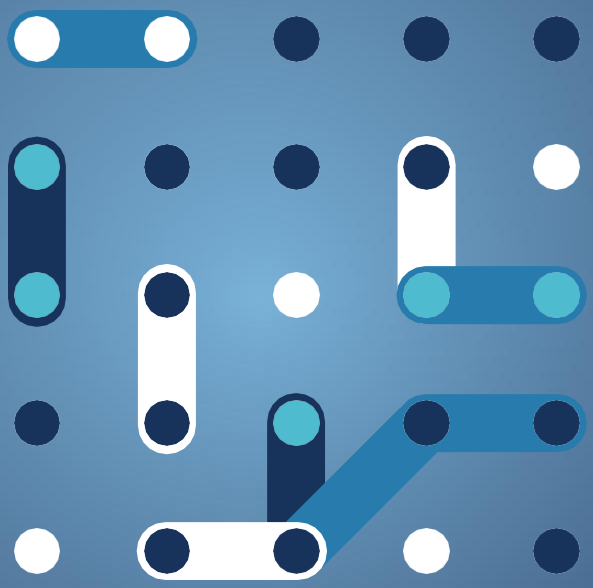
European Commission

bridge

Annual Report 2024-2025

Business Models Working Group



October - 2025

BRIDGE

Business Models Working Group

Annual Activity Report 2024-2025

October 2025

AUTHORS

Christina Papadimitriou, TU/e (eNeuron)

Evangelos Koulis, Crowdhelix (DR-RISE)

Cláudia Antunes Marante, Católica Lisbon School of Business & Economics (Omega-X)

Andrej Gubina, University of Ljubljana (SCALE)

Anastasis Tzoumpas, Ubitech (ELECTRON, ODEON)

Rafael Oliveira Rodrigues, D4P (eNeuron, COP-PILOT)

Athanase Vafeas, DOWEL Innovation (LocalRES)

Natalie Samovich, Enercotium (EDDIE)

Habib NASSER. RDIUP (FlexCHESS, Masterpiece)

SUPPORT FROM BRIDGE SECRETARIAT

Eleonora Rebora, RINA Consulting S.p.A.

Radu Alexandru Lupascu, PwC Business Services Srl

BRIDGE WG LEADERSHIP

Christina Papadimitriou, TU/e (*eNeuron*), WG Chair

Evangelos Koulis, Crowdhelix (*DR-RISE),* WG Co-Chair

Daniel Brandt, Sustainable Innovation (MASTERPIECE) Task 1 leader

Cláudia Antunes Marante, Católica Lisbon School of Business and Economics (Omega-X) Task 1 leader

Camilla Neumann, LIFE - Insitute for Climate, Energy and Society (X-FLEX) Task 1 leader

Andrej Gubina, University of Ljubljana (SCALE) Task 1 leader

Anastasis Tzoumpas, Ubitech (ELECTRON, ODEON) Task 2 leader

Rafael Oliveira Rodrigues, D4P (eNeuron, COP-PILOT) Task 2 leader

Athanase Vafeas, DOWEL Innovation (LocalRES) Task 3 leader

Natalie Samovitch, Enercotium (EDDIE) Task 3 leader

Habib Nasser. RDIUP (FlexCHESS) Task 3 leader

EUROPEAN COMMISSION

Directorate-General for Energy

Directorate B – Just Transition, Consumers, Energy Efficiency and Innovation Unit B5 – Innovation, Research, Digitalisation, Competitiveness

Contact: Eric Lecomte

E-mail: eric.lecomte@ec.europa.eu

European Commission
B-1049 Brussels

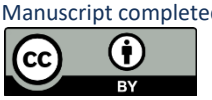
LEGAL NOTICE

This document has been prepared for the European Commission however it reflects the views only of the authors, and the European Commission is not liable for any consequence stemming from the reuse of this publication. More information on the European Union is available on the Internet (http://www.europa.eu).

PDF Web ISBN 978-92-9405-335-0 doi: 10.2926/2710825 HZ-01-25-149-EN-N

Luxembourg: Publications Office of the European Union, 2025

Manuscript completed in October, 2025



© European Union, 2025

The reuse policy of European Commission documents is implemented by the Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Except otherwise noted, the reuse of this document is authorised under a Creative Commons Attribution International (CC-BY 4.0) licence (https://creativecommons.org/licenses/by/4.0/). This means that reuse is allowed provided appropriate credit is given and any changes are indicated.

For any use or reproduction of elements that are not owned by the European Union, permission may need to be sought directly from the respective right holders

Index

List of Figures

List of Tables

List of Acronyms and Abbreviations

AEMS	Advanced Energy Management System
AI	Artificial Intelligence
B2B	Business-to-Business
B2C	Business-to-Consumer
B2B2C	Business-to-Business-to-Consumer
BM	Business Models
BMC	Business Model Canvas
CBA	Cost Benefit Analysis
CRL	Commercial Readiness Level
CSA	Coordination and Support Action
DM	Data Management
DNSH	Do No Significant Harm
DSFM	Demand-Side Flexibility Management
EC	European Commission
EEDS	European Energy Data Spaces
EMP	Energy Market Places
EPC	Energy Performance Contract
ESCO	Energy Service Company
FAIR	Findable, Accessible, Interoperable, and Reusable
FDT	Federated Digital Twins
GA	General Assembly
GAN	Generative Adversarial Network
GDPR	General Data Protection Regulation
IoT	Internet of Things
IRR	Internal Rate of Return
KER	Key Exploitable Result
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LEC	Local Energy Communities
NPV	Net Present Value
PESTLE	Political, Economic, Social, Technological, Legal, and Environmental
PM	Person-months
PV	Photovoltaic
R&I	Research and Innovation
RES	Renewable Energy Sources
TRL	Technology readiness level
ROI	Return of Investment
SAPL	Streaming Attribute Policy Language
SROI	Social Return of Investment
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TEA	Techno-Economic Analysis
UC	Use case
VPC	Value Proposition Canvas
XFSC	Cross Federation Services Components
XR	Extended Reality
WG	Working Group
WACC	Weighted Average Cost of Capital

Executive Summary

This report presents the results of the BRIDGE projects' collaboration within Working Group (WG) on Business Model (BM) in the 2024 – 2025 period.

The following needs were identified for each task:

Task 1 – Tools to capture business ideas and build business models: The Business Model Canvas (BMC) is reaffirmed as a foundational framework across the portfolio of BRIDGE projects, but there is growing need for complementary tools and tailor-made approaches to tackle specific project requirements. Various critical success factors were identified, namely:

1. The timing of business model initiation.
2. The involvement of a wide range of stakeholders and the early alignment of diverse interests and concerns.
3. The departure from generic models to more customized solutions that respond to individual needs and use cases.
4. The combination of business modeling with different types of analytical tools.
5. The external validation with potential customers to obtain real-world market feedback.

Three key challenges have emerged across the projects' portfolio that must be tackled: 1) Turning innovation into sustainable business value – many projects seem to struggle in the monetization step of the technical solutions developed; 2) Stakeholder coordination – this reflects on the complexity of managing individual versus collective objectives and the assignment of clear roles in multi-partner commercial partnerships; and 3) Quantification of business models – projects often lack access to reliable market data and benchmarks on revenues and costs, which compromises market readiness and the ability to launch competitive products and services. The task also pinpoints innovative approaches by some of the projects, such as the use of gamification for market validation, the development of business models archetypes, and the development of multi-stakeholder business models.

With the above lessons in mind, Task 1 will now evolve into the creation of active support mechanisms that can enhance the ability of new and ongoing projects to develop business models and generate market impact. Specific attention will be paid to artificial intelligence and digital tools, capacity building and knowledge transfer between projects, external validation and implementation support, and systematic mechanisms for measurement and evaluation.

Task 2 – Quantification methods: For Task 2, a primary need is the standardisation of business model development processes. While many projects use common tools such as the Business Model Canvas or Value Proposition Canvas, their application varies significantly, leading to inconsistent outcomes. There is a growing demand for harmonised templates, shared terminology, and a central repository of validated models to guide project teams across different contexts.

Another key need relates to the quantification of business model impacts. Projects often face challenges in measuring the economic, environmental, and social value created by their innovations. Though methodologies like cost-benefit analysis, return on investment, and social return on investment are cited, their application is often partial and lacks depth. This signals the necessity for clearer quantification frameworks, standardised key performance indicators, and tools that link technical outputs to business impact, particularly in integrated or multi-vector energy systems.

Data valorisation has emerged as a further area requiring targeted support. Projects report difficulties in strategically leveraging the data they generate, citing concerns over ownership, access rights, privacy regulations (such as GDPR), and compliance with FAIR principles. There is a recognised need for best practices, monetisation methodologies, and the integration of data-driven value streams within business model structures. As energy systems become increasingly digital, the capacity to extract and demonstrate the value of data becomes essential.

Additionally, cross-project collaboration and knowledge sharing were highlighted as essential to accelerate progress. Projects emphasised the need for more structured exchanges of tools, lessons learnt, and quantification

frameworks, as well as better coordination with other BRIDGE working groups, particularly those focused on data and regulation.

Task 3 – Data valorisation and business model: Task 3 continued and confirmed the activity carried out during the previous periods with some adjustment resulting from evolving needs identified during the interaction with projects and experts. The objective of the task was reformulated for more efficiency by R&I projects in their 'business model thinking and design', leveraging the discoverability of data resources.

The task therefore underscores the importance of discoverability of data from heterogeneous and evolving formats for supporting projects in building the business models of project results, allowing for scaling up of the envisioned solutions and for enhanced discoverability. Experience showed there is potential for a more systematic approach based on inputs from the BRIDGE community. We consider that the work carried out so far would gain from (a) further refining of these frameworks and from (b) facilitation of discoverability and scaling up modes based on wider feedback, especially from projects bringing core contributions to the topic such as Coordinated Support Actions. This could take the form of practical starting points, frameworks and guidelines for the projects.

When examining the activity carried out the last two years, we could notice a series of synthetic visual frameworks that were developed by Task 3 in 2024 on data sources and the current year analysis. One step back might be useful now to challenge them, benefiting from the hindsight of very relevant completed projects dealing with energy data spaces.

1.Introduction and Process

The Working Group on Business Models aims at establishing common language and frameworks around business model description and valuation. It identifies and evaluates existing and new business models from the project demonstrations or use cases.

The working group focuses on two areas:

- **Designing tools to evaluate the benefit and values of the services and solutions** developed by the projects, including the investigation of the tools to capture business ideas and build the business model and the quantification methods for business models benefits of services and solutions under various use case scenarios.
- **Designing a business model that better incorporates the integration of the data value chain and the monetisation of data**, where better observability creates additional social value.

These overarching objectives are currently addressed by 3 tasks:

- **Task 1 Investigates the tools for capturing business ideas and building BMs**, with the overall objective of establishing a standardised process for tools on BM, through a selection based on their features. The main activities of this task are to review and map the BM tools to identify barriers, gaps and best practices.
- **Task 2 Quantification Methods for BM benefits of services and solutions under different UC Scenarios**, with the overall objective to define a standardised process for using quantification methods together with the previous tools. The main activities of this task are to review and map quantification methods and link them to innovative products and services in order to provide recommendations and best practices.
- **Task 3 Investigates the types and characteristics of data value chains in BRIDGE project BMs**, with the overall objective of designing **a dynamic, contributive framework to support R&I projects in the design of their quantitative BMs, saving time and effort and facilitating 'discoverability' of data resources** (i.e. *making data resources easy to find and understandable).*

After mapping the needs of each task in 2023 – 2024 and analysing any omissions that would hinder projects' efficient development, the projects collectively worked to address these needs in 2024 – 2025, by offering universal processes and methodologies based on good practices and lessons learnt.

To perform these tasks efficiently, the WG zas structured as shown below (Figure 1.1):

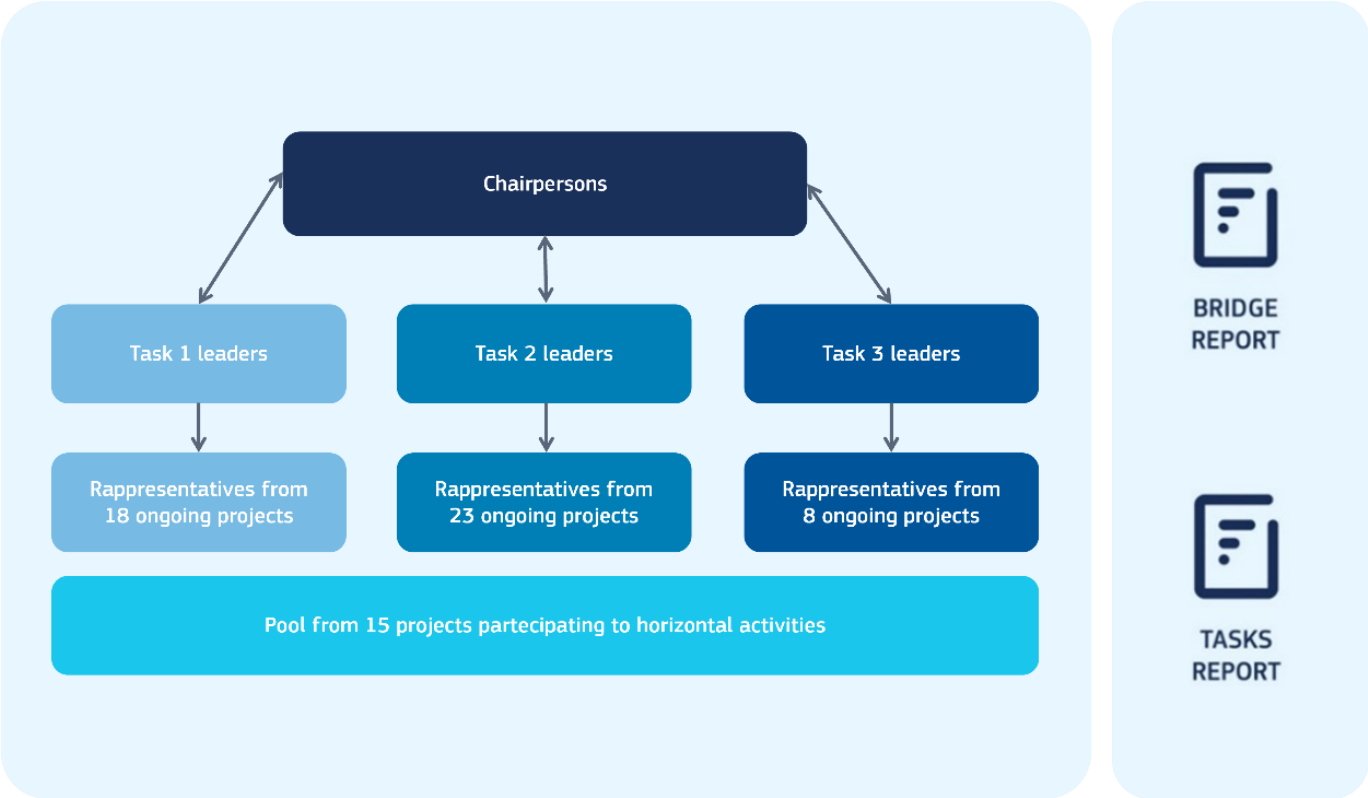


Figure 1.1 The governance of the WG on BM

88 projects have been participating in the horizontal activities to make sure that they provide their insights and feedback. The list of projects involved is presented below:

Figure 1.2 List of projects involved in the Business Model WG

Task groups have been further organising separate meetings, knowledge sharing and interviews to identify good practices and lessons learnt. The results of each task for the period 2024-2025 are reported below. It is expected that these sections will be further extended next year as the BM WG continues to address these tasks with the aim of providing standardised approaches and methodologies. This would help the projects to build BMs that highlight the revenue and other value streams, and so foster their replication and scaling-up on the market.

2.Task 1: Investigation of the tools to capture business ideas and build BM

2.1 Scope of the work

The primary objective of this task was to systematically examine and evaluate various business model development tools and methodologies through direct engagement with projects at different stages of development.

The scope of the work encompassed both theoretical foundational-building and practical knowledge exchange activities. A key component of this investigation involved the creation of an introductory guide titled "*Business Model Tool for Beginners",* for projects entering the business model development phase. It represents a separate deliverable that complements the findings presented here and provides more practical guidance for project teams seeking to implement business model frameworks.

The investigation was designed to capture insights from projects across the entire development life cycle, ensuring that the findings would be relevant and applicable to various stages of project maturity. This comprehensive approach allows for the identification of common challenges, effective practices, and tool-specific recommendations that can benefit the broader BRIDGE community.

2.2 Methodology

The methodology employed for this investigation was structured around a series of targeted knowledge exchange rounds, designed to facilitate systematic learning and insight gathering from active BRIDGE projects. The approach was deliberately designed to capture perspectives from projects at different stages of development, recognising that business model challenges and tool requirements evolve as projects progress from conception to implementation.

2.2.1 Knowledge Exchange Framework

Three distinct knowledge exchange rounds were conducted, each targeting projects based on their development status: new projects, mid-term projects, and projects approaching finalisation. This staged approach ensured comprehensive coverage of the business model development life cycle and enabled the identification of stage-specific challenges and solutions.

For projects in the early stages of development, specialised introductory sessions were provided to establish foundational understanding of business model concepts and practices.

These sessions covered several critical areas:

- **Business Models Fundamentals:** projects received comprehensive explanations of the relevance and importance of business model development within the context of their specific initiatives. This included a discussion of how business models serve as strategic frameworks for value creation, delivery, and capture (see Figure 2.1).

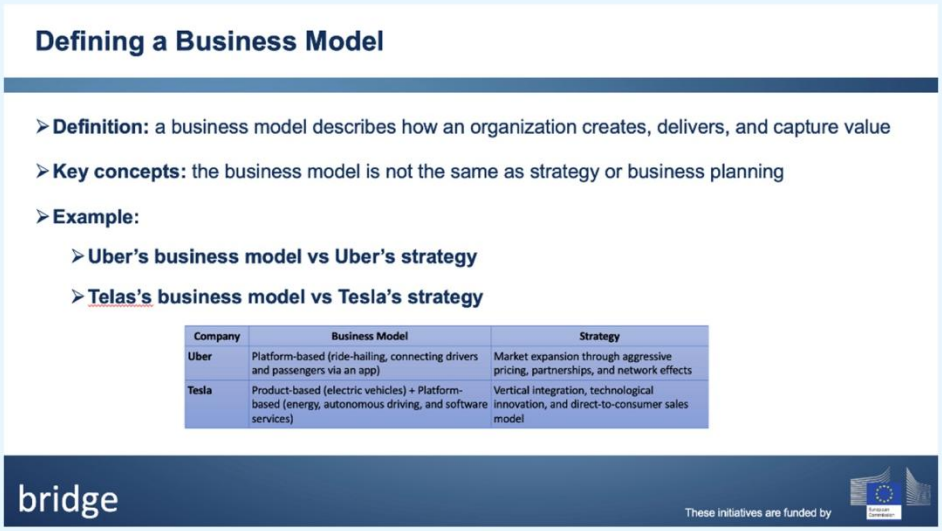


Figure 2.1: Business Model Definition

- **Key Elements and Types:** detailed presentations covered the fundamental components of business models and introduced participants to various business model archetypes relevant to their sector and project objectives (see Figure 2.2).

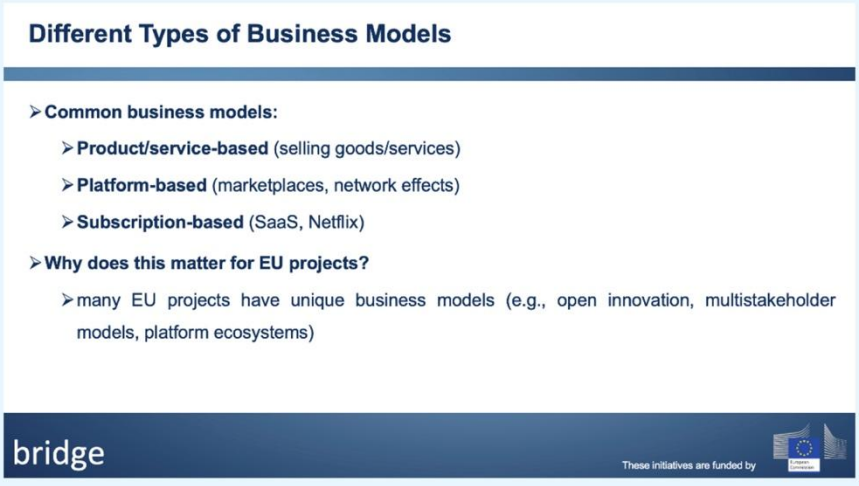


Figure 2.2: Different Types of Business Models

- **Practical Tool Introduction:** projects were introduced to a range of practical business model development tools, including the Business Model Canvas, Lean Canvas, Value Proposition Canvas, and specialised platform business model tools. Each tool was presented with context regarding its specific applications and advantages (see Table 2.1).

Table 2.1: Business Model Tools – Advantages and Disadvantages

Tools	Advantages	Disadvantages
Business Model Canvas	- Clear visual overview - Defines key business elements - Great for initial strategy	- Lacks external market analysis - Limited competitive insights
Value Proposition Canvas	- Customer-focused - Aligns products with needs - Enhances customer experience	- Overlooks internal processes - Focuses mainly on customer experience
Lean Canvas	- Ideal for startups - Highlights problem-solution fit - Focuses on competitive advantage	- Not suited for large organisations - Simplistic for complex business models
SWOT Analysis	- Quick strategic snapshot - Evaluates internal & external factors - Simple and widely used	- Static snapshot - Requires frequent updates
Porter's Value Chain	- Analyses value creation - Identifies efficiency improvements - Supports operational strategy	- Limited strategic & external focus - Doesn't assess competition
PESTLE Analysis	- Examines external business environment - Helps anticipate market changes	- Lacks internal business insights - Macro-level analysis only
Strategy Canvas	- Compares competitive positioning - Identifies differentiation opportunities	- Focuses on competition - Misses operational details
Value Builder System	- Enhances business value - Helps in acquisition preparation - Identifies key growth drivers	- Best for mature businesses - Not ideal for startups
McKinsey 7S Framework	- Holistic organisational view - Aligns seven business elements	- Lacks operational depth - More strategic than tactical
Four-Action Framework	- Encourages innovation - Challenges industry norms - Helps redefine business strategy	- Less effective in stable industries - Best for disruptive strategies
The Three Horizons Model	- Balances short-term and long-term strategy - Supports growth and innovation	- Lacks focus on daily operations - More suited for long-term planning
The PROMISE Model	- Comprehensive business assessment - Focuses on seven key growth drivers	- Best for long-term growth - Less useful for daily management

2.2.2 Detailed Methodology Framework

The methodology was designed to capture both quantitative and qualitative insights about business model development practices across the BRIDGE project portfolio. The approach recognised that business model development challenges vary significantly based on project maturity, stakeholder complexity, and technical focus areas.

