oPEN Lab
TARTU PAMPLONA GENK
LEADING THE TRANSITION TO POSITIVE ENERGY NEIGHBOURHOODS

Overview of contracts, guidelines, and best practices for value chain integration

13/10/2023

Flux50

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Abbreviations

Abbreviation	Description
3D	Three-dimension(al)
AAS	As A Service
AC	Alternating Current (in opposite to DC)
AOA	Apartment Owner Association
AR	Augmented Reality
BAFO	Best And Final Offer
B2B	Business to Business
B2C	Business to Client
BIM	Building information System
BMS	Building Management System
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
D&B	Design & Build
DBFM	Design Build Finance Maintain
DBFMO	Design Build Finance Maintain Operate
DBM	Design Build Maintain
DC	Direct current (in opposition to AC)
DSO	Distribution System Operator
ECI	Early Contractor Involvement
EPC	Energy Performance Contracting
ESCO	Energy Service Company
ESP	Energy Service Provider
GHG	Green House Gas
GPS	Global Positioning System
HVAC	Heating, Ventilation and Air Conditioning
IAQ	Indoor Air Quality
iCD	Intelligent community design
ICT	Information and Communication Technologies
IED	Integrated Energy Design
IEQ	Indoor Environmental Quality
IMU	Inertial Measurement Unit

IPD	Integrated Project Delivery
IP(R)	Intellectual Property (Rights)
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LCC	Life Cycle Cost
LEED	Leadership in Energy and Environmental Design
LiDAR	Light Detection And Ranging
MaaS	Mobility as a Service
OSS	One Stop Shop
PEB	Positive Energy Blocks
PED	Positive Energy District
PEN	Positive Energy Neighbourhood
PPP	Public-Private Partnership
PV	Photo Voltaic
R&D	Research And Development
RE	Renewable Energy
REC	Renewable Energy Community
REOI	Request for Expression Of Interest
RES	Renewable Energy Sources
RFI	Request For Information
SC	Smart Charging
SME	Small and Medium Enterprises
SNC	Sustainable Neighbourhood Contracts
SPV	Special Purpose Vehicle
TCP	Temporary Commercial Partnership
UAV	Unmanned Aerial Vehicle, commonly known as drone
UDC	Urban Development contracts
UK	United Kingdom
UMI	Urban Modelling Interface
V2G	Vehicle To Grid
VR	Virtual Reality
ZEN	Zero Emission Neighbourhood

Acronyms

Acronym	Description
AHA	Alonso Hernandez & Associates, architectural company
BAX	BAX Innovation consulting sl.
BPIE	Buildings Performance Institute Europe aisbl
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
ENoLL	European Network of Living Labs ivzw
IWT	Flemish agency for innovation through science & technology
KPMG	Klynveld Peat Marwick Goerdeler, audit, tax, and advisory services company
NAV	Flemish branch organization of architects
ORI	Branch organization of consulting and engineering firms
POM	Provincial development agency
VCB	Flemish confederation of construction
VEKA	Flemish energy & climate agency
VITO	Flemish institute for technologic research
VMSW	Flemish association of social housing
VREG	Flemish regulator for electricity
VLAIO	Flemish agency for innovation and entrepreneurship

Executive Summary

In a conventional building process the building owner first engages an architect to design the construction and create the specification file (technical part of the procurement file). Then the procurement file is published on the market and building companies can make their offer. As the procurement file already defines a lot in terms of design and materials to use, the companies don't have a lot of freedom in their offers. Therefore, the main award criterion is price. After awarding the building company can plan the works and start with the realisation of the construction. In this approach, which is typically used for large or public projects, but also (less formal) for smaller or individual projects, the experience of the building company is only used during execution. If that experience would also be used during the design phase additional value may be created.

Today we see that energy techniques and energy operations are more and more important in the construction sector, especially in a PEN-environments (Positive Energy Neighbourhoods). This means that also energy actors (construction parts, techniques, and operations) need to bring in their experience early in the design phase to optimise the result in the operational phase of the building.

In the context of PEN constructions, energy flows are not restricted to a single building but cover a district or neighbourhood. In this context energy related construction elements and preparation for efficient energy operations are even more important.

In this recent context of more energy driven construction works, actors have to find new ways to collaborate: a more integrated value chain. The conventional approach seems to be too restrictive. The concept of 'construction teams' tries to valorise experience from building companies and other execution actors early into the design phase. When working together in the design phase everyone also feels more responsible for the end result. This collaboration method is already practiced in some regions and markets. Construction teams are already an improvement, but typically the energy actors are not yet involved today.

In the first section of this document, we define the value chain, the involved actors, challenges, and drivers to further integration. Then information will be collected about the collaboration methods that happen in practice in the construction sector today. These methods are evaluated on different aspects like their specifics, when they can be applied and if they are usable in a public procurement environment. These methods are also checked from the point of view of their support for early integration.

For each of the collaboration methods a summary in the form of 5 bullets is given, listing up the most important takeaways to consider when using these collaboration frameworks. A more elaborated description will be found in the related chapters.

Conventional workflow

- In a conventional process the building owner first engages an architect to design the construction and create the specification file. Then the procurement file is published on the market and building companies can make their offer. After awarding, the building company can plan the works and start with the realisation of the construction.
- Commonly used all over the market. Very suitable for project with relatively straightforward designs, well-defined scopes, and limited complexities.
- A lot of control by the owner/client
- Less flexible to changes or innovation

- Commonly used in public procurement processes.

Construction teams and Design & Build

- The key of this approach is to involve executive parties as early as possible in the design process of a construction. So, the design can enjoy the experience of the construction company.
- "A construction team is a project-related collaboration, from the start of the assignment (design phase) to the execution phase, in which, in addition to other construction professionals, at least the principal, designers, consulting and engineering firms and executives are involved, with the aim of creating added value for the client through the optimization of, among other things, result, cost, deadline and/or quality."
- The best-known examples of integrated contracts are Design & Build (D&B), DBM and DBFM(O). The main distinction is in the scope of the contract: only the design and execution (D&B), or also the financing (Finance), maintenance (Maintenance) and/or operation (Operate)
- In a pure DBFM contract, the government limits itself to determining what it wants as the final result. It is then up to the private market parties to make a proposal regarding the form, financing, concrete execution, and maintenance. Consequently, it is the private partner who bears the risks of all this.
- Unlike the construction team organizational form for private contracts, Design & Build and DB(F)M(O) procedures for public contracts are awarded in two phases, the so-called limited procedures. The selection and award phases are separated. In the first phase, that of selection, bidders - usually in the form of a consortium - submit a request for participation. In this request, they must demonstrate that they meet the selection criteria set by the client. Only those candidates who are selected are allowed to submit a bid in the award phase.

Up to the next level of integration and value

- Further integration of building infrastructure, energy infrastructure and digital platforms/solutions.
- Integrated planning process for a neighbourhood instead of a single building; use a lot of digital design and collaboration tools.
- Engagement based on value proposition for each partner or stakeholder.
- Prominent role for energy flows.
- New value chain and business models for energy integration

Subcontracting

- A main contractor hires a subcontractor to perform specific tasks or a subproject.
- A common practice for the main contractor to acquire specialized experience or extra capacity. Energy techniques are often acquired in this way.
- Mainly used in the execution phase.
- The owner or architect is not involved in this relation; the main contractor is fully responsible towards the owner.
- Not relevant for public tendering by the owner. A public tender for subcontracting is not typical.

Temporary association for tender

- Short term partnership between two or more contractors, specific for a given project, without committing to long term partnership.
- Set up at the latest in the tendering phase.
- A common practice for large construction projects, mostly in the public domain.
- A way to handle capacity needs and share risks in large projects.
- In public procurement they are also known as joint ventures or consortia.

One stop shop

- A comprehensive service provider that offers a wide range of products or services. Instead of dealing with multiple specialized companies, clients can find everything in one place.
- Only one point of contact for the owner and one responsible party.
- Provides streamlined processes and potentially more integrated solutions.
- The term is not yet common in the construction/energy sector but can also take the form of a main contractor.
- Possible in public tendering.

Innovative public procurement process

- A public procurement process by which a public entity seeks to acquire goods, services or works in a manner that fosters innovation and promotes the development of new and advanced solutions. Not based on predefined specifications or well-established requirements.
- Encourages involvement of a wide range of stakeholders, including public, academia or industry, to contribute to problem-solving and idea generation.
- Often involve pilot projects and testbeds to trial new solutions before broader implementation.
- Not yet commonly used. Best used when conventional procurement methods are unlikely to yield the desired outcomes or when there is a need for ground-breaking, cutting-edge solutions to address complex challenges.
- Can take the form of competitive dialogue, innovation partnership, or innovation procurement of research and development services.

Energy Performance Contracting (EPC) and Energy Service Company (ESCO)

- An EPC is a contractual agreement between a client and an energy service provider, typically an ESCO. The purpose of an EPC is to improve energy efficiency, reduce energy consumption, and achieve cost savings in the client's facility. The key characteristic is that the ESCO guarantees specific energy savings.
- The ESCO takes full responsibility for identifying, designing, financing, implementing, and maintaining energy saving measures.
- An EPC approach seems to be a win-win collaboration by default: The owner sees a guaranteed reduction in energy expenses, without upfront investment, while the ESCO has a good reason to select the right measures.
- Mainly targeted to a renovation context, where a building as a whole or specific energy equipment needs renovation.
- This approach works fine in formal public procurement contexts. A good preliminary assessment is necessary to define a delimited scope of work.

Consortium formation

- Flux50 brings together consortia of companies, knowledge institutes and sometimes government organisations, to execute innovation projects in energy transition or related domains. Flux50 assists in consortium formation, supports funding proposals, and provides access to test facilities and living labs.
- Flux50 helps in disseminating the project results, facilitates gaining market access to new technologies or business models.
- Flux50 participates in European projects to exchange knowledge and experiences between their members and international markets.
- The focus is on research and development projects on topics, not yet common on the commercial marketplace.
- The services cannot be acquired via public procurement services.

Framework contracts

- Long-term agreements between a client and one or more pre-selected contractors. These contracts set out the terms and conditions under which future construction or energy projects will be awarded and executed.
- Commonly used for recurring acquirement of similar goods or repetitive construction projects or services.
- Can be used within a program to build new schools or service flats.
- Efficient and streamlined procurement.
- Commonly used in public procurement processes.

Guidelines: Conventional versus integrated approach

Ultimately, the selection of the workflow should consider project-specific requirements, owner preferences, project complexity, time constraints, and the desired level of collaboration among stakeholders. Evaluating these factors will help determine the most suitable workflow for a given project.

The choice of the conventional workflow versus other workflows depends on several factors and project-specific considerations. Here are some situations where the conventional workflow may be preferred over other workflows:

1. **Project Complexity**: The conventional workflow is often suitable for projects with relatively straightforward designs, well-defined scopes, and limited complexities. When the project requirements are clear, and there is little need for iterative design or extensive coordination, the conventional approach can be efficient.
2. **Owner Control:** If the owner/client prefers to have more control over the project and maintain separate contracts with the design team and the construction team, the conventional workflow may be favoured. This allows the owner to have direct involvement in the design development and tendering process.
3. **Project Familiarity**: The conventional workflow is commonly used for project types that are well-established and familiar within the industry. For example, residential buildings, commercial offices, or standard infrastructure projects often follow a conventional approach due to their predictable nature.
4. **Regulatory Requirements**: In some regions, regulatory frameworks or public procurement policies may favour the conventional workflow for certain types of projects. Public infrastructure projects or government-funded projects, for instance, may be mandated to follow a conventional procurement process.
5. **Competitive Bidding**: When the project owner aims to obtain competitive bids from multiple contractors, the conventional workflow allows for a clear separation between the design phase and the bidding process. Contractors can bid on a fully defined set of drawings and specifications, resulting in competitive pricing.

However, it's important to note that the conventional workflow may not be suitable for all projects, especially those with unique complexities or time constraints.

Alternative workflows such as design-build or integrated project delivery (IPD) can offer advantages in the following scenarios:

1. **Fast-Track Projects:** When time is of the essence, alternative workflows like design-build can expedite the project timeline by overlapping design and construction activities, facilitating faster project delivery.
2. **Complex or Innovative Designs**: Projects with intricate designs, sustainable features, or advanced technologies may benefit from alternative workflows that allow for close collaboration

between designers, contractors, and specialty consultants. This facilitates early input, innovation, and optimization of complex systems.

3. **Value Engineering:** Workflows like design-build or IPD provide opportunities for value engineering, where the project team collaboratively identifies cost-saving alternatives, efficiencies, and performance enhancements throughout the project lifecycle.
4. **Enhanced Risk Management**: Some alternative workflows, such as IPD, emphasize shared risk and reward among project participants. This encourages collaborative problem-solving and risk mitigation strategies, reducing the potential for disputes and claims.
5. **Client Preference for Integration:** If the owner/client prefers a more integrated project approach with a single point of responsibility, alternative workflows like design-build or IPD offer a consolidated team structure, fostering greater collaboration and accountability.

A list of recent concepts and tools, that can support the integration and information flow in collaboration, are described. Finally, attention points for a new, not yet existing, collaboration method are discussed.

Within the oPEN Lab project, methods and ideas to support further value chain integration will be validated in three PEN Living Labs, i.e., oPEN Living Lab Genk, Pamplona and Tartu. The goal at the end of the project is to provide guidelines and attention points on collaboration methods that support the replication to other PENs.

1. Value chain integration: setting the scene

1.1. Background: the changing world

In a conventional process the building owner first engages an architect to design the construction and create the specification file (technical part of the procurement file). Sometimes also an engineering company is engaged to define the specifications and design of the building techniques in the procurement file.

Then the procurement file is published on the market and building companies can make their offer. As the procurement file already defines a lot in terms of design and materials to use, the companies have not so much freedom in their offers. So, the main award criterion is price. After awarding, the building company can plan the works and start with the realisation of the construction.

This approach happens for both public buildings and larger size buildings, but also for renovation projects. In smaller (or individual) projects the specification file is also used as the means to get price offers, but the process is less formal.

In this conventional approach, the experience of the building company is limited to the execution phase. However, by valorising the know-how also during the design phase, additional value may be created.

The concept of 'construction teams' aims to valorise experience from building companies and other execution actors early into the design phase. When working commonly in the design phase, it is typical that all actors feel more responsible for the end result.

Today we see that energy techniques and energy operations are more and more important in the construction sector. This means that also energy actors (construction part, techniques, and operations) need to bring in their experience early in the design phase to optimise the result. In the context of PEN constructions, energy flows are not restricted to a single building but cover a district or neighbourhood. In this context energy related construction items are still more important. Construction teams typically do not yet involve the energy actors.

In this recent context, actors must find new ways to collaborate: a more integrated value chain.

1.2. What is the value chain?

Everybody has a different understanding what a value chain and value chain integration means. To harmonise the understanding, it is a good idea to make a definition of these terms, upon which the rest of the document is based.

Definition[1] (from the study of Papazoglou et al. (2000)):

Value system (chain) integration can be defined as ***the process*** *by which multiple enterprises within a shared market segment* ***collaboratively plan, implement, and manage*** *the flow of goods, services, and information along the value system (chain) in a way* ***that increases customer-perceived value*** *and optimizes the efficiency of the chain.*

[1]https://www.researchgate.net/publication/220196811_Integrated_value_chains_and_their_implications_from_a_business_and_technology_standpoint

Organisations continue to struggle with integrating their value chains to create and deliver more value to customers. Silo-thinking (rather than systems-thinking) is a typical symptom of poorly integrated value chains.

In the project definition of the oPEN Lab project this concept of involving the whole value chain has been applied to the PEN context (Positive Energy Neighbourhoods):

Both the construction and energy sectors have been subject to disruptions, as for example digitisation of the design and construction process, decentralised energy technologies, the uptake of energy communities, energy flexibility services, etc. While previously, the industry looked at decarbonisation as environmental regulations (burden), many players now acknowledge that disruptive technologies and innovation will be needed and strive to capture their economic opportunities (value).

In the transition towards a decarbonised building stock, the market innovators acknowledge the importance of an integrated renovation approach on neighbourhood level. A transformational change is ongoing in which they are moving towards a new value chain constellation where construction and energy actors collaborate closely together or even merge. For example, contractors providing comfort as a service shifting the business model to the total cost of ownership, manufacturers providing B2C services integrate their services into a one stop shop (see later), etc.

The trend for fading boundaries between construction and energy sectors in an integrated renovation approach, as is the objective for oPEN Lab, makes that actors from the whole value chain need to be involved. The testing of system approach uncertainties – for example on technology performances, user-willingness, and operational complexity – in a real-life setting will foster the market uptake of these solutions across the whole value chain, coping with novel services, business models, social innovations, financing mechanisms and targeting different functions of buildings.

1.3. Actors in construction and energy

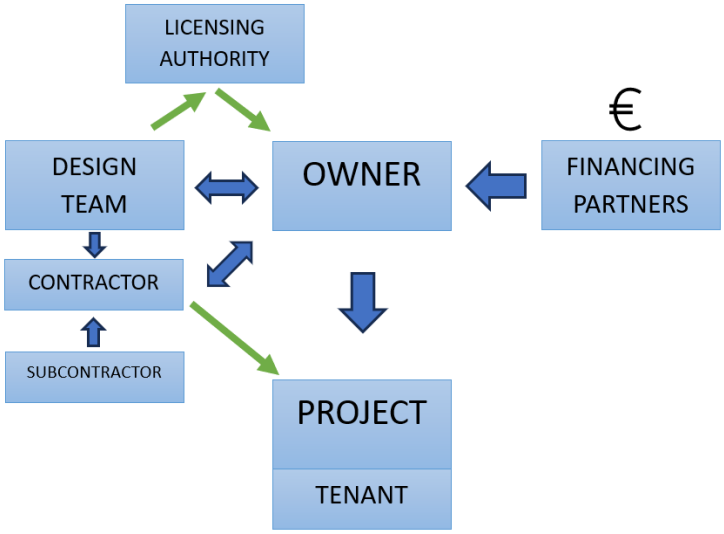

Figure 1: Overview actors in construction

The construction or renovation of a building involves many actors. Those are:

- The (future) owner who takes the initiative to a project
- Architects, designers, engineers: who manage the design and specifications of the new or renovated building
- City authorities, national policy makers
- Financing institutions
- Contractors and Sub-Contractors: who realise the works

The following actors are also involved, especially during the operation of the building:

- Building managers
- Inhabitants, tenants, users: who will live or work within the building

The following actors are more energy-related

- Building (energy) managers
- Network Operators
- Energy suppliers/retailers
- ESCOs
- Aggregators

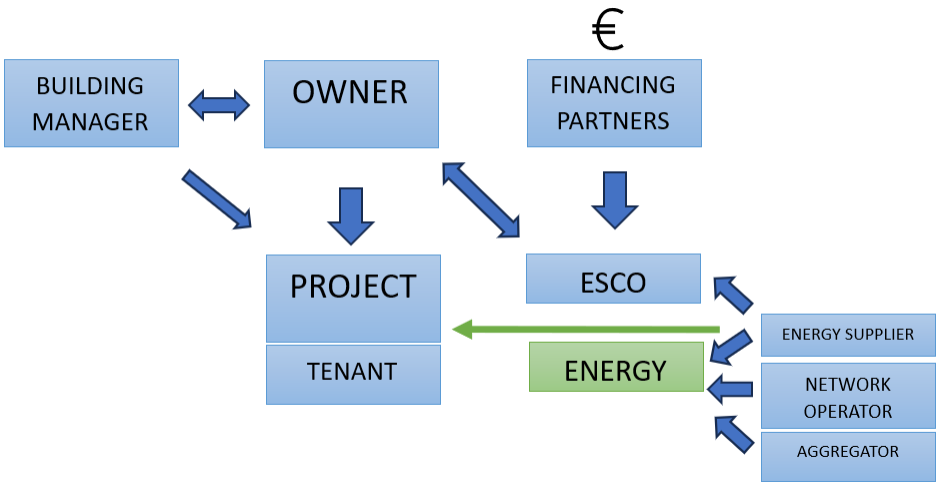

Figure 2: Overview actors in energy

In every project some other actors can be involved, but typically they all fall within the mentioned categories. So, this list is not complete, but it indicates that a lot of actors/stakeholders are involved during the project preparation, the project execution, and the operation of a construction project. Each of them has their own needs and view in the project.

1.4. Challenges and drivers

The construction industry is constantly evolving. BuildWise, an innovation centre for the construction sector in Belgium, commissioned a study to identify the main trends in the construction sector as early as possible.

It's worthwhile to keep the resulting highlights of this study in mind, when considering new collaboration methods in the construction/energy sector. Although the study has focused on the Belgian context, the trends are applicable across Europe.

This study has been completed and outlines the challenges and opportunities within the construction sector based on expected political, economic, social, technological, environmental, and legal evolutions. The in-depth analysis proposes 10 megatrends that the construction sector needs to consider. It also identified three key themes on which construction companies should focus to meet the (future) challenges: digitalisation, sustainability and investment in employees and their competences. The time of business as usual seems to be over.

These are the 10 megatrends[2] for the construction sector according to the report:

1. **The construction sector is competing in the 'war for talent' to overcome the shortage of competent personnel.** The construction sector is increasingly struggling with a shortage of personnel in terms of specific functions and the necessary skills, combined with an (r)evolution in terms of (team) composition and necessary competences within this labour market, which has an increasingly digital focus.
2. **Digitalisation is more than ever an important lever to work more efficiently, faster and more customer friendly**. The construction sector is experiencing a digitisation boom with innovations in all parts of the construction value chain, which is more than ever an important lever to work more efficiently, faster and more customer-friendly, and which will influence general working and thinking in the construction sector.
3. **Construction industrialisation makes building more affordable with increased quality.** A thorough construction industrialisation, at the level of the product but also on the level of work processes, policies and procedures, is becoming increasingly important with a goal for increasing the quality, productivity, and affordability of building.
4. **Intensified cooperation throughout the value chain with 'construction teams' as a response to complex construction process.** Structural cooperation (joining forces) between different parties throughout the value chain offers the opportunity to make the increasingly complex construction process manageable again by using 'construction teams' consisting of different stakeholders and parties with specific knowledge.
5. **Climate awareness, challenging targets and extreme weather conditions increase focus on sustainability**. The presence of extreme weather conditions on the one hand and challenging climate targets on the other requires the construction sector to assign increased focus to sustainability (environment and climate) with attention to topics such as energy efficiency and circular construction, leading to new innovative solutions and applications in the construction sector.
6. **Demographic evolutions force the construction sector to think about (alternative) forms of housing of the future.** Increasing population growth combined with ageing, migration and family thinning/extension are causing a (r)evolution in the composition of the population and forcing the construction sector to think about the (alternative) housing forms of the future.

[2] https://embuild.be/nl/nieuws/buildwise-onthult-10-megatrends-binnen-de-belgische-bouwsector

7. **Increased importance and complexity of the legal (regulatory) framework within the construction sector.** The legislative framework in which the construction sector operates, combined with the increasing importance of public opinion and the empowerment of citizens, is a major evolution that the construction sector faces, increasing the importance and complexity of the legal framework.
8. **Increased customer expectations make the construction sector change course towards customer-centricity.** Customers expect more and more transparency and customised services/products when providing products and/or services, forcing the construction sector to make a shift from product-oriented to customer-oriented thinking, with customer-centricity taking precedence.
9. **Business as usual in the construction sector is a thing of the past; an entire review of the business model urges itself.** New challenges and opportunities (in the technological field) are forcing the construction sector to question the current business model (business as usual) and to change its focus to more 'as a service' business model, with a primary focus on circularity and digitalisation.
10. **Breakthrough construction supply chain logistics are needed more than ever to deliver higher efficiency and security.** Recent (geopolitical) events have once again made the construction sector realise that a breakthrough of (new) supply strategies is becoming more necessary than ever, to proactively cope with potential price increases and increasing (planning) waiting times.

These 10 trends resulted in 5 implications for the construction sector:

1. **Transition towards process-driven construction:** deep digitalisation and standardisation should better prepare and streamline the construction process, with efficiency and effectiveness improvements and reduction of failure costs.
2. **Developing new markets:** the trends and evolutions within and outside the sector lead to new markets and opportunities for construction and installation companies (e.g., energy-efficient solutions, increase in renovations ...), whether or not accompanied by the application of new business models (e.g., as-a-service models).
3. **Evolutions and shifts in the value chain:** further evolutions and shifts in the value chain in the construction sector lead on the one hand to changes in the roles and responsibilities of different construction and installation companies, and on the other hand to new expectations with a corresponding impact on the required competences.
4. **Ecosystem thinking and co-creation:** construction and installation companies should look beyond their own company boundaries and individual projects and enter into co-creation within and across the value chain.
5. **Stimulating long-term thinking:** stimulating long-term thinking ('future awareness') within the construction sector in order to deal flexibly with unexpected events in the future.

Throughout the five implications, three main themes can be identified, on which construction installation companies should focus, in order to be able to face the (future) challenges (1) Digitalisation, (2) Sustainability and (3) Investment in employees and their competences.

1.5. Public procurement attention points

A lot of buildings are constructed to serve a public function. Social housing companies use public money to construct houses. In general, when public money is used, a formal public procurement process must be followed to contract all parties involved in the design and realisation of a construction.

The European Treaty on the Functioning of the European Union lists four principles that are crucial to public procurement issues. These principles are as follows:

- **The principle of competition**: the contracting authorities are obliged to ensure maximum competition for every public contract.
- **The principle of equality:** the contracting authority is obliged to give an equal opportunity to every citizen or company that has access to the public contract. Discriminating against citizens and companies is thus contrary to the principle of equality.
- **The principle of proportionality:** the contracting authority is obliged to remain fair when setting its requirements and assessing candidatures and bids.
- **The principle of transparency:** the obligation for the contracting authority to provide a maximum of information to the parties interested in the outcome of a public contract. In other words, the public contract must be conducted with open doors, insofar as this principle does not conflict with certain legal provisions.

As mentioned before, in the conventional process (for a public building) the building owner has to launch at least 2 public procurement processes: one for assigning the architect and for assigning the construction company.

The ambition of more integration in the value chain means that the ‘execution company’ is involved earlier in the process: during the design phase. This means that awarding only based on a project price, as an answer to a detailed design and specifications document, is no longer valid. So new procurement processes and/or other awarding criteria are needed. Depending on the chosen collaboration model, the mandatory public procurement process can be difficult to implement.

