syn.ikia

Sustainable plus energy neighbourhoods

WP6 Innovation Management Exploitation Market Uptake Business Models

D6.1 A SYSTEMATIC APPROACH TO DEVELOPMENT REGISTRATION AND REPORTING OF INNOVATIONS

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3. Executive Summary

This report presents a systematic approach to development, registration and reporting of innovations in syn.ikia. It is made up of three elements.

- First, an innovation management process in the form of an iterative cycle is being developed to coordinate activities among the partners in the consortium responsible for developing innovations.
- Second, to monitor the development of innovations, this report developed a checklist to facilitate registrations, discussions and follow ups on each innovation .
- Third, an overview of innovations that will be demonstrated during the syn.ikia project.

In the initial phase of the syn.ikia project, 12 innovations were planned. Since then, some of these innovations have been further developed. Hence, this report provides an update and status of these developments. In addition, new innovations are identified. In total, at the end of 2020, syn.ikia's consortium has identified 15 innovations. This number will likely increase over the course of the project.

The report presents the innovation management process and the tool template, both of which will be further developed as the syn.ikia project proceeds. It includes an overview of the innovations that are currently identified and being prepared for testing in one or more of the four demo projects in syn.ikia.

This is the first edition of a systematic approach to development, registration and reporting of innovations in syn.ikia. It will be updated again in month 24, 35 and 48 of the project.

4. Table of Contents

5. Roles and Responsibilities

Name	Role	Responsibility
SINTEF	Task 6.1 leader. Coordinator of deliverable contents and edition	Edition of deliverable; Developed tool template, Coordination of reporting and registration by partners
NTNU	Reviewer; Contributor	Review deliverable; Provided basis of tool template; Provided registration and reporting for 8.1, 8.10 & 8.11
TNO	Contributor	Provided registration and reporting for 8.2 and 8.13, no 1 and 2
IREC	Contributor	Provided registration and reporting for 8.3 and 8.4
ENFOR	Contributor	Provided registration and reporting for 8.5
DTU	Contributor	Provided registration and reporting for 8.6, 8.7 and 8.8
Housing Europe	Contributor	Provided registration and reporting for 8.9
BPIE	Contributor	Provided registration and reporting for 8.9 and 8.12
INCASÒL	Contributor	Provided registration and reporting for 8.13 no 3

6. Introduction

The syn.ikia project aims to increase the proportion of sustainable plus energy neighbourhoods (SPENs) with surplus renewable energy in different contexts, climates and markets in Europe. There is significant opportunity for syn.ikia to not only deliver innovations for SPENs in the demonstration sites, but to deliver incremental and possibly disruptive innovations to the wider EU market.

The syn.ikia project is an innovation action under the Horizon 2020 framework which means that identifying and developing innovations to be implemented in the market, is of high importance. Therefore, a joint approach to how innovations are systematized and commercialized from the demonstration projects and beyond, is needed. Innovation management will help bringing ideas and innovations higher up the TRL-scale and into the market. Innovation management is also useful to create organisational awareness and to allocate resources to work on the development of innovations. All partners in syn.ikia are involved in this task, as innovations can occur anywhere in the project. Innovations and innovation ideas need to be recognized when they appear, further developed and reported. This report is the first of four editions of a systematic approach to development, registration and reporting of innovations.

6.1 Objectives

Developing innovations is a challenging and sometimes messy process. Therefore, a systematic approach to registering and reporting innovations is needed. The systematic approach to development, registration and reporting of innovations in syn.ikia is made up of two elements.

- First, an innovation management process in the form of an iterative cycle is being developed to coordinate activities among the partners in the consortium responsible for developing innovations.

- Second, a tool reporting template in the form of a checklist has been developed to facilitate registrations, discussions and follow ups on innovations by WP6. The reporting tool is helpful to track syn.ikia innovations using the Technology Readiness Level (TRL) scale[1] with the interest of bringing 100% of syn.ikia innovations to be at least TRL7 at the end of the project period.

7. A systematic approach to development, registration and reporting of innovations in syn.ikia

A systematic approach to development, registration and reporting of innovations in syn.ikia is made up of two elements: an iterative innovation management process and a tool template which are further elaborated below.

7.1 syn.ikia innovation management process

The syn.ikia innovation management process is being developed in collaboration with the partners of syn.ikia, to foster a good environment for innovation. The process is closely related to the tasks of Exploitation (Task 6.2) as well as Market uptake (Task 6.3).

The process is mapped out over quarterly intervals over the project period.

- In Q1, following the registration and reporting process in the previous quarter, relevant innovation-themed activities (such as webinars/ innovation workshops) will be implemented in cooperation between WP6 and other work packages. Efforts will be made to connect the development and testing of the relevant innovations with selected demo cases as much as possible.
- In Q2, the syn.ikia Innovation Committee[2], comprising the delegates responsible for the topic of innovation from each partner, will be called on to register and report innovations. As a core activity in Task 6.1, the tool template (see 7.2) will be used to facilitate a discussion about the innovation with each partner who are in lead. Here, the objective is to provide a regular forum for partners to communicate and share the ongoing development of innovations as a consortium, with a focus to update the roles and responsibilities pertaining to each innovation and to inform the tasks and deliverables relevant for each innovation and whether innovations are relevant for and ready to be registered with DOFI (Disclosure OF Invention/ Innovation, see Appendix B).
- In Q3, the syn.ikia Innovation Committee will be called on to meet with a focus to connect with the task of Exploitation (Task 6.2) as well as Market uptake (Task 6.3). Plus energy buildings and neighbourhoods are in an exceptional stage of market development to make it possible to share and sell excess energy. The plethora of actors include and are not limited to building residents, building developers, municipalities and communities, grid operators and utilities, building owners and investors in energy efficiency and distributed generation. These actors can be expected to vary in the four demonstration sites across different climate zones, given varying regulatory environments and differing market forces in the different national contexts. The syn.ikia Innovation Committee will be

[1] Extract from Part 19 - Commission Decision C(2014)4995

[2] The innovation committee of syn.ikia comprising members from all partners, that the partners themselves have appointed. The committee gives advise and input in innovation related issues and is a resource for the innovation management work led by WP6. Furthermore, members of the innovation committee are asked to communicate and coordinate innovation related issues within their organization.

the regular forum to assess the expected impact, market potential and TRLs of the portfolio of syn.ikia innovations. Here, the objective will be to establish a regular forum to assess the expected impact, market potential and TRLs of the syn.ikia innovations. Here, as well as at any point in the process, the reporting and registration tool template is reviewed and further developed.

- Q4 is dedicated to registration and mainly reporting of innovations by each partner who leads the innovation. Similar to Q2, the tool template (see 7.2) will be used to facilitate a discussion about the innovation with each partner who are in lead, and whether innovations are relevant for and ready to be registered with DOFI (Disclosure OF Invention/ Innovation.

syn.ikia's innovation management process as an iterative cycle is outlined in Figure 1.