Structured insights collection process: throughout the knowledge exchange process, participating projects were guided through structured discussions about their business model development experiences. Three key questions formed the foundation of the discussion:

1. **Tool Usage and Application:** which specific tools were employed by the project, and for what purposes or challenges were they applied? This question aimed to understand not just which tools projects used, but also how they were adapted and applied to specific contexts.

2. **Development Challenges and Obstacles:** what were the primary struggles or obstacles encountered during the business model development process? This explored both technical and organisational challenges, including stakeholder alignment, data availability, and market validation difficulties.

3. **Commercialisation Strategy and Intentions:** to what extent were projects considering commercial exploitation of their solutions or outcomes? This question assessed the practical applicability of the business models developed and their potential for real-world implementation.

Data Collection and Analysis Approach: each knowledge exchange session was structured to facilitate both presentation and interactive discussion. Projects presented their experiences, followed by guided discussion that allowed deeper exploration of challenges and solutions. Sessions were summarised to capture both explicit lessons learnt and implicit insights about effective practices.

Cross-Project Learning Framework: the methodology was designed to facilitate learning from individual project experiences, but from comparative analysis across different project types, development stages, and application domains. This approach enabled the identification of common patterns and transferable insights.

2.3 Knowledge Exchange Implementation Outcomes

First Knowledge Exchange Round (February 12, 2025): this session targeted new projects and provided the comprehensive business model introduction described above. Despite the interest of projects in attending this session, it was not possible to have proper presentations. In some cases, this also provided valuable insights about the challenges in engaging projects in early development phases and highlighted the need for alternative engagement strategies.

Second Knowledge Exchange Round (February 19, 2025): this session focused on projects in their mid-development phases and achieved significant participation. Five projects presented their business model development experiences and insights:

- **MASTERPIECE:** demonstrated comprehensive business model approach
- **Thumbs Up:** shared experiences with environmental analysis and stakeholder alignment
- **ENFLATE:** provided insights on value proposition development and partner engagement
- **SINNOGENES:** contributed lessons learnt about timing and business model initiation
- **GLocalFLEX:** presented planned approaches and coordination challenges

Third Knowledge Exchange Round (February 27, 2025): the final session targeted projects approaching completion and featured presentation of the **FLOW Project,** which provided insights into innovative approaches such as gamification for market validation and multi-stakeholder business model development.

This methodology enabled systematic collection of both qualitative insights and practical lessons learnt, while also identifying common patterns and challenges across different project types and development stages.

2.4 Insights and Lessons Learnt from Knowledge Exchange Rounds

The knowledge exchange rounds yielded substantial insights into the practical challenges and effective approaches for business model development within the BRIDGE context.

These findings provide both tactical guidance for specific tools and strategic recommendations.

2.4.1 Early-Stage Development Insights

Despite the lack of direct project presentations in the first knowledge exchange session, the preparatory discussions and subsequent projects' interactions revealed several critical challenges faced by projects in early development phases. The primary obstacle identified was the difficulty in obtaining quantitative data for business model validation, particularly from industrial partners who may be hesitant to share sensitive commercial information during early project stages.

Projects consistently reported challenges in cost estimation within realistic operational environments. To address this fundamental issue, the methodology recommends implementing sensitivity analysis as a standard practice, allowing projects to model various scenarios and understand the impact of uncertain variables on business model viability.

A structured process for business model development was shared during the sessions, which comprise several sequential steps: definition of desired outcomes, identification of key partners (their role and strategic intentions), definition and analysis of market size and segmentation, development of the business model canvas, and formulation of the go-to-market strategy. Actually, this approach was already successfully used in the ***OMEGA-X project***, where several business models were developed for the project's pilots and an overall business model for the OMEGA-X market place.

For projects dealing extensively with data-driven solutions, specialised adaptations of traditional business models tools were identified as needed[1][2][3]. Additionally, the need for a comprehensive data repository containing cost and revenue benchmarks for specific business model archetypes, such as flexibility provision services, was highlighted as a valuable resource for the broader BRIDGE community.

2.4.2 Mid-Term Development Project Insights

The second knowledge exchange session provided the richest set of insights, with five projects sharing detailed experiences and lessons learnt. Each project demonstrated unique approaches while facing similar fundamental changes.

THUMBS UP Project

This project employed a comprehensive analytical framework combining PESTLE analysis for macro-environment assessment. Porter´s Five Forces analysis for competitive environment evaluation, SWOT analysis for internal capability assessment, and the Business Model Canvas for overall framework development. The project’s primary challenges centred on aligning individual versus collective objectives among consortium partners, setting out clear business cases that satisfied all stakeholders, and identifying the specific purpose and role of each partner within the business model structure. Notably, the project had not yet confirmed commercialisation intentions, highlighting the ongoing nature of business model validation processes.

MASTERPIERCE Project

This project demonstrated a sophisticated approach using Business Model Canvas, SWOT, and PESTLE analysis while developing five distinct business model archetypes: self-consumption, third-party services, aggregator models, integrated energy services, and e-mobility solutions. The project faced significant challenges in conducting comprehensive market analysis, reconciling business model development at both pilot scale and key exploitable

[1] https://mcusercontent.com/b8180a8737507b2a8eb213d3c/files/7417ac0a-7fda-1831-6b9b-023081410bde/The_Data_Cooperation_Canvas.01.pdf
[2] https://internationaldataspaces.org/wp-content/uploads/dlm_uploads/IDSA-Position-Paper-Data-Spaces-Business-Models.pdf
[3] https://dssc.eu/space/bv15e/766064638/Business+Model

results (KER) level, and managing complex intellectual property rights considerations across multiple business model variants.

ENFLATE Project

Using the Value Proposition Canvas and Business Model Canvas tools, this project emphasised the critical importance of initiating business model definition as early as possible in the project life cycle. Their experience demonstrated the value of involving all consortium partners in business model creation processes, while also recognising that while the Business Model Canvas provides an excellent foundation, additional analytical elements must be considered for comprehensive business model development.

SINNOGENES Project

This project's experience reinforced the lesson learnt by **ENFLATE** regarding early initiation of business model work. Using primarily the Business Model Canvas, the project team recognised that earlier engagement with business model development would have provided more comprehensive insights and better integration with technical development activities

GLocalFLEX Project

This project planned a mixed-method approach combining qualitative tools (Business Model Canvas and Value Proposition Canvas) with quantitative analysis using e3 Value Tool. The project faced challenges requiring updates to existing business cases, establishing clear distinctions between different actors and their specific roles, and coordinating with pilot implementations to align their objectives with overall business model development goals.

Cross-Project Patterns and Recommendations

Several universal themes emerged from the mid-term project experiences. The critical importance of early business model initiation was emphasised by multiple projects, with recommendations to begin this work in parallel with technical development rather than as a subsequent activity. The value of involving all consortium partners in business model design was consistently highlighted. Projects specifically recommend organising dedicated workshops that bring together pilot leaders with business model experts, recognising that pilots possess the deepest operational knowledge while potentially lacking business model development expertise.

One significant recommendation that emerged was to develop specific business models for each pilot and each technology tool rather than to create a universal business model.

Before initiating business model development, projects consistently emphasised the need to clearly identify all stakeholders, determine their specific roles within the business model and understand their strategic intentions and motivations. While the Business Model Canvas and Value Proposition Canvas were identified as excellent starting points, they were noted to lack sufficient detail regarding external environmental factors and data use strategies.

The analysis also revealed that most of projects rely primarily on qualitative assessment tools for business model development, with limited use of quantitative validation methods. Projects were encouraged to create business models based on insights gained throughout the project life cycle, particularly when initial business models for specific tools or demonstrations proved unviable.

External validation emerged as a critical success factor, with projects strongly encouraged to engage external partners to confirm genuine market interest in developed solutions. The development of archetype business models was identified as particularly valuable for enabling replication and scaling across similar contexts.

2.4.3 Advanced-Stage Development Projects

The final knowledge sharing session, featuring the **FLOW** project, introduced innovative approaches to business model validation and development. The project demonstrated the application of gamification techniques to assess willingness to pay for specific services, providing a novel approach to market validation that engages end users in realistic decision-making scenarios.

The **FLOW** project developed distinct business models for different stakeholder categories (B2C, B2B, and B2B2C), recognising that different actors require fundamentally different value propositions and revenue models. This multi-stakeholder approach provided insights into the complexity of developing comprehensive business models for solutions that serve diverse market segments.

In this sense, projects were also advised to explore the value ratio approach that helps end users to better understand and quantify the value of their time and services within the business model context.

The **value ratio** expresses the relationship between the **value a customer perceives** in a product or service and the **effort, cost, or pain involved** in adopting it. It's especially relevant when designing or testing a business model, as it helps determine whether your offer is truly compelling for a specific target segment. More precisely, the value ratio compares the **adoption gains** (the total perceived benefits of switching to your solution) with the **adoption pains** (the total perceived costs, risks, or frictions involved in making the switch). It also reflects how well your offer matches the **customer's willingness to pay**, and their time, effort, and trust.

Practical Steps to Calculate the Value Ratio

1. **Summarise your value proposition** in one short sentence.
2. Use your **Market Segment Analysis** and **Persona Canvas** to visualise your **beachhead customer segment** at the moment of adoption.
3. Assess:
    a. What are the **resistance points** (cost, time, switching effort)?
    b. What **alternative** are they currently using?
    c. What are the **main benefits** of your solution, and how much would it save or add in value (in €)?
4. Then, calculate:

$$\textbf{Value Ratio} = \frac{\text{Sum of Adoption Gains (€)}}{\text{Sum of Adoption Pains (€)}}$$

Equation 2.1: Value Ratio Formula

Interpreting the Ratio

- A **10:1 ratio** is often used as a benchmark. It means your solution delivers **ten times more value** than the friction or cost of switching.
- If the ratio is **too low**, you should:

- Identify key adoption pains and reduce them;
- Enhance adoption gains by improving your value proposition;
- Possibly introduce incentives to tip the balance in your favour.

Why It Matters

The value ratio connects directly to the **core of your business model**: it helps you understand if your offer is **worth it** for your target customer. It also provides a tangible metric to test and refine your business model before launching or scaling. A strong value ratio increases the likelihood of **customer adoption**, **retention**, and ultimately, **sustainable profitability**.

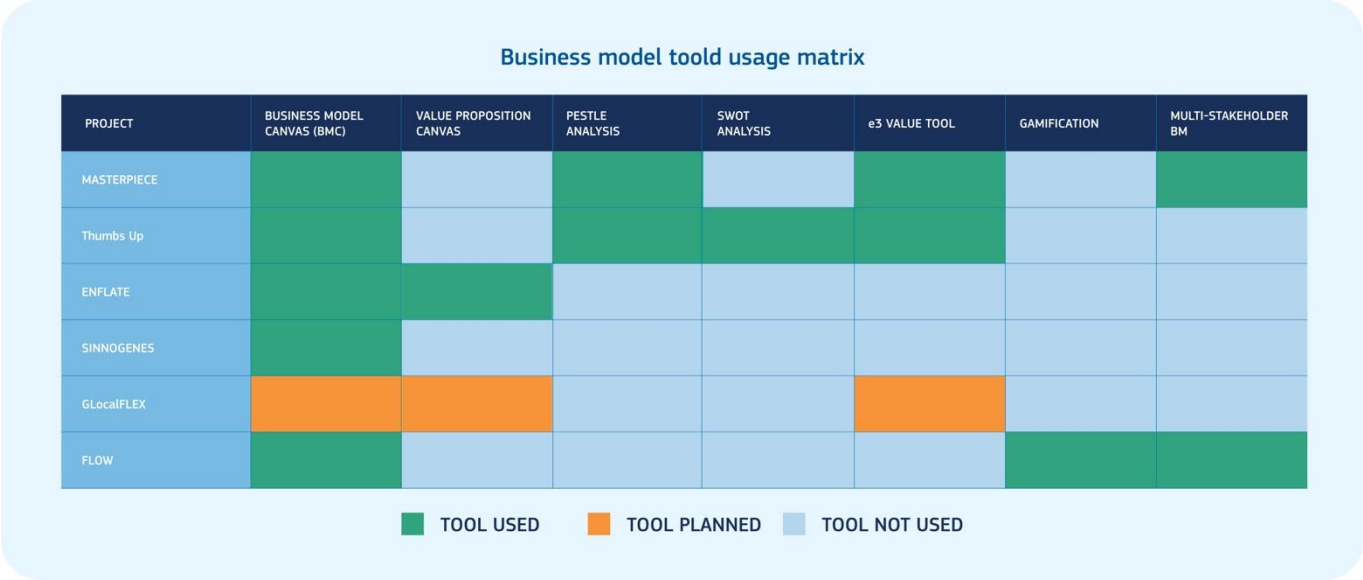


Figure 2.3: Synthesis of Common Challenges and Solutions

Across all knowledge sessions, several common challenges emerged that affect projects regardless of their development stage or technical focus. The fundamental question of how to effectively monetise the solutions developed appeared consistently, highlighting the ongoing challenge of translating technical innovation into sustainable business value.

Stakeholder engagement and alignment represented another common challenge, with projects struggling to involve all relevant parties in business model creation while managing diverse and sometimes conflicting interests and objectives.

The qualification of business models emerged as a persistent difficulty, with most projects lacking access to reliable market data, cost benchmarks, and revenue projections necessary for robust business model validation.

These insights collectively point towards the need for enhanced support tools, standardised methodologies, and shared resources to improve business model development effectiveness across the BRIDGE project portfolio.

2.5 Conclusions and next steps of Task 1

The systematic investigation of business model development tools and practices across the BRIDGE project portfolio has yielded significant insights that illuminate both the current state of business model development and the pathways for improvement. The methodology successfully captured perspectives from projects across the entire

development life cycle, providing a comprehensive understanding of challenges, effective practices, and opportunities for enhancement.

2.5.1 Key Findings Summary

The knowledge sessions revealed several fundamental conclusions about business model development within the BRIDGE context. Most notably, common adoption of the Business Model Canvas across all participating projects demonstrates its effectiveness as a foundational framework, while simultaneously highlighting the need for complementary tools and approaches to address specific project requirements and development stages.

The timing of business model initiation emerged as a critical success factor, with projects consistently emphasising that business model development should begin in parallel with technical development rather than as a subsequent activity. This early integration enables better alignment between technical capabilities and market opportunities, ultimately leading to more robust and implementable business models.

Stakeholder engagement and alignment represent both the greatest opportunity and the most significant challenge in business model development. It was demonstrated that involving all consortium partners in business model creation processes yields superior outcomes, but also revealed the complexity of managing diverse interests, knowledge levels, and strategic objectives across multi-partner initiatives. A persistent gap between qualitative business model development and quantitative validation was also identified. While projects effectively utilise qualitative frameworks for conceptualising business models, most struggle with numerical validation, market sizing, and financial modelling. This gap limits the practical applicability of developed business models and their potential for successful commercialisation.

2.5.2 Universal Challenges and Patterns

Three universal challenges emerged consistently across all projects, regardless of their development stage, technical focus, or consortium composition.

The fundamental question of how to effectively monetise developed solutions appeared in every knowledge exchange round, highlighting the ongoing difficulty of translating technical innovation into sustainable business value propositions.

Stakeholder engagement and coordination challenges manifested in various forms, from aligning individual versus collective objectives to defining clear roles and responsibilities within business models. These challenges reflect the inherent complexity of multi-partner research and innovation projects, where technical collaboration must evolve into commercial partnership models.

The quantification of business models also presented persistent difficulties, with projects lacking access to reliable market data, cost benchmarks, and revenue projections necessary for robust validation. This challenge extends beyond simple data availability to encompass fundamental questions about market readiness, competitive positioning, and value proposition differentiation.

2.5.3 Effective Practices and Success Factors

Despite the challenges identified, several effective practices that contributed to successful business model development outcomes were also revealed.

The development of specific business models for individual pilots and tools, rather than more generalised solutions, proved to be a particularly valuable approach that enabled better customisation and higher relevance to specific use cases.

External validation emerged as a critical success factor, with projects that engaged external partners and potential customers achieving more realistic and implementable business models. This validation process not only confirms market interest but also provides essential feedback for refining value propositions and revenue models.

The combination of multiple analytical tools, particularly environmental analysis frameworks (PESTLE, Porter's Five Forces) with business model frameworks (BMC, Value Proposition Canvas), provided projects with more comprehensive understanding of their operating context and competitive positioning.

2.5.4 Innovation and Emerging Approaches

Several innovative approaches were identified that demonstrate the evolving nature of business model development within the BRIDGE community. Gamification techniques for market validation, as demonstrated by the FLOW project, represent a promising approach for obtaining realistic consumer preference data, while engaging stakeholders in meaningful decision-making scenarios.

The development of archetype business models, as exemplified by the MASTERPIECE project's five distinct models, provides a scalable approach that enables knowledge transfer and replication across similar contexts. This approach balances the need for customisation with the efficiency of standardised frameworks.

Multi-stakeholder business model development, addressing B2C, B2B, and B2B2C scenarios simultaneously, reflects the complex market realities faced by many BRIDGE projects and provides a template for comprehensive market approach strategies.

2.5.5 Next Steps and Strategic Recommendations

Building upon the comprehensive insights gathered, Task 1 of the BRIDGE Business Models Working Group can now move towards active support and guidance for ongoing and future projects (see Figure 2.4). The next phase of work should focus on transforming identified challenges into opportunities for change and creating systematic support mechanisms that enhance business model development effectiveness across the BRIDGE portfolio.

Figure 2.4: Strategic Evolution – From Investigation to Impact

Shift Towards Active Project Support

Rather than continuing to document additional tools and challenges, the focus should now shift towards creating engaging, practical support mechanisms that guide projects through business model development processes in ways that are efficient and effective. This approach recognises that business model development is often underestimated in terms of its relevance to overall project outcomes.

Active support should prioritise making business model development processes more engaging and meaningful for project teams, moving away from compliance-driven approaches and towards value-creating activities, leading to project success and market impact.

Integration of Artificial Intelligence and Digital Tools

As emphasised during the General Assembly discussions, the integration of artificial intelligence capabilities represents a crucial opportunity for enhancing business model development support. AI-powered tools can address several of the persistent challenges identified through this investigation, particularly in areas of market analysis, competitive intelligence, and quantitative validation.

AI applications can provide projects with enhanced capabilities for market sizing, competitive analysis, and financial modelling, addressing the quantification challenges consistently highlighted across the knowledge exchange rounds. Additionally, AI-powered recommendation systems can guide projects towards appropriate tool selection and best-match methodological approaches based on their specific characteristics and development stage.

The development of AI-enhanced business model development platforms could provide personalised guidance, automated benchmarking against industry standards, and real-time validation of business model assumptions against market data and trends.

Enhanced Support Framework Development

The next phase of Task 1 should focus on developing comprehensive support frameworks that address the specific needs and challenges identified through the investigation. This includes creating structured guidance for early-stage business model initiation, providing templates and methodologies for stakeholder engagement and alignment, and developing tools for quantitative business model validation.

Support mechanisms should be designed to accommodate the diverse needs of different project types, development stages, and technical focus areas while maintaining consistency in quality and approach. This requires developing modular support components that can be customised and combined according to specific project requirements.

Knowledge Transfer and Capacity Building

Significant variation in business model development expertise across projects was recognised, highlighting the need for integrating explicit business modelling competences and/or systematic capacity building initiatives. Future activities should include developing comprehensive training programmes, creating mentorship networks that connect experienced practitioners with projects in early-stage business model development, and establishing communities of practice that facilitate ongoing knowledge exchange.

This capacity building should focus not only on tool use but also on strategic thinking, market analysis capabilities, and commercial evaluation skills that enable projects to independently assess and refine their business models throughout the development process.

Validation and Implementation Support

Moving beyond business model development towards validation and implementation support represents a critical next step. This includes developing frameworks for external market validation, creating networks of industry partners and potential customers for business model testing, and providing guidance for transitioning from research-phase business models towards commercial implementation.

Support for development of intellectual property strategy, partnership structuring, and go-to-market planning should be integrated into the overall business model development support framework.

Measurement and Continuous Improvement

The final component of the next phase should establish systematic measurement and evaluation mechanisms that track the effectiveness of business model development support activities and enable continuous improvement of methodologies and tools. This includes developing metrics for business model quality, implementation success rates, and commercial impact achievement.

Regular evaluation cycles should assess both the immediate effectiveness of support activities and the longer-term commercial outcomes achieved by projects, enabling refinement of approaches and identification of emerging best practices that can be integrated into the overall support framework.

Through this active support phase, Task 1 can establish a foundation for sustained excellence in business model development across the programme portfolio.

3. Task 2: Methods for quantifying the costs/benefits of the services and solutions of the business model (under various use-case scenarios)

Task 2 quantified the benefits of services and solutions in the energy sector across various use cases. It employed several methodologies tailored to specific business models and the sector's specific challenges.

These methodologies focused on economic, environmental, and social benefits to provide a holistic understanding of the value that was generated.

Ultimately, Task 2 established a standardised methodology for the quantitative analysis of business models, creating a consistent process that integrates these quantification methods with existing tools.

3.1 Methodology

The work methodology for this task included the following activities:

- **Task 2 Meetings:** Meetings were held with representatives from various European projects to understand their perspectives and gather insights.
- **Project Presentations:** Short presentations on business model quantification methods were delivered by participating projects. This allowed for an exchange of knowledge and best practices.
- **Online Survey:** An online survey was conducted among the projects to collect quantitative and qualitative data. Subsequently, the survey results were analysed using rigorous integrity checks and mapping techniques for visualisation.
- **Literature Review:** A literature review of public deliverables was performed to better understand the topic. This review identified best practices and emerging concepts related to the task.
- **Analysis of Innovative Products and Services:** An analysis of innovative products and services was undertaken to determine their value proposition in terms of potential economic, social, and environmental benefits.
- **Review of Quantification Practices:** The effectiveness of current quantification practices in capturing and measuring associated costs and benefits was assessed.
- **Identification of Gaps and Barriers:** Gaps and barriers were identified, providing insights into potential challenges and areas requiring further attention.

3.2 Scope of work and key findings

As part of Task 2 activities, we held a comprehensive survey and a final workshop, in parallel with the subgroup workshop meetings and discussions.

Overview of Task 2 Survey Questions

The survey, which was divided into **the five sections** detailed below, aimed to collect insights concerning:

- Methodologies for business model development
- Approaches to quantification and data valorisation
- Challenges, gaps, and recommendations for future improvements

Section 1: General Information

- Project Name.
- Coordinating Institution
- Project Duration (Start and End Dates)
- Brief Description of the Project Scope
- Target Groups (e.g., consumers, energy providers, policymakers)
- Contact Information for the Survey Respondent

Section 2: Standardised Processes

- What methodologies or tools are you using to develop your business models?
- Have you implemented any standardised processes in your project?
- What challenges do you face in adopting standardised processes?
- Are there any specific areas where standardisation would benefit your project?

Section 3: Business Model Quantification

- Which quantification methods (e.g., Cost-Benefit Analysis, ROI, etc.) are you using?
- How do you measure the economic, social, and environmental impacts of your solutions?
- Have you faced barriers in applying quantification methods?
- What improvements would enhance quantification efforts in your projects?