When the building owner is a private organisation, the procurement processes can be less formal, because a private organisation is not subject to the strict rules of public procurement, so, more flexibility is possible to choose a collaboration model. The award of a tender can be decided based on self-selected criteria.

2. Conventional workflow

2.1. Stages of the conventional workflow

The conventional construction workflow typically follows a sequential process that includes several distinct stages.

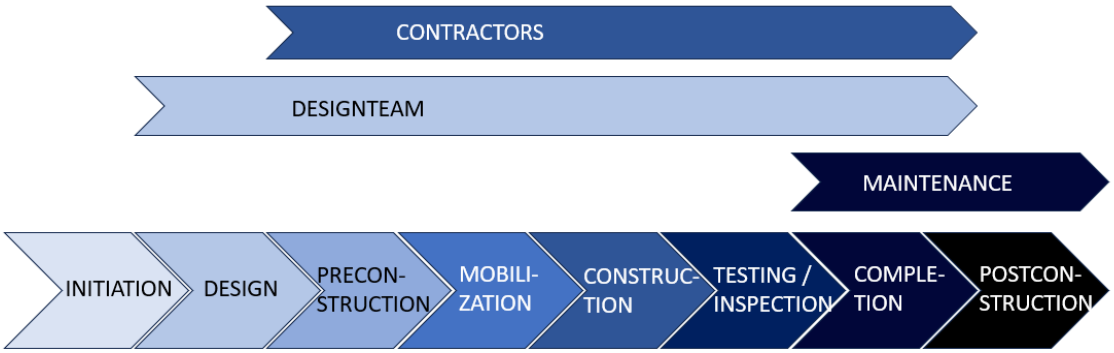

Figure 3: Stages of the conventional workflow

1) **Project Initiation**: This stage involves the identification of a need or opportunity for a construction project. It includes activities such as conceptualization, feasibility studies, and securing funding.

2) **Design**: Once the project is initiated, the design phase begins. Architects, engineers, and other design professionals work on creating detailed plans, drawings, and specifications for the project. This stage may involve multiple iterations and coordination among various disciplines.

3) **Pre-construction**: During this stage, the focus is on preparing for the actual construction work. It involves activities such as obtaining permits and approvals, selecting contractors, and procuring necessary materials and equipment.

4) **Mobilization**: Once the pre-construction tasks are completed, the construction site is mobilized. Temporary facilities are set up, including site offices, storage areas, and worker facilities. The construction team prepares the site for construction activities.

5) **Construction**: This is the primary phase of the project where the physical construction work takes place. It involves activities such as excavation, foundation work, framing, installation of utilities, interior and exterior finishes, and other tasks specific to the project. Construction progress is monitored, and quality control measures are implemented.

6) **Inspection and Testing**: Throughout the construction process, inspections and tests are conducted to ensure compliance with building codes, regulations, and project specifications. Inspections may cover structural elements, electrical systems, plumbing, and more. Any necessary corrections or adjustments are made during this phase.

7) **Completion and Handover**: When construction is finished, a final inspection is conducted to verify that all requirements have been met. Once approved, the project is considered complete, and the client takes possession. This stage may involve obtaining occupancy permits and certificates of completion.

8) **Post-construction**: After the project is handed over, there may be additional tasks such as addressing warranty issues, conducting post-construction evaluations, and completing any remaining documentation. This stage also involves transitioning to facility management or operations, depending on the type of project.

It's worth noting that the conventional construction workflow can vary a bit based on project complexity, contract types, and regional practices.

When the project is a renovation, an extra task happens before the design is initiated: measuring the existing situation and make drawings of this existing building as a 'foundation' for the new (renovated) design.

2.2. Benefits & pitfalls

Conventional Workflow	
+	-
Clear Separation of Responsibilities	Limited Collaboration and Communication
Well-Established Process	Potential for Rework and Delays
Competitive Bidding	Less Flexibility for Changes
Detailed Design Development	Limited Opportunities for Innovation
Owner Control and Decision-Making	

Table 1: Benefits & pitfalls of conventional workflow

The conventional workflow in construction projects has both advantages (pros) and disadvantages (cons).

On the positive side of the spectrum, it allows:

- **Clear Separation of Responsibilities**: The conventional workflow allows for a clear separation of responsibilities between the design team and the construction team. This can provide clarity and accountability, as each party focuses on their respective areas of expertise.
- **Well-Established Process**: The conventional workflow is a tried and tested approach that has been widely used in the construction industry for many years. It is familiar to many stakeholders, including owners, architects, engineers, and contractors, making it easier to follow and understand.
- **Competitive Bidding**: The conventional workflow often involves competitive bidding, allowing owners to obtain multiple bids from different contractors. This can help drive competitive pricing and potentially lower construction costs.
- **Detailed Design Development:** The conventional workflow typically allows for a thorough and detailed design development phase. This can result in comprehensive construction documents, reducing the likelihood of design errors or ambiguities during the construction phase.
- **Owner Control and Decision-Making**: The conventional workflow provides owners with greater control over the project. Owners can be involved in the design development, make decisions based on their preferences, and maintain direct relationships with both the design and construction teams.

But, on the negative side it implies:

- **Limited Collaboration and Communication**: The conventional workflow can sometimes hinder effective collaboration and communication between the design and construction teams. With sequential handoffs between parties, there may be less opportunities for early collaboration and input from contractors.
- **Potential for Rework and Delays**: In the conventional workflow, construction can only begin once the design phase is complete. If design issues arise during construction (which typically happen), it leads to disruptions and may require rework or modifications, leading to delays and potential cost overruns.
- **Less Flexibility for Changes:** Making changes to the project scope or design in the conventional workflow can be more challenging and time-consuming. Since the construction contracts are typically awarded based on the finalized design documents, changes may require additional negotiations, potentially impacting project timelines and costs.
- **Limited Opportunities for Innovation:** The conventional workflow may limit opportunities for innovative solutions and alternative approaches. With less early collaboration and integration of expertise, there may be missed opportunities to optimize design, construction methods, or sustainable features.

2.3. Key elements for successful project outcomes

When setting up collaboration in a conventional workflow in a construction project, several key elements should be considered to ensure successful project outcomes. Some of them are more oriented to the customer/owner or their architect; other points are more relevant for the executing contractors:

- **Clear Communication:** Establish effective communication channels and ensure that all stakeholders have a clear understanding of project goals, expectations, and timelines. Encourage open and transparent communication to foster collaboration and avoid misunderstandings.
- **Defined Roles and Responsibilities**: Clearly define the roles and responsibilities of each stakeholder involved in the project. This helps prevent confusion, duplication of efforts, and gaps in accountability. Ensure that everyone understands their specific contributions and how they fit into the overall project.
- **Mutual Trust and Respect:** Foster a culture of trust and respect among all collaborators. Encourage an environment where all stakeholders feel comfortable sharing ideas, raising concerns, and working together towards common goals. Trust is crucial for effective collaboration.
- **Collaboration Tools and Technologies**: Utilise appropriate collaboration tools and technologies to facilitate information sharing, coordination, and decision-making. This may include project management software, cloud-based platforms, BIM tools, and virtual collaboration platforms.
- **Continuous Improvement:** Foster a culture of continuous improvement by regularly evaluating collaboration processes, seeking feedback from stakeholders, and implementing lessons learned. Encourage innovation and the adoption of best practices to enhance collaboration and project outcomes.
- **Risk Management:** Identify and address potential risks and uncertainties early in the project. Regularly review and update the risk management plan throughout the project lifecycle.
- **Conflict Resolution:** Establish a structured approach for resolving conflicts and disputes that may arise during the project. Encourage open dialogue and seek mutually agreeable solutions. Mediation or alternative dispute resolution methods can be employed when necessary.

- **Change Management:** Establish a robust change management process to handle modifications, variations, and unforeseen circumstances. Clearly define the process for requesting, evaluating, and implementing changes. Ensure effective communication and agreement among stakeholders regarding changes to minimize disruptions and delays.
- **Document Control:** Implement a centralized and well-organized document control system to manage project documentation. This includes drawings, specifications, contracts, RFIs (Requests for Information), submittals, and other relevant documents. Ensure that stakeholders have access to the latest and accurate information.

2.4. When to use

The conventional workflow is often suitable for projects with relatively straightforward designs, well-defined scopes, and limited complexities. When the project requirements are clear, and there is little need for iterative design or extensive coordination, the conventional approach can be efficient.

It is commonly used for project types that are well-established and familiar within the industry. For example, construction or renovation of residential buildings and commercial offices, or standard infrastructure projects often follow a conventional approach due to their predictable nature.

Another good reason might be if the owner/client prefers to have more control over the project and maintains separate contracts with the design team and the construction team. This allows the owner to have direct involvement in the design development and tendering process.

In some regions, regulatory frameworks or public procurement policies may favour the conventional workflow for certain types of projects. Public infrastructure projects or government-funded projects, for instance, may be mandated to follow a conventional procurement process.

When the project owner aims to obtain competitive bids from multiple contractors, the conventional workflow allows for a clear separation between the design phase and the bidding process. Contractors can bid on a fully defined set of drawings and specifications, resulting in competitive pricing.

The conventional workflow may not be suitable for all projects, especially those with unique complexities or time constraints.

2.5. Applicable in public procurement environments?

The conventional workflow is commonly applicable in public procurement settings for construction projects.

The conventional workflow aligns with the typical procurement practices followed by public entities, especially for larger or more complex projects, being transparent and competitive, compliant with specific legal and regulatory frameworks, clearly accountable with attention for proper documentation and record-keeping and budgetary control.

3. Construction teams, and Design & Build, as a big next step

The construction process is becoming increasingly complex: the needs and requirements (e.g., energy performance) are increasing, more different actors are involved throughout the process, the range of materials and components is constantly expanding with increasing technical complexity, the importance of stock planning is increasing, and the customer's need for smooth communication (e.g., single point of contact) is growing. Chain cooperation, or cooperation throughout the construction chain, offers the opportunity to adapt more easily to developments in the sector, with the objective of higher quality end products, more innovation, safer working environment and less 'waste'. Improved chain cooperation can ensure that the 'just-in-time' and 'just-in-sequence' concept - in which suppliers and subcontractors have to arrive on site according to a predetermined time and sequence - can be applied more efficiently.

Construction companies can work towards improved chain cooperation by focusing more on long-term cooperation, sharing information, involving all construction partners at the start of a project, adopting a joint follow-up system, focusing on continuously improving products and processes, and having a common incentive. This allows the partners to work on the long term to optimise project time, quality, and finances.

One possible consequence is that companies increasingly start using various collaboration methods. A concrete example of this in the Belgian construction sector is the emergence of 'construction teams'[3] in large projects or public-private partnerships (PPPs). These 'construction teams' possess a project-specific character and are not yet focused on a sustainable long-term cooperation or on the duration of one specific construction project. The focus is rather on structural cooperation (joining forces) between different parties, who often have specific knowledge, to acquire the award of (large) projects, as well as then execute them jointly. Such structural collaborations also increase the need for setting up joint data models, which can be incorporated, among other things, by applying BIM throughout the construction process.

Successful collaborations in 'construction teams' regularly lead to recurring future collaborations between the same parties, partly because a bond of trust was already established. However, not all actors in the Belgian construction sector are yet convinced of the benefits of 'construction teams', with mainly smaller companies being critical of them. One point of attention concerns the fact that it must always be clear to the client/owner who the point of contact is in the complex landscape of actors who together form a 'construction team', and that the client/owner is also an integral part of the construction team. In this way, thorough cooperation can lead to the client being end-to-end unburdened and properly involved in the team. Another point of attention concerns the fact that actors in a 'construction team' should be aware that there are different legal frameworks within the different regions in Belgium and that this needs to be considered when choosing partners - and clients.

[3] https://embuild.be/nl/nieuws/buildwise-onthult-10-megatrends-binnen-de-belgische-bouwsector

A lot of the current chapter is based on a Belgian (Flemish) study 'Werken in bouwteam: een innovatief bouwproces'[4] (Working in construction teams: an innovative construction process - 2016-Dutch).

The intro of this study addresses the topic as follows:

Construction teams, Design & Build, DB(F)M(O): one is bombarded with these terms almost daily. But what exactly is meant by them? What opportunities do these new forms of procurement and collaboration offer? What concerns should you consider as a designer, contractor, or client?

With all these questions in mind, the Flemish architects' organization (NAV), the Flemish Confederation of Construction (VCB-Embuild), Bouwunie and ORI, the branch organization of consulting and engineering firms in Belgium, joined forces. With support from the Flemish agency for innovation through science and technology (IWT), they launched in 2014 the project "Working in construction teams: an innovative construction process". The aim was to gather all information about working in construction teams and other forms of integrated collaboration and to disseminate it among the various professional groups and other stakeholders. In this way, the goal is to make these collaborative formats known and, where appropriate, promote them to contractors, designers, building owners, authorities, and other parties.

This is necessary, because working in a construction team means a real break with the conventional way of working. As early as the design phase, the execution-supervisors join the table to contribute their expertise. This affects the entire work process. Because change is inevitably accompanied by cold feet, information is desperately needed. The resulting document is not an end point, but a snapshot in a landscape that is constantly changing. The ambition is to continuously deepen the knowledge of innovative ways of working together to define and answer all opportunities, risks, and questions even better.

3.1. Basic principles

The term construction team is quickly used by people but means different things by different people; it risks becoming an umbrella term. Therefore, we first try to formulate a clear definition. We deliberately make a distinction between the construction team on the one hand and integrated contracts such as Design & Build and Design Build Finance Maintain Operate (DBFMO) on the other, which have several characteristics in common with the construction team.

3.2. What is a construction team?

The essence of the construction team is to involve actors who execute the construction as early as possible in the preparatory process for the realization of a structure. The client is also an integral part of the construction team. In cooperation with the consultants and designers, he/she formulates the objectives, functional analysis, budget, and success factors of the project. On this basis, one or more contractors are involved in the construction team. From then on, the (general) contractor and possibly specialized contractors actively participate in the design process. From their expertise (construction techniques, cost calculation and execution techniques) they give advice. For instance, in the Netherlands, it is customary for the contractor to be the first and, in the first instance, the only party allowed to submit a bid for the execution of the project. In principle, he/she then works with an open budget. That is, his/her price is

[4] https://www.embuildvlaanderen.be/publicaties/werken-in-een-bouwteam.pdf

based on the cost price of the solutions, materials, techniques, and execution time chosen together (direct and indirect attributable costs, cost), plus overhead costs and a risk and profit margin (fee). The construction team formula is used to realize a project against a predetermined budget and in many cases a ditto execution time.

The construction team formula is not new and can take various forms. For example, it has been known in the Netherlands for over half a century, model agreements have been developed for it and it remains in use to date. Elsewhere in the world, all kinds of variants have existed for a long time (UK, Singapore, Australia, etc.), and are often grouped under the heading of early contractor involvement (ECI). The construction team formula is also known in Belgium, albeit mainly for private projects. For public procurement, the construction team is legally difficult in Belgium, but not impossible. The use of a construction team within public procurement legislation is a cultural rather than a legal problem. Indeed, given the evolutions in the construction sector and the construction process, there is an ever-growing interest in it.

Architects sometimes claim that they have always worked in construction teams. They then refer to their habit of contacting a contractor in case of questions or doubts. But that informal form of requesting and sharing information is far away from the more formalized way in which constructors contribute their expertise to a construction team. The involvement of the client is also completely different. So, for the sake of this document, this is not a construction team.

Cooperation between architects and consulting and engineering firms is also regularly described as a construction team, but it is not according to the above strict meaning.

During the project 'Working in construction team: an innovative construction process', the four partners involved arrived at the following definition:

> *"A construction team is a project-related collaboration, from the start of the assignment (design phase) to the execution phase, in which, in addition to other construction professionals, at least the principal, designers, consulting and engineering firms and construction companies are involved, with the aim of creating added value for the client through the optimization of, among other things, result, cost, deadline and/or quality."*

3.3. What are integrated contracts?

There is a trend toward integrated contracts, that bear some similarities to the construction team model outlined above. The best-known examples of such integrated contracts are Design & Build (D&B), DBM and DBFM(O). The main distinction is in the scope of the contract: only the design and execution (D&B), or also the financing (Finance), maintenance (Maintenance) and/or operation (Operate)

- **Design & Build (D&B)** means that the client entrusts design and execution to one party, normally a combination of contractor(s) and designers. Unlike the construction team formula, the client is not part of the combination, but supervises it. Often the general contractor functions as the lead contractor for the consortium of contractor(s), designer(s), and other parties. The contract is awarded through a tender, based on a schedule of requirements and performance specifications. Within the limits of the performance

specifications, the contractor can determine some of the details of the execution. The contract is usually awarded based on a fixed price and quality criteria.

- **DB(F)M(O)**: A DBFM contract is an integrated form of public-private partnership contract, which entrusts the execution of various components of an infrastructure project to a single private contractor (a consortium). That contractor takes on virtually all operational aspects of the project: design, build, finance, maintenance and possibly also operation.

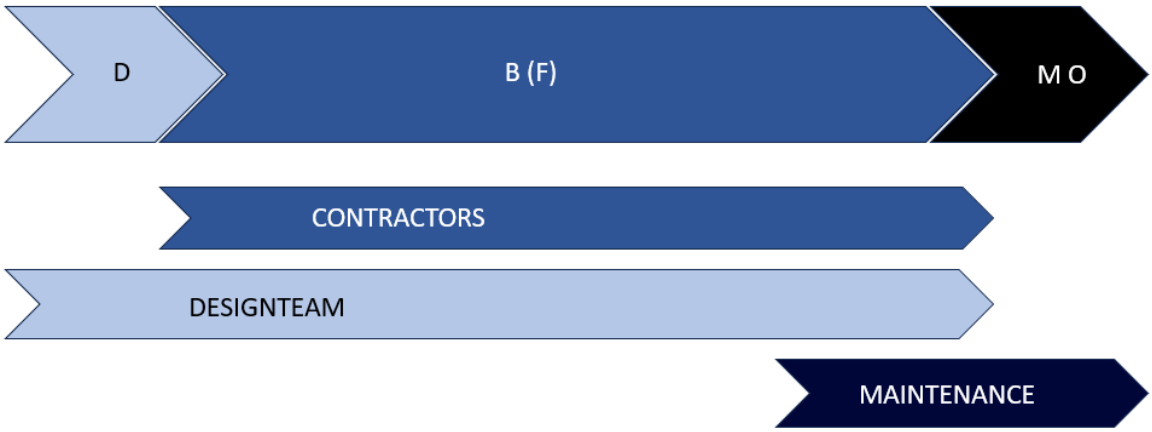

Figure 4: Description DBFMO

In a typical DBFM contract, the government limits itself to determining what it wants as the final result. It is then up to the private market parties to make a proposal regarding the design, financing, concrete execution, and maintenance. Consequently, it is the private partner who bears the risks of all this. The government that puts the project into operation after delivery pays an annual availability fee. At the end of the agreed period, ownership of the structure usually passes to the commissioning partner. Alternatively, the project generates revenue and thus pays for itself.

Unlike the construction team organizational form for private contracts, Design & Build and DB(F)M(O) procedures for public contracts are awarded in two phases, the so-called limited public procurement procedures. The selection and award phases are separated. In the first phase, that of selection, bidders - usually in the form of a consortium - submit a request for participation. In this request, they must demonstrate that they meet the selection criteria set by the client. Only those candidates who are selected are allowed to submit a bid in the award phase.

3.4. How to set up construction teams

Working in construction teams, with or without integrated contracts in a D&B or DBFM format, can only work well if several basic requirements are met. These requirements cover various aspects, including the selection of partners, the role of the client, the builder and the construction team, the formal form of the cooperation, agreements and liability arrangements, insurances, and legal & deontological constraints.

The right attitude

In the Netherlands, where working in construction teams has been a familiar given for several decades, we found the following inventory of the conditions for successful collaboration in construction teams[5]. Of course, the list refers to the Dutch situation and cannot simply be transposed to other countries. But it clearly indicates where the crucial accents lie.

A successful construction team requires that:

- the members of the team, apart from the client (who makes the final decisions), are on an equal footing
- the contractual arrangement be clearly worded and understandable, even by those not legally trained.
- obligations and risks are balanced among the members of the construction team.
- proper and extensive attention be paid to communication and information transfer between the members of the team. The basic premise of this communication is that the parties observe complete openness and knowledge sharing.
- the members of the team think integrally - that is, focused on the structure to be realized - from their own expertise and thus see their own expertise as serving the achievement of the objectives of the final design.
- the members of the team consider each other's legitimate interests.
- a clear and unambiguous regulation of the liability of all members is in place.
- explicit attention is given to dispute management to prevent conflicts and avoid recourse to external dispute setters (arbitrators or judges).
- a good definition of deliverables and adequate procedures for their measurement are set up.
- price consultations with the contractor are conducted on a reasonable basis.

A successful construction team contract is flexible, meaning there is contractual space to consider advancing insight gained during the work activities.

The involved parties

Composition and operation of the construction team

The quality of a construction team depends on its composition and operation. The team must be created in a professional and transparent manner. The selection of designers should be done with input from all other designers who will be part of the team. There should be no additional cost associated with this selection.

Team members must not only have the necessary expertise, but must also be able to cooperate, communicate, share information, give and create trust, have an eye for other people's interests, be willing to put their own interests second if necessary.

The main principle is that all construction team members put the goals of the project ahead of their own interests and always look for solutions to achieve the goal. They put the project interests first, work closely with the other partners, share their knowledge, and solve problems together. The construction team members commit to mutual trust, open communication,

5 'The construction team model. A study of its legal design and functioning in practice' - Prof. Dr. M.A.M. Chao-Duivis - Construction Law Institute Foundation, 2012. (Het bouwteam model: Een studie naar de juridische vormgeving en het functioneren in de praktijk (Dutch only).

optimal transfer of information and respect for the agreements made within the construction team. There is a “no claim commitment” and the members of the construction team do every effort to achieve the goals of the project.

The team members agree on the input expected from each partner, the division of tasks and related responsibilities, the way of execution, content and frequency of consultations, the manner of decision-making, the manner of reporting and the timing.

The client/customer chooses partners based on the nature and preconditions of the project. Possible selection criteria are:

- competence and qualification of the designers
- references relevant to the assignment
- experience in working with administrations and local authorities
- speed of action
- experience with DBFM

The client selects the partners with the intention of continuing with them until the end. Nevertheless, it may happen that during the design phase one of the partners does not want to continue participating or does not turn out to be the right candidate. Therefore, the client initiates an exit arrangement during the design phase. This can stipulate, for example, that the person concerned is bi-annually compensated for their contribution, but that the study work remains the property of the client.

The exit arrangement mentioned includes agreements on the compensation of each partner. Such agreements are important, because in their absence the general principle may apply that the contractor is not normally entitled to compensation for the costs incurred to obtain a contract, unless he/she can prove that a (pre)contracting agreement existed. This problem is less acute for consulting and engineering firms and architects. It is usually accepted that they are entitled to compensation for such preliminary studies.

For public contracts, the construction team process can take place during the negotiation process, so the board can still decide not to award the contract to the contractor.

Roles and engagement of the client

The client, as initiator/owner of the construction, plays an important role within the construction team, regardless of which formula is used.

- The client considers the wants and needs of the end-users.
- He/she considers the total lifetime cost of the structure, including maintenance and operation, and does not merely look at design and construction costs.
- He/she does not work with densely packed specifications but sets functional requirements that enable and induce creative and innovative solutions.
- He/she assigns the project based on an optimal price-quality ratio instead of merely playing for the lowest price.
- He/she handles the selection process (candidacy, bid, preliminary selection or BAFO) transparently and verifiably.
- He/she limits the offer costs wherever possible and preferably provides compensation for study costs incurred.
- He/she applies a code of conduct that encourages integrity. He/she requests the same from the contractor and demands an explanation in the absence of such a code.

Roles and engagement of the contractor

The contractor (who will execute the works) must be sufficiently professional or have a professional background to be able to participate in the construction team.

The contractor must be aware that in the construction team formula they do not have the same means of pressure regarding price formation as in a public tender.

The contractor works in a market- and customer-oriented way, taking as its starting point the needs of the end user/society and the lifecycle costs of structures. The objectives and critical success factors of the project are defined together with the client. These include the program of requirements, the budget, and the deadlines within which the project will be deliverable.

The contractor works transparently and verifiably to give clients confidence. He/she adheres to a code of conduct that encourages integrity. He/she requires the same from subcontractors and demands an explanation in the absence of such a code. He/she undertakes in a socially responsible manner.

Cooperation agreement

In a construction team, members work together on an equal basis. Ideally, construction team members usually make a cooperation agreement for the collaboration in construction team. In it, they lay down several principles and hard agreements on how the joint project preparation will take place. Depending on the collaboration formula, bilateral agreements may also be concluded between the client and the various construction partners (architectural contract, consulting and engineering firm contract, construction contract).

In a construction team, designers and contractors enter into **separate agreements** with the client. In integrated forms of cooperation, on the other hand, design and execution are bundled in the hands of one party, the contractor. The latter can therefore shape the collaboration in its own way.

The cooperation agreement

Construction team cooperation is formalized in a cooperation agreement. Important elements in it are:

- an exclusivity clause,
- 100% confidentiality from the proposal phase up to and including the BAFO (best and final offer),
- agreements on the continuation of the collaboration after the candidacy and request for proposal,
- compensation for the designers,
- freedom of the parties if the offer is not retained,
- agreements on the intellectual rights,
- agreements on compensation in the event of early termination of the collaboration for reasons unrelated to one of the partners,
- agreements on liability insurance: an umbrella insurance policy ‘Civil Liability for design and execution’ plus a ‘General construction site risks’. It is very important that the independence of the design team (architects, engineers, technicians, consultants) is guaranteed and that their civil responsibility to safeguard the public interest (safety, health, environment, planning and social aspects) and the interest of the client in particular is not at stake.

Here the question inevitably arises (at least in the Belgian context) as to whether construction team cooperation in the design phase can be combined with the legal mission of the architect,

who must personally make the execution design and control the execution. The architect may not entrust these legal tasks to non-architects. For all other tasks, this restriction does not apply, as long as the architect has the agreement of the client and respects his deontology. The architect must draw up an agreement with the client in advance that clearly shows how, considering the construction team formula, he/she will fulfil his assistance task and legal assignment. In the construction team, he/she may not make any agreements that deviate from that agreement with the client.