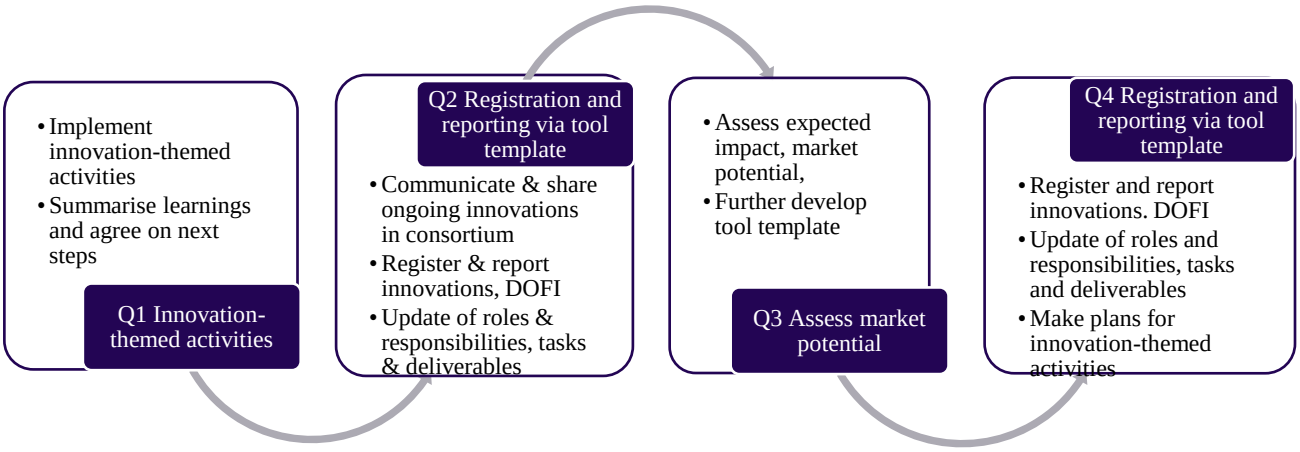

Figure 1 syn.ikia's innovation management process as an iterative cycle

7.2 syn.ikia innovation reporting tool: the template

This reporting tool template is a basis to facilitate a discussion about the innovation development with each partner who are in lead. In addition to the current and targeted TRLs, main stakeholders, expected impact, and the relevance to syn.ikia tasks and deliverables, this template includes:

- The type of innovation
- How this innovation creates new value and/or capture value in a new way
- A preliminary assessment of the market potential
- Plans for further developments

The relevance to tasks and deliverables in syn.ikia is not relevant for a public document and will be left out from the mapping of innovations in chapter 8.

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D6.1 A systematic approach to development, registration and reporting of innovations

Registration and reporting template

Working title of innovation: [ ] . 
Type of innovation: **Description:** {What is the innovation about?} **How is this innovation new:**
Main stakeholders: {Actor types in the combined value chains} **Expected impact:** {on energy, on climate?} **Market potential:** {where can it be applied?}
Relevance to syn.ikia tasks and deliverables: {Be specific} **Who has been involved:** **Lead:** [ ] . **Contributors:** [ ] .
Status of TRL: Current: [ ] . Target: [ ] . **Plans for further developments:**

Both the innovation management process and the tool template will be reviewed and developed not only in Q3, but continuously as the syn.ikia project progresses.

8. syn.ikia innovations

With four demonstration sites serving as innovation hubs, syn.ikia will deliver innovations connected to the energy and construction value chain. The syn.ikia innovations comprise a number of designs, tools, methods, and processes which will enable the large deployment of sustainable plus energy neighbourhoods (SPENs). 12 innovations were identified at the project proposal stage, as shown in Figure 2.

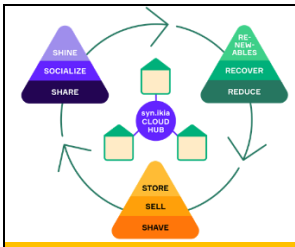
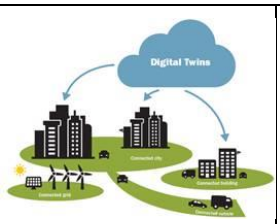
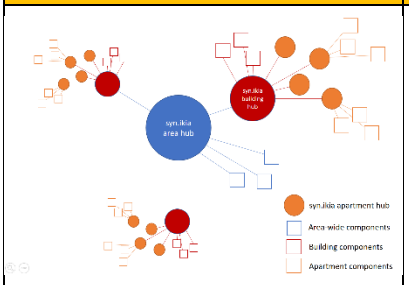
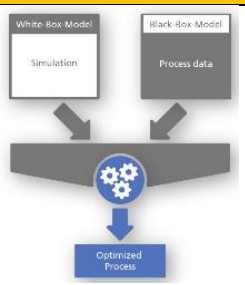
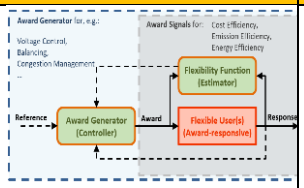
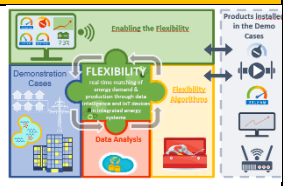
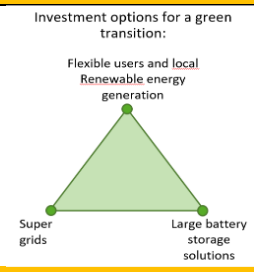
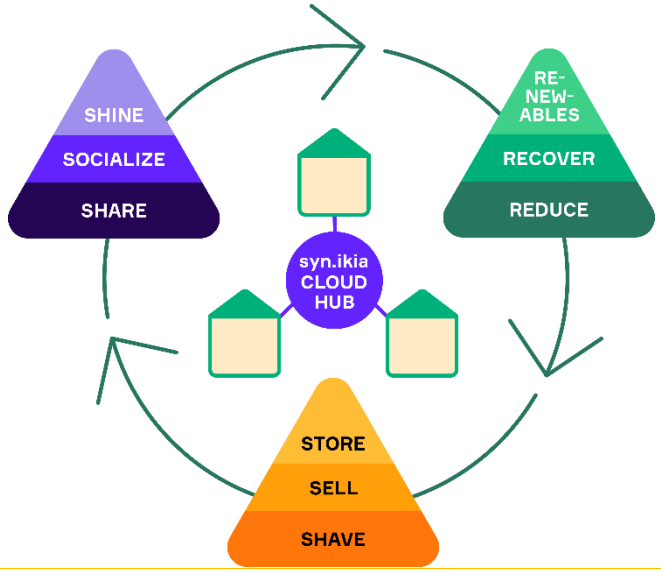
			
1) IED[N] Integrated Energy Design Process at the Neighbourhood Scale TRL 5-7	2) DigiTwin[N] Neighbourhood Scale Digital Twin TRL 5-7	3) POE[N] Post Occupancy Evaluation at the Neighbourhood Scale TRL 5-7	4) UST[N] Urban Simulation Tool at the Neighbourhood Scale TRL 5-7
			
5) DH[N] Syn.ikia Digital Cloud Hub TRL 5-7	6) GB[N] Syn.ikia Grey Box models TRL 5-7	7) FF[N] Syn.ikia Flexibility Functions TRL 5-7	8) FI[N] Syn.ikia Flexibility Index TRL 5-7
			
9) Smart Charging of Electric Vehicles at neighbourhood level TRL 7-9	10) Neighbourhood scale user engagement processes TRL 5-6	11) Business models for sustainable plus energy neighbourhoods TRL 7-9	12) Innovative policy development tools TRL 7-9

Figure 2 Overview of syn.ikia Innovations during project proposal (GA pg 17-18)

In the following section, the 12 initially identified innovations are described in more detail, including how the different innovations are defined, the main stakeholders, the expected impact and a preliminary assessment of the market potential. Furthermore, the lead participants and main contributors are given. Lastly, each innovation is also updated with the current Technology Readiness Levels (TRL) and the targeted TRL's. Some of the innovations have only been slightly developed or not yet developed at all since the project proposal. This is because syn.ikia is still in an early phase. The demonstration through the real life neighbourhoods, most of them realized over the coming years of the project, are the most important development and demonstration arenas for the syn.ikia innovations. Innovations are intended to be tested in most of the demo projects, but as a minimum to one.

At the end of this chapter, a list of emerging innovations is also provided. This list is expected to grow and materialize in demonstrated innovations during the project period.

8.1 IDP^{N} Integrated Design Process for Neighbourhoods



Previous working title: IED^{N} Integrated Energy Design Process at the Neighbourhood Scale

Type of innovation: Process Innovation

Description: Similar to the IED process, the IED^{N} process involves multi-disciplinary actors and the application of advanced simulation tools from the early design phases but applies optimization on the neighbourhood scale instead of at the single building level. In addition, the IED^{N} process involves a wider range of design issues than the traditional IED process. Based on the traditional process of integrated energy design (IED)[3] for low energy buildings, the syn.ikia team will develop and test a new process for integrated design of plus energy neighbourhoods, IED^{N}.