Section 4: Data Valorisation

- How does your project manage and utilise data for business model development?
- Are you integrating data valorisation into your business models?
- What challenges do you encounter in data management (e.g., privacy, ownership)?
- What resources or tools would improve data valorisation?

Section 5: Recommendations and Feedback

- What recommendations would you make for improving business model development within BRIDGE projects?
- Are there additional topics or activities Task 2 should address in the future?

Results Overview

This survey captured insights from 17 European research projects (as shown in the table below) regarding their approaches to developing and quantifying business models.

Table 3.1: List of projects participating in the online survey

Project Name	Project Duration (Start and End Dates)
GLOCALFLEX	01/01/2023 – 31/12/2026
DRIVE2X	01/01/2023 – 31/12/2026
SENERGY NETS	01/09/2022 – 31/08/2026
R2D2	01/10/2022 – 30/09/2025

WEFORMING	01/10/2023 – 30/09/2026
OPENTUNITY	01/01/2023 – 31/12/2026
ODEON	01/01/2024 – 31/12/2027
INDEPENDENT	01/09/2024 – 30/09/2027
ECHO	01/01/2023 – 31/12/2026
BEST-STORAGE	01/01/2023 – 31/12/2026
EVELIXIA	01/10/2023 – 30/09/2027
RE-EMPOWERED	01/07/2021 – 31/12/2024
BEFLEXIBLE	01/09/2022 – 31/08/2026
DIGITISE	01/06/2024 – 31/05/2027
AIR4NRG	01/01/2024 – 31/12/2026
PEDVOLUTION	01/01/2024 – 31/12/2026
HARMONISE	01/06/2024 – 31/12/2027

The responses highlight common methodologies, quantification techniques, and the challenges encountered. The following analysis details the **key findings** from the survey, supported by visual representations of the data.

1. Business Model Development Methodologies: A Strong Preference for Canvas Models

A majority of the surveyed projects rely on well-established visual tools to develop their business models. The Business Model Canvas (BMC) was the most popular choice, cited by 10 of the 17 projects. The Value Proposition Canvas (VPC) was also frequently used, often in conjunction with the BMC, by 5 projects. This indicates a strong preference for structured, visual, and stakeholder-centric methodologies.

Other tools mentioned include the Lean Model Canvas, SWOT analysis, and cash-flow models, suggesting that projects also incorporate strategic and financial planning into their business model development. A few projects were in their early stages and had not yet selected tools, while others used a combination of methods, such as tailored questionnaires and co-creation workshops.

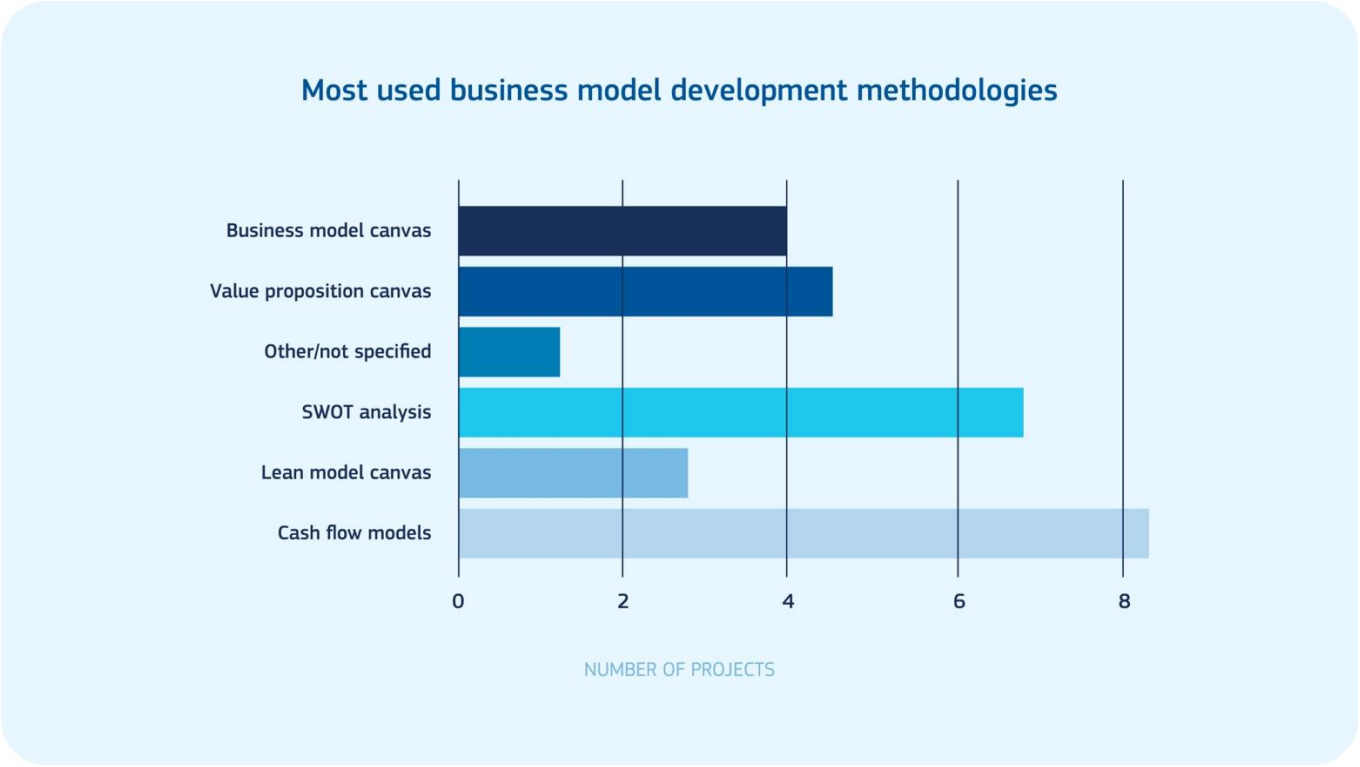


Figure 3.1: Chart for "Most Used Business Model Development Methodologies"

2. Quantification of Business Models: A Mix of Financial and Economic Analysis

To quantify the value of their business models, projects employ a variety of methods. **CBA** and **ROI** were the most frequently cited, used by 6 and 5 projects, respectively. This highlights a strong focus on assessing the economic viability and financial returns of the proposed solutions.

Other common methods included **Net Present Value (NPV)**, **Internal Rate of Return (IRR)**, and **Life Cycle Assessment (LCA)**. The application of LCA and **Techno-economic Analysis (TEA)** suggests that projects also consider broader environmental and technical aspects in their value assessments. Several projects were still setting out their quantification strategies, which indicates this activity is often addressed later in the project life cycle.

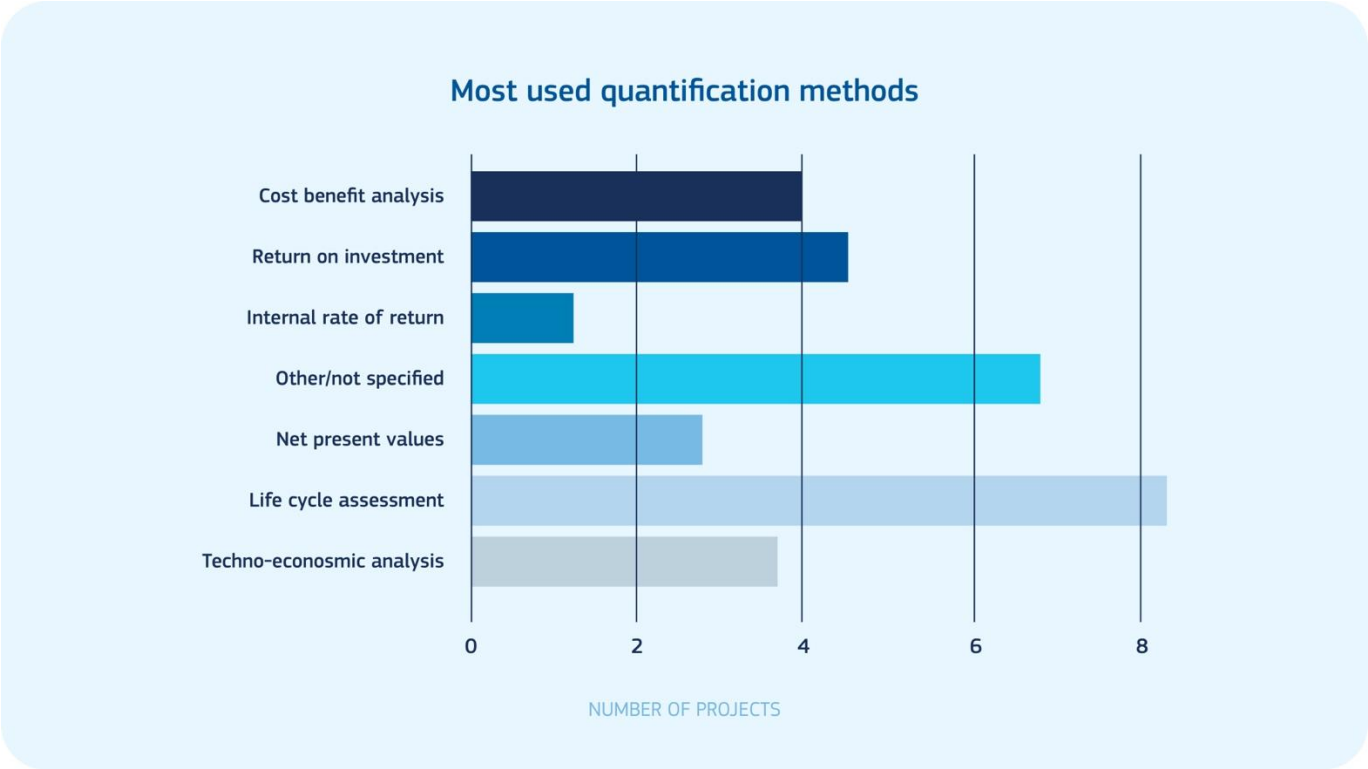


Figure 3.2: Chart for "Most Used Quantification Methods"

3. Challenges in Adopting Standardised Processes: A Call for Flexibility and Better Data

The survey reveals a range of challenges that projects face when adopting standardised processes for business model development. A significant number of respondents point to the **inadequacy and inflexibility of existing standards**, which often fail to capture the specificities of the energy sector and innovative R&D projects. Standardised models are sometimes seen as too simplistic and not easily adaptable to different national contexts and regulatory frameworks.

Another major hurdle is related to **data**. Projects report difficulties with **data availability, quality, and sharing**, which are crucial for both developing and quantifying business models. **Project and technology immaturity** is also a key challenge, with early-stage technologies and low-TRL projects facing high uncertainty, making it difficult to define and quantify business model components. The unique context and variability of each R&D project also make a one-size-fits-all approach to business model development challenging.

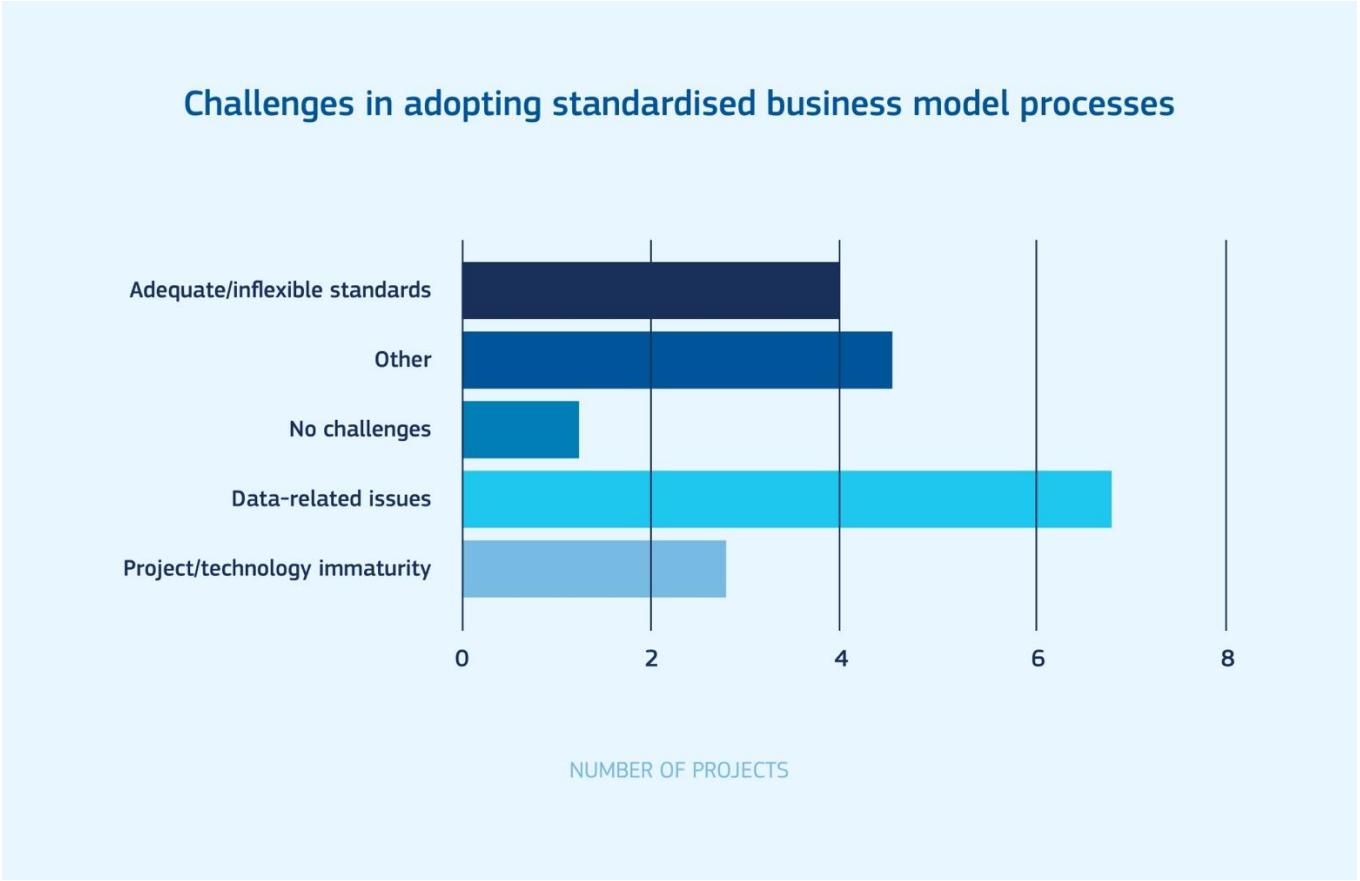


Figure 3.3: Chart for "Challenges in Adopting Standardised Business Model Processes" Conclusion

The survey provides a valuable snapshot of the current practices in business model development within EU research projects in the energy sector and naturally within the BRIDGE Initiative. While there is a clear trend towards using established tools like the BMC, the responses also underscore the need for more flexible and adaptable methodologies. The challenges related to data and the inherent uncertainty of R&D projects highlight the need for more robust support and guidance in these areas. The findings suggest that while standardisation can be beneficial, it must be balanced with the need for customisation and adaptation to the unique context of each project. Future initiatives could focus on developing more tailored frameworks and providing better access to data and tools to support projects in creating sustainable and impactful business models.

Overview of Task 2 final workshop

The Task 2 final workshop, held on March 6, 2025, focused on consolidating insights and experiences from the participating EU-funded projects around three major themes: the standardisation of business model development processes, the quantification of business model value and impacts, and the integration of data valorisation practices into business models. During the workshop the results of the Task 2 survey served as the basis for targeted discussions.

The opening session provided a synthesis of survey results, revealing that while most projects employ widely known tools such as the BMC or VPC, their application remains inconsistent across the board. This inconsistency hampers the comparability of outcomes and the replicability of business model innovations. Participants highlighted the need for common terminologies, shared templates, and harmonised structures to support more coherent and scalable business model development across the BRIDGE ecosystem. It was proposed that BRIDGE consider developing a common methodology or library of business models that can act as reference points for both ongoing and future projects.

A major theme of the workshop was the challenge of quantifying the value and impact of business models in a consistent and meaningful way. Although methodologies such as CBA, ROI, and Social Return on Investment (SROI)

were mentioned frequently, their actual implementation remains partial or qualitative. Projects struggle to measure social and environmental benefits in addition to economic returns, and there is often a disconnect between technical KPIs and business value creation. Participants called for clearer quantification frameworks and more consistent use of cross-sector KPIs. The importance of modularity and scalability in these methods was also emphasised, particularly given the diversity of TRLs (technology readiness levels) and market contexts involved in BRIDGE projects.

In response to these challenges, the SENERGY NETS project was presented as a leading example of an integrated value creation methodology. This approach assesses business models across three dimensions (socio-economic, environmental, and technical-economic) and was validated through its pilots. The methodology uses stakeholder analysis, environmental impact assessment frameworks like Driver-Pressure-State-Impact-Response (DPSIR), and techno-economic modelling to capture the full spectrum of value creation. The visual presentation of its architecture underscored the benefits of modular assessment layers and the alignment of quantitative results with societal and policy goals.

The workshop also addressed the increasingly important issue of data valorisation. Many projects produce significant volumes of data but face structural challenges in extracting value from it. These include uncertainties around data ownership, regulatory compliance—particularly with GDPR and FAIR principles—and a general lack of methodologies for assessing the monetary or strategic value of data. Discussions suggested that energy data spaces and federated digital twins could serve as enabling infrastructures for data valorisation, providing secure, interoperable platforms that facilitate new service models. Participants agreed on the need to embed data strategies into the business model layer from the outset rather than treat them as an afterthought.

Furthermore, the workshop explored how emerging concepts like energy data spaces and federated digital twins could be integrated into future business models. While these concepts are gaining traction, their definitions and technical frameworks are still evolving, leaving many project teams uncertain about how to apply them in practice. There was strong interest in receiving further guidance, use case examples, and alignment between BRIDGE working groups to better operationalise these innovations.

In conclusion, the workshop emphasised the urgent need for structured knowledge sharing, the development of harmonised tools for business model design and quantification, and the advancement of data valorisation methodologies. Participants recommended that Task 2 continue to foster collaborative work, expand the business model knowledge base, and support cross-WG efforts to ensure BRIDGE projects can design, quantify, and scale innovative energy business models with greater consistency and impact.

3.3 Business Models Quantification Approaches

Quantifying the benefits of services and solutions in the energy domain requires tailored methodologies that address specific business models and sectoral challenges. These methods typically focus on economic, environmental, and social benefits to provide a holistic understanding of the generated value.

The following quantification methodologies are applied within BRIDGE projects:

- **Cost-Benefit Analysis (CBA):** Used to measure and compare the total costs of a project against its total economic, social, and environmental benefits.
- **Life Cycle Assessment (LCA):** Systematically assesses the potential environmental impacts of a product or service throughout its entire life cycle.
- **Return on Investment (ROI):** Identifies the financial return from an investment relative to its cost.
- **Multi-Criteria Decision Analysis (MCDA):** Employs a structured assessment of conflicting factors to evaluate the optimal choice among several alternatives.

- **Social Return on Investment (SROI):** Measures social, economic, and environmental value to assess impact beyond purely financial metrics.
- **Scenario Analysis:** Evaluates possible future events to predict potential outcomes and understand a portfolio's value under various circumstances.
- **Energy Performance Contracting (EPC):** A financing model for energy efficiency measures where cost savings are used to repay the initial investment.

Analysis shows that projects often use a combination of these methods, with a strong emphasis on CBA and ROI for economic assessment. Key challenges identified include obtaining reliable data and ensuring the comprehensive measurement of all relevant impacts. Consequently, improvements are needed in data availability, granularity, and the development of standardised reporting frameworks.

3.4 The SENERGY NETS Approach to Value Creation Assessment

SENERGY NETS aims to demonstrate the potential benefits of integrating electricity, gas, heating and cooling systems into existing district heating and cooling networks. The aim is to improve energy supply management in terms of energy consumption, infrastructure maintenance and cost reduction in three demonstrators located in Milan, Ljubljana and Paris and 2 case studies in Spain and Sweden for simulating replicability.

SENERGY NETS is developing a comprehensive methodology to assess the value generated through the implementation of various flexibility measures across the three demonstrator sites. This methodology is structured around three core pillars of value: techno-economic, socio-economic, and environmental. Each pillar applies a distinct evaluation method tailored to its specific focus, and the outcomes of each will ultimately be aggregated and weighted to produce an overall value assessment.

