ARV

CLIMATE POSITIVE CIRCULAR COMMUNITIES

D10.8 A BLUEPRINT FOR PLANNING, (RE)DESIGN, (RE)CONSTRUCTION, OPERATION, AND USE OF CLIMATE POSITIVE CIRCULAR COMMUNITIES

WP 10 COMMUNICATION, DISSEMINATION, AND STAKEHOLDER OUTREACH

Jesus Daniel Garcia Melo
Inger Andresen
Niki Gaitani

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Lead Author	Jesus Daniel Garcia Melo, Norwegian University of Science and Technology (NTNU)			
Contributors	Inger Andresen (NTNU), Niki Gaitani (NTNU)			
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[1] *ARV is a Norwegian word meaning "heritage" or "legacy". It reflects the emphasis on circularity, a key aspect in reaching the project's main goal of boosting the building renovation rate in Europe.*

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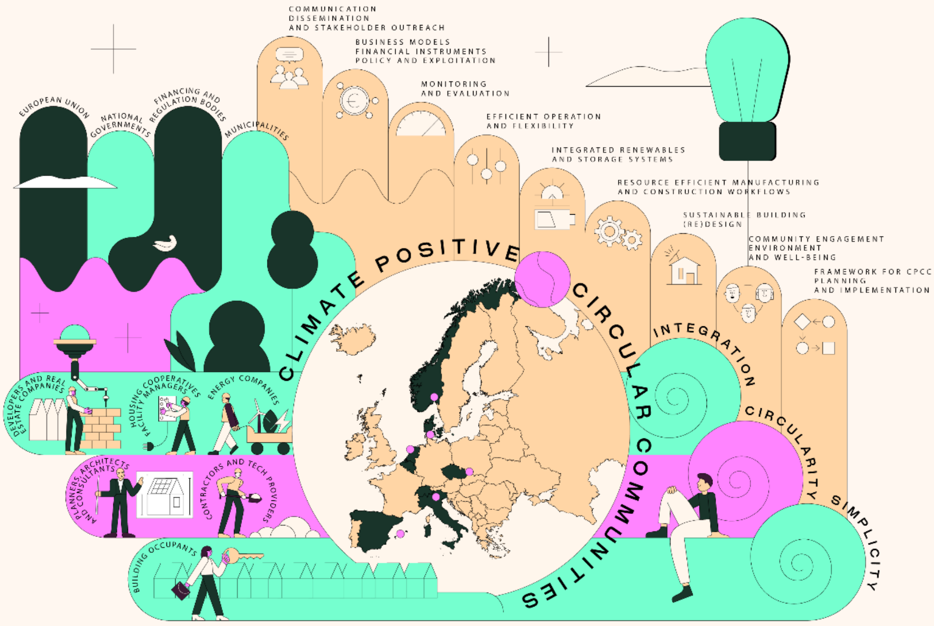
ABOUT THE ARV PROJECT

The vision of the ARV project is to contribute to speedy and wide scale implementation of Climate Positive Circular Communities (CPCC) where people can thrive and prosper for generations to come. The overall aim is to demonstrate and validate attractive, resilient, and affordable solutions for CPCC that will significantly speed up the deep energy renovations and the deployment of energy and climate measures in the construction and energy industries. To achieve this, the ARV project will employ a novel concept relying on a combination of 3 conceptual pillars, 6 demonstration projects, and 9 thematic focus areas.

The 3 conceptual pillars are integration, circularity, and simplicity. **Integration** in ARV means the coupling of people, buildings, and energy systems, through multi-stakeholder co-creation and use of innovative digital tools. **Circularity** in ARV means a systematic way of addressing circular economy through integrated use of Life Cycle Assessment, digital logbooks, and material banks. **Simplicity** in ARV means to make the solutions easy to understand and use for all stakeholders, from manufacturers to end-users.

The 6 demonstration projects are urban regeneration projects in 6 locations around Europe. They have been carefully selected to represent the different European climates and contexts, and due to their high ambitions in environmental, social, and economic sustainability. Renovation of social housing and public buildings are specifically focused. Together, they will demonstrate more than 50 innovations in more than 150,000 m² of buildings.

The 9 thematic focus areas are 1) Effective planning and implementation of CPCCs, 2) Enhancing citizen engagement, environment, and well-being, 3) Sustainable building re(design) 4) Resource efficient manufacturing and construction workflows, 5) Smart integration of renewables and storage systems, 6) Effective management of energy and flexibility, 7) Continuous monitoring and evaluation, 8) New business models and financial mechanisms, policy instruments and exploitation, and 9) Effective communication, dissemination, and stakeholder outreach.



The ARV project is an Innovation Action that has received funding under the Green Deal Call LC-GD-4-1-2020 - Building and renovating in an energy and resource efficient way. The project started in January 2022 and has a project period of 4 years, until December 2025. The project is coordinated by the Norwegian University of Science and Technology and involves 35 partners from 8 different European Countries.

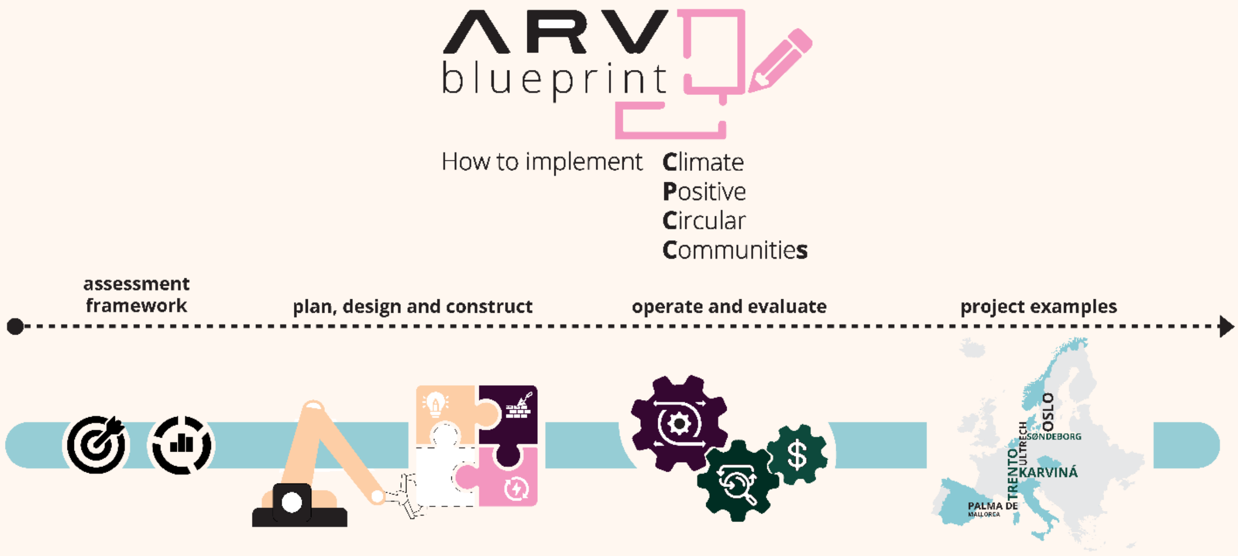
EXECUTIVE SUMMARY

The ARV project presents a pioneering initiative to craft a Blueprint that transcends conventional guidelines, offering a comprehensive framework to navigate the development of Climate Positive Circular Communities (CPCCs). With the engagement of a diverse stakeholder base ranging from urban planners and architects to product and service providers, developers, owners, and public authorities, this dynamic guideline fosters collaboration and innovation, serving both internal assessments and public reviews. It encompasses a synthesis of collective insights, lessons learned, and best practices drawn from the ARV project activities.

Beyond a static document, the Blueprint aspires to become an interactive online tool, maximising accessibility and relevance for stakeholders. Although this tool is not included as an official project deliverable, the ARV blueprint will lay important groundwork. It will provide a visually appealing digital guide with integrated links and cross-references to facilitate navigation and understanding. This dynamic evolution reflects ongoing advancements in CPCCs, forging a robust connection with the ARV e-marketplace. As we embark on the journey to realise Climate Positive Circular Communities, this third version of the report encapsulates three years of the project, providing insights into some areas while anticipating later contributions.

The report will be updated annually during the course of the ARV project, to make a complete guideline at the end of the project.

Our strategic roadmap delineates a set of objectives aimed at presenting a holistic view of CPCC development within the ARV project. These objectives encompass providing comprehensive guidance for stakeholders throughout CPCC planning, design, construction, operation, and evaluation. They also focus on fostering collaboration and innovation, integrating insights from the ARV project to facilitate practical CPCC realisation.



Main structure of the ARV Blueprint (Graphics: Jesus Daniel Garcia Melo – NTNU)

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1. INTRODUCTION

This Blueprint document is meant to be more than a set of guidelines; it should be a framework designed to serve as a compass for all stakeholders engaged in how to plan, design, construct, operate, and evaluate Climate Positive Circular Communities (CPCCs). From urban planners and architects to product and service providers, developers, owners, and public authorities, this comprehensive guideline offers a structured path toward collaboration and innovation in the pursuit of Climate Positive Circular Communities. Beyond being an overall guide for both internal assessment and public review, it is a visionary Blueprint that integrates all the work, lessons learned, and best practices from the activities in the ARV project.

Within the pages of this Blueprint, we delve into the essential domains that encapsulate CPCC development, echoing the work packages and activities delineated in ARV: the Assessment framework, Sustainable Planning and Building Design, Resource Efficient (Pre)Manufacturing and Construction, Integrated Renewables and Storage Systems, Efficient Operation and Flexibility, Methods and Tools, Business Models, and Financial Instruments. This Blueprint unifies these aspects into a cohesive narrative, bridging theory and practice, to guide users through the complex journey of CPCC development.

The document contains a high number of graphics and illustrations to summarise the information of the referenced reports, facilitation for future usability in the form of a handbook or via a digital platform. We foresee this document to evolve into a more dynamic resource, reflecting the ongoing developments in the field of CPCCs within the ARV project. We envision a strong connection with the ARV e-marketplace (Task 10.3), where knowledge and resources will converge to facilitate the realisation of CPCCs.

The first version of this document was delivered in M12 (Dec 2022) and the second version in M24 (Dec 2023). This is the third version of the report, in which results from the different focus area of the project are summarised. The final version will be delivered by the end of the project (M60) summarising all findings from the project in the form of a guideline for dissemination to relevant stakeholders.

2. OBJECTIVES

The following objectives collectively form a strategic roadmap to create an overall and illustrative picture of the work packages and activities of the ARV project and show how each area contributes to the development of Climate Positive Circular Communities (CPCCs). They encompass:

Provide a Comprehensive Guidance: To offer a robust summary framework that acts as a comprehensive guide for stakeholders involved in the planning, design, construction, operation, and evaluation of Climate Positive Circular Communities (CPCCs).

Facilitate Collaboration and Innovation: To create a structured pathway that encourages collaboration and innovation among diverse stakeholders, including urban planners, architects, product and service providers, developers, owners, and public authorities.

Integrate ARV Project Insights: To amalgamate the collective work, lessons learned, and best practices from various activities within the ARV project, ensuring that the Blueprint reflects cutting-edge developments and knowledge.

Bridge Complexity and Simplicity: To unify the essential domains of CPCC development, mirroring the work packages and activities outlined in the ARV project, thus creating a cohesive narrative that translates the complex interaction within the project areas into a compact and more visual approach.

Provide an intuitive communication method: To develop the Blueprint into a flexible and user-friendly document with information accessible to stakeholders, enhancing its reachability and usability.

Reflect Ongoing Developments: To ensure the Blueprint evolves as a dynamic resource, adapting to the evolving landscape of CPCCs and continuously incorporating the latest developments in the field.

Connect with ARV e-Marketplace: To establish a strong connection between the Blueprint and the ARV e-marketplace, where knowledge and resources converge to facilitate the practical realisation of CPCCs.

3. MAIN TOPICS OF THE BLUEPRINT

This chapter provides an overview of the main topics to be included in the Blueprint. The topics are based on the main work packages and tasks of the ARV project and will be populated with results from the work within the project. Figure 21 shows the synergy within the different areas and the workflow of the activities.

The various topics covered in the Blueprint are interconnected in diverse ways, and their organisation aims to ensure accessibility and comprehensibility for a wide range of users and contexts. The Blueprint's design will enable users to easily locate topics of interest, providing them with customised tips and recommendations that align with their specific needs. Additionally, users will have access to relevant resources for further information, ensuring a rich and informative experience.

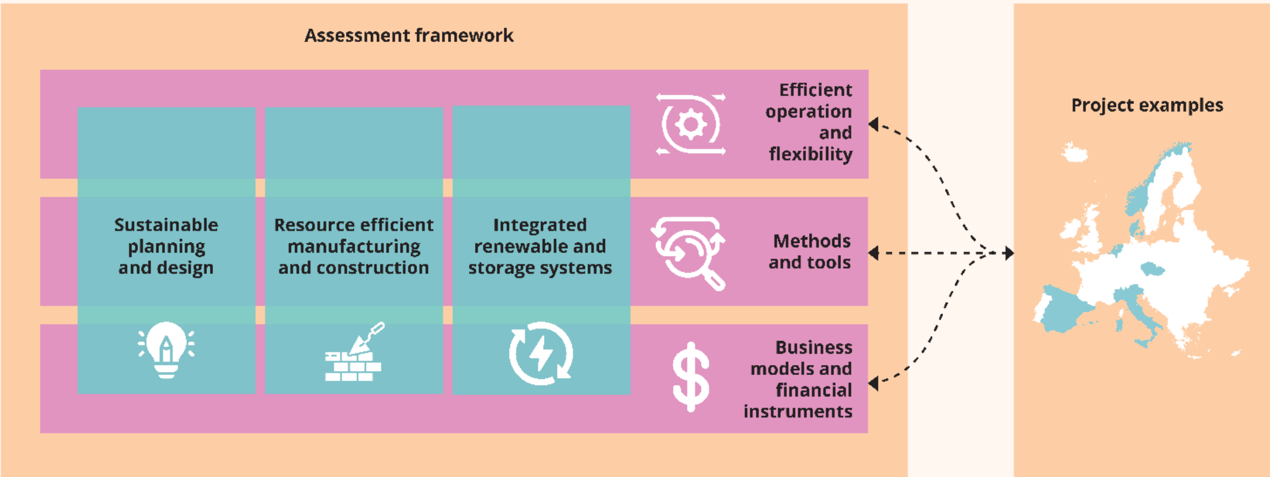


Figure 1 *Examples of main topics included in the Blueprint. (Jesus Daniel Garcia Melo – NTNU)*

The synergy workflow in the ARV project operates within a well-structured **assessment framework** that encompasses three main **process pillars:** 1) Sustainable Planning and Building (Re)Design, 2) Resource Efficient (Pre)Manufacturing and Construction, and 3) Integrated Renewables and Storage Systems; and three **cross-cutting** areas: 1) Efficient Operation and Flexibility, 2) Methods, Tools and Business Models, and 3) Financial Instruments. The process pillars and the cross-cutting areas culminate in the illustration of the **project examples**.

For this version of the report, we have organised the chapters according to the main work packages and activities in the ARV project, as follows:

Chapter 3.1 Assessment Framework: This forms the foundation, laying out the Key Performance Indicators (KPIs) that act as guiding stars for planning, design, and the ultimate evaluation of Climate Positive Circular Communities (CPCCs). The assessment framework ensures that every aspect of CPCC development is aligned with sustainability and environmental goals.

Chapter 3.2 Sustainable Planning and Building (Re)Design: This pillar is the first cornerstone in the main process, detailing the processes that underpin the planning and design of CPCCs. It outlines the principles and methodologies necessary for creating communities that not only mitigate environmental impacts but also promote sustainable living.

Chapter 3.3 Resource Efficient (Pre)Manufacturing and Construction: The second pillar delves into the workflows governing the manufacturing and construction of CPCCs. It emphasises the importance of resource efficiency and circularity in the production process, striving for minimal environmental footprint.

Chapter 3.4 Integrated Renewables and Storage Systems: Focusing on the design, operation, and performance of energy systems within CPCCs, this area ensures that renewable energy sources and storage systems are seamlessly integrated to meet energy demands and support sustainability goals.

Chapter 3.5 Efficient Operation and Flexibility: Within this cross-curricular area, the efficient operation and energy flexibility management in CPCCs are outlined. This is essential for adapting to changing energy needs and ensuring operational efficiency.

Chapter 3.6 Methods and Tools: This area provides methods and tools for assessing the environmental, social, and economic impacts of CPCCs. It enables a comprehensive evaluation of a project's sustainability across various dimensions.

Chapter 3.7 Business Models and Financial Instruments: Describing a range of tools and instruments, this area offers insight into the financial aspects of CPCC implementation, making the solutions more economically viable and scalable.

Chapter 3.8 Project Examples: Finally, the synergy is realised through Project Examples, which serve as practical demonstrations of best practices drawn from the six real-life demonstration projects of ARV. These real-world cases illustrate how the principles and methodologies from the three pillars and three cross-curricular areas are applied in actual CPCC development.

Lastly, the report provides a brief description of goals of the implementation and the transition to an interactive digital guideline.

3.1. THE ASSESSMENT FRAMEWORK

This chapter includes an overview of the goals and KPIs as defined in the ARV assessment framework for CPCCs. The framework is described in the report 'D2.1 Assessment Framework for CPCC', that was delivered in September 2022 (M9). The framework is currently being tested in the ARV demo projects and will be updated based on the lessons learnt during the implementation in the ARV CPCCs. A Climate Positive Circular Community (CPCC) is defined as an urban area which aims to achieve net zero greenhouse gas emissions, enable energy flexibility, and promote a circular economy and social sustainability. The CPCC concept focuses strongly on the interaction and integration between new and regenerated buildings, users, and energy systems, facilitated by ICT to provide attractive, resilient, and affordable solutions for citizens. The specific goals set for the ARV CPCCs are shown in Table 1.

***Table 1** The main goals for the CPCCs in ARV.*

Assessment criteria	Goals for new constructions	Goals for renovated buildings
Energy	**At least 50% reduction in energy needs** compared to current country building code. **Positive energy** level based on primary energy	**At least 50% reduction in energy needs** compared to pre-renovation levels. At least **nZEB** standard.
Indoor environment quality	High levels of indoor environment quality according to EU norms.	**At least 30% improvement** compared to pre-retrofitting levels according to EN 16798-1:2019
Noise and dust levels	According to the EU health, safety, and environment standards.	**At least 30 % reduction** in occupant disruption during retrofitting compared to local current practice
Embodied emissions	**At least 50% reduction** compared to local current practice	
Construction/retrofitting time	**At least 30% reduction** compared to local current practice	
Life Cycle Costs	**At least 20% reduction** for the community compared to local current practice	
Construction/retrofitting costs	**At least 30% reduction** compared to local current practice	
Circularity	The CPCC should be designed to support the transition to a circular economy by implementing regenerative systems in which resource input and waste, emissions, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. The building components and systems are designed to be long-lasting, easy to repair, reused, remanufactured, refurbished, and recycled. Where possible, local and second-hand materials are used.	
Social sustainability	CPCCs focus on people, i.e., their specific needs, interaction, and wellbeing, and provide good indoor and outdoor environmental conditions, spatial qualities and equal accessibility for persons with disabilities and senior citizens.	

A clear formulation of performance goals with associated Key Performance Indicators (KPIs) will help to guide the involved actors throughout the planning, design, construction, and operation phases, and is a prerequisite for a successful outcome. The ARV assessment framework goes beyond the traditional sustainability assessment of buildings, to highlight the importance of a neighbourhood-based approach in a life cycle perspective, taking into account architectural qualities, circularity aspects and energy, environmental, economic, well-being and social impacts of CPCC implementation. Hence, the main categories of Key Performance Indicators (KPIs) selected for the ARV assessment framework are *energy, environment, social, architecture, circularity, and economics*, see Figure 2.

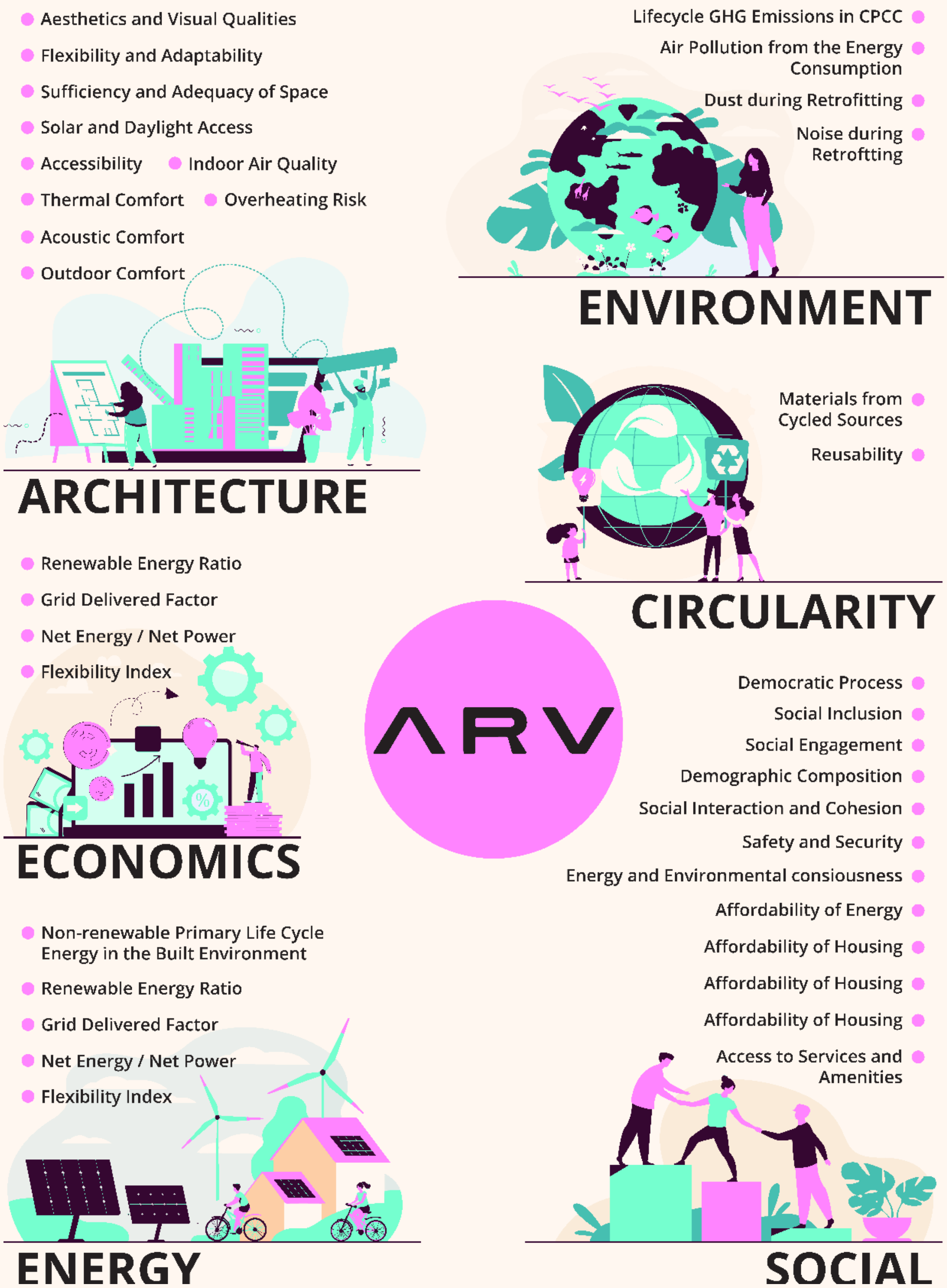


Figure 2 *The main categories of key performance indicators for CPCCs, along with sub-indicators (ref D2.1). (Graphics: Jesus Daniel Garcia Melo – NTNU)*

There are several sub-indicators for each of the 6 categories. Some of the indicators are quantitative and may be calculated or measured directly, others are more qualitative and need other methods of assessment, such as user surveys or expert evaluation. This is further described in D8.1 'Report on the monitoring, evaluation, and impact assessment' delivered in December 2022 (M12). The KPIs and assessment methods are currently being tested out in the ARV demo projects.

3.2. SUSTAINABLE PLANNING AND BUILDING (RE)DESIGN

This chapter includes descriptions of planning and design processes to be applied for CPCCs.

OVERVIEW

The design of new and retrofitting buildings to become CPPCs has as main objectives to reduce the embodied energy and emissions, increase energy efficiency, and achieve a balance between sustainability, aesthetics, and quality of life through integrated circular design processes.

Different methods and strategies are considered for the early phases of planning and design to harmonise sustainability during the entire process. Different aspects are encompassed such as adapting to local climate conditions, performing deep renovations with minimal disruption to occupants, and significantly reducing greenhouse gas emissions. The design approaches emphasise high energy efficiency using active and passive solutions, with a strong focus on circularity by reducing, reusing, and recycling materials, elements, and modules. The design also aims to add value and efficiently integrate photovoltaics (BIPV & BAPV), all while considering occupant well-being and architectural aspects.

These methods and strategies are implemented in the in the ARV demo projects as part of the design innovations, and their application vary depending on their context, climates, cultures, and markets (Figure 3).

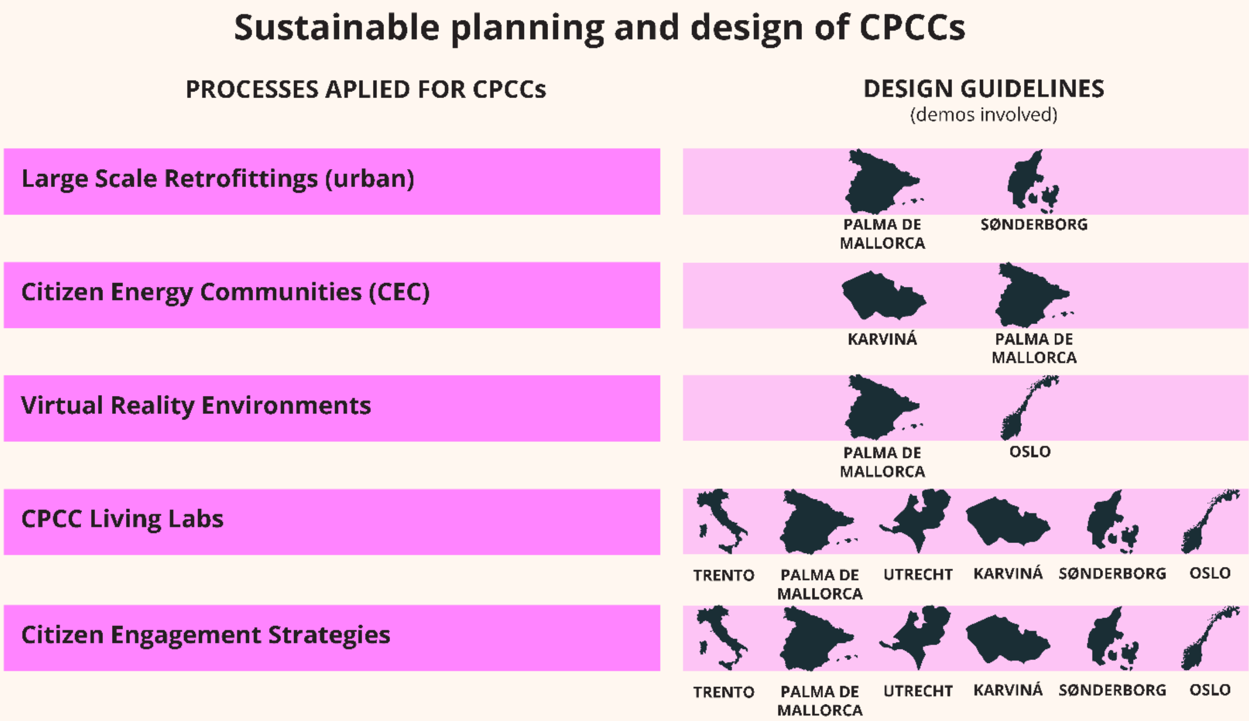


Figure 3 *Overview of processes applied for CPCCs and their respective application in ARV project demos. (Jesus Daniel Garcia Melo – NTNU)*

PROCESSES APPLIED FOR CPCCS

Large Scale Retrofitting

Deliverable

D2.4 *Application of tools for large-Scale Retrofitting actions. Use cases and guidelines for replicability, to be delivered in M42.*

When discussing tools for neighbourhood planning, it is essential to consider two key innovative aspects. Firstly, the incorporation of renewable energy sources, specifically solar and wind power, plays a critical role in addressing the distribution and sharing of energy among different participants and end-users within Climate Positive Circular Communities. Secondly, there is the challenge of retrofitting existing neighbourhoods on a large scale while considering both climate neutrality and economic perspectives.

