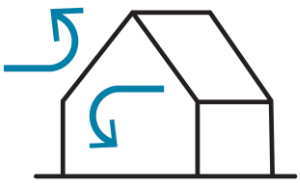
Strategic Energy Technology Plan

IWG5 Buildings

Implementation Plan

Implementation Working Group on
(Resource and) Energy Efficiency in Buildings (IWG5)



September

2024

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ABBREVIATIONS

AI	Artificial Intelligence
AMI	Advanced Materials Initiative
BIM	Building Information Modelling
B4P	Built4People Partnership
C(C)HP	Combined (cold) heat and power
CDW	Construction and Demolition Waste
CETP	Clean Energy Transition Partnership
CRMA	Critical Raw Materials Act
CoP	Community of Practice
CPR	Construction Products Regulation
DfD	Design for Disassembly
DHC	District Heating and Cooling
DUT	Driving Urban Transitions to a Sustainable Future Partnership
ECTP	European Construction and sustainable built environment Technology Platform
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
ETIP	European Technology and Innovation Platform
ETIP Geothermal	European Technology & Innovation Platform on Geothermal
ETS	Emission Trading System
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
GWP	Global Warming Potential
HEMS	Home Energy Management System
HP	Heat Pumps
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IPV	Integrated Photovoltaics
IWG CSP	Implementation Working Group on Concentrated Solar Thermal Technologies
IWG4	Implementation Working Group on Energy Systems
IWG5	Implementation Working Group on Energy Efficiency in Buildings
IWG6	Implementation Working Group on Sustainable and efficient energy use in industry
IWG PV	Implementation Working Group on Photovoltaics
KPI	Key Performance Indicators
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LHTES	Latent Heat Thermal Energy Storage
MEPS	Minimum Energy Performance Standards
NBRPs	National Building Renovation Plans
NECPs	National Energy and Climate Plans
NZEB	Nearly Zero-Energy Buildings
NZIA	Net-Zero Industry Act
OPC	Open Platform Communications
PCM	Phase Change Material
PEF	Product Environmental Footprint
PV	Photovoltaics
R&D&I	Research, Development and Innovation

REC	Renewable Energy Certificates
RED	Renewable Energy Directive
RES	Renewable energy sources
RHC ETIP	European Technology and Innovation Platform on Renewable Heating and Cooling
R&I	Research and Innovation
SET Plan	Strategic Energy Technology Plan
SRI	Smart Readiness Indicator
SRL	Social Readiness Level
TCM	Thermochemical
TES	Thermal Energy Storage
TRL	Technology Readiness Level
WLC-GWP	Whole Life Cycle-Global Warming Potential

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EXECUTIVE SUMMARY

The first version of the Implementation Plan of the Implementation Working Group on Energy Efficiency in Buildings (IWG5) dates from November 2018. It addresses 8 Research and Innovation (R&I) activities focusing on new materials and technologies for energy efficient solutions for buildings and cross-cutting heating and cooling technologies for buildings.

The second version of the Implementation Plan of IWG5 will come into force in summer 2025. For this, the update process is divided in two phases, first an update of technical issues in the summer of 2024, and then a second update in summer 2025 including societal issues and new policy developments. The update process is supported by a coordination and support action. The revised Implementation Plan of IWG5 (first update) is taking into account the Green Deal and several updated directives, most importantly the Communication on the revision of the Strategic Energy Technology Plan (SET), adopted on 20 October 2023. It is harmonising the strategic objectives of the original SET Plan with the European Green Deal and REPowerEU. It also aligns the Implementation Plan with the objectives of the new Energy Performance of Buildings Directive (EPBD) adopted in April 2024 and it supports the EU's targets in reducing greenhouse gas emissions by 2030 and reaching European Climate neutrality by 2050.