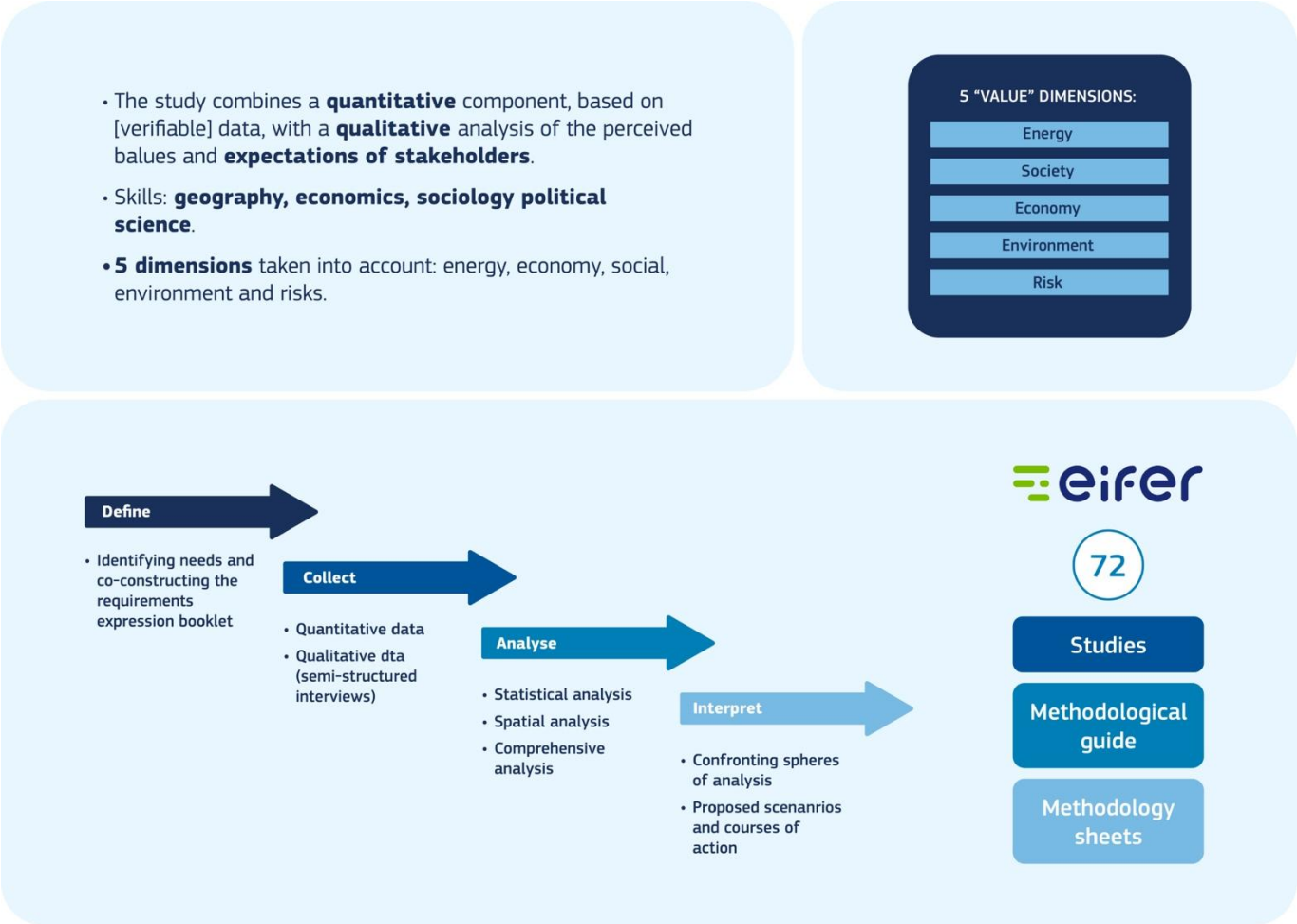


Figure 3.4: The generic method: qualify, quantify (& monetise)

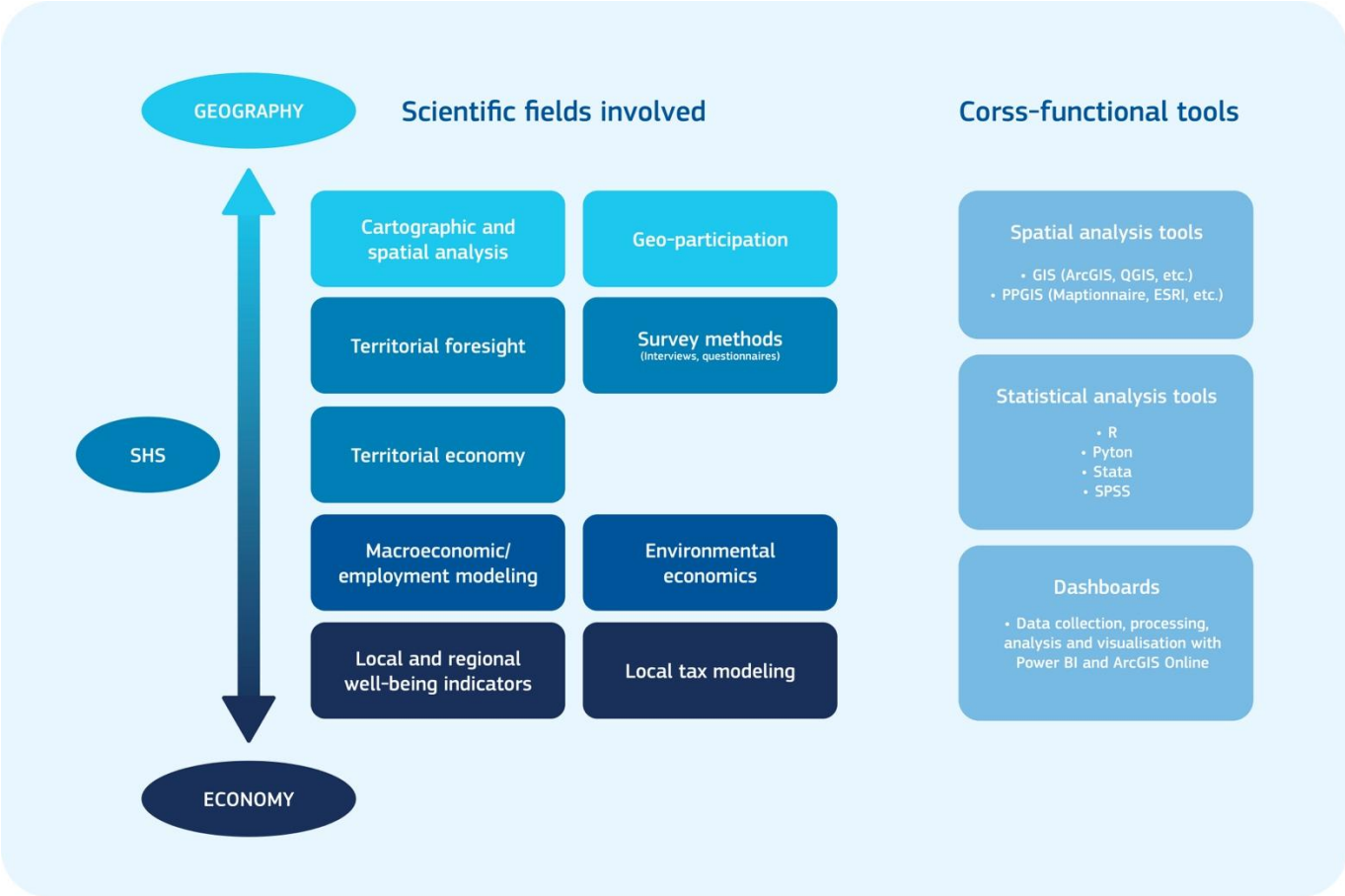


Figure 3.5: Competences and tools mobilised for the territorial value creation approach

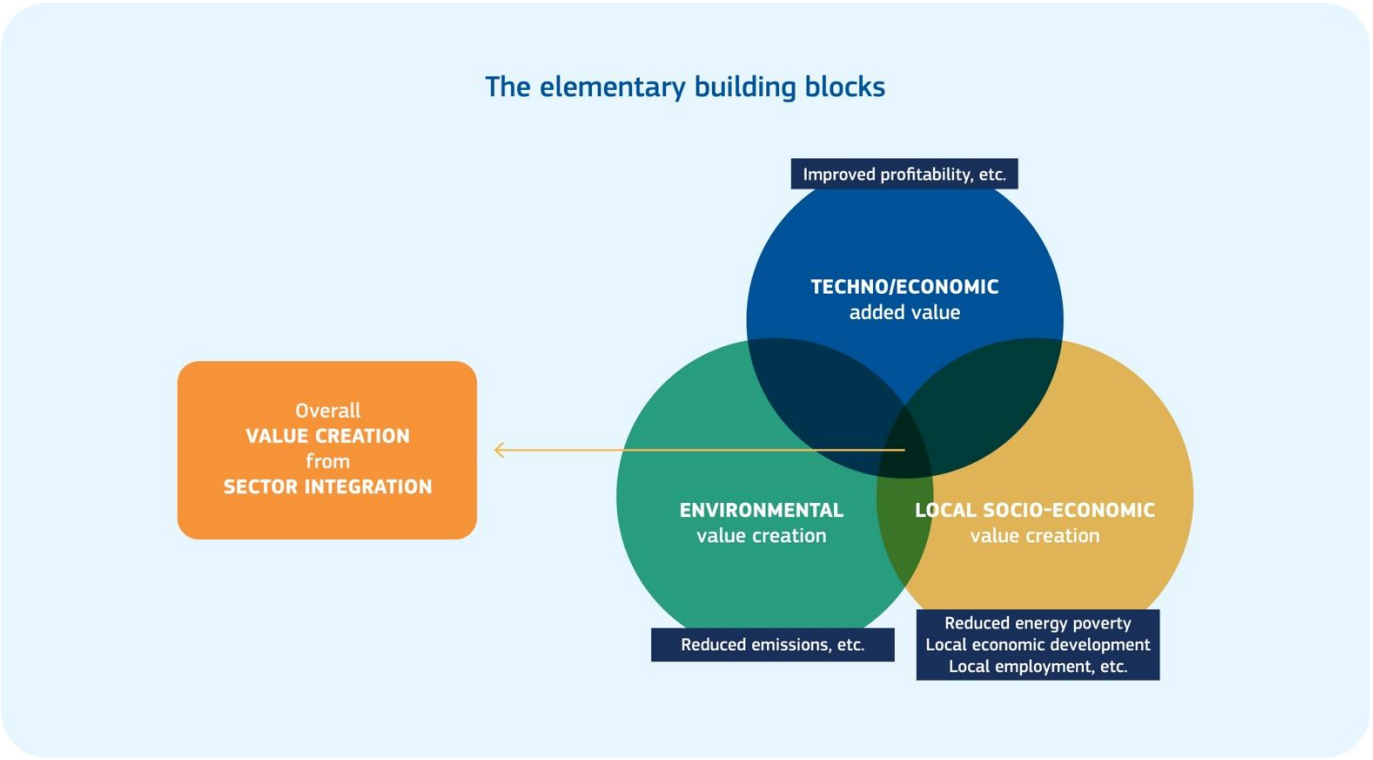


Figure 3.6: Value creation architecture

The techno-economic pillar involves setting out and measuring a set of KPIs with the demonstrator teams. These indicators are evaluated before, during, and after the deployment of flexibility measures. One of the main challenges in this pillar has been reaching consensus on a relevant and meaningful list of KPIs, as well as collecting the necessary data.

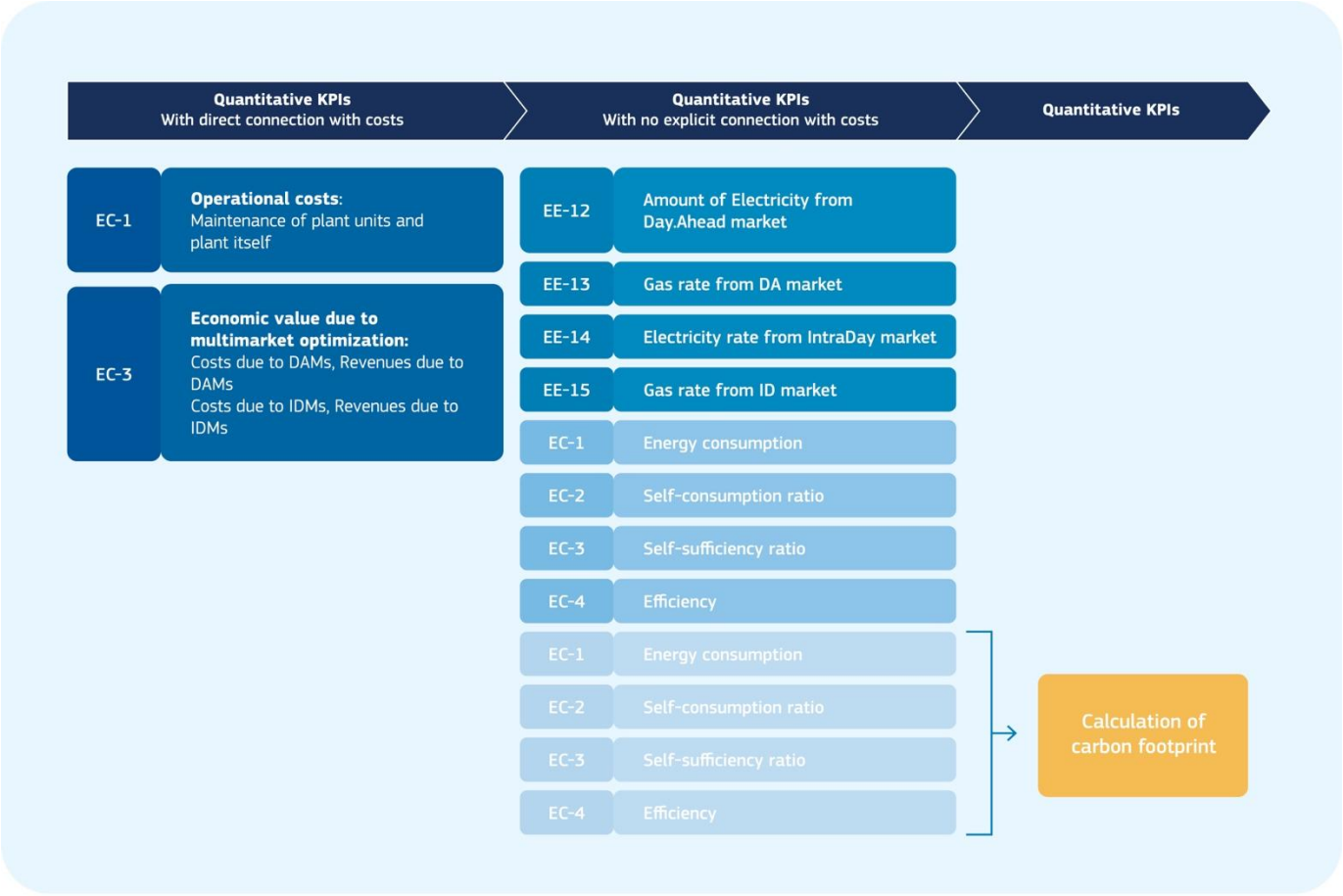


Figure 3.7: Techno-economic dimension

The socio-economic pillar relies on a combination of qualitative and quantitative data collection. Interviews and questionnaires provide valuable input from stakeholders, while additional data is sourced from the demonstrators and publicly available datasets. Challenges in this area include accounting for the cultural and contextual differences across projects, securing access to appropriate data, and raising awareness among operational partners, who often focus on technical aspects, about the importance of socio-economic impacts.

Figure 3.8: Socio-economic dimension – methodology

The environmental pillar employs a model developed internally by RSE, which translates emissions into monetary values by quantifying their impact on air quality, public health, and overall quality of life. The principal obstacle here is the acquisition of sufficient and reliable data to feed into the model.

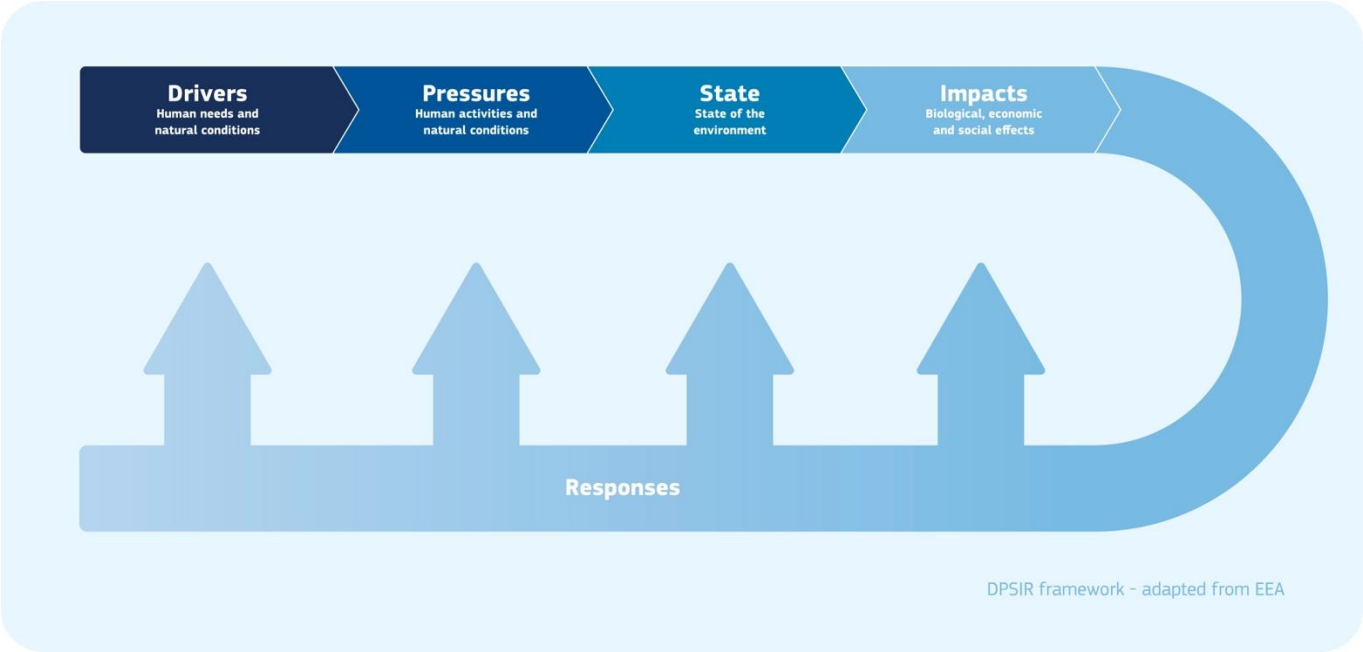


Figure 3.9: The environmental dimension – DPSIR framework

On a broader level, a major anticipated challenge is the integration of qualitative and quantitative data from all three pillars to produce a comprehensive and coherent value assessment. However, this step cannot yet be undertaken, as the project is still in the data collection phase. One general area for improvement already identified is the need for greater involvement of operational partners to facilitate timely access to data and ensure effective implementation of the assessment methodology.

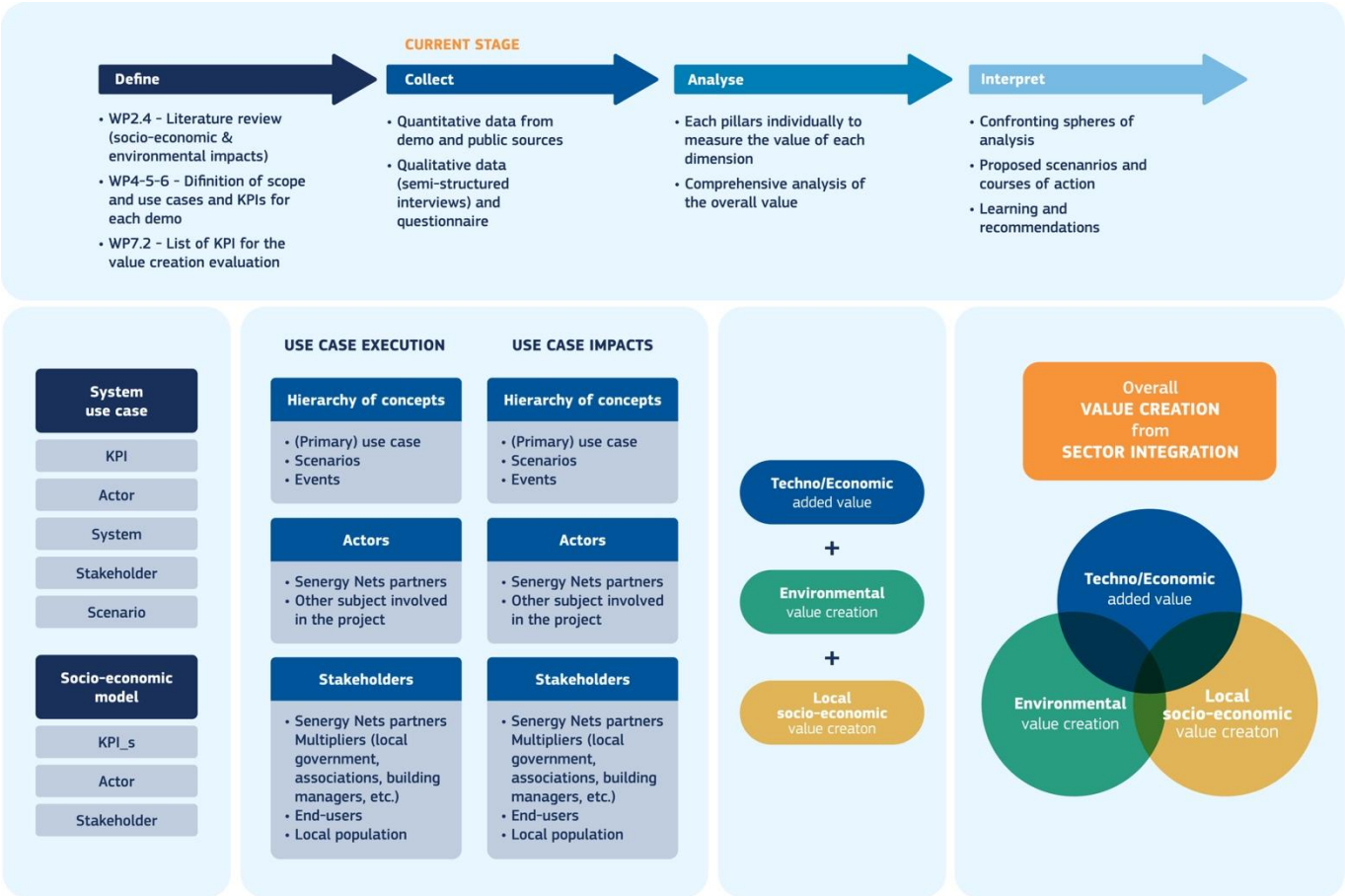


Figure 3.10: Adaptation of the generic method to SENERGY NETS

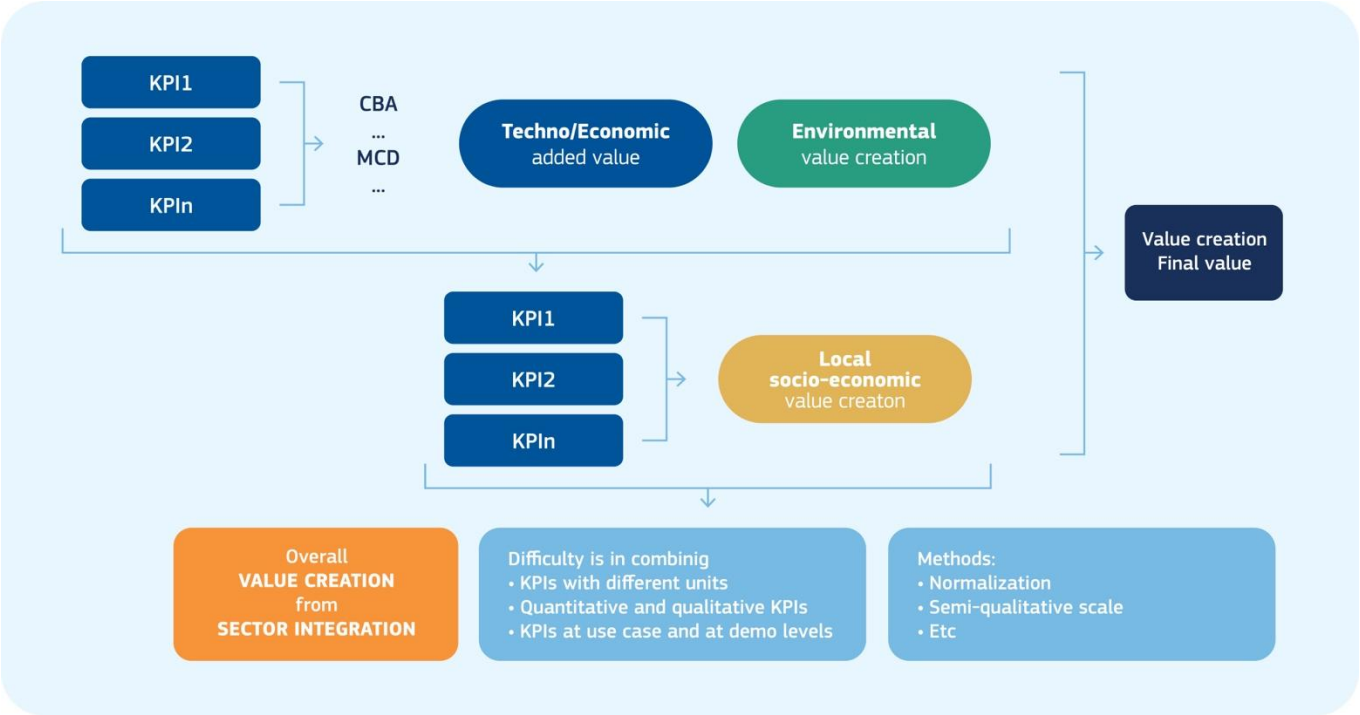


Figure 3.11: Overview of the methods in development in SENERGY NETS.