Division of labour: watch out for constraints

Some pertinent restrictions apply to the way tasks are distributed within the collaboration. For the study phase, the Architectural Act of 1939 and the Regulations of Professional Duties are important in Belgium. Agreements that disregard these rules can be sanctioned with nullity.

The tasks which, in view of the architects' law (design plus control in a personal capacity of the execution) and the regulations of professional duties (which define the design task in more detail) belong to the legal assignment of the architect, may only be performed by the architect. They are also the architect's responsibility. May contractors and engineers then not be involved in the design at all? Yet they are.

The contractor may draw up execution plans. The engineer may be called in by the architect as an expert (e.g., stability, acoustics). The architect must then assist the client in the selection of that specialist and bears responsibility for it. For the specialist study itself he/she bears no responsibility, except for matters that he/she should have noticed with his knowledge.

D&B and DBFM specific: which formal collaboration?

Specific for the D&B or a DBFM approach, the collaborative organization, to submit an offer as part of a D&B or a DBFM contract or make a commitment to a client, can take various forms.

In what ways can partners collaborate?

Regarding the way of cooperation, we can distinguish the following possibilities.

- The various construction partners can each conclude their own agreement with the client and, in addition, draw up a **memorandum of understanding** regarding the practical way in which they will cooperate with each other. If necessary, the client can be involved in this memorandum.
- With the **promoter-DBFM cooperation formula**, several construction partners organize themselves to jointly submit a bid or enter into a commitment concerning the design, construction, financing, maintenance and possibly the operation of a particular work for a user who is not the client.
- With the **building owner-DBFM cooperation formula**, different construction partners organize themselves to jointly submit a bid or enter into a commitment concerning the design, construction, financing, maintenance and possibly the operation of a given work for a user-building owner.

How can partners formalize their cooperation?

Looking at the different options when it comes to the formal form of cooperation, there are multiple possibilities.

1. **Subcontracting** in the strictly legal sense implies that there are two contracting agreements on top of each other, namely the contracting agreement between the client and the main company and the contracting agreement between the main company and the subcontractor. The architect, given his/her obligatory independence, can never work under subcontract for a contractor. He/she may,

however, work on behalf of a principal. The fact that that principal is also the promoter/contractor of the project does not prevent him from entering into a legally valid agreement with the architect. The question arises whether the architect's independence is also not compromised if the payment of his performances depends on the approval of the contractor.

2. **Temporary Commercial Partnership (TCP)** is a specific form of the commercial partnership, that is, an unincorporated company. The TCP is not bound by administrative obligations. The founding partners are free to determine the purpose of the TCP based on the agreed terms, and to tailor the form to how their respective interests relate to each other. In the absence of legal personality, the partners are solidly responsible to third parties. A temporary trading partnership (TCP) basically aims at cooperation between traders. Since the architect is not a merchant, forms of cooperation with him are in principle those of a civil partnership. The distinction is essential. In a TCP, the partners are held in solidarity towards the one with whom the TCP enters into a contract. In a partnership, this solidarity obligation does not exist. Thus, the architect is not bound by solidarity, unless he/she explicitly chooses to enter into a TCP and thereby accepts this solidarity obligation. It should be remembered that engineers, unlike architects, are traders.

3. **Specific Project company or Special Purpose Vehicle (SPV)** is a company that the members of a consortium set up specifically to realize the project within a specific time frame and with fixed resources. This allows them to exempt their own companies from the project risks and provides them with a joint working tool with a clear distribution of everyone's input. The flip side of the coin is that there is a lot of administration involved in setting up this formal form of cooperation. Resources also need to be released for capital contributions and operation. Because equity is limited, shareholders typically commit to the SPV. In a DBFM project, it is often proposed that the consortium convert to an SPV upon award, which then enters into the DBFM agreement.

3.5. Liability

In principle, working in construction teams does not compromise the different tasks that each party on the team has. Everyone is responsible for their own expertise and their own assignment. Even in terms of liabilities, the same rules continue to apply. Each partner is liable for his own assignments.

The basic principle of a construction team is that each partner contributes his specific expertise and fulfils the tasks that arise from his position, considering the construction task. In addition, the team members organize coordinated consultation on the work, supported by mutual advice where necessary.

Responsibilities are assigned in the same way as in a conventional construction process. Depending on the nature of the project (building or infrastructure), the liabilities for:

- design and supervision of execution at the expense of the architect or the engineering firm appointed for this purpose,
- special technical advice and calculations at the expense of the specialist consultancy and engineering firm concerned,
- execution errors at the expense of the contractors involved.

Even more than in the classic construction process, the construction partners have **a duty to warn each other**. Their information and warning obligation does not only relate to their own task, but also to prior actions of other construction partners. Contractors, architects, or engineers must warn of errors by a construction partner that they should or could have

foreseen and as a result of which they cannot perform a work. They must also warn of main errors by another construction partner that they should have noticed from their own knowledge.

When it comes to liability, special attention needs to be paid to following aspects:

The architect

The architect must always independently represent the interests of the client/builder and perform his legal duties.

For a D&B assignment, he/she must have the necessary safeguards built into the cooperation agreement to be able to represent, in complete independence from the contractor, the client's interests. In a DBFM project, the principal may be the SPV or TCP and thus the contractor/developer. A collaboration agreement with that SPV or TCP then does not compromise the architect's independence. But the collaboration between an architect and a contractor cannot be entered into in the context of a TCP, since this would compromise the legally required independence of the architect vis-à-vis the contractor. However, this problem does not arise when the contractor is also the promoter/constructor.

Under no circumstances may or can the architect work as a subcontractor of the contractor. But even when he/she does not work as a subcontractor, his independence may be compromised, e.g., when the payment of his fees depends on the approval or action of the contractor.

The consulting and engineering firm

Like the other construction partners, the engineer must always independently represent the interests of the client/building owner. The consultancy and engineering subscribe to a deontological code to this end. This deontology stipulates that a consultancy and engineering firm cannot simultaneously advise the principal and be part of the construction consortium. The most appropriate form of cooperation in D&B and DBFM is therefore subcontracting, provided that guarantees for respecting the aforementioned independence are laid down in an unambiguous contract with a clear mutual commitment.

The program

Contractors, architects, and engineers must ask the client what he/she wants. If this is later found to be unclear, it is often explained to the disadvantage of the construction partners.

The in-solidum holding

In a partnership (except a civil partnership, see below), in principle the in-solidum holding applies. If errors or shortcomings of different parties result in one damage, each party is bound to compensate the full damage based on its fault.

3.6. D&B and DBFM: attention points

When setting up collaborations in D&B and DBFM, several questions and considerations need to be handled

- DBFM formulas require **a long preparation time.** The contracting authority must define the contours of the project well in advance. It must determine what social objectives/added values it wants to achieve and with what budgetary resources the project will be realized.

As soon as a clear project definition is available, the contracting authority must check whether the project qualifies for PPP (Public Private Partnership) at all.

- The question in which form the project will best be realized must also be answered in advance: via a DBM, a DBFM, a DBFMO? This complexity results in longer preparation and often longer negotiations.
- DBFM formulas may involve certain risks.
  Sometimes, they face heavy (legal) procurement procedures. In certain cases, large consortia may be favoured given the long-term commitment. They may be associated with more expensive private financing (the government can normally borrow more cheaply) and higher costs, given the risks related to financing, implementation, maintenance and/or management.

3.7. Opportunities and benefits of construction teams

Both construction team and integrated forms of collaboration can potentially offer great opportunities.

Cooperation at an early stage benefits the quality of the project. Each party (client, designer, contractor) can immediately contribute its specific knowledge (e.g., the latest insights into operations, concepts, technologies, feasibility, materials) and contribute to an optimal and smoothly executable design.

Because the objective and the result take precedence and because of the intense participation of the client, in a construction team **all parties are strongly involved in the project**. The cooperation is more pleasant and efficient and leads to faster and better results. It is not a question of every man for himself. All parties look for solutions together instead of assuming mutual control and mistrust. The probability of disputes is normally lower but can vary depending on the specific formula.

The benefits are realized only if **several basic criteria** are met, such as the actual development of common goals and interests, a clear division of roles and tasks, clear agreements on working methods and decision-making, and good interpersonal relations.

3.8. When to use construction teams or integrated contracts?

Cooperation methods like construction teams or design-build can offer advantages in the following scenarios:

- **Fast-Track Projects:** When time is of the essence, design-build can expedite the project timeline by overlapping design and construction activities, facilitating faster project delivery.
- **Complex or Innovative Designs**: Projects with intricate designs, sustainable features, or advanced technologies may benefit from these cooperation methods that allow for close collaboration between designers, contractors, and specialty consultants. This facilitates early input, innovation, and optimization of complex systems.
- **Value Engineering**: Workflows like design-build provide opportunities for value engineering, where the project team collaboratively identifies cost-saving alternatives, efficiencies, and performance enhancements throughout the project lifecycle.

- **Enhanced Risk Management:** Some cooperation methods emphasize shared risk and reward among project participants. This encourages collaborative problem-solving and risk mitigation strategies, reducing the potential for disputes and claims.
- **Client Preference for Integration**: If the owner/client prefers a more integrated project approach with a single point of responsibility, cooperation methods like design-build offer a consolidated team structure, fostering greater collaboration and accountability.

3.9. Applicable in public procurement environments?

Some public entities may consider in their procurement procedures these cooperation methods, which offer increased collaboration and integrated project delivery. These methods can be adopted when public entities seek more innovative solutions, faster project delivery, or increased involvement of stakeholders in the design and construction phases.

But it is sometimes challenging to make a good marriage between the ideas of design-build or construction team versus legal aspects of formal procurement policies (and limited freedom).

4. Up to the next level of integration and value

4.1. Introduction

Construction teams and Design & Build are cooperation structures that support already some integration. In the context of Positive Energy Neighbourhoods, several demonstration projects identified the need for an even stronger transformation of the construction sector and even more integrated planning. Energy aspects are as of today not always sufficiently integrated in the urban planning processes, where the necessary legal and strategic frameworks are not yet in place. Especially in case of heterogeneous ownership structures, cooperative planning processes are indispensable.

Following challenging topics, that need to be overcome to support the implementation of PENs (Positive Energy Neighbourhoods), were identified by a panel of experts[6], in provisional order of importance.

1. **Governance**: a need for new and innovative forms of collaborative governance.
2. **Incentives**: a need for right (social and environmental) drivers and motivators.
3. **Social**: a need for local community's support and engagement.
4. **Process**: a need for integrated planning and decision-making approaches.
5. **Market**: a need for an appropriate market design and business model.
6. **Technology**: a need for balancing energy demand and supply systems.
7. **Context**: a need for considering regional and local differences.

For the transition of the building sector, that will be one of the central stakeholders in the development of PENs, different aspects are relevant:

- New actors enter the conventional building value chain, so a comprehensive stakeholder mapping is mandatory at the start of a project.
- When building processes are expanded from individual buildings to large newly built neighbourhoods or district wide renovation projects, new ways of collaboration are needed in the building value chain.
- With the development of energy solutions alongside the building process, new aspects to integrate energy technologies and services have to be added.
- Special attention needs to be paid to governance and steering mechanisms.
- Finally, a fully integrated planning process will be the best solution for the development of positive energy districts.

Examples of how these aspects are integrated in demonstration projects across Europe are given next.

4.2. Stakeholder integration and value chain

Need for stakeholder value proposition

Setting up a PEN is a complex process. It involves many stakeholders, each with their own interests, constraints, and agendas. Wide, early, and in-depth stakeholder engagement is

[6] Krangsås, Savis Gohari, et al. "Positive energy districts: Identifying challenges and interdependencies." Sustainability 13.19 (2021): 10551.

needed and having a clear understanding of each stakeholder's value proposition and role will have to happen throughout the process.

Examples of stakeholder mapping for PENs

A clear example of stakeholder mapping for PENs has been developed in the Horizon2020 project Making City[7] (see figure 5). This stakeholder map will then be used for value proposition in a wider context than the conventional business model canvas: a new dimension is added to the canvas: not only the direct customers or users have to be considered, but also the impact on other stakeholders and on the broader environment. Such approach will help designing innovative business models specific to the PEN concept by linking all stakeholders involved in or impacted by the implementation of a PEN solution.

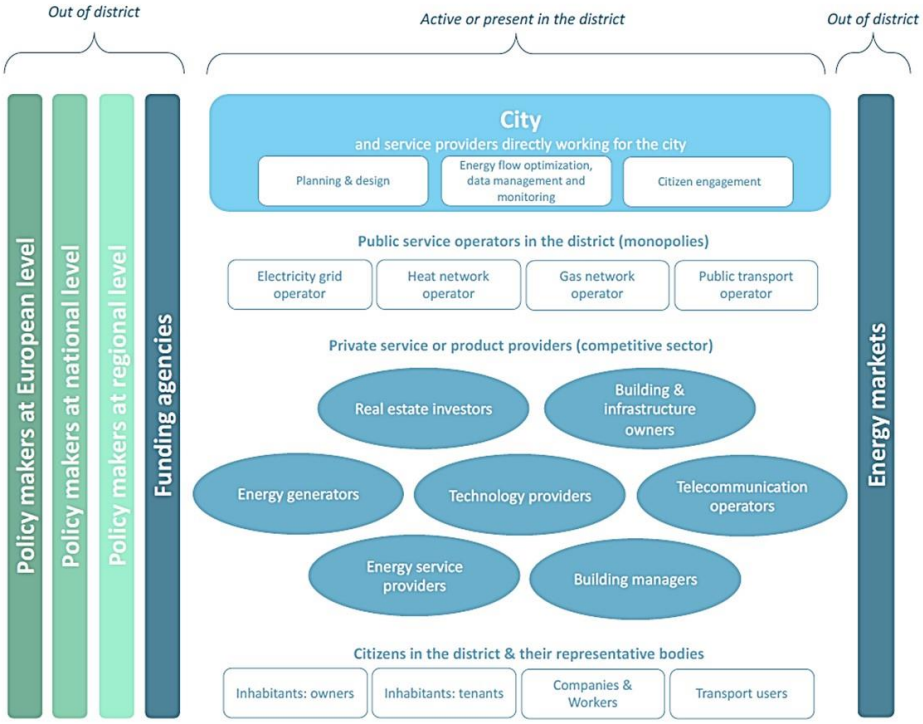

Figure 5: PEN Stakeholder mapping in the MakingCity Project

(Primary) stakeholders are also mapped along the value chain of the PEN development in the ZEN (Research Centre on Zero Emission Neighbourhoods in Smart Cities) approach, which is then used for the development of KPI's for value chain integration (Figure 6).[8]

[7] Making city, 2019. D6.1 - Ecosystem analysis for Positive Energy Districts.
[8] Backe, Stian, and Ann Kristin Kvellheim. "Zero Emission Neighbourhoods. Drivers and barriers towards future development." (2020).

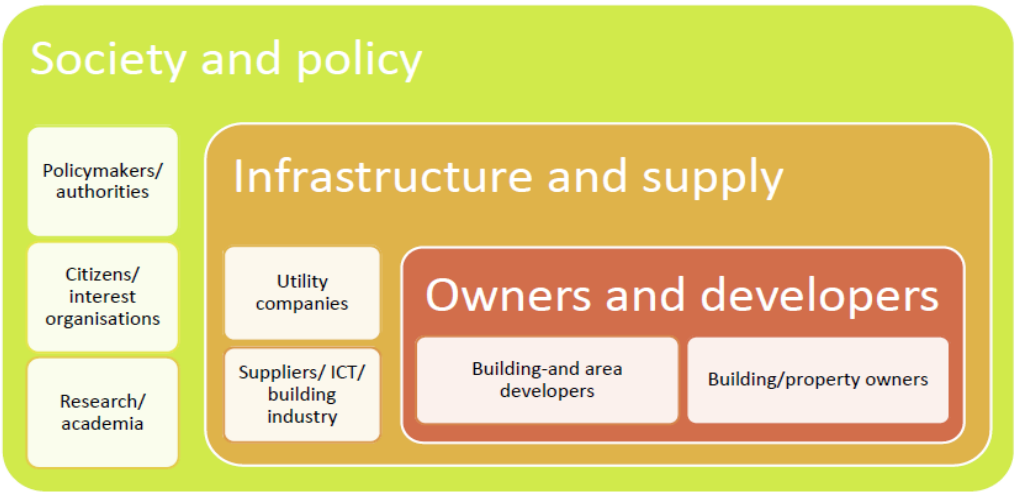

Figure 6: Stakeholder mapping in a Zero Emission Neighbourhood.

Opportunities & barriers

It is clear from these two examples that building developers and owners in PEN development will be part of a complex stakeholder network that requires a holistic integrated approach where technological, social, economic, financial, and regulatory aspects should be addressed to successfully implement an urban sustainable energy transition. It is generally agreed that PENs require a well-designed process based on different development phases. These include integrative energy planning, effective PEN implementation and monitoring, strategic capacity-building, and key stakeholder involvement starting from the initial stages of PEN processes and extending throughout all its phases. OBJ

Therefore, stakeholder mapping and analysis will be an important part of the integrated approach. It is important to recognize that stakeholders' roles, interests and values can be competing and that the same stakeholders can have different roles or switch roles. Stakeholder values can also change over time, especially when considering the different stages of PEN development (planning, implementation, and operation).

In a characterization of 60 PENs in Europe[9], it was observed that challenges associated with stakeholders' involvement, administrative and technical issues had great relevance in all PEN stages. The economic and financial feasibility was crucial in both planning and implementation stages as well as supporting studies or knowledge. However, legal, and regulatory barriers were important in the implementation and operation stages. In the operation stage environmental and social and cultural aspects were considered possible barriers for stakeholders.

4.3. Transformation of the construction sector

Why the construction sector needs to transform

With the integration of new stakeholders in the value chain and the expansion of construction and renovation projects from building to neighbourhood scale, a thorough transformation of

[9] Zhang, Xingxing, et al. "Characterizing positive energy district (PED) through a preliminary review of 60 existing projects in Europe." Buildings 11.8 (2021): 318.

the construction sector is needed, including different aspects such as building infrastructure; energy infrastructure and digital platforms/solutions.

Buildings will have to integrate (collective) solutions for energy supply, storage, charging infrastructure and logistics, ICT, and metering and steering infrastructure with a high level of interoperability.

Technical & organisational changes & needs

Technical integration is needed on four levels:

- Between a building and the neighbourhood infrastructures (e.g., electric vehicle charging, district heating, common solar PV installation).
- Within the same building: integration of technologies and techniques (e.g., active control and flexibility).
- Between buildings (e.g., shared heat pumps).
- Between the building sector and other sectors, mainly energy (e.g., demand flexibility), industry (e.g., use of excess industrial heat for district heating) and (e-) mobility.

A study from BPIE[10] looks at changes in the (conventional) construction value chain, which now also includes new entities such as energy technology manufacturers, aggregators, and utilities. Specifically, actors for smart devices, ICT and even from the electric vehicle value chain offer new products and services.

This requires an integrated approach to planning and implementation, including the development of new guides and tools for optimizing the design, operation, financing of PENs and to explore what is needed in terms of tools, guides, resources, methods, guidelines, etc[11]. As a starting point, it is often mentioned that PEN design is premised on the 'no standard' rule, in recognition of the fact that context matters; for instance, whether the development in question is a retrofit or a new construction.

Rapid evolution in energy technologies in buildings necessitates a research-to-design approach, for instance in relation to new modes of integrating energy flexibility and with benefit sharing among residents. The socio-technical innovation that accompanies such an approach implies a need to experiment with and validate the feasibility of PEN designs. Such assessment and adaptive monitoring of design solutions presents a complex challenge, on the one hand enabling high customisation and flexibility while on the other hand posing difficulties of transparency and transferability that must be dealt with for solutions to be scalable across contexts. This is a challenge for the building sector. In 'Ten questions concerning positive energy districts'[12], the trial-and-error stage of development outside the regulatory sandbox, where PENs are moving beyond experimentation to implementing various combinations of technologies, should gradually move into prototyping, to enable the scaling of PENs and ease the process of identifying which design patterns and energy system configurations are likely to match user needs in a specific district.

[10] BPIE, 2016. Buildings' interaction with the energy system. Deep dive 3.
[11] Krangsås, Savis Gohari, et al. "Positive energy districts: Identifying challenges and interdependencies." Sustainability 13.19 (2021): 10551.
[12] Sareen, Siddharth, et al. "Ten questions concerning positive energy districts." Building and Environment 216 (2022): 109017.

New tools for the construction sector

A comprehensive list of available technical tools and experimental methods for the design and development of PENs has been made by Magyari, Abel et al. in 2022[13]. For stakeholders with specific goals in mind, it is important to know in what aspects the tools are capable of providing information. For example, the Integrated Planning and Decision Support Tool can model buildings, grid infrastructure and the primary energy predictions together with socio-economic scenarios. Integrated Design PEN Tools integrate architecture and urban design with simulation and optimization, and allow also small design firms, architecture and planning professionals and researchers to participate in the development of PENs. Other examples include the Intelligent Community Design (iCD) technology which was used in the smart city project +CityxChange to develop an Integrated Planning and Decision Support Tool to model the buildings, the grid infrastructure, and the primary energy predictions together with socio-economic scenarios of Positive Energy Blocks. The scope is to obtain a neighbourhood (community) with a yearly positive energy balance. Different energy scenarios of an urban neighbourhood have been developed through the tool Urban Modelling Interface (UMI) in order to explore the potential of near-zero carbon planning solutions in the city of Dublin. The study integrated building archetype information such as dimensions, material and energy systems, local energy sources and energy infrastructure. The results show the higher potential, through the neighbourhood approach instead than the single building approach, in reducing or even eliminating carbon emission related to energy management and consumption. Additionally, the study used as energy scenarios future climate change projections and retrofit of existing buildings. For the building sector, these examples show the added technical complexity.

Legal challenges for the construction sector

Extension of the building value chain brings not only technical but also legal challenges. The Cities4PEDs project[14] identified several important legal aspects that must be considered:

- With the exchange of energy across properties, the building and spatial planning law, housing law (condominium/tenancy law), the energy law and provisions regarding subsidies must be considered.
- The actual sharing of energy across properties further requires a legal framework that enables the transfer, for example by the implementation of energy communities.
- The form in which energy is transferred across properties, whether in the form of (renewable) electricity, biogas or in the form of thermal energy (heat/cool), has relevance for the legal assessment, since different rules for different energy forms apply.
- Particularly in the area of electricity, the type of energy distribution is essential when considering individual cases. Almost every building has a connection to a public distribution grid, while private direct lines between buildings are an exception. Depending on the type of distribution, the related issues diverge.

4.4. Business models for integration of energy components

With the development of PENs, where the physical energy system is at the core of the district, important energy-related components will be integrated in the construction value chain:

[13] Magyari, Ábel, et al., 2022. "Report on existing technical PED guides and tools." COST Action 19126 Positive Energy Districts European Network.

[14] Hofbauer, S., Lindorfer, A., Pamperl, L., Wolfsgruber, K., 2022. Enabling PEDs through city instruments. WP3 Cities4PEDs.

- energy efficiency,
- renewable energy production,
- energy flexibility,
- e-mobility.

The large number of energy technologies that can be applied in the PEN, in combination with a wide variety of required energy services, leads to many energy system designs. Next to the previously mentioned building tools, new methods to calculate the energy balance in a PEN are needed, including power, gas, and thermal energy networks[15].

Because new energy infrastructures must be integrated in the urban planning processes, a PEN has to bring value proposition that meets all the different stakeholders' needs and wishes.

The EU Smart Cities Information System[16] looks at different business models to accommodate those needs, based on the above mentioned 4 energy-related components.

Energy efficiency

The energy renovation of buildings can benefit from several business models, adapted to different types of buildings and the needs of their owners. For example, in a **one-stop-shop business model**, a single service provider is responsible for holistic renovation of the building as per the wishes of the building owners, including implementation of energy efficiency measures, or building internal renovation. Thus, the one-stop-shop model foresees that a single actor offers full-service holistic renovation packages including consulting, independent energy audit, renovation work, follow-up (independent quality control and commissioning) and financing. This model is particularly well suited for social housing and individual houses.

Within the **Energy Performance Contracting (EPC**) model, an **Energy Service Company (ESCO)** enters into arrangements with property owners to improve energy efficiency of their property by implementing various energy efficiency measures (lighting, HVAC, energy management and control, envelope insulation…). The ESCO guarantees energy cost savings in comparison to a historical (or calculated) energy cost baseline. For its services, and the savings guarantee, the ESCO receives a performance-based remuneration in relation to the savings it achieves. The model is particularly suited to public buildings and industrial facilities. Some countries in Europe already have a well-developed ESCO market.

Renewable energy production

The development of local, renewable energy production within a PEN can equally be based on different business models. Within a **roof or land renting model**, the contractor offers to lease the roof or plot for up to 20-25 years and, in exchange, installs and maintains renewable energy devices, typically solar panels. Building owners do not have to do upfront investments and they benefit from the free electricity produced by the system. The contractor benefits from financial incentives like feed-in tariffs. Many commercial, industrial, and retail buildings can provide the real estate needed for these systems and are therefore viewed as excellent candidates for roof rental.

[15] Krangsås, Savis Gohari, et al. "Positive energy districts: Identifying challenges and interdependencies." Sustainability 13.19 (2021): 10551.
[16] EU Smart Cities Information System (SCIS), 2020. Positive energy districts solution booklet.

With the **leasing of renewable energy equipment**, building owners are enabled to use a renewable energy installation without having to buy it. The installation is owned or financed by another party, usually a financial institution. The building owner pays a periodic lease payment to that party. Leasing energy-related improvements is a common and cost-effective way for state and local governments to finance upgrades and then use the energy savings to pay the investments. Leases often have slightly higher rates than bond financing.

An **energy cooperative** is a non-profit entity for green energy production and consumption, which performs the same activities as any other retailer or energy producer company. The cooperative is committed to drive a change on the current energy model to promote a 100% renewable model. The cooperative only supplies energy to its members, who can participate in financing collective renewable energy projects to produce their own energy. Consumers are thus both members and co-owners, integrating various stages of the value chain. On the production side, the cooperative promotes collective financing for renewable energy installations. Thanks to this contribution, members benefit from a yearly discount on their bills.

