

HANDBOOK: PRINCIPLES OF GOVERNANCE PRACTICES FOR PED COMMUNITIES

Handbook on Principles of Governance Practices for PED communities including all the practices and processes that guides the BIPED-consortium and community in the right direction.





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Table of Contents

Executive summary.....	7
1. Introduction.....	8
1.1. Framing the handbook.....	8
1.2. Purpose of the Handbook.....	9
1.3. How to Read This Handbook.....	9
1.4. Understanding LDTs and PED Communities.....	10
1.5. Scope of the handbook.....	13
1.6. Goals.....	14
1.7. Target Audience.....	15
Part 1 – Introducing the Principles.....	17
2. Principles of Governance Practices for PED Communities.....	18
2.1. Purpose and Vision.....	18
2.2. Governance Objectives.....	19
2.3. From Objectives to Action: The Role of Principles.....	19
2.4. The 9 Core Governance Principles.....	20
2.5. Layered Governance Model.....	30
2.6. RACI Matrix for PED Digital Twin Governance.....	33
2.7. Recommendation: Critical Control Mechanisms for PED Digital Twin Governance..	36
2.8. Key Governance Risks.....	37
2.9. Concluding Governance Statement.....	39
Part 2 – Why these principles.....	40
3. Establishing the PED Community in Brabrand as a Living Lab.....	42
3.1. Case: Aarhus and Brabrand.....	42
3.2. Three interconnected steps.....	43
3.3. Living Labs as a Method for Innovation and Governance Development.....	45
3.4. Aarhus’ Ownership of the Living Lab and Its Role as Orchestrator.....	48
3.5. Building the BIPED Living Lab in Brabrand (Aarhus): Stakeholders, Method, and Practice.....	53
4. Practices and processes: From Living Lab to Governance in Practice – Brabrand as a PED Pilot.....	65
4.1. Presenting Knowledge from the Living Lab (Empirical Foundation).....	66
4.2. The Brabrand Living Lab in Full – Milestones and the BIPED Community.....	89
4.3. From Living Lab Knowledge to Governance Principles.....	99
4.4. From Living Lab Knowledge to User-Centred LDT Development.....	100
4.4.1. Example: Mobility Planning.....	101
5. Insights from the Aarhus Experience: How to Start a Living Lab From Scratch.....	102
5.1. Starting the Living Lab: An Iterative and Exploratory Process.....	102
5.2. Summing Up.....	106
PART 3 – Conclusion and Next Steps.....	108
6. Lessons Learned, Recommendations, and Future Directions.....	109
6.1. Conclusion.....	109
6.2. Limitations and Reflections.....	110

6.3. Recommendations for LDT-supported PED Communities.....	110
6.4. Future Work.....	111
References and Annexes.....	112
7. Reference list.....	112
8. Annexes.....	115
8.1. Annex 1 – Anonymised Stakeholder Engagement Activity List (Living Lab).....	115
8.2. Annex 2 - BIPED - User Profiles.....	121
8.3. Annex 3 - Recommendation: Breaking Down Silos in Governance Structures.....	122
8.4. Annex 4 - Data Journey Workshop in Aarhus.....	124
8.5. Annex 5 - Slide Deck Supporting Aarhus' Role as Living Lab Orchestrator.....	126
8.6. Annex 6 - Detailed Documentation of the Design Sprint Process in Aarhus.....	127
8.7. Annex 7 - Test-material from BIPED PED Community End-User Workshop.....	127

List of Figures

Figure 1: Overview of the handbook's 9 Core Governance Principles, which are further elaborated in the following section. Icons designed by Aarhus Municipality.....	20
Figure 2: Integrated Organisational Structure.....	33
Figure 3: Brabrand.....	43
Figure 4: The Aarhus Compass.....	43
Figure 5: BIPED Community Booklet.....	44
Figure 6: The three layers.....	47
Figure 7: Simple illustration of Aarhus team's orchestration across domains and systems...	48
Figure 8: Pictures from Data journey workshop.....	49
Figure 9: Pictures from the Innovation Education programme with BIPED.....	54
Figure 10: Pictures from prototype workshop with Aarhus Business Academy.....	55
Figure 11: Pictures from prototype workshop with the BIPED consortium, GA in Dublin 2025..	56
Figure 12: Pictures showing how the Aarhus BIPED team broke down the living lab method into different elements.....	57
Figure 13: Zoomed-in view of Gellerup.....	58
Figure 14: Design Sprint team.....	60
Figure 15: Stakeholder mapping.....	61
Figure 16: Idea development - using the Crazy 8 method.....	61
Figure 17: Solution sketches.....	62
Figure 18: Storyboard.....	62
Figure 19: Overview of public-sector decision-makers engaged in the Brabrand Living Lab	66
Figure 20: Data Journey.....	68
Figure 21: Timeline of Climate Risk and Road Condition Data for the Case.....	69
Figure 22: Overview of private enterprises engaged in the Brabrand Living Lab.....	73
Figure 23: Visit to DEKRA, showcasing sustainable solutions such as electric trucks and insect hotels.....	73
Figure 24: BIPED presentation and interactive activity at the Annual Meeting of the Brabrand Business Association.....	74
Figure 25: Overview of Citizens, communities, and local interest groups engaged in the Brabrand Living Lab.....	76

Figure 26: The board of directors of Sol over Brabrand (SoB).....	77
Figure 27: Citizens' meeting on the future energy community (SoB) in Brabrand Sports Hall, with input from Sustain and participation from the Aarhus BIPED team.....	79
Figure 28: BIPED at the Wild Technologies Festival in Aarhus (2024–2025).....	81
Figure 29: Solutions from EXPO 2025: energy visualisation, interactive waste system, and AI-powered food production.....	83
Figure 30: Solutions from EXPO 2026: electric charging, collective energy sharing, sustainable behaviour, and everyday mobility, with BIPED as case host.....	84
Figure 31: Overview of Citizens, communities, and local interest groups engaged in the Brabrand Living Lab.....	86
Figure 32: PED Community and Living Lab in Brabrand.....	90
Figure 33: Engagement with the Brabrand Business Association ESG Network.....	91
Figure 34: Citizen Engagement through Sol over Brabrand (SoB).....	92
Figure 35: Climate Action Day in Brabrand.....	92
Figure 36: BIPED PED Community End-User Workshop (January 2026) #1.....	93
Figure 37: BIPED PED Community End-User Workshop (January 2026) #2.....	93
Figure 38: IPED PED Community End-User Workshop (January 2026) #3.....	94
Figure 39: IPED PED Community End-User Workshop (January 2026) #4.....	94
Figure 40: BIPED Aarhus Team Study Visit to SNART (Copenhagen) #1.....	95
Figure 41: IPED PED Community End-User Workshop (January 2026) #2.....	95
Figure 42: User Profile 14.....	101

List of Tables

Table 1: Layered Governance Model.....	31
Table 2: RACI Matrix.....	35
Table 3: Critical Control Mechanisms Overview.....	37
Table 4: Overview of Key Governance Risks.....	38

List of Abbreviations

BIPED – Building Intelligent Positive Energy Districts

PED – Positive Energy District

LDT – Local Digital Twin

UDT – Urban Digital Twin

CFIA – Center for Innovation in Aarhus

ITK – Innovation, Technology and Creativity (Aarhus Municipality)

SME – Small and Medium-sized Enterprise

NGO – Non-Governmental Organization

ESG – Environmental, Social, Governance

SoB – Sol over Brabrand, Energy community in Brabrand

AAKS – Aarhus Minicality / The City of Aarhus

DIGTCOM – Centre for Digital and Green Transformation in Cities and Communities

Executive summary

This document presents Deliverable D3.3: Handbook: Principles of Governance Practices for PED Communities, developed as part of the BIPED project. The handbook explores how governance can support the development and implementation of Local Digital Twin (LDT)-supported Positive Energy Districts (PEDs) by bridging digital innovation with sustainable urban development and energy systems.

The handbook is built around two interconnected dimensions. **The first is digitalisation**, where Local Digital Twins enable data-driven planning, modelling, and evidence-based decision-making. **The second is sustainability**, where Positive Energy Districts contribute to climate-neutral, resilient, and resource-efficient urban development. Bringing these dimensions together requires governance approaches that align technology, data, organisations, and people through collaboration, transparency, and continuous learning.

The handbook combines conceptual governance guidance with practical experiences generated throughout the BIPED project and is structured into three complementary parts:

- **Part 1** presents a governance framework for LDT-supported PEDs, introducing principles and structures for data governance, stakeholder collaboration, layered governance, accountability, control mechanisms, and risk management. Together, these elements provide a foundation for trustworthy, transparent, and coordinated governance.
- **Part 2** demonstrates how these governance principles emerged through the establishment and operation of the Brabrand Living Lab in Aarhus. Drawing on the BIPED experience, it shows how multi-stakeholder engagement, co-creation, systematic documentation, thematic analysis, and real-world experimentation were used to identify governance challenges, translate complex concepts into shared understanding, and synthesise practical governance principles. In this way, the Living Lab is presented not only as an innovation environment, but also as a methodology for governance development.
- **Part 3** synthesises the lessons learned from BIPED, reflecting on both the strengths and limitations of the approach. It provides recommendations for municipalities and PED communities seeking to establish Living Labs, develop context-specific governance approaches, and apply the governance principles in practice. It also identifies future directions for validating and scaling the methodology across different urban contexts.

A central finding throughout the handbook is that governance for LDT-supported PEDs is not static. It is an evolving socio-technical process shaped by stakeholder relationships, data practices, organisational learning, and continuous adaptation. Technology alone does not create value; value emerges when digital tools are embedded within inclusive governance, transparent decision-making, and coordinated cross-sector collaboration.

Beyond presenting governance principles, the handbook demonstrates how these principles can be developed through a structured Living Lab methodology. The governance principles are therefore not intended as a universal model, but as an empirically grounded framework derived from the BIPED project that can be adapted and refined by other PED communities according to their local context, organisational maturity, and stakeholder ecosystem.

By combining governance theory with practical implementation experience, this handbook provides municipalities, practitioners, researchers, and other PED stakeholders with both a governance framework and a transferable methodology for supporting inclusive, data-driven, and resilient urban transitions.

1. Introduction

1.1. Framing the handbook

In cities across Europe, decisions about energy, infrastructure, and urban development are made every day. New buildings are planned, neighbourhoods are renovated, and energy systems are adapted all in response to growing climate ambitions and increasing societal needs and challenges.

At the same time, digital technologies are rapidly transforming how these decisions can be made. Data flows more freely, models become more advanced, and tools now exist that allow cities to project future transformation before they happen.

Yet, a fundamental question remains: **How do we bring these developments together in a way that is not only technologically advanced, but also socially meaningful and practically actionable?**

This handbook begins from that tension.

It is driven by three core questions:

- How are decisions about local energy systems made?
- How do governance structures and policy frameworks enable or constrain sustainable urban and energy transitions?
- How do digital technologies shape the future of cities?
- How can communities be meaningfully involved in the transition toward more sustainable urban environments?

Together, these questions point to two closely interconnected dimensions:

- **The technological dimension**, represented by Local Digital Twins (LDTs), which allow cities to model and test urban systems.
- **The sustainability and energy dimension**, represented by Positive Energy Districts (PEDs), centred on energy balance, climate neutrality, flexibility and local energy systems.

Both dimensions hold significant promise. But in practice, they often evolve separately. Data is fragmented, tools are not fully integrated, and governance structures struggle to keep pace.

This creates a gap not in ambition, but in **alignment**.

This handbook argues that bridging this gap requires more than technological innovation. It requires governance that can connect technology, institutions, and collective action.

This perspective is reflected in the BIPED project. At the project's kick-off meeting, the consortium developed a shared vision to create a PED using digital twin technologies that would bridge the gap between long-term city planning and day-to-day urban management

(BIPED D1.1, 2024, p. 4). Brabrand was envisioned as a demonstration district where digital technologies could support sustainable and inclusive urban living. To realise this vision, the project aimed to monitor and optimise energy flows in real time, enabling policymakers and city managers to use simulations to inform decisions and track progress.

BIPED therefore illustrates the handbook's central argument that governance is not simply a set of formal structures, but an evolving practice. Rather than treating technology as an end in itself, the project uses digital tools to coordinate stakeholders, align strategic objectives with operational decisions, and support collaboration across sectors. In doing so, it demonstrates how governance can integrate technology, energy systems, and collective action to drive urban sustainability.

1.2. Purpose of the Handbook

This handbook (D3.3) synthesises the work of BIPED Work Package 3, combining:

- stakeholder engagement
- governance development
- real-world experimentation

The result is:

- a set of **governance principles** ([Part 1](#))
- grounded in **Living Lab practice** ([Part 2](#))
- translated into **actionable insights** ([Part 3](#))

At its core, the handbook argues that:

Governance is the way societies are guided through cooperation between governments and other actors. It involves the processes, structures, and mechanisms used to make and carry out decisions (Pierre & Peters, 2020). Governance focuses on long-term, strategic issues rather than day-to-day operations. It is not fixed but continuously evolves as technology, energy systems, and collective action change.

1.3. How to Read This Handbook

This handbook is a strategic guide. It does not provide instructions for carrying out day-to-day tasks. Instead, it supports maintaining an overall perspective – shared values, innovation, and the long-term vision of cleaner and more efficient energy planning and consumption.

It can be read from start to finish, but it also allows selective reading of sections that align with specific roles and needs.

Section 1 introduces the purpose, objectives, key concepts, intended audience, and overall structure of the handbook. From here, different pathways can be followed:

Part 1 – Introducing the Principles

For direct access to the governance principles for LDT-supported PEDs, begin with **Part 1**.

- Section 2 presents the **core governance principles**
- Each principle includes a **definition, rationale, and practical guidance**
- The section also includes **strategic recommendations** for future LDT-supported PED governance

Part 2 – Why These Principles

Readers interested in understanding how the governance principles were developed can continue with **Part 2**.

- **Section 3** introduces the Living Lab methodology adopted within the BIPED project and explains its role in supporting governance development.
- **Section 4** describes how the Brabrand Living Lab in Aarhus generated the empirical foundation for the handbook through stakeholder engagement, co-creation, systematic documentation, and thematic analysis.
- **Section 5** presents the key lessons learned from the Aarhus experience, offering practical guidance on establishing a Living Lab, engaging stakeholders, and developing governance through real-world experimentation.

Part 3 – Conclusion and Next Steps

- **Section 6** synthesises the main findings from the BIPED project, reflects on the limitations of the analysis, provides recommendations for LDT-supported PED communities, and identifies future work needed to validate, refine, and scale the governance methodology and principles.

References and Annexes The final sections contain the references, annexes, and supporting materials that complement the handbook.

1.4. Understanding LDTs and PED Communities

To understand how governance unfolds in this handbook, two key building blocks form the foundation:

- **Local Digital Twins (LDTs)** as the digital dimension
- **Positive Energy Districts (PEDs)** as the sustainability dimension

Individually, each offers new opportunities. Together, they create the potential for **informed, collaborative, and forward-looking decision-making**. But realising this potential depends on how they are connected and by whom.

1.4.1. Local Digital Twins (LDTs)

Imagine a city where administration, planners, engineers, and citizens can explore different futures before making decisions:

- What happens if an energy solution is introduced, modified or removed?
- How will changes in mobility and buildings affect emissions?
- What trade-offs emerge between cost, comfort, and sustainability?

This is the promise of digital twin technologies.

Local Digital Twins build on the broader concept of Urban Digital Twins, which are increasingly applied in municipal management, policy development, and urban research (van Apeldoorn et al., 2025; van Eijk, 2024; Lei et al., 2023). UDTs are often described as virtual representations of real-world systems, where data and sensors create dynamic links between physical environments and digital models (Horn & Richardson, 2025, p. 4444). They have also been framed as a “techno-ideological paradigm” shaping how cities are governed and understood (Borbach et al., 2025, p. 4378). These systems can support more efficient planning and enable new forms of participation (Adade & de Vries, 2025; Dawkins & Kitchin, 2025), while also raising important questions related to data governance, power, and representation (Korenhof et al., 2023; De Jaeger & Swerts, 2026).

At a more localised scale, LDTs apply this approach to specific districts or urban areas. They function as data-driven simulations of infrastructures, environments, and policies, allowing different scenarios to be tested and explored, as for instance, supporting the development and planning of PEDs. Through real-time data, interoperability, and forecasting capabilities (Charalabidis et al., 2025; White et al., 2021),

PEDs involve complex interactions between local and neighborhood energy systems, mobility, buildings, environmental conditions, local communities and their demographic and social profiles. Planning and governing such systems require coordination among multiple stakeholders and the ability to assess the consequences of different decisions.

LDTs support this process by enabling evidence-informed decision-making through visualization, simulation, and scenario testing. They allow stakeholders to explore alternative development pathways and regulatory schemes, evaluate potential impacts, and better understand trade-offs between environmental, social, and economic objectives. Through real-time data integration and forecasting capabilities, LDTs can also support monitoring and adaptive planning over time.

In addition, LDTs create opportunities for more participatory planning processes by providing a shared platform through which different actors can engage with data, explore scenarios, and contribute to discussions about future developments (Raes et al., 2025; Almeida et al., 2024).

While LDTs offer significant opportunities for planning and decision support, their implementation also raises important governance considerations. Previous research highlights issues related to data governance, power, representation, and the ways in which digital technologies influence urban decision-making processes (Korenhof et al., 2023; De Jaeger & Swerts, 2026). As outlined in Section 1.2, the governance perspective presented in

the handbook focuses on strategic decision-making processes and structures. The governance considerations presented here are derived from BIPED's practice and should therefore not be interpreted as representing governance practices across all PED initiatives. Accordingly, the scope of governance in this deliverable is defined through the 9 Core Governance Principles (Section 2.4), the five-layer Layered Governance Model (Section 2.5), and the RACI matrix (Section 2.6), which together describe the governance principles, governance levels, and stakeholder roles and responsibilities considered within the BIPED context.

For PED initiatives, key governance considerations include:

- Transparency in how data, models, and assumptions are used.
- Participation and meaningful stakeholder engagement throughout planning and decision-making processes.
- Accountability for decisions supported by digital tools and simulations.
- Data governance practices addressing data quality, ownership, access, privacy, and security.
- Inclusion and representation of diverse stakeholder perspectives and local knowledge.

Addressing these considerations is essential to ensuring that LDTs function not only as technical tools but also as trustworthy and legitimate instruments supporting collaborative urban governance. This requires that LDTs are rigorously tested and validated before being relied upon as decision-support tools.

Within the BIPED context, the Local Digital Twin combines a 2D/3D representation of Aarhus, particularly the Brabrand area, with the Civora Data Hub. It integrates geospatial, environmental, social, energy, and infrastructure data to enable visualisation and "what-if" scenario testing. The platform supports flexible and collaborative approaches to urban planning through modular tools and external data integration. By bringing together multiple data sources within a shared environment, the BIPED LDT provides a common evidence base for planners, municipal authorities, researchers, infrastructure providers, and other stakeholders involved in PED development and governance.

Through these capabilities, the BIPED LDT supports the collaborative exploration of future clean energy transition scenarios and contributes to more informed, transparent, and evidence-based decision-making.

1.4.2. Positive Energy Districts (PEDs) and PED Communities

If LDTs represent the digital dimension, **Positive Energy Districts** represent the transformation taking place on the ground.

PEDs aim to create districts that produce more clean energy than they consume. But achieving this is not only a technical challenge – it is also a **social and organisational one**. This is where the concept of **PED communities** becomes essential.

This handbook places particular focus on PED communities, understood as the social and organisational structures that enable PEDs to function and evolve.

A PED community can be described as a local ecosystem of residents, stakeholders, and organisations collaborating to develop, operate, and learn from a Positive Energy District (Haindlmaier et al., 2025). It brings together diverse actors who contribute to and are affected by the district's energy systems and sustainability goals.

In the BIPED project, the PED community is established through a living lab approach and includes:

1. **Public sector decision makers** in charge of urban planning and policies designed to make cities more sustainable places to live, work and invest in.
2. **Private enterprises** specialising in construction, renovation, solar panel development, mobility.
3. **Citizens, communities & local interest groups** that want to further their city's green agenda.
4. **Innovation communities** e.g. SMEs, institutes, and standards organisations working on data standards for smart cities.

The purpose of the BIPED community is to support innovation, strengthen awareness and digital literacy, and enable more evidence-based approaches to energy planning and consumption (BIPED Consortium, n.d., p. 10). Strong stakeholder engagement and public participation are central to this effort, ensuring that knowledge generated within the project is both relevant and transferable, and embedded from early stages through the living lab approach¹.

The PED community is developed through broad stakeholder involvement across the city and through the living lab methodology, which is further elaborated in later sections of this handbook, Part 2.

1.5. Scope of the handbook

The successful development of LDT-supported PEDs depends not only on advanced technologies, but also on how well these solutions are anchored in everyday practice. D3.3 therefore translates the insights generated in the Brabrand Living Lab – BIPED's pilot city – through the work carried out broadly in WP3, and more specifically in *T3.2 PED Community Establishment and Principles for Governance Practices*, together with the expertise of the BIPED consortium, into a coherent and strategic governance handbook that supports cities, communities, and project partners in moving from experimentation toward long-term, sustainable implementation.

1.5.1. Introducing the Living Lab Approach

A Living Lab is a user-centred, open-innovation environment where citizens, researchers, companies, and public authorities co-create, test, and refine solutions in real-life contexts. Rather than designing innovations for people, the Living Lab approach emphasises developing them with the people who will ultimately use them, making outcomes more relevant and impactful (Living Lab approach).

As highlighted by Schuurman et al. (2025), this model strengthens innovation by embedding end-users directly into the development process. In this handbook, the concept is introduced

¹ [D3.1 BIPED Community](#) / [Booklet](#)

here for the first time and explored in greater depth later on. For a more detailed discussion, see Section 3: Establishing the PED Community in Brabrand as a Living Lab, especially 3.3.1 Living Lab: From Theory to Practice in Aarhus (Living Lab in Aarhus).

1.5.2. From Empirical Insights to Transferable Governance Principles

The work leading up to D3.3 has integrated multiple empirical methods with inductive approaches in shaping the handbook principles, meaning insights are developed directly from data rather than starting from fixed assumptions. Data is collected and analysed in ongoing cycles, combined with input from stakeholders, to identify patterns and shape the development of solutions. This approach draws on grounded theory and qualitative research practices (Creswell & Poth, 2024, Chapter 3)².

Aarhus, as the pilot city, has acted as an orchestrator ensuring that the right people meet, collaborate, and contribute – while collecting data and insights through meetings, observations, interviews, measurements, and co-creation activities (Schuurman et al., 2025; Fauth et al., 2024). The recurring patterns identified through this process form the foundation for the governance principles presented in D3.3: Principles of Governance Practices for PED Communities.

Although the D3.3 Handbook is grounded in the concept of PED Communities, it must be understood within a broader smart-city perspective, as Building Intelligence (BI) and Positive Energy Districts (PEDs) are fundamentally intertwined in the BIPED project. For this reason, the handbook places particular emphasis on the LDT and smart-city dimensions of PED governance.

While rooted in the Aarhus–Brabrand context in Denmark, the governance framework is designed for wider applicability. It provides practical guidance on how PED and digital-twin governance principles can be adapted to municipalities with different organisational structures and levels of maturity.

These aspects are explored further in **Section 5**, which reflects on the Aarhus experience and outlines how governance approaches can be adapted and developed in practice – taking into account both varying maturity levels and different ways of engaging stakeholders across local contexts.

1.6. Goals

The main objective of D3.3 is to translate real-world insights from the BIPED pilot in the Brabrand Living Lab into a practical, strategic governance framework intended to support other cities with climate and digitalisation ambitions in moving from pilot projects toward more long-term, scalable PED and digital twin implementations.

² In Chapter 3, Creswell and Poth (2024) describe qualitative research as an emergent and flexible process in which researchers build understanding from empirical data. This reflects an inductive approach, where patterns and insights develop progressively rather than being predetermined.

In more concrete terms, D3.3 aims to:

- Develop principles of practice which are useful and applicable for a wide range of cities and partners
- Explore linkages between PEDs and Local Digital Twins by framing governance within a broader smart-city perspective
- Outline a replicable governance approach that can be adapted by municipalities across Europe.

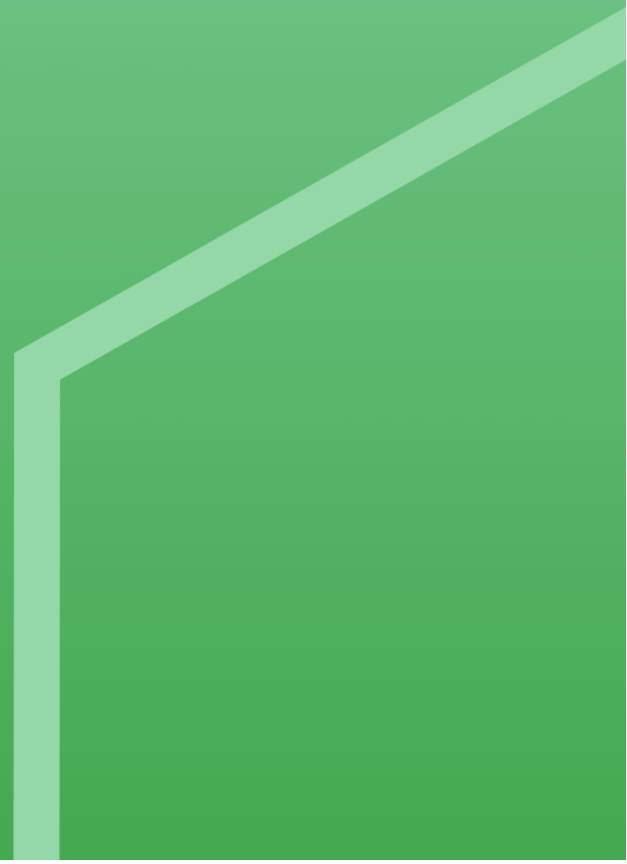
1.7. Target Audience

The handbook is aimed at practitioners working to enable co-creation, data governance, and cross-sector collaboration in the development of digital twins. While its primary audience is municipal employees and public-sector decision-makers, the guidance is equally relevant for project partners, community facilitators, and other organisations engaged in collaborative digital-twin processes.

It supports cities at different organisational stages, offering adaptable methods for both early-stage and advanced initiatives. Although the principles are rooted in municipal governance—where the city typically acts as the central orchestrator—they can be applied in broader contexts. **Part 2** illustrates this by showing how the Living Lab has been used to develop and test multi-stakeholder involvement and democratic participation as a method, ensuring that wider collaborative dimensions are fully recognised.

PART 1

INTRODUCING THE PRINCIPLES



Part 1 – Introducing the Principles

Key Insights from Part 1 - Introducing the Principles

✓Core Insight

Governance for LDT-supported PEDs is about aligning technology, data, stakeholders, and institutional processes to create trusted, sustainable, and actionable outcomes.

✓What This Part Covers

A set of **governance principles, objectives, and structures** for LDT-supported PEDs, including data governance, stakeholder collaboration, layered governance, roles (RACI), control mechanisms, and risk management.

✓Why It Matters

It provides a **practical and structured foundation** for managing complex, cross-sector systems ensuring that digital tools create **public value, trust, and long-term sustainability**, rather than fragmented or purely technical solutions.

