria for success of each pilot use case. Creating a plan for adjustments is essential to ensure flexibility and adaptability in case the initial plan is not achieving the desired results. The continuous monitoring of KPIs will facilitate the early warning signs identification including significant deviations from KPIs thresholds, projected timelines, budget overruns, or unanticipated challenges. If early warning signs are detected, a thorough root cause analysis will be conducted to understand why the plan is not achieving the desired results. This could involve examining factors such as implementation challenges, external constraints, or unforeseen risks.

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Based on the results of the root cause analysis, alternative approaches or interventions that could address the identified shortcomings and improve outcomes will be designed considering aspects of feasibility, scalability, and alignment with project objectives. The next step is the development of a detailed plan outlining specific adjustments or modifications to the current plan including revised timelines, reallocated resources, refined strategies, or additional funding sources. After the implementation and the evaluation of the adjustment plan, an iteration and refinement of the adjusted plan is needed to incorporate lessons learned from the experience to inform future decision-making and improve overall project performance.

5.3 Recommendations for action

The long-term implementation and establishment of the TSL in Western Macedonia should follow specific steps with the active involvement of the core players and key stakeholders of the regional ecosystem at a very early stage.

The first step is the identification of the core players who compose the **Co-ordination & Management Team** that coordinates and manages the entire TSL. It is critical to define the roles and responsibilities of these core players at the very beginning to avoid conflict of interest during the operation of the TSL. Specifically, in the TSL of Western Macedonia the Co-ordination & Management Team consists of the Regional Authority of Western Macedonia, ANKO and CERTH. The Regional Authority has already recognised the establishment of a cross-sectorial (i.e. mobility, energy, circular economy etc.) TSL in Western Macedonia as a regional body/mechanism for governance and leverage of the local ecosystem that will support the acceleration towards climate neutrality. ANKO is the stakeholder that will lead as **coordinator** the governance of the TSL and its management, while CERTH will be the main scientific and technical expert/consultant of the governance scheme.

The Co-ordination & Management team considering the transition needs and potentials of the entire region, as well as the specific pilot use cases will undertake the control of the TSL actions (milestones & tasks), the TSL stakeholders' engagement and management (including the veto players) and the TSL decision making (partially depending on pilot use case decisions). Also, this team will be responsible for developing and following a successful business plan, identifying human and financial resources, implementing conflict resolution mechanisms for cross sectorial stakeholders and applying mitigation measures in case of risks to ensure the long-term sustainability and viability of the TSL. Representatives of each party of the Co-ordination & Management team (Regional Authority of Western Macedonia, ANKO and CERTH) will form the **TSL Daily Working Group** (or "TSL Operational Team" or "TSL Daily Operations Team").Along with the Co-ordination and Management team, the TSL needs a **Reflexive Monitoring Scheme**, not necessary a board, that will monitor whether actions align with regional transition goals simultaneously with TSL processes, giving advises to the TSL management team on transition-related content, as well as TSL coordination and management issues (e.g., suggesting streamlining of management and coordination processes; continuously reflecting on whether all necessary stakeholders are represented in the TSL management team).

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Important role in the Reflexive Monitoring Scheme of the TSL of Western Macedonia should have regional key stakeholders who could provide scientific and technical expertise on different fields including sustainable development towards climate neutrality & systems thinking, policy analysis, stakeholder engagement & social inclusion, spatial and regional planning, economic development & innovation management, data analysis and interpretation, evaluation methodologies and risk assessment among others. Thus, the University of Western Macedonia and the Institute of Energy Development and Transition to the Post-Lignite Era should participate in the Reflexive Monitoring Scheme of the TSL sharing valuable knowledge and expertise on the transition. Representatives from the Regional Authority and CERTH will be also members of the Reflexive Monitoring Scheme to ensure the alignment between the scheme and the Co-ordination and Management team.

The identification of "**Supporting Stakeholders"** of the TSL has to be expanded to additional stakeholders that can support the TSL goals in terms of generation of ideas and innovations (not just pilot use case goals) and generation and provision of data. Thus, the Managing Authority of Just Transition Development Programme 2021-2027 is important to support the TSL in terms of planning and financing its operation. Two more stakeholders with crucial role for financial support of the TSL are the Managing Authority of Western Macedonia Operational Programme 2021-2027 along with the Regional Development Fund of W. Macedonia.

Other important supporting stakeholders for the TSL of Western Macedonia are the Cluster of Bioeconomy and Environment of Western Macedonia (CLUBE) and DIADYMA. CLUBE could support the networking and the development of cross sectorial synergies between local/regional players and businesses within TSL enhancing the regional innovation capacity and increasing the added value of the TSL. DIADYMA will support the enhancement of the circular economy in the Region as it will be the managing body of the circular economy park that is planned to be developed in the following period. In case of identification of "**Opposing Stakeholders"** (veto players), these will be strategically managed by the Co-ordination and Management Team.

As a result of the involvement of the above-mentioned stakeholders of the quadruple helix and from different sectors as identified so far, projects of small but also bigger scale should be methodologically and technically co-created and matured in order to be financed in terms of climate neutrality, considering also their transferability and scalability. Starting from small projects, but with high transferability and scalability potential (especially Pilot Use Cases 1 and 2) as described in D3.2, TSL of Western Macedonia currently follows an approach of model locations rather than the approach of a model region, demonstrating the scalability advantages of such approach.

