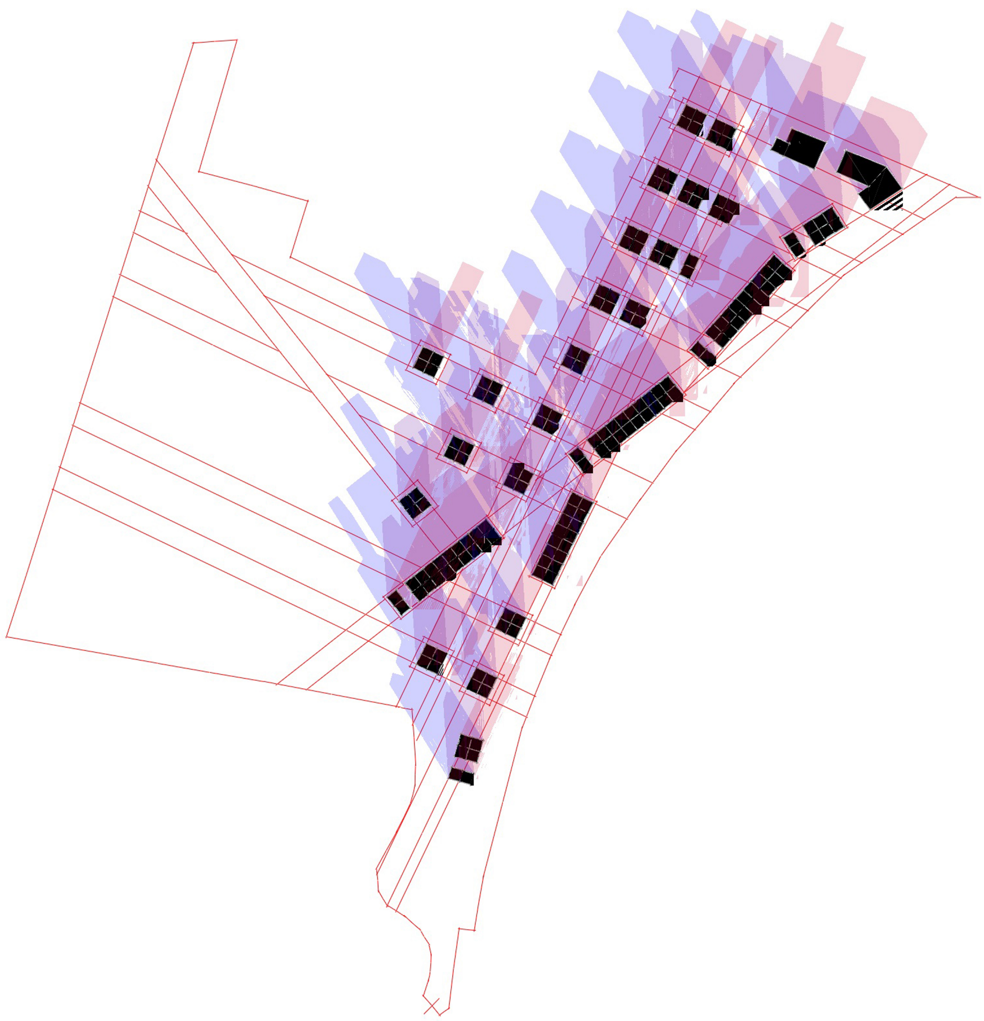
Rethinking Buildings

Should buildings simply be enclosures that house different functions?

Esra Kurul, Maurizio Sibilla



TRANSFORMING
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The function of buildings cannot be limited to being enclosures, if our life-styles and practices are to be transformed to rise to the challenge of Low Carbon Transition. As part of this transformation, we envisage a new generation of buildings as components of local, renewable energy systems, which play a significant role in reducing CO_2 emissions. In this scenario, buildings become 'active' by generating power.