The process will be based on experiences from national, European, and international projects where the syn.ikia partners have participated.

How is this innovation new: The extending of integrated energy design guidelines for plus energy neighbourhoods and the connection to the cloud hub for sharing of information among units is novel.

Main stakeholders: Architects, Engineers, Developers, Construction Companies, Urban Planners

Expected impact: More efficient design and construction processes. Higher architectural quality and indoor environmental quality. Lower energy and power use, better integration of RES. Lower life cycle costs.

Market potential: Can be applied in any neighbourhood development with high ambitions on energy savings and flexibility. It is a basis for developing different tools for the process of constructing sustainable plus energy neighbourhoods.

[3] The IED process was developed within the IEA SHCP Task 23, Optimization of solar energy in large buildings, http://task23.iea-shc.org/, and the EU-project INTEND, https://ec.europa.eu/energy/intelligent/projects/en/projects/intend, in which NTNU participated.

Who has been involved: All demo sites.

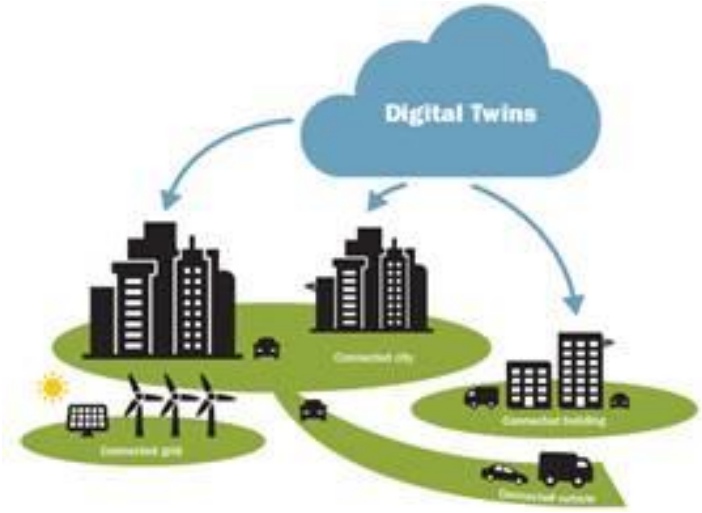
Lead: NTNU .

Contributors: IREC, TNO, DTU, ENFOR, ABUD, AREA, INCASOL, OBOS and incoming Austrian partner)

Status of TRL: Current: 5 . Target: 7 .

Plans for further developments: Ready at conceptual level, to be demonstrated in the four demo cases.

8.2 DigiTwin^{N} Neighbourhood Scale Digital Twin



Type of innovation: Model

Description: Digital twins are digital representations of objects, in this case of the neighbourhood, including the buildings, the energy infrastructure and renewable energy sources (RES). These digital twin models are derived from BIM data and tuned by IoT data and give an accurate (visual) representation of the neighbourhood. The DigiTwin^{N} aims to help with performance checks, optimisation, monitoring and control of a neighbourhood and can be applied during different stages of the neighbourhood's lifetime; design, construction, commissioning, and use phase.

How is this innovation new: The application of digital twins to enable the energy efficiency and flexibility at the neighbourhood level is new.

Main stakeholders: Project developers, engineers, electricity grid managers, building owners, housing corporations.

Expected impact: More efficient design process. Higher architectural quality and indoor environmental quality. Lower energy and power use, better integration of RES. Lower life cycle costs.

Market potential: All dwellings in Europe with renewable energy sources, where it is possible to control the HVAC systems

Who has been involved:

Lead: TNO

Contributors: AREA

Status of TRL: Current: 5 . Target: 7 .

Plans for further developments: Will be demonstrated in the Dutch demo case which expects an 18-month construction period. Will prepare user manual for the tenants.

8.3 EF^{N} Evaluation Framework for SPEN

Previous working title: Post Occupancy Evaluation at the Neighbourhood Scale

Type of innovation: Methodology

Description: The syn.ikia project has developed a methodology for the evaluation of Sustainable Positive Energy Neighbourhoods (SPEN). SPEN is defined as a group of interconnected buildings with associated infrastructure, located within both a confined geographical area and a virtual boundary. The common evaluation framework defines the Key Performance Indicators (KPIs) for the evaluation of SPEN for being implemented at two levels: building and neighbourhoods.

The selection of the main assessed categories and KPIs have been based on a holistic and exhaustive methodology which highlights the multiple dimensions when talking about sustainability in districts. At the building scale, the monitoring is done in selected dwellings of the neighbourhoods and at whole building level. At the neighbourhood scale, the assessment and the monitoring cover the whole neighbourhood, taking into consideration the interaction of buildings, the common active systems and flexibility strategies. This framework is designed to be implemented during the integrated design process and the operational phase.

According to the goals of the syn.ikia project and the SPEN definition a holistic and multidimensional framework has been designed, identifying five categories:

- Energy and Environment, which address overall energy and environmental performance, matching factors between load and on-site renewable generation and grid interaction, following the EN ISO 52000-1:2017.
- Economic, addressing capital costs and operational costs.
- Indoor Environmental Quality (IEQ), addressing thermal and visual comfort, as well as indoor air quality.
- Social indicators that address the aspects of equity, community and people.
- Smartness and Energy Flexibility.

How is this innovation new: The Evaluation Framework for Sustainable Positive Energy Neighbourhood adapts the existing methodologies for the evaluation at neighbourhood level [Van Dijk and Hogeling, 2019], including a multidimensional analysis [Valdés 2018, Tanguay et al. 2010)]. When the positive energy balance assessment moves from a single building to a group of buildings (Building Portfolio) at neighbourhood scale, new considerations are needed in terms of integrating urban and energy planning and evaluating the overall energy performance. The SPEN concept includes also more profound integration and interoperability with the grid and infrastructures, but also with its governance. Therefore, the neighbourhood scale will foster economic sustainability (e.g. some economies of scale),

aggregation synergies (e.g. efficiency deployment, flexibility, integration), at the same time governance in distributed resources and a considerable involvement of stakeholders and communities.

Main stakeholders: Developers, Users, Policy Makers

Expected impact: More efficient design process. Higher architectural quality and indoor environmental quality. Lower energy and power use, better integration of RES. Lower life cycle costs.

Market potential: Architectural construction and Engineering, Urban planning, Monitoring and Maintenance services, Energy management, Building owners and Building users.

Who has been involved:

Lead: IREC .

Contributors: NTNU, BPIE, ABUD, DTU, SINTEF, HOUSING EUROPE.

Status of TRL: Current: 5 Target: 7

Plans for further developments: Test the implementation of the Evaluation Framework for Sustainable Positive Energy Neighbourhood in the syn.ikia project, for the design process and for the operational phase.

8.4 UST^N Urban Simulation Tool at the Neighbourhood Scale

Type of innovation: Simulation Tool

Description: An Urban Simulation Tool for Sustainable Plus Energy Neighbourhoods (UST^N) has been developed for analysing the behaviour of shared infrastructures in plus energy neighbourhoods and support the design phase of the neighbourhood. The UST^N allow to simulate the behaviour of the inhabitants in the neighbourhood and test different strategies related to renewable energy integration, energy storage, energy flexibility and share of energy between buildings, from an electrical point of view (power flow analysis of the low voltage grid: voltage deviation of the nodes, loading of the transformer, peak power at the building and neighbourhood level in comparison with simultaneity factors). The urban simulation tool is useful for urban planners and energy planners when designing plus energy neighbourhoods.