The deployment of a **district energy system**, which can be combined with local heat and cold production (based on heat pumps, biomass, geothermal, solar, or waste energy), is a way to facilitate the access to renewable heating or cooling for inhabitants and the creation of a PEN. The business model for a district energy system needs to ensure that all the involved players – including investors, owners, operators, utilities/suppliers, end-consumers, and municipalities – can achieve financial returns, in addition to any wider economic benefits. Most business models for district energy involve the public sector to some degree, whether as a local policymaker, planner, regulator, or consumer, or more directly through partial or full ownership of projects. Where citizens or local enterprises can become shareholders of the local district energy system, acceptance and uptake may be higher.

Energy system flexibility

Flexibility can be combined with other pillars of PEN energy systems, in particular energy production and electric mobility. **Demand response** is nowadays perceived as a major flexibility source in the decades to come to successfully integrate high shares of RES electricity while controlling the overall cost of the power system. Also, thermal flexibility services in district heating are bringing new advantages, like better indoor environment for residents, and peak demand curving for producers. With increased feed-in of dynamic renewables, the ability to flexibly use assets is also of strong value to a DSO for grid balancing and for system services, such as frequency adaptation. **Citizen or Renewable Energy Communities** are promoted at European level and may revolutionise and decentralise energy systems and favour the creation of PENs.

Electric mobility

Electric mobility can nicely complement the other pillars of the PEN energy system. **Mobility as a Service (MaaS)** aims at providing an innovative and environmentally friendly transportation service in order to complement available transportation alternatives. When electric vehicles are well spread and technology allows for it, **smart charging (SC) or vehicle-to-grid (V2G)** can complement demand response from buildings by adjusting the charging load or even discharging the car battery depending on the energy system needs. This can create a revenue stream for car owners. In this way, electric mobility and flexibility services can thus be combined.

4.5. Governance and steering mechanisms

Need for new collaboration and governance approaches

Any conceptual framework that undergirds PENs requires a holistic integrated approach where technological, social, economic, financial, and regulatory aspects should be addressed to successfully implement an urban sustainable energy transition. It is generally agreed that PENs require a well-designed process based on different development phases. These include integrative energy planning, effective PEN implementation and monitoring, strategic capacity-building, and key stakeholder involvement, starting from the initial stages of PEN processes and extending throughout all its phases.

For this reason, a key aspect is an urban governance framework for PENs, built upon a strong partnership between several stakeholders, namely collaborative governance. This collaborative governance must enable the sharing of knowledge and experiences from a wide range of sectors and fields: research, industry, public administration, financial, economic, and social.

'Collaboration' refers to cooperation premised on recognition of the value of reciprocity to achieve common goals, working across boundaries in multi-sector relationships, and 'governance' concerns steering the process that influences decisions and actions within the public, private, academic, and civic sectors.

In the context of PEN deployment and implementation, collaborative governance can help ensure a strategic program accompanied by opportunities for collaboration and networking between and across different actors. Such synergistic, orientated networking is based on applied research including strategic innovation, innovative technological solutions, demonstration projects, urban innovation laboratories (experimental platforms), and on local capacity building that considers all relevant technological (energy efficiency, renewable integration, energy system flexibility) and non-technological (social, environmental, economic) aspects. Moreover, from an operational point of view, urban collaborative governance should be based on an effective operational structure to ensure open dialogue, and a consultative process with adequate consideration of stakeholders' interests and priorities, a transparent membership/cooperation protocol, and smooth, effective communication between partners and a wider set of stakeholders. Collaborative governance insights can thus provide an open framework where the core stakeholders not only join forces in accordance with their specific interests, but thereby create a common programme for PENs and cities[17]

Need for new steering mechanisms and incentives

It is relevant to understand the role of developers and building actors in the process, and especially, which tools can be used by them to steer the building and development process, through the adoption of the right incentives.

These incentives can be created by local governments, but they can also be used by the private sector to encourage cities, housing associations, households, and companies to implement PENs. The outcome of incentives can be focused on supporting increased deployment of targeted technologies and practices, environmental gains, liveability, and inclusiveness in districts.

[17] Sareen, Siddharth, et al. "Ten questions concerning positive energy districts." Building and Environment 216 (2022): 109017.

It is also important to recognize that incentives are contextual and specific and should be designed tailormade. Accordingly, a robust technical and economic analysis of potential technologies can support a successful incentive design. Providing the right incentives should aim at reducing limitations of long-term and low-interest investment funding schemes, regulatory barriers, absence of economic support/subsidies and unstable policy frameworks. Furthermore, to quantify the success of adequate incentives, it is necessary to consider performance indicators, i.e., the effectiveness of the proposed urban solutions through monitoring and control systems and impact indicators. [18]

Examples of steering instruments for PENs

The Cities4PEDs project[19] analysed different steering mechanisms that can be applied by local governments to reach specific goals, based on demonstration projects in different EU countries. These include both binding instruments as well as instruments without obligation, to pursue PEN-relevant objectives (figure 8).

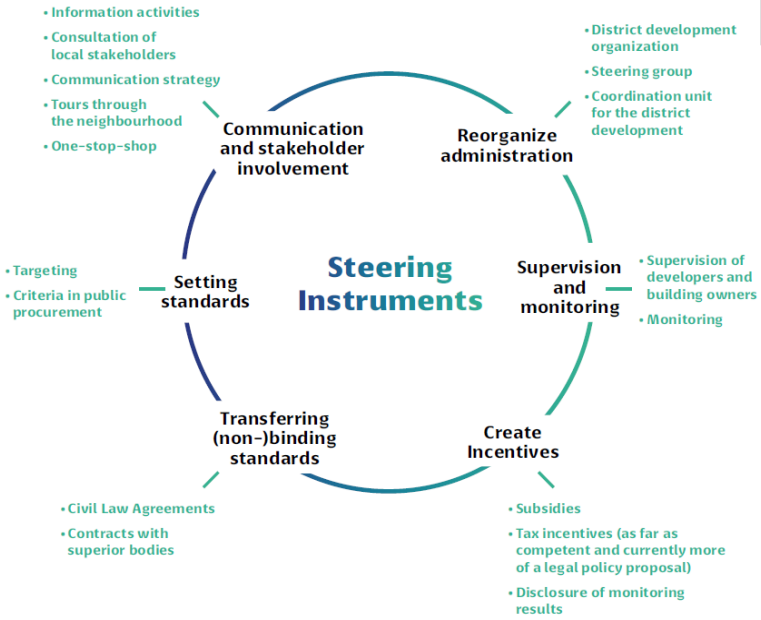

Figure 7: Different steering instruments to pursue PEN objectives (from Cities4PEDs Project).

1. **Communication and stakeholder involvement** strategies include different types of consultations and information activities. Consolidating and streamlining administrative procedures into a one-stop-shop, i.e., a single point of contact for people, can simplify interaction with the relevant public authorities and shorten communication processes.
2. In order to pursue ambitious targets and to maintain high quality performance in all PEN project stages it is of importance to **set standards** that are binding for the addressees. This can be setting city-wide and district-wide targets, where the binding character can vary depending on the level of detail. Moreover, operationalization of targets can be supported by adding

[18] Krangsås, Savis Gohari, et al. "Positive energy districts: Identifying challenges and interdependencies." Sustainability 13.19 (2021): 10551.
[19] Hofbauer, S., Lindorfer, A., Pamperl, L., Wolfsgruber, K., 2022. Enabling PEDs through city instruments. WP3 Cities4PEDs.

qualitative or quantitative indicators. Also setting specific criteria in public calls for tendering can help to implement ambitious targets and avoid high costs.

3. **Supplementary requirements**, not laid down in legislation but required to achieve PEN objectives, can be **transferred** by legal means. PEN concepts have to fulfil multiple pre-set sustainability targets. Cities and municipalities are clear political units, and the next level of legal action is the building site or the building itself. There are only a few options for setting compulsory standards for a district. In that regard, the transfer of sustainability criteria on a district level has proven particularly difficult.
4. **Urban Development Contracts (UDCs)** are conducted between municipalities and developers to set binding requirements, additional to existing legislation for the development of an area. The main objective in concluding UDCs is to involve property owners in bearing infrastructure expenses as well as to promote the realization of spatial planning objectives. The instrument of land sale and land lease contracts presents a proper method of imposing minimum sustainability requirements e.g., for energy efficiency and energy supply. These civil law agreements coupled with certain requirements can be signed for the land owned by the city. Therefore, criteria such as price, quality, innovation as well as sustainability aspects can be transferred to developers. However, in some cases concluding land sale contracts might also be associated with contradictory objectives, e.g., decreasing property value due to pushed-up requirements. These tools are often used in newly built rather than existing areas. In mixed areas (existing + newly built) another option is to establish quality assurance boards. These quality assurance boards ensure consistent quality while also taking sustainability aspects into account.
   Contracts with superior administrative bodies (e.g., Sustainable Neighbourhood Contracts) mean that the district development gets financial support for renovation and improvements via (comprehensive) program contracts targeting different areas of action (e.g., public spaces). SNCs are considered a complete and global approach that considers both urban and social difficulties.
5. **Incentives** provide on the one hand (monetary) rewards and recognition for the receiving stakeholder and on the other hand for the one giving the incentive it is an effective behavioural modification tool, used to motivate desired behaviour. With subsidies, not only the costs for district development can be covered but also thematic impulses in the district can be set. Tax incentives can help with high investment costs for renovation and improvement while undesired systems could be counteracted with higher taxation. Disclosure of monitored data is important for informed decision-making and thus can provide an incentive for better performance.
6. **Supervising and monitoring performance** is considered helpful to track the progress of PEN projects. Especially if there are deviations occurring, corrections can be made towards the joint projected path. This includes supervision of developers and building owners and monitoring. Monitoring (by local authorities) helps to assure that pre-set targets and standards are met throughout the planning and implementation process as well as the further operation of PENs.
7. To meet the requirements of modern urban development, **structurally reforming the administration** is helpful. Targeted reorganisation can not only increase efficiency but also reduce costs.

More examples are described in the project EnergyCities[20]. For newly built district different steering tools can be used. The city of Vienna developed a service platform to guide citizens, listing (among other things) trusted companies to potentially collaborate with. In the Municipality of Lille, a co-creation process was initiated with local developers and designers, to constitute together a collective basis for their Low Carbon Pact. To overcome the missing

[20] Royer, M., 2022. Scaling up positive energy districts across Europe. Discussing key topics related to positive energy districts with the cities of Brussels, Stockholm, Vienna and many more. EnergyCities Energy Lunch Talks, 2022. https://energy-cities.eu/scaling-up-positive-energy-districts-across-europe/

of targets by building developers, Stockholm developed an ambitious and compulsory capacity program for developers, to push them towards higher achievements. All developers to whom land have been sold in the district are required to share their approaches and monitor their results. The city of Delft developed a series of measures ranging from a continuous communication campaign to investing in its own real estate, subsidizing businesses, and setting clear deliverables for social housing companies.

PEDs can also develop in renovation projects. In that case, core actors in the planning, construction and implementation phase need to cooperate in different possible scenarios (new construction to different levels of energy efficiency, major renovation of all or some buildings, comprising building stock under consideration with deep energy retrofit of these buildings, minor renovations with energy-related scope of work, or demolition of some old buildings). One way of coordinating this process the application of certification schemes or KPIs.[21] In Norway, the Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN Centre), looks at the development and implementation of solutions for future buildings and neighbourhoods with no greenhouse gas (GHG) emissions, through energy efficiency, flexibility and storage embedded in a holistic approach towards build environment development including e.g. mobility and spatial qualities, including private and public user partners along the value chain of PEN deployment. The approach focuses on the development of KPI's for value chain integration. In Switzerland, the 2000-Watt Society is a vision for a liveable future and the '2000-Watt Site' certificate allows to evaluate large site developments in terms of building quality, density, mixed usage, and mobility. The concept of a 2000WS takes an integrative view of the entire site rather than individual buildings. It is a certificate that creates added value for all stakeholders and helps with increasing acceptance. Several companies have identified business models around it as e.g., the 2000WS certification scheme.

4.6. Integrated planning process

Need for an integrated planning process

Building a positive energy district goes beyond the building sector, and the planning and decision making should always be part of an integrated planning process, since it is strongly influenced by the complex interconnections between technical, economic, and political factors.

Decisions for PEN development is no longer arranged based on a priori order and hierarchy, but on different iterative decision-making rounds. As a result, decision making is about dynamic combinations of sets of problems and solutions represented by different actors and different exogenous factors (e.g., the political and governmental priorities, contextual differences, etc.). There is also a difference between newly built districts (where the planning and integration of innovative solutions are less complex, and the ambition is usually higher) and the challenging characteristics of developing PENs in buildings in historic districts. [22]

[21] Haase, Matthias, and Daniela Baer. "A case study analysis of Positive Energy District concepts between Switzerland and Norway." CEUR Workshop Proceedings. CEUR, 2021.

[22] Krangsås, Savis Gohari, et al. "Positive energy districts: Identifying challenges and interdependencies." Sustainability 13.19 (2021): 10551.

Examples of integrated planning processes

EIP-SCC

An integrated, holistic, interdisciplinary and multisectoral approach for planning and management of smart city projects at district level is proposed by EIP-SCC[23]. This approach can provide useful elements for PEDs. This approach considers not only the full life cycle of planned investments in the built environment, but also the entire community influenced by them, based on best practices. The document mentions the importance of exploiting synergies like bi-directional exchange of energy between buildings and electric vehicles in districts, or using an external advisor who educates staff in inter-disciplinary thinking. Silo-thinking within government sectors and businesses can be overcome by setting up interdepartmental taskforces, special staff units, or legal entities as associations and public- private partnerships (PPP's) to enable public-private collaboration. To include and involve all stakeholders, co-design, co-creation and co-production are needed for integrated planning and implementation.

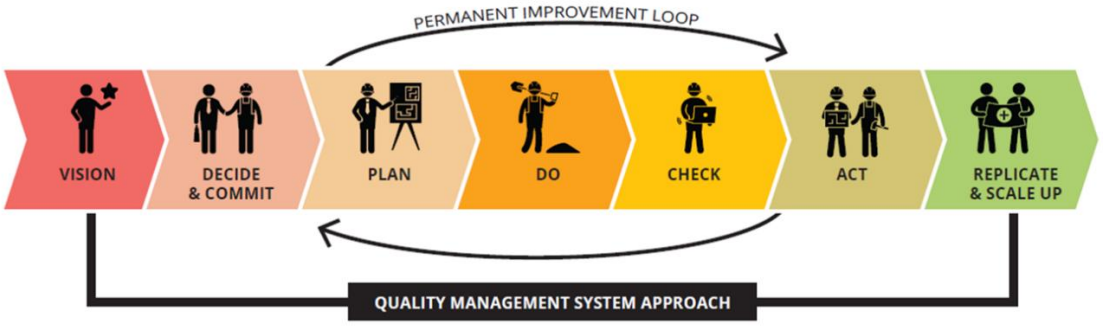

Figure 8: Steps from vision to implementation and permanent improvement loop.

The EIP-SCC[24] roadmap for smart cities follows a holistic perspective for integrated smart city planning. It includes different stages of implementation (see figure), although in reality it appears that stages are often less distinct in integrated smart city projects with high technical and organizational complexity.

1. The roadmap starts with shaping a **vision**, where a holistic approach including multiple stakeholders is used. Different tools and standards can be used in this stage (for example consultations, round tables, innovative brainstorming methods). One of the actions includes the identification of key stakeholders, their roles, and legal responsibilities.
2. The next stage is **decide and commit**, by forming a strategy and time frame. Meetings and workshops, field visit and site visits and other tools can be used in this stage. The roles of all key stakeholders must be further defined, and more formal forms of collaboration can be explored. Also, a first exploration of suitable financial schemes must be done. The roadmap includes different examples, such as a one stop shop for informing building owners about a wide range of measures, their costs, and subsidies.
3. At the **plan** stage, the envisaged and prioritized actions are operationalized by choosing approaches, technologies, and financial models. It is especially important to keep a holistic view on the different projects in different sectors, to keep an optimized alignment of the timelines, that will lead to saving time, money, and resources, as well as ensuring the ap-

[23] EIP-SCC, 2019. Smart city guidance package. A roadmap for integrated planning and implementation of smart city projects.
[24] EIP-SCC, 2019. Smart city guidance package. A roadmap for integrated planning and implementation of smart city projects.

propriate design/characteristics of future equipment/systems. Additionally, financing models have to be chosen. Typically, many solutions for smart cities and low energy districts, have high initial costs and a questionable profitability, but there are different ways to deal with high costs (for example Public-private partnerships (PPP's), bundling highly profitable project investments with less profitable or unprofitable elements, mixed financing from various sources and types of investors and others. The last thing to do for this stage is to start preparing contracts, public procurement, and public-private partnerships.

4. In the **do** stage, the actual implementation of the project starts. Here standard project management tools and standards will play a more prominent role, although they include innovative technologies (including ICT) and novel approaches, so an iterative approach is needed. A skilled team has to be composed, which can be different from the planning team. Next to making a detailed action and project plan, a monitoring process (using KPI's) has to be established before the execution of the project can start.
5. In the **check** stage, monitoring is used to steer the project or action plan during its implementation and adjust the actions if needed. If observed or foreseen problems have to be solved, the team must identify which adjustments are needed to improve the project. Successively, these possible adjustments should be widely discussed with all internal and external stakeholders in the quadruple helix.
6. In the **act** stage, corrective actions are decided upon and implemented to meet the final targets and finally in the **replicate & scale-up** stage specific actions are taken for roll-out and replication. This step includes also defining the business model.

Syn.ikia (Horizon 2020)

The Horizon 2020 project Syn.ikia[25] uses the method of Integrated Energy Design (IED), which aims to ensure that technical concerns related to environmental and energy performance of the building are addressed from the early stages of the design process when the form, construction, and technical system can still be adjusted in a way to serve the project targets. Integrated Energy Design implies that more time is spent in the early stages of the design process to evaluate the performance of alternative design options and their impact on a series of parameters used as evaluation criteria. However, the increased time spent in the early phases is gained back by a more efficient process in the later design and construction phases. The process was described, tested, and developed with the research Centre for Zero Emission Buildings. Here, it was emphasized that a team working at building scale should include competences in the use of simulation tools, able to give feedback on the effects of implementing alternative passive strategies, such as utilisation of natural ventilation, daylight and thermal mass, and active systems such as HVAC and renewable energy systems integration. When working at a neighbourhood scale, the integrated energy design processes will consider not only quantitative parameters related to the environmental and energy performance of buildings in the neighbourhood, but also qualitative variables related to social environment or economic framework.

The 7-step IED process includes:

1. **IED design team.**
   A multi-disciplinary team would generally include the developer, a contractor contributing with "hands-on" experience and a pragmatic view to cost-effective solutions, an architecture firm, a landscape architect, and an energy/environment consultant. The team should be open to continuously revising the energy and environmental solutions throughout the development of the project. In some cases, a construction consultant for feasibility studies related to foundation and terrain, and other consultants related to fire, building physics, traffic, geology, daylight

[25] Syn.ikia, 2021. D.2.1 Report on design plus energy neighbourhoods in each of the four climatic types.

etc. could provide a valid support to the project. Material suppliers (such as solar panel suppliers) could also be included as valid support for the optimization of the project architecture in relation to specific issues (renewable energy generation, etc.). Finally, user participation/input is important to implement the needs of the community and neighbours and to reduce the "noise" and resistance later in the project.

2. **Boundary conditions and ambitions**.
   Analyse the boundary conditions of the project. Which stakeholders are/should be involved? What are the stakeholders' needs and demands? Clarify the project ambition and formulate a set of specific goals for the project. Make scenarios for future developments.
3. **Quality assurance**.
   Make a quality assurance program and a quality control plan for follow-ups throughout the project phases.
4. **IEDN kick-off workshop**.
   Arrange a kick-off workshop to make sure that all stakeholders and team members have a common understanding of the project and its goals.
5. **Design team workshops, methods and tools used**.
   Facilitate close cooperation between stakeholders (e.g., landowner, municipality, energy- and utility companies) and members of the design team (e.g., urban planners, architects, engineers) through a series of workshops during the project design phase. Apply appropriate methods and tools for continuous performance prediction and evaluation of design options.
6. **Document QA.**
   Update the Quality Control Plan and document the energy and environmental performance at critical points (milestones) during the design.
7. **Contracting.**
   Make contracts that encourage integrated design and construction.

5. Other collaboration frameworks

In this section some other existing collaboration frameworks, that happen in practice in the construction sector today, are listed. These methods are evaluated on different aspects like: their specifics, when they can be applied and if they are usable in a public procurement environment. These methods are also checked from the point of view of their support for early integration. Some of them only cover part of the value chain; others are related to the above-mentioned collaboration methods.

5.1. Subcontracting

Basic principles

In the construction sector, subcontracting is a common practice where a main contractor hires another company or individual (known as a subcontractor) to perform specific tasks or portions of a larger construction project. The main contractor typically enters into a subcontract agreement with the subcontractor, outlining the scope of work, deliverables, timeline, and payment terms.

Subcontracting is a practical and efficient way for main contractors to handle various aspects of a project that they may not have the expertise, resources, or workforce to complete themselves. By subcontracting specialized tasks, the main contractor can focus on managing the overall project, coordinating various subcontractors, and ensuring the project's successful completion. The tasks most commonly executed by subcontractors are electrical work, plumbing, roofing, flooring, HVAC (Heating, Ventilation, and Air Conditioning) and concrete work.

By leveraging subcontractors, main contractors can benefit from their expertise and specialization, ensuring that each aspect of the construction project is completed by professionals with specific skills. However, effective management and coordination are crucial in subcontracting arrangements to ensure that all subcontractors work together seamlessly and meet the project's deadlines and quality standards.

Although this collaboration happens mainly in the realisation phase of the value chain, not in the design phase, it is mentioned here because it is an essential part of the construction ecosystem.

Benefits and Pitfalls

Table 2: Benefits & pitfalls of subcontracting

Subcontracting	
+	-
Expertise and Specialization	Coordination challenges
Additional Resources	Quality control
Access to Specialist Tools	Communication Hurdles (Cross-Barrier)
	Dependency

In any case, the following points are important when subcontracting:

- Clearly outline the scope of work in the subcontract agreement to avoid misunderstandings and disputes later on.
- Maintain open and clear communication with subcontractors throughout the project. Regular meetings and updates are essential for coordination.
- Set achievable deadlines and goals for subcontractors to maintain project progress and quality.
- If problems arise, address them promptly and collaboratively with the subcontractors to find solutions.
- Pay subcontractors promptly and fairly according to the agreed-upon payment terms.
- Research and select subcontractors based on their experience, qualifications, and reputation. Check references and past projects to ensure their reliability, rather than selecting subcontractors solely on price offer.

Additional to the attention points mentioned above, access to the latest technology can be a major pro for selecting a specialist who invested in the most innovative and sometimes costly tools.

With subcontracting come disadvantages such as: coordination challenges, quality control, dependency, disputes and conflicts, safety concerns, lack of direct control and communication hurdles, especially with cross-barrier subcontracting.

When to use

Subcontracting is used in the construction industry when a main contractor hires another company or individual (subcontractor) to perform specific tasks or portions of a larger construction project. This collaboration type is chosen for various reasons, and it is essential to understand when to use subcontracting compared to other collaboration types: specialized expertise, resource and capacity constraints, time-sensitive projects, cost-efficiency, project complexity, risk management or scalability.

Main contractors are typically motivated by the potential for profit and the opportunity to grow their construction business. Successfully completing projects within budget can lead to higher profits and more significant business opportunities.

Delivering successful projects enhances the main contractor's reputation and credibility in the industry. Positive reviews and word-of-mouth recommendations can lead to more project opportunities in the future.

Efficiently coordinating and managing subcontractors can lead to smooth project execution, on-time deliveries, and minimized delays.

Subcontractors are primarily motivated by financial compensation for their services. Fair and timely payments are crucial to maintain a positive working relationship.

Successful collaboration with main contractors can lead to repeated business and a steady flow of projects, providing subcontractors with a consistent source of income.

Subcontractors are often specialists in their respective fields. Engaging in high-profile projects allows them to showcase their expertise and capabilities to potential clients and partners.

Subcontracting can be utilized in **different phases of a construction project,** depending on the specific tasks, expertise required, and the project's overall structure. Here are the phases in which subcontracting is commonly used:

- **Pre-Construction Phase**

- During the pre-construction phase, subcontractors may be involved in providing input and estimates for their specialized services. This can include electrical, plumbing, HVAC, and other trades.
- Subcontractors may also be engaged to assist with site assessments, soil testing, and other preliminary activities.

- **Construction Phase:**
  - The construction phase is where subcontracting is most commonly applied. Various specialized subcontractors are brought in to carry out specific tasks.
  - Examples of subcontracted work during the construction phase include electrical installations, plumbing, roofing, flooring, painting, and other trade-specific tasks.
  - Subcontractors work under the supervision and coordination of the main contractor, who manages the overall project.
- **Post-Construction Phase:**
  - In some cases, subcontractors may also be involved in the post-construction phase, especially if there are maintenance or warranty-related tasks.
  - Subcontractors may provide ongoing support, such as HVAC maintenance, electrical repairs, or other warranty services for their specific work.

The main contractor is responsible for selecting, managing, and coordinating the subcontractors effectively throughout the project's lifecycle to ensure the successful completion of the construction project. Proper communication and collaboration between the main contractor and subcontractors are key to achieving the project's goals and meeting the client's expectations.

Applicable in public procurement environments?

The main contractor (the company awarded the public contract) is responsible for overseeing and managing the subcontractors' work to ensure that the project's objectives are met, quality is maintained, and all contractual obligations are fulfilled. So, the main contract can be awarded via public procurement. Public tendering for subcontracting is not typical.

5.2. Temporary association for tender

Basic principles

A "temporary association" typically refers to a short-term collaboration or partnership formed between two or more companies or contractors to work together on a specific project. This association is established for the duration of the project and dissolves once the project is completed. It is also known under the abbreviation TCP (Temporary Commercial Partnership).