Our starting point to deliver this vision, is to organise a multitude of actors, who often have different perspectives and scopes, and to help them find ways in which they can work collaboratively, using our ground-breaking Buildings-as-an-Energy-Service (BasES) Toolkit. BasES is designed for academics and non-academics to integrate their diverse, disciplinary knowledge to find creative ways in which buildings can become part of local, renewable energy systems. It is envisaged that academics in fields such as Architecture, Urban Design, Planning, Engineering and Economics, would utilise their exposure to BasES in developing novel programmes of study that focus on energy transition in the built environment. Non-Academics, who are interested in introducing niche innovations to deliver this transition, could use BasES to explore, for example, novel energy services that can be offered or the role of the big energy companies versus that of self-organised community energy projects in it.

BasES fosters interdisciplinary collaboration by enabling users to visualise and reflect on their existing knowledge in their own disciplines; and to integrate this knowledge with that of others. Knowledge integration is critical in this context, because operationalising local, renewable energy systems is highly dependent on it.

BasES is based on a conceptual framework, which is drawn from an extensive review of relevant publications in the social and physical sciences, and which is represented as a concept map. It constitutes four lines of research (or *domains of knowledge*) that were drawn from the literature: Trajectory, Management, Tools and Socio-technical implications. Annex A provides the definitions of the terms that are used under these domains of knowledge.

10-case studies, which are drawn from the International Energy Agency's Energy in Buildings and Communities Programme (EBC), and from the Active Building Centre's and Energy Systems Catapult's live-projects, complement this framework. The case studies are illustrations of existing practice in the four domains of knowledge. They highlight the critical issues, e.g. Modelling for System Design & Control, which need to be resolved for the novel energy systems to become mainstream.

The users of BasES are initially called to *individually* generate a concept list, which represents their existing knowledge that is related to local, renewable energy systems. The next step is to view the concept map and to edit it in order to answer the following focus questions:

How can/could the use of buildings as components of a future energy network impact your own practice or field of expertise?

How could your field of expertise contribute to defining a reliable and competitive socio-technical energy infrastructure?

Generally, users start editing the concept map by co-locating and/or associating their concepts with one or more of those illustrated in the map.

The next stage is designed to encourage collaboration between two or more users. The users are tasked with developing a joint response to the focus questions and visualising their response in a co-produced concept map. User's individual maps and the conceptual framework are the usual starting points for this process. The focus questions provide a tangible motivation for collaboration as they are joint 'problems' to be solved. Collaborative discussions on the original and edited concept maps enable the users to identify useful information that is external to their domains, and to explore and overcome barriers to transferring it into their domains. As such, knowledge that resided in separate domains is integrated in search of the answers to the focus questions.

BasES is available as an Open Educational Resource as part of IHMC Public Cmaps. Users need to download the Cmap-Tools software from https://cmap.ihmc.us/ in order to access BasES. A step by step guide to access BasES after installation can be found in the Instructions section of this article.

To conclude, BasES has the potential to deliver our vision of *Buildings-as-Energy-Service*. It is designed to inform the future practice and policy agenda at the intersection of the Built Environment and the Energy sectors, which are both critical for Low Carbon Transition. More importantly, it places future built environment professionals at the core of the Transforming Construction and energy infrastructure agendas. These professionals need to better understand the interconnections between these domains. By fostering collaboration across disciplinary and sectoral boundaries, BasES helps academics and non-academics develop this understanding.

BasES is part of the body of work the authors have been developing since 2017. Selected outputs from this work are as follows:

Sibilla M, Kurul E **(2020)**, Transdisciplinarity in Energy Retrofit, *Journal of Cleaner Production,* vol.250:119461,p. 1–17, ISSN: 0959-6526
https://doi.org/10.1016/j.jclepro.2019.119461

Sibilla M, Kurul E **(2020)**, Assessing a simplified procedure to reconcile distributed renewable and interactive energy systems and urban patterns. The case study of School Buildings in Rome, Journal of Urban Design, vol.25:3, p.328–34, ISSN: 1469-9664,
https://doi.org/10.1080/13574809.2019.1638238

Sibilla M, Kurul E, **(2019)**, "Built Environment Education Across Boundaries. The Case of Energy Retrofit As a Tool for Low Carbon Transition" in 2019 XJTLU International Conference: Architecture across Boundaries, KnE Social Sciences, pages 377–388, ISSN: 2518-668X
DOI 10.18502/kss.v3i27.5541

Sibilla M, Kurul E **(2018)**, Distributed Renewable and Interactive Energy Systems in Urban Environments. *TECHNE Journal of Technology for Architecture and Environment*, Issues and Points of View, special series vol. 1, p. 33-39, ISSN: 2239-0243
https://doi.org/10.13128/Techne-22710

Instructions

Install Cmap Tools from: https://cmap.ihmc.us/cmaptools/cmaptools-download/ and Open it.