✓What to Pay Attention To

- Treat governance as **socio-technical** (people, organisations, and technology must align)
- Prioritise **public value and sustainability** in all decisions
- Ensure **inclusive multi-stakeholder collaboration** with clear roles
- Establish strong **data governance** (ownership, interoperability, privacy)
- Build **trust through transparency, ethics, and explainability**
- Align across **governance layers** (strategic → technical → community)
- Break down silos through **cross-sector coordination**
- Use structured frameworks for accountability and decision-making
- Implement **control mechanisms** to ensure oversight and alignment
- Identify and manage **organisational, technical, social, and legal risks**
- Ensure **security, resilience, and long-term sustainability**
- Support **continuous learning, iteration, and adaptation**

2. Principles of Governance Practices for PED Communities

Transforming urban energy systems is not only technical — it requires coordination among the many actors involved. In a Positive Energy District (PED), infrastructures and the organisations behind them must align: municipal departments, utilities, housing associations, private companies, researchers, and citizens (Haindlmaier et al., 2025). Their differing priorities make governance essential. This extends to the cost and financing of PED realisation, which closely interact with governance arrangements and underscore the need for new business models.

Without governance, efforts fragment; with governance, they align. In this context, governance is defined as the process of making decisions, setting rules, and ensuring accountability to achieve goals, as well as the structuring of decision making, responsibility sharing, conflict management, and long term value creation, which together turn technical potential into lasting change. This is crucial in complex, multi-actor environments where coordinated action and shared ownership are necessary (Haindlmaier et al., 2025).

Governance is therefore what turns technical potential into real, lasting change.

2.1. Purpose and Vision

Governance Practices for PED Communities sets out how Local Digital Twins (LDTs) can be used to support the development, implementation, and long-term operation of Positive Energy Districts (PEDs). The focus is on how digital twins enable and strengthen LDT-supported PED development bringing together data, modelling, collaboration, and governance to create real public value.

The starting point is simple:

- A digital twin is not valuable on its own.
- Its value emerges when it supports better decisions, shared understanding, and collective action.

To achieve this, the handbook brings together the principles, structures, and operational mechanisms needed to ensure that LDT-supported PEDs are developed in a coordinated, transparent, and future-proof way. It is designed to support:

- cross-sector collaboration
- trusted data sharing
- integrated urban system management
- participatory governance
- and the long-term sustainable operation of PEDs

At the same time, the handbook recognises that:

- PEDs are socio-technical systems,
- digital twins are both technical and institutional infrastructures,
- and successful governance requires coordination across organisational, technological, and societal domains.

2.2. Governance Objectives

If governance is the bridge, the objectives define the direction and destination it is built to reach. The purpose of these objectives is to translate broad ambitions into **clear expectations for how governance should perform in practice**.

When applied in PED development, Local Digital Twins should support governance processes by:

- Support effective, transparent, just governance of PEDs
- Deliver better outcomes for citizens, society, and the environment
- Continuously facilitate cross-sector interoperability and collaboration

Together, these objectives clarify what the governance principles are designed to enable.

2.3. From Objectives to Action: The Role of Principles

These objectives guide everyday decisions by providing direction for strategic choices. At the same time, the governance principles ensure that this guidance does not extend into day-to-day management. Instead, they support actors in interpreting the objectives consistently and making decisions that remain aligned with the overall purpose

Each principle presented in this handbook is derived from real-world experience in the **Brabrand Living Lab** (see Part 2). They reflect what has worked, what has been challenged, and what has emerged as essential when aligning digital tools with urban sustainability goals.

In this context, a principle is a guiding rule that helps actors navigate complexity and make informed decisions. If the objectives define the destination, the principles act as a compass—keeping direction without prescribing the exact route. They are not a map to be followed step by step, but a way of staying oriented. As such, they are not meant to be applied mechanically, but to support informed, context-sensitive governance.

2.4. The 9 Core Governance Principles

A principle in this handbook is a guideline derived from the experiences and insights gained in the Brabrand Living Lab, **see part 2**. The principles presented below can help orient both thinking and action, and for the intended audience, they provide a foundation for making informed decisions when working strategically with LDT supported PEDs.

The following section presents nine principles derived from experiences in the living lab in Aarhus. They are not prioritised or ranked, but rather presented individually to reflect their complementary nature. Each principle is described in turn and includes:

- a definition
- a rationale
- and practical guidance

Together, they form the foundation for LDT-supported PED governance in practice.



Figure 1: Overview of the handbook's 9 Core Governance Principles, which are further elaborated in the following section. Icons designed by Aarhus Municipality.

The following presents an overview of the nine principles; each is explained in more detail in the sections that follow:

1. **Public Value and Sustainability First:** Prioritise societal and environmental impact in all decisions.
2. **Multi-Stakeholder Inclusion and Shared Governance:** Ensure inclusive, transparent participation across all stakeholders.
3. **Data Sovereignty and Interoperability:** Define data ownership and enable open, interoperable systems.
4. **Transparency, Traceability and Explainability:** Make data, models, and decisions visible, traceable, and understandable.
5. **Privacy, Ethics and Social Legitimacy:** Handle data responsibly to ensure trust and compliance.
6. **Cybersecurity and Operational Resilience:** Protect systems and ensure reliable, secure operations.
7. **Human-Centric Automation:** Keep human oversight and accountability in automated processes.

8. **Lifecycle Sustainability and Long-Term Stewardship:** Plan for long-term maintenance and governance.
9. **Continuous Validation and Organizational Learning:** Continuously improve through validation, feedback, and learning.

Framing the 9 Principles

A Positive Energy District (PED) can be understood as a connected urban system embedded within the wider city context, where buildings, energy systems, mobility solutions, and digital infrastructures interact. Such coordination does not emerge by itself; it depends on collaboration among actors, municipalities, utilities, and other stakeholders.

The nine principles presented below function as shared “**rules of the road**”, supporting alignment and coordination across these actors. They are not intended as a fixed framework, but as guiding orientations that can be adapted to different local contexts.

The principles are **not exhaustive**, and their sequence does not imply any form of prioritisation. Rather, they are presented in the order in which they emerged and evolved throughout the Living Lab process in Aarhus, see Part 2. Given the relatively limited practical experience in this field, it has not been possible to determine the relative importance of each principle. Readers are therefore encouraged to draw on their own experience and context when interpreting and applying them.

Some principles may appear more prominent in the empirical material – particularly those related to data. This reflects the technical focus of the BIPED project, where data has been a central area of work, as well as a key priority in the Aarhus context.

A more detailed account of the methodology – specifically how observations and data points were synthesised into themes and subsequently developed into principles – can be found in Part 2, Section 4.3.1.

Readers are encouraged to approach the principles with a balanced and context-sensitive mindset. Rather than applying them in isolation or as fixed prescriptions, their value lies in how they are interpreted, combined, and adapted to the specific conditions, challenges, and opportunities of each LDT-supported PED context.



2.4.1. Principle 1 – Public Value and Sustainability First

Every decision in the Local Digital Twin (LDT) should answer one simple question: Does this make life better for people and the planet? In the BIPED context, that means reducing CO₂, improving energy efficiency, supporting renewables, and making neighbourhoods healthier and more resilient.

Principle 1: The local digital twin shall primarily support societal and environmental value creation, including:

- CO₂ reduction,

- energy efficiency improvement,
- renewable integration,
- energy flexibility,
- resilience,
- citizen well-being, and
- *equality*, understood as ensuring that PED-related services and benefits are fairly distributed across all residents, including vulnerable groups.

All technological and organizational decisions shall align with the sustainability objectives of the PED.

Rationale

The local digital twin exists to create tangible public and environmental value. Sustainability objectives must therefore guide both technical implementation and governance decisions to ensure long-term societal benefit.

Practical Guidance

- Prioritize solutions that contribute to measurable sustainability outputs.
- Evaluate new technologies and operational decisions against PED sustainability goals.
- Ensure that optimization strategies support both environmental performance and citizen well-being.

Operational examples

- Sustainability goals built directly into dashboards.
- Regular check-ins to see whether the LDT is actually improving environmental performance, supported by a systematic assessment procedure carried out by the local, cross-sector steering group.
- Cross-sector teams reviewing whether new features support PED goals.



2.4.2. Principle 2 – Multi-Stakeholder Inclusion and Shared Governance

A PED only works when everyone who is affected has a voice. Municipalities, utilities, building owners, citizens, researchers – they all bring different knowledge and priorities. Good governance makes sure these voices are heard and decisions are transparent.

Principle 2: Governance shall ensure balanced participation from:

- municipalities,
- utilities,
- private companies,
- building owners,

- citizens,
- technology providers,
- research institutions,
- and civil society actors.

Decision-making processes shall be transparent, documented and inclusive.

Rationale

The digital twin impacts multiple stakeholders across the energy ecosystem. Inclusive governance strengthens legitimacy, trust, collaboration, and long-term adoption.

Practical Guidance

- Establish clear stakeholder engagement processes.
- Document governance decisions and make them accessible where appropriate.
- Ensure that affected stakeholders have opportunities to contribute to planning and decision-making.

Operational examples

- A stakeholder council that meets regularly.
- Public consultation rounds before major changes.
- Clear channels for feedback or objections.



2.4.3. Principle 3 – Data Sovereignty and Interoperability

Data is powerful – but only when everyone knows who owns it, who can use it, and how it can be shared safely. This is central to data sovereignty: ensuring that control over data remains with the appropriate actors, in line with legal, organizational, and local governance frameworks. *Interoperability* ensures that systems can talk to each other instead of locking cities into one vendor or one platform, while also acknowledging that – particularly for smaller municipalities – avoiding vendor lock-in is often easier said than done due to limited procurement capacity and the tension between proprietary solutions and open interoperability. Interoperability therefore includes not only technical and semantic alignment, but also organizational, legal, and policy considerations that enable secure and sovereign data sharing.

Principle 3: Ownership, stewardship and access rights for data shall be clearly defined.

The digital twin shall support:

- open standards
- interoperable data models
- semantic interoperability, including shared metadata
- documented APIs, recognising that APIs do not have exclusivity and that diverse, complex data sources should not be named separately

- open source approaches, where possible
- and practices that minimise the practical risk of vendor lock-in, which is already low when open standards and shared metadata are in place

These measures support data sovereignty by enabling actors to retain control over how data is accessed, used, and shared across systems and stakeholders.

As a result, the digital twin can adapt over time while maintaining full flexibility and independence.

Rationale

Strong data governance and interoperability support collaboration, scalability, flexibility, and long-term sustainability while ensuring that data sovereignty is maintained through appropriate technical, organisational, and legal measures.

Practical Guidance

- Define data ownership and access responsibilities early in the project lifecycle.
- Use open and standardized interfaces wherever possible.
- Select technologies and vendors that support interoperability and future integration needs.
- Look beyond technical standards by including organizational, legal, and policy aspects to achieve effective and sovereign data sharing.

Operational examples

- Clear definitions of data owners, controllers, stewards, and processors.
- Access-rights tables showing who can read, edit, or delete data and who can use them and for what purpose (purpose limitation).
- Use of open standards and document data sources.
- Agreements or governance frameworks that define how data is shared across organizations while maintaining control and compliance.



2.4.4. Principle 4 –Transparency, Traceability and Explainability

People need to trust the LDT. This includes trust in both data and the AI-driven models and decision-support tools embedded in it. Trust requires visibility into how data flows, how algorithms and AI models operate, and why the system generates specific recommendations. If something goes wrong, it must be possible to trace, audit, and explain what happened.

Principle 4: All critical data flows, algorithms, simulations, AI models, and decision-support mechanisms shall be:

- documented
- auditable
- traceable
- explainable

Rationale

Transparency, data quality, and traceability strengthen accountability, trust, and the reliability of operational and strategic decisions supported by the digital twin.

Including trustworthy AI principles ensures that AI-driven insights are understandable, fair, and responsible, reducing risks related to bias, opaque decision-making, or over-reliance on automated systems.

Practical Guidance

- Document key models, algorithms, and AI systems (purpose, data sources, assumptions, limitations).
- Use explainable AI where relevant to make outputs understandable.
- Clearly communicate assumptions, limitations, and uncertainties.
- Ensure end-to-end traceability (data → model → output → decision).
- Enable auditing of critical processes, including AI-supported decisions.
- Establish governance for validating, monitoring, and updating AI models.
- Include human oversight in high-stakes decisions.

Operational examples

- Audit logs for data access, model runs, and AI predictions, ensuring traceability of data origins and processing steps.
- Use of explainability dashboards or tools (e.g. feature importance, scenario comparisons) to show how algorithms and AI support decision-making.
- Documentation of AI models, including training data, validation results, and known biases.
- Public or stakeholder-facing documentation for key models, assumptions, and AI-supported processes.
- Version control and model registries to track changes in algorithms and AI systems over time.



2.4.5. Principle 5 – Privacy, Ethics and Social Legitimacy

Trust in Local Digital Twins (LDTs) is not created by technology alone but developed throughout the entire lifecycle, from design and development to implementation and use. While privacy is an important aspect, it is part of a broader policy governance context that includes data governance, AI accountability, cybersecurity, and relevant regulations.

For citizens and stakeholders, trust depends on transparency, understanding, and a sense of control over how digital systems operate and how data is used. Building social legitimacy

therefore requires more than GDPR compliance; it requires broader alignment with responsible governance practices and transparent approaches to data and decision-making.

Principle 5: Data processing and digital solutions shall be developed and operated in line with:

- GDPR and privacy-by-design principles
- data governance and data-sharing frameworks
- AI regulation (e.g. EU AI Act³)
- relevant cybersecurity, energy, and climate policy frameworks

Local stakeholders shall be able to understand:

- what data is used
- how and why it is used
- on what legal and governance basis it is used
- who benefits
- and what impacts and risks exist across the system lifecycle

Rationale

Trust and social legitimacy depend on designing and governing digital systems in ways that are transparent, accountable, and aligned with societal values and regulatory requirements.

A holistic governance approach ensures that privacy, ethics, and responsible innovation are embedded across the entire lifecycle of LDTs and digital solutions, not treated as isolated compliance tasks.

Practical Guidance

- Minimise the collection and storage of personal data wherever possible.
- Integrate privacy, ethical, and regulatory considerations from early design stages (“by design” approach).
- Communicate clearly how data is processed and protected.
- Ensure alignment with relevant policy frameworks beyond GDPR, including data governance, AI, and cybersecurity regulations.
- Establish governance processes that address the full lifecycle of digital solutions, from development to operation and review.

Operational examples

- A citizen-facing dashboard explaining how data and digital services are used and governed.
- Transparent procedures for objections, feedback, or complaints.
- Privacy-, ethics-, and AI-impact checklists integrated into development processes.
- Documentation showing compliance with GDPR, as well as relevant data governance, AI, and cybersecurity requirements.

³ <https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai>



2.4.6. Principle 6 – Cybersecurity and Operational Resilience

The LDT is part of critical infrastructure. If it fails, energy systems, buildings, or mobility services could be affected. So it must be secure, resilient, and ready for the unexpected.

Principle 6: The digital twin shall be governed as critical digital infrastructure. Governance shall support:

- access control,
- cybersecurity,
- incident response,
- backup and recovery,
- operational continuity,
- and infrastructure resilience.

Single points of failure shall first be identified to ensure they can be effectively avoided.

Rationale

Operational reliability and cybersecurity are essential to maintaining trust and resilience in critical infrastructure systems.

Practical Guidance

- Implement robust access management and cybersecurity protocols.
- Maintain incident response capability and recovery procedures.
- Design systems with redundancy and resilience to minimize operational disruptions.

Operational examples

- Role-based access control and multi-factor authentication.
- Regular cybersecurity testing.
- Backup systems and failover procedures.



2.4.7. Principle 7 – Human-Centric Automation and AI

Automation and AI can support operations, but humans must remain in control. Operators need to understand how automated and AI-driven systems function and must be able to intervene or override when necessary.

Principle 7: Automation and AI systems shall remain:

- proportional
- reversible

- transparent
- subject to human oversight

Critical operational decisions shall retain human accountability.

Rationale

Automation and AI should enhance human decision-making without reducing transparency, accountability, or control—especially in critical operations.

Practical Guidance

- Ensure operators can understand, monitor, and override automated and AI-driven processes.
- Clearly document and communicate how automated and AI tools function and make decisions.
- Define clear accountability for outcomes of automated and AI-supported systems.
- Apply automation and AI where they add value, while maintaining appropriate human control.
- Use human-in-the-loop or human-on-the-loop approaches for high-stakes decisions.
- Automation where it creates value while maintaining appropriate human control.

Operational examples

- Human-in-the-loop approval for automated or AI-generated actions.
- Dashboards showing how AI tools and automation reach decisions.
- Clear assignment of responsibility for automated and AI-supported outcomes.
- Training for operators on how automation and AI logic works and how to intervene.



2.4.8. Principle 8 –Lifecycle Sustainability and Long-Term Stewardship

A digital twin is not a one-off project. It must be maintained, updated, funded, and governed for many years.

Principle 8: Governance shall address the full lifecycle of the digital twin:

- design,
- deployment,
- operation,
- maintenance,
- evolution,
- and decommissioning.

Long-term organizational and financial sustainability shall be ensured.

Rationale

The digital twin must remain operationally, financially, and organizationally sustainable throughout its entire lifecycle.

Practical Guidance

- Plan for long-term maintenance, upgrades, and governance responsibilities.
- Ensure sustainable funding and operational ownership models.
- Consider lifecycle impacts during technology and architecture decisions.

Operational examples

- Multi-year funding plans.
- Roadmaps for upgrades and future capabilities.
- A governance body responsible for long-term stewardship.



2.4.9. Principle 9 – Continuous Validation and Organizational Learning

Cities change. Technologies evolve. So the LDT must learn and improve continuously.

Principle 9: Data sources, models and algorithms shall be continuously:

- validated,
- recalibrated,
- evaluated,
- and improved.

Governance shall support adaptive learning and iterative development.

Rationale

Continuous learning and validation are necessary to maintain system accuracy, relevance, and organizational capability over time.

Practical Guidance

- Regularly assess model performance and data quality.
- Incorporate lessons learned into governance and operational processes.
- Support iterative improvements through monitoring, feedback, stakeholder learning and data based decision making.

Operational examples

- Regular model validation cycles.
- Learning forums where partners share insights.
- Feedback loops from operators, citizens, and other stakeholders

2.5. Layered Governance Model

2.5.1. From Principles to Practice

Taken together, the nine principles establish a widely applicable foundation for governing Local Digital Twins in Positive Energy Districts. They define what good governance looks like – emphasizing transparency, inclusiveness, responsibility, and continuous learning.

Yet principles alone are not enough. To move from intention to action, they must be translated into structures, roles, and everyday practices. Cities and their partners need a way to operationalize these principles – ensuring they are applied consistently across decisions, systems, and stakeholder interactions.

This raises a fundamental question: how can these principles be embedded in the complex reality of urban development, where multiple actors, systems, and time horizons intersect?

To address this complexity, governance must be understood not only as a set of guiding principles but as a structure that operates across different, interconnected domains of action. The Layered Governance Model provides this structure by translating governance principles into practice across five interconnected layers: strategy, regulation, technology, operations, and community engagement. In this way, the model supports the application of the governance principles across different levels of decision-making and stakeholder involvement.

2.5.2. From Strategy to Everyday Practice

When a city commits to building a Positive Energy District, the big questions quickly become practical ones.

- How do long-term sustainability goals turn into everyday decisions?
- How are digital models integrated with legal frameworks and the working practices of planners, operators, and citizens?
- Who is responsible for what – and how do we make sure everyone is pulling in the same direction?

This handbook invites the reader to see governance in LDT-supported PEDs as something that happens across several interconnected layers. This perspective matters because PEDs and Local Digital Twins don't live in just one world – they stretch across strategic planning, legal frameworks, technical systems, operational routines, and community life.

2.5.3. Why a Layered Governance Approach Is Needed

Without a clear structure, these worlds can easily drift apart. Ambitious strategies may never reach implementation. Legal requirements may clash with technical solutions. Community engagement may happen on the sidelines instead of shaping decisions.

A layered governance model helps prevent this fragmentation. It shows how responsibilities are shared, how decisions move from one domain to another, and how alignment can be built across the entire ecosystem.

2.5.4. Creating Coherence Across a Complex System

The strength of this approach lies in its ability to create coherence in a complex socio-technical system. It gives diverse actors a shared frame of reference. It helps sectors coordinate instead of working in isolation. And it ensures that governance is not treated as a single activity at one level, but as something that must be connected across all levels.

Each layer represents a different dimension of governance, with its own purpose, actors, and responsibilities. But none of them stand alone. Decisions made at one layer shape – and are shaped by – what happens in the others. Effective governance of LDT-supported PEDs therefore depends not only on the quality of each individual layer, but on the strength of the connections between them.

The governance layers are outlined below, each offering a different lens on how cities can turn ambition into action:

Table 1: Layered Governance Model

Layer	Purpose	Responsibilities	Typical Actors
Layer 1 – Strategic Governance	To define long-term direction and ensure alignment with public value and sustainability goals.	• PED strategy development • sustainability objectives • cross-sector coordination • investment prioritisation • overall governance oversight	• city executive leadership • municipalities • utility executives • PED governance boards

Layer 2 –Institutional and Legal Governance	To establish the legal, regulatory, and organisational frameworks that enable secure and compliant operation.	• GDPR compliance • procurement governance • liability management • data agreements • policy and regulatory compliance	• legal departments • data protection officers (DPOs) • municipal authorities • regulators
Layer 3 –Operational Governance	To coordinate daily activities and ensure stable and effective implementation.	• operational coordination • incident management • access and user management • maintenance • KPI monitoring	• platform operators • utilities • facility managers • operational coordinators
Layer 4 –Technical and Data Governance	To ensure interoperability, data quality, and secure digital infrastructure.	• interoperability • Data sources governance • metadata management • cybersecurity • semantic standards • model governance	• IT architects • data engineers • cybersecurity teams • digital twin operators
Layer 5 –Participatory and Community Governance	To ensure trust, inclusion, and democratic legitimacy.	• citizen engagement • transparency • co-creation • communication • ethics oversight	• citizens • NGOs • community representatives • Participation offices

2.5.5. Towards an Integrated Organisational Structure

Together, these structures illustrate how governance can be organised to operate across layers rather than within isolated domains. Anchored in city executive leadership, they enable coordination between strategy, regulation, operations, technology, and community engagement.

This approach reflects a shift from sector-based governance to system-based governance, where responsibilities are aligned around shared objectives rather than institutional boundaries. By

introducing cross-functional units and clearly defined roles, municipalities can strengthen their capacity to implement LDT-supported PEDs in a coherent, adaptive, and inclusive manner:



Figure 2: Integrated Organisational Structure

If relevant, see Annex 3 (Breaking Down Silos in Governance Structures) for how cities can move from fragmented efforts to more coordinated and integrated ways of working.

2.6. RACI Matrix for PED Digital Twin Governance

How are responsibilities shared when multiple actors collaborate on complex urban systems? Who makes the final decisions, who carries out the work, and who needs to be involved along the way? And how can clarity be ensured when governance spans municipalities, utilities, digital twin operators, and communities?

As described throughout this handbook, LDT-supported PED development involves a wide range of actors operating across strategic, technical, operational, and participatory domains. Without a clear allocation of roles and responsibilities, governance can become unclear, leading to overlaps, gaps, or delays in decision-making and implementation.

The RACI matrix provides a simple and structured way to address this challenge. It defines who is Responsible, Accountable, Consulted, and Informed across key governance activities. By making these roles explicit, the matrix supports transparency, coordination, and effective collaboration between stakeholders.

In the context of PED digital twin governance, a RACI approach helps to:

- clarify decision-making authority
- ensure accountability across organisations

- strengthen coordination across governance layers
- reduce fragmentation and overlap in responsibilities
- support collaboration between technical, legal, and societal actors

It also contributes to:

- increased transparency in roles and responsibilities
- improved communication and stakeholder engagement
- enhanced traceability and auditability of decisions
- more effective risk management and regulatory compliance

2.6.1. How to interpret the RACI matrix

The categories used in this RACI matrix (Table 2) are defined as follows:

R (Responsible) – performs the work

A (Accountable) – has final responsibility and decision-making authority

C (Consulted) – actively contributes with input

I (Informed) – is kept informed

Together, these roles provide a shared vocabulary for governance, helping align expectations and enabling more effective implementation of LDT-supported PEDs.

The following descriptions explain what each role represents and the responsibilities it typically covers in the RACI matrix:

- **Municipality** – Sets strategy, policy direction, and overall accountability.
- **Utility** – Operates and maintains energy systems and infrastructure.
- **LDT Operator** – Manages, operates, and maintains the Local Digital Twin platform.
- **Vendor** – Delivers technology, software, and services under contract.
- **Data Steward** – Ensures data quality, governance, and proper data management.
- **Legal / DPO** – Ensures legal compliance, privacy, and data protection.
- **Research** – Provides analysis, evidence, and innovation support.
- **Civil Society** – Represents citizen interests and promotes transparency and legitimacy.

Each activity turns a governance layer (what needs to be managed) (see Table 1) into a practical function (what is actually done and assigned in RACI), while some activities intentionally bridge layers to support integrated governance:

1. **Strategic planning & investment alignment** → Translates Layer 1 (Strategic Governance) into concrete decisions on priorities, funding, and direction.

2. **Governance, legal & compliance framework** → Operationalises Layer 2 (Institutional & Legal Governance) by defining the overall rules, responsibilities, and regulatory boundaries.
3. **Data governance policy & stewardship** → Connects Layer 2 and Layer 4 by linking legal/data policies with their implementation across technical systems.
4. **Operational management & incident response** → Implements Layer 3 (Operational Governance) by ensuring systems are run, coordinated, and managed in real time.
5. **KPI management and monitoring** → Supports Layer 3, while feeding back into Layer 1, by tracking outcomes and informing strategic decisions.
6. **Technical infrastructure & interoperability** → Translates Layer 4 (Technical Governance) into the design and operation of secure, interoperable digital systems.
7. **Data & model management** → Implements Layer 4 by ensuring data quality, model reliability, and overall system integrity.
8. **Participation, communication & ethics** → Operationalises Layer 5 (Participatory Governance) by ensuring inclusion, transparency, and societal legitimacy.
9. **Procurement management** → Connects Layer 2, 3, and 4 by linking vendors and procurement rules with operational delivery and technical implementation.

2.6.2. Color-Coordinated RACI Matrix

Table 2: RACI Matrix

Activity	Municipality		Utility	LDT Operator	Vendor	Data Steward	Legal / DPO	Research	Civil Society
1. Strategic planning & investment alignment									
2. Governance, legal & compliance framework									
3. Data governance policy & stewardship									
4. Operational management & incident response									
5. KPI management and monitoring									
6. Technical infrastructure & interoperability									

7. Data & model management									
8. Participation, communication & ethics									
9. Procurement management									

Legend:

R = Responsible | **A** = Accountable | **C** = Consulted | **I** = Informed

2.6.3. How to read the RACI matrix

Each row represents a governance activity, while each column represents a stakeholder group. The colored labels show how responsibilities are distributed. In some cases (e.g. 1. Strategic planning & investment alignment), a single actor may be both Responsible and Accountable, reflecting combined operational and decision-making roles.

2.7. Recommendation: Critical Control Mechanisms for PED Digital Twin Governance

How can strategic decisions be translated into coordinated action across organisations? How can data, technology, and infrastructure be governed in a way that is secure, transparent, and aligned with public value? And how can trust be maintained when complex systems rely on data, algorithms, and multiple stakeholders?