Overall, the new Implementation Plan of IWG5 (technical update) outlines 11 Targets covering the subgroups of IWG5 on Sustainable materials and technologies for energy-efficient solutions for buildings (5.1) and Cross-cutting heating and cooling technologies (5.2). **9 key Research and Innovation Activities address the topics of IWG5:**

- **Sustainable materials for buildings**
- **Prefabricated active modules for façades and roofs or Key Enabling Technologies for active building skins**
- **Digitalisation of buildings**
- **Heat Pumps**
- **Cogeneration of (Cooling), Heat and Power**
- **District Heating and Cooling**
- **Thermal Energy Storage (sensible, PCM and TCM)**
- **Solar Thermal and PVT**
- **Technology combination and integration**

As resource efficiency and circularity is becoming more and more important in the building sector, we recommend renaming the IWG to Resource and Energy Efficiency in Buildings.

1. General introduction

1.1. Framework conditions

Europe's buildings and its construction sector face several challenges that will require new thinking and the large-scale deployment of innovative solutions supporting the green transition. The operation of buildings, including heating, cooling, domestic hot water, lighting, and powering appliances, constitute a substantial portion of global energy consumption and carbon emissions. It is responsible for 30% of global final energy consumption and 27% of total energy sector emissions while at the EU level the ratio is even higher: 40% of final energy consumption and 36% of energy related Greenhouse gas (GHG) emissions[1]. Thus, buildings significantly contribute to carbon dioxide (CO2) emissions and are a major energy consumer.

Furthermore, the construction and operation of buildings requires enormous resources and generates waste. Indeed, construction and demolition waste (CDW) accounts for almost 40% of all waste generated in the EU.[2] Europe has a limited raw materials production and is often dependent on imported materials. Resource depletion is another crucial factor affecting the construction sector that can lead to environmental destruction, deforestation, and water shortage, ultimately impacting ecosystems and biodiversity both in Europe and abroad. Moreover, the buildings and infrastructure in urban areas can contribute to the urban heat island effect, with buildings absorbing and retaining heat in urban environments. This effect can exacerbate energy demands for cooling and impact local climate patterns.

These and other challenges will require an unprecedented transformation in Europe's building stock. In addition, the clean energy transition needs to be just for building users, the construction sector and society at large, where nobody is left behind. People-centric solutions are needed to engage and mobilise all stakeholders, while identifying and helping vulnerable groups. Moreover, the clean energy and green transition is putting into evidence large skill gaps in the construction sector and related sectors across Europe.

In view of these challenges **IWG5 promotes mainstreaming innovative renewable energy and energy efficiency technologies in buildings, improving the renovation rate while also considering resource efficiency and circularity of buildings.** IWG5 offers support by showing green transformation tools and pathways. IWG5's membership is composed of political decision-makers, the construction industry and researchers, placing it at the intersection of public policies and innovation. This Implementation Plan therefore identifies innovative technologies and new approaches for sustainable buildings while also considering policy strategies, legislation and funding programmes. It also addresses the new elements of the SET Plan revision.

In line with the European Green Deal and the legally binding targets of the European Climate Law, the European Union (EU) has the objective of being climate neutral by 2050, with an intermediate target for 2030 of 55% reduction in emissions compared to 1990 levels.[3] To achieve this, the EU has agreed to significantly increase its 2030 climate and energy ambitions by revising key legislation under the Fit for 55 package. The revised Energy Efficiency Directive (EED) significantly raises the EU's ambition on energy efficiency. It more than doubles the

[1] EC, 2020: Energy efficiency in buildings
[2] EC, Techno-economic and environmental assessment of construction and demolition waste management in the European Union (2024). https://publications.jrc.ec.europa.eu/repository/handle/JRC135470 (assessed February 19, 2024)
[3] EC 2023: 2050 long term strategy

annual energy savings obligation by 2028. The Energy Performance of Buildings Directive (EPBD) increases renovation requirements with its Minimum Energy Performance Standards (MEPS) and new obligations for public buildings. The Renewable Energy Directive (RED) brings in new opportunities to mainstream renewable energy in buildings, with an ambitious renewables target and a new target for innovative renewable technologies. In addition, the EU Emissions Trading System (ETS) will be extended in 2027 to also cover carbon emissions from fossil fuel boilers in buildings, while at the same time creating a new stream to renovate buildings for the less well-off under the Social Climate Fund. With ETS2 and the revised Construction Products Regulation (CPR) the whole life carbon potential of buildings will play a more prominent role.