1_Click on Tools/search

2_select "PLACES"

3_ "WHAT TO SEARCH": Envisioning Buildings-as-Energy-Service_v01

4_click on the folder "BasES – Envisioning Buildings-as-Energy-Service_v01

5_ Click on the latest version, e.g. BaSES-v01_Rxx

(NOTE : BaseES is continuously updated. New versions will be uploaded on Cmap Tools as they become available.)

You can start working with BasES. You can copy the whole folder onto your local system.

6_In order to work collaboratively, click on the icon at the upper right-hand corner of the window.

Once this message appears: "*Synchronous Collaboration has been enabled and will begin when another user edits this Cmap*", You can start working collaboratively.

For further information about using Cmap Tools, please visit:

https://cmap.ihmc.us/publications/research-publications.php

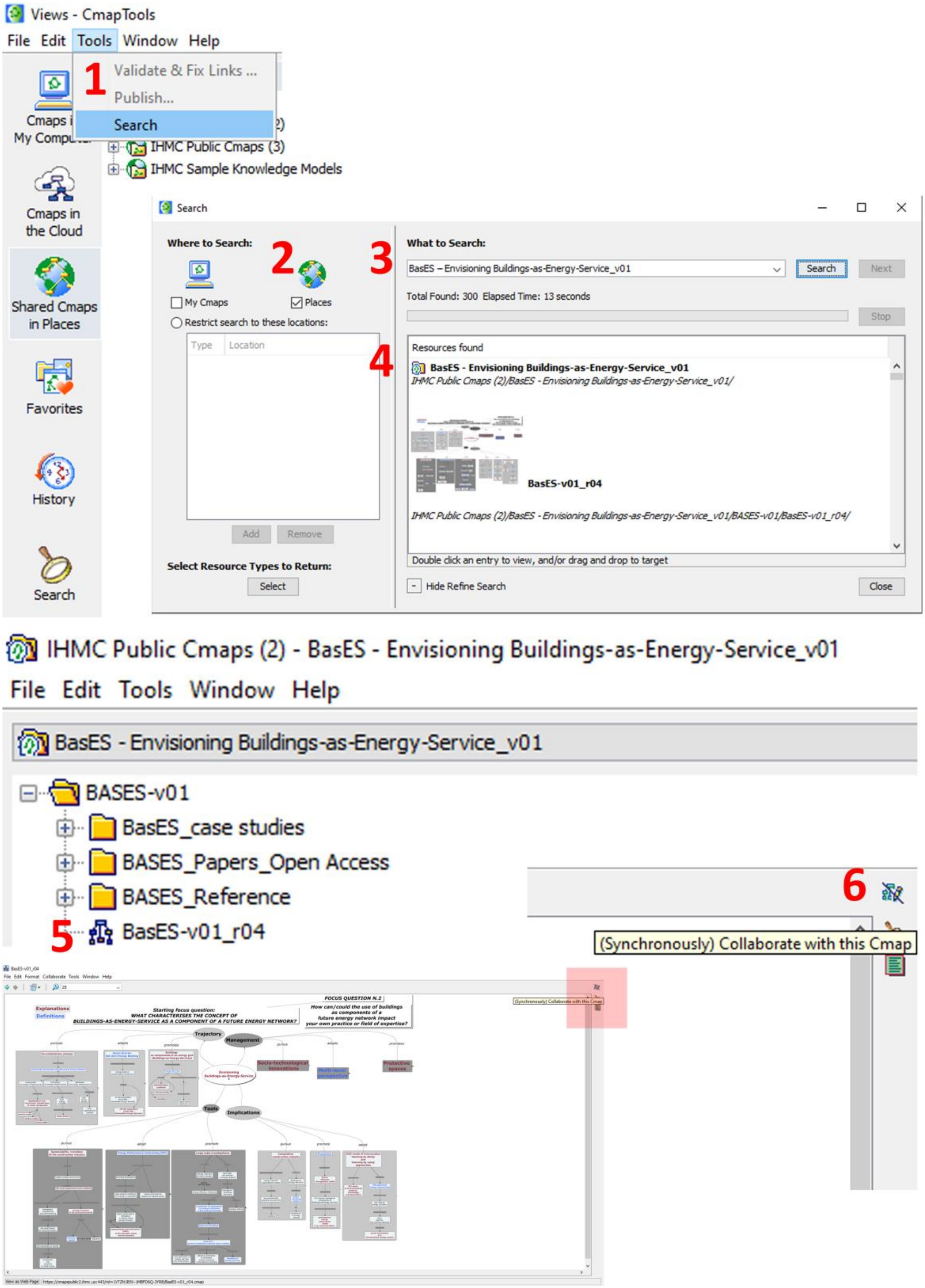

Figure 1. Instructions

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The research team

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Charles Bradshaw-Smith, member of the advisory board, is an expert in new business models required to make local energy a reality. He runs SMARTKLUB – Empowering Communities Ltd.

Tom Elliott, member of the advisory board, is an experienced Energy Consultant at the Energy Systems Catapult.