3.5 Lessons learnt from participating projects

The projects participating in the survey target a diverse range of stakeholder groups. Core target groups include system operators, technology providers, aggregators, and energy communities, alongside policy makers, regulators, and municipalities. Many projects also focus on engaging end users, both residential and commercial, to ensure that the solutions developed are user-centric and socially inclusive. Some projects aim to support market actors such as retailers and flexibility service providers, while others prioritise public institutions or research and academic stakeholders involved in shaping regulatory frameworks and innovation pathways. This broad spectrum highlights the ambition of BRIDGE projects to address the needs of both technical and non-technical stakeholders across the energy value chain.

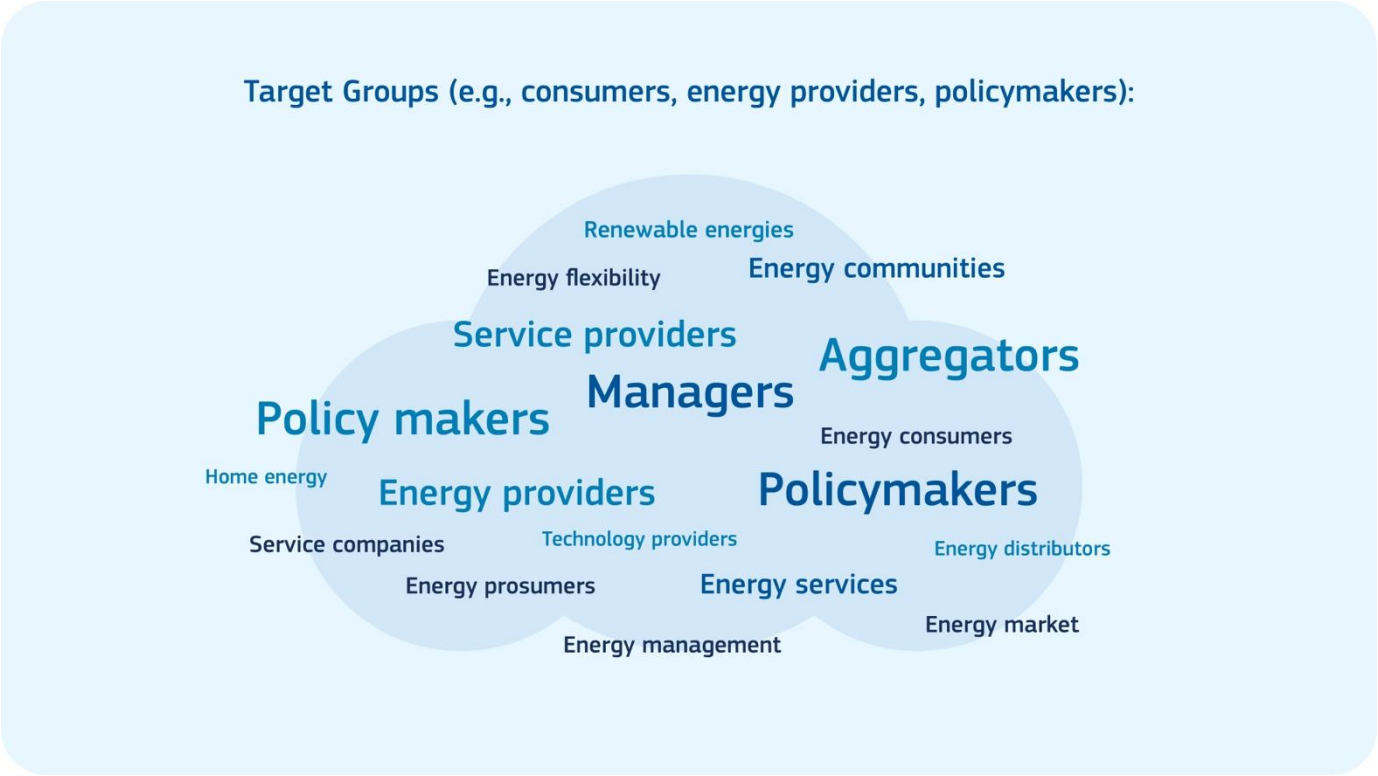


Figure 3.12: Target groups of the participating projects

The following table summarises the survey answers related to the quantification methods used by the projects.

Table 3.2: Survey answers related to the quantification methods used by the projects

Project Name	Which quantification methods (e.g., Cost-Benefit Analysis, Return on Investment, Social Return on Investment, etc.) are you using in your project?
GLOCALFLEX	We plan to use Cost-Benefit Analysis, based on the e3value (The Value Engineers.nl, e3 Value Model - Service Science) methodology.
DRIVE2X	None
SENERGY NETS	WP7 is developing a comprehensive methodology to evaluate the value created from implementing different flexibility measures in 3 demonstrators (Paris, Ljubljana and Milan). For that, values are classified in 3 pillars: the technical-economic, the socio-economic and the environment. All three pillars are using a different method to measure the value created and at the end, they will be put together and weighted to have a general value.
R2D2	Cost-Benefit Analysis

WEFORMING	Return on Investment, Net Present Value, Internal Rate of Return (IRR), Payback Period.
OPENTUNITY	We have not reached this stage yet, but our idea is to use a Financial Analysis tackling key metrics like ROI, IRR and NPV for quantifying the technologies. For quantifying the Pilot Sites, probably we will use CBA.
ODEON	Cost-Benefit Analysis with output parameters Net present value (NPV) and internal rate of return (IRR)
INDEPENDENT	We use Return on Investment as a quantification method in INDEPENDENT project. As one of the key performance indicators (KPI15), the target of the Return on Investment in DSFM business models is quantified at 10% at the end of the project and raises to 15% in +6-10 years.
ECHO	At this stage this is not yet decided. But cost-benefit analysis and return on investment of the products and the service will be defined based on the results of the demonstration cases; also LCA and LCC will be performed on the developed storage systems.
BEST-STORAGE	TEA analysis which will include a plethora of economic KPIs (ROI, PP, CBA). Our approach establishes reservation prices based on consumer and market expectations for payback (PP). PP functions are then inversed on the basis of observed technology performance during the project in order to establish what type of pricing policies can be applied.
EVELIXIA	At the moment, we haven't used any quantification method. At a later stage, we will decide which approach fits best for our pilots.
RE-EMPOWERED	The quantification of the business models, for each Demo Site, except for the Kythnos Island Demo Site, has been based on the elaboration of cash-flow models, based on the following information: • Investment cost of the Demo Site, or of the implementation of the ecoTools designed in RE-EMPOWERED in the Demo Site. • Operation and maintenance costs for the Demo Site and/or the ecoTools, yearly. • Revenues for the Demo Site, from the provision of services (mainly, the sale of electricity or heat to

	clients). • Depreciation and amortisation costs. • Corporate taxes. Based on the cash flows, the following economic parameters have been obtained: Net present value, Internal rate of return and Payback.
BEFLEXIBLE	In BeFlexible, the outcomes of implementing different business models and flexibility solutions are quantified using a comprehensive approach that includes a cost-benefit analysis to evaluate the financial viability of the proposed solutions, a scalability and replicability analysis, and an assessment of the implementation challenges. The cost-benefit analysis is used to evaluate the financial viability of the proposed solutions. It is performed for each of the project's demonstrators, comparing the different business models and flexibility options proposed against a business-as-usual baseline scenario. This analysis is supported by grid operators and partners involved in the demonstration activities. Regarding the scalability and replicability analysis, it evaluates the potential for scaling the different solutions beyond the demo sites, estimating their impact at a European level. Its focus is on the key outcomes of the project, such as the digital platform and business network for DSOs to integrate data and services for flexibility provision, and the services tested to engage consumers in energy and cross-sector business models to unlock their potential flexibility.
DIGITISE	ROI, CBA, IRR, WACC
AIR4NRG	Life cycle assessment (LCA), Social Life Cycle Assessment, Techno-economic Analysis, Life Cycle Costing, Return on Investment, stakeholder analysis, social acceptance, technical use cases, replicability and scalability analysis
PEDVOLUTION	In another previous project we use CBA and we are planning to do some quantification to see the consequences/effect of the PEDvolution by comparing before and after the project implemented. Based on the available data, use cases, we plan to validate the economic viability of the project.

HARMONISE	In the project, business models will be evaluated quantitatively and qualitatively. Further, different revenue streams, potential new markets, initial market segmentation and identification of beachhead market, pricing strategy will be developed.

The following table summarises the survey answers related to how the projects measure the economic, social, and environmental impacts of their solutions.

Table 3.3: Survey answers related concerning how the projects measure the economic, social, and environmental impacts of their solutions

Project Name	How do you measure the economic, social, and environmental impacts of your solutions?
GLOCALFLEX	We will focus on the economic impacts, not assessing social or environmental benefits.
DRIVE2X	By means of KPIs focusing on these dimensions, which have been written in the proposal phase and are currently being refined under the scope of D12.1 – Key performance indicators: definition and methods.
SENERGY NETS	1. Technical economic: - Description: a list of KPI has been elaborated together with the demo that will be assessed before, during and after the implementation of the different flexibility measures. - Barriers: agreeing on a common list of relevant KPI and to gather the data - Improvements: too early at this stage 2. Socio-economic: - Description: A mix of quantitative data gathered by interviews and questionnaires and quantitative data are gathered from demo and public data sources. - Barriers: understanding the different cultural and project context and their impacts on the local stakeholders, getting the data, raising awareness on socio-economic aspects to the operational partners (usually more aware on their field of expertise, so more technical aspects) - Improvements: too early at this stage 3. Environmental: - Descritpion: Using a model developed in house by RSE, based on methodology translating emission to

	money through impacts on air quality, life quality, etc. - Barriers: getting the data - Improvments: too early at this stage
R2D2	R2D2 has four products (C3PO – a multi-risk assessment framework for power systems; IRIS – a resilience suite for TSO and DSO; PRECOG – prevention systems for energy infrastructure security; and EMMA – an enhanced maintenance and asset management toolkit). For each product, there is a set of use cases. According to the use case, we compare the cost of not having the product feature (e.g., predictive maintenance) with the benefit of having it. This comparison can affect the three components (economic, social, and environmental) or just some of them. For example, a high-impact, low-probability use case could be how to minimise load shedding during extreme weather events. Without predictive measures, there is a cost associated with widespread power outages and long recovery times, which incurs costs for the system operator and consumers, leading to economic and social impacts.
WEFORMING	We have dedicated tasks that focus on the economic, social and environmental impacts of the solutions developed in the project. For the environmental we use Life Cycle Assessment and circular economy analysis. For the social part we use mainly surveys to assess the social aspects of the project.
OPENTUNITY	Probably to use CBA.
ODEON	Economic impacts, such as reduced electricity costs or revenues from flexibility provision
INDEPENDENT	To support rapid market adoption, we develop sustainable business models and assess their financial feasibility for the primary roles of the DSFM value chain, including SA/EMS providers, EMS service companies (e.g., ESCOs), aggregators (and AEMS providers), prosumers, and suppliers/retailers. Our analysis involves relevant value networks, modelling costs and revenue streams for individual actors, and devising incentive structures to foster a mutually beneficial value sharing. In addition, the INDEPENDENT project activities are fully compliant with the “do no significant harm”

	(DNSH) principles. The project does not support or carry out any activities that make significant harm to any of the six environmental objectives, in Articles 9 and 17 of the EU Sustainable Finance Taxonomy Regulation. We contribute substantially to the climate change mitigation, climate change adaptation, and pollution prevention and control by supporting RES integration and reducing dependency of fossil fuels. As a part of periodic project management meetings (WP1), a review of activities will be conducted taking into consideration potential environmental negative impacts. Consideration of the DNSH principle will also be considered in the business development and exploitation activities.
ECHO	At this stage this is not yet decided. But cost-benefit analysis and return on investment of the products and the service will be defined based on the results of the demonstration cases; also LCA and LCC will be performed on the developed storage systems.
BEST-STORAGE	focus on economic impacts for those wanting to implement solutions as we consider that it is the foundational condition for any purchase. Compilaton of economic benefits and costs over lifetime for energy, maintenance, dismantling, etc…
EVELIXIA	In the project, a list of KPIs was identified for the pilot sites and we measure the impacts based on them.
RE-EMPOWERED	In Deliverable 8.4 (Assessment of demos and tools and replication potential), and Tasks 8.4 (Technical and economic assessment of demos and tools), 8.5 (Social and environmental assessment) and 8.6 (Potential for replication in EU and India), the Demo Sites, and the use of ecoTools in the Demo Sites, have been evaluated from five different points of view: technical, economic, social, environmental, and replicability. To do this, a set of KPIs has been defined. Each KPI is related to one or more ecoTools, and its impact on a specific Demo Site. Not all KPIs can be measured for all Demo Site. We are attaching the not-still-approved Deliverable 8.4, for reference.
BEFLEXIBLE	A set of key performance indicators (KPIs) is defined to measure the impact of the solutions. These KPIs cover

	different dimensions, covering the technical, economic, environmental, and social gains of the solutions tested in the scope of the project. From a technical perspective, factors such as reduction in energy consumption, the efficiency of energy sharing mechanisms, and the available flexibility are evaluated. Meanwhile, economic impact is measured, for instance, by analysing the reduction in energy bills and by assessing the payback period of the investments made. The environmental dimension is assessed though indicators associated with carbon emissions reduction. At last, social impact is evaluated by examining improvements in consumer awareness and literacy regarding flexibility, as well as consumer engagement and satisfaction with the implement solutions. The exercise of defining the KPIs addresses not only the project goal but also the different stakeholders' interests.
DIGITISE	We are still at the early stages of the activities for business model development.
AIR4NRG	a. Social: Social Life Cycle Assessment, stakeholder analysis, social acceptance through the Social Readiness Level by implementing Responsible Research and Innovation and other qualitative data collection methods. b. Economic: Techno economic analysis quantifies financial viability using capital and operational costs, process efficiency and performance and revenue and profitability metrics such as return on investment, levelized cost of storage, payback period. The Life Cycle Costing extends TEA to include long-term costs such as en-of-life disposal & recycling costs along with discounting and cash flow analysis. c. Environmental: Life cycle assessment (LCA) quantifies the environmental impacts based on material and energy flows using the environmental footprint 3.1 method.
PEDVOLUTION	By defining the baselines and measuring project KPIs from the use cases.
HARMONISE	At this stage, we rely on project KPIs, and we will explore more during pilot implementation by defining the baselines together with PED pilot managers

The collective experience of the BRIDGE projects provides several key lessons regarding the current state of business model development, quantification, and data valorisation. These insights highlight systemic challenges and opportunities for maturing practices across the initiative.

1. The Strategic Under-utilisation of Data

A primary lesson is that data, while generated in abundance, remains an under-exploited business asset. Many projects acknowledge the potential of data-driven services but struggle with the practical implementation of monetisation strategies. This points to a fundamental need to shift the perception of data from a simple project output to an intrinsic asset for creating new value and revenue streams.

2. Systemic Challenges in Data Management and Governance

Significant barriers to effective data valorisation stem from foundational data management issues:

- **Lack of Methodological Harmonisation:** Projects frequently employ contrasting methodologies for data collection and processing. This creates interoperability issues and hinders meaningful cross-project analysis and data sharing.
- **Persistent Data Gaps:** A recurring challenge is the lack of reliable, high-quality data. Issues with availability, consistency, and sufficient granularity often prevent the robust analysis required for effective quantification.
- **Regulatory and Compliance Hurdles:** Navigating the complex landscape of energy data regulations, notably the General Data Protection Regulation (GDPR), presents a significant operational challenge that requires clearer guidance.

3. Opportunities for Methodological and Collaborative Enhancement

Despite the challenges, projects identify clear pathways for improvement:

- **Integrating Data into Core Business Models:** There is a recognised need to enhance standard tools like the BMC and VPC by explicitly integrating data valorisation. This involves considering from the outset how data can strengthen value propositions and revenue models.
- **The Value of Collaboration:** Projects affirm that collaborative efforts, particularly through mechanisms like the BRIDGE working groups, are crucial for advancing data monetisation strategies by sharing solutions and best practices.

4. The Overall Maturity Level

A significant number of projects are still in the preliminary stages of their business model development and quantification activities. This indicates that the full potential of data valorisation is yet to be realised and underscores the ongoing need for structured support, knowledge sharing, and the development of common frameworks to advance these practices within the BRIDGE initiative.

3.6 Recommendations and future directions

Based on the findings from Task 2, the following recommendations are put forward and structured into three key pillars:

Pillar 1: Standardise Frameworks and Data Governance

This pillar focuses on creating a consistent and compliant foundation for data handling and value assessment across all projects.

- **Standardise Data Monetisation:** Establish clear frameworks for the monetisation of data, precisely defining data ownership, access rights, and applicable pricing models to ensure legal and commercial clarity. This should not be limited to valorisation of data, but should also concern valorisation of energy services and products developed by the projects, clustered per use case (e.g. demand response, energy sharing,…).

- **Establish Metrics Early:** Require projects to establish their KPIs and quantification metrics early in the project life cycle. This will ensure consistent data collection and accurate impact measurement from the outset.

- **Ensure Proactive Data Governance:** Provide projects with clear guidance and resources to ensure full compliance with the GDPR and to implement the Findable, Accessible, Interoperable, and Reusable (FAIR) data principles.

Pillar 2: Enhance Technology, Analytics, and Strategic Alignment

This pillar aims to leverage cutting-edge technology and ensure the work of BRIDGE projects aligns with and contributes to broader European strategic objectives.

- **Leverage AI for Optimisation:** Promote the adoption of artificial intelligence (AI) and machine learning (ML) to refine business models, optimise operational strategies, and improve the accuracy of cost/benefit quantification.

- **Improve Data Sharing Mechanisms:** Develop common platforms and harmonise data formats to overcome interoperability issues, enabling deeper and more effective cross-project analysis.

- **Align with EU Digital and Energy Initiatives:** Foster active collaboration with strategic EU initiatives, including the common European energy data space and the deployment of digital twins, to boost market uptake and ensure strategic coherence.

Pillar 3: Foster Collaboration and Capacity Building

This pillar is focused on building a community of practice that promotes shared learning and enhances the technical capabilities of all project teams.

- **Systematise Knowledge Sharing:** Implement a continuous process for documenting and disseminating lessons learnt and best practices in business model quantification and data valorisation (e.g. through the implementation of a repository of business model examples).

- **Conduct Targeted Workshops:** Organise practical, hands-on training sessions on advanced quantification methods, such as CBA and SROI, to build technical capacity within the project teams.

4. Task 3: Valorising data generated by BRIDGE projects' solutions

4.1 Context and scope of the work

4.1.1 Reminder of the past findings for setting new goals for Task 3

Task 3 of Bridge WG on Business Models pursued the 2023-2024 activity on the characterisation of data value chains in the BRIDGE projects. The governance of the task was ensured by three co-leaders team included Natalie SAMOVICH, Enercoutim, Habib NASSER, CEO & Co-founder RDIUP, and Athanase VAFEAS, DOWEL Innovation[4]. They formulated a novel ambition for the period October 2024 to Spring 2025, an ambition which drew on previous work detailed in the next subsection.

4.1.2 Building upon last year results

Task 3 developed during the preceding period two synthetic visual frameworks to help BRIDGE and EU-funded projects to discover and better understand business modelling and the building blocks of Common European Energy Data Space (CEEDS) to ensure seamless adoption and integration of CEEDS. When presented and challenged by the BRIDGE projects, it appeared that content-based, the visual frameworks were quite accepted in principle, while recommendations were formulated to improve accessibility and give it more impact, while the internal recommendation was to create dynamic online tools to support these visual frameworks. At last year's General Assembly, delegates put forward the idea of producing a guide, possibly interactive, for R&I BRIDGE projects.

Such visual mapping of building blocks enabling the elaboration of quantitative business models in the domain of smart energy systems within building, mobility, and grids was founded on experts' views, projects' contributions and upon a solid state-of-the-art on of the multiple initiatives, projects or entities supporting the implementation of CEEDS.

For more details on the state-of-the-art or the visuals, see BRIDGE Working Group Business Model, Annual Report 2023-2024, pages 30-43.

4.2 Proposed goals for 2024/2025

Task 3 objectives and topic were reformulated for greater consistency, as shown below.

Table 4.1: Proposed reformulation of task objectives and topic

Item	Previous formulation	New formulation
Topic 3	**Design of BM to better include data value chain observability**	**Improved efficiency of 'Business model thinking and design' leveraging on the discoverability of data resources** (energy data

4 The co-leaders of Task3 represent the following projects: Masterpiece, FlexCHESS, LocalRES (Bridge initiative); INSIEME (data spaces in energy) under the umbrella of the Digital Europe Programme.

		spaces, federated digital twins and energy market places)
Task 3	**Investigate the types and characters of the data value chains in BMs of BRIDGE projects**	**Design a dynamic, contributive framework to support R&I projects in the design of their quantitative business models, cutting down time and effort and facilitating 'discoverability' of data resources** (i.e. *making data resources easy to find and understandable)*

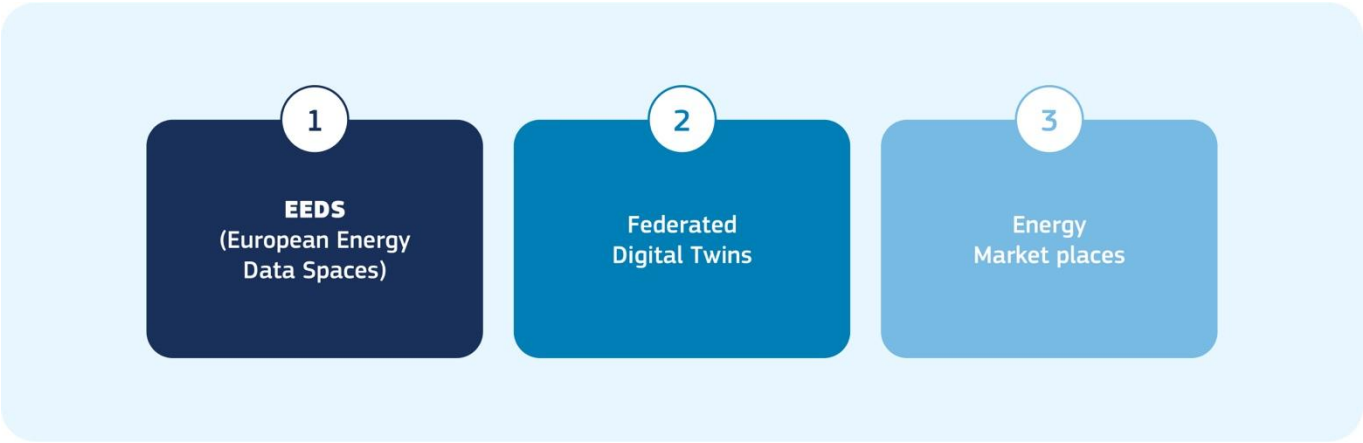
It was necessary to clarify the terms observability and discoverability. This was the very first step that led to the focus on discoverability rather than observability. Indeed,

- **discoverability** is about locating and understanding data that exists within the ecosystem, enabling users to find relevant data easily, while
  observability is about the real-time monitoring and health of data flows and processes, ensuring that data moves smoothly and accurately through the value chain. Both are important for data management and serve different purposes.