One of ARV's objectives is to enhance District Energy Simulation Tools for efficient planning, design, and analysis of large-scale retrofitting initiatives within urban areas. Such tools incorporate diverse modelling strategies, including building archetypes, white box models (simulation models), grey-box models, and other data-driven models. They leverage urban-scale data such as GIS-based information to enable well-informed decisions and accelerate building stock renovation in cities.

The deliverable D2.4 outlines the methodologies and tools used for planning and designing large-scale retrofitting actions and highlights examples from Mallorca and Sønderborg. The report provides insights into workflows, computational models, heating/cooling/DHW/appliances demand, energy consumption, and economic models. In conclusion, to strategise and execute CPCCs, it is essential to systematically tackle the combined impacts of energy, sustainability, and economic assessments and quantify the beneficial outcomes that arise from this integrated approach.

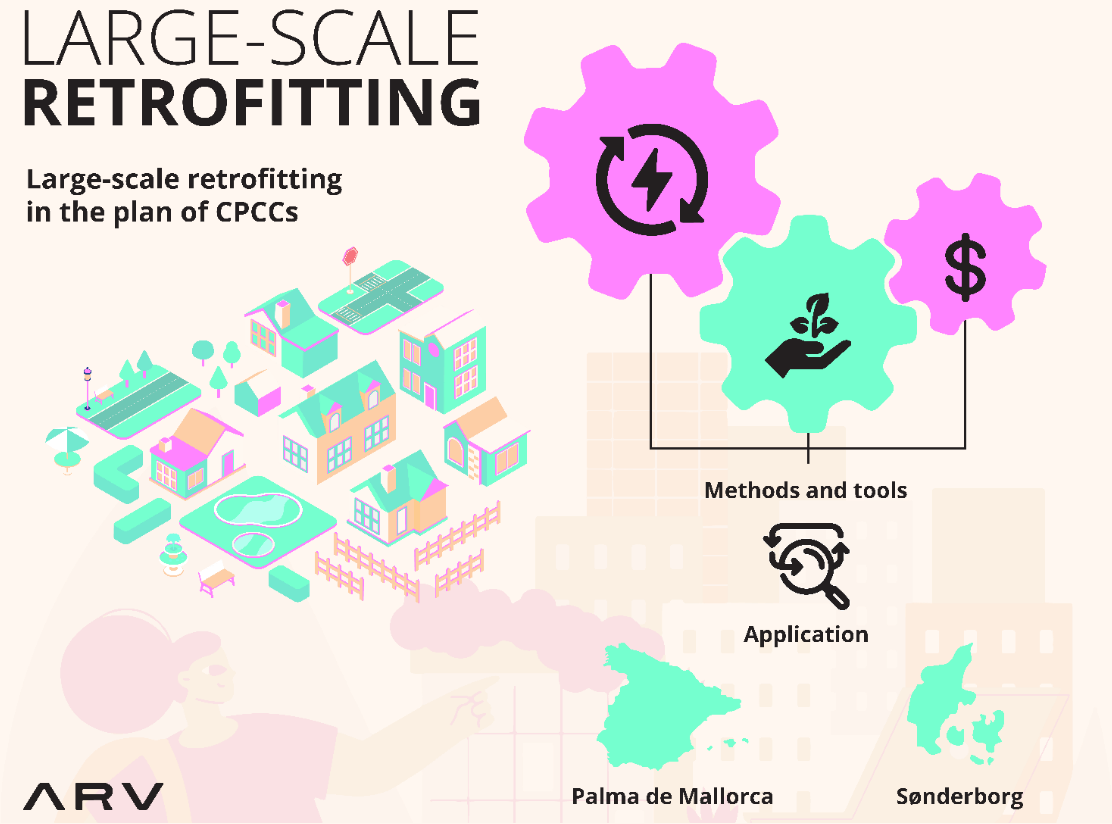


Figure 4 *Large-scale retrofitting for planning CPCCs* (Graphics: *Jesus Daniel Garcia Melo – NTNU)*

CEC Citizen Energy Communities
Deliverable
D2.5 *Application of tools for implementation of Citizen Energy Communities. Uses cases and guidelines for replicability, to be delivered in M42.*

The ARV project is investigating ways to combine established techniques and resources to assess renewable energy generation in urban environments. This effort entails utilising available space in both public and private structures and linking it to the energy consumption patterns of people and groups within Citizen Energy Communities (CECs). To accomplish this, the project is experimenting with decision-making tools that merge data from the city level, models for local renewable energy generation, and estimated energy consumption of potential CEC participants.

The deliverable outlines the concept of CECs in the energy transition and the need for integrated tools to plan and implement them. It proposes methods and tools for two urban areas in Karviná and Palma de Mallorca.

The Karviná approach focuses on geometry, solar potential, and technical potential, utilising software for modelling and analysis. It also considers grid stability and economic impacts.

The Palma demo emphasises an integrated approach, with tools divided into backend and frontend components, facilitating decision-making through photovoltaic potential simulation, energy balance calculations, stakeholder involvement, and more. Both approaches provide comprehensive workflows for CEC implementation, making them adaptable for different CECs with varying regulations and characteristics. These tools aim to streamline decision-making processes for stakeholders in various CECs.

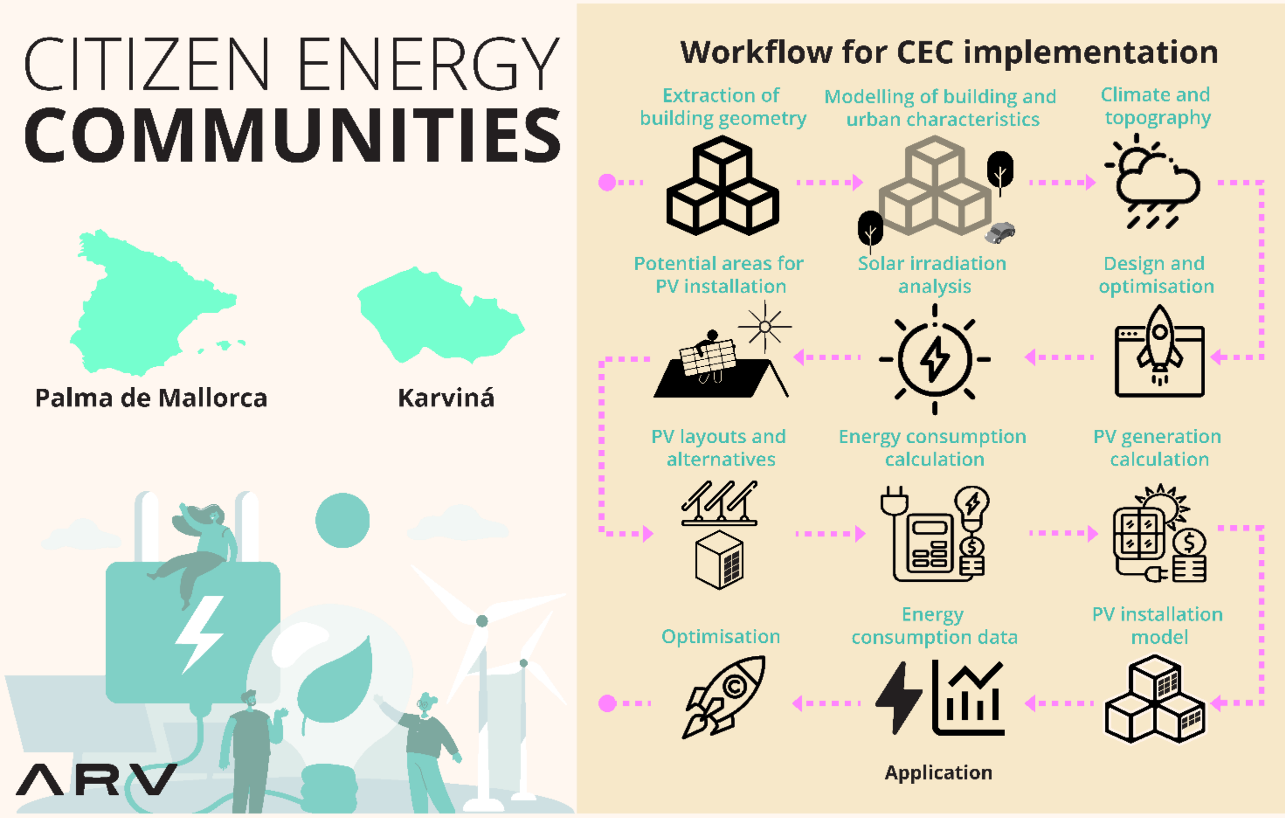


Figure 5 *Citizen Energy Communities workflow for planning CPCCs. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Virtual Reality Environments

Deliverables

D2.6: *Demos of Virtual Reality Environments, to be delivered in M36.*

D2.7: *Description and lessons learnt from training & awareness sessions using Virtual Environments, to be delivered in M48.*

The goal is to investigate, incorporate, and apply various 3D and visualisation methods in Virtual Reality (VR) and Augmented Reality (AR) to support the exploitation of results in Oslo and Palma de Mallorca demos. The objective is to enhance the communication of analysis outcomes for different scenarios to diverse stakeholder groups and to encourage citizen engagement. The implementation of AR/VR applications will be integrated into the activities of AR/VR environments as an essential component of the comprehensive approach within Living Labs (LLs) and will be employed in suitable demonstrations and contexts.

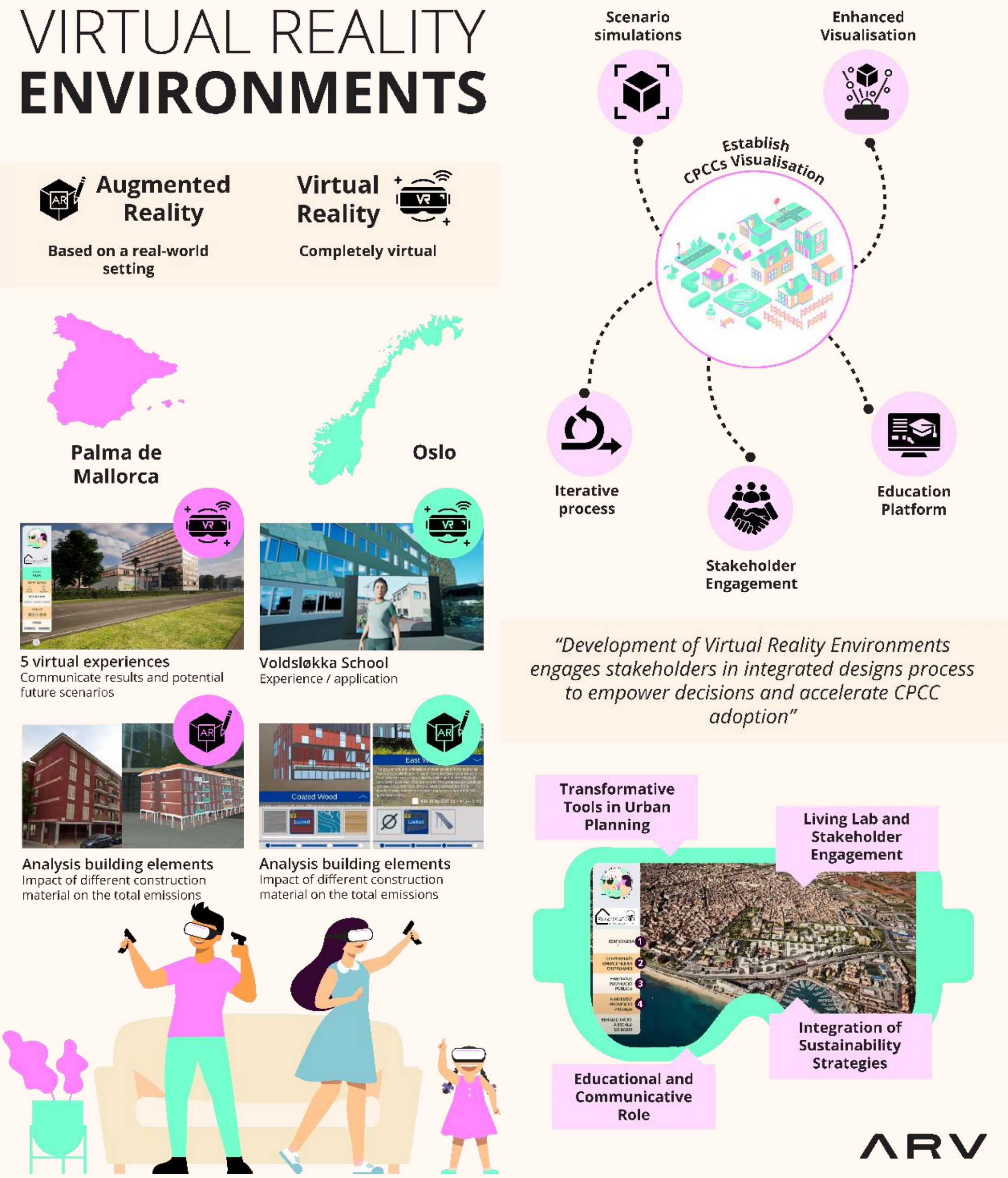


Figure 6 *Virtual Reality Environments illustration (Graphics: Jesus Daniel Garcia Melo – NTNU)*

CPCC Living Labs

Deliverables

D3.1 *Plan and overall methodology for establishing CPCC Living Labs, including Stakeholder mapping. Delivered in M12.*

D3.3: *CPCC Living Labs reports. First report delivered in M24 and to be updated in M36 and M48. Not enough available information from this deliverable yet. To be included in future updates.*

The Living Lab approach enhances citizen engagement in deep energy renovations and climate initiatives by offering practical testing grounds for innovations, involving citizens in energy-efficient planning, and fostering diverse sector partnerships. ARV Living Labs will be set up to consider various facets of citizen participation, including citizens as tenants and occupants of buildings, citizens residing in and being part of CPCC communities, and citizens serving as advocates for green initiatives. Therefore, the CPCC Living Labs employ a range of strategies directed at their intended audiences and respective functions:

CPCC Living Lab in Trento

The primary goal of the Trento Living Lab is to implement a collaborative approach involving Piedicastello residents, the community, and local authorities in the early stages of the project. This includes creating a one-stop-shop forbuilding energy renovation, introducing residents to sustainable construction technologies, involving them in renewable energy initiatives, and informing policy decisions with insights from sustainable construction practices.

CPCC Living Lab in Palma

Palma's main focus is on extensive renovation, transitioning to cleaner energy, and forming energy communities. The Palma Living Lab's core mission is to actively involve the local district community in energy renovations, with Es Laboratori – a Living Lab for Energy Transition, as a network for a community meeting place. The Living Lab's goals span various levels of community engagement, including information dissemination, awareness building, and collaborative activities. Particular attention is dedicated to engaging young people, partnering with schools, and reaching out to vulnerable segments of the district's population that are usually harder to engage.

CPCC Living Lab in Utrecht

The primary goal of the Utrecht Living Lab is to actively involve social housing tenants and local citizens in the LL districts, aiming to improve their well-being and energy consumption. The specific objectives are linked to four interventions, including social renovation to enhance the living environment, a human capital program for job creation, an energy coaching program to reduce energy usage and costs, and the establishment of a physical hub in the district to engage residents in the energy transition through training and coaching events held at the "Panini Fresco" circular pavilion in the Overvecht district.

CPCC Living Lab in Karviná

The initial phase of the Living Lab in Karviná, involves engaging schools and students through practical workshops on energy, sustainability, and climate-positive communities, using advanced technology to raise awareness among young people and inspire them to consider related careers. This effort aims at making the region known for these opportunities and equipping youth with skills for public engagement, with future phases to assess and adjust this approach. Additionally, the Living Lab aims to inform and involve various citizen groups in projects focused on reducing greenhouse gas emissions and enhancing the city environment.

CPCC Living Lab in Sønderborg

The Sønderborg Living Lab aims to increase residents' awareness of their role in the energy transition and to utilise a green ambassador program to enhance tenant participation. Their focus is on facilitating an understanding of the ARV project and the green transition among housing association members and citizens. They plan is to achieve this through various communication channels such as websites, events, letters, social media, newsletters, and local or national media. Additionally, they intend to explore and develop green ambassadors in collaboration with the housing association and residents.

CPCC Living Lab in Oslo

The Oslo Living Lab is dedicated to enhancing climate awareness among secondary and cultural school students, parents, and local residents. The Living Lab primarily concentrates on energy transition, covering energy technologies and circular solutions. It will actively involve students in diverse activities, such as learning, co-creation, and fostering youth ambassadorship, with the assistance of AR/VR technologies. The target audience for the Oslo Living Lab consists of students, school personnel (including teachers, maintenance staff, and operational employees), and parents from both educational institutions.

To establish CPCC Living Labs at each ARV demonstration site, a methodology called S.M.I.L.E was developed (Figure 7), which is informed by existing literature and developed in collaboration with representatives from all six demo sites.

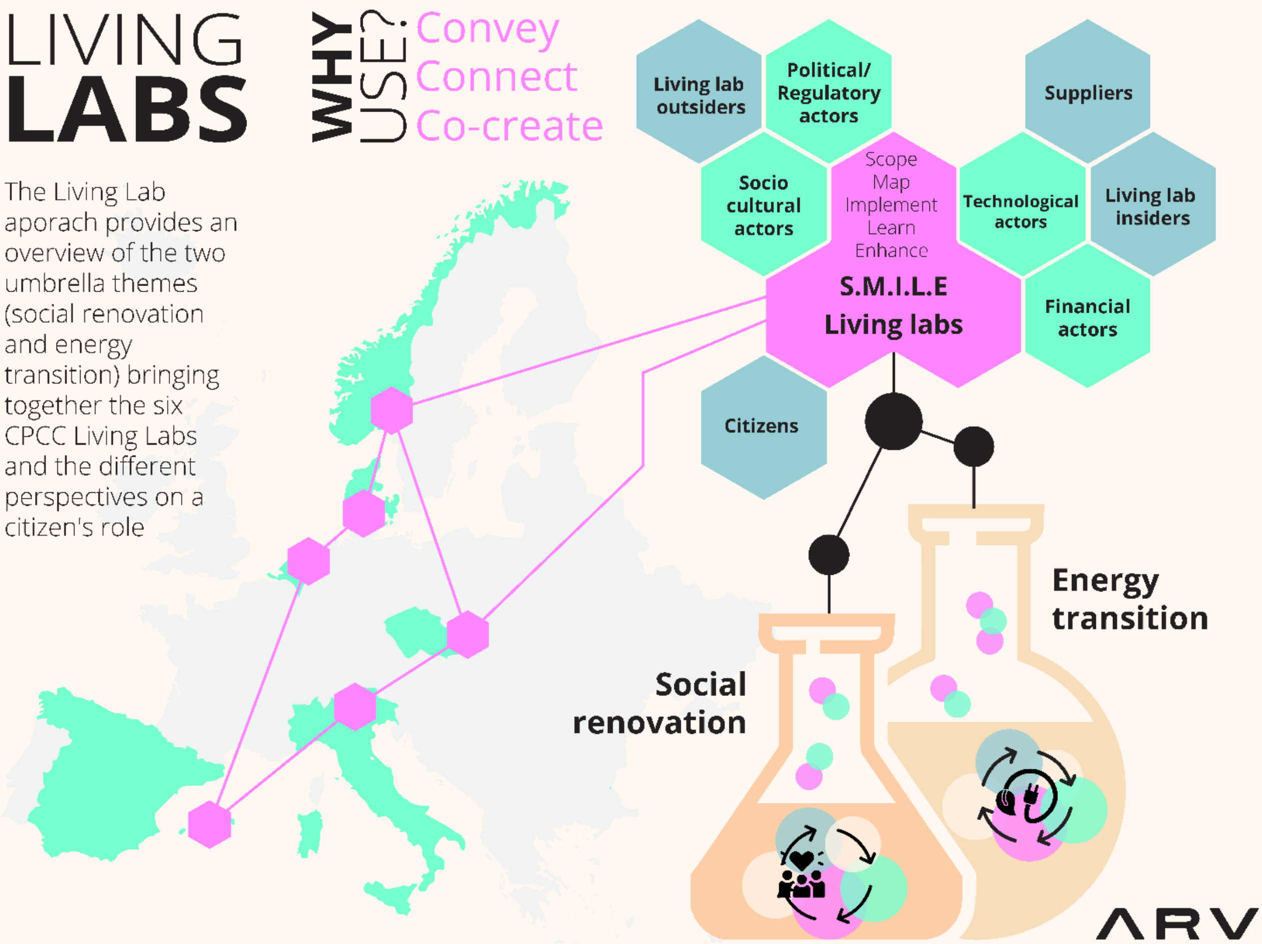


Figure 7 *Overview of the Living Labs approach and S.M.I.L.E methodology. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Citizen Engagement Strategies
Deliverables
D3.4 *Analysis of citizen engagement tools and processes using a citizen science approach, to be delivered in M40.*
D3.5 *Community-scale citizen engagement strategy and tools for the renovation wave, to be delivered in M54.*
Not sufficient information from deliverables yet. Will be updated in future updates.

This task aims to enhance the innovative social engagement strategies by analysing barriers, motivators, efficiency, costs, and learning opportunities. The primary goal is to create practical and transferable tools that can be applied in extensive renovation projects throughout Europe, ultimately harnessing the full potential of the upcoming European Renovation Wave. The expected result is heightened citizen engagement, leading to improved satisfaction, well-being, and the integration of energy-efficient behaviours as a natural part of daily life right from the start.

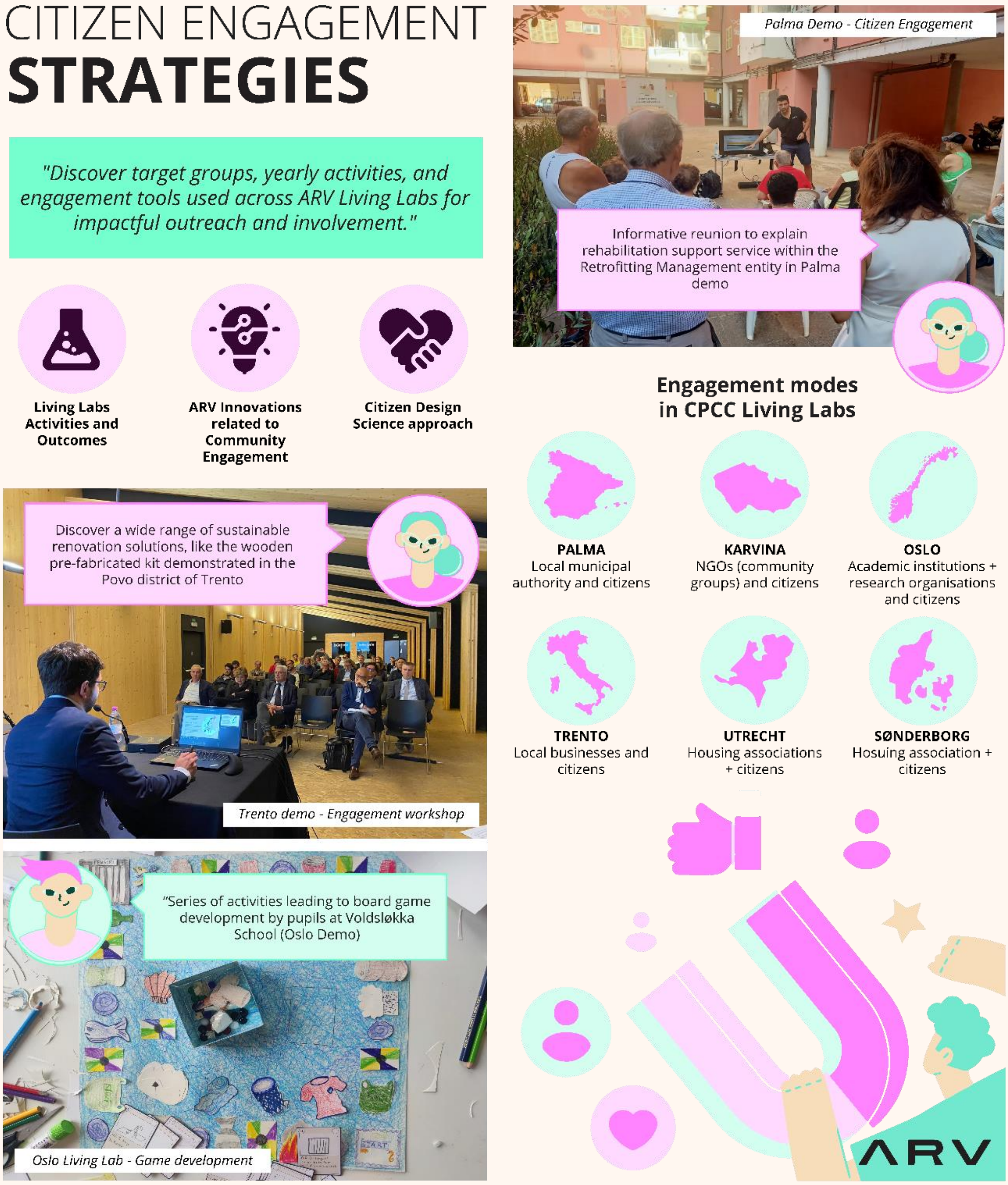


Figure 8 *Citizen Engagement Strategy illustration (Graphics: Jesus Daniel Garcia Melo – NTNU)*

DESIGN GUIDELINES

This section focuses on redesigning and retrofitting buildings to create zero-emission, positive energy structures in sustainable, climate-positive, circular communities (CPCC). The main objectives include reducing energy and emissions, increasing energy efficiency, and integrating sustainability with aesthetics and quality of life through circular design processes. This encompasses adapting to local climates, renovating with minimal disruption, reducing greenhouse emissions, emphasising circularity, and integrating efficient photovoltaics while prioritising occupant well-being and architectural aspects. The representation of these aspects is shown by the **five** demos that are integrating methods regarding to the Sustainable Building (Re) Design task.