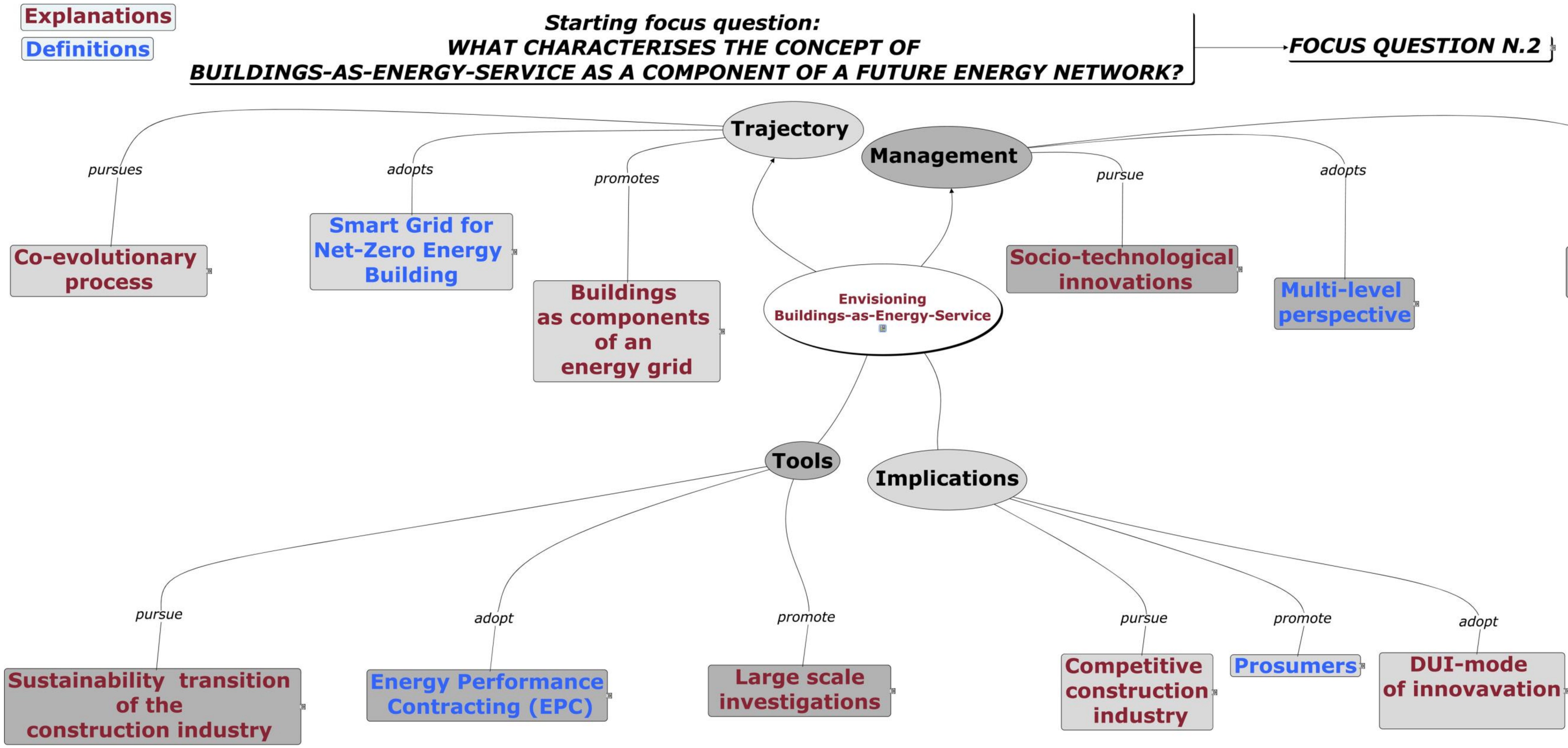

Figure 2. BasES: first level of organisation.
First focus question and definition of the Domains of Knowledge