REPowerEU[4] highlighted the necessity of decarbonising the EU's building stock to reduce its dependence on foreign energy sources and thereby increasing its energy security. A key element of this is the accelerated deployment of heat pumps (HP), with the aim to install an additional 30 million HP by 2030, that should result in important innovations for the sector in terms of manufacturing and new applications. District heating and cooling (DHC), Combined (cold) heat and power (C(C)HP), solar thermal and thermal storage industries are also expected to drive the decarbonisation efforts of the building sector. Consistent policies are needed which allow the sector to plan ahead (e.g., investments) as well as cooperation of several partners/companies in the complete value chains (e.g., R&D&I), coupled with adequate support.

The European Commission's Green Deal Industrial Plan[5] lays out a framework to strengthen the EU's clean industry and to create jobs supporting the green transition. Within it, the Net-Zero Industry Act[6] (NZIA) identifies energy efficiency and renewable energies in buildings, such as heat pumps, as key technologies that need to be fostered and supported in Europe. Among several measures supporting innovation, NZIA opens the opportunity to test new products in "Sandboxes", it frees funding for manufacturing facilities and it strengthens requirements for both green and pre-commercial public procurement. The Critical Raw Materials Act (CRMA) seeks to secure the provision of raw materials needed for the clean energy transition which requires a wide range of minerals and metals as for example for PV panels.[7]

The right implementation of these policies via well designed National Energy and Climate Plans (NECP)[8] and National Building Renovation Plans (NBRP) is essential to speed up the deployment of new technologies and innovative approaches in a way that maximises sustainability, maintains comfort for building users and reduces costs for all.

1.2. IWG5

The Implementation Working Group on Energy Efficiency in Buildings (IWG5v) works to unlock the energy savings potential of the building sector. This includes boosting the potential of existing and new buildings. It covers topics such as sustainable materials, digitalisation, and heating and cooling technologies and their integration into buildings.

4 EC 2022: REPowerEU
5 EC, 2023: The Green Deal Industrial Plan
6 EC, 2023 :The Net-Zero Industry Act
7 IEA, 2022: Mineral Transitions for the Clean Energy Transition, https://www.iea.org/reports/the-role-of-criticalminerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions (assessed July 9, 2024)
8 EC, 2024: National energy and climate plans

IWG5 is one of the 14 Implementation Working Groups of the Strategic Energy Technology Plan (SET Plan) aiming to accelerate the deployment of green technologies. IWG5 addresses a range of Sustainable Development Goals[9], notably, 7) Affordable and clean energy, 9) Industry, innovation and infrastructure, 11) Sustainable cities and communities, 12) Responsible consumption and production, 13) Climate action and 15) Life on land.

The working group was established in 2016 as a Temporary Working Group to support the structuring of European and national research programmes in order to identify common priorities and trigger investments in those technologies. An Implementation Plan (IP) was developed and endorsed by the SET Plan Steering Group in November 2018. Since then, the working group has continued as an Implementation Working Group with the aim to implement the defined activities in the Member States.

A coordination and support action (IWG5-CSA) is supporting IWG5 over a period of three years from September 2022 to the end of August 2025. IWG5 has a regular cooperation with the European Technology and Innovation Platform on Renewable Heating and Cooling (RHC ETIP) and the European Construction and sustainable built environment Technology Platform (ECTP). It also has links to other SET Plan groups including the European Technology & Innovation Platform on Geothermal (ETIP Geothermal) and the Implementation Working Groups on Photovoltaics (IWG PV), Energy Systems (IWG4), Sustainable and efficient energy use in industry (IWG6) and Concentrated Solar Thermal Technologies (IWG CSP).