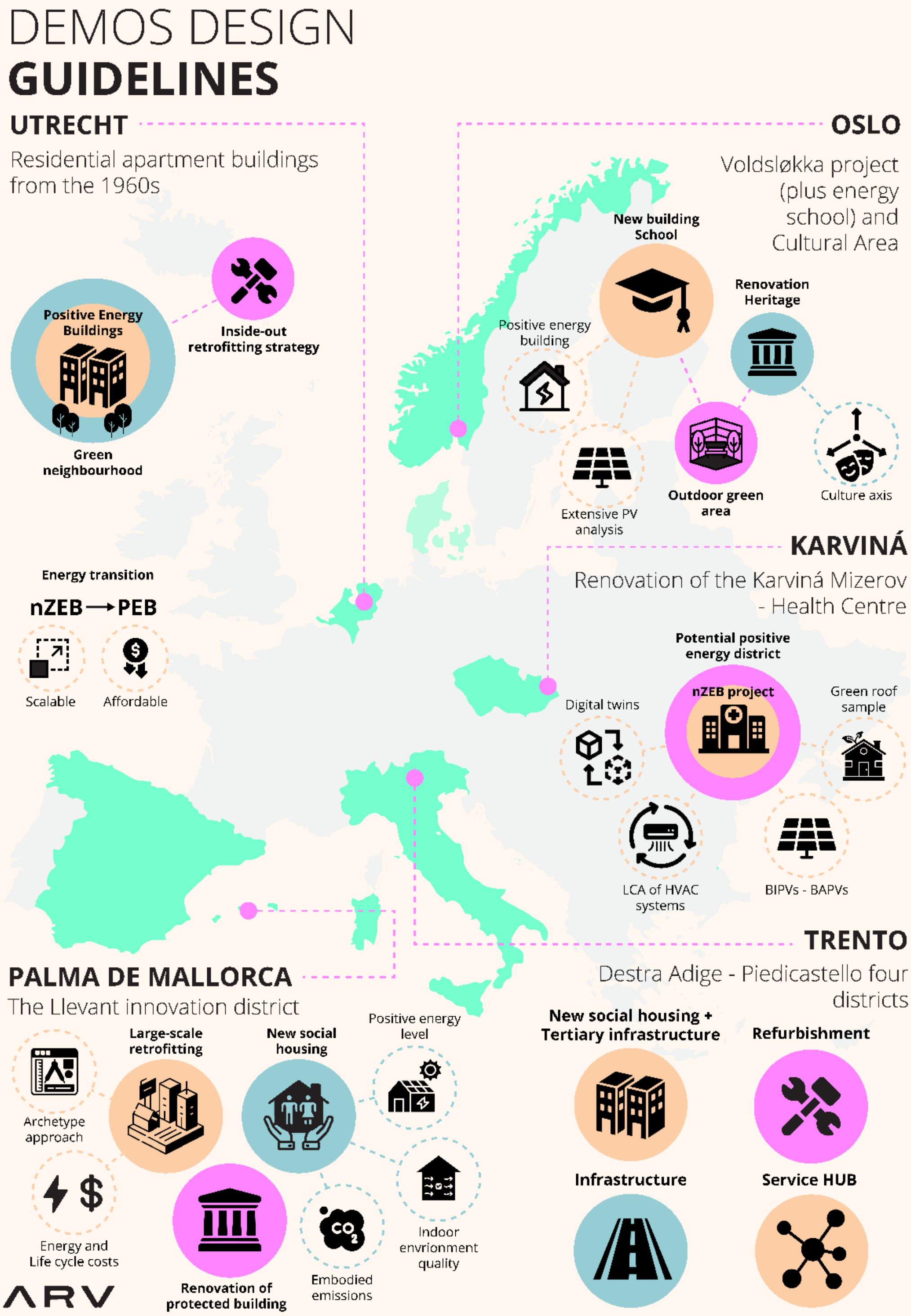
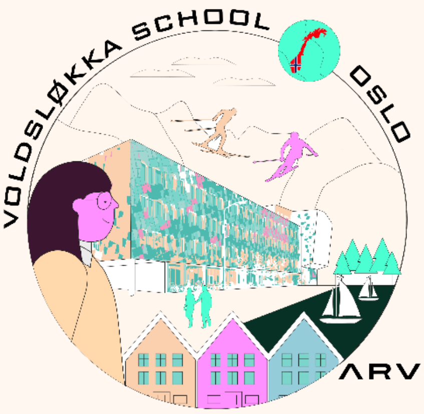


Figure 9 Overall design guidelines of the five demos involved in the design stage. (Jesus Daniel Garcia Melo – NTNU)

Deliverable D4.1: *Design guidelines of zero-emission and positive energy buildings in a climate positive energy neighbourhood in Oslo. First version delivered in M12 and to be updated in M24 and M45.*

The Norwegian demo project at Voldsløkka School and Cultural area involves constructing a secondary school, new cultural facilities, and renovating an existing historic building, totalling 14,000 square meters. One aim is to showcase Oslo's first plus-energy school, generating surplus energy, thanks to a 1,556 square meter PV installation. The project also encompasses the renovation of a culture heritage building on the site (a former industrial building called Heidenreich) to turn it into a cultural building with high environmental performance. The goals prioritise integration with the local community and green initiatives. The ARV project actions focus on efficient renovations, district energy, and enhancing social, educational, and digital aspects to foster Citizen Energy Communities.



Architectural Qualities

- Multi-layered system cladding, PV panels and windows.
- Permeable open surface for rainwater management.
- Flexible floor plan layout.
- Preservation and upgrading of Heidenreich building.

Social Qualities

- HUB for education around energy technologies and sustainability.
- Young ambassadors' program promoting energy efficiency.

Environmental Qualities

- First plus-energy school.
- Emissions-free construction site.
- Use of recycled materials, low emission concrete and wood for the renovation of Heidenreich building.

Figure 10 *Illustration of the Voldsløkka School, Oslo, Norway. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Design configuration for a modular, scalable, integrated retrofitting concept for Positive Energy Mid- & Highrise Buildings embedded in a green neighbourhood in Utrecht.

Deliverable D4.2: *Design configuration for a modular, scalable, integrated retrofitting concept for Positive Energy Mid- & Highrise Buildings embedded in a green neighbourhood in Utrecht. First version delivered in M12 and to be updated in M24 and M45.*

The Dutch demo in Utrecht includes the areas of Kanaleneiland, Rooseveltlaan and Alexander de Grotelaan. Building types are Bredero and Intervam, and two developers Bo-Ex (renovating two building types Bredero and Intervam) and Woonin (renovating an Intervam building type). In total, six apartment buildings are renovated into Nearly Zero Energy Buildings nZEB) and four apartment buildings to become Positive Energy Buildings (PEB). The interventions addressing energy transition are crucial today, as they improve housing sustainability. However, challenges like rising energy costs, housing affordability, raise of construction costs, and home overheating delay progress. Here, the Inside-Out system stands out, by being an integrated solution of modular building components that overcome these obstacles, aiming to revolutionise the design and construction process to accelerate sustainability improvements.

Architectural Qualities

- Innovative elements are included in the plug-n-play integration of PV components in façade roof, balcony, railing, and balustrade building components
- PV panels that give a clear structure inspired by the architectural character of 1960s.

Social Qualities

- PV installation save costs, reduce inconvenience, and distribute power more fairly among tenants.
- Minimal inconvenience for residents while renovating.
- All consumption is monitored according to the applicable requirements and can be viewed by residents.

Environmental Qualities

- Standardisation and flexibility of the interface connecting above modules that offer a higher adaptation potential in full life cycle and create less waste trough net assembly.
- Collective heat pumps, buffer vessels, BA/BIPV panels, insulation system.
- Heat recovery for LT heating and ventilation, DC-ready cabling and (BA/BIPV) panels

Figure 11 *Illustration of part of the housing blocks in the Sønderborg demo site, Denmark. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

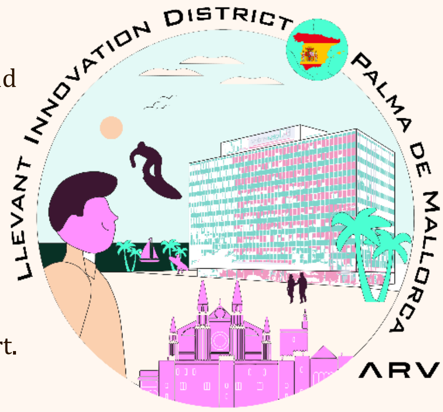
Zero-emission & positive energy refurbished and new buildings in Palma.
***Deliverable D4.3**: Design guidelines for zero-emission & positive energy refurbished and new buildings in Palma. First version delivered in M12 and updated in M24 and M45.*

The Spanish demo case in Palma de Mallorca, known as the Llevant Innovation District (DILL), involves a mixed-use development area, combining residential, tertiary, and educational buildings through both new construction and renovation efforts. The ARV project focuses on resource-efficient renovation on a large scale, district energy analysis and operations, emphasising social, educational, and digital aspects to engage citizens.

The primary aim is to achieve circular, zero-emission, and positive energy buildings within sustainable, climate-positive circular districts. Key actions include large-scale retrofitting of 250 private dwellings, the creation of a new Positive Energy Social Housing Building, and energy renovation of a heritage-protected office building with BIPV solutions.

Architectural Qualities

- Traditional low-tech construction based on load bearing walls.
- Retrofitting of thermal envelope according to energy standards
- High performance building envelope, efficiency of equipment and systems.



Social Qualities

- Integration with the environment and historical background of the neighbourhood.
- Improving a building of heritage interest that was abandoned and degraded.
- Integration of passive design strategies to improve indoor comfort.

Environmental Qualities

- Cross-ventilation, thermal intermediate spaces, solar control, and thermal inertia to reduce demand.
- Prefabricated and natural local materials to reduce greenhouse gas emissions.
- Efficient systems and energy flexibility
- Renewable energy production with transparent and opaque BIPV
- Digital twins to accelerate retrofitting actions.

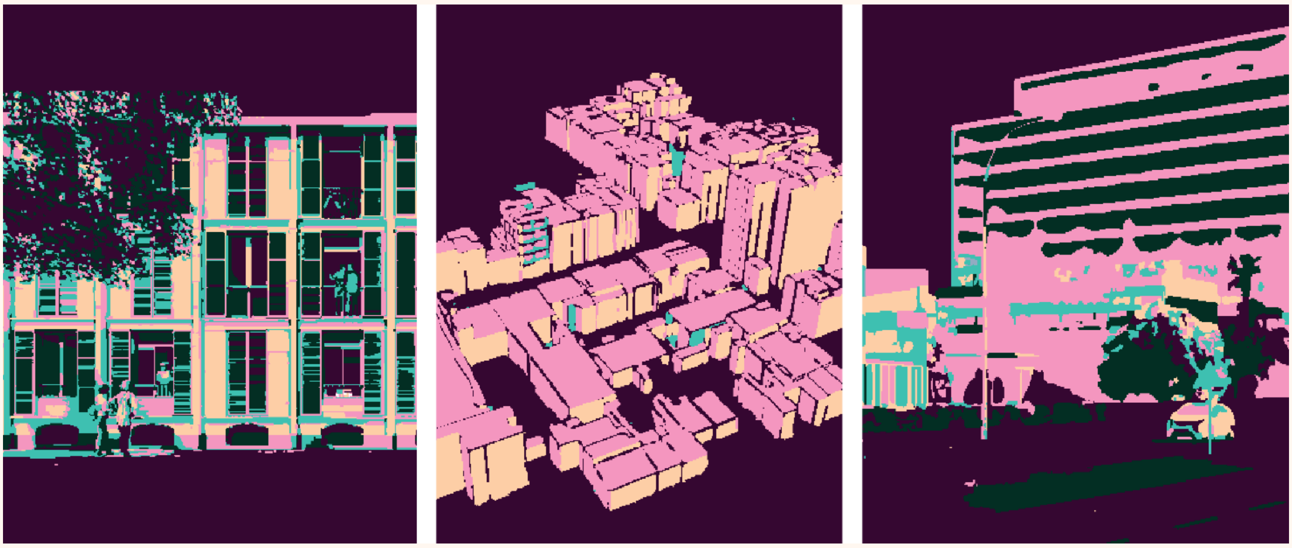


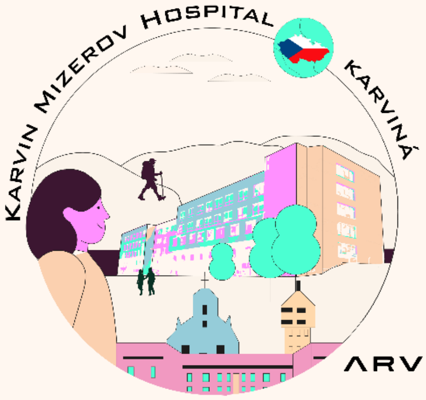
***Figure 12** Illustration of the buildings in the Palma de Mallorca demo site, Spain. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Zero-emission & positive energy renovation of the Health Care Centre in Karviná.
Deliverable D4.4: *Design guidelines for the zero-emission & positive energy renovation of the Health Care Centre in Karviná. First version delivered in M12 and to be updated in M24 and M45.*

The Czech demo case in Karviná centres on the renovation of the Karviná Mizerov Health Centre. The project's key objectives are to transform it into a nearly zero energy building (nZEB), utilising digital design and 3D simulations for solar potential and optimal shading, testing climate-resilient solutions like heat pumps for summer cooling, conducting life cycle assessments of HVAC systems with a focus on carbon footprint, implementing various renewable energy technologies, and incorporating green roof samples for heat reduction and water runoff control.

Architectural Qualities

- Digital twin as the baseline for further and larger refurbishments.
- Improvement in technical quality by architectural renovations.
- Maximising asset utilisation: Co-location and flexible spaces.



Social Qualities

- Designing user-friendly environment.
- Stakeholder outreach.
- Multi stakeholder co-creation, monitoring, and evaluation of the process.

Environmental Qualities

- Implementation of thermal insulation, window replacement, photovoltaics and heat pump installation.
- Green roof sample for reducing heat islands, rainwater management.
- Installation of mechanical ventilation systems with heat recovery combined with CO_2-VOC-humidity-temperature sensors.
- Focusing on disassembly during the design phase to increase the chance of effective second use.

Figure 13 *Illustration of the building in the demo site in Karviná, Czechia. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

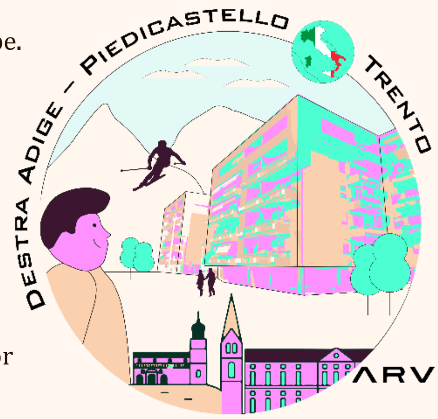
Timber-based construction & renovation of small-medium size buildings in Trento.

Deliverable D4.5: *Design guidelines of timber-based construction & renovation of small-medium size buildings in Trento. First version delivered in M12 and to be updated in M24 and M45.*

The Italian demo case in Trento, Destra Adige - Piedicastello, comprises four areas with distinct purposes. Area 1 focuses on creating a self-sufficient district with a geothermal system and PV power generation. Area 2 involves renovating social housing using standardised timber-based façade elements and encouraging private owners to join the process. Area 3 repurposes former highway tunnels for energy storage, to serve areas 1 and 2. Lastly, Area 4 transforms a parking lot into a service HUB connecting commuter flows to commercial services and supporting energy storage with a Vehicle-to-grid (V2G) system.

Architectural Qualities

- Local and circular materials for the building structure and envelope.
- Long-lasting and easy-to-be recycled building components.
- Nature based solution.



Social Qualities

- Spatial quality and social inclusion

Environmental Qualities

- Energy positive building.
- Integrated passive and active systems for energy saving and indoor living comfort.

***Figure* 14** *Illustration of the Piedicastello tunnel (upper left), a building renovated with prefabricated elements (upper right), and a new positive energy building (bottom). (Graphics: Jesus Daniel Garcia Melo – NTNU)*

New & retrofitting of existing buildings as zero-emission positive energy-buildings in climate positive circular communities.

Deliverable D4.6: *Design guidelines of new & retrofitting of existing buildings as zero-emission positive energy-buildings in climate positive circular communities, to be delivered in M50.*

The design of new and retrofitting of existing buildings as zero-emission positive energy buildings in CPCCs, will be reported in the Design Guidelines (D4.6), collecting insights from findings in the design guidelines of each demo (D4.1 – D4.5). The aim is to support and illustrate overall results and co-relation between the different demos, showcasing their similarities, differences and challenges to facilitate replication. This is a draft example, since the deliverable will be completed (M50).

Figure 15 *Examples of design activities from the ARV demo projects. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

3.3. RESOURCE EFFICIENT (PRE)MANUFACTURING AND CONSTRUCTION

This chapter presents an overview of innovative solutions designed to improve the retrofitting and construction of energy-efficient building skins for medium- and high-rise buildings. These advancements aim to address critical challenges in resource efficiency, environmental sustainability, and process optimisation. By adopting strategies such as the design of energy-neutral or energy-positive building envelopes, the automation of data collection and pre-production workflows through advanced ICT tools, and the prioritisation of sustainable practices, these solutions work to significantly reduce waste, transportation emissions, and overall environmental impact.

The workflow for these processes is structured into three distinct phases: Pre-Manufacturing, Manufacturing, and Construction. Each phase is enhanced by cutting-edge digital innovations, including the use of drones, parametric Building Information Modelling (BIM) systems, and file-to-factory manufacturing processes.

These technologies streamline the transition from design to implementation, ensuring high precision, efficiency, and integration of sustainable practices throughout the lifecycle of the building. By automating key elements of the workflow, such as design generation, performance simulation, and production, these systems help bridge the traditional gap between conceptual design and practical performance.

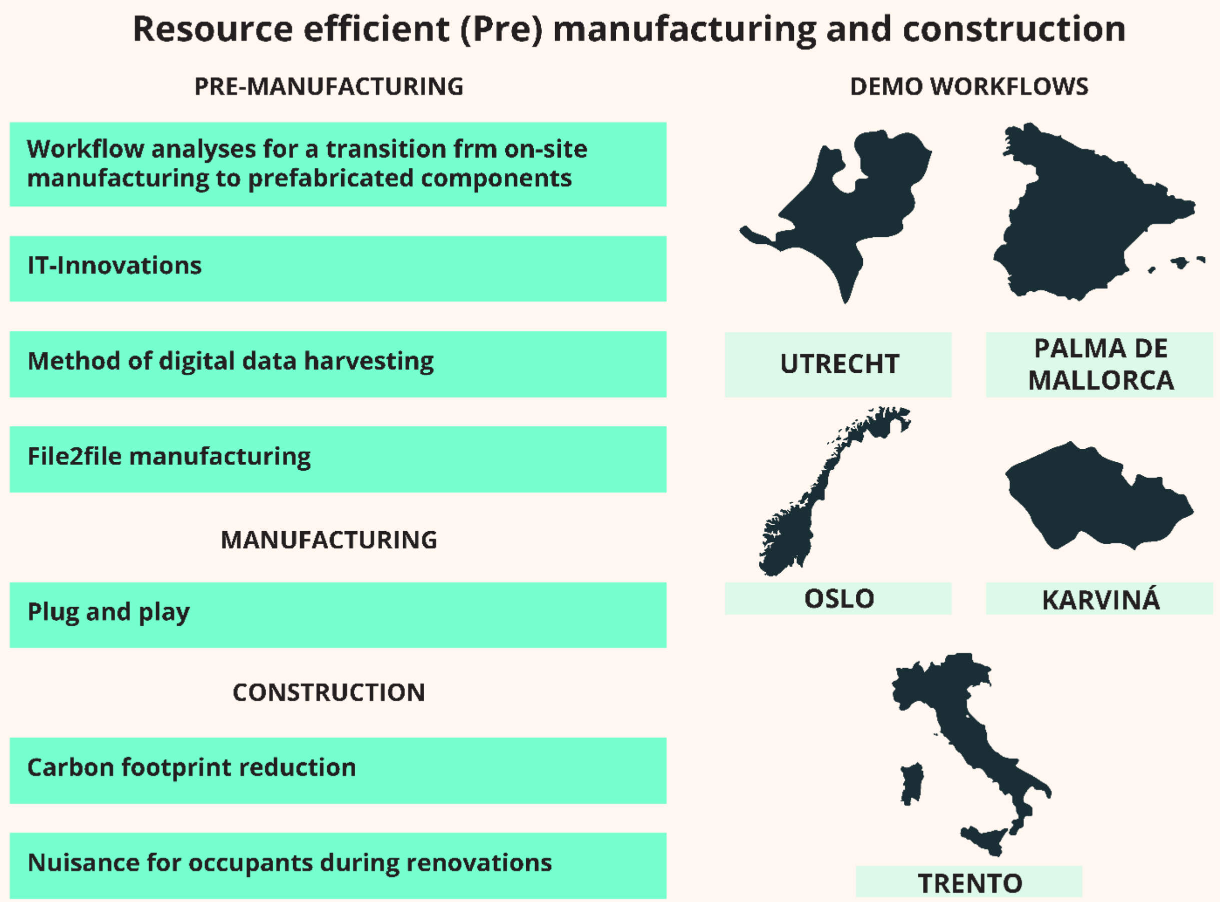


Figure 16 *Overview of the resource efficient (pre)manufacturing and constructions section. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

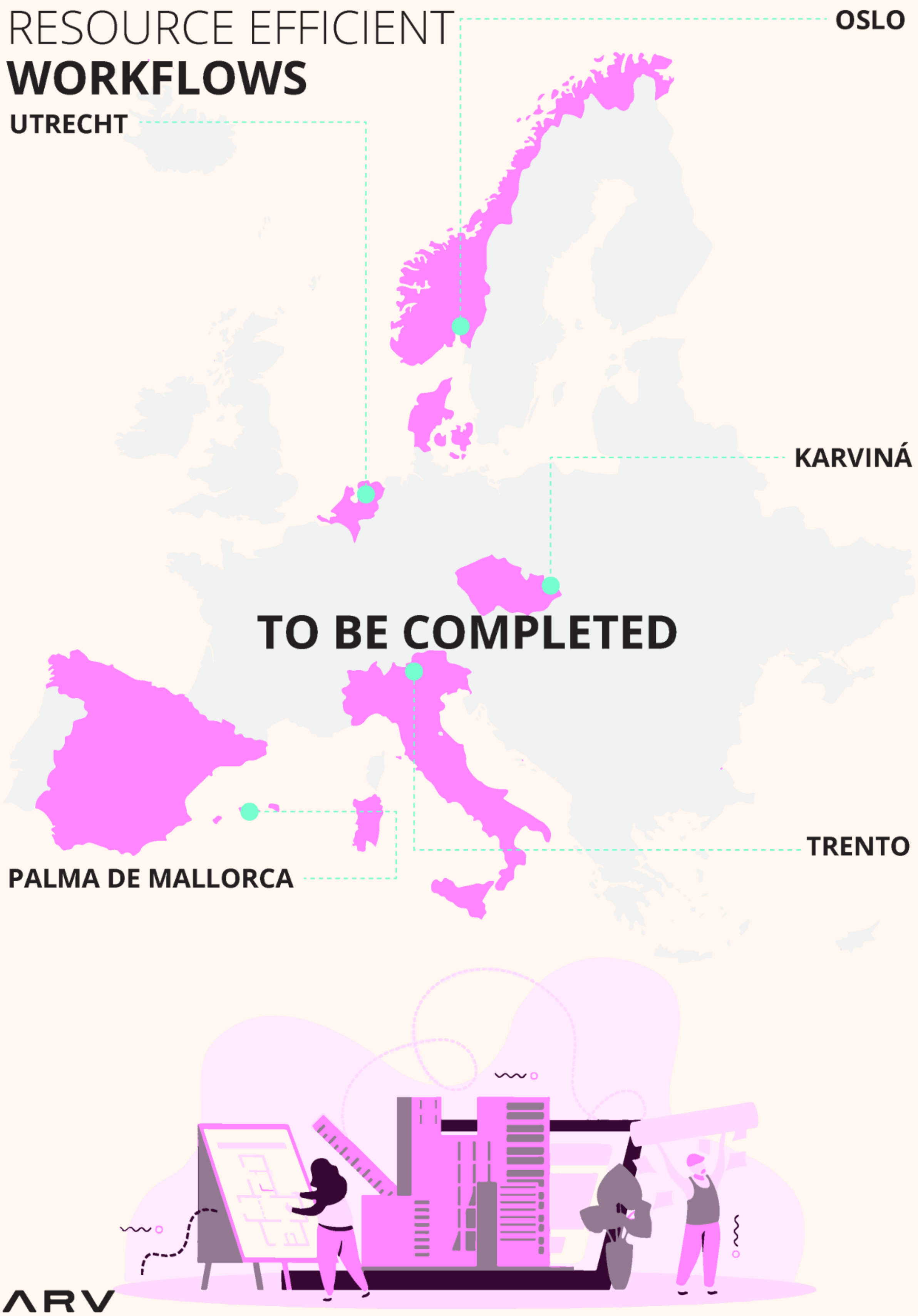


Figure 17 *Overall resource efficient workflows and demos related. (Jesus Daniel Garcia Melo – NTNU)*

PRE-MANUFACTURING

Workflow analysis for a transition from on-site manufacturing to prefabricated components.
Deliverable D5.2 *Workflow analyses and advise on how to move towards more prefabricated components and reduce work on-site, to be delivered in M60.*

The concept of Off-site Manufacturing (OSM) centres on the off-site production of building components to streamline and optimise their on-site assembly. By shifting fabrication processes to controlled environments, OSM enhances efficiency, reduces waste, and improves quality control.

This approach involves a collaborative ecosystem of stakeholders, including contractors, manufacturers, design professionals, and clients, working together to ensure seamless integration of processes. At its core, OSM relies on a combination of advanced materials, cutting-edge technologies, and digital tools, with Building Information Modelling (BIM) playing a central role in facilitating off-site production and driving innovation within the construction industry.

This section delves into the application of BIM strategies to standardise and enhance the design processes for building elements in the context of OSM. Central to this effort is the development of an interoperable workflow that promotes efficiency and consistency across stakeholders. The workflow is designed to identify and mitigate potential risks while offering a clear framework for phased implementation (as illustrated in Figure 18).

By aligning digital tools with standardised design practices, this approach aims to accelerate the adoption of OSM principles, enabling a more sustainable and efficient construction sector.

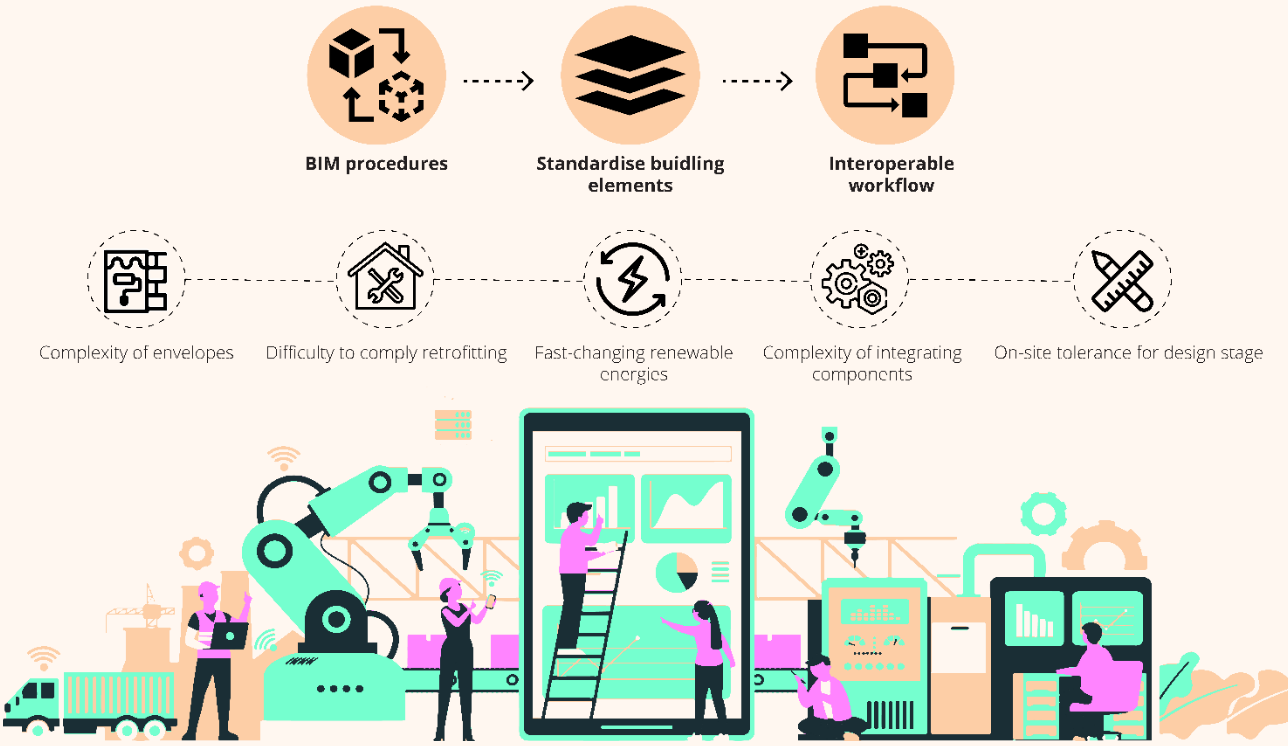


Figure 18 *Main characteristics to consider in an off-site fabrication workflow. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

IT-Innovations

Deliverable D5.2 *Workflow analyses and advise on how to move towards more prefabricated components and reduce work on-site, to be delivered in M60. Some information is available in working documents. Further updates will come later.*

THE ALPHA SOLAR MODULE

The Alpha Solar module is an innovative solution for high-rise buildings, featuring a prefabricated steel frame with plug-and-play compartments for efficient assembly and adaptability. Designed to integrate seamlessly over existing rooftop infrastructure, it maximises solar energy potential while withstanding high winds and supporting scalable energy storage systems. Its parametric design, powered by Dynamo for Revit, enables dynamic customisation based on building specifics and environmental conditions, while automated solar potential calculations optimise energy yield. Leveraging GIS data and AI for planning, the module streamlines cost estimation, collaboration, and project timelines, transforming urban renewable energy solutions.