This clarification helped us organising our exploration into business model thinking & design, and the development of 'data spaces' and to appreciate links between the two. We aimed at developing practical guidance for R&I projects answering the question, *'how to implement discoverability of energy data resources for R&I projects in their preparation of their business model?'*

4.3 Proposed methodology

Three main areas of exploration and analysis have been defined. We refer to them as 'pillars':



The proposed methodology for data collection included successive steps: **(a)** to successively collect interesting approaches to explore for our framework, and the reasons why a proposed approach would offer value for our framework. This very first step was led by the three co-leaders, while **(b)** in a second step a selection of volunteer projects was interviewed; the volunteers came forward during a dedicated BM WG plenary, **(c)** last, specific questions were added to the poll organised by Task 2 and were collected and analysed to feed this report.

A common template was developed for data collection. See Figure 4.1. This template was finally enriched with two additional components: 'Definition' and 'Sources'.

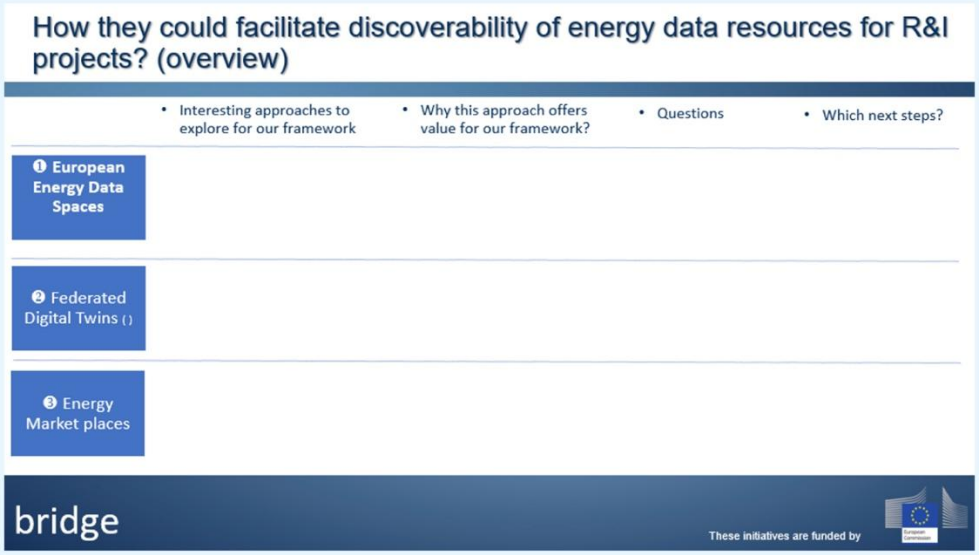


Figure 4.1: Template for data collection by experts and projects

The compilation of data collected and synthesised was then reported in section 4.5 of the present report and was organised as described in the table below.

Table 4.2: Content of the report relative to task 3 deployment in 2024/2025 (organisation of section 4.5)

Sub-section	Object	Intention and content
4.5.1 Definitions and concepts	Terminology of key concepts used in the report.	It provides a contextual background for non-experts of data spaces or federated digital twins
4.5.2 Discoverability of energy data resources	Two questions addressed: - Why discovery of energy data is a relevant concept for R&I projects wishing to build their (quantitative) business model. - How to leverage discoverability of energy resources?	EEDS, FDT and Energy market places are introduced as means to leverage on discoverability of energy resources. We called them pillars.
4.5.3-4.5.4-4.5.5 The collected feedback from Bridge R&I projects	Three subsections refer to the three pillars.	R&I projects challenged the 'claimed added value' for each pillar.

		In addition, they provided their own view on their respective contribution to the three pillars.
4.5.6 Conclusions	Lessons learnt and recommendations for further steps	Statements are provided in a synthetic mode to be confronted to ongoing or almost ending projects for reinforcing them with the latest projects KER (key exploitable results).

4.4 Relevant sources of information

Different channels were used to collect data for the three pillars.

Table 4.3: Types of channels used for the Task 3 activity

Channel	Object	Observations
Scientific literature	For the definition and state of the art.	Used as background information.
R&I projects volunteer to document Task 3 on FDT	TwinEU (Ilias Zafeiropoulos) VPP4islands (Abdelaziz Schwareb, Brunel)	Direct feedback to Task 3 as observations to the statements proposed by the Task 3 co-leaders on FDTs.
R&I projects volunteer to document Task 3 on EEDS	OPENTUNITY (Álvaro Nofuentes Prieto) FlexCHESS (Tim Farnham, Toshiba)	Direct feedback to Task 3 as observations to the statements proposed by the Task 3 co-leaders.
R&I projects volunteer to document Task 3 on energy market space	GLOCALFLEX, DriVe2X, Independent, Echo, DIGITISE, HARMONISE, WeForming, BEST STORAGE, LocalRES, U2DEMO.	Indirect feedback was collected through the Task 2 poll. The mentioned projects have indicated some contributions on energy market space.
BRIDGE R&I projects respondent to the poll of Task 2	Three specific questions were proposed by Task 3 and were included in the Task 2 poll that was deployed during the first quarter of 2025. Collected feedback was mapped and analysed by Task 3 co-leaders and is discussed in the next sections.	20 BRIDGE projects provided feedback. Out of them 16 projects provided insights for the specific questions on data spaces or federated digital twins proposed by task 3 co-leaders.
Selected BRIDGE projects targeted for their particular relevance and contribution to the 3 pillars	Projects identified as core contributors to the domain covered by Task 3: int:net, Omega-X, Data Cellar, Enershare, Synergies.	These projects have been identified and specifically targeted to provide feedback which was integrated in the current report.

4.5 Conclusions and next steps of Task 3

4.5.1 Defintions and concepts

Definitions on EEDS, FDT and EMP are proposed in the first alinea of each of the sections 4.5.3-4.5.4-4.5.5, each dedicated to one particular pillar.

4.5.2 Discoverability of energy data resources

a) Why discoverability of data matters for R&I results exploitation

After the terminology clarification, the focus of Task 3 was put on the discoverability. Indeed while **observability** is focused on the *real-time monitoring* and health of data flows and processes, ensuring that data moves smoothly and accurately through the value chain, **discoverability** deals with *locating and understanding data* that exists within the ecosystem, enabling users to find relevant data easily.

From the perspective of a R&I project aiming to build its business model, an interesting objective is to *make data more accessible* and *usable* by allowing stakeholders to find and understand data assets across a given ecosystem.

R&I projects through their exploitation leader or innovation manager (NB: we could also add each result owner) need to find and understand relevant data for analysis, decision-making, or business case development.

b) Which practical means for enhancing discoverability?

Task 3 co-leaders have proposed to include three concepts in the scope of Task 3: European Energy Data Spaces (EEDS), Federated Digital Twins (FDT) and Energy Market Places (EMP) as the three pillars to be further analysed by R&I projects in their degree of awareness about them, their effective use within their project and possible recommendations they might formulate.

This initial ambition was slightly adjusted based on the feedback received and when considering the nature of respondents. Instead of the sole perspective of a R&I project user of EEDS/FDT/EMP, additional points of view were proposed, including users of EEDS/FDT/EMP, designers/developers of EEDS/FDT/EMP, analyst, academic working on such concepts, institutions working on such concepts (e.g. regulators).

c) The four-area diagram for mapping the feedback

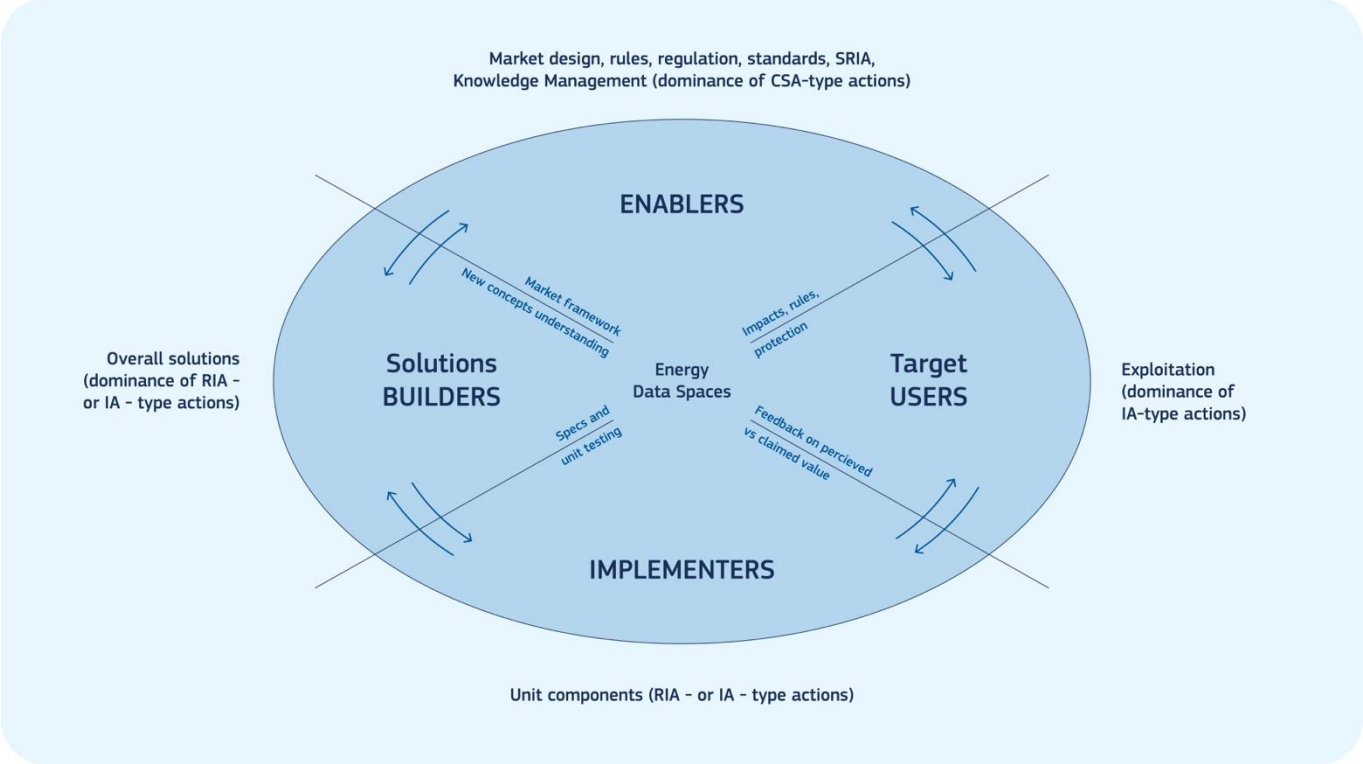


Figure 4.2: Template to collect the R&I BRIDGE projects to each of the pillar: EEDS, FDT, EMP

d) The feedback from BRIDGE projects have been requested by a poll

Twenty projects responded to the Task 2 poll. We mapped the answers to the three questions dedicated to the three pillars. We organised the feedback in the form of a heatmap. The colour code of the heatmap corresponds to the degree of relevance of the answer with the four following grades:

Do not know, or no/incomplete answer, or too early	*No relation of the concept with our project*	*Some indirect link (needs, use case for further deployment)*	*Relevant or very relevant*

Compilation of T2 poll answers for Task 3

Section 5: Questions referring to the data spaces and related concepts under	GLOCALFLEX	DriVe2X	SENERGY NETS	R2D2	WeForming	OPENTUNITY	ODEON	INDEPENDANT	ECHO	BEST-STORAGE	EVELIXIA
1. To what extent is your BRIDGE project related to Energy Data Spaces? If it is, could you please provide some concepts under your scrutiny? Additionally, why would such a concept create value for R&I projects?	*The project is not considering Data Space concept.*	*It is related to the extent that it requires collection of building and*	*Not concerned. It does not really apply. WP7 is dealing with a limited*	*R2D2 project does not deal with data spaces. R2D2 main focus is*	*We are developing a Dataspace for buildings that promotes grid*	*In OPENTUNITY we are developing a Data Space but it is not the*	*ODEON brings forward the delivery of a comprehensive and feature-*	*Very related. Standardized data formats for portability are essential,*	*N/A*	*Directly related to Energy Data Spaces. We analyze energy demand in*	*N/A*
2. To what extent is your BRIDGE project related to Federated Digital Twins? If it is, could you please provide some concepts under your scrutiny? Additionally, why would such a concept create value for R&I projects?	*The project is not considering Federated Digital Twins.*	*It is not, at all.*	*Not concerned*	*R2D2 does not include Federated Digital Twin.*	*Our project is not explicitly related to Federated Digital Twins.*	*We are not developing digital twins.*	*ODEON does not contemplate the use of Digital Twins.*	*N/A*	*N/A*	*Not related*	*N/A*
3. To what extent is your BRIDGE project related to Energy Market Spaces? If it is, could you please provide some concepts under your scrutiny? Additionally, why would such a concept create value for R&I projects?	*If we understand Energy Market Spaces as Energy Market*	*The DriVe2X project aims to implement a flexibility marketplace*	*Flexibility could have an impact on energy market but is not measured*	*No relation with R2D2 project.*	*Our project is not explicitly developing an Energy Market Service but as*	*Additionally, why would such a concept create value for R&I projects?*	*ODEON is not related to the use of Energy Market Spaces.*	*Market adaptation and TSO and DSO cooperation is*	*The market space of grid flexibility services could be exploited by*	*Directly related to energy market spaces given that storage*	*N/A*
1. Project Name:	*GLocalFlex - A Global as well*	*DriVe2X - Delivering*	*SENERGY NETS*	*R2D2*	*WeForming*	*OPENTUNITY*	*ODEON*	*INDEPENDENT - Integrated*	*ECHO*	*BEST-Storage*	*EVELIXIA*
2. Coordinating Institution:	*VTT*	*Lappeenranna n-Lahden*	*EIFER*	*ETRA*	*EUROPEAN DYNAMICS*	*ETRA I+D*	*ETRA*	*TEKNOLOGIAN TUTKIMUSKES*	*CNR-ITC*	*Solintel*	*CERTH*
3. Project Duration (Start and End Dates):	*1 January 2023 - 31 December*	*1 January 2023 - 31 December*	*9/2022 – 8/2026*	*October 2022 – September*	*1 October 2023 - 30 September*	*1 January 2023 - 31 December*	*January 2024 – December 2027*	*Sep 2024-Sep 2027*	*1 January 2023 - 31 December*	*1 January 2023 - 31 December*	*October 2023 – September*
4. Brief Description of the Project Scope:	*The main objective of*	*The DriVe2X project aims to*	*Proposition: SenergyNets*	*R2D2 aims to enhance EPES*	*WeForming seeks to*	*OPENTUNITY project aims to*	*ODEON demonstrates*	*INDEPENDENT aims to*	*Thermal energy storage*	*The EU-funded BEST-Storage*	*EVELIXIA project aims to*
5. Target Groups (e.g., consumers, energy providers, policymakers):	*Consumers, energy*	*Energy providers –*	*energy providers*	*TSO, DSO, Regulators,*	*Consumers, energy*	*DSO, Prosumer,*	*Prosumers, energy*	*Aggregators, EMS*	*Building owners,*	*Building occupants(con*	*Building occupants &*
6. Contact Information for the Survey Respondent (Name, Email, Role in Project):	*Carlos Madina, carlos.madina @tecnalia.com, leader of the Business Models WP (WP5)*	*Francisco Soares Branco, francisco.branc o@edp.pt, R&D engineer working in the global*	*Edoardo Corsetti (RSE), Heliette Darne (EIFER)*	*João Mateus, joaofilipe.mate us@edp.pt, Project Manager / Pilot Coordinator;*	*Stratis Kanarachos, stratis.kanarac hos@eurodyn. com*	*Álvaro Nofuentes; anofuentes.etr aid@grupoetra .com; Project Coordinator.*	*6. 'Camilla Neumann, Camilla.neuma nn@joanneum .at, Responsible for developing*	*Dr. Jessy Matar, matar@fortiss. org, Researcher at fortiss GmbH (https://www.f ortiss.org)*	*6. 'Luc Pockele, luc.pockele@gr eenco-srl.com, Demo case responsible of Belgian demo-*	*6. 'Hugo Grasset, hugo.grasset@ solintel.eu; Coordinator, Exploitation, Technoeconom*	*Vasiliki Gemeni v.gemeni@hae e.gr, Leading WP6 EVELIXIA'; Novel Business Models and Exploitation*

RE-EMPOWERED	BeFlexible	DIGITISE	Air4NRG	PEDvolution	HARMONISE	ENFLATE	LocalRES	U2DEMO	DATA CELLAR	SYNERGIES Shaping	ENERSHARE	int:net	OMEGA-X
Energy Data Spaces have not been used in RE-EMPOWERED.	Energy Data Spaces are considered, for example, in the architecture of	DIGITISE advances Energy Data Spaces by enabling	N/A	N/A	Our BRIDGE project is strongly linked to Energy Data Spaces, as the	The key exploitable results of the project includes a	To support the use of the Planning Tool developed by the project to	The U2Demo project will develop a reliable	The DATA CELLAR project is strongly related to Energy Data	The core objective of SYNERGIES is to deliver a reference	The Enershare Data Space will enable access, control, share and reuse of	As a CSA, the project coordinates the Energy Data Spaces Cluster,	OMEGA-X is fully centered on establishing a common
Federated Digital twins have not been used in RE-EMPOWERED.	BeFlexible is not related to Federated Digital Twins.	We are still at the early stages of the activities for business model	N/A	N/A	In HARMONISE it is planned to develop a virtual demo site that	It is not related.	It is not related.	Not related	The DATA CELLAR project is not directly aimed at developing a	SYNERGIES partially addresses the concept of Federated	Project is establishing complete new environement:	It is not related.	OMEGA-X includes the developme nt and deployment
Energy Market Spaces have not been used in RE-EMPOWERED.	We are not familiar with this concept, but we believe that the	DIGITISE advances Energy Market Spaces through a DLT-enabled	N/A	N/A	Our BRIDGE project is closely linked to Energy Market Spaces, as	It is not related.	The Multi-Energy Virtual Power Plant (MEVPP)	Not related to Energy Market Spaces. However,	The DATA CELLAR project is partially related to the concept of	The concept of Energy Market Spaces is not addressed in SYNERGIES.	EMP proposed by the Enershare will enable the involvement of	It is not related.	OMEGA-X is actively developing a federated data and
RE-EMPOWERED-	BeFlexible	DIGITISE	Air4NRG - Air	PEDvolution: Interoperable	HARMONISE (Hierarchical	ENFLATE	LOCALRES	U2DEMO - Use of open-	DATA CELLAR	SYNERGIES Shaping	ENERSHARE	int:net	OMEGA-X
Institute of Communicatio	i-DE (i-DE REDES	UBITECH	ZABALA BRUSSELS	INLECOM INLECOM	CERTH (Ethniko Kentro Erevnas	NOVA TELECOMMU	FUNDACION CARTIF	INESC ID - INSTITUTO	RINA Consulting	TXT E-TECH SRL	ENGINEERIN G THE	FRAUNHOFER	EVIDEN (ATOS
1 July 2021- 31 December	sept 2022-aug 2026	06-2024 – 05-2027	JAN 2024 – DEC 2026	Start date 1 January 2024,	1st June 2024 to 31st	01/09/2022 – 31/08/2026	1 May 2021 to: 30 April	1 September	1/06/2022 – 30/11/2025 (42	1 September 2022 – 28	1.7.2022- 30.6.2025	01.05.2022- 31.10.2025	1 May 2022 - 30 April
Microgrids are small-scale	BeFlexible aims at increasing	The DIGITISE project (Digital	The main objective of the	The pinnacle of community	The main objective of	The entire European	The LocalRES solutions will	The U2Demo	DATA CELLAR aims to create	SYNERGIES introduces a	Enershare defines a Data-	Across the EU, organisations	OMEGA-X aims to
The project is aimed at	all stakeholders of the flexibility	Prosumers, Consumers,	Industry and business	Energy service providers,	The different project outputs	Consumers, system	Prosumers, energy	Energy Communiti	Local Energy Communities	Primary à DSOs, TSOs,	ICT/data stakeholders,	Various stakeholders	Cities and communitie
Jesús Rubio Conde, Senior Manager of Deloitte. Role in the project: Co-leader of Work Package 8	6. 'José Villar, jose.villar@inesctec.pt, In charge of the demos related to grid	6. 'Efthymis Serpetzoglou, e.serpetzoglou@app-art.gr, R&D Project Manager at AppArt, ICT	6. 'Glória Gonçalves, gloria.goncalves@edp.pt, EDP NEW – WP4 Leader to elaborate	Alemu Moges Belay, alemu.belay@smartinnovationnorway.com , WP6 leader: Business model	Aaditya Dandwate, aaditya.dandwate@smartinnovationnorway.com Federico Trezza,	Katerina Drivakou, kdrivakou@ubitech.eu, Project Technical Coordinator	Martín Crespo Alemar, project coordinator, alemar@cartif.es	Gonçalo Glória, goncalo.gloria@rdnester.com, Project Manager in	Martina Galluccio, martina.galluccio@rina.org., Project coordinator	Tasos Tsitsanis (tasos@suite5.eu), Leader of WP7, coordinating with BRIDGE and other		Charukeshi.mayuresh.joglekar@fit.fraunhofer.de, collaborating and organsing work related to	Cláudia Antunes Marante, c.antunes@ucp.pt

Figure 4.3: Heatmap of the 25 R&I BRDIGE projects responding to the T2 poll (four categories according to their respective degree of relevance to EEDS, FDT and EMP)

The figure is for illustration purposes on the overall degree of relevance of respondent projects feedback. Content-wise, the detailed feedback was used to better understand the respective added values and position them into the unique framework of Figure 4.2 developed for that purpose.

4.5.3 How EEDS could facilitate discoverability of energy data resources

Definition[5]: a decentralised infrastructure designed to facilitate secure, interoperable, and privacy-/sovereignty-focused data sharing among stakeholders in the energy sector. The concept aims to broaden access to data needed for developing innovative energy services that will help balance and optimization of electricity grids, improve energy efficiency in buildings, and push further the integration of renewable energy sources and enhancing cross-sector interoperability and coupling (e.g., coupling with mobility, heating)[6].

The following table identifies six areas related to EEDS with the aim to help projects searching for energy data resources. Feedback from some contributors was integrated for each item.