IWG5 is divided into 2 subgroups:

Sustainable materials and technologies for energy efficient solutions for buildings (5.1)

Cross-cutting heating and cooling technologies for buildings (5.2)

The work of IWG5 is aligned with EU initiatives ramping up resource and energy efficiency and renewables in buildings, including:

- The Renovation Wave strategy (COM/2020/662) with the objective to at least double the annual energy renovation rate of buildings by 2030;
- The Fit for 55 (COM/2021/550) and REPowerEU (COM/2022/230) communications to increase the ambition in the buildings sector by 2030;
- The New European Bauhaus initiative (COM/2021/573), bringing together stakeholders to reimagine sustainable and aesthetic in buildings;
- The EU Partnerships Clean Energy Transition, Built4People, Driving Urban Transitions to a Sustainable Future, bringing private and public partners together to address some of Europe's most pressing challenges through concerted research and innovation initiatives;
- Funding instruments supporting the renovation and construction of buildings, including the Recovery and Resilience Facility, the Just Transition Fund, the European Structural and Investment Funds, the European Fund for Strategic Investments, and funding instruments

9 THE 17 GOALS | Sustainable Development, (n.d.). https://sdgs.un.org/goals (assessed June 11, 2024).

financed by the EU Emissions Trading Systems Revenues, such as the Innovation Fund, the Modernisation Fund and the Social Climate Fund.

IWG5 is composed of national representatives of EU and associated countries, industrial stakeholders, non-governmental organisations and research institutes. IWG5 is managed by an organisational board, a team of a chair, (a vice-chair) and three co-chairs covering the subtopics of IWG5. The board was elected at the end of April 2024 for a period of three years. IWG5 meets online every two months and in person during annual study trips in June-July and at the SET Plan conferences in November.

Currently, 24 countries and 25 stakeholder organisations are part of IWG5 (see Table 1 and 2):