QUOTATION ACCELERATOR OF FAÇADE PANELS

The Quotation Accelerator streamlines retrofitting quotations using public data, such as GIS and Google Street View, to calculate building dimensions without site visits. It integrates manual and semi-automated tools for selecting building elements, measuring floor plans, and configuring facade panels. Photogrammetry and point cloud recognition are explored for accurate 3D modelling, reducing engineering costs. Future enhancements aim for automated image recognition, integration of data sources, and BIM model generation with minimal manual intervention. This approach reduces back-and-forth communication, accelerates processes, and enhances data accuracy for retrofitting solutions.

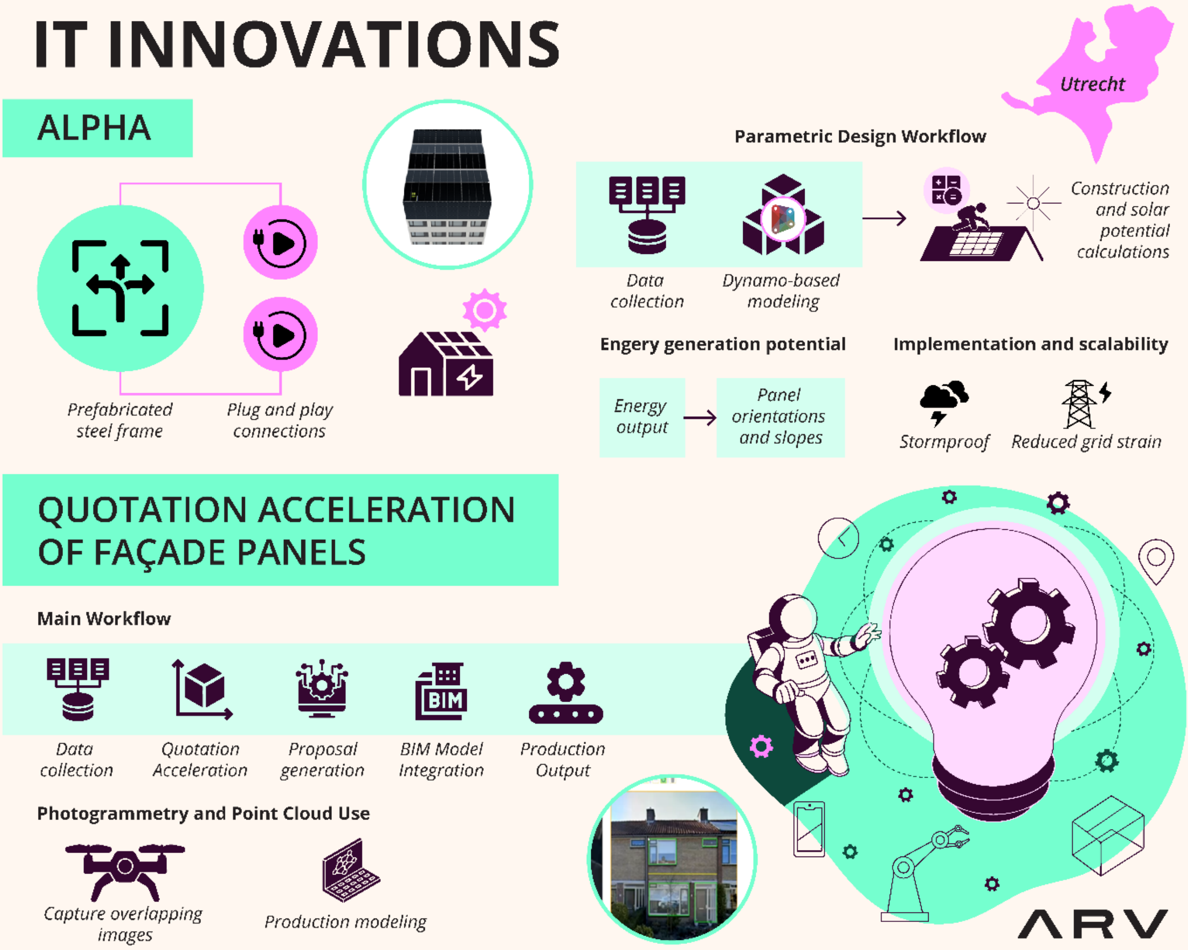


Figure 19 *Illustrations of an overview of the IT Innovations implemented in the Dutch demo*

Method of digital data harvesting

***Deliverable D5.2** Workflow analyses and advise on how to move towards more prefabricated components and reduce work on-site, to be delivered in M60. Some information is available in working documents. Further updates will come later.*

A robust methodology for describing modular panels leverages systematic digital data harvesting to create a "smart repository" that organises information for easy retrieval. This repository supports the identification of common challenges, solutions, and streamlined reporting processes. Drawing insights from existing modular panel standards, the framework focuses on key features of prefabricated modules by addressing both off-site production and on-site installation needs. National demonstration projects can adopt this framework for consistent descriptions of modular solutions, enabling cross-comparison and knowledge sharing. Each case includes a concise overview of the production context, company background, relevant projects, and prior assessments.

The methodology is built around three classification criteria. First, unit types are categorised by function, excluding aesthetic variables, to optimise workflows in material quantification, storage, transport, and installation. Second, unit components are documented layer by layer, differentiating invariant structural elements from variable or optional features, enabling comparisons of traditional and innovative materials. Third, interfaces with existing structures are digitally modelled to mitigate disruptions like noise or dust, integrating solutions early in the design phase to minimise on-site challenges. This digital approach standardises modular panel descriptions, enhances collaboration, and supports scalable, innovative construction practices.

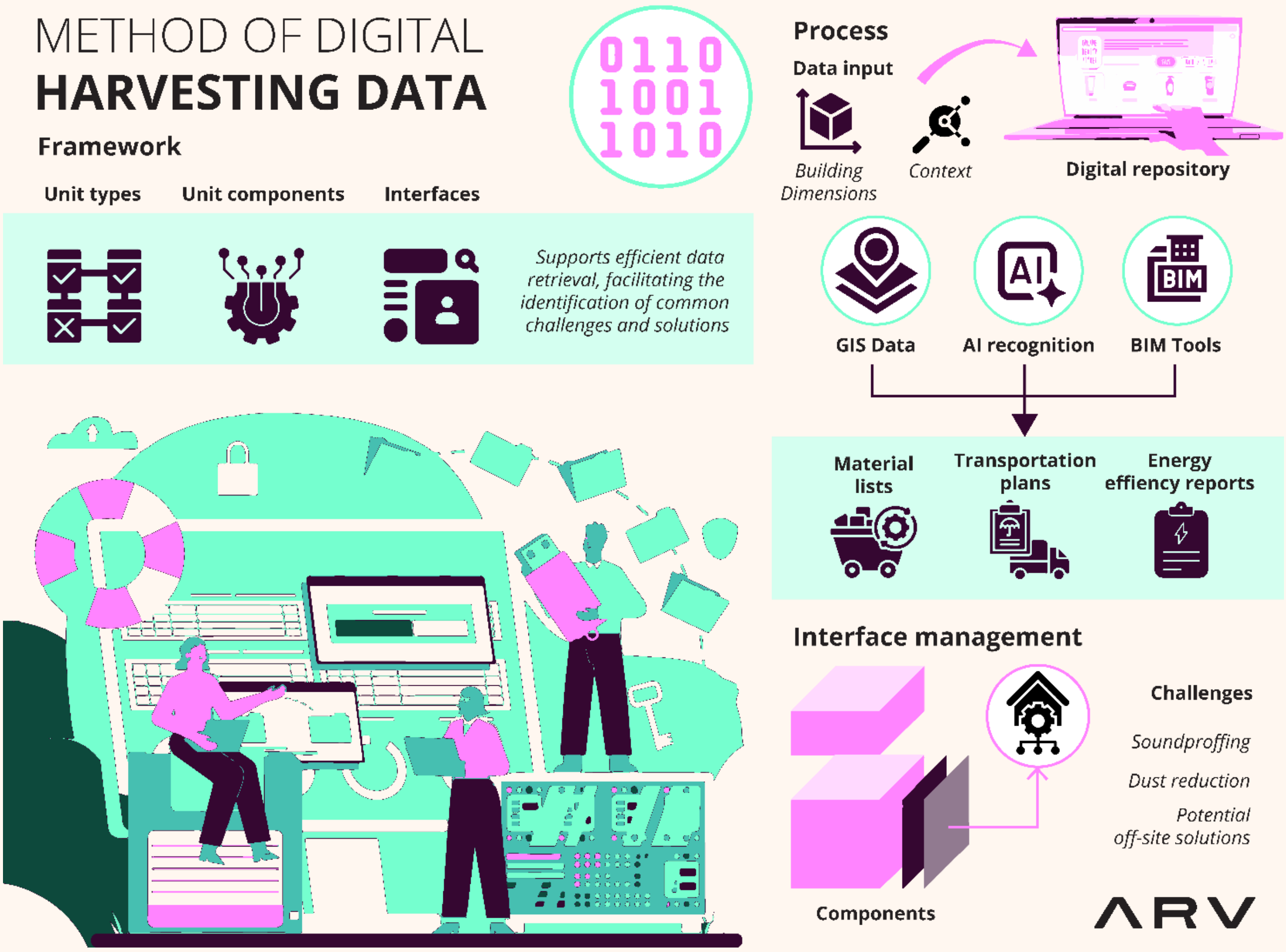


***Figure 20** Illustration of the method for digital data harvesting. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

File2Factory manufacturing

Deliverable D5.1 *Manufacturing configurator for high-rise apartment buildings to directly start production (File2Factory) process partly validated in participating European demo countries.*

To establish the preliminary workflow for recognition of architectural features, distinct subtasks are currently under development across multiple project teams, as elaborated in the subsequent sections. These tasks involve amalgamating a comprehensive set of building attributes, gathering pertinent GIS data, and initiating the initial stages of AI-based recognition for architectural types and structural elements.

To streamline the transition from digital design to factory production, a methodology was introduced to directly generate machine-ready files from building information models. This innovation was specifically tailored for the façade manufacturer Rc Panels (an ARV partner), where advanced tools were developed to optimise the operations of both their cutting machinery and a specialised robot for laying stone slips. These solutions enhance automation, reduce the potential for human error, and improve production efficiency.

For the cutting machinery, a custom tool was created within Revit to produce machine-compatible files. While initial efforts relied on exporting geometry-based data, this approach proved insufficient for more complex manufacturing requirements. The solution evolved to include design families with embedded operational parameters, allowing adjustments in the model to automatically update production instructions. For the stone slip laying robot, a similar tool was developed to export detailed positioning and orientation data for each stone. This system grants designers the freedom to create intricate patterns while ensuring precise execution by the machine. Together, these advancements eliminate redundant manual steps and promote a seamless, efficient connection between digital design and factory output.

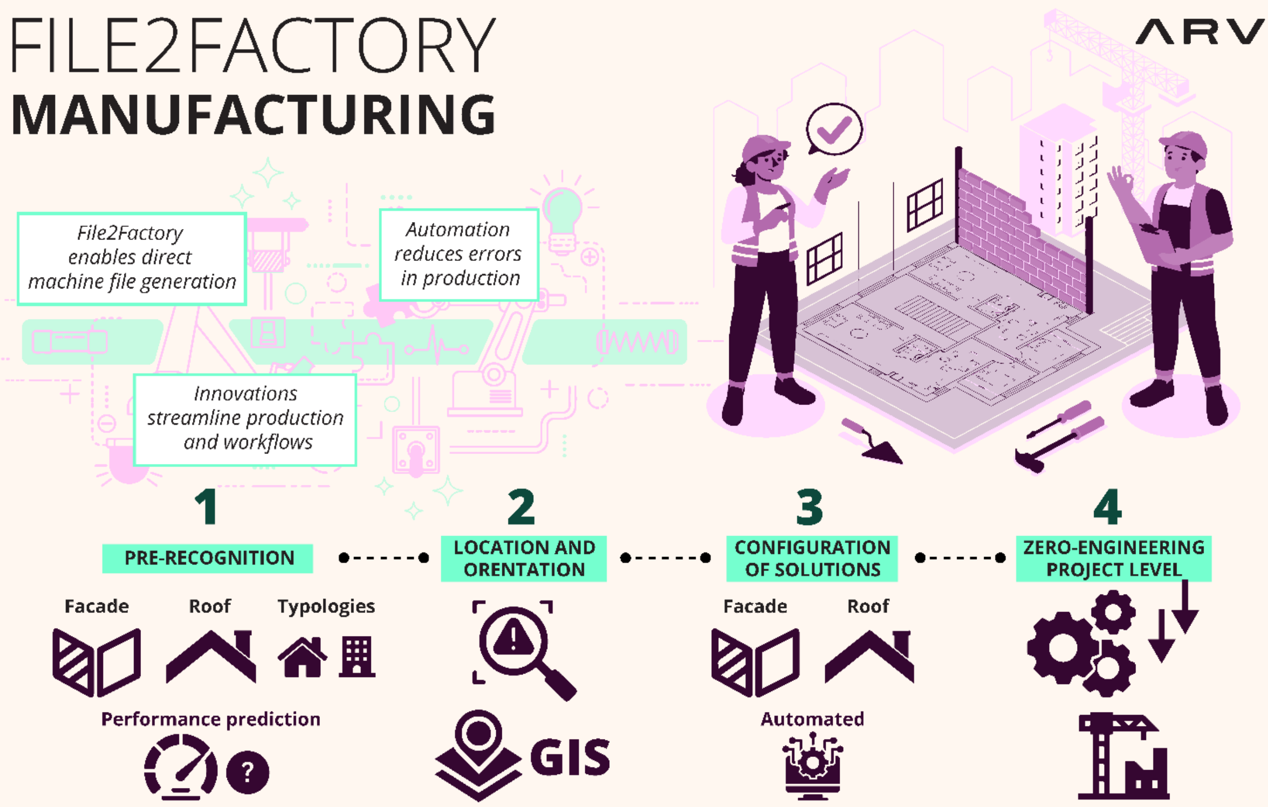


Figure 21 *File2Factory manufacturing process. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

MANUFACTURING

Plug and Play Elements.

No available information from deliverables yet. To be included in future updates.

***D5.3** Resource Efficient (Pre)Manufacturing & Construction Workflows – Demo Utrecht, to be delivered in M60.*

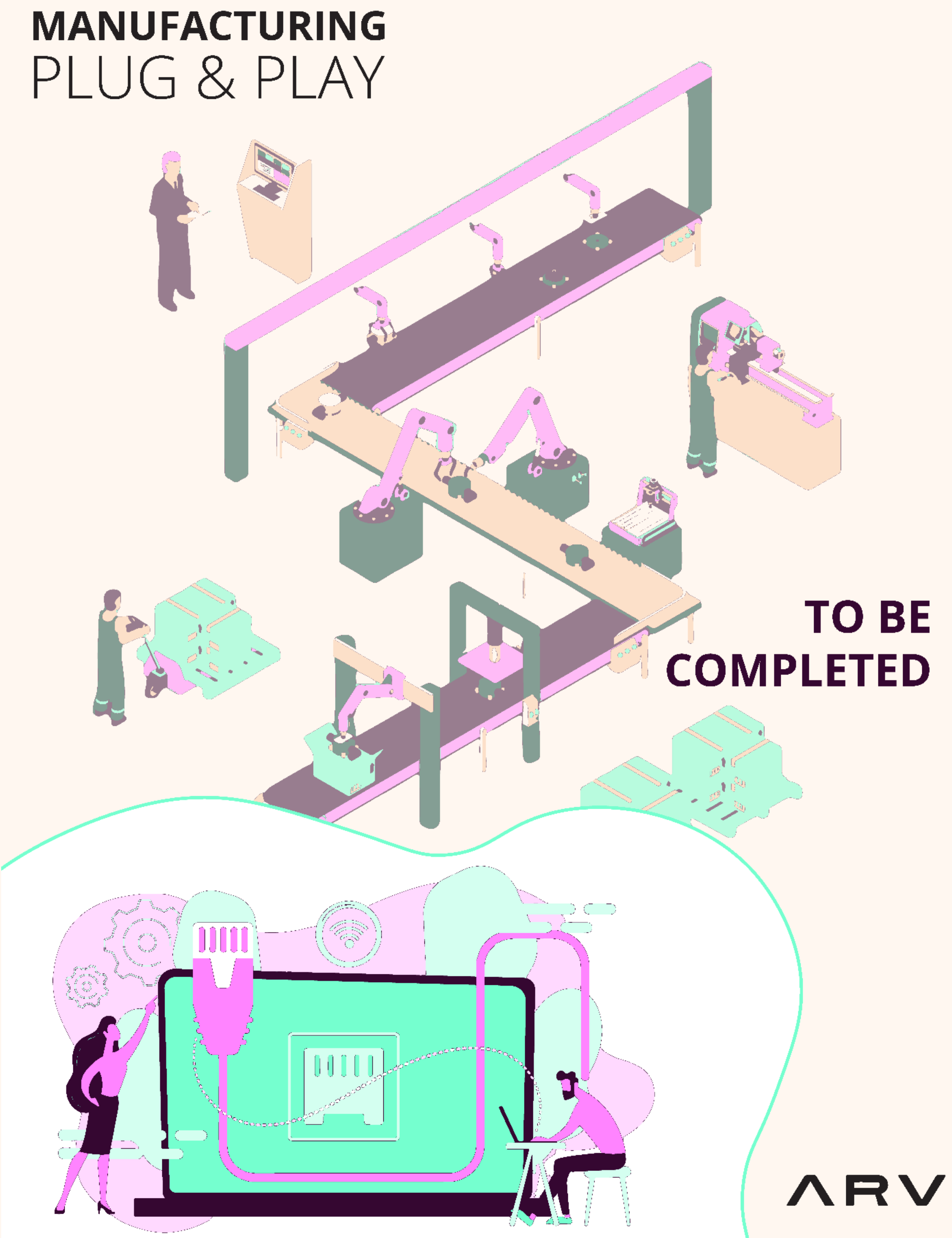


***Figure 22** Overview of the manufacturing workflows and the Plug&Play concept (Graphics: Jesus Daniel Garcia Melo)*

CONSTRUCTION

Carbon footprint reduction

No available information from deliverables yet. To be included in future updates.
Deliverable D5.2 *Workflow analyses and advise on how to move towards more prefabricated components and reduce work on-site, to be delivered in M60.*

Figure 23 *Overview of the carbon footprint reduction during the construction process (Graphics: Jesus Daniel Garcia Melo)*

Reduction of nuisance for occupants during renovations

No available information from deliverables yet. To be included in future updates.

***Deliverable D5.2** Workflow analyses and advise on how to move towards more prefabricated components and reduce work on-site, to be delivered in M60.*

***Figure 24** Overview of the nuisance for occupants during renovations section (Graphics: Jesus Daniel Garcia Melo – NTNU)*

DEMO WORKFLOWS

Utrecht

No available information from deliverables yet. To be included in future updates.
***Deliverable D5.3** Resource Efficient (Pre)Manufacturing & Construction Workflows – Demo Utrecht, to be delivered in M60.*

Palma

No available information from deliverables yet. To be included in future updates.
***Deliverable D5.4** Resource Efficient (Pre)Manufacturing & Construction Workflows – Demo Palma, to be delivered in M60.*

Oslo

No available information from deliverables yet. To be included in future updates.
***Deliverable D5.5** Resource Efficient (Pre)Manufacturing & Construction Workflows – Demo Oslo, to be delivered in M60.*

Karviná

No available information from deliverables yet. To be included in future updates.
***Deliverable D5.6** Resource Efficient (Pre)Manufacturing & Construction Workflows – Demo Karviná, to be delivered in M60.*

Trento

No available information from deliverables yet. To be included in future updates.
***Deliverable D5.7** Resource Efficient (Pre)Manufacturing & Construction Workflows – Demo Trento, to be delivered in M60.*

***Figure 25** Resource Efficient (Pre)Manufacturing and Construction Demo workflows (Graphics: Jesus Daniel Garcia Melo – NTNU)*

3.4. INTEGRATED RENEWABLES AND STORAGE SYSTEMS

This section focuses on the planning, implementation, and assessment of the ARV project's novel solutions in various demonstration locations, particularly regarding the integration of renewable energy and energy storage systems within buildings and neighbourhoods. These efforts are crucial for conceiving the ARV project's objectives of establishing communities that generate surplus energy and have minimal emissions.

The integration of renewables and storage systems in the ARV demo projects stands at the intersection of aesthetics, environmental sustainability, user acceptance, economic life cycle considerations, and operational flexibility, encapsulating a holistic approach to energy systems in buildings (Figure 26). From an aesthetic perspective, the integration of renewables and storage systems aims for seamless incorporation into the architectural fabric, promoting visual harmony and acceptance within the built environment. Environmentally, this approach prioritises clean energy sources, reducing carbon footprints and fostering a more sustainable future. User acceptance is crucial, highlighting the importance of designs that align with occupants' preferences and needs. Assessing economic life cycles ensures long-term viability and cost-effectiveness, reinforcing the project's commitment to financially sustainable solutions. Finally, operational flexibility is a key feature, adapting to dynamic energy demands and promoting efficient resource utilisation.

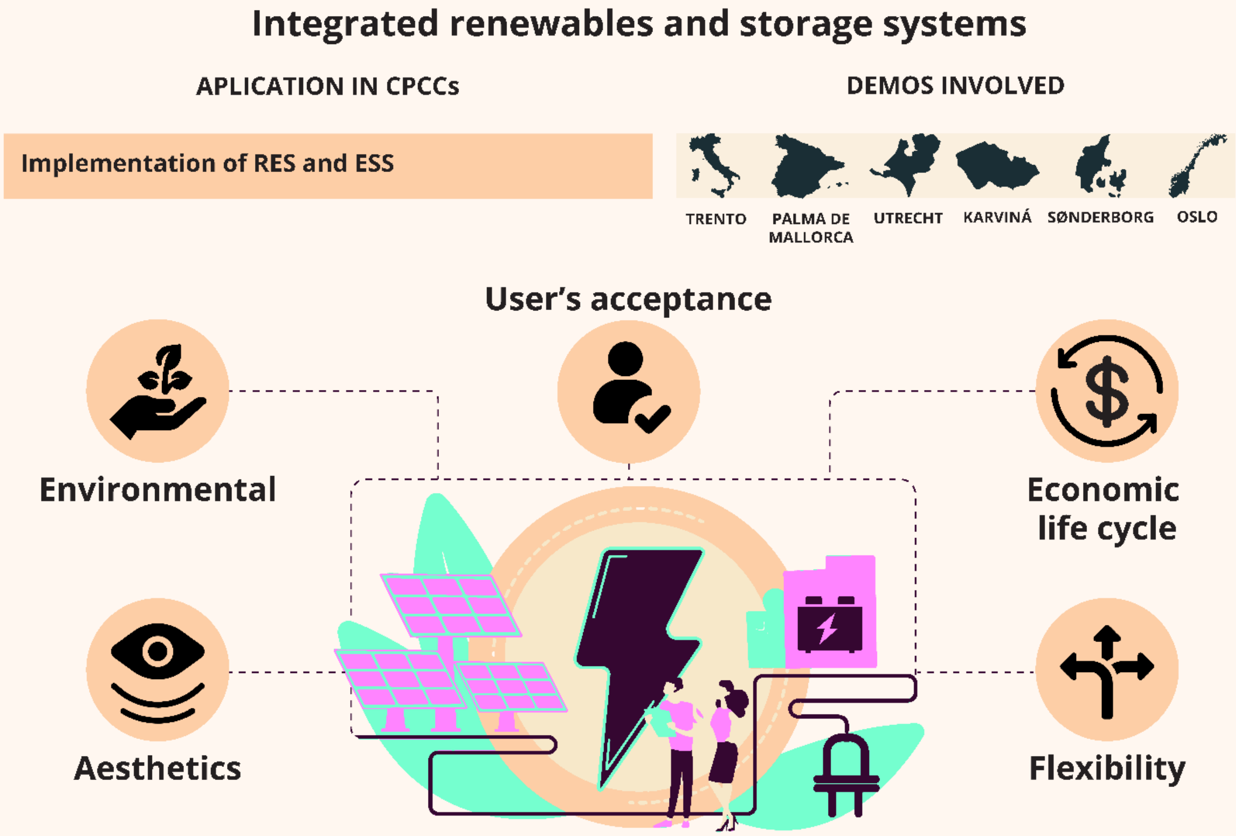


***Figure 26** Different criteria for the implementation of renewables and storage systems in ARV (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Figure 27 shows the overall implementation plan of Renewable Energy Systems (RES) and Energy Storage Systems (ESS) from the five demos involved.