The pilot use cases require a project-specific form of governance that may significantly differ from the overall TSL governance (depending on the complexity and scope of the project) and specific stakeholders to be involved (for the four pilot use cases that have been co-created within TRANSFORMER project, the specific stakeholders to be involved have been already presented in the previous sections). However, every pilot use case needs to have at least one responsible organization/person (Pilot Use Case

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Coordinator/Manager) that interacts with the TSL Co-ordination and Management team and a Pilot Use Case Operational Team, while the related tasks depend on focus, complexity and scope of the pilot use case.

Although the four pilot use cases as described in the previous sections will generate the first datasets for the TSL of Western Macedonia, a long-term operation requires the creation of a framework for the collection of data per TSL's sector that will provide a sufficient data base for the region, along with measuring and monitoring of Key Performance Indicators that will assess the success and efficiency of the transition process of the Region of Western Macedonia.

Thus, a dynamic database with reference to all the key indicators related to the just transition will be created. In this way, the public debate and the effectiveness of any policies or actions will not be based simply on announcements of intentions nor on fragmentary evidence that is based more on intuition and less on the reliability of scientific analysis. On the contrary, it will be based on objective data that will enable policymakers to assess the effectiveness of their decisions in a timely and valid manner and to make corrective actions when needed. The TSL is suggested to analyse, assess and document the dynamic impacts of de-lignification on key sectors and indicators providing useful data to examine the feasibility of cross sectorial actions. All the former information is part of the content of the Action Plan of the Pilot Use Case 4 as it is described in section "Developing concrete actions through pilot use cases". Although the first aspects of this Action Plan have been already presented, discussed and validated by the key stakeholders in the Transitioncamp organised on 14 March 2024 additional aspects related to the implementation of the TSL's operation will be examined. Thus, following continuous communication, experimentation, monitoring, and iterations in TSL operations joint learning will take place and the TSL's Action Plan will be further re-framed and re-designed beyond the lifetime of TRANSFORMER project.

The initiative for the creation and establishment of the TSL in the Region is in progress, as the preparation of a **Memorandum of Understanding (MoU) among the core players** has already been discussed and matured. As announced by the Regional Governor of Western Macedonia during the TRANSFORMER Consortium Meeting that took place in Kozani (21 March 2024), this MoU will be signed by the Region of Western Macedonia, ANKO and CERTH in the following months while it is foreseen to be signed by more stakeholders at a next stage.

Finally, the TSL, should be active in networking on a national and European level. Thus, the recognition of Western Macedonia's TSL as an official certified member of ENOLL is recommended.

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6 Conclusions and Outlook

The four TSL regions have developed their Action Plans following the ambitious goal of the deliverable. On the one hand, they have elaborated on concrete actions that will take place in a short term, some of them even during the project-lifetime. Here, the TSLs have demonstrated in detail how individual pilot use cases can contribute to the development of a TSL: which resources are necessary, which stakeholders need to be involved etc. On the other hand, the TSL regions have addressed another core claim of this deliverable: long-term implementation and establishment of TSLs. As already mentioned in the introduction to this deliverable, bringing both aspects together in a constructive way can be quite challenging, especially when there is no role model to follow.

TRANSFORMER is developing a new concept and, therefore, it is not only about experimentation but the project itself is a case for experimentation. Transition Super-Labs are definitely more than just what is known as the concept of living labs, and TRANSFORMER is exploring the new concept, also through the Action Plans.

Certainly, the four Action Plans differ from each other in several aspects. There are many factors, for example, specific regional peculiarities that influence the direction and the focus of an action plan. Furthermore, under the umbrella of the general topic of climate neutrality, there are many different topics, and a variety of them is covered by TRANSFORMER. In the project, we are aware that such a complexity cannot be addressed just by a template or a too schematic approach. Nevertheless, from the very start of the task development, we have worked on a common structure for the Action Plans. This structure was developed through numerous intensive discussions among the project partners. The four TSLs have built their Action Plans upon this structure. Hence, despite all the differences between the regions, a common structure can be clearly recognised in the deliverable.

At the same time, the Action Plans have different strengths and probably also weaknesses. Some of them have been addressed by two external reviews of the deliverable. Generally, they confirm the good quality of the Action Plans. However, they also critically discuss some aspects of the Action Plans and share suggestions for improvements. The TSL regions have responded to all comments made by the external reviewers and have addressed them in their Action Plans whenever they considered it necessary and feasible.

The external reviews deliver many valuable suggestions. At the same time, they reveal that there is a significant challenge for further development of the TSL concept: there is a considerable gap between the theoretical approach and the practical implementation. For example, while achieving a high level of co-creation and involving of a broad variety of different societal groups and actors are some of the core principles of Transition Super-Labs, the Action Plans still need to be realistic and feasible when it comes to implementation in concrete environments with real power relationships, budget limits and, altogether, a room for manoeuvre which is usually not as spacious as the concept is suggesting. While the concept should be ambitious and aim to help accelerate the shift to climate neutrality through unexplored

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methods and topics, it should always consider the real factors for the development of such collaborative governance arrangement and not guide itself primarily by wishful thinking.

The Action Plans are demonstrating how important it is to find a balance between ambitious and complex approaches on the one hand and pragmatic solutions on the other hand. Furthermore, through the Action Plans development it has become even clearer that the TSL concept needs to deal with the challenge, if not to say dilemma, of speeding up the transition to climate neutrality, while at the same time creating sufficient space for experimentation and inclusion of unusual suspects. The latter might imply more time, and patience and support for promising initiatives can be an important success factor.

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