As outlined in the previous sections, LDT-supported PED development requires coordination across governance layers, sectors, and actors. While the layered governance model structures responsibilities and the RACI matrix clarifies roles, effective governance also depends on dedicated mechanisms that provide oversight, coordination, and control across the system.

Without such mechanisms, governance risks becoming fragmented. Strategic priorities may not be consistently followed, technical systems may evolve without alignment, and issues related to data, ethics, or risk may remain insufficiently addressed. Critical control mechanisms help to ensure that governance is not only defined, but actively managed and continuously aligned across domains.

This handbook therefore recommends a set of core governance bodies and functions that support coordination, oversight, and decision-making across LDT-supported PEDs. These mechanisms operate across the governance layers and help to connect strategy, operations, technology, and community engagement.

Together, they serve to:

- ensure alignment between strategic goals and implementation

- support accountable and transparent decision-making
- manage risks related to data, technology, and infrastructure
- strengthen trust, ethics, and public legitimacy
- enable coordinated action across sectors and actors

The following control mechanisms are recommended as key components of a robust governance structure:

Table 3: Critical Control Mechanisms Overview

Governance Mechanism	Description	Core Responsibilities
PED Governance Board	A cross-sector strategic governance forum.	• strategic alignment • investment priorities • risk oversight • stakeholder coordination
Data Stewardship Function	A dedicated function focused on managing and governing data.	• metadata management • interoperability • data quality • access governance
Ethics & Trust Board	A governance body ensuring ethical and transparent use of data and technology.	• ethical oversight • transparency • privacy risks • AI accountability • public legitimacy
Technical Architecture Board	A technical governance forum overseeing system design and standards.	• architecture governance • interoperability standards • cybersecurity approval • technical roadmap management

2.8. Key Governance Risks

As highlighted throughout this handbook, LDT-supported PED development brings together organisational, technical, social, and legal dimensions. While this integration creates new opportunities, it also introduces a range of risks that can affect coordination, performance, trust, and compliance.

Understanding these risks is essential for effective governance. By making them visible, it becomes possible to anticipate challenges, design appropriate control mechanisms, and strengthen resilience across governance layers.

The following risk categories highlight the most critical areas to consider:

Table 4: Overview of Key Governance Risks

Risk Category	Risk	What it means in practice
Organisational Risks	Fragmented ownership	Responsibilities are spread across actors without clear accountability.
	Silo governance	Departments or organisations operate separately without coordination.
	Insufficient coordination	Weak alignment between strategy, operations, and implementation.
	Dependence on individual actors	Critical knowledge or processes rely on specific individuals.
Technical Risks	Poor interoperability	Systems cannot effectively connect or exchange data.
	Insufficient cybersecurity	Systems are vulnerable to risks or disruptions.
	Low data quality	Data is incomplete, inaccurate, or unreliable for decision-making.
	Data access constraints	Restricted access to relevant data due to ownership issues, legal barriers, or unclear permissions, limiting effective data use and informed decision-making.
	Model drift	Digital twin models become outdated or misaligned with reality.
Social Risks	Lack of trust	Stakeholders or citizens do not trust systems or decisions.
	Weak citizen engagement	Limited involvement reduces relevance and acceptance.
	Opacity in decision-making	Decisions are not transparent or easy to understand.
Legal Risks	GDPR non-compliance	Personal data is not handled according to legal requirements.
	Unclear liability	Responsibility is not clearly defined if problems occur.

PART 2

WHY THESE PRINCIPLES



Part 2 – Why these principles

Key Insights from Part 2 – Why These Principles

✓ Core Insight

Governance principles are not predefined – they emerge through **real-world practice, collaboration, and iterative learning in the Living Lab**.

✓ What This Part Covers

How the Living Lab in Brabrand was established and used as a **method for multi-stakeholder engagement, co-creation, and experimentation**, including how knowledge from practice was **collected, analysed, and translated into governance principles**.

✓ Why It Matters

It demonstrates that effective governance must be **grounded in real-life contexts**, ensuring that LDT-supported PEDs are **relevant, usable, and democratically anchored**, rather than abstract or purely technical solutions.

✓ What to Pay Attention To

- Treat Living Labs as a **way of working**, not a physical setup
- Use **real-world testing and stakeholder engagement** to generate insight
- Recognise the municipality's role as **orchestrator and facilitator**
- Build **shared understanding** of complex concepts (LDT & PED)
- Combine **data, technology, and local knowledge** ("soft data")
- Engage stakeholders differently based on **their needs and roles**
- Use **co-creation and prototyping** to explore and learn
- Accept that development is **iterative and non-linear**
- Ensure **continuous dialogue, trust, and relationships**
- Focus on the key challenge: translating **individual motivation into collective action**

Part 2 of this handbook presents the practical processes, methods and collaborative approaches that have shaped the principles described in **Part 1**.

Through an inductive approach, Aarhus moved from observing and engaging with multiple individual cases across BIPED's four stakeholder groups to formulating broader conclusions that ultimately shaped a coherent set of principles. As described in Section 1 (Creswell & Poth, 2024), the inductive approach means that work in Aarhus does not begin with a predefined theory, but instead develops understanding step by step through activities in the

living labs. The collected data was examined for recurring patterns, and these patterns formed the basis for deriving the principles.

Aarhus moved from observing and engaging with multiple individual cases across BIPED's four stakeholder groups to formulating broader conclusions that ultimately shaped a coherent set of principles. The collected data was examined for recurring patterns, and these patterns formed the basis for deriving the principles.

As a pilot city, Aarhus bears a particular democratic responsibility for the technologies developed in BIPED and for how these technologies shape everyday life and shared urban futures. This responsibility can be understood as a commitment to taking into account people's different prerequisites and ensuring that technological development is grounded in plurality, transparency and active participation. Plurality refers to the idea that many different people, perspectives, and ways of living must be recognised and included in how technology is developed and used in the city.

In this context, democracy is approached not merely as a formal structure, but as an ongoing practice in which differing perspectives are actively engaged. Within BIPED, this translates into designing technologies that can accommodate disagreement rather than suppress it, support diversity rather than standardization, and foster trust rather than control (Løgstrup, 1956/1997).

Consequently, democratic technology in BIPED is characterized by the extent to which local actors are able to meaningfully engage with LDT-supported PEDs. This includes the capacity to:

- understand how the technology works
- question and challenge its assumptions and outputs
- influence and modify its development
- reject or opt out of its application where relevant

In this sense, democratizing technology development is not only a methodological approach, but a fundamental ethical and democratic requirement for a contemporary European city.

Part 2 in this handbook illustrates how PED communities can be established and how collaboration unfolds in real-world settings when working with Local Digital Twins (LDTs) and Positive Energy Districts (PEDs) in a local context, see section 3. It further shows that by examining numerous individual cases within a PED community, it becomes possible to identify shared characteristics and translate these into more or less general rules expressed as principles, see section 4.

Within BIPED, this commitment is operationalized through the Living Lab method. Living Labs provides a structured yet flexible framework in which technologies are co-developed, tested and adapted in close collaboration with local stakeholders. They create the conditions for continuous dialogue, mutual learning and iterative refinement, ensuring that technological solutions remain responsive to local contexts, needs and values.

3. Establishing the PED Community in Brabrand as a Living Lab

How do you begin building a PED (Positive Energy District) community? By identifying who should be involved, mapping what they know, or by creating a space to explore how technologies can support cities in managing CO₂ emissions?

Section 3 addresses this question by describing how the PED Community in Brabrand has been established as a Living Lab – with Aarhus as the orchestrator, and with the community itself taking shape through collaboration, shared learning and real-life engagement. Rather than following a fixed sequence, the process has unfolded through iterative interactions between stakeholders, knowledge and technological exploration. A living lab with Aarhus as orchestrator means that the city coordinates collaboration between stakeholders in Brabrand to co-create and test solutions in real-life urban settings.

This section introduces the Living Lab method further and demonstrates how it has been applied in practice to create a functioning PED community. It shows how a structured yet open framework can bring together diverse actors, support collective learning and enable the joint exploration of how LDT-supported PED solutions can respond to local needs and conditions.

3.1. Case: Aarhus and Brabrand

To understand the context of the Living Lab, the following case briefly introduces the Brabrand area in Aarhus.

Brabrand, located approximately 6 km west of Aarhus city centre, is a diverse suburban district consisting of Brabrand, Gellerup, and smaller surrounding communities. With around 20,000 residents, the area combines varied socioeconomic groups, building types, and urban functions, ranging from social housing and single-family homes to public institutions and businesses.



Figure 3: Brabrand

The district is characterised by strong contrasts: Gellerup consists mainly of large-scale social housing from the 1960s, while Brabrand includes both older detached homes and newer residential developments with higher-income residents. Over the past decades, the area has been a key focus of urban transformation in Aarhus, with ongoing redevelopment aimed at creating a more mixed, inclusive, and sustainable neighbourhood.

Within this context, the BIPED project uses Brabrand as a living lab to explore the integration of digital and green transitions through the development of Local Digital Twin and Positive Energy District solutions.

3.2. Three interconnected steps

In Brabrand, the PED community emerged through **three interconnected steps**: a mindset, a framework/tool, and a method:

3.2.1. A mindset: many perspectives, one shared purpose

The starting point was a mindset already shaped in and by the city of Aarhus – a belief that meaningful change happens when many perspectives are invited in. Not only public actors. Not only experts. Not only the BIPED project team. But the full diversity of local actors who live in, work in, and influence Brabrand.

This mindset is grounded in Aarhus' commitment to:

- **Value for citizens and society**
- **Co-creation and co-production**
- **Knowledge-informed practice**

Aarhus also recognises that it does not have all the answers. The city learns by doing – guided by the Aarhus Compass⁴ and shares what it discovers along the way, a mindset stated in the BIPED Grant Agreement (BIPED Consortium, n.d.), together with methods from the Center for Innovation (CFIA) (Center for Innovation in Aarhus, n.d.) and Aarhus Omstillert (Aarhus Adjusts). This openness to experimentation created the foundation for the next step (Aarhus Municipality, 2022).

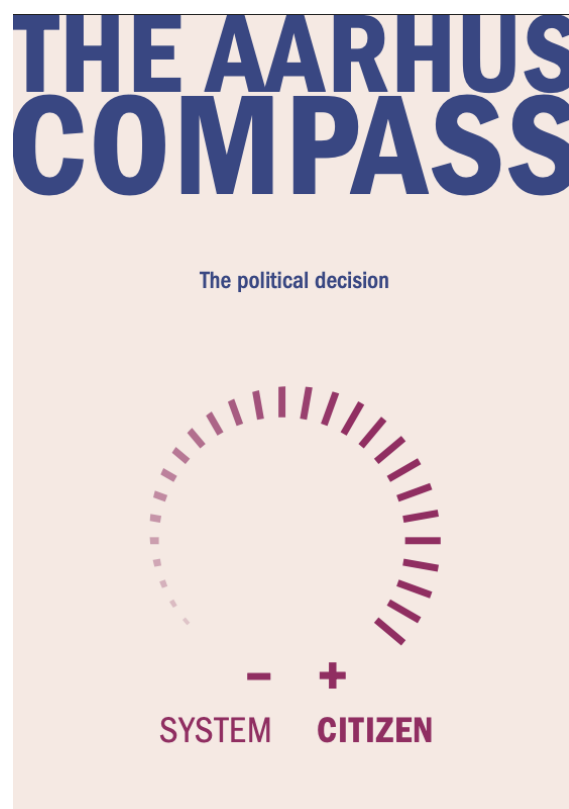


Figure 4: The Aarhus Compass

⁴ [Aarhus Compass](#)

3.2.2. A framework: visualising who matters, why, and how

The second step was the shaping and use of a visualised stakeholder-mapping tool and an accompanying framework for engaging local PED stakeholders in Brabrand, an engagement framework and foundation that had already been created within the first 6 months of the project⁵:

This framework/tool made it possible to:

- Identify who in the PED community needed to be involved
- Ensure involvement of a wide range of stakeholders
- Understand relationships, influence, and interests
- Plan meaningful engagement
- Create a shared language for discussing roles and responsibilities

It turned scattered insights into a coherent picture of the emerging Positive Energy District community.

It helped reveal who was missing, who needed to be invited, and how different groups could contribute to the development of a PED in Brabrand for more concrete inspiration and step-by-step guidance take a look at the BIPED Community Booklet⁶ derived from D3.1.

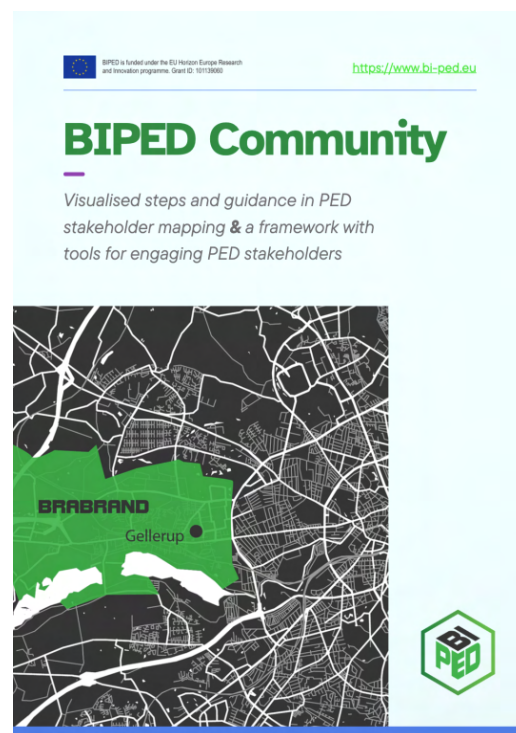


Figure 5: BIPED Community Booklet

3.2.3. A method: turning mindset + framework into a Living Lab

The third step was to integrate the thinking and the framework including the tools through a **Living Lab approach**.

This method created a shared space where the PED community could be invited in, and where Aarhus – as a city working alongside local stakeholders – could explore, question, and co-create based on lived experiences.

In practice, this meant actively incorporating the perspectives of others (Aarhus Municipality, 2022):

⁵ [D3.1 BIPED Community](#)

⁶ [BIPED Community Booklet](#)

- What do citizens care about?
- What do local businesses need?
- What knowledge do community groups hold?
- What hopes or concerns shape their everyday decisions?
- And from public decision-makers: How can local digital twins support better climate decision-making?

This user- and community-centred approach was essential for uncovering the values, needs, and insights that ultimately shaped the principles presented in Part 1. The Living Lab method is described in more detail below, as it has served as the core innovation framework throughout the process. The following section makes it clear that the city takes on the role of orchestrator and conductor within a living lab environment:

3.3. Living Labs as a Method for Innovation and Governance Development

In BIPED, the Living Lab approach serves as the methodological backbone for developing innovative, data-driven, and community-anchored solutions. The approach is strongly informed by the ENoLL Living Lab framework as presented in Schuurman et al. (2025). ENoLL the European Network of Living Labs – is the world’s largest and most established network of Living Labs, and its principles provide a robust foundation for structuring experimentation, stakeholder engagement, and iterative learning.

This handbook also draws on how Fauth et al. (2024) conceptualise the orchestrator role within a Living Lab. Their work highlights the importance of a coordinating actor who can align interests, mediate between stakeholders, and ensure continuity across the phases of co-definition, co-creation, and co-implementation. Together, these perspectives shape the methodological grounding for how the Living Lab has been developed and practiced in Brabrand. Therefore, this handbook also spends time describing the method in combination with how Aarhus has done it in the pilot city of Brabrand:

3.3.1. Living Lab: From Theory to Practice in Aarhus

At the heart of a Living Lab is a simple idea: *meaningful innovation doesn’t happen in isolation. It grows out of the everyday realities of the people, organisations, and places it aims to serve.* This is why the project builds on the Living Lab, which, according to ENoLL, can be defined as;

“a user-centred, open innovation ecosystem based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings” (Schuurman et al., 2025, p. 18).

Rather than designing solutions behind closed doors, the Living Lab approach brings innovation into the real world – into homes, streets, organisations, and neighbourhoods. It creates a structured way to explore complex societal challenges such as the energy

transition, climate adaptation, and digital transformation through iterative learning, experimentation, and collaboration. Insights emerge not from assumptions, but from lived experience.

Living Labs operate as collaborative ecosystems grounded in the quadruple-helix model of innovation, where four distinct groups co-create solutions:

- **Citizens and civil society** –bringing lived experiences, everyday challenges, and real-world needs
- **Academics** –contributing research insights, analytical methods, and scientific evidence
- **Private-sector actors** –offering market knowledge, entrepreneurial drive, and pathways for scaling
- **Public authorities** –ensuring alignment with policy goals, regulatory frameworks, and societal priorities

In BIPED, these four groups have been central. By connecting all four perspectives, BIPED enables innovation that is both grounded in real needs and capable of achieving meaningful, scalable impact, see BIPEDs four local stakeholder groups in section 1.1.2.

Over time, Aarhus has built its innovation practice in D3.3 on six core principles that together form a solid framework for responsible and democratic development, in line with Schuurman et al. (2025, p.20–21):

1. **Active user involvement** ensures that needs, preferences, and lived experiences shape the direction of the work, resulting in solutions that are relevant and usable.
2. **A multimethod approach** blends qualitative and quantitative methods workshops, interviews, prototyping, field studies, and data analysis allowing challenges to be understood from multiple angles.
3. **Real-world testing** anchors innovation in the environments where solutions must ultimately function, providing realistic feedback and reducing implementation risk. In the Brabrand Living Lab, this often involves engaging directly with stakeholders in their own contexts meeting them where they are, rather than expecting them to come to us which further strengthens the relevance and grounding of the work.
4. **Multi-stakeholder participation** brings together citizens, public authorities, researchers, companies, NGOs, and community groups, enriching the process with diverse expertise and interests.
5. Effective coordination and orchestration ensure that these actors collaborate coherently, align expectations, and maintain momentum.
6. At the centre is co-creation, where stakeholders jointly shape ideas, prototypes, and decisions, building shared ownership and legitimacy.

Living Labs operate across three interconnected levels, ensuring that innovation is both strategically anchored and practically grounded. Aarhus has applied this approach from the outset and has consistently found that Living Labs work best when these levels create a clear connection between strategic direction and the realities of everyday life.

In BIPED, this can be illustrated as follows:

- **Macro level:** The City of Aarhus, in its role as pilot city, provides the strategic direction and alignment with city priorities, while DTU, as coordinator of BIPED, and the European Commission, as funding and policy actor, contribute to governance frameworks and long term direction.
- **Meso level:** Projects such as BIPED translate strategy into concrete innovation initiatives. In relation to BIPED, the project's sister projects - ExPEDite and TIPS4PED⁷ can also be mentioned at this level. Both projects also focus on Positive Energy Districts and Digital Twins.
- **Micro level:** Hands-on activities – workshops, interviews, prototypes, and field tests engage people directly in their everyday environments.

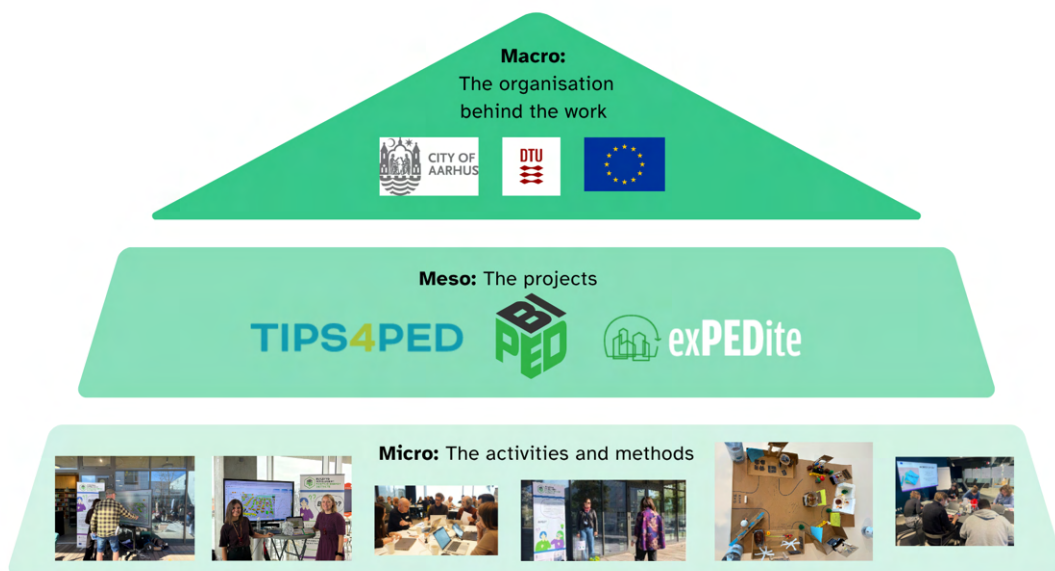


Figure 6: The three layers

In BIPED, the City of Aarhus steps into a dual role as both owner and orchestrator of the Living Lab. This role has grown naturally from the city's long tradition of bringing people together around shared challenges. Aarhus convenes partners, aligns interests, and creates the conditions for collaboration –while also safeguarding the ethical and responsible use of data and upholding a governance framework built on transparency, inclusion, and evidence-based decision-making (Fauth et al., 2024).

As the Living Lab unfolds in real neighbourhoods and real organisations, it generates insights that cannot be produced from behind a desk. These insights flow directly into the development of the D3.3 *Handbook on Governance Practices and Principles*, ensuring that the handbook is shaped not by abstract models, but by tested methods, lived experiences, and the everyday realities of the communities involved. In this way, the Living Lab becomes both a place of experimentation and a source of grounded knowledge that strengthens governance going forward.

⁷ ExPEDite: <https://expedite-project.eu/> and TIPS4PED: <https://tips4ped.eu/>

3.4. Aarhus' Ownership of the Living Lab and Its Role as Orchestrator

Aarhus holds the mandate for the Living Lab and acts as its orchestrator, taking responsibility for governance, coordination and strategic alignment. In this role, Aarhus ensures that the Living Lab functions as an open, inclusive and well-structured environment for experimentation, collaboration and capacity building (Schoorman et al., 2025, p. 20).

In line with Fauth et al. (2024), the role of the orchestrator is not to direct the process in a top down manner, but to create the conditions for collaboration. This involves bringing diverse actors together, establishing and maintaining the collaborative process, and enabling stakeholders to actively contribute to and shape the development of solutions.

Through this dual role as owner and orchestrator, Aarhus both provides the institutional foundation for the Living Lab and facilitates the interactions through which the PED community is formed and evolves.

Aarhus Municipality played a central role as orchestrator of the living lab, managing complex systems across multiple domains. This included navigating both the city itself and the Brabrand district as a complex system of interconnected infrastructures, as well as aligning the BIPED consortium and the city as two distinct domains that needed to function cohesively.

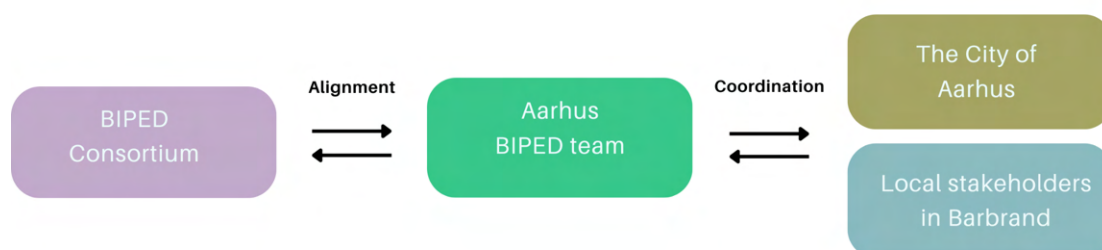


Figure 7: Simple illustration of Aarhus team's orchestration across domains and systems

For other cities seeking to establish PED communities, this highlights the importance of assigning a clear orchestration role. While the specific actor may vary depending on local context, it is essential that one entity assumes responsibility for convening stakeholders, aligning interests and sustaining the collaborative process over time. Rather than controlling outcomes, this role should focus on enabling participation, fostering trust and ensuring that experimentation and learning can take place in a structured yet open environment.

3.4.1. Early Governance Principles in the Living Lab Approach

Already in the early methodological development of the Living Lab in Brabrand, several core principles began to emerge. Through the Aarhus Compass and the strong anchoring in municipal collaboration, sustainability and public value were not treated as abstract goals, but as guiding criteria for concrete decisions – pointing clearly towards **Principle 1**. At the same time, the deliberate focus on co-creation, stakeholder mapping, and the inclusion of diverse local actors reflected a fundamental commitment to shared governance and participation, laying the

foundation for **Principle 2**. Finally, the role of Aarhus as both owner and orchestrator – responsible for aligning actors, maintaining momentum, and embedding the work within municipal structures – highlighted the importance of long-term responsibility and organisational anchoring, which directly informed **Principle 8**. Together, these elements show how key governance principles were not defined upfront, but emerged naturally from the methodological choices and collaborative practices shaping the Living Lab.

3.4.1.1. From Emerging Principles to Structured Insight

While these early activities established an initial direction for governance, they were primarily grounded in conceptual framing and collaborative design practices. As the project progressed, a need emerged to better understand how data work unfolded in practice, particularly in relation to identifying, accessing, and mobilising data across organisational boundaries.

This marked a shift from normative and exploratory principles to a more empirical and practice-based investigation. To support this, a dedicated workshop was conducted to map the data journey in Aarhus.

Where the Living Lab approach revealed what governance should aim for, the data journey workshop focused on how work actually happens.

It is within this transition from early principles shaped by design and collaboration, to insights grounded in operational experience that the following method was developed.

3.4.2. Mapping the Data Journey: A Method for Condensing Practice-Based Knowledge

In the early phase of the BIPED project in Aarhus in November 2024, a workshop was conducted to support a concrete objective: to identify, access, and understand relevant data for the technical team.



Figure 8: Pictures from Data journey workshop

At this stage, the challenge was not one of formal data governance, but of locating and mobilising data across organisational boundaries. The workshop therefore functioned as an analytical method to transform fragmented, experience-based knowledge into a shared and structured understanding of the data landscape.

3.4.2.1. Approach

The workshop applied a practice-based mapping approach, focusing on how participants actually work with data rather than how processes are formally described (See Annex 4 for more on the data journey workshop).

To create a shared starting point, participants were introduced to a simple data journey model covering the lifecycle from data collection to use. This model was then translated into the Aarhus context through four operational phases:

- Data demand and initial collection
- “Detective work” (identifying data and data owners)
- Dialogue on access (permissions, agreements, constraints)
- Data transformation, processing, and analysis (when needed)
- Data delivery and use

This translation was critical, as it shifted the discussion from a technical pipeline to a lived organisational workflow, making it possible to analyse how data work unfolds in practice.

3.4.2.2. Workshop process

Participants worked systematically through each phase using two guiding questions:

- What are the main challenges?
- What has worked well?

This simple structure enabled the group to:

- compare experiences across roles and organisations
- surface recurring patterns
- capture both barriers and enabling practices

A key analytical outcome was the identification of “detective work” as a distinct and central phase. This revealed that much of the effort in working with data lies in:

- locating data, as it is rarely centrally documented
- identifying relevant data owners
- building relationships to gain access

In the second part of the workshop, participants prioritised the most critical challenges and highest-value areas for action, moving from reflection to collective evaluation and direction-setting.

3.4.2.3. Key insights from the workshop

The workshop enabled a shift from fragmented individual experiences to a shared understanding of how data moves in practice.