Table 4.4: Claimed added value for leveraging on discoverability of energy data resources (EEDS)

Item	Interesting approach	Why this approach offers value	Promising use cases, impacts for the Business Model, or still open questions
#1	Adoption of common data standards and protocols	EEDS, once deployed, should offer easy understanding and access by various stakeholders	*How should registries, catalogues, or platforms be designed for indexing and efficient retrieving of data?* • Registry is the term used by most dataspaces to describe the discovery of resources. Methods to decentralise or distribute registries securely and efficiently are needed, also, across-data spaces. • OMEGA-X is explicitly aligned with major European frameworks such as IDSA, Gaia-X, FIWARE, and SGAM, which form the foundation of the project's data architecture. By adopting and promoting these standards, OMEGA-X aims to ensure cross-sector compatibility, vendor neutrality, and future-proof interoperability. • DATA CELLAR addresses all the critical dimensions necessary for complete dataspace deployment: Security and Privacy, Quality and Integrity, Governance and Policy. It follows the 5 core dimension of a data space: namely: Business, Legal, Operational Functional, Technological dimensions. • SYNERGIES delivers a reference energy data space implementation consisting in a secure and isolated data sandbox environment that is provided to or is available by each stakeholder (from the energy data value chain and its interrelated, coupled sectors) through different modalities in order to collect, monitor, control, analyse and share their data in their own terms and to obtain, access and use external data (from other data spaces) through a reliable, interoperable and

[5] **Sources:**
https://digital-strategy.ec.europa.eu/en/library/european-commission-advances-development-common-european-energy-data-space-ceeds March 2024;
https://www.entsoe.eu/2024/11/06/data-spaces-in-the-energy-sector-enabling-the-green-energy-transition/ November 2024;
https://oascities.org/event/the-emerging-common-european-energy-data-space-state-of-play-and-next-steps-11-march-2024/ int:net project, March 2024.

[6] Examples can be found in the Blueprint of the Common European Energy Data Space, version 2.0, July 2024
https://intnet.eu/images/resources/Blueprint_CEEDS_v2.pdf

			sovereignty preserving approach, effectively enhancing their data-driven intelligence and increasing their data outreach.
#2	Interoperability and facilitation of Data Exchange by using standardised metadata and data models	users can search across various databases in a more unified way (users do not need to know where the data is stored)	*How to measure such a positive impact? Are there indicators of interoperability?* • Common data dictionary methods are an accepted way to facilitate domain independent definition and mapping of data. But mapping between domain specific data models can add overhead and complexity. So methods to measure and reduce this burden are necessary. • The question on how to measure a positive impact and the indicators for interoperability is at this stage a central question for Opentunity. It is proposed to evaluate the performance and successfulness of Data Spaces so if there is any project or initiative that has already defined KPIs and some metrics (baselines or target values) could be very relevant for other projects. • Int:net project recommended the FAIR maturity indicators to measure the INTEROPERABILITY of the data and metadata7. More the project confirmed the importance of this item to break silos within industries, as well as the examples of all cross-sector initiatives. • The project places strong emphasis on semantic harmonisation and uses standardised ontologies to ensure that energy data can be efficiently indexed, discovered, and exchanged. This fosters a unified ecosystem where data from diverse sources becomes immediately usable across multiple applications and domains (OMEGA-X). • The Enershare data space will enable access, control, share and reuse of large amount of currently dispersed energy data for private consumers, energy and non-energy business stakeholders, regulated operators and the public sector that will make the energy industry more secure and sustainable, while allowing energy consumers to take their energy future in their hands.
#3	Decentralised data governance	The governance structures ensure that each entity retains control over its own data while still allowing others to access	*Any example of federated data governance?* • The Simpl[8] middleware framework from Sovereign-X / InfrateX consortium supports federated governance across EU member states. The Open product MVP has launched and could be evaluated in the context of EEDS to see which components are suitability. • OMEGA-X promotes federated data governance where data providers retain sovereignty and control over their assets. Rather than centralising data, the platform enables trust-based sharing through certified connectors and access control mechanisms aligned with the Gaia-X compliance framework. • The design principles for the SYNERGIES energy data spaces are: flexibility (including the freedom to configure an energy data

[7] See https://fairtoolkit.pistoiaalliance.org/methods/interoperability-maturity-indicators/
[8] Simpl refers to Smart, open source, interoperable middleware for EU data spaces, as an initiative of the EC to underpin the development of Common European Data Spaces.

			space according to the end user needs), controllability, usability and inclusiveness.
#4	Comprehensive data catalogues / metadata repositories	Key descriptive features of data value (quality, reliability and completeness) and access conditions are included in these repositories	*Any example of such data catalogues?* • The OMEGA-X project integrates a federated catalogue system where data assets are discoverable, described using common standards, and tagged with trust and sovereignty attributes. These catalogues are critical enablers for the service and data market places foreseen by the project • IDTA supports digital twin template (metadata) definition registry used in Catena-X/Cofinity-X and other dataspace domain registries including for battery / digital product passports and carbon footprint data. • In OPENTUNITY, we are using Gaia-X ontology. It constantly evolves with input from the open-source community and in alignment with future standards like DCAT (Data Catalogue Vocabulary). Open development takes place, with modules (e.g., core, resource, contract) being released publicly to repositories like GitLab, promoting collaboration and code optimization. • The Cross Federation Services Components (XFSC) Federated Catalogue is the reference implementation for Gaia-X. It provides full compliance with Gaia-X out-of-the-box, by being implemented with the Gaia-X Architecture Document as a requirement specification. The XFSC Federated Catalogue is built using Java and is an actively maintained project. It allows sematic metadata management by leveraging Neo4J as the backend storage and provides fully trusted services using SSIs. All added resources must be in the form of a signed Verifiable Presentation which the XFSC Federated Catalogue verifies upon insertion. It is an actively maintained project and provides a working deployment environment using docker and/or kubernetes (plain or helm). • Pros and cons of XFSC Catalogue are also reported. Pros include full compliance to standard (Gaia-X compliance, Gaia-X Trust Framework preinstalled; trust and security: Validation of all VPs proofs and trust anchors, actively maintained); the only cons refer to a complicated deployment based on multiple sub-components. • Once the XFSC Federated Catalogue is selected as the metadata broker solution for the Federated Data Exchange Infrastructure, the next steps include deploying and configuring it to suit the OPENTUNITY Data Space requirements with actions on Deployment method; XFSC catalogue configuration; Ontology (Gaia-X Trust Framework Ontology) tweaking and usage in OPENTUNITY; Possible extensions of the ontology to cover OPENTUNITY specific use cases and requirements; Trust anchor selection (in tandem with the Trust Services configuration); Usage documentation (API). *Can this approach be used to harmonise metadata/templates across EEDS?* • The templates are based on IEC 61360 common data dictionary specification which supports domain independence.

#5	AI and data analytics	Tooling could ensure automatic tagging, categorisation, and guidance towards recommend datasets	*Do we have any good practice testing learning patterns based on past data queries? Or more generally on the use of AI?* • large language models offer benefits for automatic selection and analysis of data using Retrieval Augmented Generation (RAG) agents, which can be tailored for specific tasks. The process is simplified by using smaller token sets in the data which can be achieved with task specific templates and data model standards. • OMEGA-X supports advanced use cases that rely on AI-enabled services, including forecasting, flexibility optimization, and anomaly detection. By enabling access to high-quality, real-time data in a standardised format, the project creates fertile ground for deploying reliable, explainable, and efficient AI models. • The core block of SYNERGIES energy data space – SYNERGIES Data Interoperability & Governance Block – involves a wide variety of data ingestion and harvesting methods and formalised templates for the effortless check-in for data "in rest" and data "in motion", along with appropriately specified open standards-based connectors (IDS, IoT, OPC-UA, Modbus) for facilitating data ingestion from legacy systems and individual devices that utilise widely adopted data and communication protocols. It involves advanced ML-supported data curation mechanisms for increasing quality of collected data, as well as automated predictive features will be employed for the semantic annotation and mapping of data assets to the synergies network of data models.
#6	GDPR compliance and collaboration	Legal compliance is expected to increase trust and confidence in the use of data and encourages collaborative initiatives	*Any example of collaborative platforms for peer review and validation of datasets?* • Consent and revocation mechanisms for compliance and automated compliance verification methods could be necessary for sensitive / personal data • Data privacy and trust are central to OMEGA-X. The platform is designed to be fully GDPR-compliant, ensuring that all data transactions are auditable and traceable. Consent management, anonymisation, and secure access protocols are integrated by design to enable lawful and ethical data use.

The synthetic visual provides an overview of the respondent projects to energy data spaces. The visual is expected to be further complemented by other very relevant projects such as:

- OMEGA-X, the project aims to develop a sovereign, interoperable, and federated multi-vector energy data space, grounded in European open standards and aligned with Gaia-X and IDSA frameworks. The project will implement and validate a federated infrastructure, data and service market places, and demonstrate its value through concrete use cases in renewable energy, electromobility, flexibility, and local energy communities.
- DATA CELLAR, that aims to create an energy dataspace to support the creation, development, and management of local energy communities in the EU. The dataspace will facilitate data sharing among energy players, ensuring interoperability, integration with other EU energy dataspaces, and offering services and tools to foster the growth and management of energy communities. It is strongly related to energy data spaces and is actively contributing to their conceptualisation and implementation at the European level. It is designing and deploying an interoperable, modular, and secure energy dataspace focusing on the sharing of energy-related datasets across stakeholders in local energy communities.

Concepts investigated include data governance, interoperability standards, integration with initiatives like GAIA-X and IDSA, ethical data handling, and reward-based data collection approaches. This concept creates value for R&I projects by enabling access to structured and standardised datasets, fostering innovation in energy management, promoting best practices, and supporting the energy transition towards decarbonisation goals. It collaborates actively with the Energy Data Space Cluster, joining forces with sister projects OMEGA-X, ENERSHARE, SYNERGIES, and EDDIE to build a CEEDS.

- int:net project, aiming at 'Developing, testing and deploying interoperable energy services to further pave the path for a carbon free European society in 2050'. AS a CSA (coordination and support action), the project coordinates the Energy Data Spaces Cluster, which brings together several projects working towards developing and deploying energy data spaces. The project has played a key role in the development and publication of the Blueprint of the CEEDS. In addition to this, the project has also contributed and collaborated with IDSA on publication of the Energy Interoperability Task Force Paper. Overall, several concepts related to energy data spaces have been analysed as a part of the project and are aimed towards accelerating the deployment of CEEDS.
- enershare as the Energy Data Space for Europe, aims at 'bringing together energy and data value chains to enable the energy transition'. It defines a data-driven reference architecture for the energy domain, which is compliant with FIWARE, IDSA and GAIA-X. The project creates a market place based on blockchain and smart contracts with the aim of improving mutual trust among the actors of the ecosystem and increasing the security of the shared data. It also enables a compensation system (even non-monetary) of assets and resources related to data (e.g., datasets, algorithms, models) with energy assets and services (e.g., maintenance of heating system, surplus transfer of locally self-produced energy).
- Synergies: Synergies is for *"Shaping consumer-inclusive data pathwaYs towards the eNERGy transition, through a reference energy data space implementation"* and aims at establishing a reference energy data space through sharing innovation in value chains in the energy field, which is fragmented due to the growing number of distributed energy resources connected to the network. This reference energy data space implementation will attempt to unleash the data-driven innovation and sharing potential across the energy data value chain by leveraging data and intelligence from diverse energy actors and coupled sectors (buildings, mobility) and effectively making them reachable and widely accessible. The transition from siloed data management approaches to collaborative ones will be facilitated, hence promoting the creation of a data and intelligence ecosystem around energy (and other types of) data and enable the realisation of data (intelligence)-driven innovative energy services that
    - (i) value the flexibility capacity of consumers in optimising energy networks' operation, maximising RES integration and self-consumption at different levels of the system (community, building),
    - (ii) evidently support network operators in optimally monitoring, operating, maintaining and planning their assets and coordinating between each other (TSO-DSO collaboration) for enhancing system resilience,
    - (iii) create an inclusive pathway towards the energy transition, through consumer empowerment, awareness and informed involvement in flexibility market transactions,
    - (iv) step on real data streams and intelligence to deliver personalised and automated features to increase prosumer acceptance and remove intrusiveness,
    - (v) facilitate the establishment of sustainable local energy communities by enhancing their role with aggregator and balancing functions, and
    - (vi) establish solid grounds for the creation of a new economy around energy data produced and shared across a complex value chain, in a secure, trustful, fair and acceptable manner.

  The main features of the SYNERGIES energy data space span over four core axes: (a) data interoperability & governance, (b) data security & sovereignty, (c) trusted data sharing and (d) data value accrual, that represent the core building blocks, properly integrated to realise the envisaged reference energy data space. The project has established a robust and solid technological basis for the creation of an inclusive ecosystem of stakeholders characterised by a mesh of data, service and market flows, towards safeguarding energy system resilience under increased decentralisation and stochasticity conditions, along with the

subsequent active engagement and involvement of consumers in the energy transition and energy activities.

- EDDIE introduces a decentralised, distributed, open-source Data Space, in alignment with the efforts of the EU Smart Grids Task Force on Implementing Acts on Interoperability and other European initiatives. The European Distributed Data Infrastructure for Energy (EDDIE) significantly reduces data integration costs, allowing energy service companies to operate and compete seamlessly in a unified European market. Additionally, an administrative interface for In-house Data Access (AIIDA) ensures secure and reliable access to valuable real-time data based on customer consent.
- The cooperation within the Energy Data Space Cluster will be highlighted for building a CEEDS. Within this collaboration, the solutions developed across the projects are assessed to propose future interoperability standards across different layers (technical, semantic, governance), ensuring that they are aligned, complementary, and capable of forming the basis of future European regulations on data sharing and federation of energy dataspaces. This cooperative effort is crucial for enabling the seamless integration of different national and regional energy initiatives, the creation of harmonised, interoperable ecosystems that support innovation, efficient energy management, and decarbonisation strategies, and the standardisation of governance and operational frameworks to facilitate cross-sectoral and cross-border data exchanges.

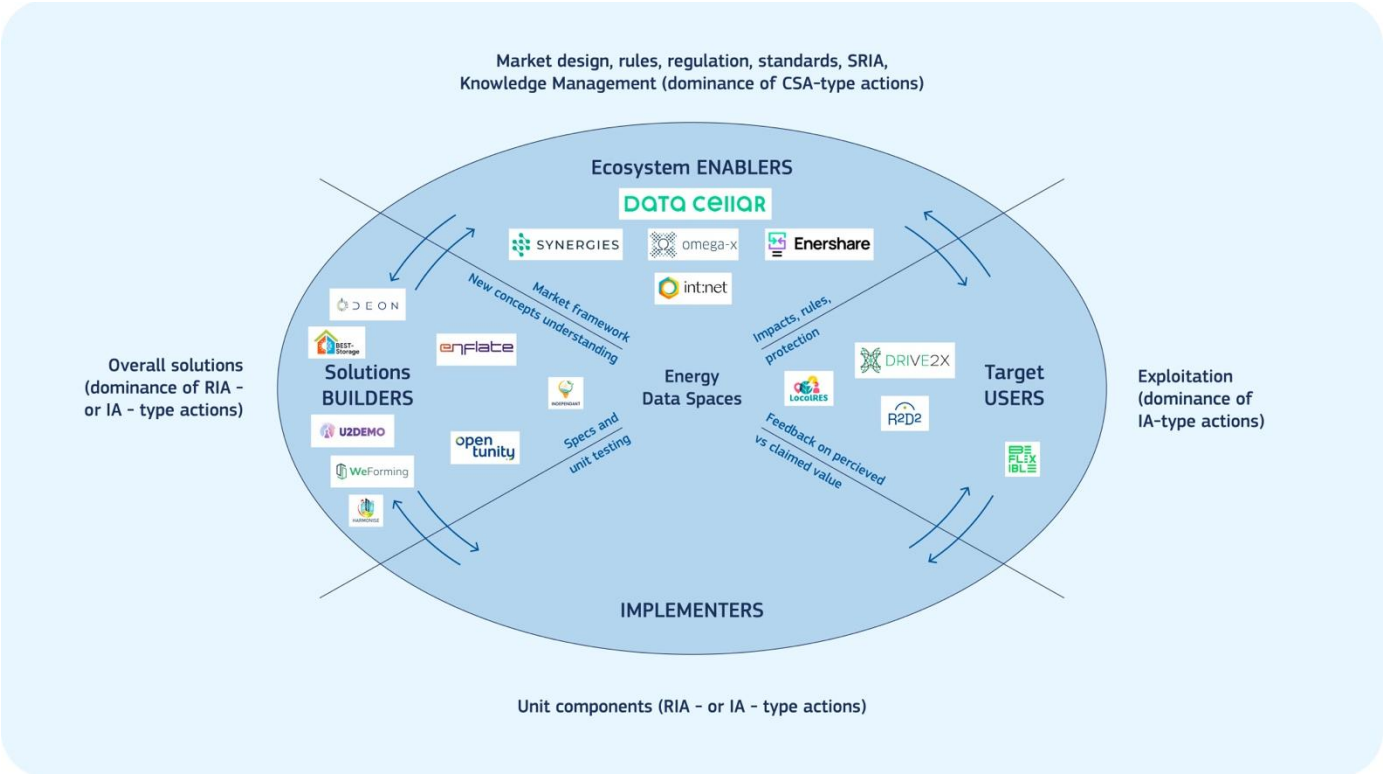


Figure 4.4: Mapping of respondent projects to the Energy Data Spaces pillar

4.5.4 How federated digital twins could facilitate discoverability of energy data resources?

Definition[9]: federated digital twins are interconnected virtual representations of physical assets, systems, or processes that are distributed across organisational and sectoral boundaries. They enable the sharing and integration of data from multiple sources while maintaining individual ownership and control. FDT allow for seamless collaboration across geographical locations, interoperability between different systems and organisations, enhanced insights through the combination of diverse data sources. They enhance informed collaborative decision-making in complex, interconnected systems.

Seven components of added value have been identified and constitute the basis for building use cases.

Table 4.5: Claimed added value for leveraging on discoverability of energy data resources (FDT)

Item	Interesting approach	Why this approach offers value?	Promising use cases, impacts for the Business Model or still open questions
#1	**The FDT 'by design'**	An interconnected ecosystem of virtual representations that span organisational and sectoral boundaries, is expected to enable seamless access to diverse data sources	• Improved asset management and life cycle planning with positive economic impacts on Business Model • Ability to simulate scenarios in real-time for fine tuning business strategies without risking physical assets or disrupting operations
#2	**Common framework for data sharing**	A common framework for data sharing, shall facilitate the discovery of relevant information across multiple platforms and organisations	• Collaboration between stakeholders widening the scope of innovative Business Model • The DATA CELLAR project while not directly aimed at developing a FDT as a standalone entity, provides the foundational infrastructure and services within its federated energy dataspace that allow Local Energy Communities and other stakeholders to create and deploy their own customized Digital Twins. It thus offers a Data-Driven Digital Twin Service for energy communities to model, simulate, and optimise their systems using the real-world data stored and managed in the dataspace. This service is integrated as one of the modular functionalities accessible through the federated platform, ensuring interoperability with other data sources and supporting future expansions towards broader EU energy dataspace initiatives.
#3	**Use of open and standardised data**	They increase interoperability and access to sources	• Improved discoverability of data needed in the business model
#4	**APIs for access to FDT data services**	Easy discovery and access	• Improved discoverability of data needed in the business model

[9]**Sources:** https://ieeexplore.ieee.org/document/10305745 ; https://ieeexplore.ieee.org/document/9943622 ; https://innovate.ieee.org/innovation-spotlight/digital-twins-for-energy-systems/ ; https://www.itwinjs.org/bis/guide/intro/federated-digital-twins/ ; https://www.nature.com/articles/s41598-023-47078-9 https://www.cdbb.cam.ac.uk/files/gemini_papers_-_what_are_connected_digital_twins.pdf ; https://discovery.ucl.ac.uk/id/eprint/10169376/1/ASCE_JCCE_Moretti.pdf May 2023.

#5	**Semantic interoperability**	It enables connection of information from different domains and semantic enrichment	• Increased value for the customer
#6	**Secured role-based access to data in a clear ownership and governance framework**	For securely shared data	• New value proposition on data security • Energy market space, proposed by the Enershare project will enable the involvement of many in energy sector involved parties. Complete data flow and exchange will be managed, Enershare offers a complete overview over the governance in proposed common data space.
#7	**Efficient multi data services offer from a diversity of sources**	The offer ensures minimising the need for centralised replication and storage which in turn improves data discoverability and informed collaborative decision-making in complex, interconnected systems	• New multi-source data integration offer • New data-based, value-added services (e.g., prediction of maintenance needs, risk management, RES generation forecasting, market insights for demand forecasting and pricing strategies or RES integration)

Overall feedback confirmed the proposed analysis. We report below the statements collected from two projects:

VPP4Islands project confirmed that the proposed approach is clear and practical. Role-based access, semantic interoperability, and standardised data formats are expected to help bridge organisational silos. Real-time data integration and predictive maintenance can also enhance business models. Two concrete examples have been proposed to illustrate how data ownership and governance significantly enhance data discoverability within FDT implementations (point #6).

- The federated smart planning tool developed by VPP4Islands allows stakeholders (energy communities, DSOs, renewable producers) to maintain ownership of their datasets, securely sharing relevant data through clearly defined role-based access. This federated structure facilitates efficient discovery and access to essential data for optimisation and decision-making, without compromising data sovereignty.

- The VPP4Islands digital twin with SAPL integrates the Streaming Attribute Policy Language (SAPL), enabling robust, attribute-based access control to real-time operational data. SAPL allows stakeholders to precisely govern who can discover and access specific data streams from renewable assets, storage systems, and grid sensors. This ensures secure, controlled discoverability of data critical for effective real-time energy management.

OMEGA-X includes the development and deployment of digital twins for energy assets (e.g., PV plants, smart grids) integrated into a federated environment. The project goes beyond data-driven twins by combining them with physics-based modeling and AI techniques such as GANs. This federated approach allows for improved forecasting, decision support, and operational optimisation, enhancing the scientific and commercial value of R&I outcomes.

Observations from R&I project TwinEU were also collected on the above statements on FDT. Federated digital twins enable cross-stakeholder and cross-sector collaboration and cooperation interconnecting Digital Twin in an interoperable and seamless way. The FDT should be implemented ensuring interoperability both at technical and semantic level for data and model sharing, ensuring at the same time control and security over shared data and models. FDT should thus not only consider the data and model exchange but also implement an ecosystem in which the integration of new business models, services, apps and technologies (AI, XR, IoT, etc..) can be easily approached.

In this context, federated data space and its decentralised approach can support the implementation of FDT, providing a structured and interoperable environment for data sharing and integration. The main aspects to be considered include[10]

- Interoperability, digital twins must communicate and share data seamlessly, regardless of the underlying systems or platforms. This can be achieved using standardised protocols, data format and communication mechanisms
- Data sovereignty, since data from multiple sources is collected and shared, it is important to maintain control over data and FDT models, including tracking of transactions and usage during the whole process
- Scalability, a large amount of data can be shared, so it is important to provide a scalable architecture/infrastructure
- Security, since sensitive data can be exchanged, it is important to ensure end-to-end security, maintain trust among the stakeholders.