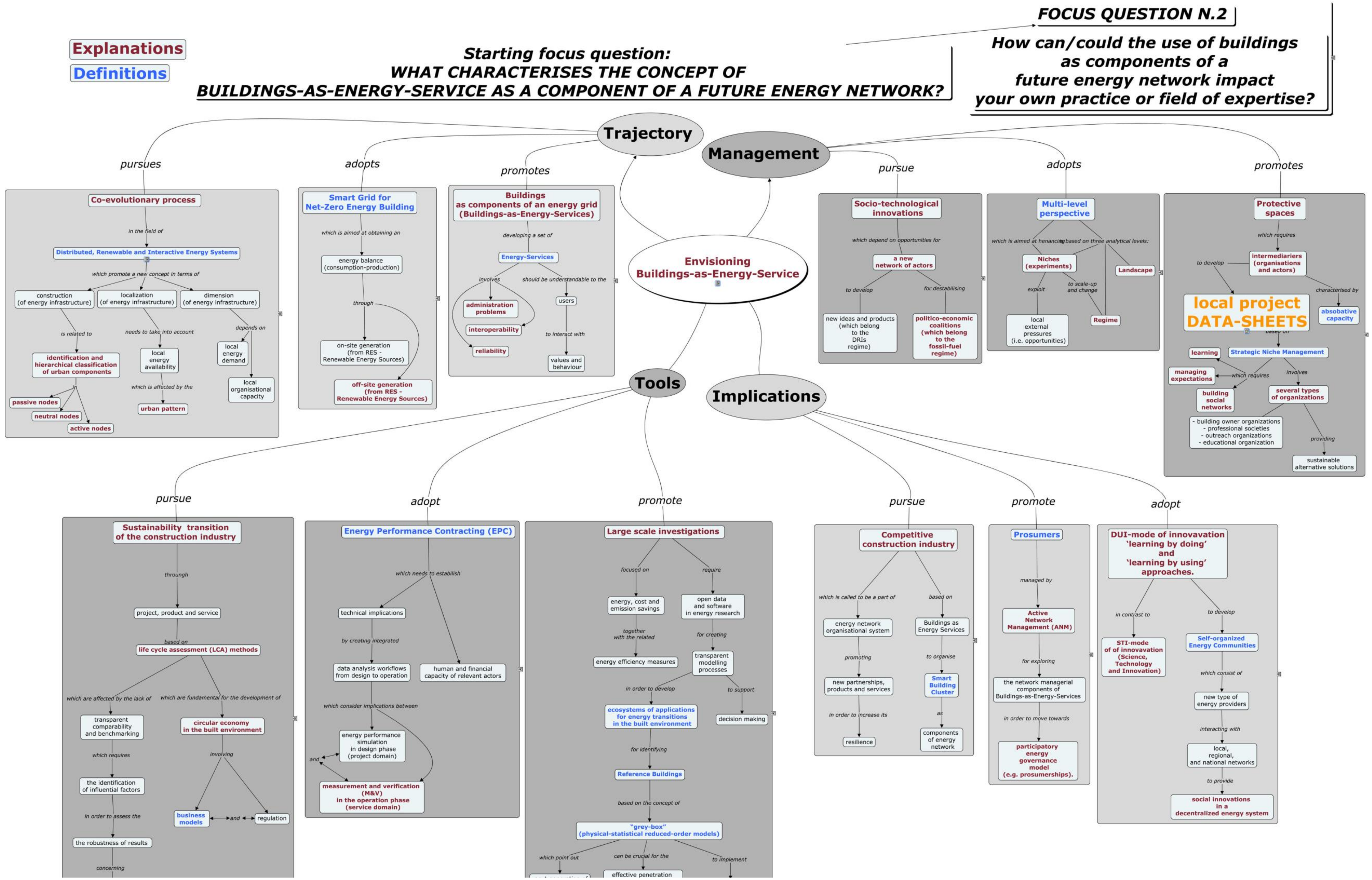

Figure 3. BasES: second level of organisation.
Second focus question and articulation of the Domains of Knowledge

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ANNEX A

Explanations (red) and definitions (blue) of concepts

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Explanations (red) and definitions (blue) of concepts

TRAJECTORY

Co-evolutionary process

Co-evolutionary process: It involves interactions between technologies, institutions, users, business strategies, and wider ecosystem change (Foxon, 2011).

Distributed, Renewable and Interactive Energy Systems (DRIs): DRIs are described as small units, directly connected with the place of consumption and assembled in a sequence of nodes in order to organize a micro-energy network. Interactivity is a new property of these systems which describes their capacity to manage energy and information flows in real time to optimize energy production, storage, consumption, and cost (Sibilla and Kurul 2018).

Identification and hierarchical classification of urban components: Sibilla and Kurul (2020) provided a simplified procedure to reconcile distributed renewable and interactive energy systems and urban patterns.
In order to address this issue, the following stages were examined: 1) Defining the reconciliation criteria; 2) Gathering renewable energy data; 3) Assessing environmental design indexes; 4) Elaborating a hierarchical classification of DRI nodes; and 5) Visualising DRI clusters.

Once all parameters are defined, individual buildings are hierarchically organised as components of the DRI system. The hierarchical organisation facilitates the visualisation of the main urban and architectural factors involved in the process and allows for the identification of the buildings that have more potential to become part of a DRI.

Passive Nodes: where renewable energy production is less than the building's energy demand.

Neutral Nodes: where renewable energy production meets the building's consumption.

Active Nodes: where the renewable energy production from the building is greater than its consumption.