Three types of insights emerged (Annex 4):

Structural bottlenecks

- Limited overview of available data
- Unclear ownership and responsibilities
- Time-consuming and complex access processes

Hidden dependencies

- Strong reliance on individuals and relationships
- Data access as a social and organisational process

Enabling practices

- Shared data mapping and visibility
- Early and continuous dialogue with data owners
- Iterative coordination and follow-up

Taken together, these insights demonstrate that data work is often manual, distributed, and relational, rather than fully systematised.

3.4.2.4. Methodological contribution: Workshop as analytical process

This workshop illustrates how a facilitated, participatory format can function as a structured analytical process—especially in situations where no one has the full picture, and where knowledge is scattered across people, departments, and everyday practices.

In the Aarhus case, participants entered the room with very different perspectives. Someone from IT might understand how data is technically stored, while a project manager knows how data is actually used in practice, and another colleague might be aware of the informal workarounds that happen when systems don't quite fit reality. None of these perspectives alone provide a full overview—but together, they form a more complete picture.

The challenge, however, is that this knowledge is rarely documented. It exists in conversations, routines, and individual experience. At the same time, the exact problems are often unclear: Is the issue missing data? Lack of access? Unclear ownership? Or something else entirely?

To make this visible, the workshop introduces a simple structure—the “data journey”—as a shared starting point. Rather than presenting it as a fixed model, it is treated as something

participants can shape. As they go through it step by step, they begin to recognise their own work in the process:

“Actually, there’s a step missing here.”

“This is where we usually get stuck.”

“This part works surprisingly well.”

Gradually, the abstract idea of “data challenges” becomes more concrete. Participants write down specific experiences on post-its—small observations like “we don’t know who owns this data” or “we have good collaboration in this phase.” These individual fragments are then placed onto the shared framework, making it possible to compare and connect them.

As the workshop progresses, patterns begin to emerge. What initially felt like isolated issues turns out to be repeated across departments. Several participants point to the same step as problematic. Others highlight similar successes. What was previously invisible—or seen as individual frustration—starts to take the shape of shared challenges and opportunities.

In the second part of the workshop, this emerging overview allows the group to shift from exploration to prioritisation. Instead of discussing abstract problems, participants can now point to concrete steps in the process and collectively decide:

Where does it matter most to act?

What creates the most value if improved?

Using simple tools like stickers, they highlight the areas that require attention. This step is important—not because it produces final solutions, but because it creates alignment around what the problem actually is.

Through this process, the workshop moves from fragmented experiences → shared structure → collective insight. What began as dispersed, informal knowledge is gradually translated into a small number of clearly articulated themes that can support decision-making.

This is what makes the method particularly valuable in early stages. It does not attempt to solve the problem immediately. Instead, it creates a space where the problem can be understood—systematically, collaboratively, and grounded in real practice.

3.4.2.5. From Data Journey to Principles

Although the data journey workshop was not designed as a governance exercise, it generated empirical insights that directly informed the development of the nine principles in this handbook.

Across the different phases of the data journey, recurring patterns emerged that pointed to underlying structural needs:

- Challenges related to unclear data ownership and fragmented responsibilities directly informed **Principle 3** – Data Sovereignty and Interoperability
- The strong dependence on relationships, trust, and dialogue informed **Principle 2** – Multi-Stakeholder Inclusion and Shared Governance

- The need for shared understanding across actors informed **Principle 4** – Transparency, Traceability and Explainability
- The identification of “detektivarbejde” as a central activity informed **Principle 7** – Human-Centric Automation
- The iterative nature of working with data informed **Principle 9** – Continuous Validation and Organizational Learning
- The need to prioritise high-value data efforts informed **Principle 1** – Public Value and Sustainability First
- The misalignment between technical ambitions and organisational realities informed **Principle 8** – Lifecycle Sustainability and Long-Term Stewardship
- Legal, ethical, and access-related concerns informed **Principle 5** – Privacy, Ethics and Social Legitimacy
- The need for stable and reliable data infrastructures informed **Principle 6** – Cybersecurity and Operational Resilience

The data journey workshop demonstrates how a structured, participatory process can transform fragmented, experience-based knowledge into shared and actionable insight.

By making invisible work visible and organising lived experiences into patterns, the workshop functions as an effective analytical method – and a critical pre-governance step for understanding complex data practices in early project stages.

3.5. Building the BIPED Living Lab in Brabrand (Aarhus):

Stakeholders, Method, and Practice

How does a city begin to build a living lab from scratch? Where is the starting point within the organisation, out in the local community, or somewhere in between? And how do you engage citizens in topics as complex as LDT-supported Positive Energy Districts (PEDs)?

In Aarhus, as the BIPED pilot city, the answer did not lie in one place. Instead, it emerged over time by moving across the city, engaging with departments, local actors, and communities, and gradually building the living lab through practice.

3.5.1. Building the Foundation: Stakeholders and Shared Understanding

As described earlier, the living lab in Aarhus was initially established by:

- identifying who in the PED community needed to be involved
- ensuring the involvement of a wide range of stakeholders
- understanding relationships, influence, and interests
- planning meaningful engagement
- creating a shared language for discussing roles and responsibilities

Getting this process started took time. Based on the BIPED project, the Aarhus team's project manager participated in the Innovation Education programme, which consisted of four modules focused on designing and implementing innovation processes:

- Module 1: Innovative project design
- Module 2: Design thinking
- Module 3: Co-creation and partnership
- Module 4: Implementation and benefit realisation

This training helped establish a strong foundation for the development of several innovation processes within the living lab.



Figure 9: Pictures from the Innovation Education programme with BIPED

At the same time as the Innovation Education programme, Aarhus prioritized involving representatives from the City's Climate Secretariat due to BIPED's focus on sustainability and energy. As a result, one of the first steps was to establish a series of meetings exploring the project's two core dimensions: Positive Energy Districts (PEDs) and digital twins.

Neither of these concepts were well known within Aarhus Municipality. As a result, significant effort was spent building a shared understanding before the work with the living lab could move forward. It became clear that both the living lab method and BIPED's core focus were new within the organisation, and that anchoring them internally required time and effort (Annex 1).

The technological dimension was initially explored through the Aarhus team's anchoring in ITK (Innovation, Technology and Creativity) (Aarhus Kommune, n.d.), which provided a strong foundation for working with digital and technological innovation.

Building internal understanding and involving key municipal actors, such as the Climate Secretariat, particularly contributed to **Principles 2, 8, and 9**, as the process required stakeholder alignment, organisational anchoring, and continuous learning to establish a shared foundation for the Living Lab.

3.5.2. Moving into Practice: Exploring Through Co-Creation

From this point, curiosity in Aarhus grew around how this work with living labs could take shape locally particularly in Brabrand.

To explore this, more than 30 students from Aarhus Business Academy were invited to participate in a co-creation session. Their task was to prototype a living lab in Brabrand with a focus on communication:

How can a BIPED Living Lab be designed to make technology as accessible and usable as possible for a wide audience (democratising technology), while also strengthening skills and knowledge about the technology (digital literacy)?

The students worked within the six living lab principles and explored different scenarios:

- a digital solution in a library
- a physical installation outdoors
- and a “joker” constraint where they could introduce their own ideas



Figure 10: Pictures from prototype workshop with Aarhus Business Academy

To ensure that this work remained closely connected to the broader BIPED project and the expertise of the consortium and could move beyond experimentation towards long-term implementation the BIPED consortium conducted a similar exercise.



Figure 11: Pictures from prototype workshop with the BIPED consortium, GA in Dublin 2025.

The co-creation workshops and prototyping activities particularly informed **Principles 2 and 9**, while the focus on making technology accessible also relates to **Principle 4**.

3.5.3. Understanding the Living Lab Approach in Aarhus

Following these activities, Aarhus moved more directly into understanding the living lab method itself.

It became important to clarify:

- how a living lab can be created
- how it generates value within BIPED
- and how this approach relates to existing ways of working in Aarhus

To address this, Aarhus developed a shared position on the value of a living lab in a city context. The following perspectives emerged:

- Solutions work because they are developed in real-life settings
- Testing and experimentation take place in the real world not only in controlled environments
- Active user involvement can strengthen democratic processes, provided participants can genuinely influence development
- The municipality takes on the role of orchestrator, ensuring the right actors meet and collaborate
- Solutions are developed together with those who have the most relevant practical knowledge

At the same time, an important realisation emerged:

While this appeared to be a new way of working, Aarhus had in many ways worked like this for years – just under different labels. This led to a longer process of understanding how Aarhus could take ownership of the living lab method. Along the way, a number of key questions arose:

- Is a living lab a place?

- Does it require a specific artefact to make it tangible?
- Or does it emerge through a way of working, where the municipality acts as an orchestrator guided by principles?

This resulted in a slide deck titled “Fair and Sustainable Digital Transition Living Labs in Practice,” which has guided Aarhus in its role as orchestrator of the living lab, while also communicating the methodological approach internally in the city of Aarhus (see the slide deck in Annex 5).

This phase highlighted how understanding the Living Lab required continuous reflection and learning, pointing clearly to **Principle 9**, while the focus on co-creation and stakeholder involvement relates to **Principle 2**. At the same time, the emphasis on real-life contexts and the municipality’s role as orchestrator connects to **Principles 7 and 8**.

3.5.4. Breaking Down the Method

These reflections led to a deeper exploration of the method. The role of Aarhus was examined in relation to both the six living lab principles and the overarching objectives of BIPED:

- Empowerment and Capacity Building
- Innovating Positive Energy District (PED) Development
- Democratising Access to Technology
- Fostering Awareness and Digital Literacy
- Enabling Evidence–Based Clean Energy Action

At the same time, the method was broken down into smaller components to better understand how it could be operationalised in practice.

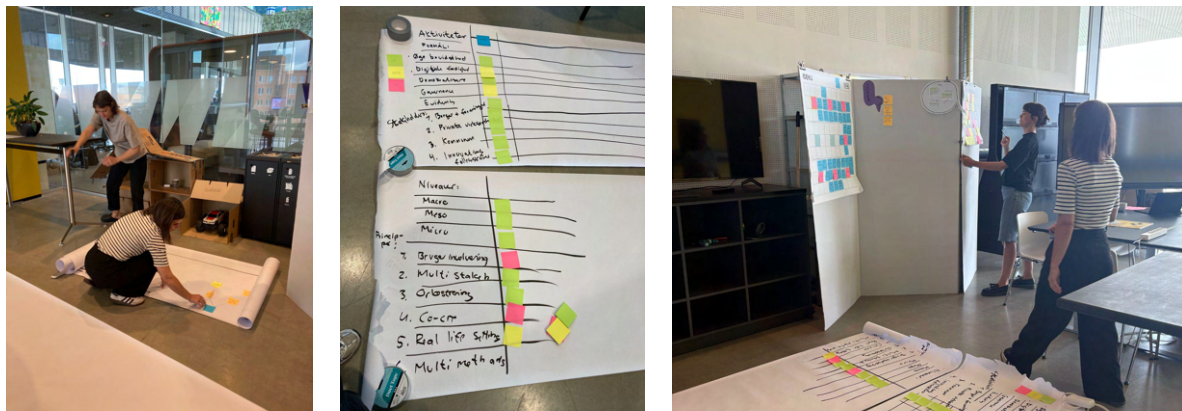


Figure 12: Pictures showing how the Aarhus BIPED team broke down the living lab method into different elements

This phase particularly informed **Principles 9** and **1**, as the method was explored and translated into practice with a clear focus on societal value, while the emphasis on empowerment, accessibility, and operational clarity also connects to **Principles 2** and **4**.

3.5.5. Learning by Moving Around the City

A central part of this work involved moving across and around in the city Aarhus to gather inspiration and perspectives.

The living lab journey naturally began in Brabrand, where Aarhus explored what had already taken place prior to the BIPED project. This involved meeting people who understood the area from within project actors, practitioners, and the local journalist behind Vores Brabrand, a hyper-local media platform covering everyday life in all of Brabrand (Vores Brabrand. (n.d.)).

Another key stakeholder was the collaboration between Brabrand Housing Association (Brabrand Boligforening, n.d.), which brought valuable experience with citizen engagement particularly in Gellerup. Gellerup, a neighbourhood in the eastern part of the Brabrand district, serves as a central focus area for the project. BIPED activities therefore target the wider Brabrand district of Aarhus, with a particular emphasis on Gellerup.

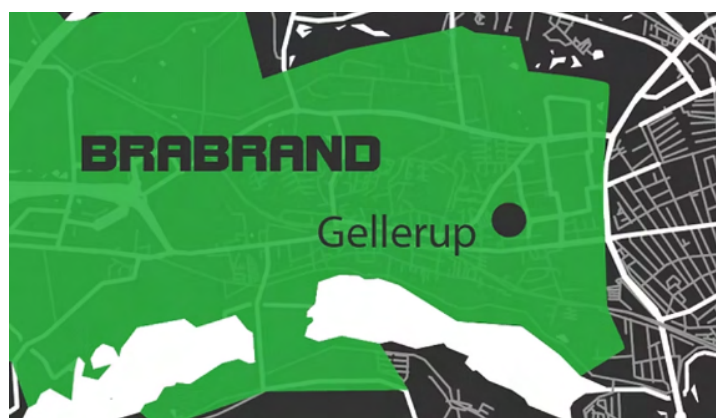


Figure 13: Zoomed-in view of Gellerup

These insights pointed Aarhus in a clear direction:

Rather than expecting local actors to come to the project, Aarhus needed to go out to them.

This approach moving into the local context – became a defining principle for how the living lab was developed.

This shift towards engaging directly with local actors highlighted the importance of grounding the Living Lab in real-life contexts, pointing clearly to **Principles 2** and **7**, while also reflecting an iterative learning process aligned with **Principle 9**.

3.5.6. Inspiration Across Aarhus and Beyond

The next question was whether Aarhus should engage physically in the local area, and if so, how.

To explore this, Aarhus visited several relevant cases⁸:

- **Kredsløb's exhibition "Maskinrummet"** An interactive exhibition that makes complex energy systems tangible through visualisation and physical installations.
- **Kollision** (design studio) A design studio specialising in participatory and engaging design methods for communicating complex topics.
- **Aarhus Eye** A physical and digital exhibition space combining scenography and storytelling to present urban development and city data.
- **SNART** A laboratory for exploring possible futures, using scenarios and storytelling to engage people in discussions about sustainable development.
- **DAC** (Danish Architecture Center) A cultural institution that communicates architecture, urban development, and sustainability through exhibitions and public programmes.

Kredsløb supplies district heating to almost all supply areas and handles waste for 186,000 households in Aarhus Municipality. Their exhibition made complex energy systems tangible for example, by visualising the entire district heating network beneath Aarhus on the floor of the exhibition.

Kollision provided insight into how interaction and design can engage people in new ways, while Aarhus Eye demonstrated how physical scenography, digital tools, and real-world objects can be combined.

Insights were also drawn from DAC's 2025 campaign "How should we live in 2050?", where four short films presented visions for future ways of living in Denmark. SNART, a laboratory for possible futures, offered inspiration for working with future-oriented scenarios and LDT-supported PEDs.

Together, these visits informed how complex systems could be communicated and made accessible in practice.

3.5.7. From Inspiration to Action: Exploring an Artefact

These experiences led Aarhus to explore whether BIPED could develop a central artefact, a tangible element that could act as a focal point for engagement in Brabrand.

To support this work, Aarhus collaborated with the Center for Innovation in Aarhus Municipality, which develops new solutions to welfare challenges together with citizens, professionals, and external actors.

This collaboration became an important driver for innovation within BIPED.

These experiences highlighted the importance of making complex systems accessible and engaging, pointing strongly towards **Principle 4**, while the collaborative and exploratory approach also reflects **Principles 2** and **9**.

⁸ [Kredsløb's exhibition "Maskinrummet"](#) (Kredsløb, n.d.), [Kollision \(design studio\)](#) (Kollision, n.d.), [Aarhus Eye](#) (Aarhus Øje, n.d.), [SNART](#) (Fremtid SNART, n.d.), [DAC](#) (Danish Architecture Center, n.d.)

3.5.8. A Key Challenge: Engaging Citizens

At this stage, Aarhus recognised a key challenge:

Engaging citizens was difficult – not because of a lack of interest, but because of the complexity of LDT supported PEDs.

To address this, a **BIPED Living Lab sprint** was initiated with a focus on citizens.

Participants included:

- Aarhus Municipality (user involvement, UX design, strategy, climate, technology)
- external partners such as Tiny Office and Kollision
- facilitators from the Center for Innovation



Figure 14: Design Sprint team

The purpose of the sprint was to explore how a BIPED Living Lab could support citizens' understanding of and engagement with Positive Energy Districts in Brabrand.

The focus was on developing an inspiring and mobile element that could make the concept understandable and allow citizens to explore their role in an energy community.

However, after the first day, it became clear that the focus needed to be adjusted. Rather than moving directly to testing, the process shifted towards clarifying:

- what the element should do
- and what value it should create for citizens

This phase strongly informed **Principles 7** and **9**, as the sprint centred on citizen understanding and iterative adjustment, while the shift towards clarifying value also connects to **Principle 1**.

3.5.8.1. The Sprint Process

The sprint took place over five days in November 2025:

- Day 1: Understanding the challenge and defining focus
- Day 2: Refining goals and exploring possibilities
- Day 3: Developing and prioritising ideas
- Day 4: Developing concepts
- Day 5: Finalising concept and building the prototype
- The prototype was then tested.

Below is a snapshot of the Design Sprint process:



Figure 15: Stakeholder mapping



Figure 16: Idea development – using the Crazy 8 method



Figure 17: Solution sketches



Figure 18: Storyboard

Design sprint methodology

The sprint followed the principles of the classic Google Design Sprint, an innovative five-day process designed to address complex business challenges. The approach enables teams to move from identifying a problem and generating ideas to developing a prototype and conducting user testing within a single week. The sprint was structured and facilitated according to the methodology described by Knapp et al. (2016). For further insights into the planning and execution of Design Sprints, readers are referred to Knapp et al. (2016) and their book *Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days*, which provides a comprehensive guide to the methodology and practical application of Design Sprints. A comprehensive documentation of how Aarhus conducted the Design Sprint is provided in Annex 6.

3.5.8.2. Collaboration and Key Learnings from the Sprint

The collaboration during the sprint was shaped by different starting points and agendas. The BIPED team entered the sprint with a clear project focus, while the external participants

brought their own professional perspectives and interests. At times, this led to a lack of a shared sense of “what was at stake,” and the overall direction was not always fully aligned from the outset. At the same time, all participants worked with strong engagement and dedication, which became particularly evident during the prototype phase, where solid and concrete contributions were delivered.

The sprint also highlighted a number of competency-related and professional tensions. In particular, work on the Local Digital Twin and the climate dimension proved complex, and there were periods where a sufficient shared understanding and specialized knowledge were lacking. As a result, the process became strongly centred around existing uncertainties. In this way, the sprint acted as a magnifying glass, making the challenges already experienced within BIPED more visible and more pressing.

From a methodological perspective, the sprint also raised questions about whether a design sprint was the right approach for addressing such a complex and still relatively undefined problem. The need for clearer framing became evident – both in terms of purpose, budget, expectations, and communication. A sharper framework could have strengthened alignment and collaboration throughout the process.

At the same time, the sprint highlighted challenges in internal collaboration. Although partners shared a strong commitment to achieving a successful outcome together, this collective ambition also introduced pressure that sometimes made it harder to openly address disagreements or uncertainties. To mitigate this, it is important to consciously create space for honest dialogue, clarify expectations early on, and establish a shared understanding that constructive disagreement is a valuable part of the process rather than a risk to progress.

In terms of content, the sprint provided valuable insights into the citizen perspective. Testing showed that participants responded more strongly to local stories, communities, and concrete examples from Brabrand than to data and technical explanations. This suggests that engagement is not necessarily driven by understanding the digital twin, but by identification and relevance in everyday life. At the same time, it became clear that there was a tendency to “fall in love” with certain aesthetic or conceptual elements – such as the mirror and the artistic expression which both opened up new possibilities but also risked shifting focus away from the core purpose.

The sprint therefore raised several key strategic questions:

- What value is the living lab expected to create?
- Are citizens interested in the digital twin or in something else?
- How can technological opportunities be meaningfully connected to everyday life and existing communities?

Finally, the process pointed forward to a need for clearer direction:

- to work more systematically with existing local communities,
- to better understand citizens’ concrete needs and motivations,
- and to clarify how and whether a physical format such as a “mobile laboratory” is the right solution.

Summary

The sprint did not only result in a concept – it led to a deeper understanding of the challenge:

- A need for clearer purpose and framing
- The complexity of LDTs and PEDs requires new forms of collaboration and competencies
- Citizen engagement is driven by relevance, community, and storytelling not technology alone
- The sprint functioned as an important clarification rather than a final solution

3.5.9. A Living Lab Already in Motion

Importantly, the living lab in Aarhus was already underway before the sprint.

Within the first three months of the project, Aarhus had already:

- conducted workshops
- held initial stakeholder meetings
- begun engaging with local actors

This highlights a key insight: the development of the method and its practical application evolved iteratively in parallel, supported by a Scrum-based framework that enabled continuous feedback, adaptation, and learning throughout the process.

This phase particularly informed **Principle 9**, as method development and practical application evolved in parallel, while the early stakeholder engagement also connected to **Principle 2**.

3.5.10. From Method to Practice

To understand how the living lab in Brabrand has functioned, it must be seen as both:

- a methodological development process
- and a practical, hands-on approach

The task for Aarhus has been twofold:

- to understand and take ownership of how a city can democratise and implement LDT-supported PEDs through a living lab approach
- and at the same time to actively engage in practice through involvement and co-creation

For this reason, this handbook moves beyond the method itself and focuses on how Aarhus has worked in practice.

All interactions and activities are documented in an activity log (Annex 1).

This phase highlighted how governance emerges through practice, pointing strongly to **Principles 9** and **2**, while the use of structured documentation and activity logs also reflects **Principles 4** and **8**.

3.5.11. The PED Community in BIPED

In the BIPED project, the PED community is established through a living lab approach and includes:

1. Public sector decision makers responsible for urban planning and sustainability policies
2. Private enterprises working with construction, renovation, solar energy, and mobility
3. Citizens, communities, and local interest groups
4. Innovation communities, e.g. SMEs, institutes, and standards organisations working on data standards for smart cities.

The interactions across these groups and how the empirical insights connect to the living lab principles are described further in Section 4.

4. Practices and processes: From Living Lab to Governance in Practice – Brabrand as a PED Pilot

Section 4 outlines the process through which insights from the Living Lab were synthesised into principles. It explains how we examined the four stakeholder groups and used the empirical foundation described in Section 3 to:

- synthesise the collected knowledge,
- categorise insights for analysis, and
- translate them into governance principles.

Through an inductive approach, Aarhus moved from observing multiple individual cases / activities / engagement across BIPED's four stakeholder groups to formulating broader conclusions that ultimately shaped the set of principles in **Part 1**. The collected data was examined for recurring patterns, and these patterns served as the basis for deriving the principles.

The Brabrand Living Lab has served as an experimental environment where new technologies, behavioural insights, and collaborative methods could be tested under real-world conditions. Through this work, a substantial body of knowledge has been generated – not only about energy use and digital tools, but also about how people,

organisations, and systems interact within the context of Positive Energy District (PED) development.

4.1. Presenting Knowledge from the Living Lab (Empirical Foundation)

The process begins with gathering and presenting the empirical insights generated through activities in the Living Lab. This includes data, observations, stakeholder experiences, and lessons learned from real-world experimentation.

4.1.1. Working with Public-Sector Decision-Makers in the Brabrand Living Lab

In Brabrand, the Living Lab created a space where public-sector decision-makers and municipal employees could explore new ways of working with data, planning, and sustainability under real-world conditions. All the public-sector actors involved were locally rooted – either working directly in Brabrand or in municipal units responsible for Aarhus’ urban planning, sustainability policies, mobility, energy, and digitalisation. Their local knowledge and everyday responsibilities shaped the Living Lab from the very beginning. Below is an overview of the public-sector decision-makers Aarhus has engaged with in the Brabrand Living Lab.



Figure 19: Overview of public-sector decision-makers engaged in the Brabrand Living Lab

4.1.1.1. The BIPED Steering Group as a Strategic Anchor in Aarhus

A key element in anchoring BIPED within Aarhus Municipality has been the BIPED steering group, which brought together central decision-makers across administrative domains. The group consisted of the Head of Digitalisation (initially in Culture and Citizen Services, later anchored in the Mayor's Department), the Head of Climate & Energy in Technical and Environmental Services, a programme consultant for Nature and Urban Development, and the Head of Tech Lab. This composition ensured both strategic oversight and operational insight, enabling BIPED to be embedded within existing municipal structures while supporting its ongoing development. In particular, the strong representation from both the digitalisation and climate–energy agendas positioned the steering group as a critical link between the technological and the sustainability dimensions of BIPED. As a result, the group played an important role in clarifying how LDT-supported PEDs could be meaningfully integrated into the Aarhus context. Moreover, the steering group functioned as a bridge to broader public-sector decision-making, helping to challenge, validate, and communicate the project's value internally, while also contributing to building legitimacy and momentum around BIPED's objectives within the municipality.

The establishment of the steering group highlights the importance of long-term organisational anchoring and alignment with sustainability goals, pointing clearly to **Principles 8** and **1**, while its role in connecting domains and validating the project's direction also reflects **Principles 2** and **9**.

4.1.1.2. A Living Lab that began with data

The first phase of engagement centred on the data journey. Early needs from WP2 in BIPED, the technical work package, made it clear that understanding Brabrand as a potential PED required a deep dive into municipal datasets. This was not a technical exercise alone – it became a collaborative process that brought planners, sustainability officers, mobility specialists, GIS teams, and policy staff into the Living Lab as active participants.

The work began with broad data requests to map what information existed across topics that were not foreseen at the very outset of the project; it quickly became clear that it would be a critical part of the journey. These conversations revealed the realities of municipal data work: siloed systems, unclear ownership, inconsistent terminology, and uncertainty about what BIPED actually needed as the project evolved as already described in section 3.4.2.

Decision-makers helped navigate these uncertainties, often by connecting the Living Lab team to the right colleagues or by clarifying how data was collected, stored, and governed.

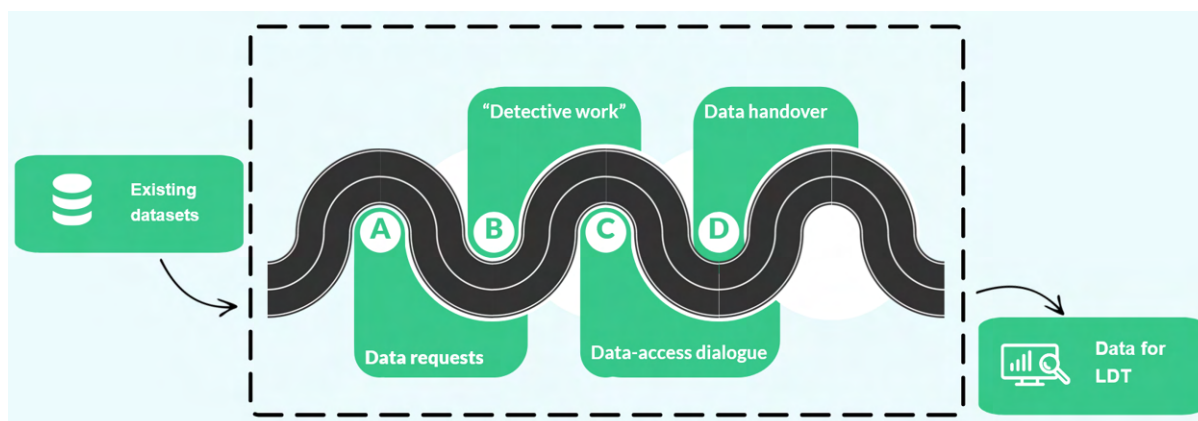


Figure 20: Data Journey

This phase strongly informed **Principle 3**, as challenges related to data ownership, silos, and interoperability became visible in practice, while the cross-departmental collaboration and iterative clarification of data needs also relate to **Principles 2** and **9**.