UST^N is developed using co-simulation techniques (e.g. using TRNSYS, EnergyPlus, IDA-ICE for the building model, PandaPower Python package for the energy grid, R for the flexibility optimization algorithms, and Functional Mock-up Units to communicate the simulation engines). The UST^N includes:

- A dynamic building model to take into consideration the final design of the building (including on-site renewable systems) and potential flexibility strategies.
- Socio-economic characteristics of the neighbourhood, through the characterization of the building occupants and their electric devices (number of occupants and type of appliances).
- Different building typologies. The urban simulation incorporates (if needed, depending on the demonstration case) additional building typologies in order to emulate the interaction and synergies between the different energy profiles.
- Electrical grid characteristics, implementing the design and elements of the grid in order to evaluate the energy flows and optimize the design for plus energy neighbourhoods.

How is this innovation new: When planning a distribution grid, the leading design factor is the expected peak load which defines the magnitude of the power flows to be accommodated by the grid components. One method to size a system according to the number of connected buildings is the Velander method, which relates the expected peak power of a certain customer type to the total

annual electricity consumption of a group of customers [Salom et al. 2013]. This method might be appropriate for a conventional grid with a power flow in a single direction, however it is difficult to forecast the necessary level of grid enhancement for the bidirectional grids with increasing electrical demand and a supply from fluctuating Distributed Energy Resources (DERs) The design and validation of such increasingly complex networks is challenging, especially since experimental data is not easily obtained for such large scales. Therefore, simulation-based approaches, as UST^{N}, are possibly an appropriate tool to support the development of innovative grids [Steinbrink et al. 2017]. The simulation of such complexity calls for integrated models that can link specialized tools for each key element of the Low Voltage (LV) grid, the communication and control devices, the LV distribution grid equipment, and each connected building with its unique energy profile [Schumacher et al. 2017].

Main stakeholders: Urban planners, Developers, Energy Companies, Distribution System Operators

Expected impact: More efficient planning process. Higher architectural quality and environmental quality. Lower energy and power use, better integration of RES. Lower life cycle costs.

Market potential: Grid operators and utilities, Urban planning, Smart cities, flexibility and demand response services. Will be elaborated more in next reporting.

Who has been involved:

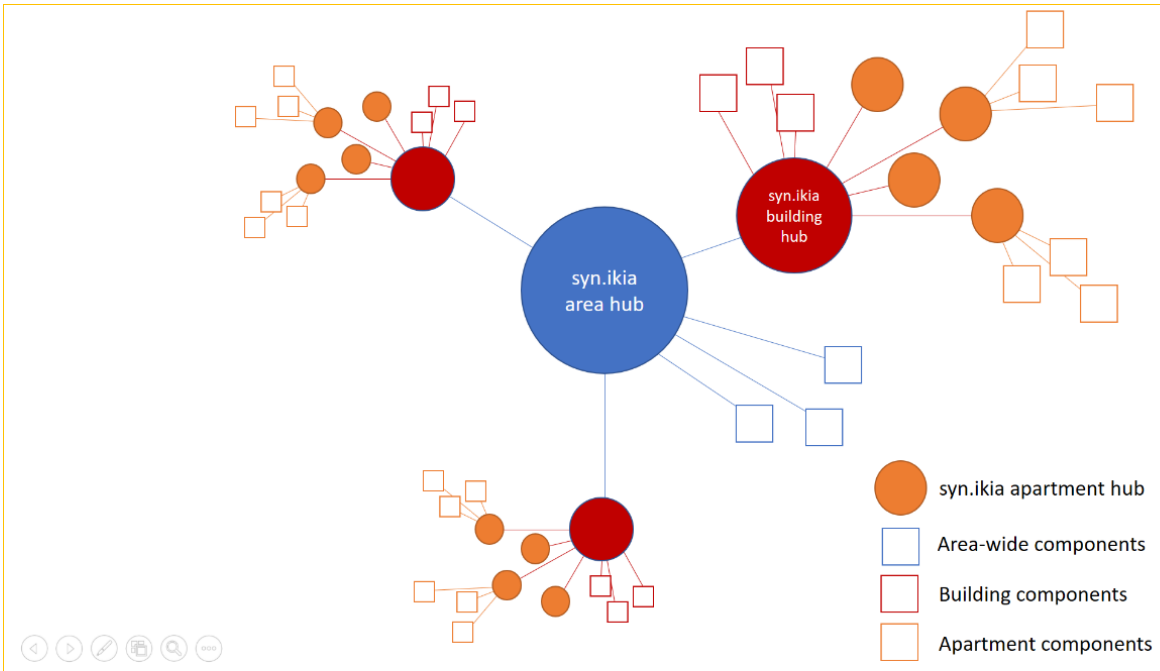
Lead: IREC .

Contributors: DTU, TNO, HE, NTNU, ABUD .

Status of TRL: Current: 5 . Target: 7

Plans for further developments: To be elaborated in the next report.

8.5 DH[N] Syn.ikia Digital Cloud Hub, Digitalisation Hub



- Design of syn.ikia building hub (red circles) FOG
- Design of syn.ikia apartment hub (orange circles) EDGE
- Interfaces to all active components/installations (all squares)
- Design of syn.ikia Cloud Hub (blue circle)

Type of innovation: Systems design

Description: syn.ikia will develop a digitalization hub (cloud hub) that enables the exchange of data between the building systems, the occupants and external cloud applications. This will provide storage for monitoring data and allow efficient evaluation of this data, and it is closely connected to the grey box models and flexibility functions described in other innovations (Grey Box models, Flexibility Function, Flexibility Index). It could also host user interfaces for occupants, operators, building owners, and other stakeholders.

How is this innovation new: This innovation will be demonstrated in new contexts, with several demo neighborhoods and offering opportunities (monitoring, evaluation and control) to different stakeholders.

Main stakeholders: ICT companies, Energy Companies, Aggregators, Developers, Facility Managers

Expected impact: The impact described here embodies the value created by other syn.ikia innovations, i.e. Grey Box models, Flexibility Function, Flexibility Index, and plays the role of the enabler, the system that can make all other innovations work together. This will lead to:

- Increased integration of RES and avoidance of curtailment.
- Enhanced energy security.

- Discovering and delivering demand flexibility to the operatives/aggregators and enables shifting/shedding to times of cheap, green generation, facilitating the reduction of RES curtailment and the decarbonisation of the EU energy system.
- Higher level system, yet designed with a human-centric aspect, so with intelligent building energy management it will achieve all the above but with positive impact on user health and comfort aspects.

Market potential: To be elaborated in the next reporting.

Who has been involved:

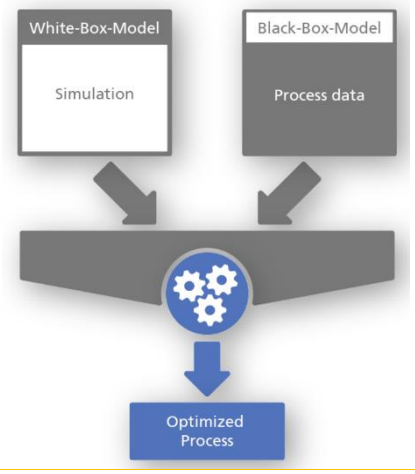
Lead: ENFOR .

Contributors: DTU, NTNU, IREC, TNO, SINTEF, ABUD .

Status of TRL: Current: 5 . Target: 7 .

Plans for further developments: To be elaborated in the next reporting

8.6 Neighbourhood Scale Grey Box Models, GB^N



Type of innovation: Model (software)

Description: syn.ikia will develop and use grey box models to perform model predictive control to optimize the performance of syn.ikia. neighbourhoods. These models will be based on existing research on using grey box models performed by other project partners. The syn.ikia grey box models will take into account physical characteristics of buildings and energy systems, weather forecasts, as well as monitoring data based on occupant behaviour and actual weather data from the demonstration sites.