Benefits and Pitfalls

Table 3: Benefits & pitfalls of temporary association (for tender)

Temporary Association (for tender)	
+	-
Capacity and Resources	Hard Legal Agreements
Expertise and Specialization	Distribution of Responsibilities
Geographical Reach	Outlining of Roles
Risk Sharing	Discussion on Profit-Sharing

Temporary associations can be formed for various reasons and benefits, such as:

- **Capacity and Resources**: Sometimes, a construction project may require more resources, equipment, or expertise than a single company can provide. By forming a temporary association, multiple companies can pool their resources to meet the project's requirements.
- **Expertise and Specialization**: Different construction companies may have unique expertise in specific areas of construction. By coming together, they can leverage each other's specialized knowledge to deliver a comprehensive and high-quality project.
- **Geographical Reach**: A construction project may span a large area, and companies from different regions may join forces to efficiently cover the entire project site.
- **Risk Sharing**: Collaborating in a temporary association can help distribute and mitigate risks associated with the project among the participating companies.
- **Market Access**: For some companies, entering a new market or securing a larger project might be challenging individually. By forming a temporary association with a local company or a company experienced in that market, they can enhance their chances of winning the project.
- **Regulatory Requirements**: In some cases, local regulations may mandate the involvement of local companies or contractors. A temporary association can help fulfil such requirements while also benefitting from the expertise of other non-local members.
- **The temporary association model** allows companies to collaborate strategically without committing to a long-term partnership. It offers flexibility and an opportunity to work on projects that may have been beyond the scope of individual companies.

A pitfall for temporary associations can be:

- It's important to note that temporary associations in construction are typically formalized through legal agreements, outlining the roles, responsibilities, profit-sharing, and dissolution terms among the participating parties. These agreements help ensure clarity and transparency throughout the project's duration.

When to use

Temporary associations in construction are typically used in situations where individual companies or contractors recognize the advantages of pooling their resources and expertise to work together on a specific project, such as: large and complex projects, resource constraints, new market entry, specific expertise required, risk distribution, complementary skills and services, project deadlines and constraints, improving competitiveness and innovation and problem-solving.

In some cases, local regulations or tendering rules may encourage or mandate the formation of temporary associations involving local companies.

The motivating factors for each party in a temporary association or collaboration in construction can vary depending on their individual goals, strengths, and specific needs. Here are some common motivating factors for each party:

Construction Companies or Contractors (Architect and Engineers) might be interested in:

- **Access to New Projects**: Temporary associations allow companies to access and bid on larger or more complex projects that may have been beyond their individual capabilities.
- **Risk Mitigation**: By pooling resources and expertise, companies can share risks associated with the project, reducing the financial burden on any single participant.
- **Geographical Expansion**: Joining forces with local companies can help non-local contractors enter new markets and gain a foothold in different regions.

- **Leveraging Specialized Expertise**: Each company brings its unique skills and expertise to the collaboration, which can enhance the overall quality and efficiency of the project.
- **Competitive Advantage**: Collaborating with other reputable firms can improve the consortium's overall competitiveness in the tendering process.
- **Learning and Networking Opportunities**: Companies can learn from each other, exchange best practices, and expand their professional network through the collaboration.

The same goes for **Clients or Project Owners:**

- **Comprehensive Solutions**: Temporary associations can offer clients a more comprehensive package, with a diverse range of expertise and resources from multiple companies.
- **Reduced Project Risk**: With multiple companies sharing the project's responsibilities, clients can have greater assurance that risks will be managed efficiently.
- **Innovation and Creativity:** The collaboration of different experts can lead to innovative solutions and creative problem-solving for the project.
- **Cost and Time Efficiency**: Combining resources can potentially lead to cost savings and streamlined project timelines.
- **Single Point of Contact**: Clients deal with the collaboration as a single entity, simplifying communication and coordination during the project.
- **Meeting Local Requirements:** In some cases, local regulations may require the involvement of local companies in a project. Collaborating with local partners helps fulfil these requirements.

Temporary associations in construction are typically formed during the early stages of a project, particularly during the pre-construction phase. The pre-construction phase is a critical stage where project planning, feasibility studies, and preparations are made before the actual construction work begins.

Applicable in public procurement environments?

Yes, temporary associations can be applicable and are commonly used in public procurement environments, especially in the context of construction projects.

In public procurement, temporary associations, also known as consortiums or joint ventures, can be formed by multiple companies coming together to bid on a specific construction project.

5.3. One stop shop

Basic principles

A one stop shop in the construction and energy sector refers to a comprehensive service provider that offers a wide range of products and services related to both construction and energy needs. Instead of dealing with multiple specialized companies, clients can find everything they require in one place, streamlining the process and potentially saving time and effort.

A one stop shop may offer services such as:

- **Design and Engineering**: Providing architectural and engineering services for construction projects, including energy-efficient designs and sustainable building practices.
- **Construction Services**: Offering a complete range of construction services, from site preparation and foundation work to building construction and finishing.

- **Energy Efficiency Solutions**: Providing expertise and products to enhance the energy efficiency of buildings, such as insulation, energy-efficient windows, and HVAC systems.
- **Renewable Energy Systems**: Supplying and installing renewable energy technologies like solar panels, wind turbines, and geothermal systems.
- **Energy Audits**: Conducting energy audits of buildings to identify areas for energy efficiency improvement and recommending appropriate solutions.
- **Green Building Certifications**: Assisting clients in obtaining green building certifications such as LEED (Leadership in Energy and Environmental Design) or BREEAM (Building Research Establishment Environmental Assessment Method) to showcase the environmental sustainability of their projects.
- **Energy Management and Monitoring**: Implementing energy management systems and technologies to monitor and optimize energy consumption in buildings.
- **Financing and Incentives**: Providing information about available financing options and government incentives for energy-efficient and sustainable construction projects.
- **Maintenance and After-Sales Support**: Offering ongoing maintenance services for installed energy systems and equipment.

By offering a diverse array of services and products, a one stop shop aims to simplify the process for clients, promote integrated solutions, and contribute to more sustainable and energy-efficient construction practices. It allows clients to address their construction and energy needs comprehensively and ensures that the different components of a project work seamlessly together.

Benefits and pitfalls

Table 4: Benefits & pitfalls of one stop shop

One Stop Shop	
+	-
Increased Business Opportunities	Limited Scope/offer
Time and Cost Savings	Quality assurance
Diversification of Services	Flexibility Constraints
Convenience	Limited Market Presence
Integrated Solutions	

Possible benefits for construction companies are:

- **Increased Business Opportunities**: Joining a one stop shop collaboration can expand a construction company's range of services, allowing them to take on a broader range of projects and attract more clients.
- **Cost Savings**: By collaborating with other partners, construction companies can share resources and expertise, leading to potential cost savings in terms of marketing, overhead expenses, and operational efficiency.
- **Enhanced Reputation**: Being part of a reputable one stop shop can boost a construction company's credibility and market position, potentially leading to more significant and high-profile projects.

For Energy Service Providers the benefits are:

- **Access to New Markets**: Energy service providers can access new customer segments through the collaboration, as construction projects may require energy-efficient solutions and renewable energy technologies.
- **Diversification of Services**: By partnering with a one stop shop, energy service providers can diversify their service offerings beyond just providing energy solutions, expanding their revenue streams.
- **Increased Awareness of Energy Efficiency**: Collaborating with construction companies can help energy service providers promote energy-efficient practices and solutions, contributing to a more sustainable construction industry.

Benefits for clients:

- **Convenience:** Clients benefit from a one stop shop as it simplifies the process of acquiring construction and energy services. They can access a wide range of services under one roof, streamlining project management.
- **Integrated Solutions**: One stop shops can offer integrated solutions that consider both construction and energy needs, resulting in more efficient, sustainable, and cost-effective projects.
- **Time and Cost Savings:** Clients can potentially save time and money by dealing with a single entity for multiple services, reducing coordination efforts and administrative burdens.

For Government and Regulatory Bodies:

- **Promotion of Sustainability:** One stop shops with a focus on energy-efficient and sustainable practices align with government goals to promote environmental responsibility and reduce carbon emissions.
- **Streamlined Regulation Compliance:** Collaborations that adhere to energy efficiency and green building standards can help governments meet their regulatory targets and sustainability objectives.
- **Economic Growth:** Successful one stop shops can contribute to economic growth by attracting more construction and energy-related investments and creating employment opportunities.

For Environmental Organizations:

- **Promotion of Sustainable Practices**: Collaborations that prioritize sustainability and energy efficiency align with the goals of environmental organizations in reducing the impact of construction on the environment.
- **Advocacy and Awareness:** One stop shops that actively promote green building practices and renewable energy solutions contribute to raising awareness about the importance of sustainable development.

Overall, the motivating factors for each party in a one stop shop collaboration can be multifaceted, combining financial incentives, market opportunities, environmental considerations, and the desire to offer more comprehensive and integrated solutions to clients.

Besides the advantages mentioned above, a One-Stop-Shop Collaboration can also result in time efficiency. By coordinating different aspects of a project, a one stop shop can help expedite timelines and reduce delays, improving project delivery.

The possible disadvantages might be found in:

- limited scope/offer
- quality assurance
- flexibility constraints
- limited market presence

In summary, a one stop shop collaboration in the construction and energy sector can offer significant advantages in terms of convenience, integration, and efficiency.

When to use

The decision to use a one stop shop collaboration in the construction and energy sector depends on various factors and considerations. The main advantages are streamlining services, enhanced integration, diverse expertise, reputation and credibility, customer convenience, improved project management, access to energy-efficient solutions, possibly cost savings and subscription to sustainability goals

In regions where there are government incentives or programs that promote energy-efficient and sustainable construction, using a one stop shop that specializes in these areas can help clients take advantage of such benefits.

Applicable in public procurements?

Yes, the concept of a one stop shop collaboration can be applicable in public procurement environments, especially in the construction and energy sector.

An important attention point is that the implementation of a one stop shop collaboration in public procurement environments may require careful consideration of legal and financial aspects. Public entities need to ensure that the collaboration complies with procurement regulations and that the partners involved meet the necessary qualifications and certifications.

5.4. Innovative public procurement process

Basic principles

Innovative public procurement refers to the process by which public entities, such as government agencies or institutions, seek to acquire goods, services, or works in a manner that fosters innovation and promotes the development of new and advanced solutions. The conventional public procurement process typically focuses on acquiring goods and services based on predefined specifications and well-established requirements. In contrast, innovative public procurement aims to encourage creativity, problem-solving, and the implementation of cutting-edge technologies and approaches to meet the public sector's needs.

Key characteristics of innovative public procurement include:

- **Focus on outcomes**: Instead of prescribing specific solutions, innovative procurement concentrates on defining the desired outcomes and allowing bidders to propose creative ways to achieve those objectives.
- **Collaboration with industry**: Public procurement authorities actively engage with private sector companies, start-ups, and research institutions to tap into their expertise and novel ideas.
- **Flexibility**: The procurement process is designed to be agile and adaptable to accommodate emerging technologies and rapidly evolving market conditions.
- **Risk-sharing**: In some cases, innovative procurement may involve risk-sharing arrangements, where both the public entity and the private sector participants share the risks and rewards of the project.
- **Long-term perspective**: The emphasis is on fostering long-term partnerships and sustainable solutions rather than short-term transactions.

- **Open innovation**: This approach encourages the involvement of a wide range of stakeholders, including the public, academia, and industry, to contribute to problem-solving and idea generation.
- **Pilot projects and testing**: Innovative procurement methods often involve pilot projects and testbeds to trial new solutions before broader implementation.

It is essential to keep the procurement process transparent and maintain clear communication with all stakeholders throughout the collaboration's setup and execution. Additionally, fostering a culture of openness to new ideas and innovation within the public sector can further facilitate successful collaborations for innovative public procurement.

Benefits and pitfalls

Table 5: Benefits & pitfalls of innovative public procurement

Innovative Public Procurement	
+	-
Efficiency and Cost Savings	Higher Level of Uncertainty and Risk
Showcasing Expertise and Innovation	Higher Cost
Access to Funding and Resources	Flexibility Constraints
Improved Services	Lack of Expertise
	Limited Number of Suppliers

Innovative public procurement fosters collaboration between the public sector and private suppliers, bringing together diverse expertise and resources to tackle societal issues. It is supporting innovative businesses and start-ups and can lead to economic growth and job opportunities within the region.

Innovative public procurement can prioritize sustainability and environmentally friendly practices, contributing to a greener and more socially responsible society.

It is important to:

- **Maintain transparency** throughout the procurement process to build trust with potential suppliers. Ensure that the process is fair and that all interested parties have an equal opportunity to participate.
- **Create an environment that encourages innovative ideas and solutions**. Avoid rigid specifications that stifle creativity and limit potential breakthroughs.
- **Ensure that the budget and funding for the collaboration are sufficient** to support the development and implementation of innovative solutions.
- **Establish clear and relevant evaluation criteria** for the proposals, giving due weight to innovation, technical feasibility, and long-term sustainability.
- **Be open to adjusting the procurement approach** if necessary. An iterative approach may be more suitable for innovative projects where solutions evolve over time.
- **Maintain open and regular communication with potential suppliers and other stakeholders**. Provide feedback during the dialogue phase to guide proposal improvements.
- **Assess the public entity's internal capacity to manage innovative procurement projects.** Consider investing in training and building expertise in managing such collaborations.
- **Consider the environmental and social impact of the collaboration.** Encourage solutions that promote sustainability and contribute positively to society.

By paying attention to these key points, public entities can effectively set up and manage collaborations for innovative public procurement, fostering the development of cutting-edge solutions that address real-world challenges and deliver value to society.

On the contrary, implementing innovative procurement can be more complex and time-consuming than conventional procurement methods due to the need for dialogue, negotiation, and risk assessment.

Innovative solutions may have a higher level of uncertainty and risk, especially when dealing with emerging technologies or unproven approaches and may initially come with higher costs compared to off-the-shelf solutions, especially during the development and pilot phases. Evaluating the success and effectiveness of innovative solutions can be challenging, especially when the outcomes are intangible or difficult to quantify.

Public entities may lack the expertise and resources needed to evaluate and manage innovative projects effectively.

Depending on the nature of the project, there might be a limited number of suppliers with the required expertise and capabilities to propose innovative solutions.

Public sector stakeholders may be risk-averse and resistant to adopting new and unfamiliar approaches.

Public entities should carefully weigh these pros and cons and assess the project's specific characteristics before deciding whether to pursue innovative public procurement. Mitigating risks and challenges requires thoughtful planning, stakeholder engagement, and building internal capacity to manage such projects effectively.

In order to avoid pitfalls, it is key to:

- **Identify and address potential risks** associated with the collaboration, including technical, financial, and legal risks. Implement risk-sharing mechanisms where appropriate to promote commitment from suppliers.
- **Clearly define the ownership and usage rights** of any intellectual property developed during the collaboration. Balancing the interests of both the public entity and the private sector is crucial to foster continued innovation.
- **Implement robust project management practices** to monitor progress, milestones, and outcomes. Regular reporting helps keep stakeholders informed and engaged.
- **Plan for a smooth exit strategy** if the collaboration does not achieve the desired results or needs to be terminated prematurely.
- **Avoid favouring specific suppliers or solutions** before the evaluation process and ensure a competitive environment.
- **Address intellectual property rights** issues and ownership of developed solutions clearly in the contract.
- **Learn from previous procurement experiences** and consider lessons learned to improve future collaborations.
- **Extra attention is essential to achieve long-term impact** and ensure the collaboration adheres to all legal, regulatory, and ethical requirements.

Specific benefits for each party are:

Public Entity (Government/Agency):

- **Efficiency and Cost Savings:** Innovative solutions may lead to increased efficiency and cost savings in the long run, benefiting the public entity and taxpayers.
- **Enhancing Reputation:** Successful collaborations for innovative public procurement can enhance the reputation of the public entity as a forward-thinking organization that fosters innovation and supports local industries.
- **Fostering Economic Growth:** By supporting innovative businesses and start-ups, the public entity contributes to economic growth and job creation.

Private Sector Suppliers:

- **Showcasing Expertise and Innovation:** Collaborating with the public sector allows suppliers to showcase their expertise, capabilities, and innovative solutions, potentially attracting more business opportunities in the future.
- **Access to Funding and Resources:** Government collaborations may provide access to funding, resources, and research facilities that suppliers might not have on their own.

End-Users (Citizens or Government Departments):

- **Improved Services:** End-users benefit from innovative solutions that lead to improved and more efficient public services.
- **Better Quality of Life:** Innovative public procurement initiatives that address societal challenges can contribute to a better quality of life for citizens.

The success of a collaboration for innovative public procurement often relies on aligning these motivations and creating a win-win situation for all parties involved.

When to use

Innovative public procurement can be utilized in different phases of a project or initiative. The specific phase to use innovative procurement methods depends on the nature of the project and the goals set by the public entity.

Innovative public procurement is best used when conventional procurement methods are unlikely to yield the desired outcomes or when there is a need for ground-breaking, cutting-edge solutions to address complex challenges. Here are some situations where using innovative public procurement is particularly beneficial:

- **Complex Problems**: When the problem or challenge faced by the public sector is multifaceted and requires creative, out-of-the-box solutions that go beyond standard offerings.
- **Emerging Technologies:** For projects that involve emerging technologies or solutions that are not yet mature in the market, innovative procurement can be used to foster their development and implementation.
- **Lack of Mature Solutions:** When no off-the-shelf solutions are available to meet the specific needs of the public sector, innovative procurement can encourage suppliers to develop tailor-made solutions.
- **Promoting Local Innovation:** Innovative public procurement can support local businesses, start-ups, and research institutions, driving economic growth and technological development within the region.
- **Long-Term Transformation:** When the objective is to achieve long-term transformation or modernization of public services, innovative procurement can facilitate the adoption of innovative approaches.
- **Sustainability Initiatives:** For projects with a strong emphasis on environmental and social sustainability, innovative procurement can attract solutions that prioritize eco-friendly and socially responsible practices.

- **Pilot Testing and R&D:** When piloting or research and development are necessary to test the feasibility and effectiveness of potential solutions before full-scale implementation.
- **High-Risk Projects:** In cases where projects involve substantial risks, innovative procurement can allow risk-sharing arrangements with suppliers.
- **Encouraging Competition:** Using innovative procurement methods can attract a diverse range of suppliers and foster healthy competition, leading to the selection of the most suitable solution.

It is important to note that innovative public procurement may not be suitable for every project or situation. It requires a willingness to embrace uncertainty, a commitment to openness and flexibility, and a collaborative mindset from all parties involved. Additionally, the public entity should have the necessary expertise and resources to manage and evaluate innovative procurement processes effectively.

Public entities should carefully assess the specific needs, objectives, and risks of each project to determine whether innovative procurement is the most appropriate approach. In some cases, a combination of conventional and innovative procurement methods may also be employed to achieve the best results.

Applicable in public procurement environments?

Yes, innovative public procurement is applicable and can be highly beneficial in public procurement environments. While conventional procurement methods serve their purposes, there are situations where innovative procurement approaches offer significant advantages in the public sector.

Public entities should weigh the benefits and challenges, assess project suitability, and foster a supportive environment that embraces innovation and experimentation.

However, implementing such procurement practices may require overcoming regulatory hurdles, addressing risk aversion, and fostering a culture of innovation within the public sector.

5.5. Energy performance contracting (EPC) and Energy service company (ESCO)

Basic principles

Energy Performance Contracts (EPCs) and Energy Service Companies (ESCOs) are related concepts that involve the implementation of energy efficiency measures in buildings or facilities.

An Energy Performance Contract (EPC) is a contractual agreement between a client and an energy service provider (ESP), typically an ESCO. The purpose of an EPC is to improve energy efficiency, reduce energy consumption, and achieve cost savings in the client's facility.

Under an EPC, the ESCO assumes responsibility for identifying, designing, financing, implementing, and maintaining energy-saving measures within the client's premises. These measures can include upgrading lighting systems, installing efficient HVAC (heating, ventilation, and air conditioning) equipment, improving insulation, optimizing energy management systems, and more.

The key characteristic of an EPC is that the ESCO guarantees specific energy savings to the client. The contract typically outlines the expected energy performance improvements and the

resulting cost savings. If the savings fall short of the agreed-upon targets, the ESCO is often responsible for covering the difference.

Energy Service Companies (ESCOs) are entities that specialize in providing energy efficiency services to clients. ESCOs are typically private companies, although they can also be public or non-profit organizations. Their primary role is to deliver comprehensive energy solutions to help clients optimize energy usage, reduce costs, and achieve sustainability goals.

ESCOs offer a range of services that may include energy audits, feasibility studies, project design and implementation, financing arrangements, and ongoing monitoring and maintenance of energy-saving measures. They act as the main contractor and project manager, coordinating various aspects of the energy efficiency project, including technology procurement, installation, and performance monitoring.

ESCOs often operate under EPCs, whereby they guarantee energy savings to their clients. By assuming the financial risks and providing expertise, ESCOs make it easier for clients to implement energy efficiency measures without upfront capital investment.

In summary, EPCs and ESCOs provide a framework for implementing energy efficiency projects. EPCs are contractual agreements between clients and ESCOs, where the ESCO guarantees energy savings and takes responsibility for implementing energy efficiency measures. ESCOs, are companies specialized in delivering energy services, including energy audits, project implementation, and performance monitoring.

Benefits and pitfalls

Table 6: Benefits & pitfalls of EPC and ESCO

EPC and ESCO	
+	-
Guarantee of Energy Savings	High Financing Cost
Lower Energy Cost	
Aligning of Interest of Parties	
No Upfront Investment	

The main advantage of this approach is that the interests of the owner and the interests of the ESCO align very well. It's a win-win for both sides.

When to use

This approach is mainly targeted to a renovation context, where a the energy system as a whole or specific energy equipment needs renovation. The concept covers the whole project, form the assessment (specification) phase, through execution and some years of the operations phase.

An EPC approach seems to be a win-win collaboration by default:

- The owner sees a guaranteed reduction in energy expenses, without upfront investment.

- The ESCO has a good reason to select the right measures.

Applicable in public procurement environments?

This approach works fine in formal public procurement contexts. A good preliminary assessment is necessary to define a delimited scope of work.

5.6. Consortium formation (Flux50 way for VLAIO projects)

Flux50 is an innovation platform based in Flanders, Belgium, that aims to accelerate the transition to a sustainable energy system. It supports and facilitates innovation projects in various ways. The main working domain is (smart) energy (technology, services, business models, ecosystems…), but strong links exist to the construction sector and energy consumption in buildings. Similar organisations exist in different countries or regions. The way how Flux50 forms consortia to execute (innovative) projects is mentioned here as an example.

VLAIO, or Vlaams Agentschap Innoveren en Ondernemen, translates to "Flemish Agency for Innovation and Entrepreneurship". It is a government agency in Flanders, the Dutch-speaking northern region of Belgium. VLAIO is responsible for promoting and supporting innovation, entrepreneurship, and economic development in Flanders. The agency provides various programs, services, and funding opportunities to help businesses and entrepreneurs foster innovation and growth within the region. This includes initiatives related to research and development, technology transfer, start-up support, and more.

Basic principles

Flux50 brings together a diverse network of industry stakeholders, including businesses, research institutions, and government organizations. By facilitating collaboration and networking opportunities, Flux50 helps connect innovators, researchers, and potential partners to foster knowledge exchange and joint projects.

Overall, Flux50 plays a vital role in supporting innovation projects by fostering collaboration, providing funding support, offering access to test facilities, facilitating knowledge exchange, assisting with regulatory compliance, and promoting market access.

Benefits and pitfalls

Table 7: Benefits & pitfalls of the Flux50 way of consortium formation

The Flux50 Way of Consortium Formation	
+	-
Funding Support	Funding Dependency in Flanders
Gain of Market Access	Awareness of Foreign Options
Facilitation of Matchmaking Opportunities	
Collaboration Opportunities	
Test Facilities and Living Labs	

Any stakeholder can benefit from a collaboration with Flux50:

- Flux50 supports the development of innovation projects by providing guidance and expertise throughout the project lifecycle. This includes helping project partners refine their ideas, defining project scopes and objectives, and identifying potential funding opportunities.
- Flux50 assists innovation projects in securing funding from various sources, including government grants, regional funds, and European programs. They provide guidance on available funding options, help partners navigate the application process, and support the development of funding proposals.
- Flux50 helps innovation projects navigate the complex regulatory landscape related to energy and sustainability. They provide guidance on regulations, standards, and policies, ensuring that projects comply with legal requirements and identifying opportunities for regulatory advancements.
- Flux50 supports innovation projects in gaining market access by connecting them with potential customers, investors, and partners. Through its network, Flux50 facilitates matchmaking opportunities and promotes the visibility of innovative solutions to accelerate their adoption in the market.
- Especially these triple helix partners do benefit from collaboration with Flux50:

Businesses and Innovators:

- **Collaboration Opportunities:** Businesses and innovators can benefit from networking and collaboration opportunities facilitated by Flux50. They can connect with potential partners, including research institutions, other businesses, and government organizations, fostering innovation and joint projects.
- **Funding Support:** Flux50 provides guidance on securing funding for innovation projects, assisting businesses in accessing government grants, regional funds, and European programs. This financial support can help businesses bring their innovative ideas to life.
- **Test Facilities and Living Labs:** Flux50 offers access to test facilities and living labs, providing businesses with real-world environments to validate and demonstrate their technologies or solutions. This access allows for reliable performance testing and scalability assessments.
- **Market Access:** Through its network, Flux50 helps businesses gain market access by connecting them with potential customers, investors, and partners. This exposure and visibility can lead to increased commercial opportunities and faster adoption of innovative solutions.
- **Regulatory Guidance:** Flux50 assists businesses in navigating the complex regulatory landscape related to energy and sustainability, ensuring compliance with regulations, standards, and policies. This support helps businesses mitigate regulatory risks and identify opportunities for regulatory advancements.

Research Institutions and Universities:

- **Collaborative Research:** Research institutions and universities can collaborate with businesses and other stakeholders through Flux50's platform. This collaboration enables knowledge exchange, joint research projects, and access to practical applications of research findings.
- **Funding Opportunities:** Flux50 provides guidance on funding sources for research projects related to sustainable energy. Research institutions can benefit from the support in identifying funding options and securing financial resources for their research activities.
- **Test Facilities and Living Labs:** Flux50 offers access to test facilities and living labs, allowing research institutions to conduct experiments and validations in real-world settings. This access enhances the practical applicability and impact of their research.
- **Industry Engagement:** Flux50's network facilitates closer ties between research institutions and industries, enabling better alignment between academic research and industry needs. This collaboration can lead to valuable insights, joint projects, and knowledge transfer.