IMPLEMENTATION OF
RES and ESS

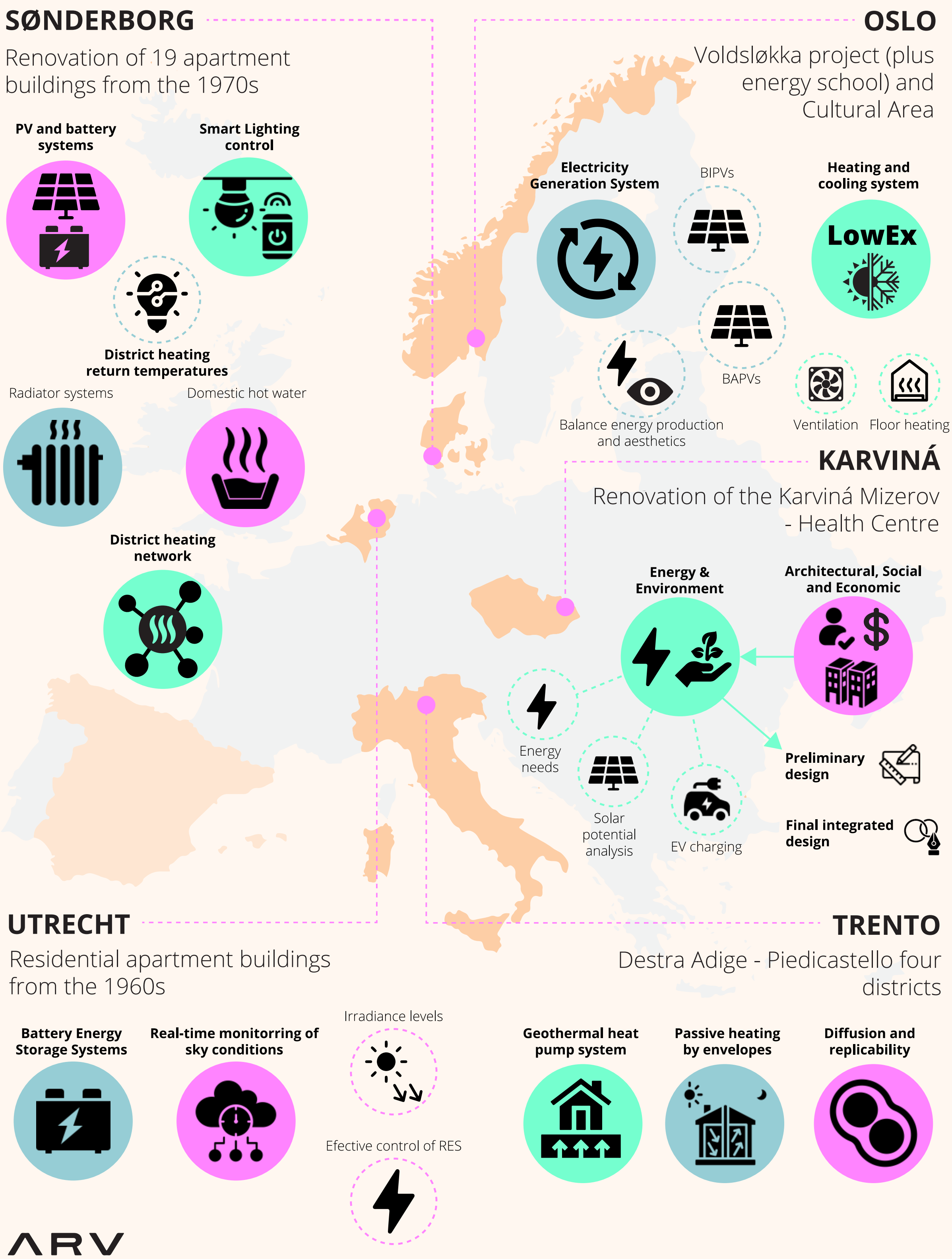


Figure 27 *Overall implementation plan of Renewable Energy Systems (RES) and Energy Storage Systems (ESS) from the five demos involved. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Oslo

Deliverable D6.1 *Guidelines for integrated design and implementation of RES and ESS for buildings'/ neighbourhoods' energy needs in Oslo, to be delivered in M42. Some information is available in working documents.*

The Voldsløkka School project integrates renewable energy systems (RES) and energy storage systems (ESS) to meet sustainability goals while considering architectural and cultural constraints. A Ground Source Heat Pump (GSHP) provides 80–90% of the heating needs, supplemented by district heating during peak demand. The school building, designed as a plus-energy building, uses a combination of Building Integrated PV (BIPV) and Building Applied PV (BAPV) systems to generate more energy than required, making it a 'plus energy building'. Custom façade PV panels meet aesthetic requirements while ensuring the building meets the 'plus energy building' standard, demonstrating how architecture and energy efficiency can work together.

The project also offers environmental and social benefits, with reduced operational costs and increased public awareness of renewable energy. The visible PV façades contribute to sustainability awareness for students, while the low-energy systems lower school expenses, freeing funds for other activities. Although custom BIPV systems come with higher initial costs, the shorter payback period due to rising energy prices makes the investment viable. Voldsløkka School serves as a model for future sustainable building projects by integrating energy systems with innovative architectural solutions. The Voldsløkka project builds on previous Oslo initiatives, combining BIPV and BAPV systems to meet plus energy goals. Due to limitations in space and orientation, neither system alone could meet energy needs, and BAPV provided most of the energy production. The project demonstrates the potential of BIPV to merge energy generation with aesthetics, offering architects more design flexibility. Successful integration requires multidisciplinary expertise across all project phases.

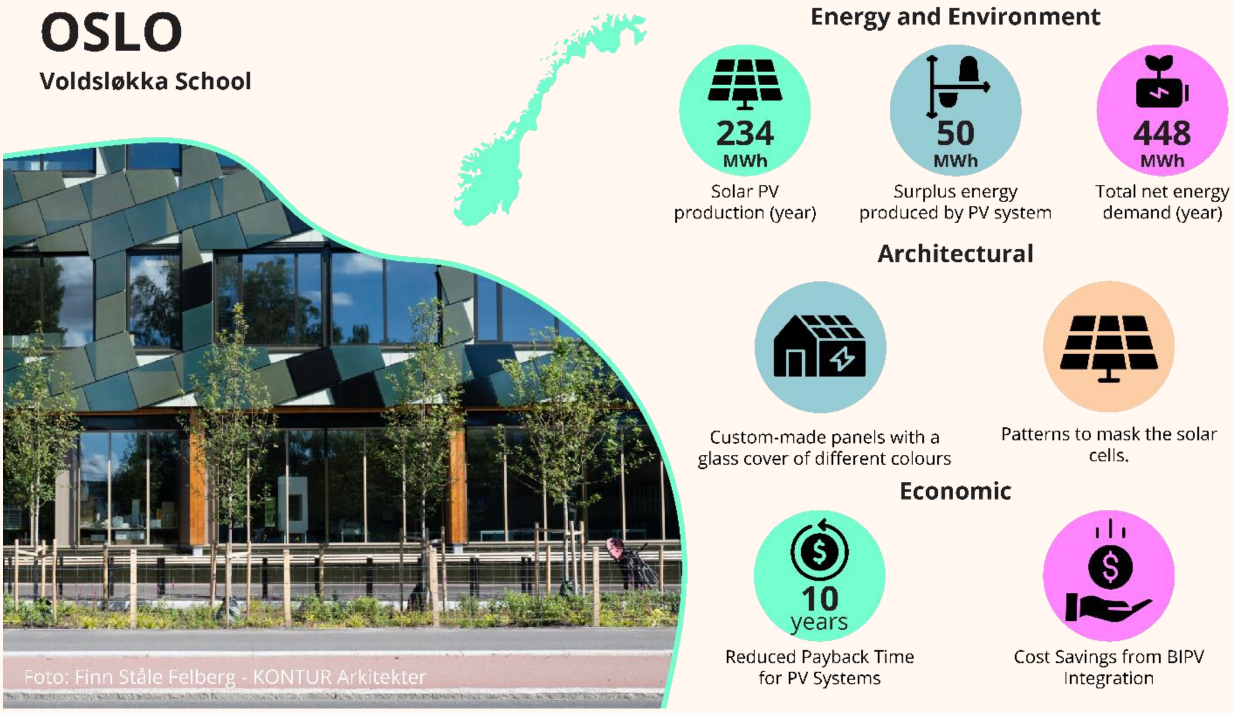


Figure 28 *Overall implementation plan of RES and ESS the demo project in Oslo, Norway. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Sønderborg

Deliverable D6.2 *Guidelines for integrated design and implementation of RES and ESS for buildings'/ neighbourhoods' energy needs in Sønderborg, to be delivered in M26.*

The demo project in Sønderborg focuses on renewable and storage systems (RES) in larger residential buildings, targeting significant social housing and private rental properties. This initiative highlights the economic and environmental feasibility of integrating solar photovoltaic (PV) systems with advanced battery storage technologies, optimising electricity consumption to align with solar production peaks. By enabling residents to utilise more of the electricity generated on-site, the project promotes energy independence and reduces reliance on the grid during peak periods.

Beyond electricity, the project takes a holistic approach to energy systems by leveraging the district heating network as a dynamic heat storage solution. Through predictive modelling of local heat demand and network heat losses, the system enables the creation of temperature zones within the city, allowing for the efficient integration of heat pumps and surplus heat from industrial processes, renewable sources, or other waste heat streams. This approach not only enhances energy efficiency but also supports the municipality's broader goals for sustainable urban development.

The integration of roof-mounted solar panels and basement-located battery storage exemplifies innovative design, promoting on-site solar electricity generation and consumption within residential buildings.

The project also emphasises continuous advancements in battery storage solutions, exploring the latest developments in lithium battery technology while investigating sustainable and scalable alternatives such as "flow batteries." These flow batteries, though still in the early stages of development, offer promising potential for larger-scale applications, contingent upon further research and cost reductions.

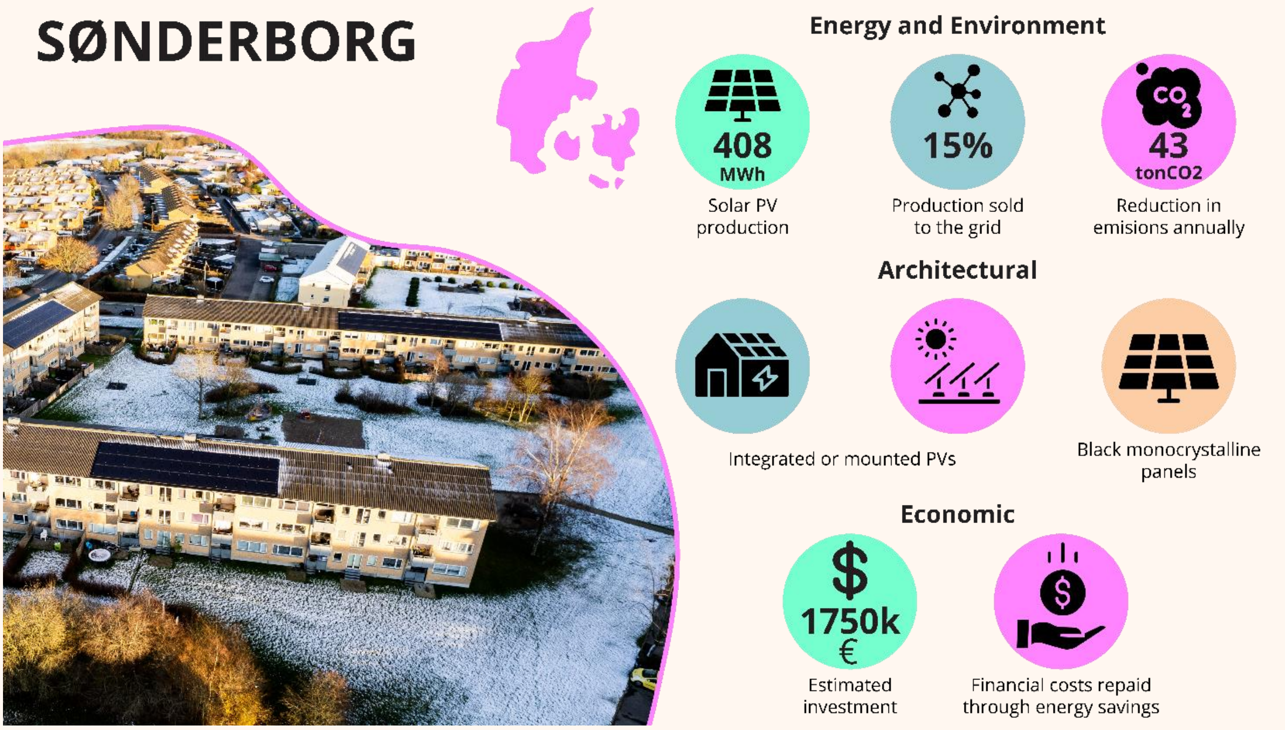


Figure 29 *Overall implementation plan of RES and ESS in Sønderborg demo. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Utrecht

Deliverable D6.3 *Guidelines for integrated design and implementation of RES and ESS for buildings'/ neighbourhoods' energy needs in Utrecht, to be delivered in M44.*
No available information from deliverables yet. To be included in future updates.

Karviná

Deliverable D6.4 *Guidelines for integrated design and implementation of RES and ESS for buildings'/ neighbourhoods' energy needs in Karviná, to be delivered in M44. Some information is available in working documents.*

The Czech demo project in Karviná aims to showcase innovative energy solutions focused on reducing CO_2 emissions and enhancing urban environments. It involves nine municipal buildings and aims for future scalability across the district. The demo integrates renewable energy sources (RES) and digital tools, with a focus on climate-positive circular communities. Key innovations include BIPV/BAPV systems, a second-life battery, hybrid heat pumps, and electric vehicle (EV) charging stations, all designed for high energy performance and potential replication. The project also explores business models to assess economic viability and operational feasibility.

The energy systems in the demo building focus on both electrical and thermal solutions. The building features a combination of BIPV/BAPV with high-efficiency panels, a second-life battery storage system, and PVT collectors, all enhancing the building's energy performance. The hybrid heat pump, powered by electricity from PVT, provides heating, cooling, and hot water, optimising energy use. Advanced controllers ensure the heat pump runs on PV electricity, reducing grid dependency.

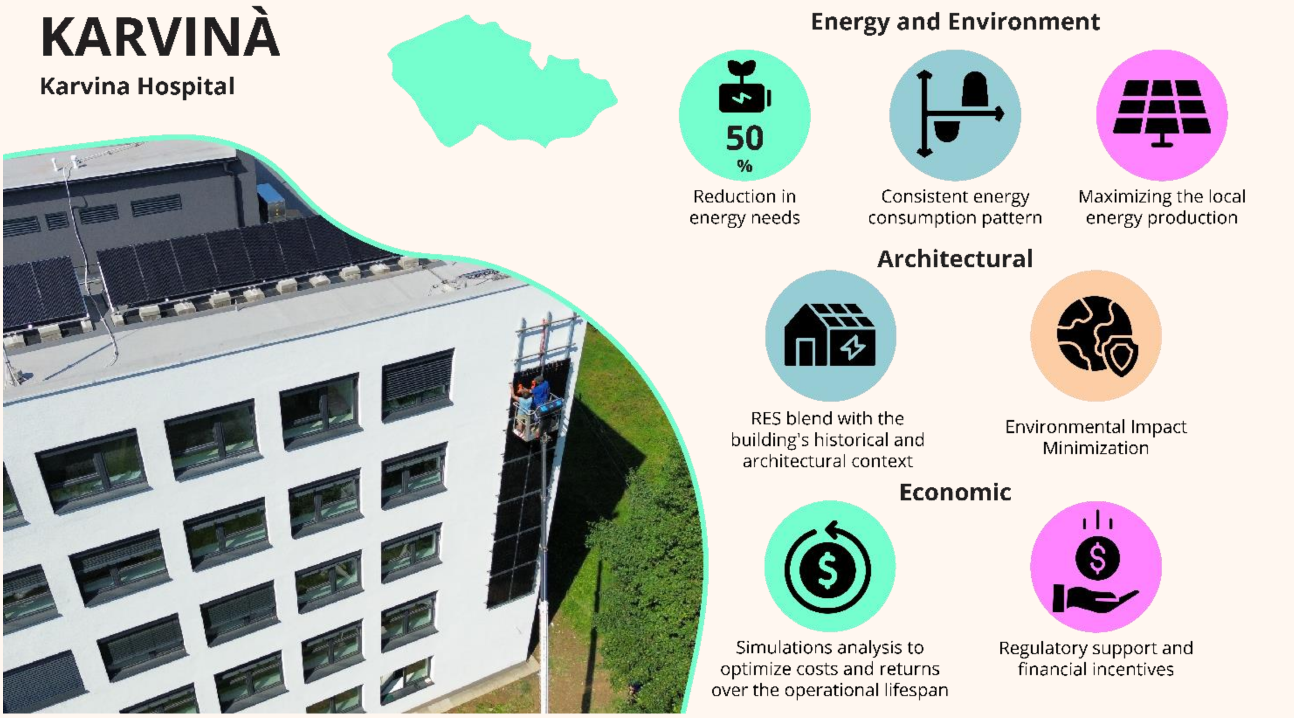


Figure 30 *Overall implementation plan of RES and ESS in Karviná demo. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Trento

Deliverable D6.5 *Guidelines for integrated design and implementation of RES and ESS for buildings'/ neighbourhoods' energy needs in Trento, to be delivered in M54.*
No available information from deliverables yet. To be included in future updates.

3.5. EFFICIENT OPERATION AND FLEXIBILITY

This chapter provides guidelines on how to efficiently operate CPCCs with respect to optimising the energy and power performance as well as the indoor environment quality and minimise greenhouse gas emission and costs.

It mainly focuses on deploying methods to describe and identify energy flexibility related to demand response solutions, formulating Flexibility Functions (FFs) that provide local grid support and other power system services. The approach integrates modelling, forecasting, and control solutions, using a hierarchical control framework to exploit distributed resources' flexibility for market optimisation and ancillary services provision.

Emphasis is placed on wholesale energy trade functions, ancillary services (e.g., fast operating reserves), and Peer-to-Peer (P2P) trading among positive energy buildings and regular buildings. The implementation includes a handbook for smart communities and guidelines for business models, energy system integration, and market interfaces. The task aims to foster a scalable framework for providing flexibility in power systems operations through aggregators, promoting the efficient use of local renewable energy generation and innovative market models.

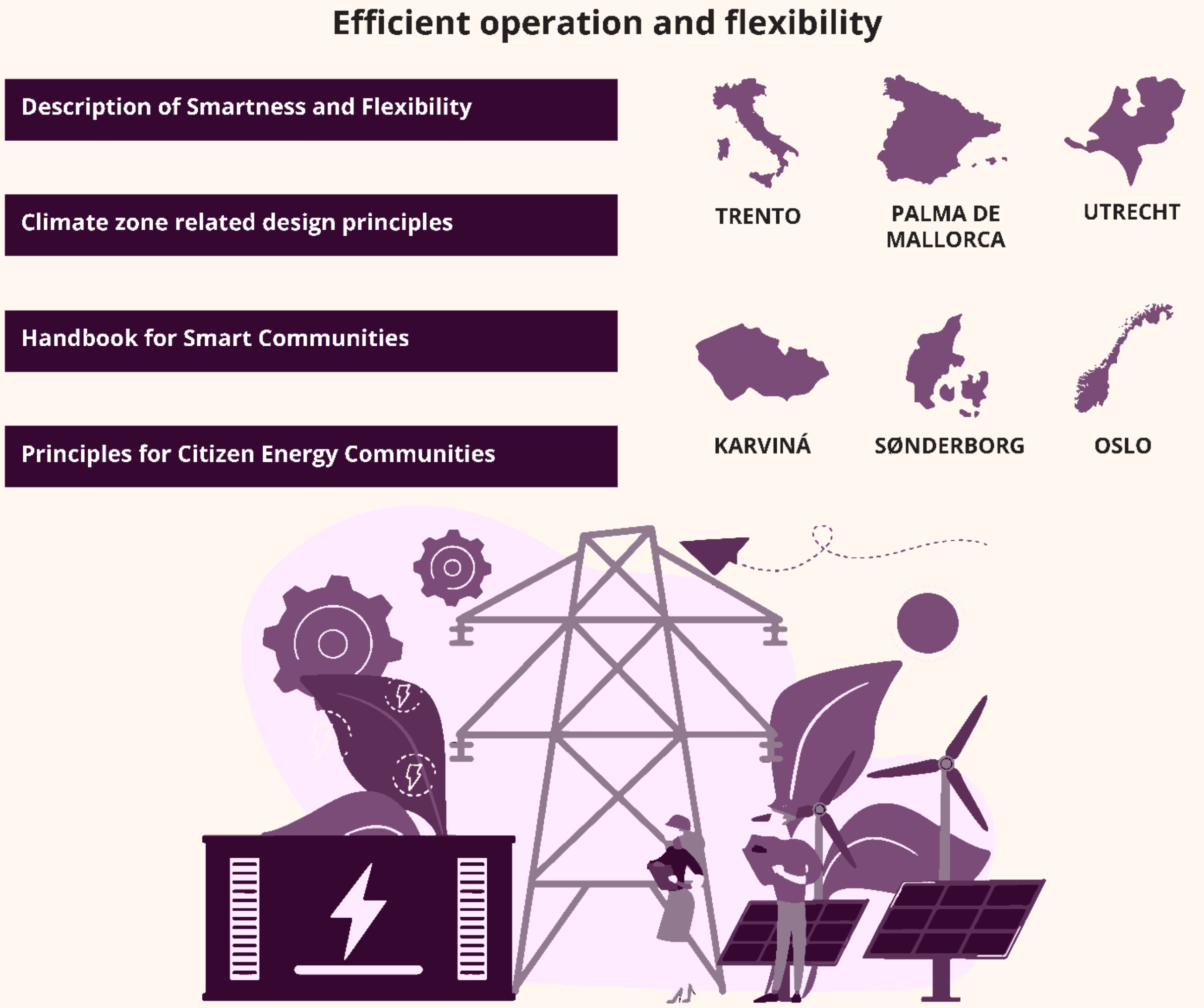


Figure 31 *Overview of ARV focus areas related to Efficient Operation and Flexibility . (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Description of smartness and flexibility

Deliverable D7.6 *Guidelines on descriptions of smartness and flexibility, delivered in M24.*

Smart readiness indicator

As the need for adaptive and efficient energy systems grows, the Smart Readiness Indicator (SRI) emerges as a critical metric for assessing the intelligence and adaptability of individual buildings. The SRI provides a comprehensive framework to evaluate a building's ability to interact with occupants and energy systems, optimise energy use, and respond dynamically to external conditions. By delving into the overall “smartness” of a building, the SRI facilitates a standardised approach to benchmarking and enhancing energy system flexibility across various types of buildings. It not only supports the transition to sustainable energy practices but also promotes user comfort and operational efficiency, ensuring that modern buildings are equipped to meet future energy demands.

Flexibility function and flexibility index

Flexibility in energy systems, crucial for efficiency and sustainability, is quantified through the Flexibility Function (FF) and Flexibility Index (FI). The FF dynamically illustrates how systems respond to external signals, like energy prices, utilising penalty signals for cost, emission, and energy efficiency. In cases of adaptable loads, such as heating systems, a controller generates penalty signals that guide flexible users (buildings or energy systems) to dynamically adjust energy consumption patterns based on changing conditions.

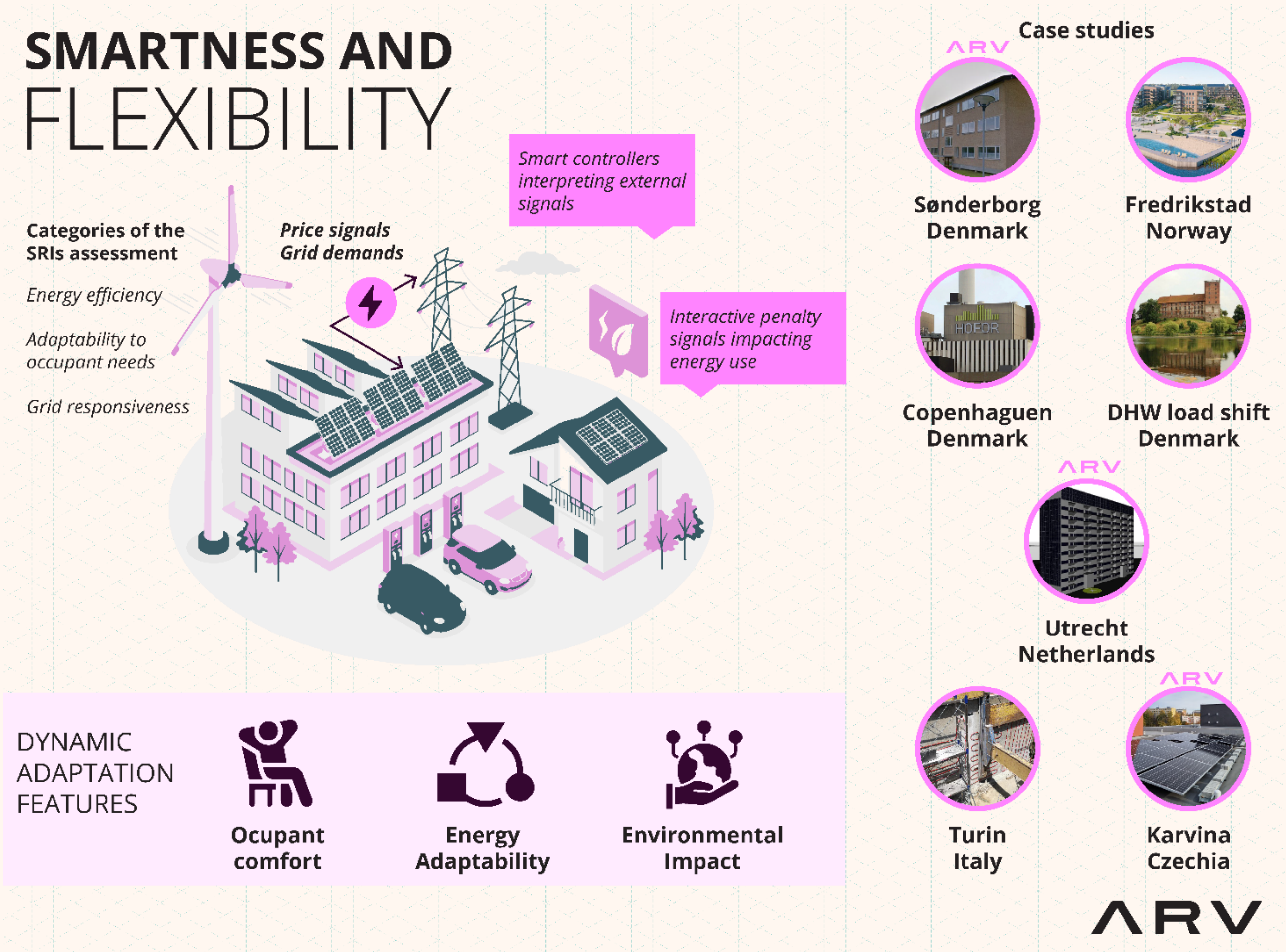


Figure 32 *Smartness and flexibility iteration for energy systems optimisation. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Climate zone related design principles

Deliverable D7.7 *Guidelines on climate zone related design principles, to be delivered in M36. Some information is available in working documents.*

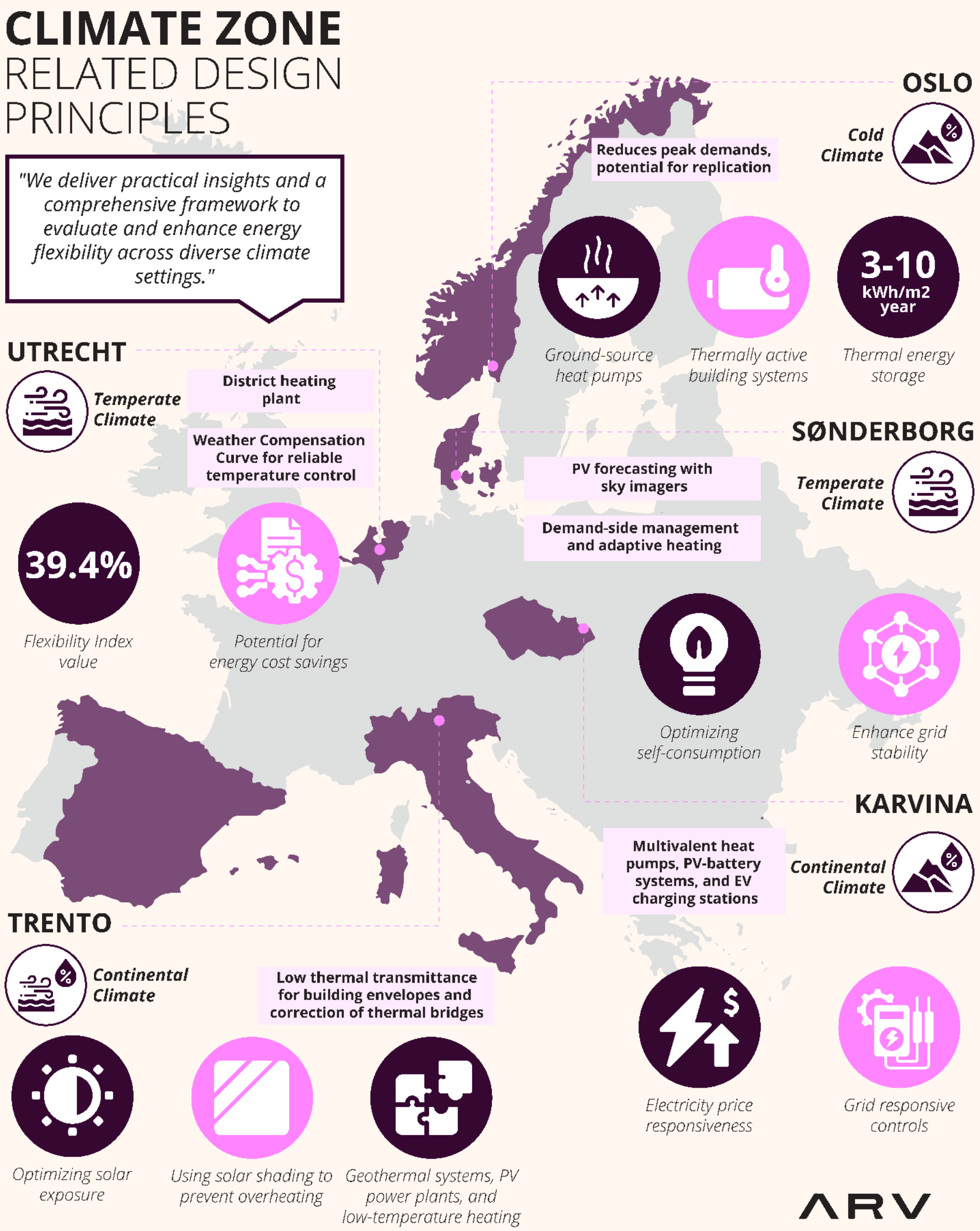


Figure 33 *Overview illustration with the Climate zone related design principles of each demo (Graphics: Jesus Daniel Garcia Melo – NTNU)*

HANDBOOK FOR SMART COMMUNITIES

Deliverable D7.8 *Handbook for smart communities , to be delivered in M54.*
No available information from deliverables yet. To be included in future updates.