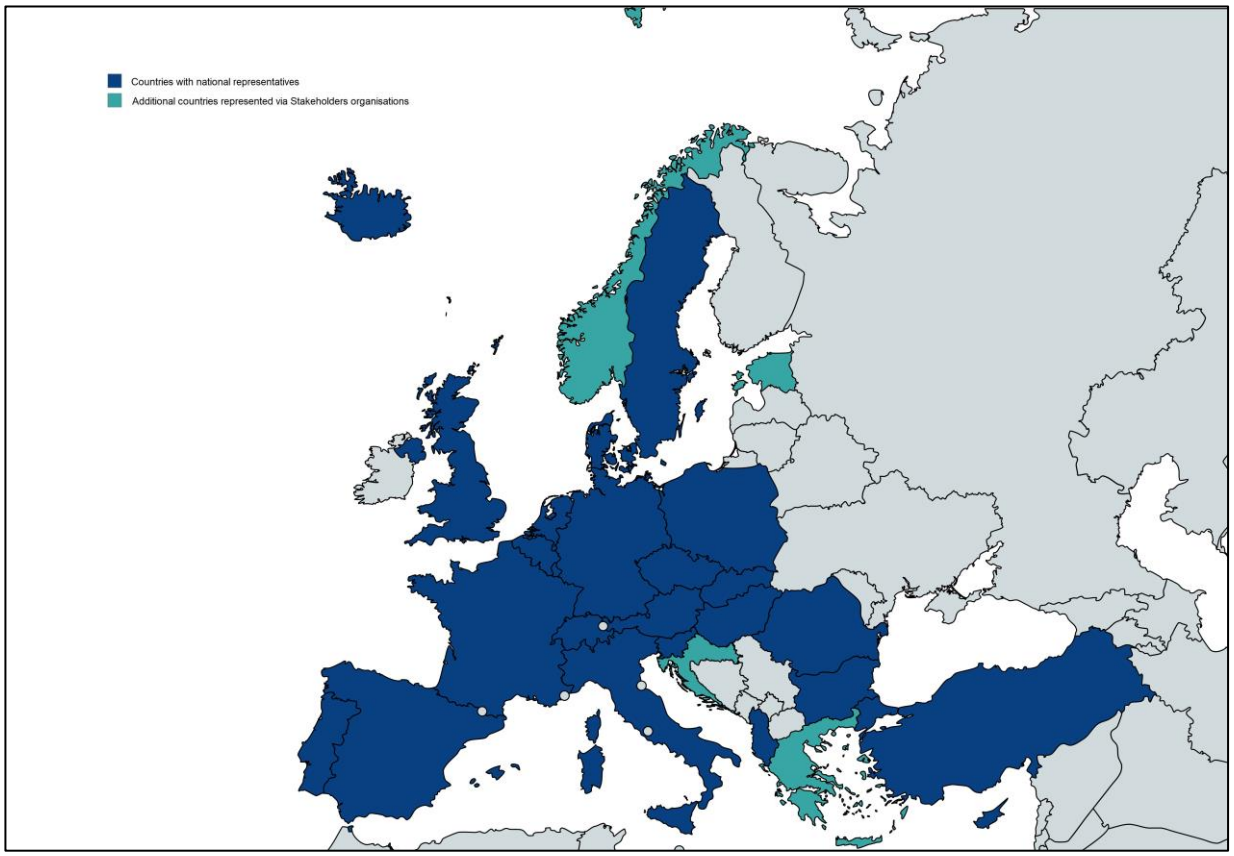
Member States and other countries (July 2024)* https://www.iwg5-buildings.eu/about-iwg5/iwg5-members/	
• Albania (AL) • Austria (AT) • Belgium (BE) • Bulgaria (BG) • Cyprus (CY) • Czechia (CZ) • Denmark (DK) • Germany (DE) • Hungary (HU) • France (FR) • Iceland (IS) • Italy (IT) • Luxembourg (LU)	• Netherlands (NL) • Poland (PL) • Portugal (PT) • Romania (RO) • Slovenia (SI) • Slovakia (SK) • Spain (SP) • Sweden (SE) • Switzerland (CH) • Turkey (TR) • United Kingdom (UK)
*Further countries are represented via stakeholder organisations: Croatia, Greece, Estonia, Norway (see table 2).	

Table 1: Countries represented in IWG5

Stakeholders: European associations and research organisations (July 2024) https://www.iwg5-buildings.eu/about-iwg5/iwg5-members/
• Architect's Council of Europe (ACE) • Association of European Renewable Energy Research Centers (EUREC) • Buildings Performance Institute Europe (BPIE) • Energy Materials Industrial Research Initiative (EMIRI) • EERA Joint Programme Initiative on Energy System Integration • European Heat Pump Association (EHPA) • Energy & Turbomachinery Network (ETN) • European Association for the Promotion of Cogeneration (COGEN Europe) • European Building Automation and Controls Association (eu.bac) • European Construction and sustainable built environment Technology Platform (ECTP) • European Geothermal Energy Council (EGEC) • Energy Materials Industrial Research Initiative (EMIRI) • European Polyurethane Insulation Industry (PU Europe), • European Technology and Innovation Platform on Renewable Heating & Cooling (RHC) • District Heating and Cooling Technology Platform (DHC+)/ Euroheat & Power Austria • Federation of European Heating Ventilation and Air Conditioning Association (REHVA) • SINTEF Energy Research (Steering Committee of the RHC Biomass panel)

Stakeholders: European associations and research organisations (July 2024) https://www.iwg5-buildings.eu/about-iwg5/iwg5-members/
• Solar Heat Europe (SHE)
• Czech Technical University in Pague, University Centre for Energy Efficient Buildings • National Technical University of Athens (N.T.U.A) • Plataforma Tecnológica Española de Eficiencia Energética (PTE-ee) • REGEA (North-West Croatia Regional Energy and Climate Agency) • RINA Consulting • Tallinn University of Technology (TalTech), Technical University of Munich (TUM) • Vision on technology for a better world (VITO)