4.1.1.3. Detective work as a shared practice

As the Living Lab progressed, stakeholder engagement gradually evolved into a form of collective detective work. Rather than following a straightforward process of data collection, public employees, planners, data specialists, and decision-makers worked together to uncover where relevant information was located, who was responsible for it, and whether it was accessible and usable. This investigative process revealed the complexity of municipal data landscapes, where datasets were often distributed across departments, documentation was incomplete, and responsibilities were not always clearly defined. While these challenges slowed progress, they also created opportunities for collaboration and relationship-building across organizational boundaries. From November 2024, when Aarhus first articulated the data journey challenge through a workshop, an increasing number of examples and insights into related challenges emerged as the project progressed. The case below illustrates these challenges in practice:

Case: Climate Risk and Road Condition Data

The search for climate risk and road condition data became one of the clearest examples of detective work within the Living Lab. What initially appeared to be a straightforward task – obtaining data needed to assess climate-related impacts on local infrastructure – quickly revealed a far more complex reality. Information was dispersed across departments, responsibilities were not always clear, and key knowledge often resided with individuals rather than documented systems.

As a result, the work shifted from simple data collection to investigation. Participants followed leads, identified new contacts, explored digital platforms, and combined technical expertise with local and organizational knowledge to piece together a fragmented picture of the municipality's data landscape. The case demonstrates how detective work emerged not as the responsibility of a single actor, but as a shared practice through which stakeholders collectively navigated uncertainty and generated new understanding.

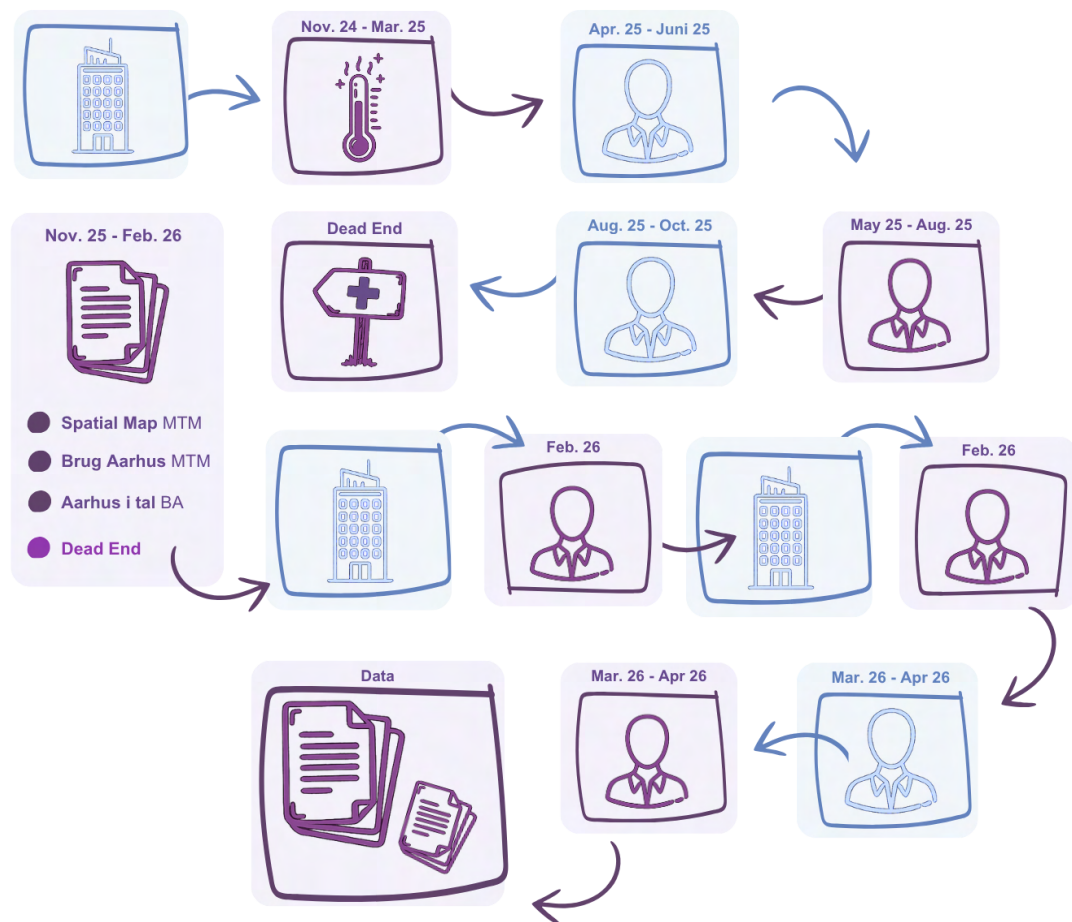


Figure 21: Timeline of Climate Risk and Road Condition Data for the Case

The process began in November 2024 when Aarhus Kommune assigned a data specialist to support the project and initiated contact with the department assumed to hold relevant road condition and climate-risk data. However, shortly after the first dialogue had begun, the key contact person became unavailable due to illness. With no clear handover and limited documentation, the project lost its primary point of entry. What initially seemed like a routine request for information quickly became an investigation into how data, responsibilities, and expertise were organized across the municipality.

Over the following months, project participants worked to identify alternative contacts, clarify departmental responsibilities, and trace potential data sources. Multiple employees and departments were approached, yet progress remained fragmented. Rather than revealing a clear pathway, each interaction uncovered new questions about data ownership, storage locations, and existing procedures. One conversation would point to another department, while a newly identified dataset often raised additional questions regarding its accessibility, relevance, or maintenance. The challenge was no longer simply obtaining data but understanding the organizational

structures through which data was managed and shared.

Faced with these uncertainties, the detective work expanded beyond stakeholder dialogue. From late 2025 to early 2026, the project team began independently exploring publicly available GIS platforms, mapping services, and municipal data portals, including Spatial Map, Brug Aarhus, and Aarhus i Tal. These resources became important investigative tools, helping to identify potential datasets, visualize climate-related vulnerabilities, and generate new leads for further inquiry. Digital exploration provided pieces of the puzzle that could be brought back into discussions with municipal actors, allowing increasingly targeted questions and requests.

Throughout the process, municipal employees, planners, and decision-makers became co-investigators rather than simply data providers. Their knowledge of Brabrand's infrastructure, planning history, organizational structures, and administrative procedures was crucial for interpreting fragmented information and connecting isolated findings.

Technical investigation and stakeholder engagement continuously informed one another, creating an iterative cycle in which new discoveries led to new questions, new contacts, and new insights.

By early 2026, these collective efforts began to yield results. Contact was established with additional departments and stakeholders, communication channels improved, and a clearer understanding emerged of where relevant data existed and how responsibilities were distributed across the municipality. Progress was achieved not through a linear workflow, but through persistence, collaboration, and the gradual assembly of knowledge from multiple sources.

The case demonstrates how climate adaptation work often depends as much on uncovering and connecting knowledge as on analysing data itself. At the same time, this challenge is not unique to climate-related data but applies more broadly across municipal databases and domains. Accessing and understanding the information required for decision-making demanded more than technical expertise; it required collaboration, persistence, local knowledge, and the ability to navigate complex organizational systems. In this sense, the process of finding and interpreting information became just as important as the information itself, strengthening relationships and building a shared understanding across the municipality.

The “detective work” around data revealed the fragmented nature of municipal data landscapes, pointing clearly to **Principle 3**, while the collaborative and exploratory process also reflects **Principles 2** and **9**.

4.1.1.4. Dialogue, governance, and trust

Once datasets were identified, the Living Lab moved into data-access dialogue. Here, governance challenges came to the forefront GDPR concerns, questions about purpose, uncertainty about workload, and hesitation about sharing data for a still-developing digital

tool. This was not limited to a single case but emerged as a general issue across all models and partners involved.

These conversations were honest and sometimes difficult – but they were also productive. Decision-makers helped clarify what was possible, what required additional safeguards, and how data could be shared responsibly. The Living Lab showed that GDPR is not only a constraint but also a guide for designing privacy-aware processes from the start.

The data-access dialogue brought questions of trust, ethics, and responsibility to the forefront, pointing clearly to **Principles 5** and **3**, while the need to clarify possibilities and constraints also reflects **Principle 4**.

4.1.1.5. Testing solutions with real municipal context

As data was handed over and integrated into early prototypes of the LDT, public-sector actors played a key role in testing emerging solutions. They questioned assumptions, pointed out mismatches between modelled behaviour and real-world practice, and helped refine expectations about what the digital twin could realistically deliver.

This phase revealed another important insight: **technology and trust develop together**. Decision-makers needed tangible examples, prototypes, visualisations, and early demonstrations – to understand how the LDT could support planning and sustainability work in Brabrand.

This phase strongly informed **Principles 9** and **4**, as testing and refining solutions highlighted the need for continuous validation and clear communication, while the active role of decision-makers in challenging assumptions also connects to **Principle 7**, and the link between technology and trust relates to **Principle 5**.

4.1.1.6. What the Living Lab revealed about working with the public sector

Through this continuous engagement, several honest insights emerged:

- **Access to data is a process**, requiring coordination, persistence, and early dialogue.
- **Uncertainty about data needs is normal** in an evolving project; staying close to the process is essential.
- **GDPR shapes responsible innovation**, pushing teams to think carefully about privacy from the beginning.
- **Data value must be made visible**, as many data stewards were unsure of the potential of the datasets they held.
- **PED concepts require translation**, using real examples and local cases to make them meaningful.
- **Support grows through understanding**, especially when working with technologies still under development.

4.1.1.7. Public-sector actors as co-creators in the Living Lab

Ultimately, public-sector decision-makers were not passive contributors. They became **co-creators** in the Living Lab shaping the data journey, testing new tools, challenging assumptions, and grounding BIPED's work in the realities of municipal planning and sustainability governance.

Their involvement ensured that the Living Lab remained rooted in Brabrand's everyday context, and that the solutions tested there were shaped by the people responsible for implementing them. The data journey was not just a technical process; it was the backbone of a collaborative experiment that strengthened internal practices, clarified governance needs, and demonstrated how municipal data can actively support PED development in Aarhus.

The public-sector section primarily reflects **Principles 3, 2, and 9**, supported by **Principles 5 and 4**, while also reinforcing **Principles 8 and 1** as part of broader governance anchoring.

4.1.2. Working with Private Enterprises in the Brabrand Living Lab

In Brabrand, the Living Lab also became a space where private enterprises could explore new technologies, business opportunities, and data-driven approaches under real-world conditions. The companies involved were all locally rooted – either based directly in Brabrand or operating in Aarhus with strong ties to the district. This included actors from construction, renovation, solar energy, mobility, logistics, and local business development. Below is an overview of the private enterprises Aarhus has engaged with in the Brabrand Living Lab:

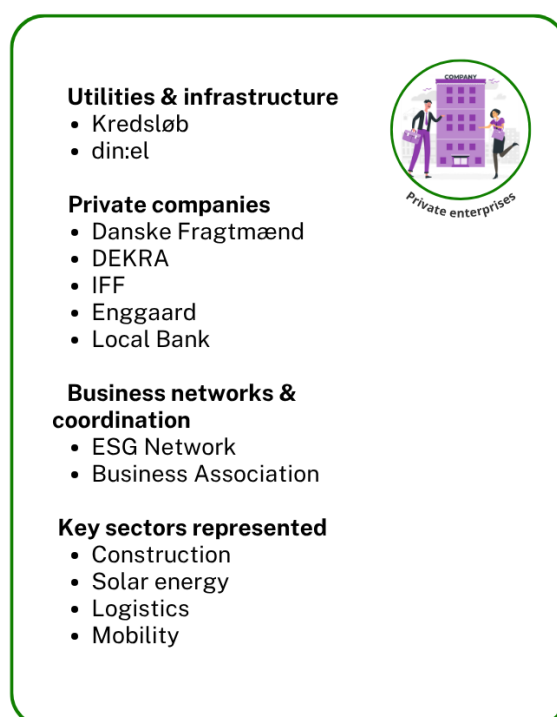


Figure 22: Overview of private enterprises engaged in the Brabrand Living Lab

4.1.2.1. Reaching out to local companies

The engagement began with outreach to local actors representing key sectors such as energy and utilities, logistics, industrial services, construction, and finance. These early conversations opened access to Brabrand's business community and eventually led to participation in an ESG network meeting hosted by the Brabrand Business Association. The network became an important entry point for understanding how local enterprises approached sustainability, energy transitions, and the use of digital tools.

This phase primarily reflects **Principle 2**, as outreach to local companies and engagement through existing networks supported multi-stakeholder involvement, while the focus on sustainability and shared learning also connects to **Principles 1** and **9**.

4.1.2.2. Meetings, workshops, and early misunderstandings

Through meetings and workshops, companies were introduced to BIPED and the idea of a Local Digital Twin. It quickly became clear that private enterprises faced the same challenge as public employees: understanding what a digital twin or a Positive Energy District actually is. Many found the concepts abstract or overly technical, especially while the tools were still under development (Annex 1).



Figure 23: Visit to DEKRA, showcasing sustainable solutions such as electric trucks and insect hotels

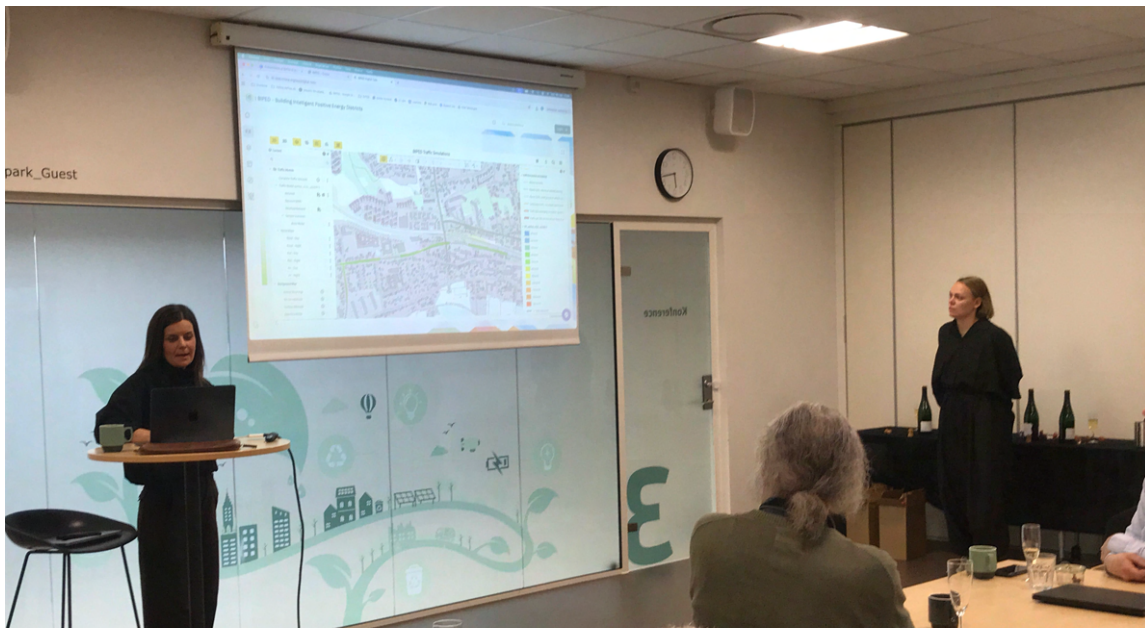


Figure 24: BIPED presentation and interactive activity at the Annual Meeting of the Brabrand Business Association

These conversations revealed a key insight: clarity comes from concrete examples, not abstract descriptions. Prototypes, visualisations, and early demonstrations became essential for building shared understanding.

This phase strongly reflects **Principle 4**, as the need to make complex concepts understandable became evident, while the iterative learning process and stakeholder dialogue also connect to **Principles 9** and **2**.

4.1.2.3. What mattered to companies

Across all interactions, companies consistently emphasised three priorities:

A strong business case: Enterprises needed to see how PEDs and digital twins could support their commercial interests – whether through new services, efficiency gains, or improved planning.

Reliable, accessible data: Data was seen as a prerequisite for innovation. Companies wanted to understand what data they could contribute, what they could access, and how it would be used.

Opportunities to test solutions in real conditions: The Living Lab offered a unique chance to experiment with new technologies and collaboration models directly in Brabrand.

These priorities shaped how companies engaged with the project and how the Living Lab evolved.

Over time, it became clear that engagement hinges on three factors: tangible value, access to usable data, and the ability to test ideas in real-world settings. This grounded perspective connects strongly to **Principles 1** and **3**, while the importance of learning through experimentation and collaboration is reflected in **Principles 9** and **2**.

4.1.2.4. Testing the twin together

Because data was so important to private enterprises, many chose to participate directly in testing the digital twin. Their participation took several forms, including:

- exploring how their own operational data might fit into the LDT
- evaluating whether the twin could support planning, logistics, or energy optimisation
- giving feedback on usability, relevance, and potential business value

This testing phase helped companies understand the potential of the twin – and helped the Living Lab team understand what private actors actually needed from such a tool.

This phase strongly reflects **Principles 9** and **3**, as testing and data integration were central, while the active involvement of companies in shaping the tool also connects to **Principle 2**, and the focus on practical value relates to **Principle 1**.

4.1.2.5. What the Living Lab revealed about working with private enterprises

Through this engagement, several valuable insights emerged:

- Companies need tangible value, not just visionary concepts.
- Business cases drive interest, especially in sectors like construction, mobility, and energy, by demonstrating the value, costs, risks, and expected returns of an initiative.
- Data is a shared challenge, and companies face many of the same issues as municipalities: unclear ownership, inconsistent formats, and uncertainty about GDPR compliance and ethical implications.
- Early prototypes are of great importance, because they make abstract ideas real.
- Local anchoring is essential – companies were more willing to engage because the work took place in Brabrand, where they operate daily.

These insights show that companies engage when solutions are tangible, relevant, and grounded in their everyday context. The need for clear value and robust data practices points to **Principles 1** and **3**, while the role of prototypes and local anchoring highlights the importance of **Principles 4** and **2**.

4.1.2.6. Private enterprises as co-explorers in the Living Lab

Ultimately, private enterprises became **co-explorers** in the Living Lab. Their participation helped test BIPED's tools, challenge assumptions, and ensure that the solutions developed in Brabrand were grounded in real business needs and market realities.

Their involvement demonstrated that PED development is not only a municipal or technical task – it is a shared endeavor where local companies play a crucial role in shaping sustainable, data-driven urban futures.

The private enterprise section primarily reflects **Principles 2**, **9**, and **1**, supported by **Principles 3** and **4**, highlighting the importance of co-creation, testing in practice, value creation, and accessible data and communication.

4.1.3. Working with Citizens, communities, and local interest groups in the Brabrand Living Lab

In Brabrand, the Living Lab became a platform for engaging citizens, communities, and local interest groups in the exploration of Local Digital Twin (LDT)-supported Positive Energy Districts (PEDs). Rather than building engagement from scratch, the work was anchored in strong local initiatives, combined with active local outreach and collaboration with Aarhus University.

This approach ensured that the development of digital tools and energy systems was grounded in everyday practices, local knowledge, and community dynamics. Below is an overview of the Citizens, communities, and local interest groups Aarhus has engaged with in the Brabrand Living Lab:



Figure 25: Overview of Citizens, communities, and local interest groups engaged in the Brabrand Living Lab

4.1.3.1. A Strong Local Anchor: Sol over Brabrand

A central entry point for working with citizens and communities was the energy initiative Sol over Brabrand (SoB), supported by the company Sustain. The following case focuses specifically on Sol over Brabrand as a key example from the Living Lab:

Case: Sol over Brabrand – A Citizen-Driven Foundation for LDT-Supported PEDs

Sol over Brabrand (SoB) is an energy community in Brabrand, and at its core, a local story. It begins not with technology, but with a small group of residents in Brabrand who asked a simple question: how can we make the green transition something we can actually see, influence, and benefit from in our own neighbourhood? From this starting point, the initiative has developed into a citizen-driven energy community with

the ambition to produce and share renewable energy locally – turning rooftops, institutions, and everyday spaces into active components of the energy system.



Figure 26: The board of directors of Sol over Brabrand (SoB)

What defines Sol over Brabrand is that it is not just an energy project, nor a finished solution. It is an organisational and social structure in development – an energy community where citizens, institutions, and organisations work together to explore how energy can be produced, shared, and governed collectively. In this sense, it represents a shift from seeing people as passive consumers of energy to active co-creators of the system. This is particularly significant in the context of Positive Energy Districts (PEDs), which depend not only on infrastructure, but on coordination, ownership, and participation across actors.

For BIPED, Sol over Brabrand has played a crucial role – not as a ready-made case, but as a real and ongoing experiment. It has brought the Living Lab down to the level of everyday practice, making abstract ambitions tangible. Through its work, SoB has revealed what it actually takes to build an energy community: mobilising participants, establishing trust, navigating partnerships, and aligning expectations. These are not peripheral challenges – they are at the core of what it means to realise a PED in practice. Without actors like SoB, the Living Lab would risk remaining conceptual; with them, it becomes grounded, relevant, and actionable.

A defining characteristic of SoB is its early focus on data. Instead of beginning with the installation of solar panels or technical infrastructure, the initiative started by collecting and understanding local energy data. This approach reflects a high level of maturity and mirrors the underlying logic of a Local Digital Twin (LDT), where data is used as a foundation for building a shared understanding of the system before decisions are made. However, the process has also revealed the significant effort required to work with data in practice. Data collection has depended on coordination,

voluntary contributions, and external support, highlighting how fragmented and inaccessible energy data often is.

This is where the relationship between SoB and BIPED becomes particularly important. The experiences from SoB point directly to the need for tools and structures that can better support such initiatives. The development of the Living Lab and the Local Digital Twin can be understood as a response to exactly these challenges – offering ways to systematise data access, improve visualisation, and support scenario-building. For SoB, this represents a significant potential: not to replace their work, but to strengthen it. An LDT could reduce the burden of data handling, make insights easier to communicate, and help translate complex system behaviour into meaningful information for participants and partners. At the same time, SoB has been essential for BIPED by making these needs visible in practice – highlighting where current systems fall short and shaping the direction of the tools being developed.

Equally important is what SoB contributes beyond data and technical understanding. The initiative represents something that no digital system alone can provide: local enthusiasm, ownership, and persistence. It demonstrates that the success of LDT-supported PEDs depends not only on advanced technological tools, but on engaged communities willing to invest time, energy, and effort into shaping their own environment. These local actors act as pioneers, testing ideas, revealing challenges, and building the social foundation necessary for broader transformation.

Ultimately, Sol over Brabrand should not be understood as a finished example of an LDT-supported PED being built or created, but as a critical stepping stone towards one. It highlights both the potential and the gaps: what is already possible through local initiative, and what is needed to support it further. As part of the Brabrand Living Lab, SoB functions as a bridge between vision and reality – demonstrating that the transition to positive energy systems is driven not only by data and technology, but by people who are willing to act, experiment, and build new forms of collaboration from the ground up.

Sol over Brabrand represents a citizen-driven effort to make the green transition visible and tangible, focusing on local energy production and shared ownership. Through BIPED, the initiative became a key use case for exploring energy communities within a PED context.

Sustain supported the initiative by helping mature the project and acting as a sparring partner on the practical application of digital tools, raising key questions about:

- Data needs and availability
- Processes and decision-making
- User needs across citizens, advisors, and organisations

Together, these contributions highlight Sustain's broader role in bridging data, processes, and implementation, as explored in the following case:

Case: Sustain – Bridging Data, Practice, and Implementation in LDT-Supported PEDs

In the Brabrand Living Lab, Sustain was connected to BIPED as a sparring and knowledge partner with a specific role in the development of the handbook “Principles for management practice/governance in PED communities.” Through the involvement Sustain contributed expertise within energy communities, including input on content and structure, identification of regulatory barriers, and sharing practical experiences from establishing energy communities. In addition, they participated in workshops and ongoing dialogue to ensure that the work reflected real-world needs and processes.

While Sol over Brabrand illustrates the energy and potential of citizen-driven initiatives, Sustain represents a different – but equally essential – role in the development of LDT-supported Positive Energy Districts: that of the translator, facilitator, and implementer. Where citizen initiatives bring motivation and local anchoring, actors like Sustain bring the capacity to connect ideas with execution, and concepts with practice.



Figure 27: Citizens' meeting on the future energy community (SoB) in Brabrand Sports Hall, with input from Sustain and participation from the Aarhus BIPED team

Sustain entered the process not as a technology developer or a purely analytical partner, but as a practice-oriented advisor working closely with initiatives such as Sol over Brabrand. Their role has been inherently dual. On the one hand, they have contributed as a concrete advisor – supporting the maturation of local projects, helping to structure processes, and translating ambitions into actionable steps. On the other hand, within BIPED, they have functioned as a sparring and follow partner, providing critical input on how a Local Digital Twin can become a usable and meaningful tool for real actors.

This dual position is crucial. It places Sustain directly in the interface between the development of digital tools and the realities of implementation. Rather than viewing the digital twin as an abstract technological solution, Sustain approaches it from the perspective of use: what data is needed, how it should be structured, and what must the tool actually enable in order to support decision-making in practice.

Through this role, Sustain has contributed an important learning to BIPED: that the value of an LDT does not lie in the technology itself, but in its ability to support real processes. A digital twin only becomes meaningful when it is able to inform concrete questions – where are the opportunities? Which actors should be involved? What scenarios are realistic? – and when it can translate complex data into a format that is understandable for both professionals and local stakeholders.

At the same time, Sustain's involvement highlights the persistent challenges of working with data in the context of PEDs. Their experience points to a central insight: data is not simply "available" or easily integrated. It is fragmented across systems, constrained by regulations, and often difficult to access and interpret. As a result, a significant part of the advisory role lies not in advanced modelling, but in assembling, validating, and translating data into something that can be used as a decision-making foundation.

In this context, the potential of LDT-supported PEDs becomes particularly visible. An effective digital twin could significantly shift this dynamic. By providing a shared and structured data foundation, it could reduce the need for manual data collection and allow advisors like Sustain to focus more on what they do best: developing scenarios, assessing trade-offs, and supporting decision-making processes. In other words, it could move the advisory role from data handling towards strategic and process-oriented work.

However, Sustain's perspective also serves as an important reminder: digital tools cannot stand alone. Even with a well-developed LDT, there remains a need for actors who can interpret, contextualise, and communicate the results. In fact, as tools become more accessible, the advisory role may become even more important. When local actors gain access to data and begin to explore scenarios themselves, expectations rise – and with them, the need for guidance to ensure that conclusions are robust, assumptions are transparent, and decisions are well-founded.

In this sense, Sustain exemplifies a key function in the Living Lab: acting as a bridge between systems and people. They connect the technical possibilities of the LDT with the lived realities of citizen initiatives, municipalities, and projects. They translate between different types of knowledge – data, local insight, governance needs – and help align them into coherent development processes.