Government Organizations and Policy Makers:

- **Accelerated Transition to Sustainable Energy:** Flux50's support and promotion of sustainable energy innovation projects contribute to the government's goals of transitioning to a sustainable energy system. The initiatives and projects facilitated by Flux50 align with governmental policies and help achieve environmental targets.
- **Economic Growth and Job Creation:** Flux50's support for innovation projects stimulates economic growth and fosters job creation, particularly in the sustainable energy sector. This can be beneficial for regional and national economies.
- **Enhanced Collaboration**: Flux50 helps government organizations collaborate with businesses, research institutions, and other stakeholders in the sustainable energy domain. This collaboration leads to knowledge sharing, policy insights, and effective implementation of sustainable energy initiatives.

On the contrary, there are some pitfalls:

- While Flux50 can support in identifying funding opportunities, it's important not to rely solely on them for funding. Explore multiple funding sources and diversify your approach to increase the chances of securing financial support. Flux50 mainly looks for regional funding options for their members. European programs (like Horizon Europe) are less often advised, but Flux50 participates itself as project partner in those European projects.
- Flux50's focus is on sustainable energy innovation. It's important to consider and incorporate sustainability aspects into your project. Aim to align your innovation with environmental goals, energy efficiency, and sustainable practices.
- Stay updated on the regulations and policies related to energy and sustainability. Flux50 can provide guidance, but it's important to be aware of the legal and regulatory landscape and ensure compliance with relevant guidelines.

Examples

DITUR - A district renovation tool

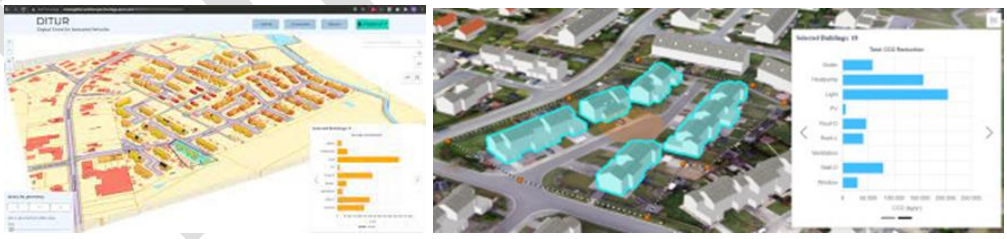

Figure 9: Example of Flux50-supported project: DITUR

Almost 40% of the building stock in Europe pre-dates 1960 and was not built according to an energy efficiency plan. Therefore, an intelligent and 'thorough' renovation of residential buildings would enable significant reductions in energy use and CO2 emissions. However, the conventional, fragmented market and the lack of 'renovation packages' in Flanders make it challenging to meet European and national targets: the current renovation rate is only around 1% per year. Achieving the CO2 reduction ambition requires a renovation rate of 3% per year.

Identified blocking factors to achieve this renovation rate are lack of drivers, high renovation costs, decrease in the number of contractors, missing ambition in the legislative framework for renovations, etc. Crucial blocking factors can be reduced to the benefit of contractors, authorities, homeowners, and tenants through efficient use of new and existing data sources, resources (man hours, materials, equipment, etc.), adequate planning (clustering, combining works, etc.) and targeted objectives.

Within this project[26], project partners want to develop a digital twin concept for scaled-up renovations. In addition, a proof of concept for user engagement will be developed. They will test this approach with two different target groups: urban environment and social housing companies. A data management plan will be developed to address the legislative framework. This project will also report on the potential of scaling up to a broader perspective, considering insights from consultations with society, including the value network and business model for digital twin concepts in Flanders[27].

The project[28] aims to achieve an accuracy of 5-10% of the recommended renovation packages and an accuracy of 5-10% of the renovation cost estimate (compared to individual audits); wants to show that 60% of the dwellings in cities are eligible for an energetic renovation and that 30-40% of the relevant dwellings can be renovated using a large-scale renovation approach, achieving a cost reduction of 20-25% compared to an individual renovation. At the same time, the renovation rate is increased by 20% and discrepancies between predicted and actual renovation effectiveness are reduced to 10%.

De Vlaamse staak - A ROLEC's demonstration site

This pilot project[29], supported by the Flemish Region, in collaboration with POM Vlaams-Brabant, the municipality of Opwijk, Haviland, Th!nk E, Powerdale and Wattson aims to realize a sustainable energy concept for the SME business parks "De Vlaamse Staak".

Due to the high cost to extend the natural gas network to the business park, alternative sustainable energy concepts were sought.

The feasibility of various alternatives was studied by Wattson, Th!nk E, Boydens Engineering and Fieldfisher. A geothermal-based grid was not eligible due to the excessive investment cost. Heating the buildings based on heat pumps and solar panels was the alternative put forward as a sustainable solution.

[26] https://flux50.com/innovation-support/projects-overview/digital-twins-for-upscaled-retrofits-ditur

[27] https://www.energyville.be/onderzoek/ditur-digital-twin-concept-voor-opgeschaalde-renovaties

[28] https://www.youtube.com/watch?v=-eHyFIlFsT4

[29] https://flux50.com/innovation-support/projects-overview/sustainable-vlaamse-staak

Figure 10: Example of Flux50-supported project: De Vlaamse Staak

Awaiting the possible establishment of a Renewable Energy Community, an ESCO-light approach will be provided that optimizes the energy concept for each SME. It is important that Wattson gives advice on the realization of the heat pumps/solar panels concept starting from the design phase of the building and that the sizing of the concept elements can be done based on the specific energy needs of each SME.

Wattson finances and manages the heat pumps through monitoring, control of energy performance and maintenance. The monitoring system is developed along with Powerdale and Th!nk E and aims to optimize the energy consumption of every SME. By monitoring, Wattson gets a much better view of SMEs' effective energy profiles, which in itself is an important fact to be able to transform De Vlaamse Staak into a Renewable Energy Community (REC)[30].

If this potential exists, combined with more clarity on the fare structures and modalities, the business case will be reviewed to finally decide or not to decide for a "REC De Vlaamse Staak".

De Nieuwe Dokken (The New Docks) - Gent

The north of Ghent will undergo a genuine metamorphosis in the coming years. Among other things, the Oude Dokken district, a pivotal part of the city's industrial history, will be given a new purpose thanks to several new projects and neighbourhoods. The residential and living project De Nieuwe Dokken[31], on the east side of the Handelsdok, will be one of the first realizations around the docks. Construction of the project is proceeding in phases. First up is the central field and the Deck. Then it will be the turn of the north field and south field. A unique location.

[30] https://www.youtube.com/watch?v=JgxkUa1n9e0

[31] https://denieuwedokken.be/over

Figure 11: Example of Flux50-supported project: De Nieuwe Dokken

The New Docks is located on the Schipperskaai, with the Bataviabrug as its connection to the city centre and with the concrete plant and cranes as beacons. The entire south-west façade of De Nieuwe Dokken overlooks the water. Residents can therefore enjoy a relaxing walk there, in the afternoon sun or in the evening at sunset.

De Nieuwe Dokken is a project by Schipperskaai Development (a consortium consisting of CAAAP and Van Roey Vastgoed) in cooperation with SO Gent and the city of Ghent that is being realized in the Oude Dokken district.

About 400 new flats and houses for Ghent residents of all ages will be built in this neighbourhood, but of course a neighbourhood consists of more than just houses. There is plenty to do along the quay and in the various buildings, at local traders, a brasserie, a sandwich shop, offices... Surrounded by greenery and water, there will also be various public facilities (such as a crèche, after-school childcare, primary school, and community sports hall) and numerous recreational opportunities (such as promenades, community parks and playgrounds).

Those who prefer shopping in the historic city centre will easily cross the docks via the convenient pedestrian and cycle bridges.

The 'New' in De Nieuwe Dokken does not simply refer to the fact that a brand-new neighbourhood is being built on the Ghent Handelsdok. No, it also points to how, with De Nieuwe Dokken, we are going to redefine the concept of 'ambitious building project'. We dare to look beyond tomorrow and want to actively think about the sustainable neighbourhood of the future.

This includes Het Stroompunt, a project which will ensure that De Nieuwe Dokken will use energy and heat very efficiently. De Nieuwe Dokken is also resolutely promoting the transport of tomorrow. The area, within walking distance of Gent-Dampoort and many bus stops, is already easily accessible by public transport. The infrastructure of De Nieuwe Dokken will focus on cyclists and pedestrians, making a large part of the site car-free. As mentioned earlier, the Bataviabrug already provides a good connection with Ghent city centre and a second bridge will soon be added.

The car parks at De Nieuwe Dokken have been developed so that they can change function over time - when fewer people will have cars. Residents are especially encouraged to opt for car-sharing, which is not only ecologically but also economically interesting.

Thanks to projects such as Het Stroompunt and the approach to mobility, De Nieuwe Dokken scores no less than 93.9 on the City of Ghent's sustainability meter, a principle inspired by the well-known BREEAM score.

Learning network energy sharing

To support the living lab in Genk, Flux50 set up a learning network on energy sharing. Energy sharing is considered a necessary step to accelerate the energy transition and help realize the rollout of PENs. While looking for technical solutions for the Genk living lab's business case, it turned out that there were still some stumbling blocks in the legislation in Flanders. Flux50 tries to overcome those hurdles. A learning network was set up where, during six half-day sessions, parties were brought together who have already tried to make energy sharing possible in different ways. Besides these early adopters, experts were invited who tried to clarify parts of the energy-sharing story and offered solutions to facilitate the roll-out. These experts included legislators (VEKA - Flemish Energy and Climate Agency), VREG (Flemish Regulator for Electricity and Gas), Fluvius (DSO), law firms and start-up advisers.

The first sessions have been completed and Flux50 will prepare a two-pager with lessons learnt and start-up advice. Together with VEKA and Fluvius, it will be decided how this info can be widely disseminated in the Flemish landscape.

Interviews with the other oPEN Lab Living Labs show that also in Estonia and Spain energy sharing is important in the PEN context and that in these countries, too, the rollout is not obvious due to difficulties with legislation.

5.7. Framework contracts

Basic principles

Framework contracts in the construction and energy sectors are long-term agreements established between a client (typically a public authority or a large organization) and one or more pre-selected contractors. These contracts set out the terms and conditions under which future construction or energy projects will be awarded and executed.

Here's how framework contracts generally work in both sectors:

Construction Sector:

- **Pre-qualification:** Contractors interested in participating in framework contracts must first go through a pre-qualification process. This involves demonstrating their technical capabilities, financial stability, and relevant experience to be eligible for consideration.
- **Selection:** After the pre-qualification stage, the client will select a group of qualified contractors to be included in the framework. The selected contractors become the framework contractors.
- **Specific Projects:** Once the framework is established, individual projects are then tendered or assigned to the contractors within the framework. Instead of going through a full procurement process for each project, the client can directly appoint one of the framework contractors based on predefined criteria and competitive pricing.
- **Flexibility:** Framework contracts provide flexibility to both the client and contractors as they can cover a wide range of projects and services over an extended period (usually several years). This streamlines the process of awarding contracts and facilitates collaboration between the parties.

Energy Sector:

In the energy sector, framework contracts work in a similar way, but they are specific to energy-related projects and services. This may include areas such as renewable energy development, energy efficiency projects, maintenance of energy infrastructure, or supply of energy products.

Benefits and pitfalls

Table 8: Benefits & pitfalls of framework contracts

Framework Contracts	
+	-
Reduced Bidding Costs	Lack of Competition
Stable Workload	Rigid Framework Terms
Efficiency	Exclusion of New Entrants
Streamlined Procurement	Potential for Overloading Contractors

Framework contracts in the construction and energy sectors come with their own set of benefits and pitfalls:

Benefits:

- Efficiency and Streamlined Procurement:
  - Clearly define the objectives and scope of the framework agreement. Both parties should have a shared understanding of the goals they want to achieve through collaboration.
  - Conduct the pre-qualification and selection process for framework contractors in a transparent and fair manner to promote competition and encourage the participation of qualified contractors.
- Reduced Bidding Costs
- Stable Workload

Pitfalls:

- Lack of Competition
  - Avoid any form of discrimination or exclusionary practices during the pre-qualification and selection process. The process should be open to all qualified contractors.
- Rigid Framework Terms:
  - Periodically review the framework agreement to assess its effectiveness and relevance. If needed, consider renewing or updating the agreement to adapt to changing circumstances.
  - Develop a comprehensive framework agreement that covers all essential aspects of the collaboration, including project scope, pricing, performance indicators, dispute resolution mechanisms, and other relevant terms and conditions.
  - Ensure that the framework agreement and project executions comply with all applicable laws, regulations, and industry standards.
- Exclusion of New Entrants:
- Potential for Overloading Contractors:
  - Be flexible in allocating projects or services among framework contractors based on their expertise, capacity, and performance. Ensure that payment terms are fair and reasonable, providing incentives for timely and quality project delivery.

The effectiveness of framework contracts largely depends on how well the agreement is designed, how the collaboration is managed, and whether the anticipated benefits outweigh the potential drawbacks in the specific context of the projects and parties involved.

When to use

Framework contracts are typically used in situations where there is a foreseeable need for a series of products, projects or services over an extended period. They offer a more efficient and streamlined approach to procurement and collaboration between clients and contractors. They are especially common in repetitive and complex projects or services, long-term partnerships, and emergency situations.

However, it's important to note that framework contracts may not be suitable for all situations. They work best when there is a clear understanding of the anticipated projects or services and a stable, long-term demand for them. For one-off projects or smaller-scale endeavours, conventional procurement methods might be more appropriate. Additionally, the success of framework contracts depends on a well-designed agreement and effective management throughout its duration.

The motivating factors for each party involved in a collaboration through framework contracts in the construction and energy sectors can vary based on their individual goals and interests.

Client (Public Authority or Large Organization):

- **Efficiency and Streamlined Procurement:** Framework contracts enable the client to streamline the procurement process. Instead of conducting individual procurements for each project, they can work with pre-qualified contractors, saving time and administrative resources.
- **Cost Savings:** Framework contracts can lead to cost savings for the client, as they may negotiate favourable pricing with framework contractors due to the volume and long-term commitment of work.
- **Quality Assurance:** By selecting reputable and qualified framework contractors, the client can ensure a certain level of quality and expertise in the execution of projects.
- **Flexibility and Responsiveness:** Framework contracts provide the client with the flexibility to adapt to changing project requirements or emergencies, as they have a pool of contractors ready to take on new projects.
- **Long-term Partnerships:** Framework contracts allow the client to establish long-term partnerships with reliable contractors, fostering collaboration and trust over time.

Framework Contractors:

- **Stable Workload:** Framework contracts offer a steady flow of projects and work for contractors, providing stability for their businesses.
- **Reduced Bidding Costs:** Participating in a framework agreement reduces the need for contractors to bid on individual projects, saving time and money on each tender.
- **Business Development Opportunities:** Framework contracts give contractors access to a broader range of projects and opportunities they might not have pursued individually.
- **Enhanced Credibility:** Being part of a framework agreement with a reputable client can enhance a contractor's credibility and reputation in the market.
- **Potential for Growth:** Successful execution of projects under the framework can lead to more opportunities and growth for the contractor's business.
- **Efficient Mobilization:** Since the contractors are pre-selected, they can mobilize quickly and start working on projects without significant delays.

The specific motivating factors can vary depending on the context, the individual goals of each party, and the terms negotiated within the framework agreement. It's essential for both parties to clearly communicate their expectations and objectives during the establishment of the collaboration to ensure a mutually beneficial partnership.

Applicable in public procurement environments?

Yes, framework contracts are commonly used in public procurement environments and are particularly prevalent in the public sector.

In public procurement, framework contracts are often used for various types of projects, such as construction, infrastructure development, energy-related initiatives, IT services, consultancy, and more.

It's essential to note that public procurement is subject to specific laws, regulations, and guidelines, depending on the country and jurisdiction. The use of framework contracts must comply with these legal requirements to ensure transparency, fairness, and accountability in the procurement process. Public entities must follow proper procedures for pre-qualification, evaluation, and contract award to uphold integrity in the procurement system and to achieve the intended benefits of using framework contracts.

6. Cooperation agreement and IP templates

6.1. Cooperation agreement templates

In this chapter a short list of available templates is provided. Unfortunately, until now, not many examples of these templates were to be found during our research on it.

Conventional workflow: client-contractor agreement

The (Dutch) document on the oPEN Lab website (Annex 1) is a template document provided by the Flemish building association Embuild and is widely used amongst contractors when the client is not supported by an architect. This document is an agreement between a contractor and a company (B2B-contract). There also exists an agreement with a private customer (B2C), but it is not included in this document.

Conventional workflow: subcontracting agreement

The (Dutch) document on the oPEN Lab website (Annex 2) is a template document provided by the Flemish building association Embuild and is widely used when services are delivered by subcontractors.

Construction teams as big next step

In the chapter about construction teams, section 4.3 is devoted to elements that need to be included in the cooperation agreement. A publicly available document was not found and parties that had already worked with such an agreement were not eager to share it publicly.

Innovative procurement process

The innovative procurement process in Flanders is a two-step agreement. The (Dutch) document on the oPEN Lab website (Annex 3) is the first step and is a selection guide with a subscription form for the interested contractor.

Flux 50 approach for VLAIO projects

Annex 4 on the oPEN Lab website is the standard collaboration agreement for Flux50-projects. It is adapted to companies and knowledge institutes but can easily serve for other parties as a standard agreement for innovative collaboration.

6.2. IP templates

Agreements of Intellectual property are typically integrated into the cooperation agreement. Some contractual articles cover these topics. Sometimes a separate document will be prepared.

The first 3 added annexes do not include specific IP agreements.

There are 2 paragraphs in the Flux50 document that deal specifically with confidential information (§6) and intellectual rights (§7). These sections from Annex 4 are specifically formatted for knowledge transfer between knowledge institutions and companies but can be freely adapted at will.

7. Supporting tools

Different collaboration frameworks can work more efficient if supported by specific IT tools or common standards, some of which are described here.

Also, some specific technical concepts like prefabrication of construction elements or prefabrication of energy boxes can have an influence on the needed partnership and collaboration framework. That's why they are described in short in this chapter.

7.1. BREEAM

It is important to understand the growing importance of sustainable practices and environmental responsibility in the built environment. With the rise of green building certifications, two prominent systems stand out: BREEAM (Building Research Establishment Environmental Assessment Method) in the UK and LEED (Leadership in Energy and Environmental Design) in the US. Since LEED is not commonly used in European countries, we focus on BREEAM.

Figure 12: BREEAM logo[32]

Basic principles

BREEAM stands for Building Research Establishment Environmental Assessment Method. It is a widely used sustainability assessment method and certification scheme for buildings, developed in the United Kingdom. BREEAM was first launched in 1990 by the Building Research Establishment (BRE), an independent research organization.

The purpose of BREEAM is to evaluate and quantify the environmental performance of buildings based on various sustainability criteria. It assesses a building's impact on the environment across a range of categories, including energy usage, water consumption, waste management, materials selection, pollution, and ecological impact. It also considers factors like indoor environmental quality (IEQ) and innovation.

BREEAM uses a scoring system to rate buildings on their environmental performance. The assessment is carried out by trained assessors who evaluate the building's design, construction, and operation plans, as well as its actual performance after completion. Based on the assessment, the building can be awarded a BREEAM rating, ranging from "Pass" to higher levels like "Good," "Very Good," "Excellent," or even "Outstanding."

BREEAM is not limited to specific building types and can be applied to a wide range of developments, including new constructions, refurbishments, and large-scale infrastructure projects. The certification helps developers, building owners, and occupants demonstrate their commitment to sustainability and environmental responsibility. It also encourages best

[32] https://commons.wikimedia.org/wiki/File:BREEAM_logo.svg

practices in the construction and operation of buildings to reduce their impact on the environment and promote more sustainable living and working spaces.

Pros and cons

Table 9: Pros and cons of BREEAM

BREEAM	
+	-
Sustainability and Environmental Benefits	Cost and Time
Recognition and Marketing	Subjective Scoring
Improved Indoor Environment	Limited Scope
Regulatory Compliance	Complexity
Long-Term Cost Savings	Regional Adaptation
	Performance vs. design

Pros of BREEAM:

1. **Sustainability and Environmental Benefits:** BREEAM encourages and promotes sustainable building practices, leading to reduced environmental impact, lower energy consumption, water conservation, and better waste management. This can contribute to an eco-friendlier and resource-efficient built environment.
2. **Recognition and Marketing:** Achieving a higher BREEAM rating provides recognition and marketing opportunities for developers, building owners, and occupants. It demonstrates their commitment to sustainability, which can be appealing to environmentally conscious tenants, investors, and customers.
3. **Improved Indoor Environment:** BREEAM considers indoor environmental quality factors, such as air quality (IAQ), thermal comfort, and lighting, which can enhance the well-being and productivity of building occupants.
4. **Regulatory Compliance:** In some regions, BREEAM compliance might be a requirement to obtain planning permissions or meet certain environmental regulations, making it essential for developers to adhere to sustainable building practices.
5. **Long-Term Cost Savings:** While achieving higher BREEAM ratings might involve initial investment, sustainable buildings often have lower operating costs over their lifecycle due to reduced energy and water consumption.

Cons of BREEAM:

1. **Cost and Time:** The process of obtaining a BREEAM certification can be time-consuming and expensive, especially for complex projects. The assessment and certification fees, as well as potential design modifications, can add to the overall project costs.
2. **Subjective Scoring:** The BREEAM assessment involves subjective judgment by assessors, which may lead to inconsistencies in ratings and interpretations of criteria.
3. **Limited Scope:** BREEAM primarily focuses on the environmental impact of a building and may not comprehensively address other aspects, such as social and economic sustainability.
4. **Complexity:** The BREEAM assessment methodology can be intricate and challenging to understand for some stakeholders, particularly smaller developers or those new to sustainable construction practices.
5. **Regional Adaptation:** BREEAM was developed in the UK, and while it has been adapted for use in other countries, certain criteria might not fully align with specific local regulations and climatic conditions.

6. **Performance vs. Design:** BREEAM initially assesses buildings based on their design and plans, which may differ from the actual performance once the building is in operation. Actual performance might not always align with the design intentions.

In summary, BREEAM offers several benefits in promoting sustainability and environmental responsibility in the built environment. However, it also comes with some challenges, including cost implications, subjective assessments, and potential limitations in addressing all aspects of sustainability. Developers and stakeholders need to carefully consider these factors before pursuing BREEAM certification for their projects.

Support of PEN/PED-setup

BREEAM can support the setup of positive energy neighbourhoods by providing a comprehensive framework to assess and guide sustainable building practices at both the individual building and district levels. Positive energy districts aim to generate more energy from renewable sources than they consume, resulting in a net surplus of energy that can be distributed to other parts of the district or back to the grid. Here's how BREEAM can facilitate the establishment of such districts:

1. **Energy Efficiency:** BREEAM places a strong emphasis on energy efficiency in buildings. It encourages the adoption of energy-efficient technologies, design strategies, and renewable energy systems, which are crucial for creating low-energy and energy-positive buildings within the district.
2. **Renewable Energy:** The assessment methodology of BREEAM includes credits for using renewable energy sources such as solar, wind, and biomass. By promoting the integration of renewable energy technologies, BREEAM can contribute to the generation of clean energy within the district.
3. **District-Wide Assessments**: While BREEAM initially focuses on individual buildings, it also allows for district-wide assessments. This enables planners and developers to evaluate the collective environmental performance of multiple buildings and infrastructure within the district, facilitating the identification of opportunities for energy sharing and optimization.
4. **Collaboration and Coordination:** BREEAM encourages collaboration and coordination among various stakeholders, including developers, local authorities, energy providers, and communities. This fosters a holistic approach to planning and designing the district, ensuring that energy generation, distribution, and consumption strategies align to achieve a positive energy balance.
5. **Infrastructure Planning**: BREEAM addresses key elements of infrastructure planning, such as transportation, waste management, and water supply. Properly planned and integrated infrastructure can support the creation of a sustainable district with reduced energy demands and efficient resource management.
6. **Post-Occupancy Evaluation:** BREEAM includes post-occupancy evaluations to assess the actual performance of buildings over time. This ongoing monitoring can help identify opportunities for improvement, optimize energy use, and address any discrepancies between predicted and actual energy performance within the district.
7. **Innovation Credits**: BREEAM offers innovation credits for projects that demonstrate innovative strategies or technologies that contribute to sustainable development. This incentivizes the exploration and implementation of cutting-edge solutions, which can be valuable for creating positive energy districts.

By utilizing the BREEAM framework, planners, developers, and local authorities can assess, plan, and implement sustainable building practices that align with the principles of positive energy districts. It promotes the integration of renewable energy, efficient building design, and collaborative efforts, ultimately contributing to the establishment of energy-efficient and environmentally friendly districts.

7.2. BIM

Basic principles

BIM, which stands for Building Information Modelling, is a digital process that involves creating and managing a 3D model of a building or infrastructure project. It allows all stakeholders, including architects, engineers, contractors, and owners, to collaborate and share information throughout the project's lifecycle.

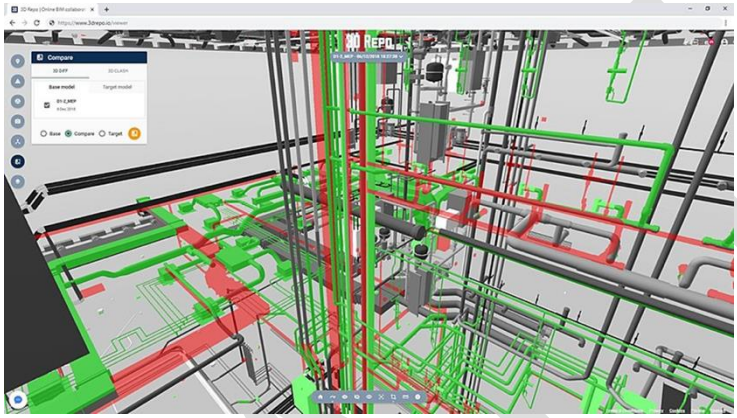

Figure 13: Screenshot example of Building Information Modelling (BIM)[33]

The basic principles of BIM include:

1. **Centralized Information**: BIM centralizes all project information in a shared digital model. This includes geometric data, construction details, materials, quantities, costs, schedules, and other relevant data. Having a single source of truth helps prevent discrepancies and improves communication among team members.
2. **Collaboration and Coordination**: BIM encourages collaboration and coordination among all project participants. Various disciplines can work together in real-time, reducing conflicts and potential errors. This integrated approach fosters better decision-making and a more efficient construction process.
3. **3D Visualization**: BIM emphasizes 3D visualization, enabling stakeholders to better understand the project's design and construction processes. This visual representation helps identify potential issues early on and enhances communication.
4. **Data-Rich Elements:** BIM elements carry extensive data attributes, providing information beyond just their geometry. For instance, a wall object in the BIM model can have data on its material, fire rating, insulation properties, supplier, and cost.
5. **Parametric Modelling**: BIM employs parametric, where elements in the model are defined by parameters and relationships with other elements. This approach allows for efficient design changes, as modifications to one element can automatically update related elements.
6. **Change Management**: BIM facilitates change management throughout the project lifecycle. As revisions occur, the model is updated, ensuring all stakeholders have access to the latest information.
7. **Clash Detection**: BIM software includes clash detection capabilities, which automatically identify clashes or conflicts between different building systems or components. This helps avoid clashes during construction, reducing costly rework.