How is this innovation new: The grey box models will be used in a new dimension of implementation, upscaled to building neighborhoods (previous experience are related to building/unit level). Moreover, the four demo-cases in four different climate zones offer opportunities (monitoring, evaluation, and control) to different stakeholders.

Main stakeholders: Building engineering companies, BMS companies, ICT companies, Energy Companies, Facility Managers.

Expected impact: The impact of this innovation is strictly connected to the value created by the syn.ikia innovations "syn.ikia Digital Cloud Hub", "Flexibility Function", "Flexibility Index". The grey box models will lead to:

- Easy modelling of existing and new buildings, for model predictive control goals
- Easy characterization of buildings

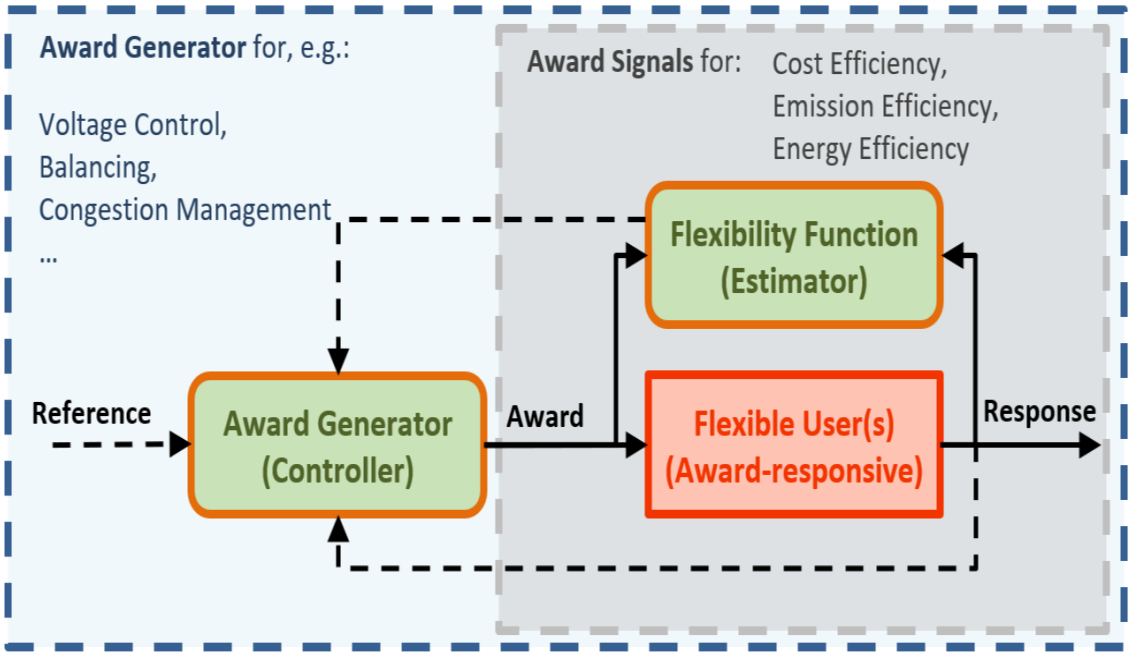
Market potential: New and existing building stock. Will be further elaborated in the next report.

Who has been involved:

Lead: DTU .

Contributors: NTNU, IREC, TNO, ABUD .
Status of TRL: Current: 5 . Target: 7 . **Plans for further developments:** To be elaborated in the next reporting

8.7 FF^N syn.ikia Flexibility Functions



Type of innovation: Model (Software)

Description: Based on **Neighbourhood Scale Grey Box Models, GB^N**, the syn.ikia team will develop flexibility functions **FF^N** and forecasts to unlock the flexibility potential of plus energy neighbourhoods. The flexibility functions are prerequisites for dynamic optimization of buildings and their HVAC systems in different climates and future price/tariff scenarios.

How is this innovation new: As for the grey box model, also the FF^N will be used in a new dimension of implementation, upscaled to building neighborhoods (previous experiences are related to building/unit level). For the FF^N, the four demo-cases in four different climate zones offer new opportunities for improved monitoring, evaluation, and control of energy-, emission- and cost-efficiency at the neighbourhood scale while avoiding peak loads and ensuring a good indoor climate.

Main stakeholders: Building engineering companies, BMS companies, ICT companies, Energy Companies, Facility Managers.

Expected impact: The impact of this innovation is connected to the values created by the syn.ikia innovations "syn.ikia Digital Cloud Hub", "Neighbourhood Scale Grey Box Models", and "Flexibility Index". The FF^N will lead to:

- Higher usage of renewables for heating, cooling and ventilating buildings in neighbourhoods
- Lower CO_2 emissions of neighbourhoods
- Lower running costs for heating, cooling, and ventilation

Market potential: New and existing building stock. Will be more elaborated in the next report.

Who has been involved:

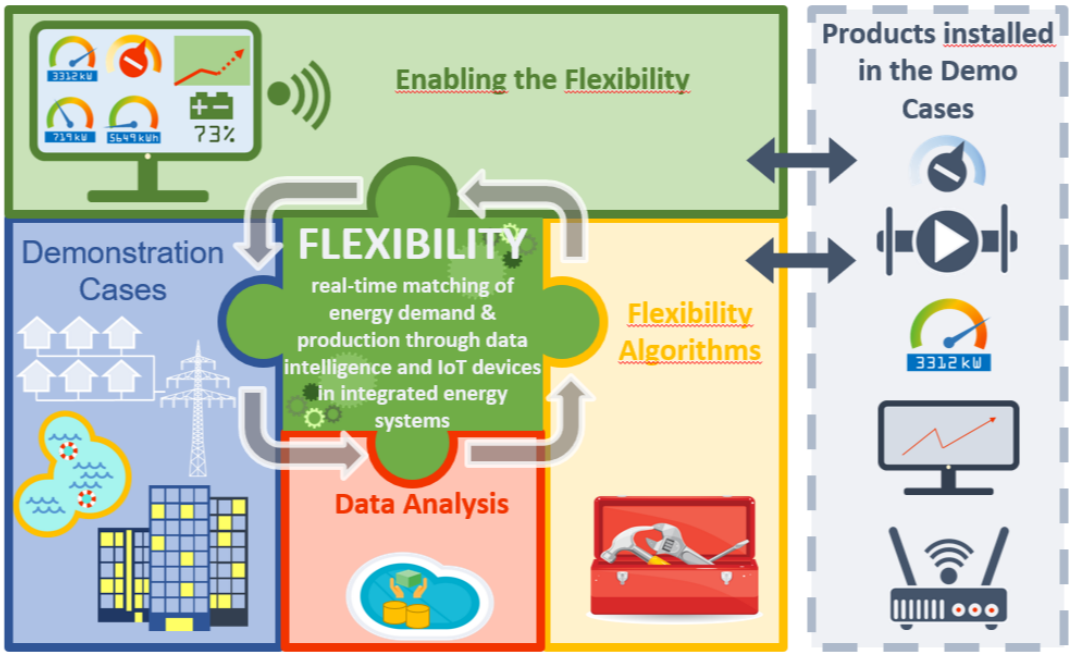
Lead: DTU .

Contributors: DTU, NTNU, IREC, TNO, ABUD .

Status of TRL: Current: 5 . Target: 7 .

Plans for further developments: To be elaborated in next reporting

8.8 syn.ikia Flexibility Index



Type of innovation: Model

Description: Based on the **Neighbourhood Scale Grey Box Models, GB^N**, we will develop a flexibility index, **FI^N**, for different climate zones, that will provide inputs to regulatory bodies on how to design future taxes, tariffs, and markets, to help promote sustainable plus energy neighbourhoods. In relation to this, the syn.ikia team will also use **forecast algorithms** for predicting the renewable energy production and the use of energy in the demo cases. For scaling up the flexibility models to the European level, the syn.ikia team will use **virtual demo cases** combined with sensitivity analyses to show the effect of different energy prices, legislation, climate changes, as well as social and technological developments.