Urban Pattern: The identification of existing buildings as active, neutral and passive nodes in DRIs can make a contribution to Urban Design decisions to exploit the renewable energy production capacity inherent in urban patterns. Sibilla and Kurul's (2020) study takes into consideration the concept of Urban Pattern in line with Alexander's definition (1966), drawing attention to the geometric properties of buildings and urban spaces in relation to DRIs.

Smart Grid for Net-Zero Energy Building

Smart Grid for Net-Zero Energy Building (ZEBs): ZEBs are defined as buildings that work in synergy with the grid, avoiding putting additional stress on the power infrastructure. Achieving a ZEB includes minimizing the energy required and covering the minimized energy needs by adopting renewable sources (Zhao and Magoulès 2012).

Off-site Generation (from RES - Renewable Energy Sources): Off-site generation is a relevant stratergy because it allows buildings with limited solar access for PVs due to urban morphologies (e.g. high density) or building typology (e.g., high-rise) (Torcellini, Pless, & Leach, 2015) to take part as components of the energy network. In other words, the integration of on-site and off-site generation from RES can be an exceptional opportunity for creating smart grids to assemble active, neutral or passive nodes of the network.

Buildings as components of an energy grid (Buildings-as-Energy-Services)

Buildings as components of an energy grid (Buildings-as-Energy-Services): The concept of Buildings-as-Energy-Services provides a new way of looking at the role of buildings as components of an energy grid. This requires insights from disparate disciplines or expertise to understand how technologies and services may interact with values, behaviour and society (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013).

Energy-Services: ES is defined as a variety of activities, such as energy analysis and audits, energy management, project design and implementation, maintenance and operation, monitoring and evaluation of savings, property management, and energy and equipment supply (Bertoldi, Rezessy, and Vine 2006).

Administration Problems: Administration problems involves the people who will manage such services, which permeate into the building.

Interoperability: Adoption of universal standards for communications protocols for the services offered.