[33] https://commons.wikimedia.org/wiki/File:3D-Diff.jpg

8. **Data-Driven Decision Making**: BIM enables data-driven decision-making throughout the project. With access to real-time data, project participants can make informed choices about design alternatives, construction methods, and resource allocation.
9. **Facility Management and Maintenance**: BIM's benefits extend beyond the construction phase. The data-rich BIM model becomes a valuable asset for facility management and maintenance, aiding operations throughout the building's life cycle.
10. **Standardization and Open BIM**: BIM relies on standardized processes and data formats to ensure interoperability among various software applications and disciplines. The concept of "Open BIM" promotes the use of open standards, allowing different software tools to exchange information seamlessly.

By adhering to these principles, BIM enhances collaboration, reduces errors, and improves overall project efficiency from conception to the operational phase of the building.

Pros and cons

Table 10: Pros and cons of BIM

BIM	
+	-
Improved Collaboration	Initial Investment
Error Reduction	Learning Curve
Efficient Project Management	Software Compatibility Issues
Interoperability	Data Management Challenges
Enhanced Decision-making	Intellectual Property Concerns

BIM (Building Information Modelling) offers several advantages and has some limitations. Here's a list of the pros and cons of using BIM in construction and design projects:

Pros of BIM:

1. **Improved Collaboration**: BIM encourages better collaboration among project stakeholders, including architects, engineers, contractors, and owners. Information sharing in a centralized model fosters efficient communication and coordination, reducing conflicts and misunderstandings.
2. **Error Reduction**: With clash detection and 3D visualization capabilities, BIM helps identify potential clashes and design errors early in the project. This leads to fewer costly mistakes during construction and improves project outcomes.
3. **Enhanced Decision-making**: BIM provides real-time data and simulations that aid in informed decision-making. It allows project participants to evaluate design alternatives, assess cost implications, and make data-driven choices.
4. **Efficient Project Management**: BIM enables better project management through accurate scheduling, resource allocation, and construction sequencing. It streamlines processes, leading to improved project timelines and cost control.
5. **Facility Management and Maintenance**: Beyond the construction phase, BIM data remains valuable for facility management and maintenance. Building owners can access crucial information, such as maintenance schedules, component specifications, and energy usage data.
6. **Sustainable Design**: BIM supports sustainable design practices by facilitating energy analysis, material selection, and environmental impact assessments during the planning and design phases.

7. **Life Cycle Costing**: BIM's data-rich model allows for life cycle cost analysis, helping owners make cost-effective decisions by considering long-term operational expenses.
8. **Interoperability**: Many BIM software platforms support open standards, ensuring compatibility and interoperability between different software tools. This allows teams to work seamlessly across various disciplines and software applications.

Cons of BIM:

1. **Initial Investment:** Implementing BIM requires an initial investment in software, hardware, and staff training. Smaller firms may find it challenging to allocate resources for the transition.
2. **Learning Curve**: Learning to use BIM software proficiently may take time, especially for those new to the technology. This learning curve could slow down project initiation in the early stages.
3. **Software Compatibility Issues**: Although open BIM standards aim to address interoperability, issues can still arise when exchanging data between different software platforms.
4. **Data Management Challenges**: Handling large amounts of data in a BIM project can be complex, especially on large-scale projects. Proper data management protocols are necessary to avoid confusion or data loss.
5. **Dependency on Technology**: BIM relies heavily on technology, and any technical issues, such as software glitches or hardware failures, can disrupt workflows and cause delays.
6. **Lack of BIM Adoption**: Despite its advantages, some regions or stakeholders may not fully adopt BIM, leading to challenges in sharing and collaborating with non-BIM participants.
7. **Intellectual Property (IP) Concerns**: Sharing detailed BIM models could raise concerns about intellectual property rights, as certain design elements and innovations may be vulnerable to unauthorized use or replication.

Despite the challenges, the benefits of BIM have led to its increasing adoption in the construction industry, as it significantly improves project efficiency and collaboration while reducing costs and errors.

Support of PEN/PED-setup

Building Information Modelling (BIM) can play a crucial role in supporting the setup of positive energy districts (PEDs). BIM can aid in the planning, design, and management of such districts by offering the following support:

1. **Energy Analysis and Simulation**: BIM tools can integrate energy analysis and simulation capabilities, allowing designers to assess the energy performance of buildings within the district. This analysis helps optimize the placement of buildings, orientation, and renewable energy systems to maximize energy generation potential.
2. **Solar Potential Assessment**: BIM can analyse the solar potential of rooftops and facades within the district. This information aids in identifying suitable locations for solar panels, solar thermal systems, and other renewable energy installations.
3. **Renewable Energy Integration**: BIM facilitates the integration of renewable energy systems, such as solar panels, wind turbines, and geothermal systems, into the district's infrastructure. It enables accurate placement, sizing, and connection of these systems to the buildings and the grid.
4. **Energy-Efficient Building Design**: BIM supports the design of energy-efficient buildings with optimized insulation, ventilation, lighting, and heating/cooling systems. It allows for the simulation of various design alternatives to identify the most energy-efficient solutions.
5. **Whole-District Energy Simulation**: BIM enables the simulation of the entire district's energy consumption and generation. This holistic approach allows planners to evaluate the energy balance and identify potential surplus energy that can be fed back into the grid.

6. **Life Cycle Assessment**: BIM's data-rich model allows for life cycle assessments of buildings and infrastructure within the district. By considering the embodied energy of materials and the operational energy use over the building's life, planners can make sustainable choices.
7. **Infrastructure Coordination**: BIM enhances coordination between various infrastructure components, such as district heating and cooling networks, electric vehicle charging stations, and smart grid systems. This coordination ensures an efficient and integrated energy distribution system.
8. **Smart Energy Management**: BIM can integrate with smart energy management systems to monitor and control energy consumption and generation within the district. Real-time data from BIM models helps optimize energy use and respond to fluctuations in demand and supply.
9. **Facility Management for Efficiency**: Beyond the construction phase, BIM supports facility management in PENs. Building operators can utilize BIM data to optimize energy use, track performance, and implement energy-saving measures.
10. **Communication and Stakeholder Engagement**: BIM's visualizations and simulations facilitate effective communication with stakeholders, including residents, developers, and policymakers. Clear presentations of the district's sustainable features help garner support and ensure collaboration.

By leveraging BIM's capabilities, planners and designers can create well-integrated positive energy districts that optimize renewable energy use, reduce environmental impact, and foster sustainable urban development.

7.3. Prefab(rication)

Prefab, short for "prefabrication," is a construction technique that involves assembling building components or modules off-site in a controlled factory environment and then transporting them to the construction site for final assembly. This method offers several advantages, including increased efficiency, reduced construction time, and improved quality control.

Figure 14: Example picture of prefabrication[34]

Basic principles

The basic principles of prefab in construction include:

1. **Component Standardization**: Prefab relies on the standardization of building components and modules. This means that the elements are manufactured in consistent sizes, shapes, and specifications, allowing for easy assembly and interchangeability on-site.
2. **Factory-Based Construction**: Prefabricated components are fabricated in a factory or manufacturing facility, away from the actual construction site. This controlled environment ensures

[34] https://commons.wikimedia.org/wiki/File:Manufactured_Home_Side_walls_are_built_and_attached.jpg

that construction is not affected by weather conditions, and quality control can be closely monitored.

3. **Efficient Mass Production**: Prefab allows for mass production of standardized building elements. This efficiency often leads to cost savings as the assembly line approach streamlines production processes.
4. **Interlocking and Joining Methods**: Prefabricated components are designed to fit together seamlessly using interlocking and joining methods. This ensures that the different modules can be easily connected and secured on-site, reducing the need for complex on-site construction work.
5. **Integration of Services**: Services such as electrical wiring, plumbing, and HVAC (heating, ventilation, and air conditioning) are often integrated into prefabricated components during the factory construction stage. This simplifies the installation process on-site.
6. **Design for Manufacturability**: The design of prefabricated elements is optimized for manufacturability. This means that architects and engineers work closely with manufacturers to create designs that are practical for assembly-line production while maintaining aesthetic and functional requirements.
7. **Site Efficiency**: Prefab construction often requires fewer workers on-site, reducing congestion and improving safety during construction. The assembly process is typically faster than conventional construction methods, minimizing disruption to the surrounding area.

Overall, the basic principles of prefab in construction aim to streamline the building process, increase efficiency, and maintain consistent quality while offering potential cost and environmental benefits.

Pros and cons

Table 11: Pros and cons of prefab

Prefab(rication)	
+	-
Speed of Construction	Transportation Challenges
Quality Control	Limited Customization
Cost Efficiency	Upfront Investment
Design Flexibility	Design and Planning Complexity
Reduced Site Disruption	Aesthetics and Stigma

Prefab construction, like any construction method, has its share of advantages (pros) and disadvantages (cons). Let's explore them:

Pros of Prefab Construction:

1. **Speed of Construction**: Prefabricated components are manufactured simultaneously while site preparation occurs, enabling faster construction compared to conventional methods. This can lead to significant time savings, allowing projects to be completed more quickly.
2. **Quality Control**: Prefab components are manufactured in a controlled environment with strict quality control measures. This reduces the likelihood of errors and ensures that each element meets high-quality standards.
3. **Cost Efficiency**: Although upfront costs for prefabrication may be higher due to factory setup and transportation, the overall construction process can be more cost-effective. Time savings,

reduced labour requirements, and less material waste contribute to potential long-term cost benefits.

4. **Design Flexibility**: Prefab construction is not limited to simple designs. Advances in technology have expanded the possibilities, enabling architects to create complex and innovative structures using prefabricated components.
5. **Environmental Benefits**: Prefabrication can reduce construction waste and minimize the environmental impact by optimizing material usage during manufacturing and assembly. Additionally, factory-controlled conditions may lead to better energy efficiency.
6. **Consistency:** Prefabricated components are manufactured according to strict standards, ensuring uniformity and consistency across the project. This can result in a more aesthetically pleasing and cohesive end product.
7. **Reduced Site Disruption**: The assembly of prefab components generates less noise, dust, and traffic on-site compared to conventional construction, minimizing disruption to the surrounding area and neighbouring properties.

Cons of Prefab Construction:

1. **Transportation Challenges**: Moving large, prefabricated modules to the construction site requires careful planning and coordination. Transportation costs can also be significant, especially for projects in remote or inaccessible locations.
2. **Limited Customization**: While prefab offers design flexibility, it may not be as customizable as conventional construction. The standardization of components could restrict certain design features, making it less suitable for highly unique or custom projects.
3. **Upfront Investment:** Setting up a factory for prefab construction involves substantial initial investment. Smaller projects may not benefit as much from prefab due to the overhead costs.
4. **Design and Planning Complexity**: Integrating various prefabricated components necessitates meticulous planning and coordination among architects, engineers, and manufacturers. Ensuring that all elements fit seamlessly together can be challenging.
5. **Permits and Regulations**: Some regions might have specific regulations or building codes that can affect the feasibility of prefab construction. It's crucial to ensure compliance with local requirements before proceeding with a prefab project.
6. **Limited On-Site Alterations**: Prefabricated components are designed and manufactured off-site, limiting the ability to make on-site changes or adjustments once the modules arrive at the construction site.
7. **Aesthetics and Stigma**: Prefab construction, historically associated with low-cost housing, may carry a stigma that affects perceptions of quality and prestige. However, this perception is changing as modern prefab techniques produce high-quality structures.

Ultimately, the decision to use prefab construction depends on the specific needs and requirements of each project. Many construction projects today are hybrids, incorporating both prefab and conventional construction methods to leverage the benefits of both approaches.

Support of PEN/PED-setup

Prefab construction can play a significant role in supporting the setup of positive energy districts. Here are some ways prefab can contribute to the creation and success of positive energy districts:

1. **Energy-Efficient Design**: Prefabrication allows for precise design and manufacturing of building components, enabling energy-efficient features to be integrated seamlessly. This can include high-performance insulation, energy-efficient windows, and advanced HVAC systems, which collectively reduce energy consumption in buildings.
2. **Renewable Energy Integration**: Prefab buildings can be designed with renewable energy technologies, such as solar panels, wind turbines, and geothermal systems. These energy

sources can be incorporated into the construction process more efficiently, maximizing their contribution to the district's energy production.

3. **Standardization for Smart Grid Integration**: Prefab construction often involves standardization of components. This makes it easier to integrate buildings into a smart grid, enabling better management of energy production, consumption, and distribution within the district.
4. **District-Level Planning**: Prefabrication facilitates modular construction, which can be well-suited for districts designed with a coordinated approach. Standardized components and designs ensure uniformity, aesthetics, and performance across buildings, contributing to the overall energy efficiency of the district.
5. **Rapid Deployment**: Prefabrication allows for faster construction, meaning positive energy districts can be developed and operational more quickly, accelerating the transition to sustainable urban areas.
6. **Retrofitting Existing Buildings**: Prefab elements can be utilized to retrofit existing buildings, transforming them into energy-efficient structures within the district. This approach helps in upgrading older buildings without the need for extensive demolition and reconstruction.
7. **Energy Storage Solutions**: Prefabrication can also include the integration of energy storage solutions, such as batteries or thermal storage systems. These technologies help store excess energy generated during peak times for use during low-demand periods, balancing energy production and consumption in the district.
8. **Reduced Construction Waste**: Prefabrication minimizes construction waste, making the construction process more sustainable. This aligns with the overall goal of creating positive energy districts that prioritize environmental responsibility.
9. **Innovative Technologies**: Prefab construction allows for the incorporation of cutting-edge technologies and materials that can enhance the energy efficiency of buildings. For instance, lightweight and insulating materials can improve thermal performance, while smart sensors and controls can optimize energy use.
10. **Demonstrating Scalability**: Successful implementation of prefab construction in a positive energy district can serve as a model for other urban developments, demonstrating the scalability of the approach and encouraging wider adoption of sustainable building practices.

By combining prefab construction with sustainable design principles, renewable energy solutions, and smart technologies, positive energy districts can become a reality. These districts not only contribute to global sustainability goals but also offer residents healthier and more environmentally conscious places to live and work.

7.4. Energy box approach

The term "prefabricated external energy unit" is not a standard or widely used term in the field of energy systems or engineering. It is a new concept that has been used in recent years in the Netherlands and Belgium during renovation projects of social houses.

Basic principles

The idea is that all energy related components are build inside a prefabricated energy box, for example a container of L*W*H 1.5*1*2m. Components mean: solar inverter, heat pump, hot water boiler, ventilation unit, home battery, smart controllers, … That module is positioned near a wall of the house and only the pipes and wires need to be connected between the module and the house (water, hot water, heating and retour channel, ventilation channel, PV DC wires, power wires, sensors). The goal is to avoid a lot of complicated installation works on-site and

so reducing costs. Recent developments on this concept include an esthetical integration into or on the house.

Figure 15: Example pictures of prefabricated energy boxes[35]

Some general principles that are often associated with prefabricated energy systems or units are mentioned here:

1. **Modularity**: Prefabricated energy units are designed to be modular, which means they can be easily assembled, disassembled, or connected to other units. This modularity allows for scalability and flexibility in meeting different energy needs.
2. **Plug-and-Play Installation**: These units are typically designed for easy installation and integration with existing energy infrastructure. They may come pre-wired and pre-configured, simplifying the installation process.
3. **Energy Generation or Storage**: Prefabricated external energy units might be designed for energy generation, such as solar panels, or for energy storage, like battery banks or energy storage systems.
4. **Portability**: Depending on the specific application, some prefabricated energy units may be portable and easily relocated to different sites as needed.
5. **Monitoring and Control**: These units may come equipped with monitoring and control systems that allow for remote management and optimization of energy production or storage.
6. **Sustainability and Efficiency**: Many prefabricated energy units are designed with an emphasis on sustainability and energy efficiency, using renewable energy sources or advanced technologies to minimize environmental impact.

Pros and cons

Table 12: Pros and cons of energy box approach

Energy Box Approach	
+	-
Easy assembly/disassembly	Transport
Portability	Dependency
Cost	
Time	
Integration	

The concept of an "energy box" has several pros and cons. Here are some advantages:

[35] https://lito.be/en/products

1. **Easy assembly/disassembly**: Energy boxes which are prefabricated off-site can easily be assembled on the construction site. They are usually connected to a built-in interconnection block that has all the connections waiting for them to be techniques in the box. The connections are made reversible in case the box should be replaced or disassembled in total.
2. **Portability:** Energy boxes are typically designed in transportable sizes, to be hand-lifted or crane-lifted.
3. **Cost**: in general, energy boxes are less expensive than a conventional setup. The on-site installation time is reduced by a factor 10 to 20, depending on the amount and complexity of the techniques.
4. **Time**: Since the energy boxes are built in an industrial and potentially automated context, the construction time is reduced. As mentioned above, also the on-site time is heavily reduced.
5. **Integration**: The energy box is designed as an integrated system of qualitative component who are aligned to be working together with a smart controller (Building Management System) on top.

The main disadvantages are:

1. **Transport**: Instead of arriving on the construction site with numerous assembly parts, the energy box comes in one piece. This means that the weight and size of the box is a design component to be addressed. In almost any cases, the box can be installed by manpower. Otherwise, lifting eyes can be provided for the on-site construction crane.
2. **Dependency**: The installation of the energy box can be done quickly on site, but the proper functioning of the installation depends on the correctness of execution of the installation done beforehand in the building.

Support of PEN/PED-setup

The concept of an "energy box" can play a crucial role in supporting the setup of positive energy districts. Here's how the energy box concept can contribute to the creation and success of positive energy districts:

1. **Localized Energy Generation**: Energy boxes can incorporate various renewable energy technologies, such as solar PV panels and solar thermal systems. By installing these energy generation sources within the district, it enables localized and sustainable energy production.
2. **Flexibility and Modularity**: Energy boxes are typically designed to be modular, scalable, and easily deployable. This flexibility allows for a customizable setup tailored to the specific needs and energy demands of the district. As the district grows or its energy requirements change, additional energy boxes can be added or modified.
3. **Integration with Smart Grids**: Energy boxes can be designed to integrate with smart grid systems. Smart grids enable efficient management and distribution of energy, ensuring that excess energy produced in the district can be shared with neighbouring areas or stored for future use.
4. **Energy Storage Solutions**: Positive energy districts often require energy storage solutions to balance supply and demand, especially during periods of low energy generation or high demand. Energy boxes can incorporate battery storage or other storage technologies to store surplus energy for later use.
5. **Decentralization of Energy Production**: By deploying energy boxes throughout the district, energy production is decentralized, reducing the need for long-distance energy transmission. This reduces transmission losses and improves the overall energy efficiency of the district.
6. **District Energy Management**: The concept of an energy box can include sophisticated energy management systems that monitor and control energy production, consumption, and

storage within the district. This level of control allows for optimal energy usage and efficient operation of the positive energy district.

7. **Sustainable and Low-Carbon Solutions**: Positive energy districts aim to minimize carbon emissions and promote sustainable practices. Energy boxes that utilize renewable energy sources align with these goals, making them an ideal component of such districts.
8. **Community Engagement**: The implementation of energy boxes can involve the local community, promoting awareness and participation in sustainable energy initiatives. Residents and businesses can be encouraged to adopt energy-efficient practices and make use of the district's renewable energy resources.
9. **Resilience and Reliability**: Positive energy districts with energy boxes are more resilient and reliable in the face of energy disruptions. Local energy generation and storage reduce dependence on centralized energy systems and increase the district's ability to withstand power outages.

Overall, the concept of an energy box provides a versatile and adaptable solution to support the establishment of positive energy districts. It empowers communities to take control of their energy needs, promote sustainability, and pave the way for a cleaner, greener, and more resilient future.

7.5. 3D-scanning and drone scanning

3D-scanning and drone-scanning are two related technologies used to capture three-dimensional information about real-world objects and environments.

These systems are typically used to create 3D models of existing buildings, before they are renovated or integrated into a larger PEN. The measurements are input for the design of the renovation and also for the execution (like parameterised prefab modules).

Basic principles

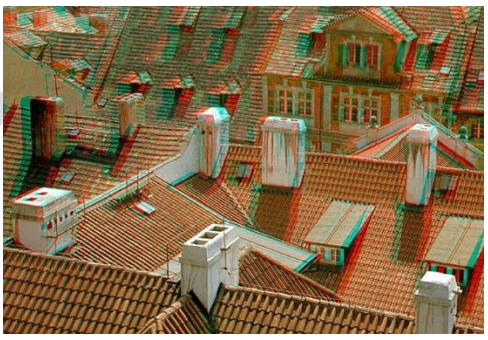

Figure 16: Example picture of 3D scanner[36]

Figure 17: Example picture of 3D scanned rooftop[37]

3D scanning is the process of capturing the shape, size, and texture of physical objects to create digital 3D models. There are various methods of 3D scanning, but the underlying principle generally involves the following steps:

[36] https://commons.wikimedia.org/wiki/File:Lidar_P1270901.jpg
[37] https://commons.wikimedia.org/wiki/File:Old_Prague_roofs_anaglyph.jpg

- **Data Acquisition**: 3D scanners use lasers, structured light, or other sensor technologies to measure the distance between the scanner and the object's surface. They emit signals (such as laser beams) and measure the time it takes for the signals to bounce back to the sensor.
- **Triangulation**: In many 3D scanning methods, triangulation is used to determine the object's shape and location. By measuring the angles and distances between the scanner and different points on the object's surface, the scanner creates a point cloud.
- **Point Cloud Generation**: The collected data from multiple measurements form a point cloud, which is a set of 3D coordinates representing the object's surface.
- **Mesh Generation**: The point cloud is then used to create a mesh, which is a network of connected triangles that define the object's surface more accurately.
- **Texture Mapping** (optional): In some cases, a 3D scanner can also capture colour and texture information of the object's surface to create realistic 3D models.

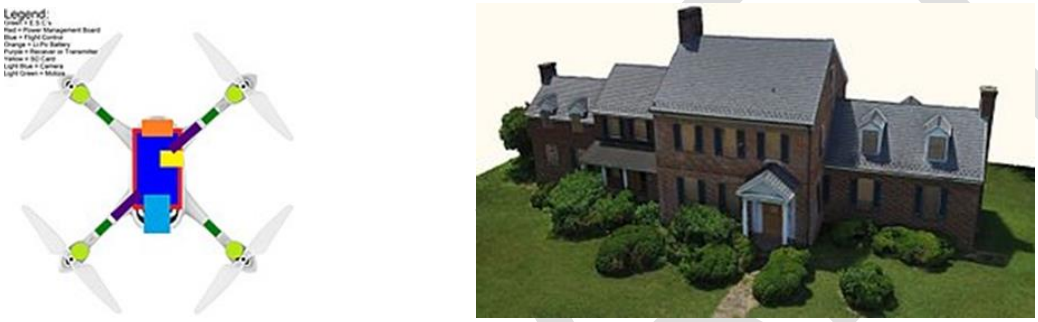

Figure 18: Example pictures of drone scanning (LiDAR)[38] [39]

Drone scanning **(also known as LiDAR drone scanning or aerial scanning)** involves the use of drones equipped with LiDAR (Light Detection and Ranging) sensors or photogrammetry cameras to capture 3D data of large areas, terrains, buildings, or other objects from above. The key principles of drone scanning include:

- **LiDAR Technology**: Drones equipped with LiDAR sensors emit laser pulses towards the ground while flying. The laser pulses bounce back when they hit the objects or the ground below, and the sensor measures the time it takes for the light to return. This data helps create a 3D representation of the terrain and objects.
- **Photogrammetry**: Instead of LiDAR, some drones use photogrammetry techniques. They carry high-resolution cameras that capture multiple overlapping images of the area of interest. Software then processes these images to create a 3D model by identifying common features and matching points between images.
- **GPS and IMU Integration**: Drones use GPS (Global Positioning System) and IMU (Inertial Measurement Unit) sensors to precisely track their position, altitude, and orientation during flight. This data is crucial for accurately geolocating the 3D information captured by the drone.
- **Data Processing**: The collected LiDAR point cloud or photogrammetry images are processed using specialized software to create detailed 3D models and maps of the surveyed area.

[38] https://commons.wikimedia.org/wiki/File:Drone_Diagram.jpg

[39] https://commons.wikimedia.org/w/index.php?search=drone+scanning&title=Special:MediaSearch&go=Go&type=image

Drone scanning is valuable for applications such as land surveying, construction planning, environmental monitoring, archaeology, and disaster response, as it allows for the efficient and precise capture of large-scale 3D data from above.

Pros and Cons

Table 13: Pros and cons of 3D-scanning

3D-Scanning	
+	-
Accurate Representation	Cost
Timesaving	Data Processing
Non-Destructive	Limited Material Compatibility
Replication and Reverse Engineering	Size and Mobility
Visualization	

Pros of 3D Scanning:

1. **Accurate Representation**: 3D scanning provides highly accurate and detailed representations of real-world objects and environments, allowing for precise measurements and analysis.
2. **Timesaving**: Compared to manual measurements or traditional surveying methods, 3D scanning can significantly reduce data collection time, making it more efficient for various applications.
3. **Non-Destructive**: 3D scanning is a non-destructive technique, meaning it doesn't damage the scanned object during the process, making it suitable for delicate or valuable items.
4. **Replication and Reverse Engineering**: 3D scanning allows for easy replication or reverse engineering of physical objects, which is valuable in fields like manufacturing and product design.
5. **Visualization**: The generated 3D models can be visualized from different angles and manipulated digitally, enabling better understanding and communication of complex structures.