How is this innovation new: As for the grey box model and for the FF^N, the FI^N will be used in a new dimension of implementation, upscaled to building neighborhoods (previous experiences are related to building/unit level). For the FF^N, the four demo-cases in four different climate zones offer opportunities for improved monitoring, evaluation, and control of energy performance. In addition it will positively impact indoor climate, costs and CO2 emissions.

The FF^N will offer the opportunity to fairly evaluate the real flexibility potential of buildings with a relatively easy-to use tool.

Main stakeholders: Building engineering companies, BMS companies, ICT companies, Energy Companies, Facility Managers

Expected impact: The impact of this innovation is strictly connected to the value created by the syn.ikia innovations “syn.ikia Digital Cloud Hub”, “Neighbourhood Scale Grey Box Models”, and the FF^N. The FI^N will mainly make the evaluation process of the flexibility potential of buildings easier, and comparable across Europe.

Market potential: New and existing building stock. Will be more elaborated in the next report.

Who has been involved:

Lead: DTU .

Contributors: DTU, NTNU, IREC, TNO, ABUD .

Status of TRL: Current: 5 . Target: 7 .

Plans for further developments: To be elaborated in next reporting

8.9 Neighbourhood scale user engagement processes

Type of innovation: User Engagement Process

Description: An online platform for market-based optimisation of energy supply and demand. The residents of the neighbourhood can be *prosumers* of energy, i.e. they both consume and produce energy. A user-friendly online engagement platform aims at empowering building users to control their energy systems and adapt their behaviour accordingly. The goal is to use the locally generated energy in the most efficient way.

This innovation has a two-fold goal: first, on a technological level, to enable regular monitoring of real behaviour of buildings and usage patterns and user comfort. The aim is to enhance user involvement and - satisfaction by taking an active part in the energy production and distribution in your neighbourhood. Second, on a social level, to empower user's control as prosumers, environmental awareness and behavioural change through user-friendly digital platforms, user engagement methods and tools and training.

The User Engagement Process will take different approaches for the new built and renovation demo projects that will be implemented during the design and operational phases of the project (from M12 onwards).

How is this innovation new: This innovation is expanding on platform prototypes currently under development in other projects. In syn.ikia, these platform prototypes will be extended and adapted for specific needs, and demonstrated in dwellings owned or managed by social, public or cooperative housing providers.

Main stakeholders: End users (building users/residents); Housing companies/ housing associations (Building owners); Energy companies, Manufacturers of renewable energy systems (PV, BIPV) and maintenance service providers; Software providers; Planners/ developers/ architects; Facility/ District managers.

Expected impact: Technological and Social, elaborated below.

Technological: A regular monitoring of energy consumption in buildings, usage patterns and indoor environmental quality (IEQ) parameters might enhance the user involvement and satisfaction.
In this first phase, concrete impacts on energy saved or GHG reductions are difficult to estimate.

Possible indicators: Watts of energy conserved (kW), Renewable energy generated (kWh), Tons of CO_2 equivalent emissions reduction, Urban infrastructure efficiency, Energy flexibility function, Energy costs saved, Number of final users involved.

Social: Empowerment within the neighbourhood/ community driven by housing affordability, improved quality of life, and environmental consciousness to inform and enable behavioural change. Peer-to-peer learning and training of the tool and exchange/ knowledge transfer of sustainable use of energy between neighbours might increase the involvement of residents.

Possible indicators: Number of people accessing training and actively using an engagement tool; Wellbeing & satisfaction of users, IEQ indicators; Number of people with increased ability to manage their energy consumption.

Market potential: To be elaborated upon in the next report.

Who has been involved:

Lead: Housing Europe and BPIE .

Contributors: Enfor, ABUD, IREC, NTNU, Incasol, OBOS, AREA and SINTEF.

Status of TRL: Current: 5 Target: 7

Plans for further developments: Housing Europe and BPIE will explore the plans and needs of the pilot projects for a potential online user engagement platform in more details, either by direct interaction in online meetings or by carrying out an initial survey among the syn.ikia pilot partners to better understand their planned stakeholder involvement which would help the decision-making process and streamline user journeys.

BPIE and HE will take snapshots of the project development stages in the initial stages and of the neighbourhoods' energy system status quo (M12-M54).

Towards the end of the project, BPIE will lead a survey targeting the demo cases residents to get insights on all aspects relating to energy and their behaviour/perceptions and actions related to the project and more, and produce an infographic, a video and short guidebook based on the results.

8.10 Smart Charging of Electric Vehicles at neighbourhood level

This innovation aims at controlling time and rate at which the electric vehicles are charged according to signals from the grid (price, CO_2), the local renewable energy generation, loads and weather forecasts.

TRL: Current: 7. Target: 9

Main stakeholders: Energy companies, ICT Companies, Developers, Facility managers, End users

Expected impact: Load shaving, increased use of RES, reduced emissions

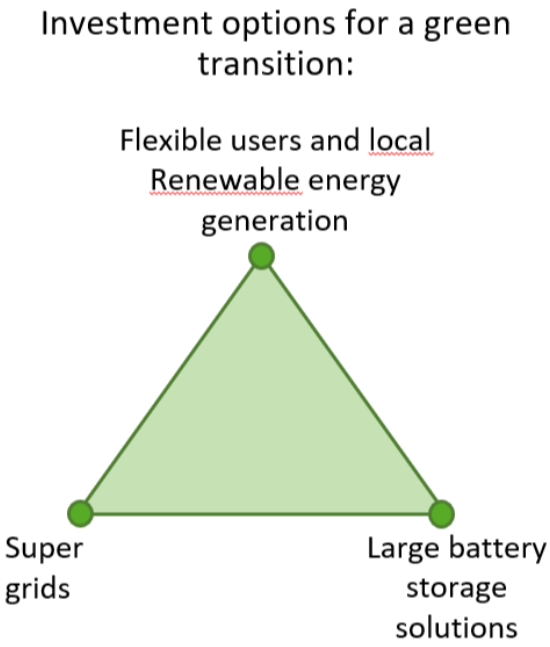
Description: Controlling time and rate at which the electric vehicles are charged according to signals from the grid (price, CO_2), the local renewable energy generation, loads and weather forecasts.

Plans for further developments: To be elaborated in next reporting

WP2 Lead: NTNU	Contributors: Demo Developers

8.11 Business models for sustainable plus energy neighbourhoods

This innovation will be further developed as work in the responsible task starts.



TRL: Current: 7. Target: 9

Main stakeholders: Energy companies, ICT Companies, developers, FMs, end users

Expected impact: Commercialisation of innovations, identifying emerging business cases, quantifying revenues and cost-benefits, supporting long-term viability of SPEN.

Description: Concrete guidelines on the exploitation and commercialization of plus energy neighbourhoods. Syn.ikia identifies sustainable business models needed for a full commercial deployment of plus energy building solutions. These have a proven value creation and business cases in line with different stakeholders and impact on best financing opportunities.

Plans for further developments: To be elaborated in next reporting

WP6 Lead: NTNU	Contributors: All

8.12 Innovative policy development tools

TRL: Current: 7. Target: 9

Main stakeholders: Policy makers at local, national and EU-level

Expected impact: A web-based instrument will valorise the potential non-energy benefits of SPEN and increase the understanding and value. Policymakers and investors can use this to build a convincing case for plus energy neighbourhoods

Description: Trigger systemic change by empowering decision-makers to develop innovative policies and programmes, and increase the uptake of SPEN. The development of a replicable methodology of plus energy houses at neighbourhood level for the measurement of social, economic and environmental benefits and their potential impact, will guide decision makers to have a holistic impact assessment of plus energy buildings, rather than just costs. For example, the tool can attribute the saved health care costs in the area due to better living conditions and improved air quality.