Ultimately, Sustain demonstrates that the development of LDT-supported PEDs depends on more than technology and more than engagement. It requires actors who can operate in between: who understand data, but also people; who can navigate complexity, but also simplify; and who can turn potential into action. As part of the Brabrand Living Lab, Sustain has played a key role in making this connection

visible – showing how digital tools, local initiatives, and advisory practices must evolve together if PEDs are to move from concept to implementation.

Together, Sol over Brabrand and Sustain became active contributors within the Living Lab, shaping how citizen-driven initiatives can engage with data and digital tools.

At the same time, BIPED played an active role by:

- Acting as a door opener to municipal networks, institutions, and partners
- Supporting visibility and positioning of the initiative
- Exploring how LDT tools could support visualisation, planning, and dialogue

This collaboration demonstrated how local initiatives, professional actors, and the municipality can work together to develop and scale energy communities.

The collaboration around Sol over Brabrand highlights how citizen-driven initiatives can act as catalysts for sustainable change, pointing clearly to **Principles 2** and **1**, while the exploration of data use and the need to make energy systems visible and understandable also reflect **Principles 3** and **4**.

4.1.3.2. BIPED in the Local Context

In addition to Sol over Brabrand, the Living Lab expanded through engagement with a wide range of local actors and community networks.

Activities included:

- Dialogue with **housing associations** about the role of BIPED in local operations
- Participation in **community networks and meetings**
- Workshops with **local groups such as community mothers and Brabrand Local History Archive**
- Engagement with **grassroots initiatives and local projects**
- And participation in the Aarhus Municipality's *Wild Technologies* festival in both 2024 and 2025, where we showcased BIPED's solutions and engaged with citizens, stakeholders, and visitors through demonstrations and dialogue.



Figure 28: BIPED at the Wild Technologies Festival in Aarhus (2024–2025)

A key activity was participation in Climate Action Day in Brabrand, a national Danish initiative developed to bring climate action into local communities. Here, the Aarhus BIPED team

engaged directly with citizens and tested elements of BIPED's solutions in practice, using the event as a platform for dialogue, visibility, and feedback.

These activities strengthened the connection between BIPED and local everyday practices, while building relationships, trust, and awareness.

These activities highlight the importance of meeting citizens and communities in their everyday contexts, pointing clearly to **Principle 2**, while the emphasis on local climate action, practical experimentation, and building trust also reflects **Principles 1, 9, and 5**.

4.1.3.3. Survey and Local Insights

To complement local engagement, a large-scale citizen survey was conducted in Brabrand.

Using Aarhus Municipality's official channels, a digital survey was distributed via e-Boks to 14,781 citizens aged 18–80 living in postcode 8220 Brabrand (excluding those exempt from Digital Post). The survey was sent out at the end of February and resulted in 1,347 responses.

The responses provided valuable insight into local attitudes towards the green transition:

- There is a high level of individual motivation among citizens
- However, there is less collective organisation and coordination

This points to an important role for the Living Lab: bridging the gap between individual willingness and collective action, for example by using data not only as a technical foundation, but as a means to support shared understanding and coordination.

The survey respondents primarily represented:

- Middle-aged and older citizens
- People in work or retirement
- Residents from both owner-occupied and public housing
- Predominantly Danish backgrounds

This means that younger people and minority groups were underrepresented, and that the survey alone does not capture the full diversity of Brabrand.

For this reason, the survey has been complemented by the broader Living Lab engagement, including workshops, events, and student collaboration, which reached a more diverse set of communities.

The survey highlights how data can support understanding and coordination across citizens, while also revealing limitations in representation. This points clearly to **Principles 9 and 2**, while the focus on sustainability, data use, and legitimacy also reflects **Principles 1, 3, and 5**.

4.1.3.4. Aarhus University and Living Lab Activation

The Centre for Digital and Green Transformation in Cities and Communities at Aarhus University played an important role in activating the Living Lab in both 2025 and 2026.

Through fieldwork, collaboration with local actors, and the development of prototypes, students helped connect local experiences and needs with emerging digital and data-driven approaches. This made it easier to explore how concepts such as LDTs and PEDs could be applied in practice.

These activities demonstrate how innovation becomes meaningful when rooted in everyday life and shaped by diverse communities, pointing clearly to **Principles 7** and **2**, while the focus on making digital tools accessible, testing solutions in practice, and building trust also reflects **Principles 4, 9, and 5**.

Case: Design EXPO 2025 – Grounding Solutions in Everyday Life

The Design EXPO 2025⁹ (Aarhus Universitet, 2025) showed how working closely with local communities helps make complex concepts more relevant and understandable.

Students engaged with a wide range of groups, including residents, housing communities, volunteers, schools, care institutions, and local organisations. Through this, they explored how energy use, waste, and consumption are shaped by daily routines and local conditions.



Figure 29: Solutions from EXPO 2025: energy visualisation, interactive waste system, and AI-powered food production

Key insights included:

- Sustainability efforts are closely linked to everyday habits and practices
- Digital tools need to be clear and relatable to be useful
- Different groups require different approaches
- Local communities and meeting places are essential for testing ideas

The resulting prototypes demonstrated how digital and local actions can be combined to support dialogue, engagement, and practical change.

Case: Design EXPO 2026 – Broadening Participation and Perspectives

The Design EXPO 2026¹⁰ (Aarhus Universitet, 2026) expanded this approach by engaging an even wider range of local actors and communities.

⁹ <https://digtcom.au.dk/student-expo-1>

¹⁰ <https://digtcom.au.dk/education/student-expo-2026>

Students worked with:

- Residents across different housing types (including social housing, villas, and student housing)
- Vulnerable and underrepresented groups, including citizens with limited access to resources or digital tools
- Children, youth, and families
- Community groups, associations, and social initiatives
- Local businesses and mobility actors

This work highlighted the importance of recognising that people have different starting points, needs, and opportunities when it comes to participating in the green transition.

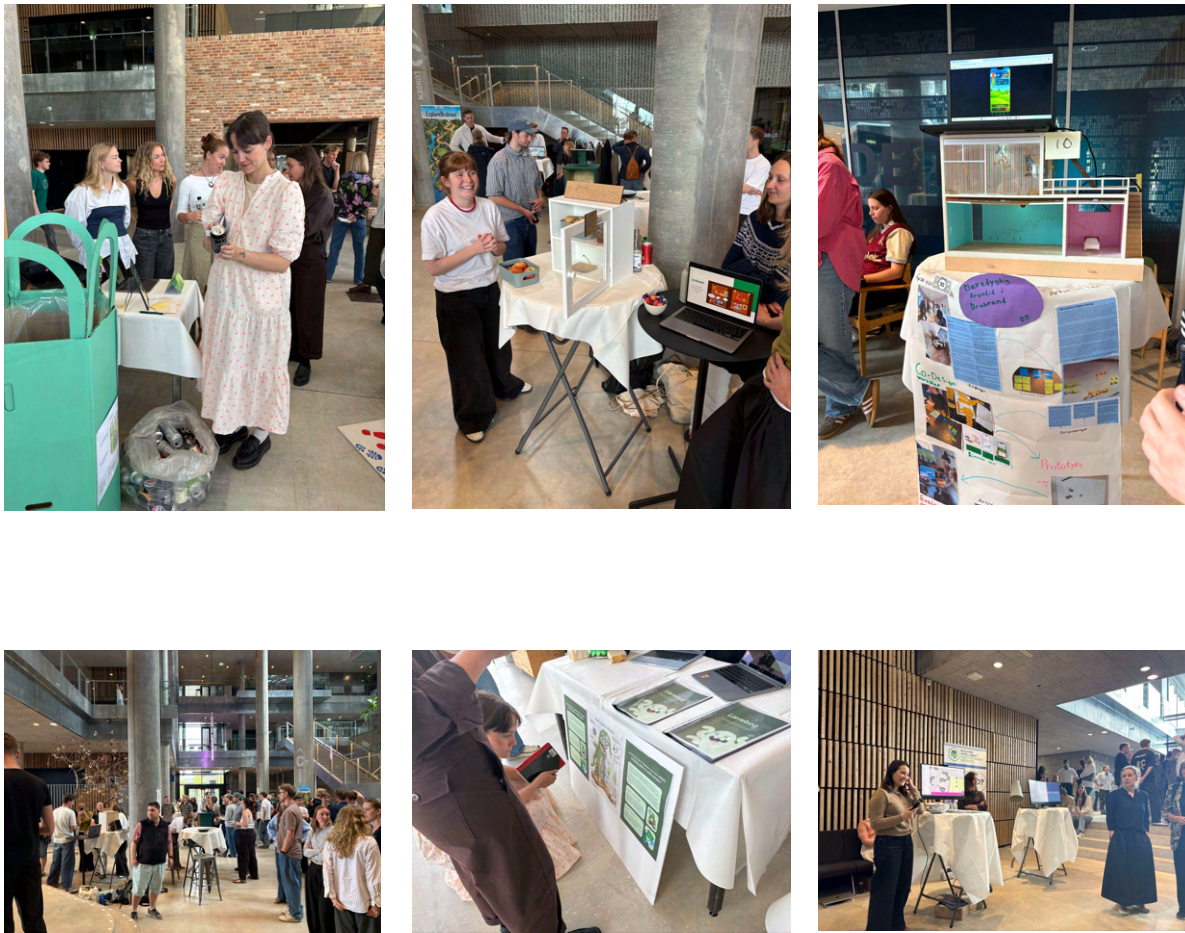


Figure 30: Solutions from EXPO 2026: electric charging, collective energy sharing, sustainable behaviour, and everyday mobility, with BIPED as case host

Key insights included:

- Solutions must take into account diverse living conditions and capacities
- Accessibility and clarity are crucial when working with data and digital tools
- Trust and local relationships are key to engagement

- Everyday experiences provide important input for shaping solutions

The prototypes explored how LDT-supported approaches can support more inclusive decision-making and local collaboration, while staying relevant to different user groups.

4.1.3.5. Key Insights on Working with Citizens and Communities

Across all activities, several insights emerged:

- Strong local cases are key entry points
- Engagement must be connected to everyday life and local context
- Clarity and relevance are essential for digital tools
- Inclusion matters, especially across diverse groups
- Relationships and trust are fundamental

4.1.3.6. Citizens and Communities as Co-Creators

In the Brabrand Living Lab, citizens and communities acted as co-creators, contributing actively to shaping both solutions and approaches.

Through strong local initiatives, direct engagement, survey insights, and collaboration with Aarhus University, the Living Lab demonstrated how LDT-supported PED development becomes stronger when it is rooted in real communities, everyday practices, and local collaboration.

The citizen and community section primarily reflects **Principles 2** and **1**, supported by **Principles 9, 7, and 5**, highlighting the importance of inclusion, everyday relevance, continuous learning, and trust. It is further supported by **Principles 4** and **3**, emphasising the need for accessible communication and meaningful use of data.

4.1.4. Working with Innovation Communities in the Brabrand Living Lab

In Brabrand, the Living Lab brought together innovation communities, including research institutions, educational actors, and SMEs, to support the development of Local Digital Twin (LDT)-supported Positive Energy Districts (PEDs). These actors played a key role in linking research, technology development, and real-world application, ensuring that solutions were both innovative and grounded in practice. Below is an overview of the Innovation Communities Aarhus has engaged with in the Brabrand Living Lab:

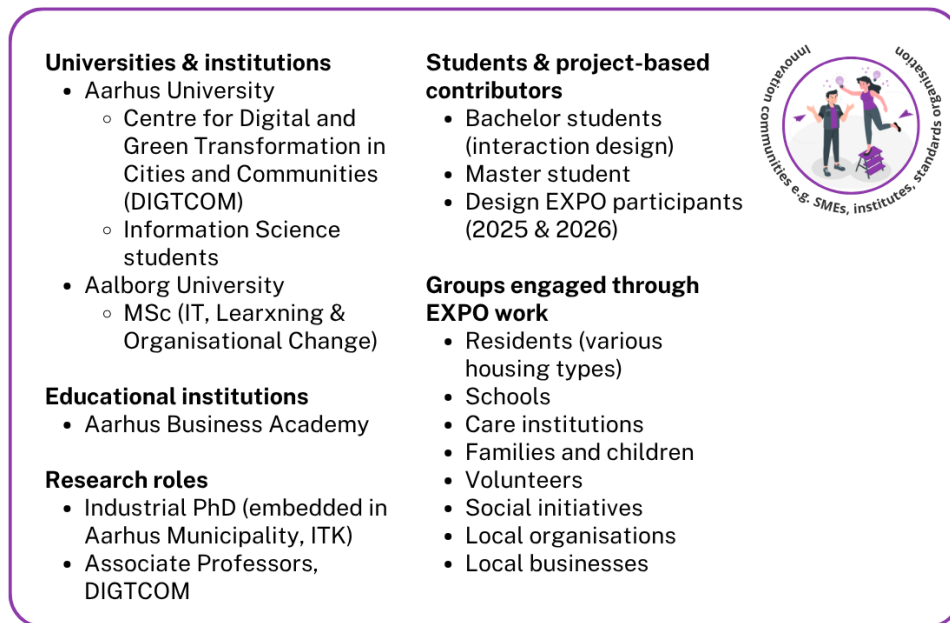


Figure 31: Overview of Citizens, communities, and local interest groups engaged in the Brabrand Living Lab

4.1.4.1. Engaging Research and Innovation Actors

The engagement was centred around a set of strong partners:

- Aarhus University, through the *Centre for Digital and Green Transformation in Cities and Communities (DIGTCOM)*
- Aarhus Business Academy, where around 30 students developed prototypes for the Living Lab
- An Industrial PhD embedded in Aarhus Municipality, focusing on the development of the digital twin in Brabrand
- Aarhus University students in Information Science, including bachelor projects on interaction design
- A Master's student from Aalborg University (MSc in IT, Learning, and Organisational Change), who contributed with a literature-based study

Together, these actors contributed with expertise in data, technology development, user interaction, and applied research, while working directly with the Living Lab as a real-world test environment.

The involvement of innovation communities highlights how research and practice come together through experimentation and collaboration, pointing clearly to **Principles 9** and **2**, while the emphasis on usability, design, and data integration also reflects **Principles 4** and **3**.

4.1.4.2. Developing and Testing Solutions in Practice

A core feature of the collaboration was the ability to develop and test solutions in a real local context.

This included:

- Testing BIPED's digital tools and platforms with real users and stakeholders
- Developing and integrating soft data (local knowledge, behaviours, and practices) alongside technical datasets
- Experimenting with databases and interoperability in practice
- Iterating on platforms and dashboards, including the development of the CIVORA interface

A concrete contribution came from Information Science students, whose interaction design project and workshop helped shape how BIPED worked with dashboards and user interfaces, strengthening usability and relevance.

Similarly, students from Aarhus Business Academy contributed by developing early-stage prototypes, supporting experimentation and new ideas within the Living Lab.

Through hands-on experimentation, solutions evolved in close dialogue with real users and local contexts. This iterative process reflects **Principles 9** and **3**, while the focus on usability and human interaction also points to **Principles 4** and **7**.

4.1.4.3. Research Perspectives on Living Labs, LDTs, and PEDs

The Master's thesis from Aalborg University contributed a conceptual perspective that helped frame the work in Brabrand.

Key insights included:

- Living Labs function as social organisational structures, not just technical test environments
- The Local Digital Twin acts as a bridge between data and understanding, supporting decision-making
- Positive Energy Districts depend on collective action, but must be activated through individual motivation

A central challenge identified is therefore:

How to translate individual motivation and available data into collective action in practice?

This insight reflects a core dynamic observed in the Brabrand Living Lab and connects directly to both technology development and community engagement.

This section strongly reflects **Principles 2** and **3**, as it highlights the need to connect collective action with data-driven understanding, while the focus on iterative learning and individual motivation also connects to **Principles 9** and **7**.

4.1.4.4. The Role of the Industrial PhD

The Industrial PhD played a central role in structuring and analysing the development of the digital twin in Brabrand.

The research highlights that developing an LDT in a municipal and cross-sector context involves several key challenges:

- Ensuring value creation across all stages of the development cycle
- Aligning internal project logic and vision with the needs of end-users and external stakeholders
- Continuously adapting the overall vision of the digital twin as the project evolves
- Navigating institutional constraints, limited data availability, and complex collaboration processes

The study shows that LDT development is not a linear process, but requires ongoing coordination between diverse stakeholders, as well as balance between ambition, feasibility, and user relevance.

At the same time, the findings provide a process-oriented perspective on LDT development, offering guidance on how to address risks early – particularly in cross-sector collaborations. While based on the Brabrand case, these insights are transferable to other municipal contexts (Vijayasundaram & Raetzsch, 2026).

The Industrial PhD highlights how developing an LDT is an evolving and non-linear process shaped by continuous learning and collaboration, pointing clearly to **Principles 9** and **2**, while the emphasis on long-term value creation and lifecycle thinking also reflects **Principles 1** and **8**.

4.1.4.5. What Mattered to Innovation Communities

Across collaborations, several shared priorities emerged:

- Access to real-world testing environments
- High-quality and usable data
- Interaction with users and stakeholders
- Opportunities for iteration and experimentation

These needs shaped the Living Lab as a space where innovation and application could be developed simultaneously.

4.1.4.6. Key Insights on Working with Innovation Communities

- The collaboration highlighted several important insights:
- Real-life testing is essential for developing usable and relevant technologies
- Local context and soft data are critical complements to technical systems
- User interaction and design strongly influence adoption and usability
- LDT development requires continuous alignment between vision, stakeholders, and implementation

- A key challenge is bridging the gap between individual engagement and collective action

4.1.4.7. Innovation Communities as Co-Developers

Innovation communities acted as co-developers within the Living Lab, contributing both to technological development and to how solutions are applied in practice.

Through collaboration with Aarhus University, Aarhus Business Academy, Aalborg University, and the Industrial PhD, the Brabrand Living Lab demonstrates how research, education, and local experimentation can be combined to support the development of LDT-supported PEDs in a real urban context.

The Innovation Communities section primarily reflects **Principles 9** and **2**, highlighting the importance of continuous experimentation, learning, and cross-sector collaboration between research, education, and practice. It is strongly supported by **Principles 3, 4, and 7**, emphasising data integration, usability, and human-centred design, and further reinforced by **Principles 1** and **8**, which point to value creation and lifecycle thinking in the development of LDT-supported PED solutions.

4.2. The Brabrand Living Lab in Full – Milestones and the BIPED Community

4.2.1. Introduction

The Brabrand Living Lab has not developed as a series of isolated activities, but as a continuously evolving ecosystem shaped through interactions between stakeholders, experiments, and shared learning processes. While engagements with public authorities, companies, citizens, researchers, and innovation actors have each provided valuable insights, the strength of the Living Lab lies in bringing these actors together in shared settings.

It is within these collective moments—workshops, meetings, events, and collaborative experiments—that the Living Lab has gradually taken shape as a connected PED community. Here, knowledge is continuously exchanged, tested, and translated across sectors, enabling new forms of collaboration to emerge.

This interconnected ecosystem is illustrated in Figure 25, which presents the Living Lab as a network of relationships and interactions.

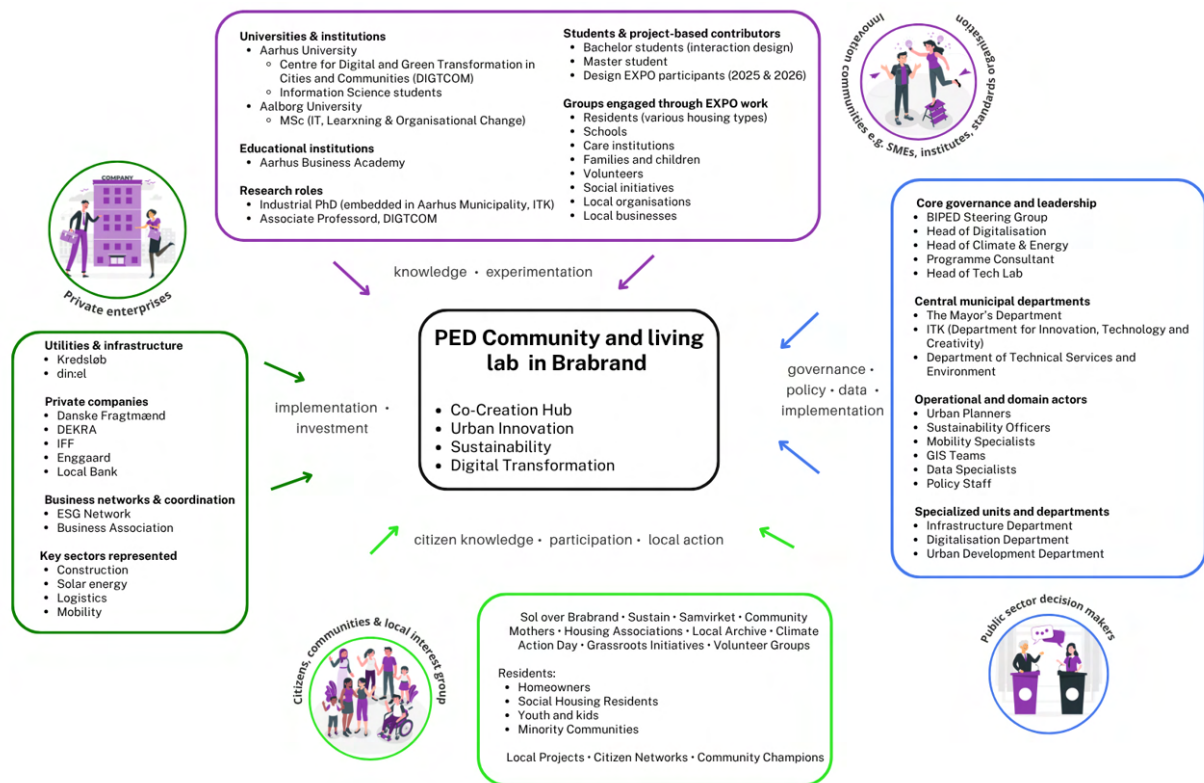


Figure 32: PED Community and Living Lab in Brabrand

A number of key milestones illustrate this development and highlight how BIPED in Brabrand transitioned from parallel activities into a more integrated PED ecosystem. The timeline below presents selected milestones that have been particularly relevant in shaping this progression. While many additional activities have contributed, these examples highlight key moments where direction was shaped, connections were strengthened, and new insights emerged. For a full overview of activities, see Annex 1.

The development of the Living Lab can be understood through four interconnected themes:

- **Private sector engagement**
- **Local anchoring and citizen engagement**
- **Intensive co-creation and experimentation**
- **Learning and capacity building**

These themes did not develop separately but evolved alongside each other. Activities within one area often informed and strengthened progress in others, creating a dynamic and iterative development process. The colour coding throughout the timeline illustrates how these different strands of activity contributed to the continuous development of the Living Lab over time.

4.2.2. Four Interconnected Themes in the Living Lab

Each theme represents a distinct set of contributions, actors, and insights, but their value emerges through how they continuously interact and reinforce each other:

Private Sector Engagement

Engagement with private actors revealed both the importance and complexity of cross-organisational collaboration. Early dialogue with actors such as Kredsløb demonstrated that collaboration required time, persistence, and careful navigation of internal structures, rather than simple coordination.

Through continued interaction with the Brabrand Business Association and its ESG network, the Living Lab expanded into the local business ecosystem. These engagements provided insight into how companies work with sustainability, data, and innovation in practice, while also connecting BIPED to existing networks and initiatives.

Overall, private sector engagement grounded the Living Lab in real-world practice, while highlighting the importance of trust-building, alignment, and long-term collaboration.

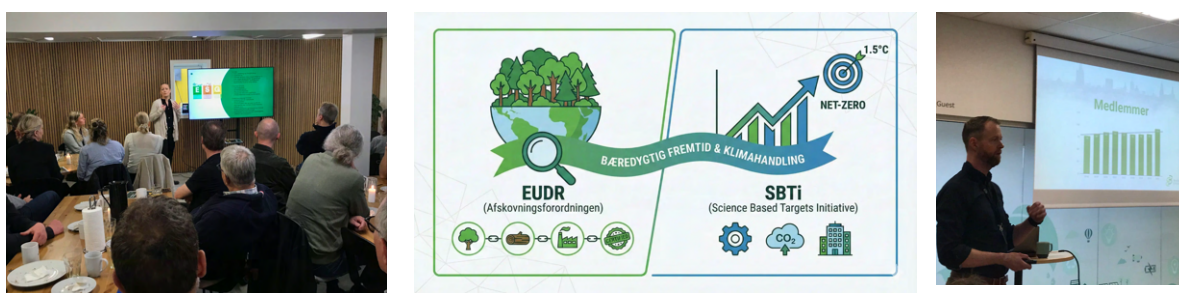


Figure 33: Engagement with the Brabrand Business Association ESG Network¹¹

Local Anchoring and Citizen Engagement

Local actors and citizens played a key role in ensuring that the Living Lab was grounded in place, context, and everyday realities. Engagements with the housing association and local archive provided important insights into the social, historical, and spatial development of Brabrand.

At the same time, activities such as citizen meetings (SoB) and Climate Action Day brought the Living Lab into direct interaction with residents. These events demonstrated strong local interest in the green transition and created opportunities to test ideas in practice. The large-scale citizen survey further strengthened this by providing broader insight into attitudes, motivations, and coordination challenges.

These engagements also revealed a gap between technological solutions and everyday life, emphasising the need for accessible, inclusive, and locally relevant approaches.

¹¹ Photo credit: [Brabrand Business Association](#)



Figure 34: Citizen Engagement through Sol over Brabrand (SoB)



Figure 35: Climate Action Day in Brabrand

Intensive Co-Creation and Experimentation

Co-creation activities played a central role in moving from individual inputs to shared understanding and joint development. Workshops, such as the Digital Twin co-design workshop, created spaces where stakeholders from different sectors could engage with shared challenges and opportunities.

The design sprint marked a key milestone, bringing together diverse actors in an intensive collaborative process. It generated insights into user needs, system complexity, and communication challenges, while also revealing the interdependencies between data, technologies, actors, and local contexts.

Importantly, the process shifted the project from aiming for a single solution towards recognising the need for multiple engagement formats tailored to different stakeholder groups. Co-creation thus became not only a method, but a driver of direction and learning.

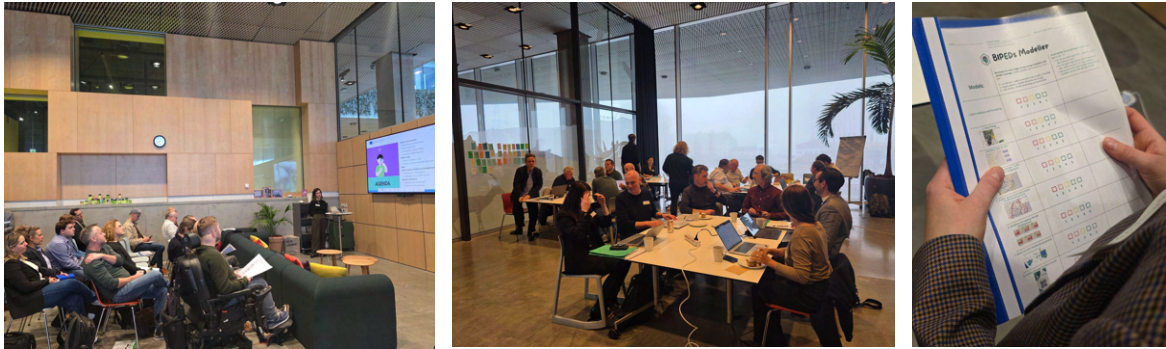


Figure 36: BIPED PED Community End-User Workshop (January 2026) #1

This figure shows the BIPED PED community end-user workshop held in January 2026. From left to right, participants represent the broader PED community in Brabrand. In the centre, participants include representatives from the Sustain and Energy team in Aarhus Municipality, an Energy employee from Aarhus Municipality, the Head of Digitalisation (ITK, Aarhus Municipality), the Chairman of Sol over Brabrand (SoB), and BIPED project partners. On the right side of the figure, evaluation and UX materials are displayed, illustrating how the BIPED Digital Twin was tested and assessed during the workshop.