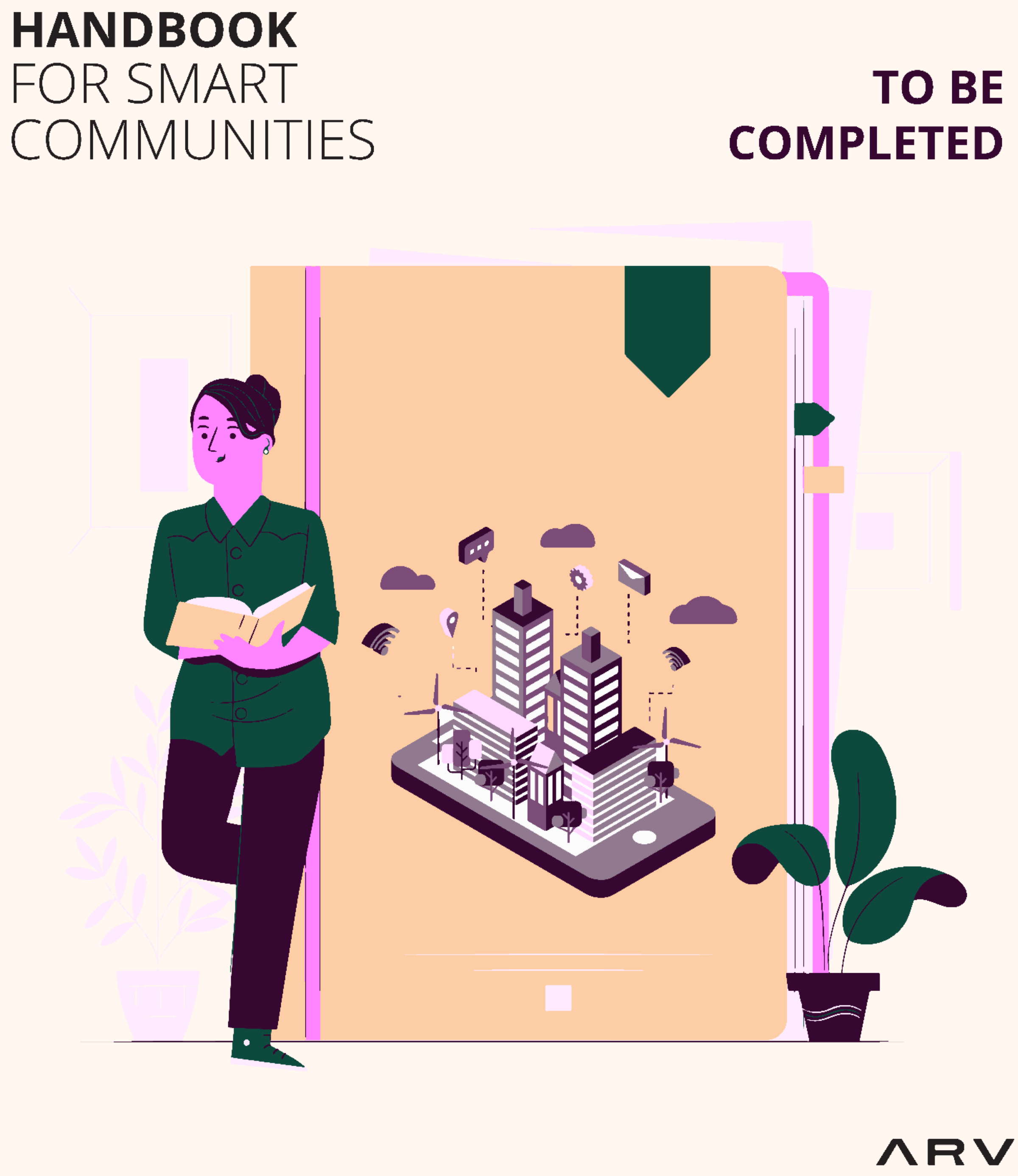


Figure 34 *Illustration for the draft of the Handbook for Smart Communities (Graphics: Jesus Daniel Garcia Melo – NTNU)*

PRINCIPLES FOR CITIZEN ENERGY COMMUNITIES – DISTRIBUTION SYSTEMS OPERATORS INTERACTIONS

Deliverable D7.9 *Principles for CEC-DSO interaction, to be delivered in M46.*
No available information from deliverables yet. To be included in future updates.

3.6. METHODS AND TOOLS

This section is designed to cover all the methods and tools applied in the planning, design, construction operation and use of CPCCs. A collection of the essential project components is linked to ARV's main framework, including KPIs, user information, stakeholder engagement, and energy monitoring, with the primary goal of providing a comprehensive understanding of the project's environmental, economic, and social impacts (Figure 35).

A pivotal aspect of this methods and tools' collection involves establishing specifications and guidelines for monitoring, evaluation, and impact assessment. This encompasses the definition of standards for monitoring systems across the six ARV demos. Additionally, it defines methodologies for impact assessment, incorporating internationally standardised approaches like life-cycle assessment to assess environmental, social, and economic impacts. Furthermore, it entails the management of static and dynamic data collection and monitoring, tailoring monitoring systems for the related demos. Finally, this section aims to show and measure the success of ARV through an impact investing approach, considering financial, economic, environmental, and social criteria, having in mind the goal to leverage further investments, contributing to scale-up and replication and aligning with the UN SDGs.

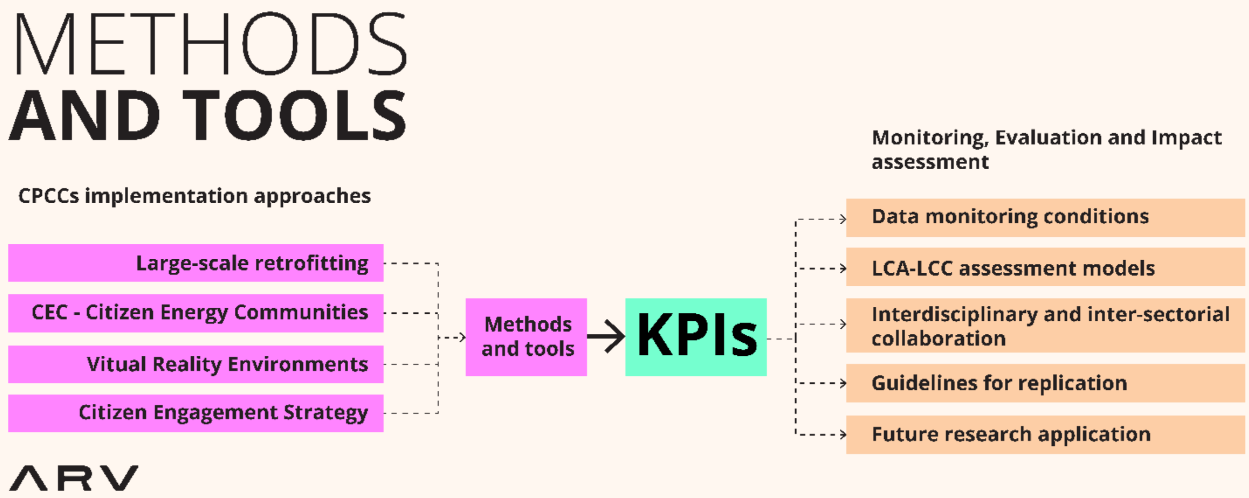


Figure 35 *CPCCs implementation approaches linked to the assessment processes through the methods and tools of each demo. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

CPCCS IMPLEMENTATION APPROACHES

Large Scale Retrofitting

Tools Description

Deliverable D2.2 *Description of methods and tools for Large-Scale Retrofitting in CPCC, delivered in M18.*

In the context of implementing Climate Positive Circular Communities (CPCC) initiatives, the adoption of large-scale retrofitting emerges as a significant approach. Large-scale retrofitting not only addresses climate neutrality challenges but also offers economic perspectives for transforming existing neighbourhoods. This approach involves integrating renewable energy sources, especially electricity generated from PV or wind, to efficiently distribute and share energy within Citizens' Energy Communities.

To facilitate the practical implementation of this approach, a comprehensive review of available methods and tools has been conducted, focusing on planning, and analysing extensive retrofitting initiatives. The review of large-scale retrofitting processes in this Blueprint highlights the outlining methods, evaluation horizons, associated KPIs (with a bold emphasis on economic analysis and Indoor

Environmental Quality), and a general workflow. Moreover, the compiled list of relevant methods and tools provides a foundation for their subsequent application in the demonstration projects, ensuring a strategic alignment with the goals of the CPCC initiatives. Figure 36 provides an overview of methods and tools for large-scale retrofitting processes and their associated KPIs.

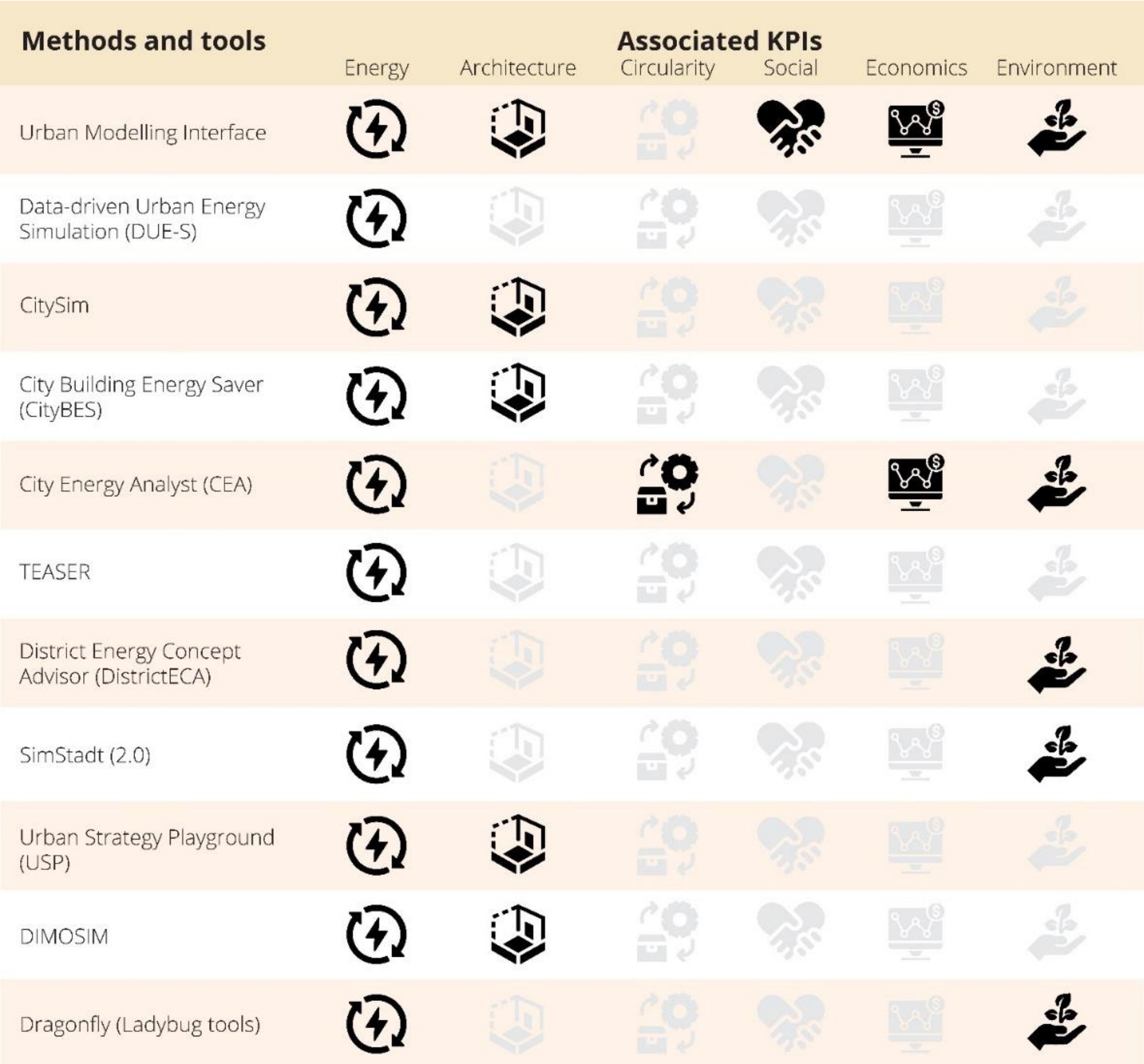


Figure 36 *Overview of methods and tools in Large-Scale retrofitting processes and their associated KPIs. (Graphics: Jesus Daniel Garcia Melo- NTNU).*

Use cases (applications)

Some information is available from previous report. It will be updated and expanded in future reports.
Deliverable D2.4 *Application of tools for large-Scale Retrofitting actions. Uses cases and guidelines for replicability, to be delivered in M46.*

The methods and tools for large-scale retrofitting, meticulously reviewed for planning and analysing extensive retrofitting initiatives, are poised for practical application in the demonstration projects of Palma de Mallorca and Sønderborg. These tools are designed to integrate renewable energy sources and address economic considerations in the retrofitting process, with a workflow that align seamlessly with the Climate Positive Circular Communities (CPCC) processes (Figure 37).

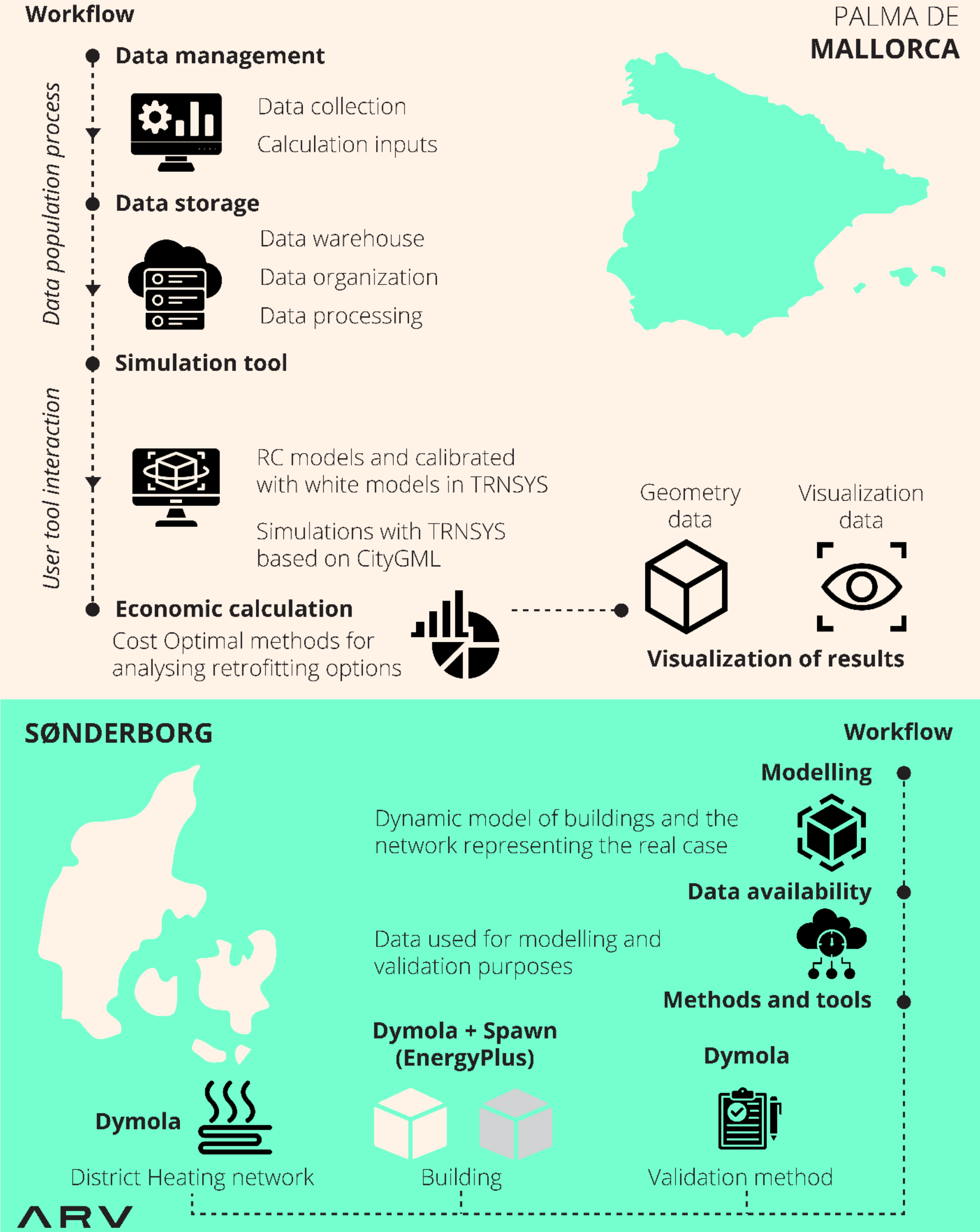


Figure 37 Application of methods and tools in Large-Scale retrofitting processes in Palma and Sønderborg demos. (Graphics: Jesus Daniel Garcia Melo – NTNU)

Guidelines

Deliverable D2.4 *Application of tools for large-Scale Retrofitting actions. Uses cases and guidelines for replicability, to be delivered in M46.*

No available information from deliverables yet. To be included in future updates.

CEC Citizen Energy Communities

Tools (Description)

Deliverable D2.3 *Description of methods and tools for CEC in CPCC, delivered in M15.*

The methods and tools related to Citizen Energy Communities are highly focused to Energy, Architecture and Economic KPIs, see Figure 39, and are applied in the demonstration projects of Palma de Mallorca and Karviná. In Figure 38, these tools, tailored for the CPCCs, illustrate the integration of energy sources analysis to storage processes are based on data collection and processing workflows, having as end goal a complete visualisation and management of information by energy communities for further use.

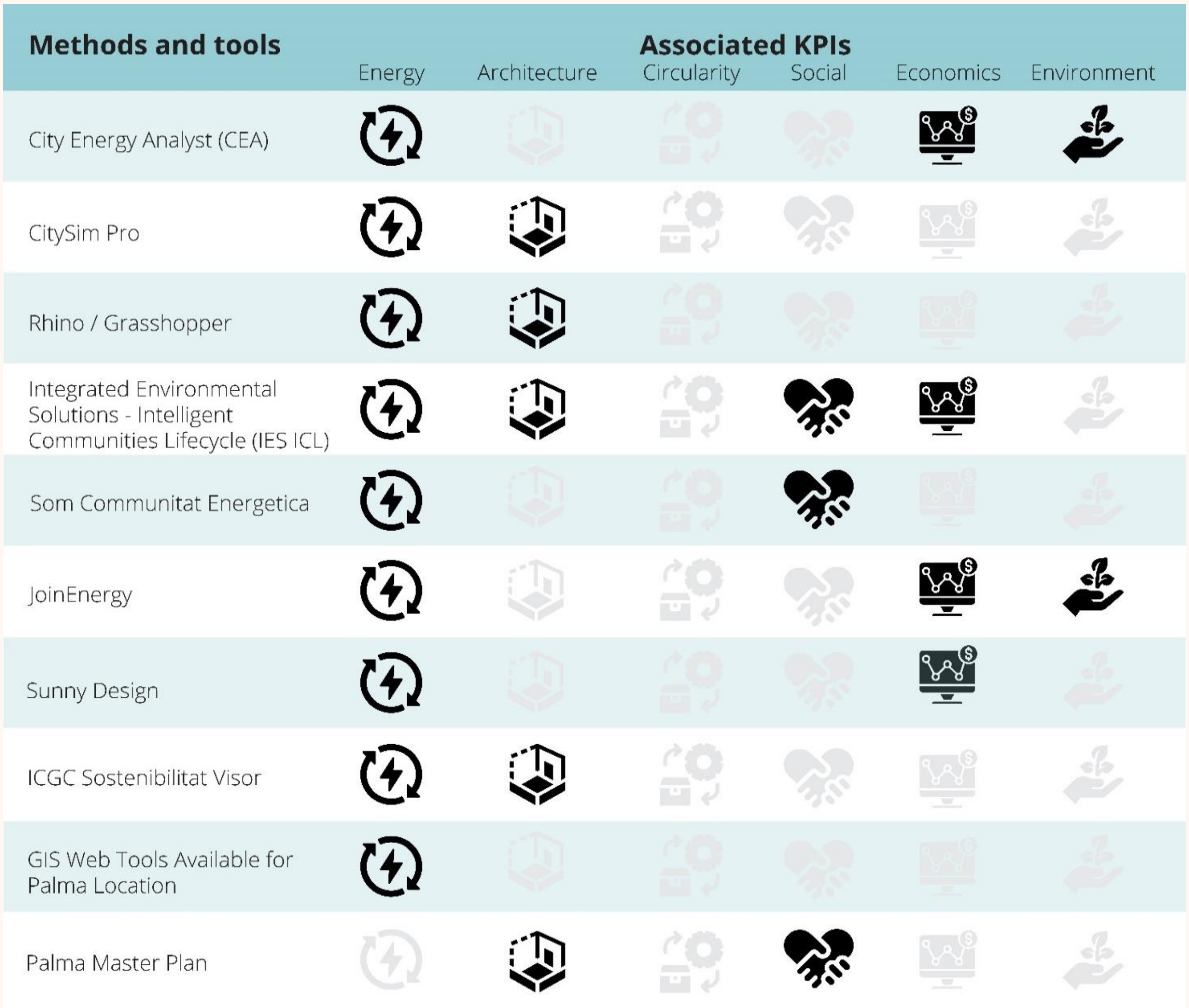


Figure 38 *Description of methods and tools in Citizen Energy Communities processes and their associated KPIs. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Use cases (Application)

Some information is available from previous report. It will be updated and expanded in future reports.
Deliverable D2.5 Application of tools for implementation of Citizen Energy Communities. Uses cases and guidelines for replicability, to be delivered in M42.

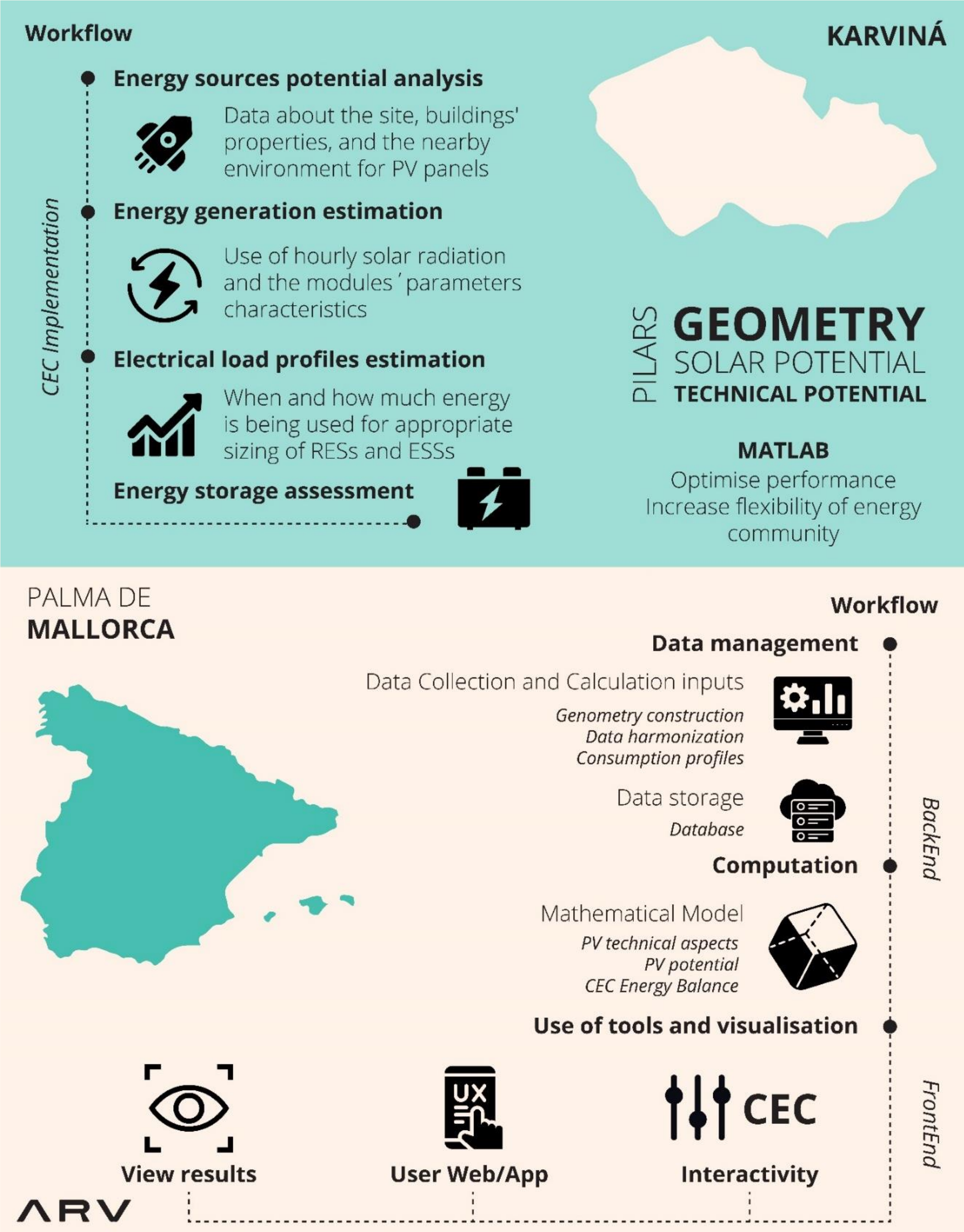


Figure 39 *Application of methods and tools in Citizen Energy Communities processes in Palma and Sønderborg demos. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Guidelines

Deliverable D2.5 *Application of tools for implementation of Citizen Energy Communities. Uses cases and guidelines for replicability, to be delivered in M42.*
No available information from deliverables yet. To be included in future updates.