Reliability: Reliability involves the interconnection of technologies with different tolerances to deal with technical difficulties.

MANAGEMENT

Socio-technological innovations:

Socio-technological innovations: Low-carbon energy transition involves a new network of actors, such as energy authorities, governments, utilities, consumers/producers, and technology providers. On the one hand, socio-technological innovations depend on opportunities for these actors to access new information, knowledge, and resources, which are critical for developing new ideas and products.

A new network of actors: Such as energy authorities, governments, utilities, consumers/producers, and technology providers.

Politico-economic coalitions (which belong to the fossil-fuel regime): Traditionally, energy infrastructures have been established around distinct groups of actors (e.g. policymakers, regulatory authorities, transmission and distribution authorities, amongst others), organising strong politico-economic coalitions. The Multi-level perspective (MLP) outlines pathways for destabilising such coalitions which belong to the fossil-fuel regime (Loorbach, Frantzeskaki, & Avelino, 2017).

Multi-level perspective

Multi-level perspective: The concept of MLPs is defined as an innovative strategy that helps to transform the cultural, institutional, social, political, market, industry, infrastructure, technology, and science “subsystems of society” that are locked-in and characterize the dominant socio-technical regime (Smith et al. 2010).

Niches (experiments): Successful niches are those which are able to attract more participants and which translate niche ideas into ordinary settings (Seyfang & Haxeltine, 2012).

Landscape: which provides the context for regime stability or change (Kivimaa & Kern, 2016).

Regime: Where technologies, institutions and practices are aligned and conformed.Policymakers and incumbent firms often represent a core alliance at the regime level. They are oriented towards maintaining the status quo (F. W. Geels, 2014).

Protective spaces:

Protective spaces: Protective spaces are contexts for experimentation, where uncertainty and poor returns are accepted (Schot & Geels, 2008).

Intermediariers (organisations and actors): Intermediaries are actors that facilitate relationships between key actors and enable sharing and pooling of knowledge (Bush et al., 2017). The role of intermediaries in SMEs is relevant in order to promote eco-innovations, and to seek network contacts to reduce time and knowledge constraints and increase the absorptive capacity of SMEs.

Absobative capacity: AC refers to an individual’s or organisation’s ability to take in new external impulses and translate these into innovations. It encompasses the process of recognizing and understanding external knowledge, assimilating it to the firm context, and continuing to create new knowledge (Cohen and Levinthal 1990).

Strategic Niche Management (SNM): SNM consists of the creation of protected spaces for the development and use of promising technologies by means of experimentation. The scope is to learn about a new technology and enhancing it’s further development and rate of application (Kemp et al. 1998).

Learning: Learning processes are useful to point out how people deal with regime systems.

Managing expectations: Expectation management concerns how niches present themselves to external audiences. Expectations should be widely shared, realistic and achievable.

Building social networks: Networking activities have to embrace many different stakeholders, who can support the niche’s growth.

Several types of organizations: These organisations are engaged to identify best practices to control the cost of innovative solutions (e.g. ZEB) (Torcellini et al., 2015)

TOOLS

Sustainability transition of the construction industry

Sustainability transition of the construction industry: Conceptualization of sustainability transitions is the identification of knowledge domains that are needed to organize them. Research into Sustainability transitions research aims to explore how a radical change can take place while satisfying fundamental societal needs. The construction industry can be subdivided into three fundamental domains: project, product, and service (Thuesen et al. 2016). Each domain has different markets, companies, business models, and regulation. Proposed technical and technological solutions have to account for these domains of knowledge and their interaction.

Life cycle assessment (LCA) methods: LCA applications are fundamental for the development of innovative economic paradigms such as the circular economy in the built environment. However there are significant variations in how the method is currently used in practice, making it difficult to use for transparent comparability and benchmarking (Pomponi & Moncaster, 2018).

Circular Economy in the built environment: Pomponi, Moncaster's (2017) review discussed the emerging paradigm of the circular economy, with a focus on a new generation of "circular buildings". This new paradigm goes beyond the topics of energy consumption and carbon emissions. It encompasses a better management of resources, involving the life cycle of buildings, which interact dynamically in space and time within local built environments. Nevertheless, as stressed by Wolf et al's (2017) review, there is very unclear information on how life cycle approaches are being carried out by industry.