Out of the 25 projects interviewed, only a few indicated some links with the concept of federated digital twin and are positioned in the figure below.

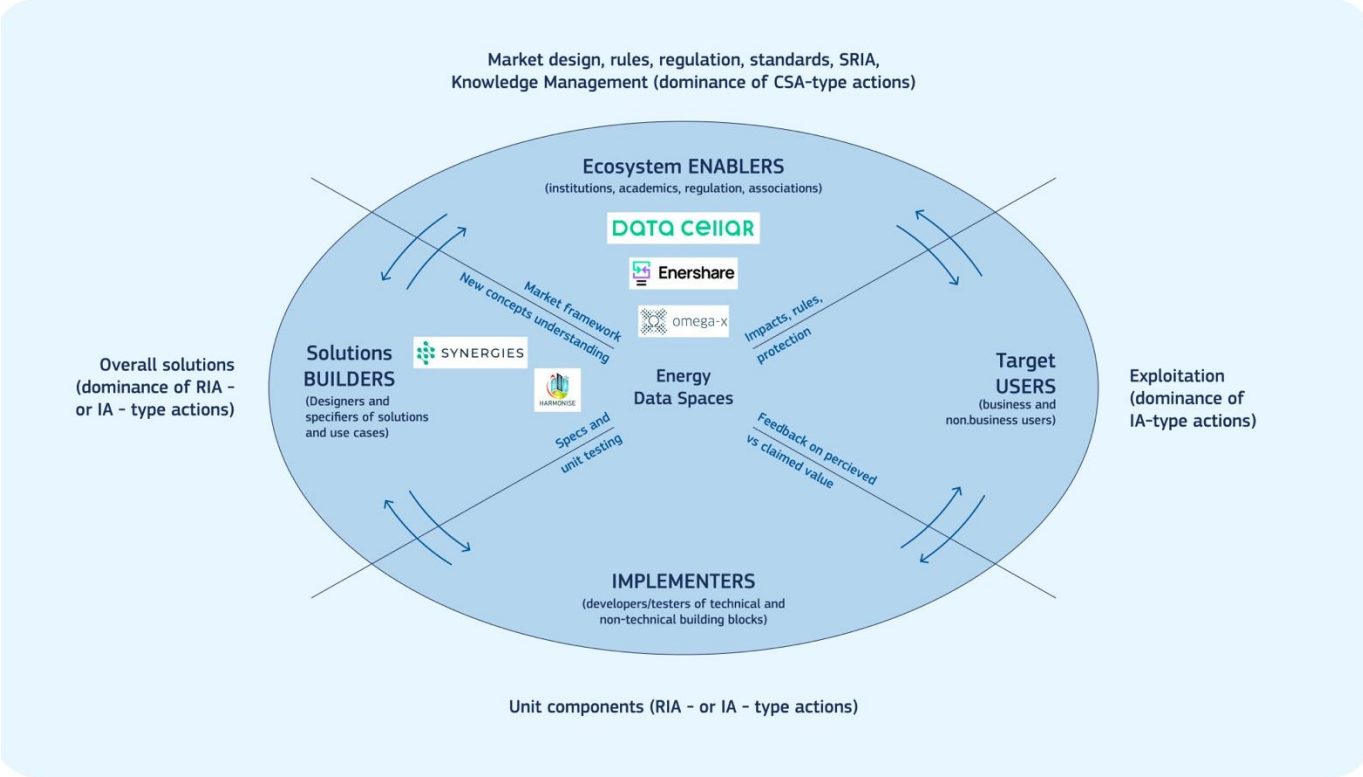


Figure 4.5: Mapping of respondent projects to the federated digital twin pillar

4.5.5 How Energy market places could facilitate discoverability of energy data resources?

Definition[11]: An energy market place is a digital platform that facilitates the buying, selling, and trading of electricity and related services among producers, consumers, and prosumers. It enables decentralised energy transactions, promotes competition, and optimises energy distribution using technologies like blockchain, AI, and IoT. These

[10] Guidance-for-the-Integration-of-Digital-Twins-in-Data-Spaces, AIOTI, August 2024.
[11] **Sources**: Quarterly report On European electricity markets, Market Observatory for Energy, DG Energy, Volume 17, 2024 ; Website Electricity market design May 2024 ; https://energy.ec.europa.eu/data-and-analysis/market-analysis_en, 2024; https://www.eex.com European Market place, 2025.

market places can operate at wholesale, retail, or peer-to-peer levels, supporting flexibility markets, renewable energy trading, and demand-response mechanisms to enhance grid stability and sustainability.

The following table identifies some building blocks in relation with energy market places: their added value and option questions are reported. These questions could drive a further interaction with the BRIDGE projects.

Table 4.6: Claimed added value for leveraging on discoverability of energy data resources (energy market places)

Item	Interesting approach	Why this approach offers value?	Promising use cases, impacts for the Business Model or still open questions
#1	**Centralised Data Platforms**	Open data standards ensure interoperability and efficient data sharing.	• How can EMPs enhance data accessibility and interoperability for energy stakeholders? Standardisation makes it easier for users to find, access, and use data. In addition higher interoperability would mean that users can search across multiple databases and platforms in a more unified manner.
#2	**AI-Driven Insights & Predictive Analytics**	Helps businesses identify profitable energy trading opportunities and demand response strategies.	• How can AI-driven analytics help businesses identify profitable energy trading opportunities? AI-driven search tools can help users uncover hidden data patterns, identify data they might not have initially considered, and recommend new datasets, improving thus efficiency in the discovery process of opportunities
#3	**Blockchain for Transparent Transactions**	Smart contracts automate transactions, reducing intermediaries and increasing efficiency.	• How can blockchain technology improve trust, security, and automation in energy data transactions? Blockchain improves trust by ensuring transparent, tamper-proof energy data; enhances security through decentralised, encrypted records; and enables automation via smart contracts for real-time, efficient transactions. The DATA CELLAR project is partially related to the concept of energy market spaces. As part of its federated dataspace infrastructure, DATA CELLAR foresees the development of a decentralised and tokenised market place dedicated to the exchange and valorisation of energy-related datasets, AI models, and digital services supporting LECs and broader energy stakeholders. This market place will enable stakeholders to share, sell, or rent datasets and AI models in a transparent and secure manner, leveraging Distributed ledger technologies (DLT) to guarantee data integrity, provenance, and trust. It will allow the use of smart contracts to automate transactions, ensuring that exchanges are secure, efficient, and auditable without the need for intermediaries. Furthermore, stakeholders will have access to a token-based incentive system that rewards data providers and model developers, thereby encouraging active participation and the continuous enrichment of the dataspace. In addition, the market place will facilitate the exploration of new business

			models based on data valorisation, including subscription-based services, pay-per-use access models, and dynamic brokerage of energy-related digital services.
#4	**Peer-to-Peer (P2P) Energy Trading & Flexibility Markets**	Flexibility services allow businesses to monetise energy storage and demand-side response.	• How do EMPs enable direct energy trading and flexibility services for consumers and businesses? Any flexibility services catalogue and P2P platforms? EMPs enable P2P energy trading by connecting prosumers and consumers directly, and support flexibility services by linking users with grid operators to monetise load shifting, storage, and demand response.
#5	**Real-Time Monitoring & IoT Integration**	Enables dynamic pricing models and adaptive trading strategies	• How does IoT integration in EMPs enhance real-time decision-making for energy trading and optimization? IoT integration in EMPs enables real-time data collection on energy usage, generation, and storage, allowing for instant decision-making, dynamic pricing, and automated trading. This enhances optimisation by aligning supply and demand efficiently and responding instantly to market or grid signals.
#6	**Regulatory Compliance & Standardisation**	Legal compliance increases trust and confidence in the use of data and encourages collaborative initiatives	• How can EMPs support regulatory compliance and facilitate participation in green energy markets? Which regulation needs ? EMPs support regulatory compliance by ensuring secure data handling, auditability, and adherence to energy market rules. They enable participation in green energy markets by tracking renewable generation, managing certificates (e.g., Guarantees of Origin), and aligning with GDPR, energy directives (RED II/III), and grid codes. This builds and reinforces trust, and thus encourages collaboration among stakeholders.

Feedback was also collected from Bridge projects on their contribution to energy market spaces:

OMEGA-X confirmed it is actively developing a federated data and service market place that enables secure and sovereign exchange of energy data and services. This market place facilitates peer-to-peer trading, dynamic supplier selection, and matchmaking between data/service providers and users. It supports new market mechanisms and business models, which can significantly accelerate the commercialisation and scalability of R&I results in the energy domain.The synthetic visual below provides an overview of the respondent projects to energy market places.

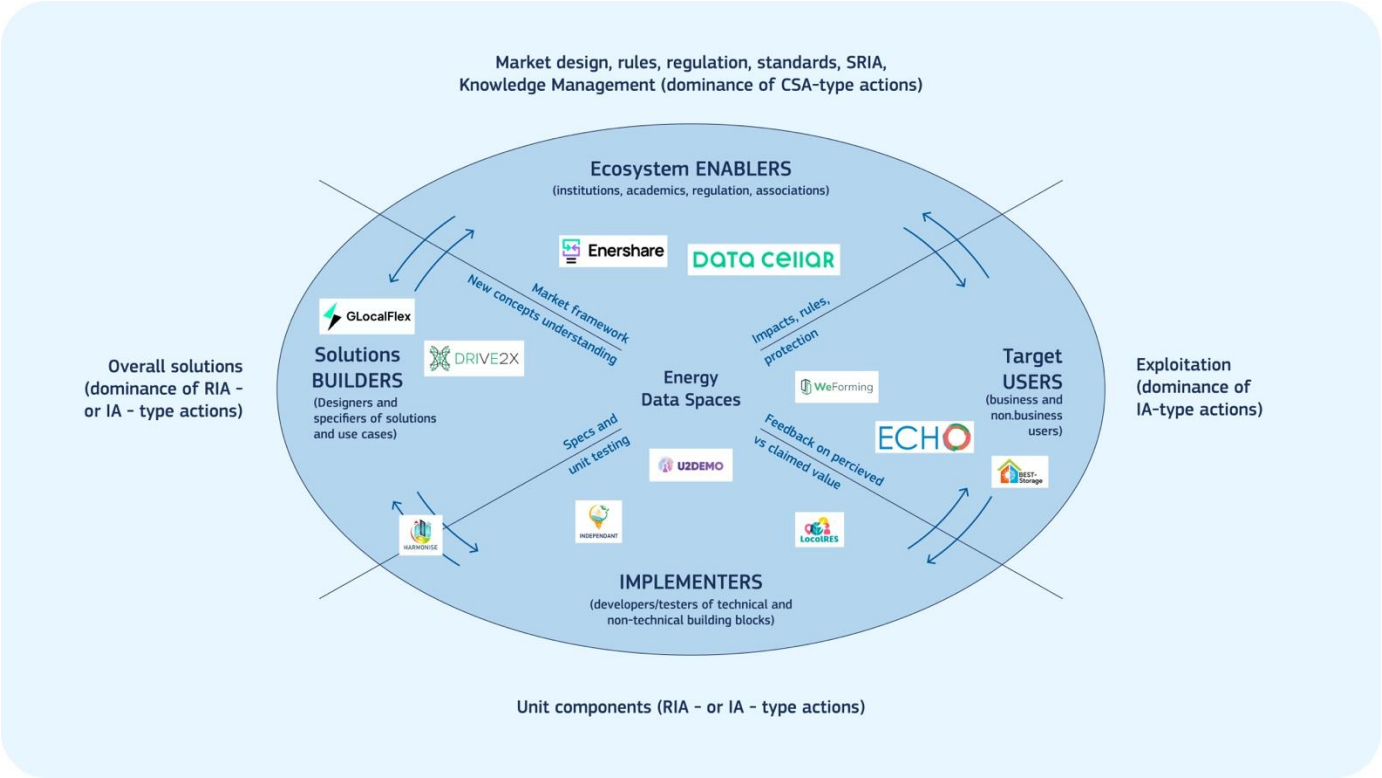


Figure 4.6: Mapping of respondent projects to the energy market places pillar

4.5.6 Conclusions and recommendations for next steps

a) Highlights per pillar

The following highlights have been synthesised for each pillar regarding the facilitation of discoverability of energy data resources.

Table 4.7: Overview of the collected feedback

Item	Highlights
European Energy Data Spaces	• Several Bridge R&I projects claim to align with the relevant data spaces frameworks (GAIA-X, IDS-RAM) • Data sharing platforms are being developed to enhance transparency and interoperability • Six areas of created value by EEDS enable discoverability of energy data resources to be leveraged (see Table 4.4) • Most of the respondents BRIDGE projects have positioned their role either as system DESIGNERS or USERS in this framework (see Figure 4.4).
Federated digital twins	• Limited adoption so far for federated digital twins, but some projects use digital twins for their scenario analysis or for energy optimisation • Seven areas of created value by FDT are expected to facilitate discoverability of energy data resources (see Table 4.4). Projects confirmed that the proposed approach is clear, and that role-based access, semantic interoperability, and standardised data formats are expected to help bridging organisational silos. • Among the project results, real-time data integration and predictive maintenance are expected to reinforce the elaboration of business models

	• More generally a holistic perspective is confirmed by projects as a must-go route. Indeed, FDT enable cross-stakeholder and cross-sector collaboration and cooperation interconnecting digital twins in an interoperable and seamless way. The FDT should be implemented ensuring interoperability both at technical and semantic level for data and model sharing, ensuring at the same time control and security over shared data and models. FDT should thus not only consider the data and model exchange but also implement an ecosystem in which the integration of new business models, services, apps and technologies (AI, XR, IoT, etc.) can be easily approached.
Energy market places	• Five areas of created value by Energy market places enable leverage of discoverability of energy data resources (see Table 4.6) • 9 projects have been identified as contributors to Energy market places: the respondent BRIDGE projects cover a more diverse spectrum of roles. They have positioned it either as system DESIGNERS or IMPLEMENTERS or USERS (see Figure 4.4) • Two particular focuses can be made: a growing interest in block-chain-based flexibility markets is shown by projects; smart contract automation is being explored for secure energy transactions.

b) Outcomes and lessons learnt

Overall, the activity led in Task 3 led to the following conclusions.

- Discoverability of data is confirmed to be a central concept for R&I projects when building their exploitation strategy or building a quantitative business model on their exploitable results
- The exploration of Energy data discoverability routes as assets for increased discoverability of energy data resources. The three pillars: Energy Data Spaces, federated digital twins and energy market places were analysed with regards to their role to increased discoverability of energy data resources and was divided in 5 to 7 components with added value, promising use cases and open questions
- This breakdown, when combined to projects feedback, enabled us to identify four roles - System BUILDERS, IMPLEMENTERS, Target USERS, Ecosystem ENABLERS for each pillar: the 4-area framework.
- A selection of 25 Bridge projects have been positioned in the proposed framework: a limited adoption so far for federated digital twins but several Bridge projects claim to align with the relevant data spaces frameworks (GAIA-X, IDS-RAM).

The growth of data-sharing platforms federated digital twins, and energy market places is advancing transparency, interoperability, and collaboration within the energy sector. While energy data spaces projects primarily focus on system design and user engagement, federated digital twins adoption remains limited but shows strong potential for scenario analysis and energy optimisation. The emphasis on role-based access, semantic interoperability, and standardised data formats is expected to bridge organisational silos.

Additionally, energy market places are gaining traction, with blockchain-based flexibility markets and smart contract automation being explored for secure energy transactions. Ensuring interoperability, security, and seamless integration of emerging technologies will be essential to maximising the impact of these initiatives.

c) Moving forward

Task 3 underscores the importance of discoverability of data from heterogeneous and evolving formats for supporting projects in building the business model of project results, allowing for scaling up of the envisioned solutions and for enhanced discoverability. Experience showed there is potential for a more systematic approach based on inputs from the BRIDGE community. We consider that the work carried out so far would gain from (a) further refining of these frameworks and from (b) facilitation of discoverability and scaling up modes based on wider feedback, especially from projects bringing core contributions to the topic such as Coordinated Support Actions. This could take the form of practical starting points frameworks and guidelines for the projects.

The evolving data driven business model's development towards data spaces in energy remains an important focus, which could have dedicated cross WGs focus for the next period closely linked to the AI in energy focus. The recent paper of ETIP-SNET on AI in Energy (April 2025) identifies such needs, which should be closely examined in Task 3 and the Business Model WG overall. In addition, progress and developments related to specific priorities areas within D4E and enabling flexibility call for closer focus on data driven facilitation of data-driven business models.

A set of new topics emerged from the activity, and it is proposed to focus on AI driven tooling for reinforcing discoverability of data (common features in all three pillars). A collection and compilation of all actions led by BRIDGE projects on AI impact for energy data spaces could be valuable for the community in the light of the recommendation related to data spaces topics and AI impact on business models. We consider that the next period is relevant for updating the visual frameworks developed by Task 3 in 2024 on data sources, since it will coincide with the projects' final recommendation maturity. The outcomes of the CSA recommendations and EEDS should therefore be processed and included in the update of the frameworks. Further adjustments and recommendations should be made, and dynamic tool development should be considered.

Moving forward, the Business Model WG proposes therefore to review its objectives in light to the above evolving needs and its focus areas, while maintaining its methodological and data collection effort. Task 3 should thus organise its activity with a close interaction with the full range of BRIDGER&I projects over their life cycle: the onboarding of the new BRIDGE projects to integrate novel ideas and concepts, while capitalising on the results of the most mature ones reaching their term with formalised deliverables.

Practically the activity could take diverse forms. First, at the level of the WG by further collaboration with projects and among the different tasks of the WG. Then, at the level of Task 3 to continue the mapping of roles of active BRIDGE projects for each of the three pillars, transform the lessons learnt of the past two years in a recommendation based on the impact and progress analysis for R&I projects. There is also a need to link the expected impact reflected in activities towards the competitiveness imperative and the facilitation of socio-economic impact priorities and scaling up topics. A roadmap to reflect these focus areas will be proposed is that direction.

Lastly, in collaboration with the other WGs the outcomes of a number of the ongoing EU Task Forces, high level forums and other formats on energy data spaces should be discussed and integrated as to priorities for the upcoming period in addition to the above roadmap.

5. Synthesis of results and conclusions

The activities of the Business Models Working Group in 2024–2025 provided a comprehensive understanding of the current practices, challenges, and opportunities in business model development, quantification, and data valorisation across BRIDGE projects. Drawing from the insights generated in Tasks 1, 2, and 3, this section summarises the key findings, identifies cross-cutting challenges and best practices, and outlines recommendations for future actions.

5.1 Key Findings Across Tasks

The analysis revealed that BRIDGE projects are progressing towards more structured and effective business model practices, yet significant gaps remain that require targeted support.

- **Task 1 – Business Model Development Tools:**
  Projects commonly rely on well-established tools such as the Business Model Canvas and Value Proposition Canvas. While these provide a solid starting point, they often lack the depth required for quantitative validation, environmental analysis, and stakeholder alignment. Early initiation of business model development and comprehensive stakeholder engagement were consistently identified as critical success factors. Innovative approaches, such as gamification and archetype modelling, showed promise in enhancing relevance and replicability.

- **Task 2 – Quantification Methods:**
  Quantification of business model benefits remains an underdeveloped area, with projects struggling to implement robust, standardised methodologies. Cost-benefit analysis and ROI are the most frequently used methods, but gaps persist in the systematic measurement of environmental and social impacts. Data quality and availability remain barriers to reliable quantification, and there is a clear need for practical guidelines and training to support projects in adopting advanced methods such as SROI, MCDA, and scenario analysis.

- **Task 3 – Data Valorisation:**
  Data generated by projects is often underutilised as a key exploitable result. Discoverability of data resources emerged as a critical concept, enabling projects to locate and leverage valuable data assets through European energy data spaces, federated digital twins, and energy market places. Ownership, compliance (e.g., GDPR), and FAIR principles remain significant challenges, underscoring the importance of improved data management plans and cross-WG collaboration. The task also enabled to collect contributions of about 25 R&I projects in the domain of energy data spaces, federated digital twins, and energy market places (the pillars) and proposed a tentative mapping according to four different profiles: ecosystem enablers, solutions builders, implementers, target users, the very same approach being followed for each of the three pillars.

5.2 Cross-Cutting Challenges

Several universal challenges have been identified that cut across all three tasks:

- **Monetisation of innovation:** Translating technical results into viable, market-ready products and services with viable business models remains a persistent difficulty.

- **Stakeholder engagement:** Aligning diverse interests and clarifying roles within multi-partner consortia require dedicated strategies and facilitation.

- **Quantitative validation:** Lack of reliable benchmarks and standardised metrics hampers the validation and

comparison of business models.

- **Data governance and utilisation:** Fragmented data practices, unclear ownership, and insufficient awareness of data spaces limit the potential of data-driven business models.

5.3 Best Practices and Emerging Approaches

Despite the challenges, several effective practices have been identified:

- Early and parallel integration of business model development with technical work.
- Tailoring business models to specific pilots, tools, and market segments rather than generic approaches.
- Combining qualitative frameworks with quantitative validation and external market feedback.
- Leveraging collaborative tools and workshops to align partners and co-create business models.
- Integrating data valorisation considerations from the outset, supported by visual frameworks and mapping exercises.

Innovative approaches, such as the use of gamification for market validation, multi-stakeholder business model design (B2C, B2B, B2B2C), and the development of archetype models for replication, demonstrated strong potential.

5.4 Recommendations for Next Steps

To build on the progress achieved and address the remaining gaps, the BM WG proposes the following next steps:

- Enhance the task 1 outcomes to a practical and user-friendly “Business Models Cookbook” consolidating best practices, tools, and case studies to guide projects at different stages.
- Establish standardised yet flexible guidelines for business model quantification, including metrics and templates tailored to energy-sector challenges.
- Enhance capacity building through targeted training, mentoring, and knowledge-sharing initiatives.
- Strengthen collaboration with other BRIDGE WGs (e.g., Data Management, Regulation) to leverage synergies and address cross-cutting issues.
- Ensure that R&I projects get involve all along the exploration activity led by the Task, with more emphasis on the engagement of projects that are close to their completion with solid conclusions that would deserve increased visibility.
- Initiate a repository of exemplary BRIDGE project results (products, services) and related business models, clustered by use cases, to increase visibility and foster replication.

5.5 Conclusion

The 2024–2025 activities of the BM WG underscored the importance of systematic, integrated approaches to business model development, quantification, and data valorisation. While projects demonstrate increasing maturity in these areas, targeted support, structured methodologies, and improved data practices are essential to unlock the full potential of BRIDGE project outcomes and accelerate market uptake. The WG remains committed to supporting projects in building robust, impactful, and replicable business models aligned with European strategic objectives.

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (european-union.europa.eu/contact-eu/meet-us_en).

On the phone or in writing

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696,
- via the following form: european-union.europa.eu/contact-eu/write-us_en.

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website (europa.eu).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (eur-lex.europa.eu).

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

The Service Contract (n. CINEA/2023/OP/0001/SI2.901723) supports BRIDGE activities, funded by the EU.