Plans for further developments: To be elaborated in next reporting

WP5 Lead: BPIE	Contributors: All

8.13 Emerging innovations

In this sub-section, we will give an overview of emerging innovations that are to be further developed and demonstrated throughout the next years. This list of emerging innovations is expected to grow as the syn.ikia project progresses.

1. Flexible use of heat pumps for space heating.

Description: Implementation of flexibility models in the control of the heat pumps for space heating.

Expected impact: Better use of renewable energy sources, peak load shaving

Lead partner: TNO

Status of TRL: Current: 5 Target: 7

2. Flexible use of boilers (domestic hot water)

Description: Implementation of flexibility models in the control of the boiler for domestic hot water.

Expected impact: Better use of renewable energy sources, peak load shaving.

Lead partner: TNO

Status of TRL: Current 5 Target: 7

3. Integral Energy Management

Description: The development and implementation of energy management on a neighbourhood scale is necessary to achieve the syn.ikia goals. The scope of energy management will be studied to bring together energy communities in a network, constituting a microgrid for exchange of energy. These communities may consist of both public facilities and housing buildings. Energy production will be higher than consumption, so there will be energy surpluses. Given the time lag between production and consumption, strategies need to be made to optimize the production. That is why the management of production coordinated with instantaneous consumption through the creation of energy communities is a priority of the project.

Expected impact: More efficient design and construction processes. Higher architectural quality and indoor environmental quality. Lower energy and power use, better integration of RES. Lower life cycle costs. More control over the energy market. Improved management of energy and of the networks included in the microgrid.

Lead: INCASÒL

Status of TRL: Current: 4 Target 7

9. Future updates

Three more editions of this deliverable are planned over the course of the project due in M24, M36 and M48 respectively.

10. References

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11. Appendices

Appendix A Relevant innovation terms and definitions for syn.ikia

Open innovation principles

Syn.ikia's innovation management process works on open innovation principles. Open innovation is understood as an open way of innovating where ideas can be generated inside or outside the company (or brought outside the company). Coined by Chesbrough (2003), open innovation is a paradigm that assumes that firms can, and should, use external ideas and internal ideas, as well as external and internal paths to market, in order to advance their technology. Open innovation also assumes that internal ideas can be taken to market through external channels, outside the current businesses of the firm, to generate additional value. In other words, open innovation means that ideation can happen in the company or outside during the development and testing phases. In the same way, exploitation can also be done in the company or done by others during the commercialisation phase (see Figure 3).

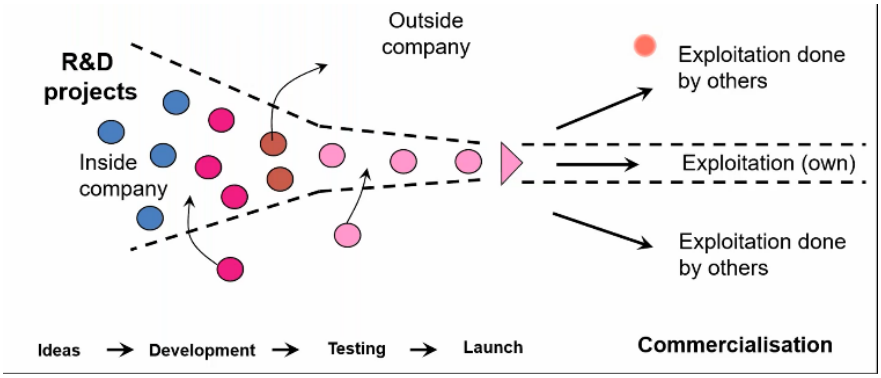

Figure 3 Open innovation (Chesbrough, 2003)

Classifying innovations

While the development of innovations has been characterized to be a non-linear process and cannot be managed in traditional ways (Van de Ven et al. 2008; Van de Ven, 2019), it can be very useful to classify them. While most practitioners and researchers agree on the distinction between invention (new ideas) and innovation (implementing these in practice), the typology of innovation is less clear.

Innovations have quite commonly been classified into product, process and organisational innovations (Fagerberg et al. 2012). For a more nuanced classification, innovations have also been systematically broken down into ten types (Keeley et al., 2013). These ten types encompass new ways of doing business and creating value, new systems of products and services, and even new interactions and forms of engagement

between a firm and its customers. As shown in Figure 4, the Ten Types Framework spans from the blue components on the left, which are focused on the innermost workings of a firm and its business system, to the orange components on the right, which are focused on more customer-facing elements of a firm and its business system.

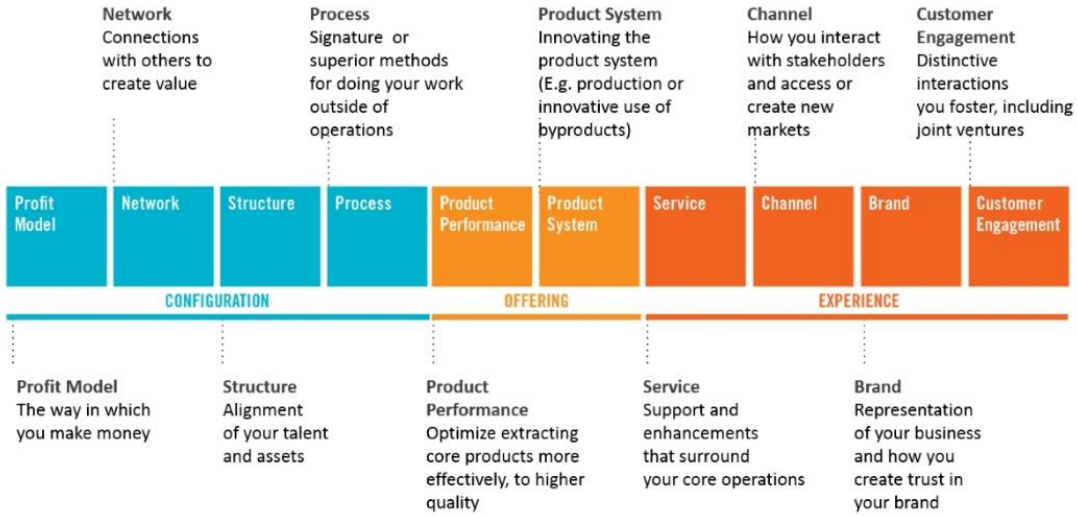

Figure 4 Innovation: The Ten Types Framework (Keeley et al. 2013)

In the context of developing processes, technologies, systems and tools for SPENs, the syn.ikia project can be expected to generate many types of innovations. The Ten Types Framework could be useful for identifying and classifying some of these emerging innovations.

Technology Readiness Levels (TRLs)

As syn.ikia is an Innovation Action project within the Horizon 2020 Research and Innovation Framework Programme, we draw from the EU definition of the Technology Readiness Levels[4], which specifies:

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified

[4] Extract from Part 19 - Commission Decision C(2014)4995

- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

As shown in 7.2 syn.ikia innovation reporting tool: the template , syn.ikia innovations will be tracked using the Technology Readiness Level (TRL) scale with the interest of bringing 100% of syn.ikia innovations to be at least TRL7 at the end of the project period. In other words, all the innovations should be tested and operating in each of the demonstration sites at pre-commerical scale.

Assessing expected impact and market potential

All innovations registered and reported with Task 6.1 will have expected impact and market potential regularly assessed. The project description has outlined the combination of two value chains (see Figure 5), that of the *built environment* and that of *residential energy*, that can serve as a useful point of departure to identify the relevant stakeholders for assessing the expected impact and market potential of an innovation.