Virtual Reality Environments

Deliverables

D2.6: *Demos of Virtual Reality Environments, to be delivered in M36. No available information from deliverables yet. To be included in future updates.*

D2.7: *Description and lessons learnt from training & awareness sessions using Virtual Environments, to be delivered in M48.*

Figure 40 *Draft illustration for the application of methods and tools of the Visual Reality Environments (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Citizen Engagement Strategy

Deliverables

D3.4 *Analysis of citizen engagement tools and processes using a citizen science approach, to be delivered in M40. No available information from deliverables yet. To be included in future updates.*

D3.5 *Community-scale citizen engagement strategy and tools for the renovation wave, to be delivered in M54.*

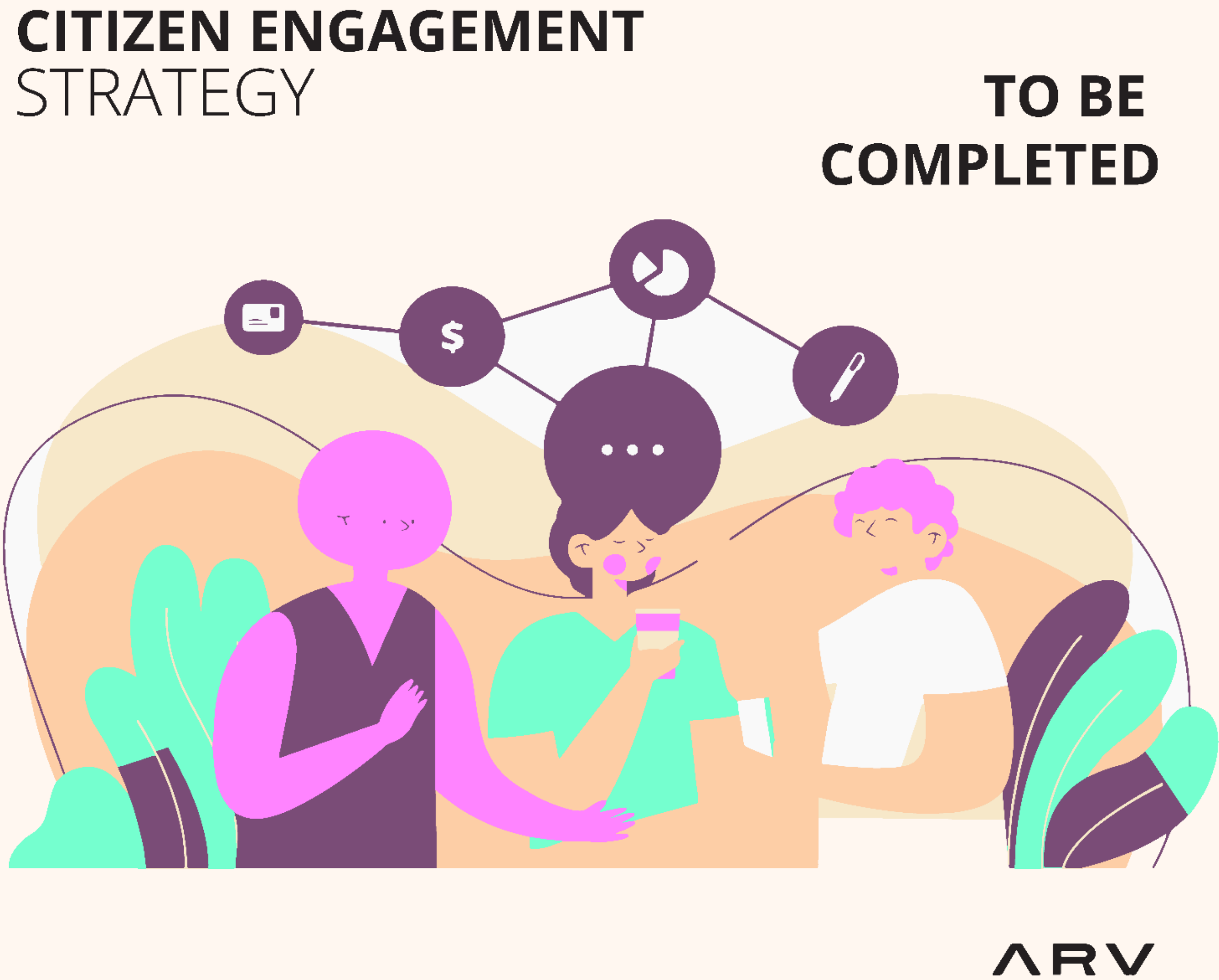


Figure 41 *Draft illustration for the application of methods and tools of the Citizen Engagement Strategy (Graphics: Jesus Daniel Garcia Melo – NTNU)*

MONOTORING, EVALUATION, AND IMPACT ASSESSMENT

Data monitoring conditions

Deliverable D8.1 *Monitoring, evaluation, and impact assessment frameworks, delivered in M12.*

In the ARV project, monitoring campaigns are essential for evaluating demo cases, covering energy, environmental requirements, construction activities, CPCC interaction with energy grids, and indoor environmental quality. The detailed data from monitoring, crucial for key performance indicators (KPIs) in ARV's Blueprint, requires automated procedures due to varying temporal characteristics. Parameters like energy-related aspects demand continuous data collection, while others, like construction time, are determined through measuring activities. This comprehensive data is subsequently processed and aggregated for use in environmental, economic, and social impact assessments in line with the ARV project's assessment framework. Figure 42 illustrates the monitoring strategies and their connection to ARV KPIs and different methods and tools.

MONITORING

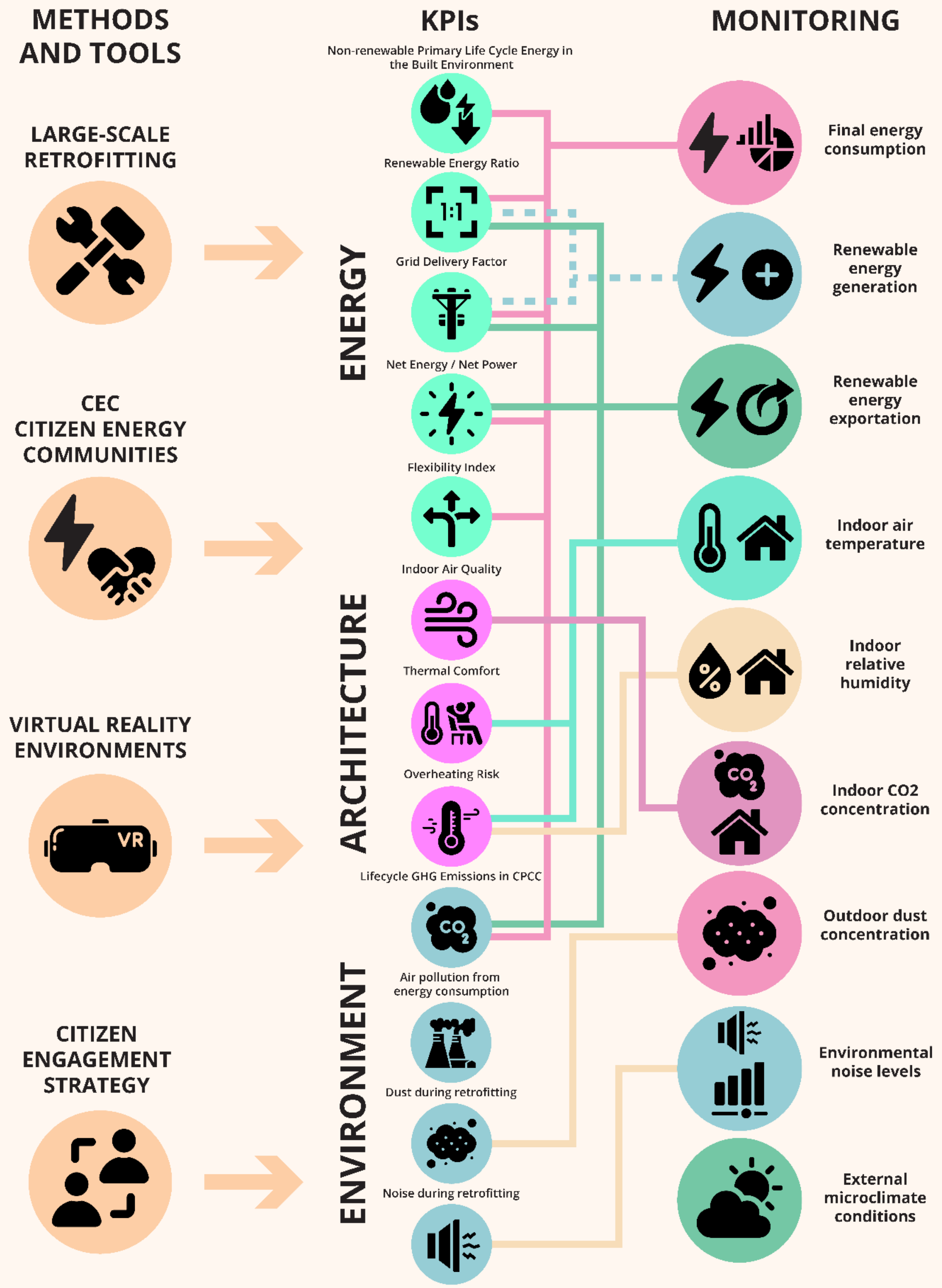


Figure 42 *Monitoring strategies and their connection to ARV KPIs and different methods and tools (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Deliverable D8.1 *Monitoring, evaluation, and impact assessment frameworks, delivered in M12.*

The assessment framework functions as a measuring tool in the ARV project. The evaluation involves periodic data collection, providing specific information on a range of criteria. This framework serves as the basis for systematically assessing the progress and long-term impact of demo cases. Aligned with the ARV project's objectives, the evaluation framework contributes vital information for calculating KPIs. Its dual approach combines subjective elements, utilising surveys, with an objective component involving the measurement of quantities relevant to KPI determination. Figure 43 highlights surveys and monitoring as main methods for evaluation with their respective associated KPIs.

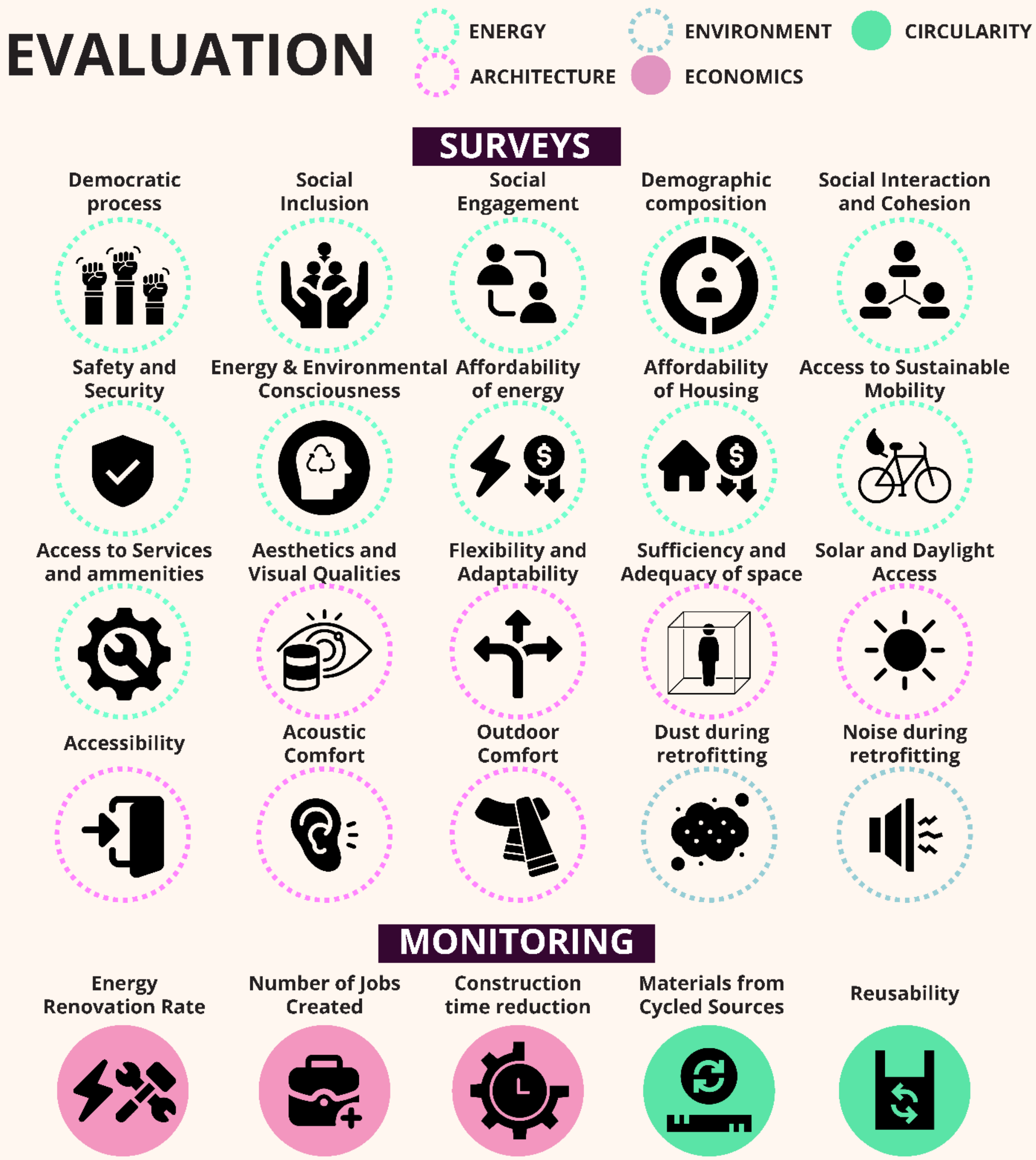


Figure 43 *Evaluation strategies and their connection to ARV KPIs and different methods and tools (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Impact Assessment

Deliverables

D8.1 *Monitoring, evaluation, and impact assessment frameworks, delivered in M12.*

D8.5 *Report on streamlined LCA-LCCA comparing alternative solutions and scenarios. delivered in M24. Some information is available from previous report. It will be updated and expanded in future reports.*

The impact assessment framework is designed for a holistic evaluation of project performance throughout its entire life cycle. This framework extends its evaluation to cover environmental, economic, and social dimensions. Three key methodologies—Life Cycle Analysis for environmental assessment, Life Cycle Costs for economic evaluation, and Social Life Cycle Analysis for social aspects—are proposed, aiming to complement each other and offer a comprehensive sustainability evaluation of ARV interventions, and its connection with KPIs, see Figure 44. To achieve its goals, the impact assessment framework integrates information collected through monitoring and evaluation activities with additional relevant data.

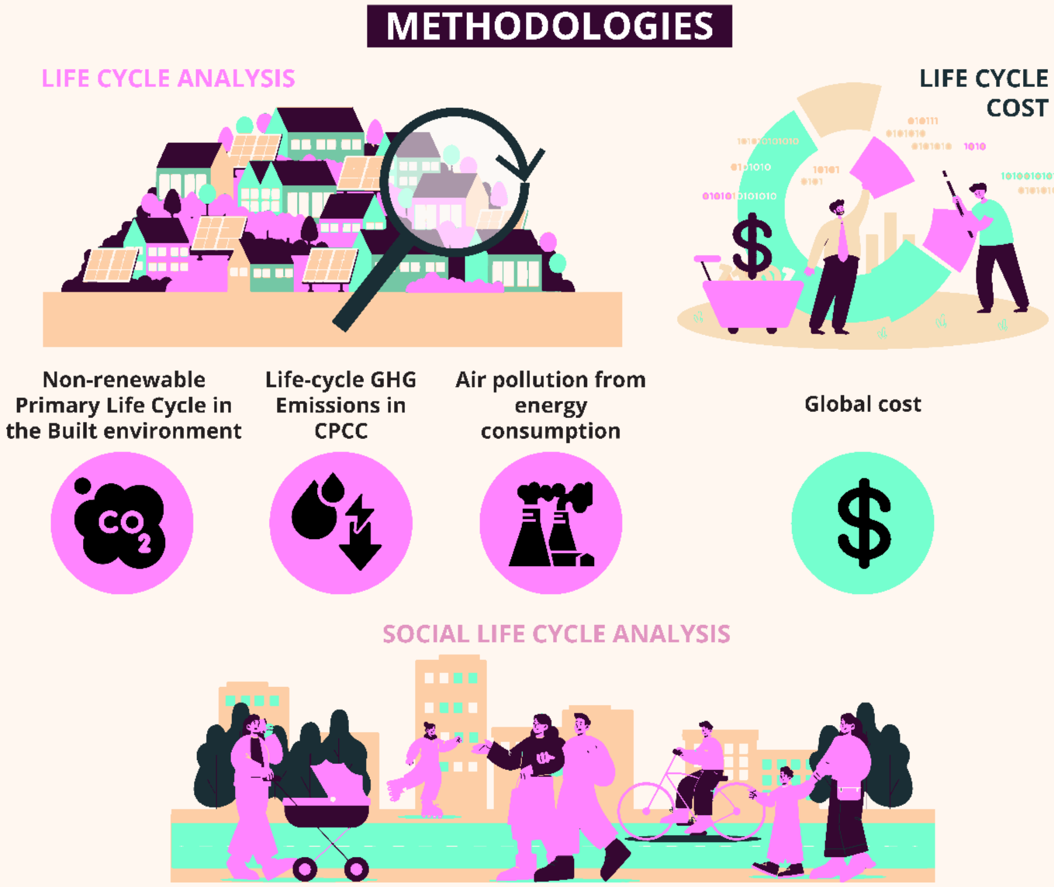


Figure 44 *Impact assessment methodologies and their connection to ARV KPIs and different methods and tools (Graphics: Jesus Daniel Garcia Melo – NTNU)*

LCA – Environmental Life Cycle Analysis

Deliverables

D8.1 *Monitoring, evaluation, and impact assessment frameworks, delivered in M12.*

D8.5 *Report on streamlined LCA-LCCA comparing alternative solutions and scenarios. delivered in M24.*

This section of the Blueprint exemplifies how Life Cycle Assessment (LCA) is used to check the energy and environmental impacts. In this case both the application on the built environment and the GHG emissions from CPCCs are addressed through the KPIs scope, reflecting how it is applied in each demo in synergy with the overall project goals. Figure 45 illustrates the connection with the KPIs, showing the main assessment criteria, and inventory.

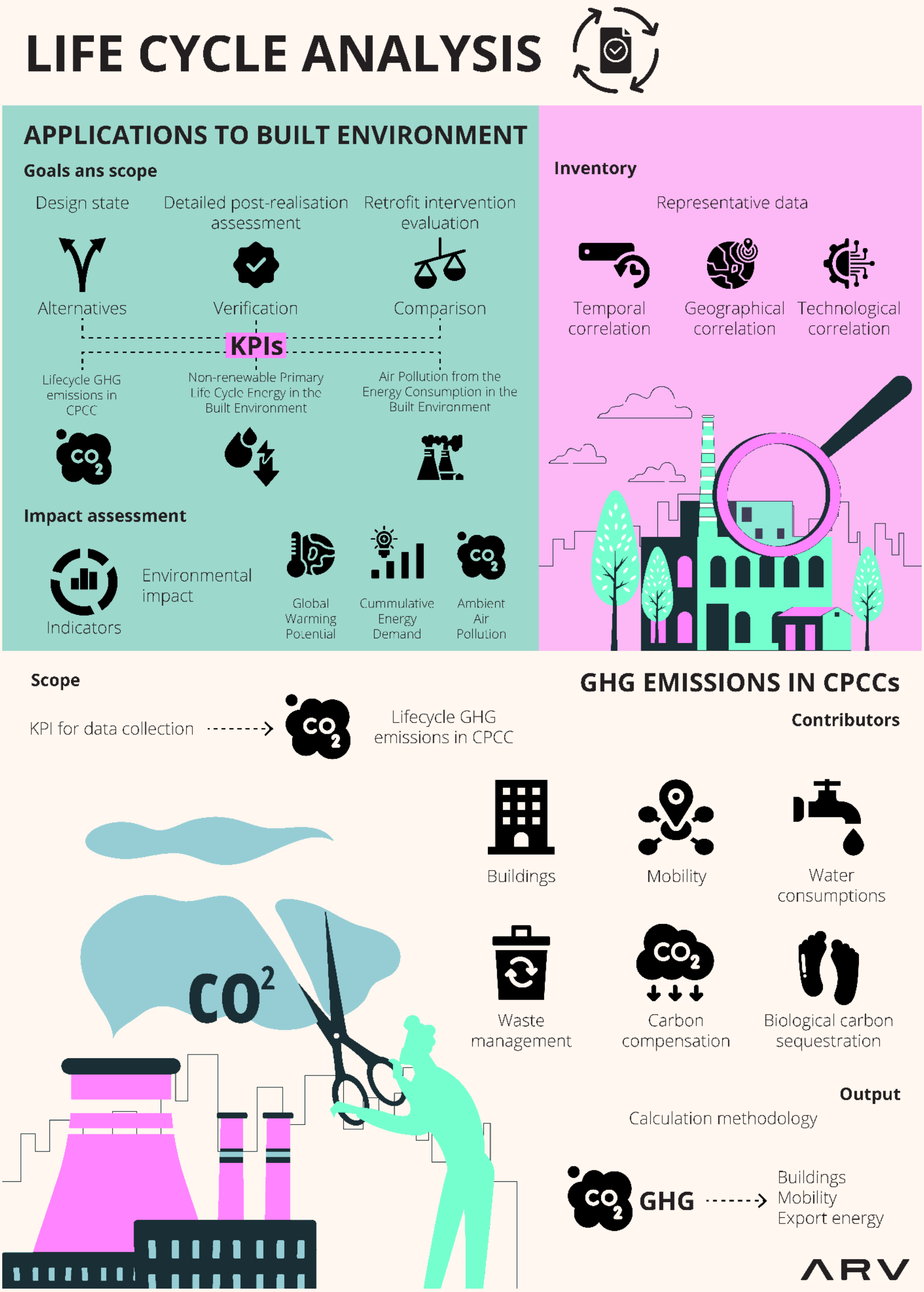


Figure 45 Life-cycle analysis from the LCA application to the built environment to the CPCC scale (Graphics: Jesus Daniel Garcia Melo – NTNU)

LCC – Life Cycle Cost Analysis

Deliverables

D8.1 *Monitoring, evaluation, and impact assessment frameworks, delivered in M12.*

D8.5 *Report on streamlined LCA-LCCA comparing alternative solutions and scenarios. delivered in M24. Some information is available from previous report. It will be updated and expanded in future reports.*

The Life Cycle Cost (LCC) method assesses the overall economic performance of an asset throughout its life cycle, encompassing planning, design, capital, maintenance, and operating costs, as well as the asset's residual value at the end of its lifespan. Although LCA and LCC analyses have similarities, there are two key distinctions: LCC includes acquisition costs and market value, whereas LCA concentrates on environmental impacts, excluding socio-economic aspects. Integrating both methodologies enhances the evaluation, offering a comprehensive analysis that considers both economic and environmental factors.

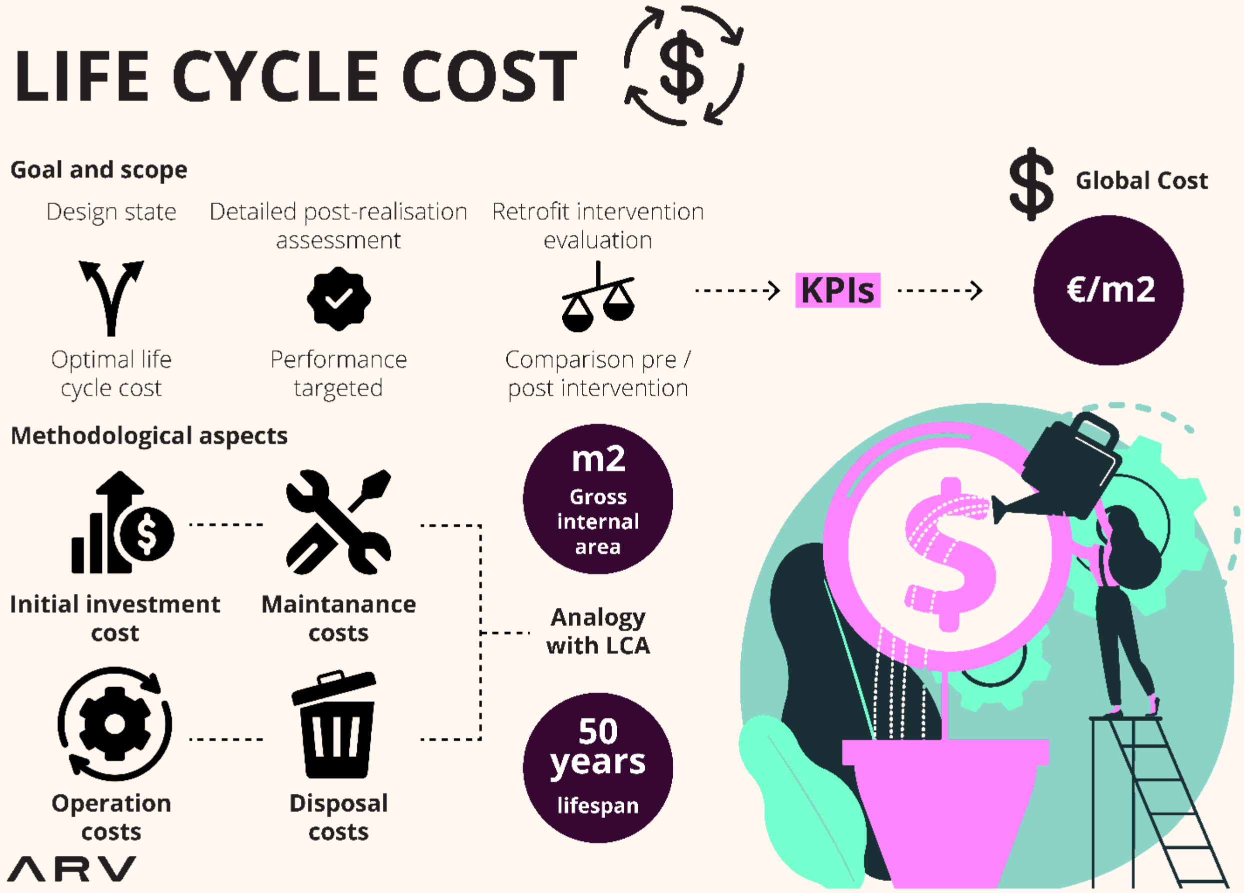


Figure 46 *Goals and methodological aspects of Life-Cycle cost assessment (Graphics: Jesus Daniel Garcia Melo – NTNU)*

SLCA – Social Life Cycle Analysis

Deliverables

Some information is available from previous report. It will be updated and expanded in future reports.

D8.1 *Monitoring, evaluation, and impact assessment frameworks, delivered in M12.*

D8.5 *Report on streamlined LCA-LCCA comparing alternative solutions and scenarios. Delivered in M24.*

Social Life Cycle Assessment (SLCA) is a method designed to evaluate the social impacts of products and services throughout their life cycle. In the ARV context, SLCA offers decision-makers insights into social and socioeconomic aspects, with the goal of enhancing the social performance of the project's activities.

The intended audience for the analysis includes project participants, evaluation bodies, and social groups impacted by ARV projects. The evaluation focuses on demo projects as functional units, considering stages like design, construction, functioning, and end-of-life. Stakeholders encompass ARV participants, both research and industrial entities, as well as social groups directly affected by the projects, emphasising the need for a clear statement regarding the demo's intended function (Figure 47).