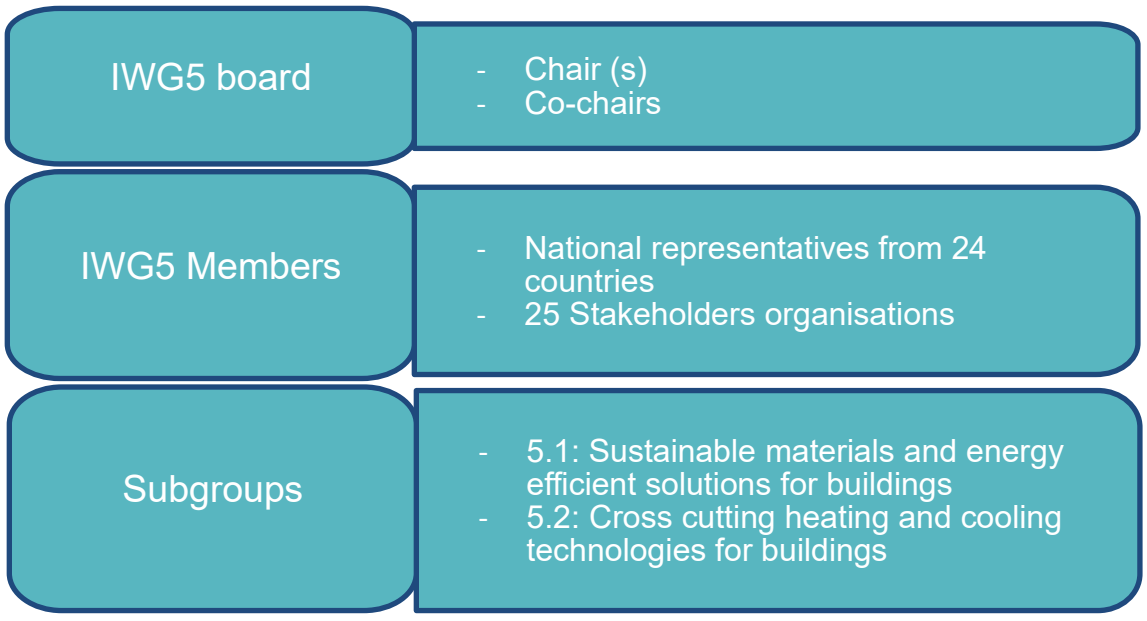
Table 2: Stakeholder organisations of IWG5



Graph 1: Map of IWG5 Members

IWG Board (2024-2027) Board webpage	
IWG5 Chair: Annett Kühn, PtJ (Project Management Juelich, Energy and Climate) a.kuehn@fz-juelich.de	
IWG5 Vice-chair: Constanze Marambio, PtJ c.marambio@fz-juelich.de	
5.1 Sustainable materials and technologies for energy-efficient solutions for buildings	5.2 Cross-cutting heating and cooling technologies
Co-chair: Petra Ruether, SINTEF petra.ruther@sintef.no **Co-chair**: Francesco Guarino, UNIPA francesco.guarino@unipa.it	**Co-chair:** Teresa Cuerdo, IETcc-CSIC teresacuerdo@ietcc.csic.es