The workshop demonstrates cross-sector collaboration in practice, bringing together local stakeholders, municipal actors, technical partners, and end users to explore, test, and evaluate Digital Twin solutions within the Living Lab. See all the workshop material in Annex 7.

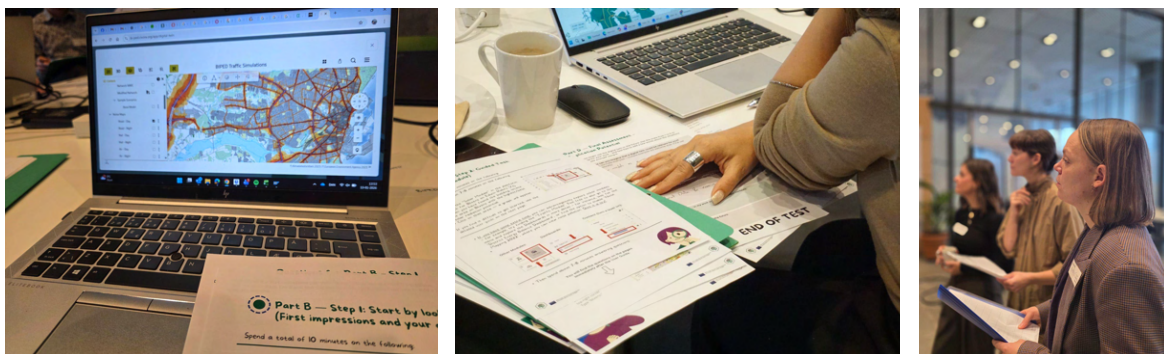


Figure 37: BIPED PED Community End-User Workshop (January 2026) #2

On the left and in the centre of this figure, the BIPED Digital Twin is displayed and actively tested through interactive engagement and evaluation. On the right side, members of the Aarhus BIPED team are present, facilitating the session and supporting the testing process. The figure illustrates how the Digital Twin was explored in practice, combining technical testing with stakeholder interaction in a Living Lab setting.



Figure 38: IPED PED Community End-User Workshop (January 2026) #3

From left to right in this figure, the programme consultant from the Climate Secretariat is shown together with BIPED partner, followed by a central section illustrating how futures research and systems thinking were introduced and applied in the workshop, drawing on ideas from SNART. On the far right, representatives from Sol over Brabrand (SoB) are present.

The figure highlights how the workshop combined technical, strategic, and community perspectives, integrating future-oriented methods into stakeholder engagement within the Living Lab.

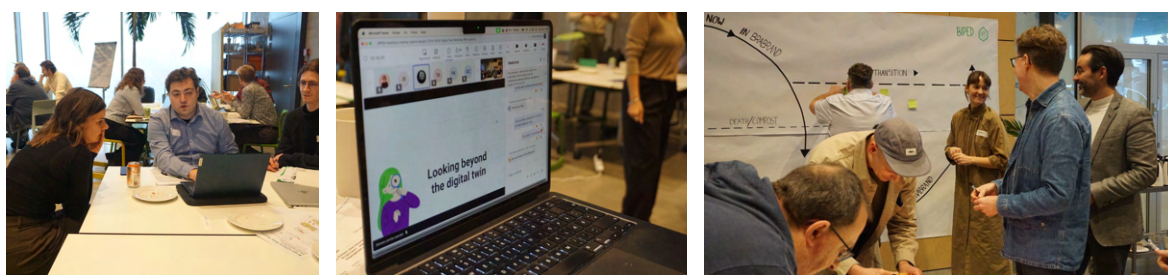


Figure 39: IPED PED Community End-User Workshop (January 2026) #4

From left to right, the figure shows representatives from Brabrand's local archive together with BIPED partners, highlighting the integration of local knowledge and project collaboration. In the centre, technical BIPED partners participated online, contributing to the workshop by answering questions and supporting the training process. On the right, the closing phase of the workshop is illustrated, where a future-oriented element was introduced, focusing on how BIPED can support systemic change thinking.

The figure demonstrates how the workshop combined local insights, technical expertise, and forward-looking perspectives within a Living Lab setting.

Learning and Capacity Building

Learning and capacity building underpinned the entire Living Lab process, both internally and across stakeholders. Steering group meetings (#1–6) functioned as an ongoing platform for alignment, reflection, and governance, while also revealing the challenges of communicating complex and evolving concepts.

Student involvement and innovation activities further strengthened this dimension by translating abstract ideas, such as Local Digital Twins and PEDs, into tangible prototypes and user-oriented solutions. This helped bridge research and practice.

External inspiration, such as the study visit to SNART in Copenhagen, introduced future-oriented and cross-disciplinary perspectives, highlighting the role of imagination, storytelling, and co-creation in shaping sustainable development.

Together, these activities strengthened the Living Lab's capacity to learn, adapt, and evolve over time, both within the project and across the broader PED community.



Figure 40: BIPED Aarhus Team Study Visit to SNART (Copenhagen) #1

From left to centre, the Aarhus BIPED team is shown engaging with an interactive AI-based language model developed at SNART, built on a collection of future-oriented articles covering topics such as economics, climate, and societal values. The installation allows participants to “call” the system and ask questions, engaging directly with speculative future knowledge.

On the far right, letters written by children about the future are displayed, offering personal and imaginative perspectives on what lies ahead.

The figure illustrates how the study visit combined technological experimentation with creative and human-centred approaches to future thinking, broadening the Living Lab perspective beyond data-driven methods.

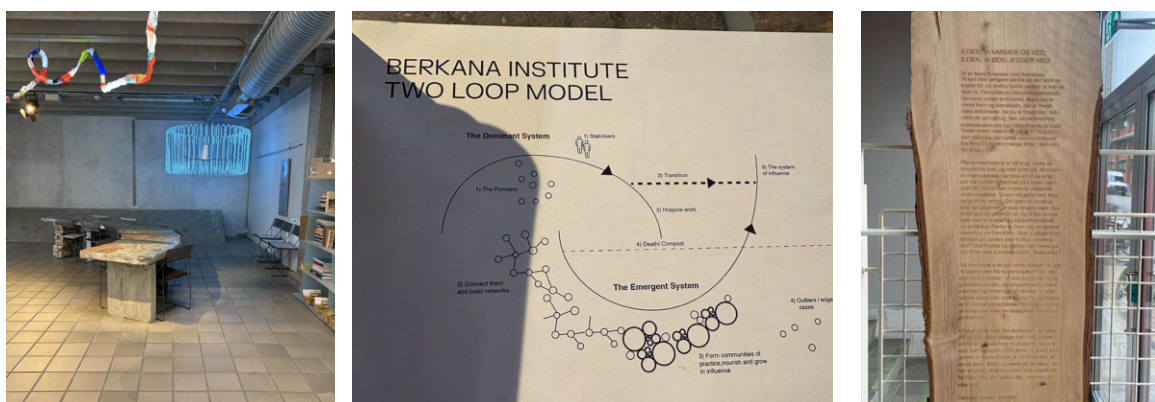


Figure 41: IPED PED Community End-User Workshop (January 2026) #2

From the left and in the centre of this figure, SNART's interpretation of the Berkana Two-Loop Model is presented. Originally developed by Margaret Wheatley and Deborah Frieze from the Berkana Institute, the model illustrates how complex social systems change through the simultaneous decline of an existing system and the emergence of a new one (Wheatley & Frieze, 2011). In this setting, the model is realised as a physical installation, where the table itself represents the framework in tangible form.

On the far right, an artistic wooden text installation is displayed, featuring a climate and societal message written by Carsten Jensen. Within workshop settings, the installation functions as a symbolic "armoury," where participants are encouraged to put down both their mobile phones (the concrete) and uncritical habits (the abstract), and instead carry forward awareness and responsibility into processes of change.

The figure highlights how the study visit to SNART combined systems thinking, physical interaction, and artistic expression to support reflection on transformation and future-oriented action.

4.2.3. Timeline of Key Milestones

The following timeline presents key milestones chronologically while highlighting the themes they contribute to (Annex 1). Together, the activities illustrate how BIPED in Brabrand gradually moved from parallel engagements towards a more integrated, collaborative, and locally grounded PED ecosystem, built through ongoing interaction, experimentation, and shared learning within an evolving PED community:

2024 – Exploring Complexity and Establishing Foundations

- **12.03.2024 – Initial municipal data meetings (Mobility, Energy, Geodata)**
Learning and capacity building – *Understanding data landscape and ownership*
Initial meetings with municipal actors in mobility, energy management, and geodata provided key insights into data ownership, access, and fragmentation. They revealed both the potential and the structural complexity of working with public data. This established an early foundation for the Digital Twin work. It also highlighted governance as a critical challenge.
- **21.03.2024 – Early engagement with private actors (Kredsløb)**
Private sector engagement – *Navigating complexity*
Engagement with Kredsløb revealed the complexity of cross-organisational collaboration. Identifying contacts and decision pathways required persistence. The process highlighted that collaboration depends on trust and internal structures. This shaped future engagement strategies.
- **04.04.2024 – Follow-up municipal data meetings**
Learning and capacity building – *Deepening data collaboration*
Follow-up meetings clarified opportunities and barriers in data sharing. Discussions on solar energy and geodata integration highlighted both technical and organisational constraints. Relationships with municipal actors strengthened. Data governance emerged as central to the Living Lab.
- **29.05.2024 – Steering group meeting #1**
Learning and capacity building – *Establishing common ground*

The first steering group meeting created a shared understanding of BIPED in general. Roles and expectations were clarified. It established a structure for ongoing coordination. This became a key internal anchor.

- **19.09.2024 – Meeting with Brabrand Housing Association**

- Local anchoring and citizen engagement** – *Grounding in context*

- Insights into local conditions strengthened the connection between technical development and community needs. The Living Lab became more locally grounded. Social context gained importance. This shaped future engagement.

- **22.10.2024 – Steering group meeting #2**

- Learning and capacity building** – *Strengthening coordination*

- The second meeting reinforced alignment as activities expanded. It highlighted the need for continuous dialogue. Internal coordination became more structured. Adaptability remained central.

- **27.09.–22.11.2024 – Business association and ESG network engagement**

- Private sector engagement** – *Expanding ecosystem*

- Engagement with local businesses developed over multiple meetings. It provided insights into sustainability practices and business priorities. The network expanded significantly. The Living Lab became more embedded across sectors.

2025 – Learning, Experimentation and Integration

- **06.03.2025 – Steering group meeting #3**

- Learning and capacity building** – *Consolidating understanding*

- Insights from earlier activities were aligned into a clearer direction. The Living Lab approach matured. Coordination improved. Learning became more structured.

- **15.05.2025 – EXPO Sustainable Futures**

- Learning and capacity building** – *Bridging research and practice*

- Student work made concepts like digital twins tangible. New ideas and prototypes emerged. Collaboration between research and practice strengthened. The project gained fresh perspectives.

- **02.06.2025 – Steering group meeting #4**

- Learning and capacity building** – *Reflecting across activities*

- The meeting ensured coherence across an expanding set of activities. Shared reflection improved decision-making. Alignment remained strong. Coordination supported growth.

- **02.08.2025 – Study visit to Copenhagen (SNART)**

- Learning and capacity building** – *Expanding perspectives*

- The study visit to Copenhagen, including engagement with SNART, introduced new perspectives on future-oriented urban development, citizen engagement, and innovation practices. The visit highlighted the role of creativity, storytelling, and imagination alongside data and technology in exploring sustainable futures.

- These insights broadened the Living Lab's innovation approach and informed later activities by strengthening the focus on future thinking, shared exploration, and co-creation.

- **18.09.2025 – Steering group meeting #5**

- Learning and capacity building** – *Adapting to complexity*

- Increasing stakeholder involvement required stronger coordination. The meeting supported adaptation. Alignment remained central. The process stayed flexible.

- **11.–17.11.2025 – Design sprint**
Intensive co-creation and experimentation – *Intensive experimentation*
Stakeholders collaborated intensively, revealing system complexity and user needs. The process showed that multiple solutions and engagement formats were needed. Co-creation became central. Interdependencies became clear.
- **24.11.2025 – Meeting with local archive**
Local anchoring and citizen engagement – *Adding depth*
Historical insights enriched the understanding of Brabrand. The Living Lab became more contextually grounded. Local identity became more visible. This informed future engagement.

2026 – Scaling, Co-creation and Wider Engagement

- **13.01.2026 – Co-design workshop: Digital Twin testing**
Intensive co-creation and experimentation – *Cross-sector collaboration*
Stakeholders jointly explored the Digital Twin. Shared understanding increased. The tool became more concrete and relevant. Collaboration deepened.
- **18.02.2026 – Citizen survey**
Local anchoring and citizen engagement – *Scaling engagement*
Citizen input expanded significantly. Strong interest in sustainability was evident. Coordination challenges also became visible. Insights improved at scale.
- **24.02.2026 – Steering group meeting #6**
Learning and capacity building – *Maintaining direction*
The meeting ensured alignment during scaling. Governance remained stable, and internal coordination supported external growth while maintaining strategic direction. It also marked an important point where the steering group developed a stronger understanding of the essence of BIPED and increasingly recognised its value and potential contribution within the city.
- **25.03.2026 – Annual meeting of Brabrand Business Association**
Private sector engagement – *Deepening integration*
Connections with businesses strengthened further. Visibility increased. Collaboration matured. The Living Lab became embedded locally.
- **14.04.2026 – Citizens' meeting: Sol over Brabrand**
Local anchoring and citizen engagement – *Community engagement*
Citizen-driven energy initiatives became part of the Living Lab. The transition became tangible and local. Engagement deepened. Ownership increased.
- **24.04.2026 – Climate Action Day in Brabrand**
Local anchoring and citizen engagement – *Public visibility*
The Living Lab engaged a broader audience. Ideas were tested in real settings. Awareness increased. New stakeholders were reached.
- **05.05.2026 – Sustainable Futures: Brabrand 2030**
Learning and capacity building – *Future-oriented collaboration*
Stakeholders explored future scenarios together. Dialogue across sectors strengthened. Long-term perspectives were developed. The Living Lab's role became clearer.

4.2.4. Interconnected development

Across the timeline, the four themes developed in parallel and continuously influenced each other. Rather than representing a linear process, the development reflects a continuous feedback loop where insights from one activity informed and shaped the next. This interconnected progression has been central to transforming BIPED in Brabrand into a more integrated, collaborative, and locally grounded PED ecosystem.

This development also reflects the principles of the Stakeholder Engagement Life Cycle described in the Community Booklet¹² (p. 32–33), where stakeholder engagement is understood as an ongoing and evolving process rather than a one-time activity. Stakeholder relationships, roles, and levels of interest can change throughout a project, meaning that stakeholder mapping and engagement approaches need to be revisited continuously. The Living Lab development demonstrates this dynamic process, as new actors became involved, existing relationships evolved, and engagement approaches were adapted over time.

4.2.5. Linking Milestones to Governance Principles and Conclusion

Across these milestones, clear patterns emerge that directly inform the governance principles developed in Part 1. The experiences emphasise the importance of **multi-stakeholder collaboration and local anchoring (Principle 2)**, as well as the need to ensure **clear value creation and contextual relevance (Principle 1)**. At the same time, recurring challenges related to **data access, ownership, and organisational complexity (Principle 3)** highlight how data functions as both a foundation and a barrier in practice.

Many milestones further demonstrate the need for **translation and accessible communication (Principle 4)**, particularly when engaging diverse actors, alongside the importance of **trust and legitimacy (Principle 5)**. Insights from citizen engagement underline the relevance of **human-centred and inclusive approaches (Principle 7)**, while the continuous experimentation and iterative learning observed throughout the Living Lab reflect **Principle 9**. These processes are supported by efforts to ensure **long-term anchoring and capacity building (Principle 8)**.

Taken together, the milestones show how the Brabrand Living Lab evolved from a series of activities into a functioning governance ecosystem. Through continuous interaction between actors, data, and experimentation, the Living Lab has enabled the co-creation of knowledge and practices that support the development of PEDs in a real urban context.

4.3. From Living Lab Knowledge to Governance Principles

As outlined in the introduction, this handbook emphasises multi-stakeholder engagement while recognising that the principles are primarily designed for municipal structures, with the city acting as the central orchestrator. The Brabrand Living Lab in Aarhus served as a testing ground for developing and validating these governance practices.

¹² [Community Booklet p.32-33](#)

4.3.1. Documentation – Analysis – Synthesis Process

The governance principles were developed through a three-step process of Documentation, Analysis, and Synthesis:

Documentation involved systematically capturing Living Lab activities through a comprehensive activity log, documenting stakeholders, interactions, meeting notes, invitations, visual material, and other supporting documentation (Annex 1). This created a transparent and traceable knowledge base of technical, behavioural, and collaborative experiences.

Analysis consisted of an iterative thematic review inspired by thematic analysis (Braun & Clarke, 2006), combined with multimodal analysis (Kress & van Leeuwen, 2001) and sensemaking (Weick, 1995). Insights were first explored in a 1.5-hour workshop with the Aarhus project team, followed by an initial thematic categorisation. Subsequently, two workshops with the wider BIPED consortium expanded the analysis with perspectives from partners and cities (Annex X). Project documentation—including workshops, meetings, field observations, and visual material—was then reviewed across data sources to identify recurring patterns, tensions, barriers, and successful practices.

Synthesis translated these analytical findings into nine governance principles. Rather than representing a hierarchy, the principles emerged iteratively from the Living Lab process and function as complementary guidelines for collaboration, decision-making, and role distribution among municipalities, utilities, citizens, researchers, and companies. Grounded in practical experience, they provide an empirically informed framework for organising future PED governance while reflecting the technical and collaborative focus of the BIPED project.

4.4. From Living Lab Knowledge to User-Centred LDT Development

Building on the governance principles presented earlier, Aarhus developed a structured approach for translating Living Lab insights into user-centred Local Digital Twin (LDT) development. Grounded in the living lab methodology—understood as "a user-centred, open innovation ecosystem based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings" (Schuurman et al., 2025, p. 18)—the approach embeds stakeholder needs directly into the design and implementation of the LDT-supported Positive Energy District (PED).

Through continuous engagement with citizens, municipal departments, utility providers, and private actors, Aarhus identified user needs and translated them into operational user profiles (personas). These personas bridge user insights and technical development, providing structured inputs for technical partners including DKSR (CIVORA Data Hub), VCS (Digital Twin), DTU, and Road Twin (Annex 2).

4.4.1. Example: Mobility Planning

A representative example is **User Profile 4**, a mobility planner in Aarhus Municipality. Living Lab activities identified a need to evaluate the impacts of road closures and other mobility interventions before implementation. This requirement was translated into LDT functionality, enabling users to simulate traffic scenarios through the CIVORA platform and the Digital Twin. Supported by Road Twin traffic models, the solution allows planners to assess traffic flows, congestion, and the impacts of interventions on mobility, while CO₂ impact modelling is currently being integrated. This illustrates how identified user needs were directly translated into operational LDT services.



Figure 42: User Profile 14

4.4.2. From User Insights to Technical Development

User profiles and Living Lab findings were continuously integrated into development through a lightweight Scrum-inspired collaboration between Aarhus, VCS, DKSR, and other technical partners. Aarhus contributed validated user needs and priorities, VCS coordinated technical development, while DKSR and the technical partners implemented and refined LDT functionalities.

The process was supported by:

- continuously updated user logbooks and personas;
- UX/UI mock-ups translating user requirements into implementable designs;
- regular stakeholder validation workshops and Scrum meetings; and
- traceability between user inputs, technical requirements, and implemented LDT functionalities.

This created a continuous development cycle in which Living Lab insights informed personas, personas informed design, and design guided implementation, with ongoing validation by end users throughout the project.

4.4.3. Gender-Aware and Inclusive User Profiling Approach

Aarhus also adopted a systematic and transparent approach to inclusive user profiling. Where relevant and GDPR-compliant, stakeholder engagement activities recorded sex/gender data following the framework established in BIPED D3.1, with further operationalisation planned in D3.4 to support inclusive deployment of the LDT.

Beyond data collection, inclusivity was embedded in persona development. User profiles were based on real stakeholder needs while deliberately avoiding stereotypical representations. Aarhus' experience demonstrated the importance of moving beyond binary gender classifications when designing personas, recognising that traditional categorisations can unintentionally reinforce bias or exclude users. Instead, personas were developed to reflect a broader diversity of identities, backgrounds, and lived experiences, resulting in user profiles that are both authentic and representative of the communities the LDT is intended to support.

Overall, this approach demonstrates how Living Lab co-creation, user profiling, UX design, and iterative technical development can be integrated into a coherent process that ensures the Local Digital Twin is not only technically robust but also usable, relevant, and inclusive in practice.

5. Insights from the Aarhus Experience: How to Start a Living Lab From Scratch

The previous sections outlined how the Brabrand Living Lab was established (Section 3) and how its activities were transformed into structured knowledge and governance principles (Section 4).

Building on this, Section 5 reflects on the Aarhus experience to provide practical insights into how a Living Lab can be initiated and developed from scratch.

5.1. Starting the Living Lab: An Iterative and Exploratory Process

Starting a Living Lab is not primarily about creating a physical space or launching a predefined concept – it is about establishing a way of working. In Aarhus, this way of working emerged through iterative learning, stakeholder engagement, and real-world experimentation, which over time generated the knowledge later synthesised into governance principles.

A key reflection is that there is no single “right” starting point. In Brabrand, activities began simultaneously with:

- Identifying and engaging stakeholder groups

- Exploring available data and organisational capacities
- Testing how technologies such as the Local Digital Twin (LDT) could be applied in practice

As shown in Section 4, these parallel activities are not a weakness but a strength – they produce the diversity of experiences needed to identify patterns, challenges, and governance needs.

5.1.1. Start with a Purpose – But Expect It to Evolve

It should also be noted that this work is inherently ongoing and continuously evolving. Throughout the process, new stakeholders were identified and engaged relatively late in the project, and the understanding of both the challenges and opportunities developed over time.

In Aarhus, the initial purpose was to explore how a Living Lab could support PED development through LDTs. However, this purpose evolved continuously as stakeholders engaged and as new insights emerged. Section 4 illustrates that this evolution is not a weakness, but a necessity: developing Local Digital Twins requires continuous adaptation of both vision and stakeholder alignment. Starting with a clear direction is important – but equally important is allowing the purpose to be reshaped through practice.

5.1.2. Engage All Relevant Stakeholders Early

A Living Lab is inherently multi-stakeholder. In Aarhus, this included public authorities, private companies, citizens and communities, and innovation actors.

As demonstrated in Section 4, each group brings:

- Different understandings of value
- Different expectations and timeframes
- Different relationships to data, technology, and decision-making

Early engagement is therefore essential – not only to involve stakeholders, but to begin the process of aligning perspectives and identifying shared challenges, which later become the basis for governance.

5.1.3. Build a Shared Understanding

Core concepts such as PEDs and digital twins were not widely understood across stakeholder groups. Aarhus therefore invested significant effort in building a shared language and understanding.

At the same time, this process made it clear that communication could not be standardised. For each engagement, Aarhus developed tailored presentations and approaches, adapting content and format depending on the audience – whether elderly residents, companies, students, or local community groups. In some cases, the concept of the digital twin was introduced explicitly; in others, it was intentionally left out in favour of more relatable entry points. This adaptive approach proved necessary to ensure relevance and engagement across diverse stakeholders.

Section 4 highlights that this is critical:

- Abstract concepts limit engagement
- Misalignment slows down collaboration
- Shared understanding is a prerequisite for data sharing, testing, and decision-making

Prototypes, visualisations, and local examples proved essential in making concepts tangible.

5.1.4. Take an Orchestrating Role

A key lesson is the importance of a clear orchestrator – typically a public actor. In Aarhus, this role involved:

- Connecting stakeholders across sectors
- Facilitating access to data and resources
- Maintaining momentum across activities

As shown in Section 4, this role is especially important when navigating complex data landscapes, institutional constraints, and cross-sector collaboration challenges. The orchestrator must continuously balance internal project logic with external stakeholder needs.

5.1.5. Go Where the People Are

Engagement must take place in real-life contexts. Aarhus moved activities into local communities, organisations, and everyday settings in Brabrand. Aarhus' experience showed clearly that stakeholders do not naturally come to the municipality – engagement works better when the municipality goes to them. This made activities easier to organise and created a more relaxed and open atmosphere for participants, who engaged on familiar ground rather than in formal or institutional settings.

Section 4 reinforces why this matters:

- Local context reveals how technologies actually work in practice
- Everyday settings generate behavioural and “soft” data
- Trust and relationships are built through presence and continuity

5.1.6. Combine Broad Engagement with Targeted Formats

While all stakeholder groups were engaged overall, Aarhus also worked with targeted formats such as workshops, design sprints, surveys, and local events.

This reflects a key insight from Section 4:

Different stakeholders require different forms of engagement, and no single format can capture all perspectives or needs. Combining broad outreach with focused interactions strengthens both inclusion and depth.

5.1.7. Use Co-Creation to Explore and Learn

Co-creation was used as a method for exploration rather than delivery. Workshops, student projects, and collaborations helped test ideas and uncover:

- What creates value for different stakeholders
- Where misunderstandings arise
- How solutions can be adapted

As shown in Section 4, these activities generate the empirical foundation needed to identify patterns and develop governance principles.

5.1.8. Make the Abstract Tangible

The complexity of LDT-supported PEDs made it necessary to work with prototypes, dashboards, and visualisations.

Section 4 shows that:

- Stakeholders engage more when solutions are concrete
- Testing reveals gaps between modelled systems and real-world practices
- Tangible tools are essential for building trust and understanding

5.1.9. Learn by Doing

The Living Lab in Aarhus was already in motion before the method was fully defined. Early workshops, data work, and stakeholder engagement shaped the approach as it developed.

Section 4 confirms that this is not only acceptable but necessary:

knowledge emerges through practice, and governance can only be developed once real experiences have been generated.

5.1.10. Embrace Iteration

The process in Aarhus involved continuous adjustment of activities, focus areas, and approaches.

As highlighted in Section 4:

- LDT development is not linear
- Stakeholder alignment takes time
- Data availability and collaboration evolve over time

Iteration is therefore not a deviation, but a core feature of both Living Lab work and governance development.

5.1.11. Adapting Governance to Maturity Levels and Stakeholder Engagement

An important consideration when establishing Living Labs and implementing LDT-supported PEDs is the varying levels of digital, organisational, and collaborative maturity across municipalities. Cities differ not only in their technical capabilities, but also in their experience with stakeholder engagement, co-creation practices, and cross-sector collaboration.