Business models: Innovative business models for energy transitions are plans for the successful operation of businesses in this area, which are specifically designed to overcome barriers to the achievement of stringent energy efficiency goals that are critical in energy transitions. Energy Performance Contracting is an essential part of an innovative business model, which has to be carefully constructed to ensure the techno-economic feasibility and effectiveness on the field, considering barriers and bottlenecks (Shang et al. 2017).

Energy Performance Contracting (EPC)

Energy Performance Contracting (EPC): An EPC is a particular form of service contract in that the contractor pledges, through a binding commitment, that a specified amount of energy will be saved through the project (Winther and Gurigard 2017).For instance, Shan et al (2017) reviewed relevant aspects of the Energy Performance Contracting Business Model that could allow Energy Service Companies (ESCOs) and energy customers (e.g. public institutions/enterprises) to establish roles, responsibilities, and risks about new mechanisms to promote energy services associated with buildings.

Measurement and Verification (M&V) in the operational phase (service domain): The availability of data and models can be a key driver for the development of ecosystems of applications for energy transitions in the built environment (Bollinger, Davis, Evins, Chappin, & Nikolic, 2018). Indeed, by employing M&V principles together with large scale data analysis techniques, it could be possible to characterize energy performance transparently and effectively (Meng et al., 2020), from single buildings up to building stocks. Large scale data acquisition can potentially take place inexpensively, employing state-of-the-art of metering technologies (i.e. smart meters) (Oh, Haberl, & Baltazar, 2020), even though applications should be conceived considering the principle of preserving privacy.

Large scale investigations

Large scale investigations: It could be possible to characterize energy performance transparently and effectively (Meng et al., 2020), from single buildings up to building stocks.

IMPLICATIONS

Competitive construction industry

Competitive construction industry: The trajectory of the evolution of new energy networks can have an impact on the energy sector. This means shifting investments from the expansion of large scale generation systems to the energy efficiency in the building sector, i.e., improving building fabric and increasing decentralised and renewable infrastructure in the community (Kolokotsa, 2016). Furthermore, it can advocate the concept of Buildings-as-Energy-Services.

Smart Building Cluster (BC): BC identifies a group of buildings interconnected to the same energy infrastructure, such that the change of behaviour/energy performance of each building affects both the energy infrastructure and the other buildings of the whole cluster. This definition does not assign fixed dimension and boundaries to the building cluster scale, but it is based on building interconnection that could be physical and/or market related (Vigna et al. 2018).

Prosumers

Prosumers: they are new actors of the energy supply chain who can act as an investor and owner, making key investment decisions for themselves individually, or collectively as 'clean energy communities (Gui and MacGill 2018).

Active Network Management (ANM): A concept which involves both the management of supply-side and demand-side options (Arapostathis et al., 2013).

Participatory energy governance model (e.g. prosumerships): This new model seeks to understand co-evolutionary interactions between a broad range of social and institutional actors as utility companies, sector regulators, policymakers, and end users. Prosumership is expected to be increasingly embedded in energy communities, promoting the configuration of renewable energy clusters (Lowitzsch, Hoicka, & van Tulder, 2020).

DUI-mode of innovation - 'learning by doing' and 'learning by using' approaches

DUI-mode of innovation 'learning by doing' and 'learning by using' approaches: It focuses on social interactions in configuration of Self-organized Energy Communities.

STI-mode of innovation (Science, Technology and Innovation): It emphasizes research and development investment in green technologies.

Self-organized Energy Communities (SoECs): These consist of a small number of households (up to hundreds of thousands of households) in close proximity, covering a wide geographic area. These households will however share specific common goals as members of the community. These goals may include promoting cleaner production, energy autonomy and self-sufficiency, participating in the electricity market as a group, and revitalizing the local economy (Gui & MacGill, 2018).

Social innovations in a decentralized energy system: Members within the community can formally organise these SoECs. This can include external actors, which are outside of the community, for example, technology companies, utilities, governments, or NGOs in order to provide expertise. So, members in Self-organized Energy Communities may play different roles, such as producers, consumers, or prosumers, investors, asset owners, or a combination of these (Gui & MacGill, 2018).

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