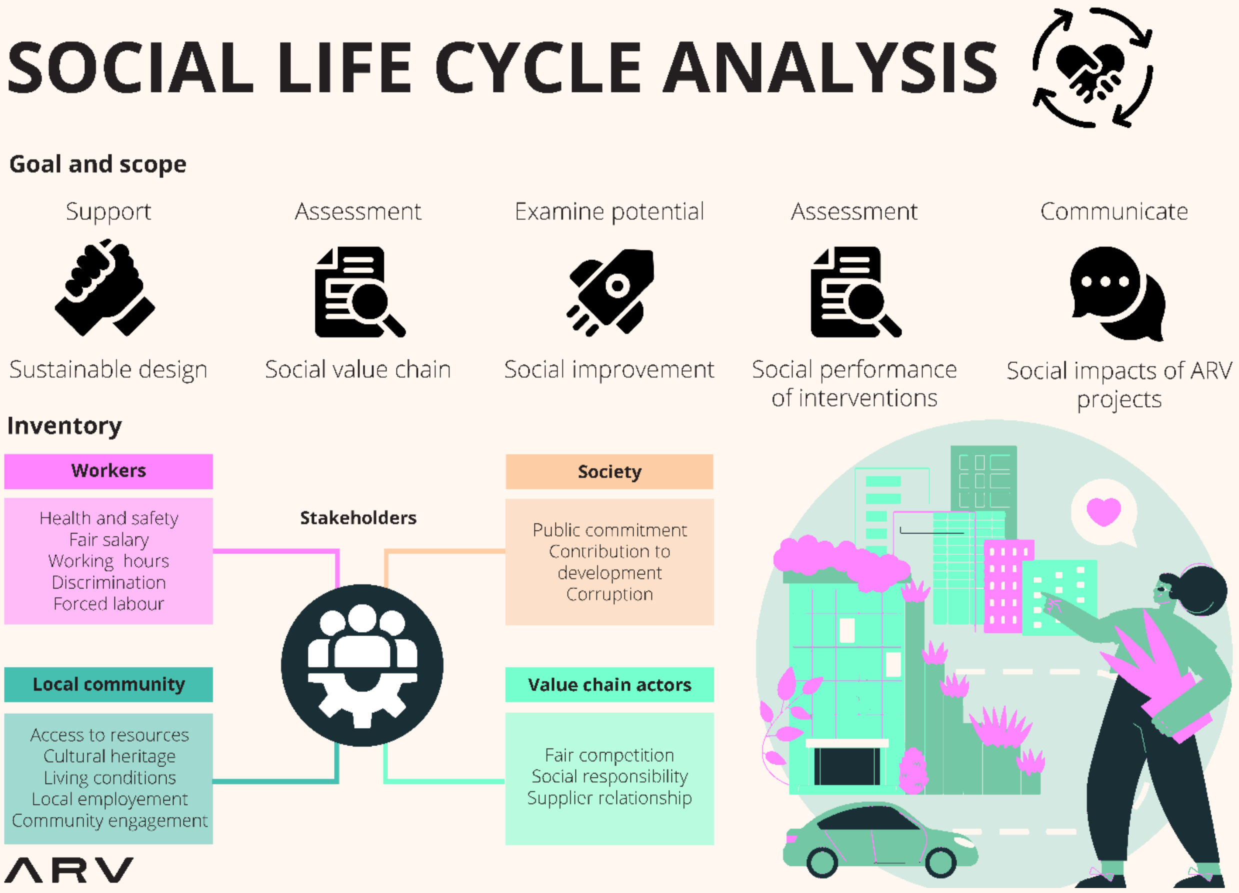


Figure 47 *Goals, scope, and inventory of the Social Life-cycle analysis in the ARV project (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Interdisciplinary and inter-sectorial collaboration

Deliverable D8.7 *Report on Multiple Benefits analysis and assessment, to be delivered n M48.*
No available information from deliverables yet. To be included in future updates.

Multiple benefit analysis

Deliverable D8.7 *Report on Multiple Benefits analysis and assessment, to be delivered n M48.*
No available information from deliverables yet. To be included in future updates.

Guidelines for replication

Deliverable D8.8 *Guidelines and recommendations for replication, to be delivered in M58.*
No available information from deliverables yet. To be included in future updates.

Future research application

Deliverable D8.8 *Guidelines and recommendations for replication, to be delivered in M58.*
No available information from deliverables yet. To be included in future updates.

3.7. BUSINESS MODELS AND FINANCIAL INSTRUMENTS

This chapter provides a description of business models and financial instruments to be used for the efficient implementation of CPCCs in Europe.

BUSINESS AND FINANCIAL MODELS'CATALOGUE

Deliverable D9.2 *Encyclopenergy – A business and financing models catalogue, delivered in M6.*

The compilation represents an inclusive repository of global models for energy-efficient retrofit projects and can be found here: https://encyclopenergy.org/. The models and tools encompass both well-established and innovative approaches. The catalogue includes essential details for each model, comprising its name, a concise description, references to sources providing a comprehensive overview of the model itself, and, where relevant, insights into the underlying technologies. Additionally, crowd-sourced labels assign specific or multiple asset classes to applicable models, enhancing the catalogue's utility and accessibility. Figure 48 shows an overview of the catalogue of the business models' archetypes organised into three different areas: energy flexibility, energy efficiency, and primary energy demand. Figure 49 shows an overview of the financial models' archetypes included in the catalogue.

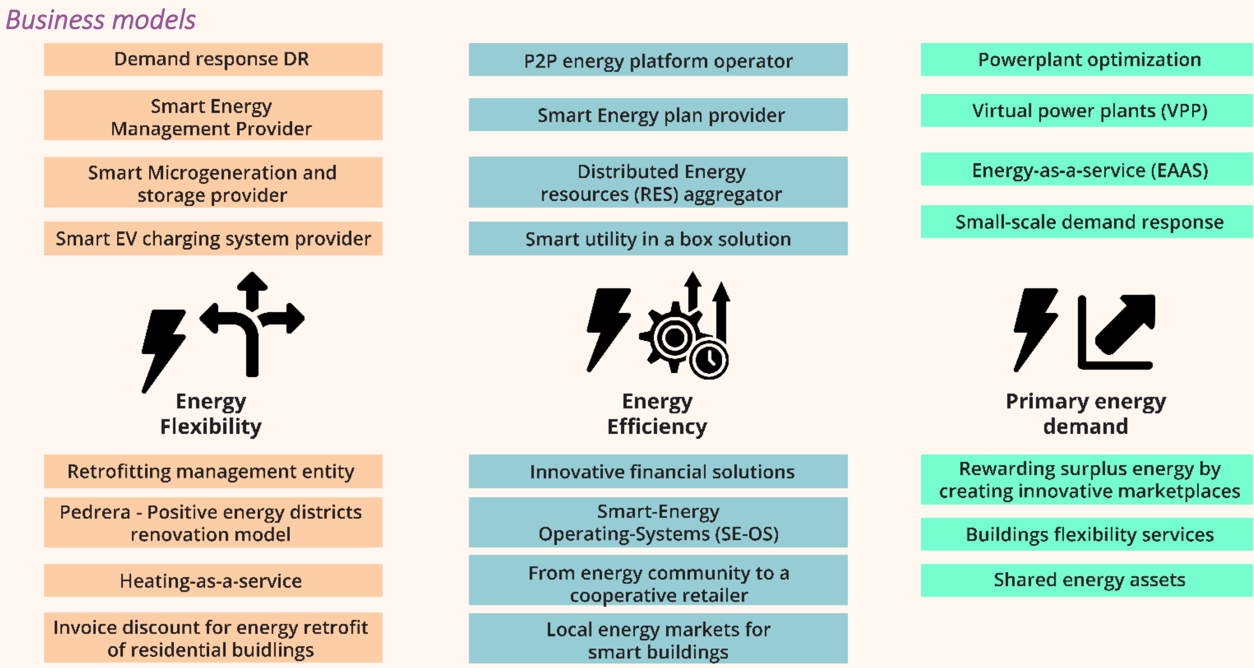


Figure 48 *Business models' catalogue archetypes in three different areas (Graphics: Jesus Daniel Garcia Melo – NTNU)*

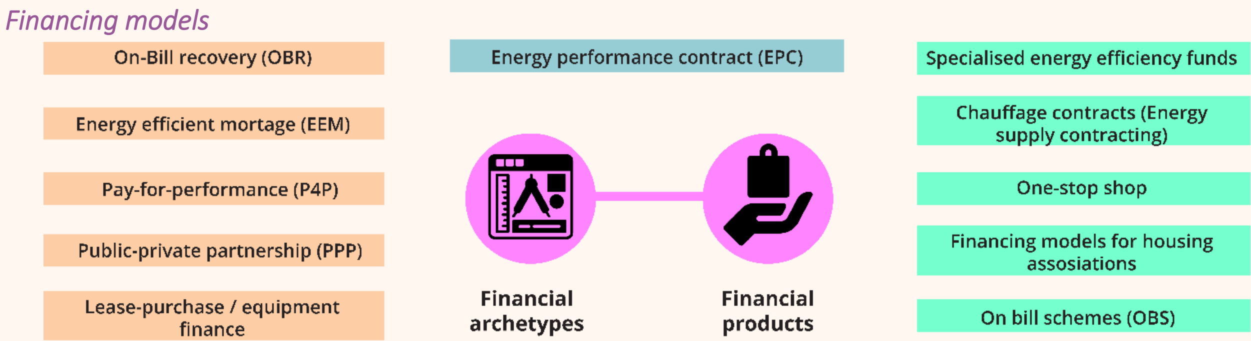


Figure 49 *Financial models' catalogue. (Graphics : Jesus Daniel Garcia Melo – NTNU).*

Deliverable D9.3 *Design business model Blueprints for energy positive retrofits for different asset classes as modules for replication across the EU, to be delivered in M36.*

The blueprints' strategy leverage environmental and social impacts, digitalisation, and economic analysis to innovate climate-positive business models. Insights from ARV demo sites offer a replicable approach for sustainable built environment solutions in a unified visual template (Figure 50). Final blueprints will be allocated in D9.3.

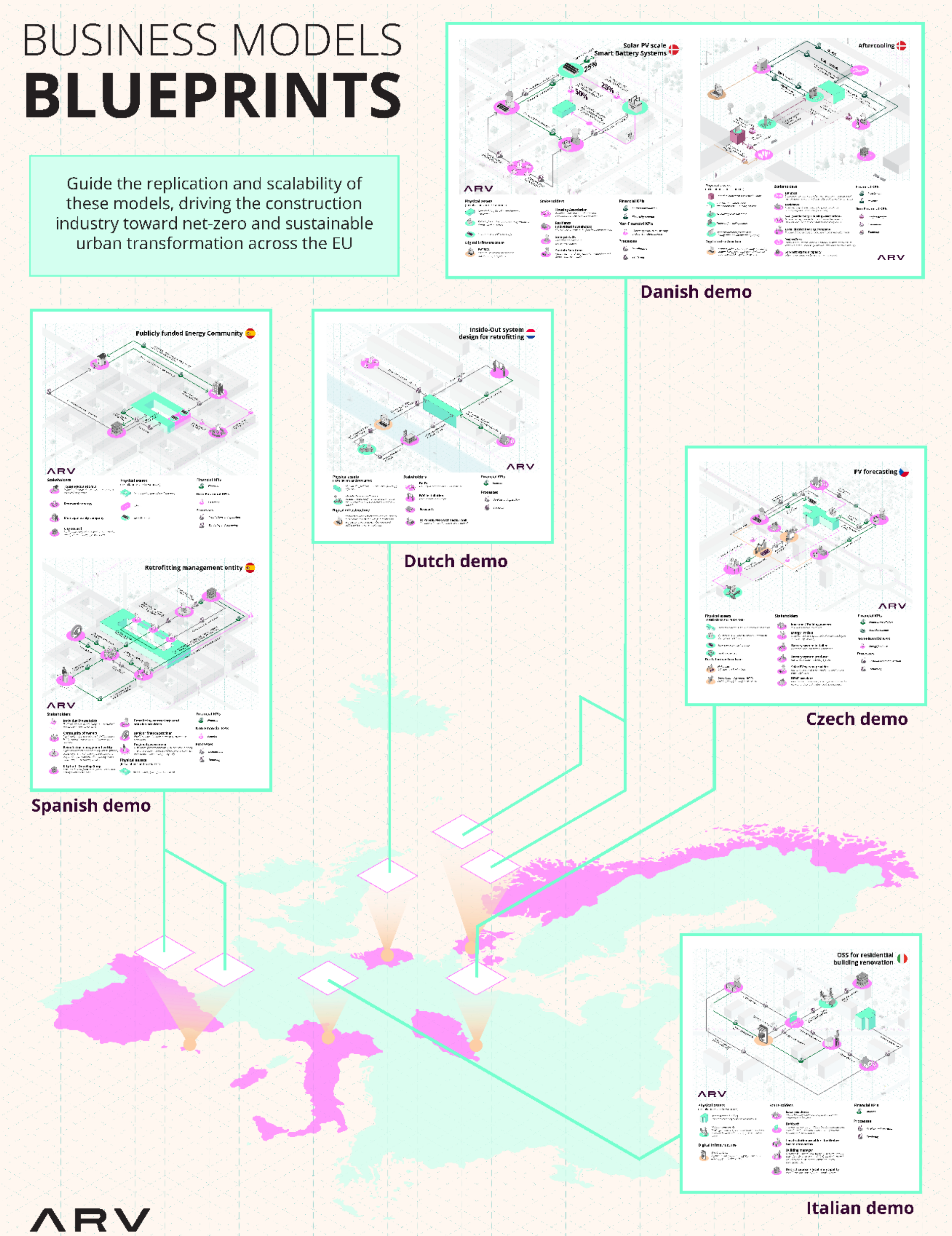


Figure 50 *Graphic representation of the business models blueprints on European context for further replication (Graphics: Jesus Daniel Garcia Melo – NTNU)*

INSTRUMENTS AND STRATEGIES

Prosumer Business Models

Deliverable D9.4 *Design Platform Based Prosumer Business Models with clear policy and regulatory recommendations, to be delivered in M48.*
No available information from deliverables yet. To be included in future updates.

Financing instruments for FI adoption

Deliverable D9.5 *Design Building-linked financing instruments for FI adoption in re-estate portfolios, to be delivered in M36.*

The financing instrument tested in the Llevant Innovation District in Palma de Mallorca, as part of ARV project, is a proof of concept (POC), that examines whether retrofitting carbon credits, traded in voluntary carbon markets, can lower the financial burden of energy renovations and serve as an alternative or supplement to conventional funding options. The initiative focuses on enabling energy upgrades in low-income areas where financial constraints are significant. Success hinges on the cost-effectiveness of generating carbon credits, their technical applicability, and compliance with established standards.

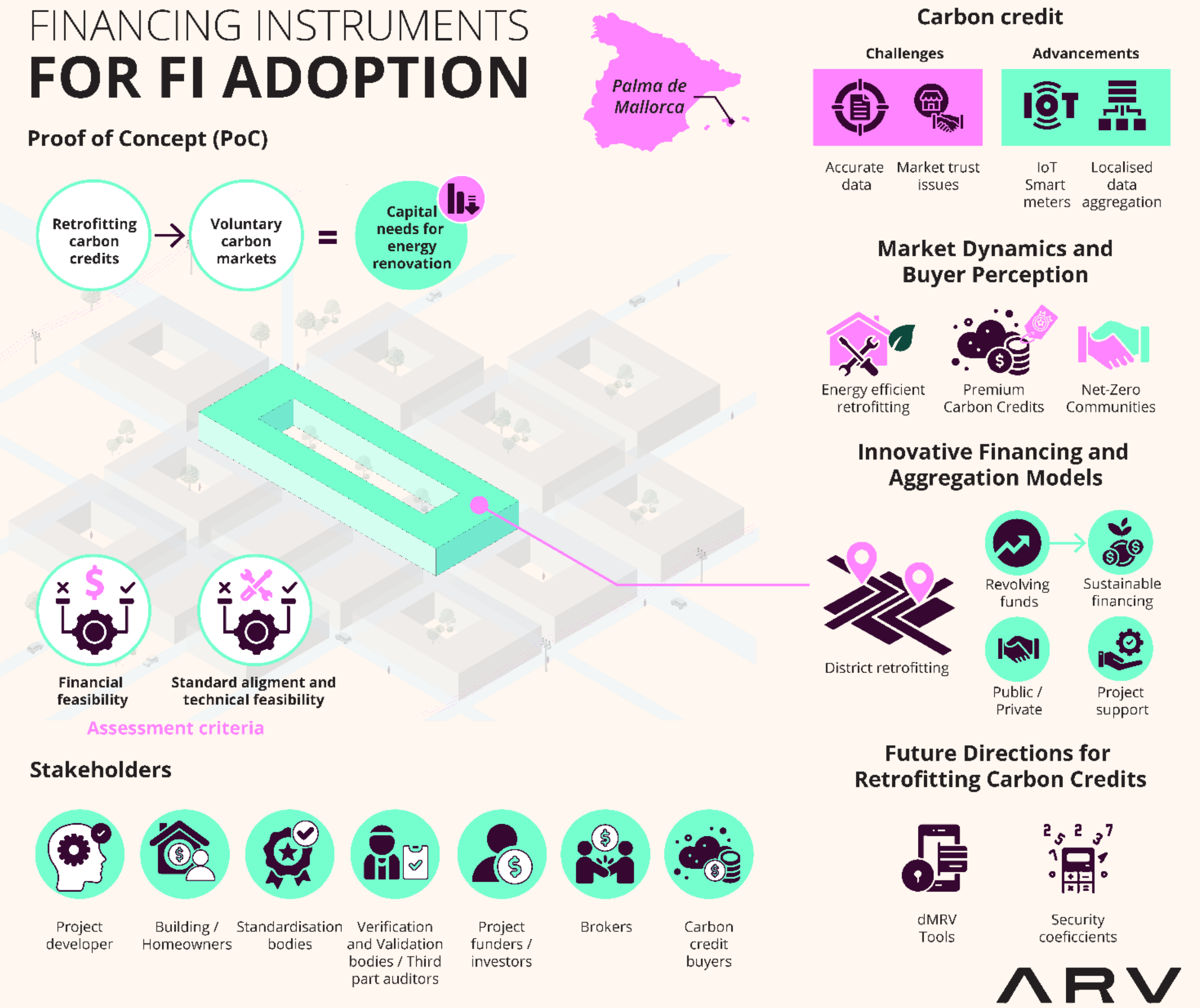


Figure 51 *Illustration of a summary of the Financing Instruments for FI adoption based on Palma de Mallorca demo (Graphics: Jesus Daniel Garcia Melo – NTNU)*

Green digital bonds guide

Deliverable D9.6 *Develop green digital bonds guide to scale prosumer flexible energy markets, to be delivered in M55.*
No available information from deliverables yet. To be included in future updates.

CPCC pathways for scaling for EU markets

Deliverable D9.7 *Enable scaling across EU markets of energy positive renovation, to be delivered in M46.*
No available information from deliverables yet. To be included in future updates.

3.8. PROJECT EXAMPLES

This chapter provides descriptions of the six demonstration cases in ARV. It focuses on description of how the different demo cases have achieved the goals and KPIs described in the assessment framework, and show examples of different solutions, strategies, and technologies.

Since the different demos have different timelines and are in different stages, the main results will not be presented in this version of the Blueprint. However, to have a common language and a similar approach among all demos in how to present their results in terms of goals, solutions, strategies, and technologies, a draft of a template is designed that could fit all the information, see figure 53. This template will be updated in the final delivery of the Blueprint, when outputs of the project are available(M60).

The template includes two main sections representing both the goals and results of the interventions reflected in the KPIs. The performance of the demonstration projects will be represented by numbers or other indicators, e.g., representing the reduction or improvement of performance compared to the pre-renovation conditions or traditional interventions.
In the second section, the solutions, strategies, technologies, and methods used to reach those results and goals will be described. All the information collected in this report, will be once more summarised in specific interventions or innovations.

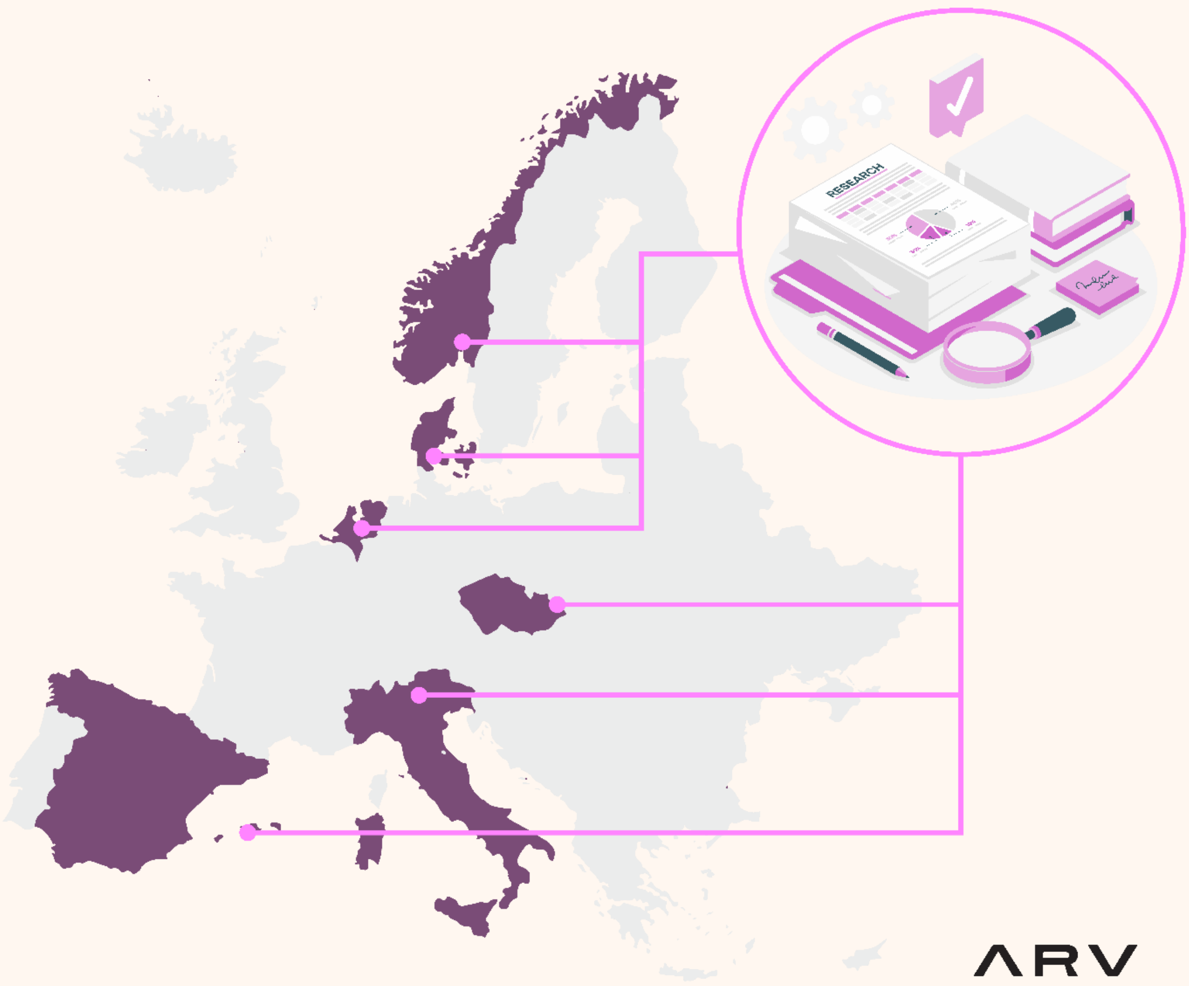


***Figure 52** Illustration of the process of gathering the outputs from each demo for the project examples section. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

PROJECT EXAMPLE TEMPLATE

OSLO, NORWAY

VOLDSLØKKA SCHOOL

GOALS

ENERGY	IEQ	NOISE AND DUST LEVELS	EMBODIED EMISSIONS	CONSTRUCTION RETROFITTING TIME	LIFE CYCLE COSTS	CONSTRUCTION RETROFITTING COSTS	CIRCULARITY	SOCIAL SUSTAINABILITY
%	%	%	kgCO2	%	%	%	-	-

SOLUTIONS, STRATEGIES AND TECHNOLOGIES

SUSTAINABLE, PLANNING AND DESIGN

RESOURCE EFFICIENT MANUFACTURING AND CONSTRUCTION

SUSTAINABLE, PLANNING AND DESIGN

METHODS AND TOOLS

EFFICIENCY AND OPERATION

MONITORING, EVALUATION AND IMPACT ASSESSMENT

BUSINESS AND FINANCIAL MODELS

Figure 53 *Template for the representation of project example overall results. (Graphics: Jesus Daniel Garcia Melo – NTNU)*

4. FUTURE APPROACH AND DISSEMINATION OF THE BLUEPRINT

Since the goal of the blueprint is to reach communities beyond the project stakeholders and direct users, the blueprint should ideally be delivered in a visual, awe-inspiring, and direct format. In that sense, the ARV project team envisions to create an interactive online tool to showcase the synergies within the project activities. However, such a tool is not currently described as a deliverable of the project. Nevertheless, the ARV blueprint will be a step on the way towards such a tool, as we will deliver a visually attractive digital guide, with active links and cross-references.

5. CONCLUSION

This report has provided a comprehensive overview of the various deliverables and topics addressed within the ARV project, laying the groundwork for the development of guidelines that cater to diverse contexts and stakeholders involved in CPCC processes. The blueprint document serves as an essential resource, encompassing critical elements such as monitoring, evaluation, and impact assessment. By detailing methodologies, tools, and frameworks, the document ensures a robust foundation for the effective execution of ARV initiatives, fostering consistency and clarity in implementation.

The inclusion of graphical illustrations significantly enhances the document's utility by transforming complex concepts into digestible visuals. These illustrations not only summarise intricate information but also foster inclusivity and understanding among a broad spectrum of stakeholders. From construction and energy professionals to evaluation bodies and impacted social groups, these visuals bridge communication gaps, ensuring that the guidelines remain accessible and actionable.

Looking ahead, the organization and refinement of these guidelines will be central to the project's final phases. The final update of this report will elaborate on these developments, providing a cohesive and well-structured framework. This framework will enable stakeholders to effectively navigate CPCC processes, encouraging collaboration, transparency, and impactful outcomes. Through this iterative approach, the ARV project aims to set a benchmark for excellence and inclusivity in the sustainable transformation of the built environment.

The organisation and streamlining of the guidelines will be further developed and described in the final update of the report.

FUTURE UPDATES

This deliverable will be updated in month 60 (December 2026, final version) of the ARV project.

ACKNOWLEDGEMENTS AND DISCLAIMER

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101036723.

APPENDIX A – GLOSSARY OF TERMS

Table A.1 *Abbreviations used in the report.*

Abbreviation	Description	References
CPCC	Climate Positive Circular Communities.	See ARV Deliverable D2.1 for a detailed definition of CPCC: https://greendeal-arv.eu/library/d2-1-assessment-framework-for-cpcc-2/
BAPV	Building Applied Photovoltaics	https://en.wikipedia.org/wiki/Building-integrated_photovoltaics
BIPV	Building Integrated Photovoltaics	https://en.wikipedia.org/wiki/Building-integrated_photovoltaics
ESS	Energy Storage Systems	https://www.sciencedirect.com/topics/engineering/energy-storage-system
GHG	Greenhouse Gas Emissions	https://en.wikipedia.org/wiki/Greenhouse_gas_emissions
GIS	Geographic Information System	https://en.wikipedia.org/wiki/Geographic_information_system
HVAC	Heating, Ventilation, and Air-Conditioning	https://en.wikipedia.org/wiki/Heating,_ventilation,_and_air_conditioning
LCA	Life Cycle Analysis	https://en.wikipedia.org/wiki/Life-cycle_assessment
LCC	Life Cycle Costs	https://en.wikipedia.org/wiki/Life-cycle_cost_analysis
PEB	Positive Energy Buildings	https://www.sustainableplaces.eu/positive-energy-buildings-definition/
RES	Renewable Energy Systems	https://cityxchange.eu/knowledge-base/renewable-energy-systems-res/
SLCA	Social Life Cycle Analysis	https://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/social-lca/
UN SDG	United Nations Sustainable Development Goals	https://sdgs.un.org/goals

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