Governance approaches should therefore be adaptable and people-centred, allowing cities to engage at different starting points. In early-stage contexts, the focus may be on building shared understanding, trust, and stakeholder relationships, alongside basic data capabilities. In more mature contexts, governance can support advanced data use, system integration, and coordinated decision-making across sectors and actors.

Recognising these differences is essential. Rather than applying a fixed model, governance should support progressive development, where both technical systems and ways of working with people evolve over time.

This means that successful implementation depends not only on digital maturity, but also on the ability to engage stakeholders, translate complex concepts into meaningful dialogue, and foster collective ownership of solutions.

By combining technological development with strong collaboration practices, municipalities can move from individual engagement to coordinated, collective action, ensuring that LDT-supported PEDs are both technically effective and socially grounded.

5.1.12. From Experimentation to Long-Term Impact

Finally, Aarhus emphasised the importance of linking experimentation to long-term impact.

Section 4 shows that this includes:

- Connecting Living Lab activities to organisational structures and decision-making
- Ensuring that data, tools, and collaborations can be sustained and scaled
- Translating insights into governance principles that guide future work

5.2. Summing Up

The Aarhus experience shows that starting a Living Lab is both a structured and emergent process, where learning happens through real-world engagement.

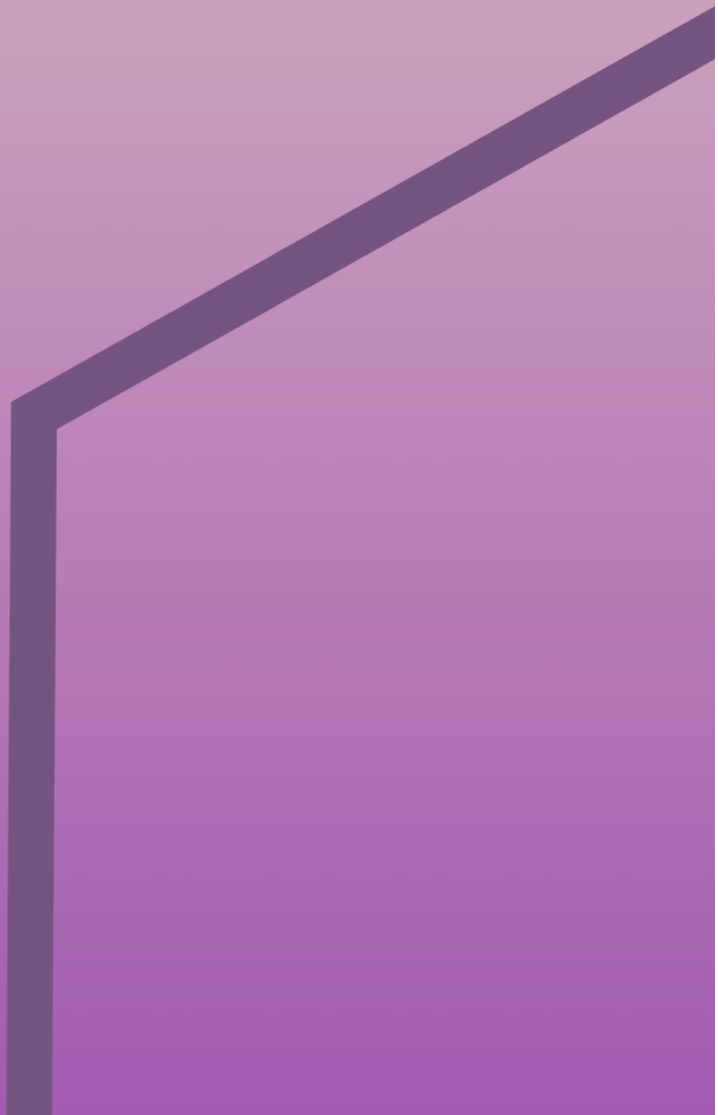
Sections 3 and 4 demonstrate that this process not only enables experimentation, but also generates actionable knowledge about collaboration, data, and governance.

Section 5 builds on this by showing how these experiences can guide others in starting their own Living Lab.

Rather than waiting for a perfect starting point, the key is to begin, engage, and learn in practice – and to use these experiences to gradually shape both the Living Lab and the governance structures that support it.

PART 3

CONCLUSION AND NEXT STEPS



PART 3 – Conclusion and Next Steps

Key Insights from Part 3 – Conclusion and Next Steps

✓ Core Insight

Governance for LDT-supported PEDs is not static. It is an evolving process shaped by technology, data, people, collaboration, and continuous learning.

✓ What This Part Covers

- Key lessons from the BIPED Living Lab and governance development process
- Reflections on challenges and limitations
- Recommendations for PED communities
- Next steps for testing, adapting, and scaling governance approaches

✓ Why It Matters

It shows how governance moves from principles to practice, ensuring that LDT-supported PEDs are adaptable, implementable, and grounded in real-world needs.

✓ What to Pay Attention To

- Governance requires more than structures; it depends on relationships, trust, and engagement
- Data creates value when translated into shared understanding and action
- Collaboration must evolve from individual interests towards collective action
- Governance should be continuously tested, refined, and embedded in long-term strategies

6. Lessons Learned, Recommendations, and Future Directions

6.1. Conclusion

This handbook has explored how governance can support the development of Local Digital Twin (LDT)-supported Positive Energy Districts (PEDs) by combining technological innovation with real-world practice. While the handbook presents governance principles applicable to PED communities more broadly, these principles have been developed through the empirical experiences of the BIPED project and the Brabrand Living Lab in Aarhus.

A central contribution of the BIPED project is the demonstration that governance cannot simply be designed in advance. Instead, governance emerges through an iterative process of experimentation, stakeholder engagement, systematic documentation, analysis, and continuous learning. The Brabrand Living Lab provided the environment in which governance challenges could be observed in practice, allowing technical, organisational, and social dimensions to be explored simultaneously.

This process represents an important shift from viewing governance as a static framework towards understanding governance as an evolving practice. Throughout BIPED, governance principles were not predefined; they were identified through repeated interactions between municipalities, utilities, companies, researchers, and citizens while developing and testing Local Digital Twin solutions in real-world settings. The nine governance principles presented in this handbook therefore represent an empirical synthesis of experiences generated throughout the project rather than purely theoretical recommendations.

As highlighted throughout the handbook, the challenge is not a lack of ambition. Across stakeholders there is considerable willingness to contribute to sustainable urban development. The more persistent challenge lies in achieving alignment between organisations, data, technologies, responsibilities, and communities.

The governance vision presented in this handbook reflects this ambition:

The PED Digital Twin shall operate as a trusted, interoperable and human-centric digital infrastructure that enables collaborative, transparent and sustainable decision-making across sectors and stakeholders while safeguarding privacy, resilience and public value throughout the lifecycle of the district.

The BIPED experience demonstrates that achieving this vision requires more than governance structures alone. It requires methods that enable cities to understand their own context, build relationships across stakeholders, translate complex technologies into meaningful dialogue, and continuously adapt governance as new knowledge emerges. In this sense, the Living Lab should be understood not only as an innovation environment, but also as a methodology for governance development.

6.2. Limitations and Reflections

The governance principles presented in this handbook are grounded in the experiences of the Brabrand Living Lab and therefore reflect both the strengths and limitations of the BIPED project.

Living Lab approaches are inherently complex. Building collaboration across municipalities, utilities, companies, researchers, and citizens required continuous coordination, repeated clarification of roles and responsibilities, and significant investments in trust-building. Collaboration evolved gradually and often required multiple iterations before common objectives and ways of working could be established.

Stakeholder and citizen engagement also presented important challenges. While broad participation was achieved across many activities, maintaining representative and sustained engagement proved considerably more difficult. As experienced throughout BIPED, citizens were generally willing to contribute perspectives and ideas, but translating individual participation into long-term collective action remained a recurring challenge.

The project also highlighted the gap between technological innovation and everyday practice. Concepts such as Local Digital Twins and Positive Energy Districts often required extensive translation into concrete examples, visualisations, and locally relevant use cases before stakeholders could meaningfully engage with them. This reinforced the importance of communication, facilitation, and user-centred design alongside technical development.

Likewise, governance development proved to be a non-linear process. Stakeholder relationships, project priorities, data availability, and organisational capacities evolved continuously throughout the Living Lab. Data governance emerged as a particular challenge, with fragmented ownership, legal constraints, organisational boundaries, and differing interpretations of data repeatedly influencing collaboration and implementation.

These experiences underline that the governance principles presented here should not be interpreted as a universal or final governance model. Rather, they constitute a first empirical synthesis derived from one Living Lab context. Their broader applicability should therefore be tested, refined, and adapted through implementation in additional PED communities with different institutional settings, stakeholder configurations, and levels of digital maturity.

6.3. Recommendations for LDT-supported PED Communities

Based on the experiences generated throughout BIPED, this handbook recommends that governance development should begin not with organisational structures alone, but with establishing a Living Lab capable of generating the empirical knowledge upon which governance can be built.

The Aarhus experience demonstrates that effective governance develops through a structured process of experimentation, documentation, analysis, and synthesis. Municipalities seeking to develop LDT-supported PEDs are therefore encouraged to adopt an iterative methodology that:

- establishes broad multi-stakeholder engagement from the outset;
- systematically documents activities, observations, and lessons learned;

- analyses recurring patterns, barriers, and opportunities across technical, organisational, and social dimensions; and
- translates these insights into governance principles, operational procedures, and collaborative practices.

The Living Lab methodology and the governance principles should be viewed as complementary. The methodology provides a process through which cities can understand their local context and identify governance needs, while the governance principles provide a common framework for organising collaboration, decision-making, stakeholder engagement, and data governance.

Importantly, governance should remain adaptive. Different municipalities will have different organisational capacities, stakeholder ecosystems, and levels of digital maturity. Rather than replicating the Aarhus experience directly, cities should apply the methodology to develop governance approaches that respond to their own local conditions while drawing inspiration from the principles identified through BIPED.

6.4. Future Work

The governance principles presented in this handbook should be regarded as a starting point rather than an endpoint.

Future work should focus on validating and refining these principles across a wider range of PED contexts. Applying the methodology in cities with different governance traditions, organisational structures, and technical capabilities will help assess which principles are broadly transferable and where local adaptation is required.

At the same time, further work is needed to operationalise the governance principles into practical tools and organisational routines. This includes developing decision-making procedures, stakeholder engagement models, data governance practices, evaluation frameworks, and mechanisms for continuous learning that can support implementation beyond pilot environments.

Building on the experiences from BIPED, Aarhus also recommends developing an Easy-to-Read PED & Digital Twin Governance Handbook that complements the strategic guidance presented here. Such a handbook could provide municipalities with practical step-by-step guidance for establishing Living Labs, facilitating stakeholder engagement, documenting experiences, conducting governance analyses, and translating findings into operational governance practices.

Ultimately, the principal contribution of BIPED is not only the identification of governance principles, but the demonstration of a practical methodology through which governance can be developed. By combining Living Lab experimentation with systematic documentation, thematic analysis, and iterative refinement, municipalities can generate governance approaches that are both evidence-based and responsive to their own local contexts. Continued testing across future PED communities will be essential for strengthening, validating, and expanding this emerging governance methodology.

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8. Annexes

8.1. Annex 1 – Anonymised Stakeholder Engagement Activity List (Living Lab)

This annex presents an overview of stakeholder engagement activities carried out within the BIPED Living Lab in Aarhus.

Data Protection and Anonymisation

This dataset has been anonymised in accordance with GDPR principles and applicable European Data Protection Board guidance.

All personal names and directly identifiable information have been removed.

Stakeholders are described using **roles, organisations, or group-level identifiers only**, ensuring that individuals cannot be identified from the dataset.

Sensitive personal data (e.g. ethnicity, age, gender in identifiable combinations) has been **removed or aggregated**, and small groups or individual participants have been described in a way that prevents re-identification.

The dataset is intended solely for **reporting, monitoring, and evaluation purposes** within the BIPED project. Any further use of the dataset may require additional aggregation and/or explicit consent, depending on the context.

Scope of Documentation

The living lab activity list documents a broad range of engagement formats and is supported by supplementary materials, including:

- Meeting minutes
- Photographic documentation
- Presentation slides
- Meeting invitations and notices
- Workshop materials

These materials provide further context and evidence of stakeholder engagement activities conducted throughout the project.

Limitations and Completeness

It should be noted that this activity list does not represent **all interactions** that have contributed to the development of the Living Lab in Aarhus.

Some engagements have taken place in **parallel processes or external collaborations**, where BIPED partners were not the primary organisers. For example, interactions with stakeholders such as **Kredsløb** have also occurred in other contexts led by different actors, and may therefore not be fully reflected in this list.

Nevertheless, the annex provides a **representative and structured overview** of the core stakeholder engagement activities conducted within the BIPED Living Lab framework.

Date	Stakeholder (Anonymised)	Purpose with the engagement
11-12-2023	Sol over Brabrand (community organisation)	First official meeting with community energy group
12-03-2024	Mobility Data Owner – Aarhus Municipality	Initial meeting regarding mobility data and end-user needs
12-03-2024	Energy Management Team Lead – Aarhus Municipality	Initial meeting on energy management and data ownership
12-03-2024	Digitalisation & Geodata Team – Aarhus Municipality (3 participants)	Initial meeting with municipal geodata team
21-03-2024	Utility Data Team – Kredsløb + partners (6 participants)	Initial data collaboration meeting
02-04-2024	ITK Staff – Aarhus Municipality	Internal presentation of BIPED
04-04-2024	Energy Management Team Lead – Aarhus Municipality	Follow-up meeting on data and collaboration
04-04-2024	Mobility Data Owner – Aarhus Municipality	Follow-up meeting on data and collaboration
04-04-2024	Energy Infrastructure Representatives – Aarhus Municipality (2 participants)	Meeting on solar energy initiatives
04-04-2024	Digitalisation & Geodata Team – Aarhus Municipality (3 participants)	Follow-up on collaboration
11-04-2024	Utility Company – Kredsløb	Follow-up on data access
16-04-2024	Culture & Citizen Services Dept – Aarhus Municipality	Stakeholder mapping workshop

30-04-2024	Students – Business Academy Aarhus (28 participants)	Presentation of BIPED
02-05-2024	Energy Management Stakeholder – Aarhus Municipality	Technical clarification meeting
03-05-2024	Mobility Stakeholder – Aarhus Municipality	Preparation meeting for Road Twin
06-05-2024	External Mobility Data Provider	Data sourcing for mobility
06-05-2024	Mobility Stakeholder Group – Aarhus Municipality (3 participants)	Coordination meeting
17-05-2024	Local Media Representative – Brabrand / Journalist	Insights into local communication
28-05-2024	University Students – Aarhus University (2 participants)	Knowledge sharing on energy communities
29-05-2024	Steering Committee – Aarhus	Governance meeting
31-05-2024	Senior Digitalisation Representative – Aarhus Municipality	Strategic alignment
31-05-2024	Senior Public Sector Representative – Aarhus Municipality	Intro meeting on data collaboration
17-06-2024	Energy Management Stakeholder – Aarhus Municipality	Follow-up on data
18-06-2024	Geodata Specialist – Aarhus Municipality	Meeting on 3D data
19-06-2024	Cross-sector Data Stakeholder – Aarhus Municipality	Initial data meeting
02-08-2024	Data Support Student – ITK	Support on data access

08-08-2024	Data Support Student – ITK	Follow-up support
08-08-2024	Citylab – ITK Department	Internal presentation
15-08-2024	GovTech Midtjylland Network	Collaboration meeting
26-08-2024	IT Data Governance Specialist – Aarhus Municipality	Data governance discussion
26-08-2024	Mobility Stakeholder – Aarhus Municipality	Follow-up meeting
26-08-2024	Nordic Digitalisation Network (27 participants)	Smart city network presentation
30-08-2024	Citizens – Vilde Teknologier Festival (37 participants)	Presentation and survey
03-09-2024	Community Stakeholders – Multi-organisation event (25 participants)	Joint presentation
11-09-2024	University Students – Aarhus University (2 participants)	Collaboration discussion
17-09-2024	Citizens (48 participants)	Vox pop engagement
19-09-2024	Housing Association Representative – Brabrand	Initial collaboration meeting
27-09-2024	Business Association Representative – Brabrand	Introductory meeting
22-10-2024	Steering Committee – Aarhus	Governance meeting
31-10-2024	ESG Network Participants (15 participants)	Introduction and alignment

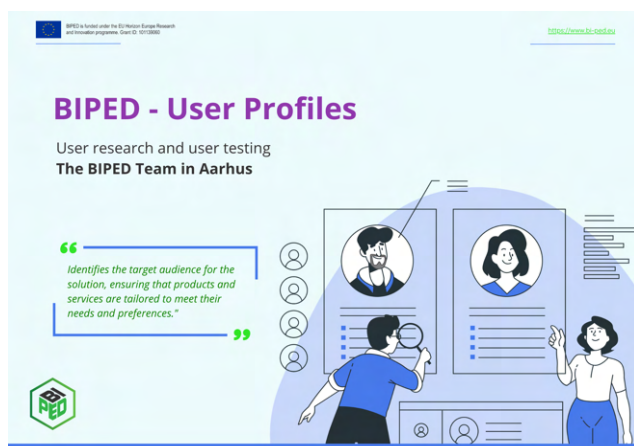
18-11-2024	Financial Sector Representative – Bank	ESG collaboration discussion
22-11-2024	Logistics Company Representatives (2 participants)	ESG collaboration
25-11-2024	Internal Municipal Stakeholders (6 participants)	Data workshop
26-11-2024	Samvirket Community (100+ participants)	Community presentation
04-12-2024	Survey Respondents (14 participants)	Questionnaire
12-12-2024	Mixed Stakeholder Group (5 participants)	Digital twin workshop
24-01-2025	Community Organisation – Bydelsmødre (15 participants)	Co-creation workshop
28-01-2025	Samvirket Gellerup (100+ participants)	Community event
29-01-2025	Green Areas Dept – Aarhus Municipality	Knowledge sharing
25-02-2025	Private Enterprise – DEKRA	Visit and collaboration
26-02-2025	National Data Authority Representative	Knowledge sharing
27-02-2025	Private Construction Company Representative	Knowledge sharing
06-03-2025	Steering Committee – Aarhus	Governance meeting
31-03-2025	Students – Business Academy Aarhus (32 participants)	Living lab workshop
15-05-2025	Expo Sustainable Futures (100+ participants)	Exhibition engagement

15-05-2025	International Delegation (17 participants)	Smart city presentation
19-05-2025	BIPED Consortium + Municipal Dept (2 participants)	Coordination meeting
21-05-2025	Sol over Brabrand (community organisation)	Follow-up and demo
21-05-2025	Private Enterprise – IFF	Collaboration meeting
02-06-2025	Steering Committee – Aarhus	Governance meeting
23-06-2025	Climate & Energy Stakeholders (2 participants)	Follow-up meeting
29-08-2025	Festival Participants (73 participants)	Citizen engagement
03-09-2025	DigiHub Network (25 participants)	Digitalisation collaboration
08-09-2025	Digital Twin Workshop Participants (10 participants)	Training and demo
09-09-2025	Private Enterprise Stakeholders (2 participants)	Presentation
15-09-2025	Mobility Workshop Participants (3 participants)	Scenario session
18-09-2025	Steering Committee – Aarhus	Progress presentation
29-09-2025	Internal Municipal Stakeholders (2 participants)	Internal alignment
11–17-11-2025	Mixed Stakeholder Group (9 participants)	Living lab design sprint
27-11-2025	Sol over Brabrand (community organisation)	General assembly

13-01-2026	Digital Twin Testing Participants (24 participants)	Co-design workshop
04-02-2026	University + Stakeholders (161 participants)	Co-design event
18–24-02-2026	Survey Respondents – Residents (1347 participants)	Data collection survey
24-02-2026	Steering Committee – Aarhus	Governance meeting
25-03-2026	Business Association Participants (31 participants)	Annual meeting
14-04-2026	Citizens – Brabrand	Citizen engagement
24-04-2026	Climate Action Event Participants	Public outreach
05-05-2026	Design Expo Participants (150+ participants)	Sustainability engagement

8.2. Annex 2 – BIPED – User Profiles

The user profiles have been developed using a gender-aware and inclusive approach to ensure that they do not reinforce stereotypes or bias. All profiles use neutral language and avoid assumptions related to gender, household roles, or technical competencies. Instead, they reflect diverse life situations, levels of digital literacy, and socio-economic contexts. The profiles also consider varying needs, capacities, and participation barriers across different user groups, including underrepresented stakeholders. This approach supports more equitable, accessible, and inclusive design and decision-making, in line with EU requirements on integrating the gender dimension in research and innovation.



→ See the full slide deck [here](https://www.bip-ed.eu)

8.3. Annex 3 – Recommendation: Breaking Down Silos in Governance Structures

How can strategic ambition be translated into coordinated action across sectors? How can data, infrastructure, and community engagement be governed as part of a single system rather than separate domains? And how can municipalities move beyond fragmented responsibilities toward integrated forms of governance?

Following the introduction of governance principles and the layered governance model, this handbook suggests that effective implementation requires organisational structures capable of operating across layers. While the layered model clarifies responsibilities, traditional municipal structures often remain organised in silos – separating policy, infrastructure, data, and community engagement into distinct units with limited coordination.

Such fragmentation can limit the effectiveness of LDT-supported PED development. Strategic goals may not align with operational realities, data governance may evolve independently of infrastructure planning, and citizen engagement may remain disconnected from decision-making processes. Addressing these challenges requires governance structures that are explicitly designed to bridge sectors, integrate knowledge, and support collaboration across domains.

The following structures are recommended as ways to break down silos and support more integrated, cross-functional governance. They reflect the need for coordination across strategic, institutional, operational, technical, and participatory layers, as outlined in the layered governance model.

8.3.1. Overview of Recommended Governance Units

Turning ambition into action requires more than good intentions – it requires organisation. The table below introduces a set of governance units that work together to connect strategy with practice, bridging sectors, data, infrastructure, and community. Together, they show how cities can move from fragmented efforts to a more coordinated and integrated way of working:

Unit	What it does	Main tasks	In practice, this means	Key characteristics / roles
Urban Systems Office	Brings different parts of the city together to work towards shared sustainability goals, especially for Positive Energy Districts.	• sets the overall PED strategy • connects different sectors (energy, housing, mobility, etc.) • ensures collaboration across departments • coordinates projects and investments • plans for long-term resilience	Acts as the “big picture” coordinator, ensuring that different sectors and activities move in the same direction. Closely linked to city leadership and works across departments rather than within just one.	• mission-oriented • cross-sectoral • directly anchored in city leadership
City Data & Digital Twin Office	Manages data and the digital twin so that information can be shared, trusted, and used effectively.	• ensures data is handled properly and securely • makes different systems work together • manages platforms, APIs, and data standards • oversees the use of AI and advanced analytics	Ensures that data flows between systems and actors and turns data into something useful for decision-making and planning. Supports the digital twin as a shared resource.	• Chief Data Officer • Data Stewards • Digital Twin Managers • Semantic Architects
Urban Innovation & Transition Lab	Creates a space for testing ideas and learning what works before scaling up.	• runs living labs • supports co-creation with stakeholders • tests new solutions and policies • manages innovation processes	Provides a structured environment for experimentation where new ideas can be tested, supporting learning and adaptation over time.	• living labs • co-creation • policy experimentation • pilot governance
Integrated Infrastructure Coordination Unit	Makes sure different infrastructure systems work together smoothly.	• connects energy, buildings, and mobility systems • ensures infrastructure is robust and future-proof • coordinates day-to-day operations • manages how assets are used and integrated	Focuses on how physical systems function together in practice, ensuring that planning aligns with real-world operations and systems are integrated.	• energy, mobility, and building integration • operational coordination • asset integration • infrastructure resilience
Civic Participation & Trust Office	Builds trust and ensures that people are included in decisions.	• engages citizens and stakeholders • ensures transparency • communicates clearly about projects and decisions • handles ethical questions • supports dialogue and resolves conflicts	Ensures that governance is fair, open, and trusted. Connects communities with decision-making and supports dialogue across stakeholders.	• citizen engagement • transparency • communication • ethics governance • conflict mediation

8.4. Annex 4 – Data Journey Workshop in Aarhus

Workshop Guide: The Data Journey in Aarhus

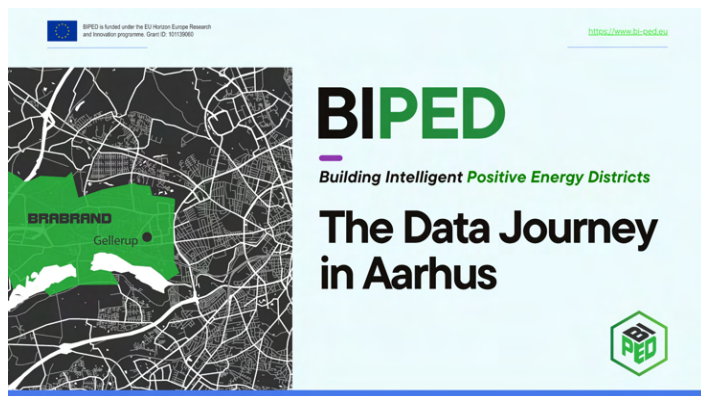
Location: VIP room, Dokk1, Aarhus

Time: 12:15–14:00, November 25, 2024

Agenda

Time	Topic	What	Practical
12:15–12:25 (10 min.)	Roundtable introduction	Welcome and introduce yourself: - Name? - Department? - Position? - Role in BIPED?	Remember to take photos! Ask Christian. Documentation
12:25–12:35 (10 min.)	Goals and expectations for the day	Share why you are participating: - Write for 2 min. - 8 min. plenary sharing	Post-its, pens
12:35–12:50 (15 min.)	Presentation from BIPED	Introduction to BIPED: - Our data journey - What is a data journey? - Why map the data journey? - Challenges - Experiences	PowerPoint slides

12:50–13:30 (40 min.)	Workshop – Part 1	What: - Present the case - Are any steps missing? (add steps if needed) Review each step and discuss: 1) What are the biggest challenges with data collection in Aarhus Municipality? 2) What has worked well with data collection in Aarhus Municipality?	Posters with all steps Post-its in two colors Pens
	Break		
13:30–13:50 (20 min.)	Workshop – Part 2	Next steps: - What should we focus on going forward? - What are the biggest challenges to address? - What creates the most value to focus on? Activity: - Place stickers and highlight key challenges - Each participant gets 5 stickers	Stickers
13:50–14:00	Wrap-up	Closing and summary of the day	



See all insights from Data journey [here](https://www.bi-cad.eu)

8.5. Annex 5 – Slide Deck Supporting Aarhus’ Role as Living Lab Orchestrator

This annex contains a slide deck that supports Aarhus’ role as living lab orchestrator. The material, presented in Danish, has been used as an internal tool to guide Aarhus in this role while also communicating the methodological approach within the municipality in the BIPED project and beyond:



→ See the full slide deck [here](https://www.bi-cad.eu)

8.6. Annex 6 – Detailed Documentation of the Design Sprint Process in Aarhus



→ See the full slide deck of the detailed documentation of the Design Sprint Process in Aarhus [here](#)

8.7. Annex 7 – Test-material from BIPED PED Community End-User Workshop

Annex 7 presents the test materials used during the BIPED PED Community End-User Workshop held on January 13, 2026. The materials supported the workshop activities and provided a basis for collecting feedback, testing concepts, and engaging end-users in the evaluation and further development of the BIPED approach.



→ See the full workshop material [here](#)