Cons of 3D Scanning:

1. **Cost**: High-quality 3D scanners can be expensive, making the initial investment a barrier for some individuals or smaller businesses.
2. **Data Processing**: Processing large point clouds or meshes generated by 3D scanning can be computationally intensive and time-consuming.
3. **Limited Material Compatibility**: Some materials, particularly those that are highly reflective or transparent, can be challenging to scan accurately.
4. **Size and Mobility**: Conventional 3D scanners can be bulky and require a stable setup, limiting their use in certain environments or for scanning larger objects.

Table 14: Pros and cons of drone scanning

Drone-Scanning	
+	-
Large-Scale Data Collection	Cost and Complexity
Accessibility	Weather Dependency
Rapid Data Acquisition	Regulations
Multi-Purpose	Data Accuracy
	Limited Indoor Application

Cons of Drone Scanning:

1. **Cost and Complexity**: High-quality drones and LiDAR/photogrammetry equipment can be costly, and the technology requires skilled operators and data processing specialists.
2. **Weather Dependency**: Adverse weather conditions, such as strong winds or rain, can affect the drone's flight and data accuracy.
3. **Regulations**: Drone operations are subject to various regulations and restrictions, which can vary by region, limiting their use in some areas.
4. **Data Accuracy**: While drone scanning is generally accurate, the data quality may vary depending on factors such as sensor specifications, flight parameters, and ground control measures.
5. **Limited Indoor Application**: Drones are primarily designed for outdoor use, making indoor scanning, or inspecting confined spaces challenging.

In summary, both 3D scanning and drone scanning offer powerful capabilities for capturing 3D data, but each has its specific advantages and limitations. The choice between them depends on the specific application, budget, desired accuracy, and the environment in which the scanning will take place.

Support for the PEN/PED-setup

Both 3D scanning and drone scanning play crucial roles in supporting the setup of positive energy districts by providing valuable data and insights for planning, design, and monitoring. Here's how these scanning techniques can contribute to achieving this goal:

1. **Data Collection for Sustainable Design:** Both 3D scanning and drone scanning can capture detailed data of existing urban areas, buildings, and infrastructure. This data can be used to create accurate 3D models and maps, providing a solid foundation for sustainable design and planning.
2. **Building Energy Performance Analysis:** 3D scanning can be employed to assess the energy performance of buildings in the district. By scanning existing buildings and generating 3D models, architects and engineers can conduct simulations and energy modelling to optimize building design and identify areas for energy efficiency improvements.
3. **Solar Potential Assessment:** Drones equipped with LiDAR or photogrammetry cameras can be used to assess the solar potential of rooftops and facades in the district. This information helps identify optimal locations for solar panel installations to maximize energy generation from renewable sources.
4. **Urban Heat Island Analysis:** 3D scanning and drone scanning can provide data for analysing urban heat islands, which are localized areas with higher temperatures compared to their surroundings. Understanding these heat islands helps in designing urban spaces that mitigate heat, such as incorporating green spaces and cool roofs.

5. **Infrastructure and Utility Planning:** The data collected through scanning techniques can assist in planning and optimizing the layout of infrastructure, such as roads, public transportation, and utilities, to minimize energy consumption and maximize efficiency.
6. **Environmental Impact Assessment:** Drone scanning can be used to monitor changes in the environment during the construction and operation phases of the positive energy district. By regularly scanning and comparing the data, stakeholders can ensure that the project aligns with sustainability goals and minimizes adverse environmental impacts.
7. **Monitoring and Maintenance:** After the setup of the positive energy district, 3D scanning, and drone scanning continue to be valuable tools for ongoing monitoring and maintenance. Drones equipped with sensors can inspect solar panels, wind turbines, and other renewable energy installations to detect issues early and ensure optimal performance.
8. **Community Engagement and Visualization:** 3D models and visualizations created from scanning data can aid in community engagement and stakeholder discussions. Showing residents and decision-makers realistic representations of the planned district can facilitate understanding and support for sustainable initiatives.

By leveraging 3D scanning and drone scanning technologies, planners, architects, and engineers can gather precise data, analyse energy use patterns, optimize design decisions, and ensure the effective implementation and long-term success of positive energy districts. These scanning techniques contribute to sustainable urban development, energy efficiency, and the transition towards renewable energy sources.

8. oPEN Lab Cases

Th oPENlab project features 3 Living Labs, where the concept of PENs (Positive Energy Neighbourhoods) is tested in practice, in the context of renovation of a group of buildings. Elements of different collaboration models will also be tested, especially in the earlier phases of those projects. A short presentation of these living labs and selected collaboration models can be found in this section.

8.1. oPEN Living Lab Genk

Project scope

oPEN Living Lab Genk is in the suburban residential neighbourhood called “Waterschei”. This neighbourhood consists of two distinct areas: a former miners’ district constructed in the 1920s and a more recent social housing district called “Nieuw Texas” built in the 1990s. In oPEN Living Lab Genk, the following activities will take place to develop a Positive Energy Neighbourhood:

- Demonstrate PEN (Positive Energy Neighbourhood) in an existing neighbourhood.
- Transform 35 houses into energy-positive buildings by means of a collective renovation concept, applicable for both rental and private dwellings.
- Test, monitor and compare different (combinations of) renovation measures, energy technologies and systems.
- Create an ‘Open’ Living Lab – test infrastructure for future developments.
- Develop general guidelines for the scalable design of Positive Energy Neighbourhoods based on real demonstration, focusing on achieving a balance between collective and individual measures.

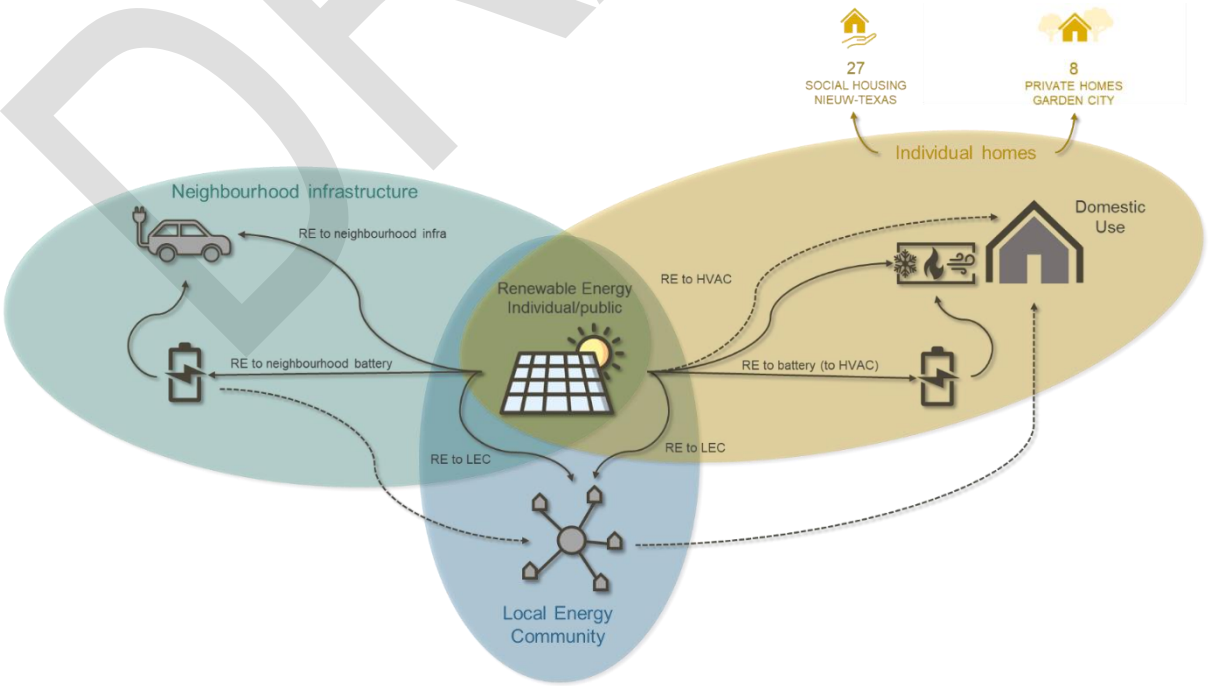

Figure 19: Energy flows in the oPEN living lab Genk

Until now, the majority of the renovation activities have taken place in the Nieuw-Texas neighbourhood where 27 social houses will be deeply energetically retrofitted. The housing estate is set up as a garden district with winding roads, gardens and green areas. The various typologies of dwellings, with semi-detached houses and small building blocks and apartments are all brickwork architecture, in tune with the surrounding neighbourhoods. All those houses are owned by the Social Housing corporation. The goal is to transform the houses in the district into energy positive buildings. The overall ambition of the Living Lab in Genk is to develop general guidelines for the scalable design of positive energy neighbourhoods based on real demonstration. The design of the positive energy neighbourhood is composed of four main concepts: (1) highly energy-efficient building design, (2) integrated building services solutions, (3) optimization of the building operation and (4) sustainable and circular building design.

The renovation activities are grouped into 2 parts:

- The building envelope including walls, roofs, doors and windows.
- The building technologies including PV, heat pumps, thermal storage, heat distribution, hot water provision, ventilation, control systems and sensors.

The building envelope renovation will be executed under the supervision of the building owner, the social housing corporation Wonen in Limburg. This entity must follow the principles of public procurement, in a strict way, as directed by Wonen in Vlaanderen (Flemish Association of Social Housing).

The building technologies – integrated in exterior energy boxes - will be bought, provided and operated by VITO. They will integrate the houses in a Living Lab, where different building technologies and building/district energy management systems can be tested at full scale, with real tenants living in those houses. Some of these technologies will be delivered by the oPEN Lab industrial project partners, the remaining missing technologies will be acquired via public procurement processes.

Apart from the 27 social houses, another subproject is linked to the renovation of eight houses in the ‘Tuinwijk Waterschei’. Those houses are privately owned. The goal is to also renovate the building envelope and the building technologies, where investments in the building envelope are to be made by the private homeowner, and building technologies will be provided by VITO. Because of private ownership the business case is different, as is decision making. In this subproject, the project partners are not the final decision makers. The progress is subject to the homeowners’ personal timelines; therefore, it is not considered further in this section.

Chosen model

The specification phase was approached in a different way than the conventional approach. A lot of attention was given to stakeholder involvement during so called co-design workshops. Especially the tenants were actively participating in this process, together with local oPEN Lab project partners, including the industrial partners. During this phase the high-level functional criteria were defined.

In this phase also the selection of 27 houses out of the neighbourhood of 100+ houses was realised. The selection was based on willingness of tenants to participate as well as having a

representative mix of dwelling types. Social engineering techniques were used to reach the number of 27 houses with highly motivated tenants.

The preparatory phase was organized within the boundaries of the oPEN Lab project, including close interactions between Wonen in Limburg, VITO and the industrial partners. Based on those interactions, high-level concept notes were developed, describing the desired functionalities and innovations to be implemented in the Living Lab dwellings.

In a second design stage, a public procurement process was organised to assign a design team – including an architect, an engineering office and an EPC consultant – to formally develop the design plans, permits and tender documents, in line with the described functionalities.

For the building envelope renovation, a workflow process was selected, where Wonen in Limburg, the architect, the tenants and other local stakeholders were involved during the detailed engineering and specification phase. The Planning Department of the City of Genk was also consulted, as both the position of the energy boxes and the volume of the renovated homes would extend the boundaries of the buildable land. This resulted in a tender document that was published on the market to receive offers from construction companies. Because of the innovative character of the prefab concepts and the desire to formulate mainly functional requirements (e.g., in terms of material use), the decision was made to follow a Competitive Procedure with Negotiation.

A similar approach was adopted for the building technologies, but with the difference that both Wonen in Limburg and VITO are both decision-making entities, as they are co-investing. Again, a Competitive Procedure with Negotiation was used, given the innovative character of the demanded solutions.

Implementation

The pre-design phase of both the building envelope and the building technologies was executed by a co-design team with Wonen in Limburg, VITO and the oPEN Lab industrial project partners. In order to structure the co-design sessions, this phase was thematically organised around some technical tracks:

1. Renovation and prefab concepts
2. Business models
3. HVAC and The Energy box
4. Renewable energy systems
5. Monitoring and control

Each technical track has a responsible and relevant partners contributing to the design. Both group workshops and bilateral meetings were used. Concept notes were drawn up to reflect the questions that were examined in the tracks, the strategies that were considered and the suggested way forward.

These concept notes were used:

- to introduce the project to the architect-team.
- as an agreed point in the design phase for the building technologies. These concept notes were used as input for the design team to proceed with the procurement files.

Apart from these five tracks relating mainly to the buildings, another one was defined on ‘neighbourhood infrastructure’.

Main take-aways

The strength of collaboration across the quadruple helix

A quadruple helix model (for innovation) involves collaboration of actors from knowledge institutes, companies, authorities and citizens. Bringing stakeholders across the quadruple helix together in an early design stage strengthens the quality of the solutions and helps to create a support base around the topic. This is especially useful/necessary for complex projects such as PENs because so many stakeholders are involved.

Experience in the Living Lab Genk shows that early-stage involvement of end users through social innovation techniques is time consuming but was clearly identified as highly valuable and is considered as an added value by all professional stakeholders involved. For Wonen in Limburg the experience was so valuable that they intent to roll out a similar approach in future projects.

For local authorities the process can be challenging because they are typically not organized for high involvement across different departments. Also, many local authorities face a lack of capacity to support energy-transition related initiatives. Energy Cities has created a dedicated study 'Human capacity in local governments: the bottleneck of the building stock transition' [40]

Early-stage consultation with technology providers helps to elevate coherence and innovation to a next level

- In this project the early consultation happened through the research project
- In other cases, this could be tackled through feasibility studies or innovative procurement techniques.

Public procurement and innovation

Integrating innovation in rigid public procurement rules can be challenging. When defining the specifications for the 'open calls' for the Genk Living Lab it was difficult to involve specific innovations, since procurement rules require a neutral description of the envisaged solution and ideally multiple solution providers should be able to respond with their offering (principle of competition).

In Genk case, it was a valuable choice to select a procurement procedure that involves a negotiation phase. This gives some more flexibility to support better integration of innovations. Negotiations also allowed the candidates to present additional proposals and modifications to optimize the budget. During negotiations the original scope, which was described in the specifications file at a rather general level, has to be maintained, but the more detailed specifications can be refined during negotiations. To ensure fair competition, all providers should have access to the same information when the Best And Final Offer (BAFO) is requested.

Besides procedures with a negotiation phase, there are other public procurement procedures that enable even more extensive collaborations on innovation, like the Innovative public procurement, mentioned above. They were not selected here because they typically also include the pre-design of the technical concept. This pre-design was part of the oPEN Lab project itself, in this case. But without the project, using an approach of construction teams or innovative public procurement would have been highly interesting.

[40] https://energy-cities.eu/policy/give-cities-the-staffing-means-for-their-climate-ambitions/

8.2. oPEN Living Lab Pamplona

Project scope

oPEN Living Lab Pamplona will implement one of the first operational PEN concepts in Spain, demonstrating an advanced, scalable, and replicable urban energy model. The main area of operations will be the northern district of Rochapea, a working-class neighbourhood whose origins date back to the 1940s. The chosen building is the San Pedro apartment block with social housing. Next to this, an industrial complex is selected to be renovated. It is the IWER building owned by the Obenasa company. It has a floor space of over 40,000 m².

The idea is to have a PEN with the two sites together. It will be monitored by a Building Management System (BMS), preferably one system for the two sites, otherwise a combined system of the two BMS. It will be organized as an energy community in which consumption and production are balanced. At the moment, it is setup in two different renewable energy communities, but the scope is to combine it in one as demanded in legislation. The two sites are less than 2000m apart from each other, again a legislative restriction for an energy community.

Another scope of the project is a social track to implement public engagement in the city's procedures on a sustainable basis. The project is a sandbox environment for this social engagement track.

Chosen model

For the San Pedro building, the city as owner is responsible for the renovation. Although it is a classic public procurement, an interview with the existing tenants was organized to obtain info about the current living situation. These tenants are relocated before the renovation and new tenants will be in the building afterwards. It is in fact a conventional workflow, but with thorough attention on energy production and -consumption.

In the IWER building the owner is also the construction company. They hired an architect/Engineering company (AHA) who did the design and registered the documents for the city approval. Obenasa itself will carry out the renovation project, but in extensive discussions with the future users (elderly home, commercial owners, ...) For the public/private square in front of the IWER building a public cocreation session was organized.

Implementation

As mentioned, the existing tenants of San Pedro were interviewed on their experience with the building. For the design, a group of typical habitants (elderly people) were interviewed on their expectations for the building. The future tenants were given the opportunity to modify the design through Virtual Reality/Augmented Reality (AR/VR), regarding colours, interior wall setup and materials for floor and walls. Further input was given by tenant companies. For the new square in front of the IWER building, neighbours were interpellated in a few cocreation sessions. They could give suggestions on the use and design of the square. The architect modified the design plans according to these suggestions and submitted it to the city's approving department.

Main take-aways

In the design process the involved companies and partners sharpened the scope, both technically and socially. They thought about the user-friendliness of the interface of the techniques for the San Pedro housing, especially because the future inhabitants will be elderly people. The partnership put up training workshops for the future inhabitants.

In the IWER building the future owners are partners in the design process because the partners insist on the approval and uptake of the renewable energy techniques by the new owners. Different supporting tools were used to facilitate the whole project:

BIM

- The whole municipal planning department changed software (from AutoCAD to REVIT) to support the build-up of a 3D-model in BIM.
- The model was used for designing other technical aspects, especially for support of the prefabrication workflow.

3D-scanning

- Both 3D-scanning and drone scanning were used to generate point clouds for the BIM-model.
- Some parts are being done with each technology to be able to compare the differences (speed, cost, accuracy, …)
- 3D-scanning is usually cheaper, although slower, but is labour-intensive.
- Drone scanning comes with a higher cost, is quicker, but is at present less accurate. In IWER-building indoor drone scanning is applied. For the external scanning, the process is prone to strict regulations due to the vicinity of the Pamplona airport.
- The scanning output serves as an input for the BIM-model.

Prefabrication

In the San Pedro-building, a part will be executed through prefabricated walls including vacuum insulation. The comparison with the “conventional” workflow for the same building will be made for timing, cost, and environmental impact (e.g., waste production)

Virtual/Augmented Reality

- Is used for the design of the interiors of the San Pedro-building.
- In IWER, AR is used as a supporting tool for the cocreation with the future tenants.

Website[41]

- Under oPEN-Lab-flag a website is created for information and cocreation purpose.
- The public finds a 2D/3D-model of the city with information on mobility, energy (and -poverty), execution and disturbance of planned public works, …
- In an easy way, everyone can provide input on district and personal level (e.g., provide used and desired mobility routes and transport medium)

In the execution phase, the designers hope for a good understanding with the contractors and subcontractors to end close to the scope of the project or even outperform it.

[41] www.rochapealivinglab.com

8.3. oPEN Living Lab Tartu

Project scope

oPEN Living Lab Tartu lies in the city district of Annelinn and is a socio-demographically diverse as well as a densely populated neighbourhood. The main characteristics of the neighbourhood are:

- a region built during the Soviet occupation (in the 1970s and 1980s), i.e., low-quality construction, typically 5- and 9-story apartment buildings with small apartments and limited public space around the buildings,
- a multi-lingual community of both Estonian, Russian, and third language speakers,
- a neighbourhood with the highest population density in Tartu, nearly a third of the population of Tartu lives there.

The oPEN Living Lab area consists of 22 nine-story buildings at the far end of the district, which house nearly 3,500 people. In this area, three nine-story apartment buildings will be renovated, the surrounding area rejuvenated and improved, and the residents engaged in social learning and experiments.

In the oPEN Living Lab, the following activities will take place to develop a Positive Energy Neighbourhood:

- Full renovation of three apartment buildings, including PV panel and solar energy storage installation and smart home installation.
- Co-creating original artworks on and around the renovated buildings.
- Improving the public urban space, e.g., constructing new bicycle parking, improving the accessibility of services, etc.
- Studies on behaviour change, incl. changes in mobility and technology acceptance.
- Social innovation experiments, including experiments with gamification.

Chosen model

The involved partners in oPEN Lab are mainly Universities and Energy Agencies. They determine the requirements and criteria of the renovation and the energy level to be achieved to achieve a PEN at the district level.

The to be renovated buildings are privately owned. The owners are associated in a formal AOA (Apartment Owner Association) and the building blocks are represented through a Block Manager and decisions are made in regularly held general meetings.

The project's partners defined a list of tasks and must-haves (implementation methods, energy score, 3D measurement, etc.) that were laid down in a public tender. The bidders in this tender must make up a consortium with a design team and building contractors familiar with prefabrication. The latter is a requirement within the project and has recently been encouraged by the government and supported by subsidies.

This form of collaboration is very similar to the description of the construction team set-up. Moreover, it leaves open the opportunity to offer the techniques and the insulated building envelope in an ESCO formula and itself in an AAS (As A Service) model.

An additional requirement within the public tender is the use of a way to perform a 3D measurement and feed this information into a BIM model. The prefabrication only allows a deviation of 1 cm on a 3 x10-metre panel and therefore high accuracy is required from the BIM model.

Implementation

The project implementation is situated in 2 tracks: on the one hand, preparing the public tender with the requirements and necessary documents and, on the other hand, obtaining the commitment of the residents. The first part has already been described above.

For convincing the owners, the following steps were taken:

- Two information events aimed to provide the residents of the pilot houses with the most up-to-date information on the renovation of the houses, their costs, and technical solutions. Residents were mainly concerned about the cost of renovation and the overall financial situation and support schemes, which has generated doubts and concerns about the ability of the housing association to pay the loan that they still would need to take. Residents were also interested in the innovative solutions to make 9-story apartment buildings smart and energy efficient.
- The project partners held several meetings with the block managers to discuss the technical details of implementation and financing of the whole thing.
- Moreover, they attended the annual general meetings of the building owners where they provided detailed explanations about the renovation and its impact on their housing quality and energy bills and their repayment options.

In total, the owners of 10 of the 22 buildings could be convinced to see if the renovation was within their possibilities.

The project has started well. of the 22 buildings that were approached, 10 were really interested in accepting the renovation proposal. After all the information rounds, 3 remained who committed themselves to be effectively guided by the project partners to carry out the works.

Main take-aways

The project has started well. Of the 22 buildings that were approached, 10 were really interested in accepting the renovation proposal. After all the information rounds, 3 remained who committed themselves to be effectively guided by the project partners to carry out the renovation works.
Although the income category of the residents was among the lowest in Estonia, it seemed that negative interest rates for housing loans in combination with subsidies from the project and profit on the energy bill made the implementation financially viable.
But then the global situation changed. The war in Ukraine temporarily caused sharply increased energy prices, European inflation, and interest rate hikes (from negative to above +4%). In addition, the material costs of wood and steel increased and Estonia turned out to rely heavily on foreign workers (especially from Ukraine). All of this suddenly made the investment unbearable for most owners. Their living costs would almost double after the renovation, with the result that all the committed blocks suddenly gave up. Energy prices have fallen back, even to prices lower than before the crisis, but even with the very high energy prices of 2022, the energy savings calculations did not make a positive business case. Solutions will now be sought during the project to still achieve renovations, but for the time being there is no viable proposal for the residents.

Conclusions & Recommendations

As discussed earlier in this document there are a lot of drivers to integrate further the activities of the actors in the value chain, especially during the design phase of a project. Further integration can lead to extra value for the collective project as well as for the individual actors. Further integration seems to be even necessary to successfully implement PENs, because energy elements play a more important role and the project scope is not a single building but an entire neighbourhood with energy flows between the buildings.

Integrating energy actors early in the project can create significant advantages, especially during the operation of the building. Integrating these actors into the existing value chain, that is more oriented on construction works, will be a challenge, because those construction actors are not used to talk to the energy actors that early in the process.

This document describes existing collaboration methods. Some methods are commonly used, others are only used in specific cases. Some of them allow more integration in the design phase than others. Some of them fit better into public procurement processes than others.

The already more integrated approach, of construction teams and DBFM-alikes, has clear advantages but is not yet common on all markets and project-sizes. There is still a lot of opportunity to deploy this method on a larger scale.

In chapter ‘Up to even more integration and value’ different aspects of the need for further integration are discussed, along with potential value. It also covers some elements on how to reach this further integration. But this chapter does not result (yet) in a fully described new collaboration model.

Some take-aways

- Until now, the construction sector and energy sector are typically working on 2 parallel paths. If we want to achieve PENs, a common path will have to be found.
- The need for deep energy-driven renovations requires additional resources, that many individuals do not have. The need for alternative financing is increasing.
- The days, when interventions in/on housing were decided over the heads of residents, are behind us. If we want to keep the chances high to accelerate the renovation wave, we need to get/acquire the commitment and consent of residents.
- The transition of ways of working, from "conventional workflow" through “construction teams” to ESCO models and advanced collaboration methods, makes the whole value chain more complex and increases the need for collaboration. This runs parallel to an increasingly complex society that increasingly relies on high-speed computing, ML and AI to handle these complex thought processes. The construction sector (and to a slightly lesser extent the energy sector) still has big steps to take in digitalisation. These new ways of working together could (potentially) skip a number of intermediate steps and the listed "tools" can help in this regard.
- Find inspiration in other sectors (automotive and manufacturing) can be useful to get the scaling-up of the renovation sector done. Off-site preparation of elements assembled on a logical production line with minimal human handling can bring a reduction in construction costs over time.

- Avoiding individual protocols in data processing increases its speed and reliability. Open data seem to be a must to make on-site interventions faster and with minimal input of knowledge from (service) technicians.

As the oPEN Lab project continues the experiences in the 3 Living Labs will indicate which elements of the collaboration methods seem to be more important than others, which elements work well, and which don't (in the actual context). These experiences will be collected near the end of the project.

An important goal at the end of the project is to create a 'toolbox', that can be used to replicate the project findings to other PEN/PED-initiatives. That toolbox will contain a lot of topics, but the next 2 topics should be included:

- A more concrete, practically validated, collaboration method that is more suited to the development of PENs. This will be based on the analysis in this document and practical validation of aspects in the 3 Living Labs.

- Best practice templates are needed. To ease implementation of one collaboration method or another, best practice templates or contract templates should be available. From the current analysis it seems that those templates are not easy to find in the public domain. Further investigation could bring up additional templates. If discovered templates do not address enough the specific needs in PEN-development, the project may propose (elements of) its own template in the toolbox.

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