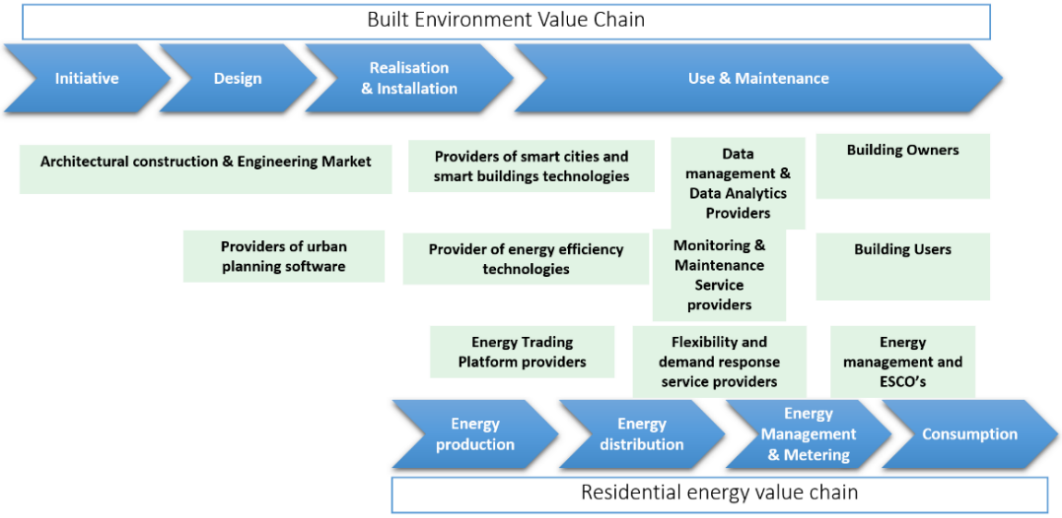

Figure 5 Combined value chain for SPENs

(GA pg 30)

Appendix B Disclosure OF Invention/ Innovation (example)

NTNU
Technology Transfer as

DISCLOSURE OF INNOVATION/INVENTION

Please use this form to disclose any of your innovations/inventions.

An innovation/invention can be a product, method, component, process or sub process, model or sub model, concept, system (software/hardware), a service that is new or significantly improved with respect to properties, technical specifications or ease of use. An innovation/invention can also be a new application of existing knowledge or commercialization of R&D results.

After submitting this form to **ide@tto.ntnu.no** and (**faculty@email**) or initiating any contact with NTNU Technology Transfer (TTO), you will be contacted by TTO to learn more about your innovation/invention and agree on the appropriate way forward.

In order to obtain a valid patent, it is crucial that public disclosure of any information related to the innovation/invention does not occur until AFTER an appropriate patent application has been filed.

This form fulfills the requirements of the Norwegian law of "Arbeidstakeroppfinnelser" and NTNU's internal Guidelines and policy for IPR.

The innovation/invention

Title/Short name:

Date of innovation/ invention:

Description: (Purpose, Technical description, Applications, New Features, Advantages & improvements to existing solutions)

Potential utilization and users(s) of the innovation/invention:

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DISCLOSURE OF INNOVATION/INVENTION

Status

At what stage of development is the innovation/invention?

☐ Concept ☐ Preliminary data ☐ Tested in practice ☐ Prototype etc. ☐ Other (comment):

How is the work financed?

Is the innovation/invention dependent on further research and/or development in order to reach a product/solution? ☐ No ☐ Yes (comment):

Innovator(s)/Inventor(s)

Department / Centre / Engineering area:

Main contact person:

Name: E-mail: Phone:

☐ I approve that my email and phone number is handled in line with NTNU Technology Transfers Privacy Policy.

Contributors to the innovation/invention:

Name:	Role/contribution:	Signature: *	Date:

* can be collected later

R&D partner(s):

Name:	Role/contribution:	Company

Disclosure of innovation/invention, page 2/2 **CONFIDENTIAL**

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NTNU Norwegian University of Science and Technology

DTU Technical University of Denmark

BPIE

SINTEF

HOUSING EUROPE

IREC Shaping Energy for a Sustainable Future

OBOS

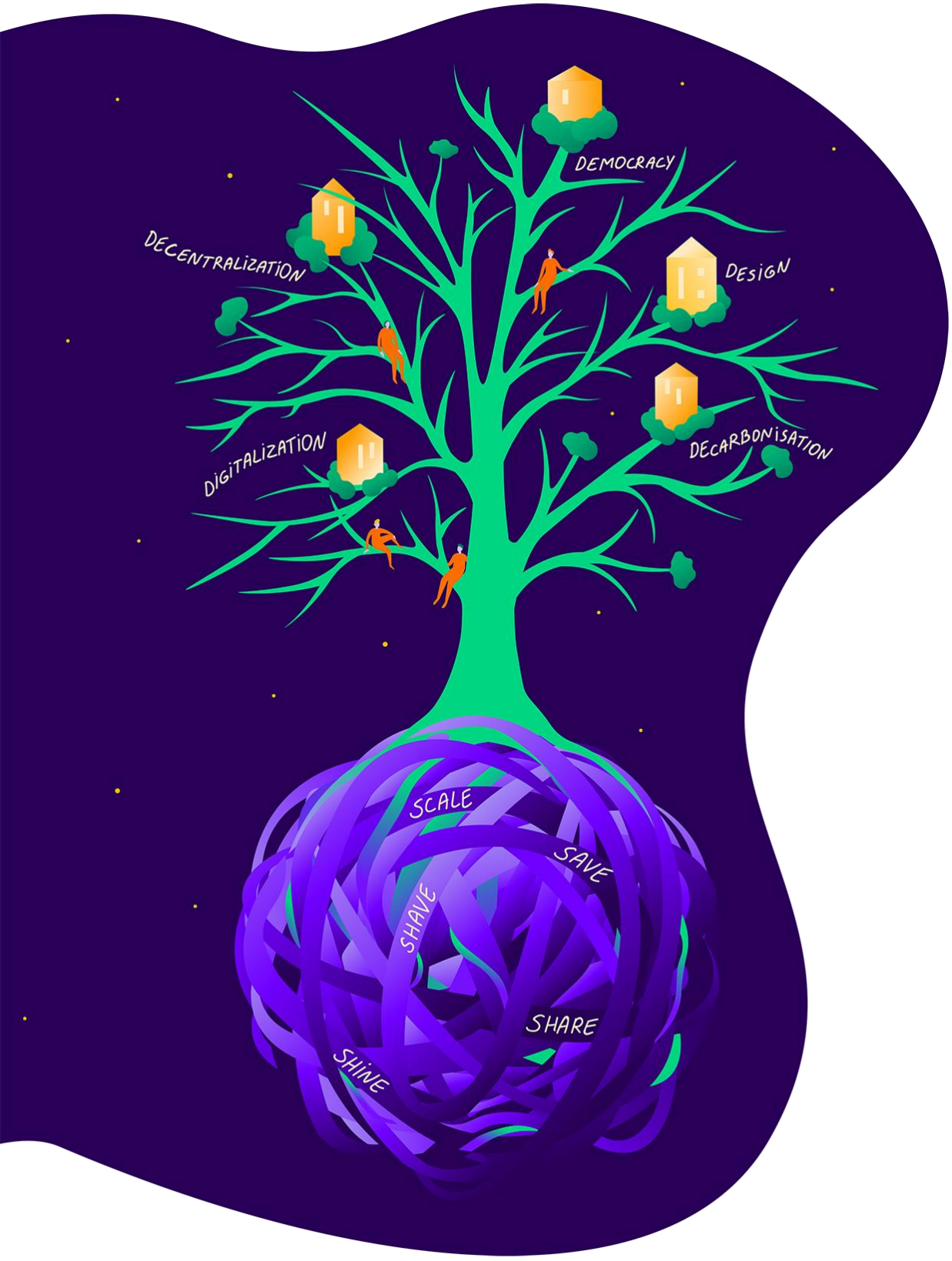
area

INCASÒL Institut Català del Sòl

TNO innovation for life

ENFOR

ABUD Advanced Building & Urban Design


DEMOCRACY
DECENTRALIZATION
DESIGN
DIGITALIZATION
DECARBONISATION
SCALE
SAVE
SHARE
SHARE
SHINE