Table 3: IWG5 Board



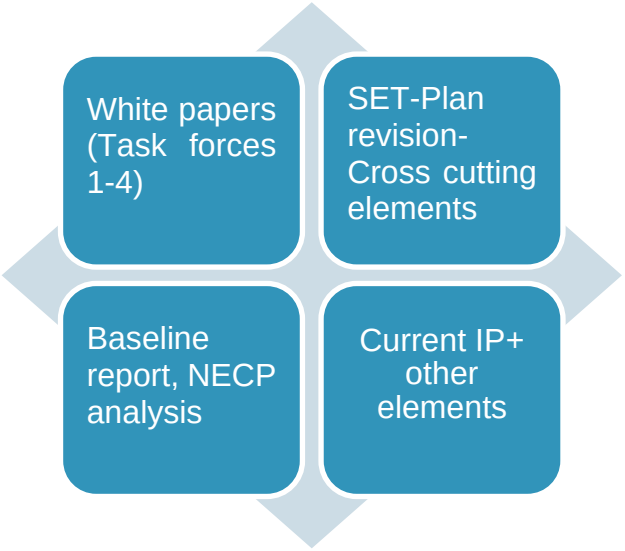
Graph 2: Organisation of IWG5

2. Update of the Implementation Plan

2.1. Process

The Implementation Plan is IWG5's strategic document, laying out the challenges that the group seeks to address, its key areas of work, priorities and quantifiable sectoral targets for the introduction of new technologies. This document should be updated every few years to keep track with policy and technological developments relevant to the built environment. The final version of the Implementation Plan has to be approved by IWG5 members and the SET Plan Steering Group.

The first version of the Implementation Plan of IWG5 dates from November 2018. The update process is divided in two phases, first an update of technical issues in the summer of 2024, and then a second update in 2025 including societal issues. So, the full update will come into force with the second update in summer 2025.



Graph 3: Elements of IWG5 2024 IP-Update

The coordination and support action (IWG5 CSA) is supporting the update with a refined toolset. **Four task forces on sustainable materials, active modules, digitalisation in buildings, and clean heating and cooling technologies were established** to prepare white papers and revise the targets and activity fiches. The task forces first identified gaps and barriers and then focused on possible new targets and activities. The first white papers of the task forces have already been published. In the coming year, **IWG5 will focus on social aspects to ensure a just transition where no groups are left behind**. A dedicated task force will look into skills gaps in the buildings sector and strategies to address them. Another task force will explore how to mitigate risks and costs for socially vulnerable groups potentially affected by the clean energy transition. This will include looking at good practices of renovation examples for vulnerable groups and how to use the renovation wave as an opportunity for building owners and tenants to reduce energy bills and increase their standard of living.

Furthermore, the National Energy and Climate Plans (NECPs) of several EU Member States have been analysed with regard to measures concerning innovation in buildings. The report and a factsheet have been published. To support the initiatives and actions aimed at improving

energy efficiency in buildings, an online tool has been developed, presenting a range of baselines for each European climate zone. This tool allows each member state to define baselines based on the characteristics of existing buildings, including parameters such as building envelope U-values, HVAC system types, and efficiency levels. By incorporating data from extensive simulations and life cycle assessments, the tool provides a comprehensive framework for evaluating renovation options. This facilitates targeted and effective renovation strategies by enabling users to compare the energy performance, environmental impact, and economic feasibility of various retrofit solutions under different climatic conditions. To consider the impact of climate change on baselines and renovations, the simulations are based on both current and future (2050) weather data files.

The proposed R&I activities of the new Implementation Plan are approaching a 2030 horizon timeframe (the same set by the revised Energy Performance of Buildings Directive to achieve at least a 55% reduction in GHG emissions, as legally required under the 2021 European Climate Law). The long-term approach is aligned with the target of European climate neutrality in 2050. It is expected that a new update will be needed after the 2040 EU climate and energy framework has been agreed.

2.2. Cross cutting issues

The updated and new innovation targets cover the major drivers of the green transition for the buildings aligning SET Plan goals with the Green Deal. Some of the transversal and cross-cutting encompass the digitalisation of buildings, circularity and sustainability, industrialisation and standardisation.

Digitalisation of buildings

In general, there is a large potential to significantly enhance energy-efficient and sustainable construction practices by further digitalisation. Digitalisation is an enabler of many operational processes and makes buildings part of the solution of a number of current days issues like energy inefficiency and carbon footprint of buildings, net congestion and shortage of materials.
Whereas the previous version of the Implementation Plan of IWG5 solely focused on the potential of digital planning and operational performance to obtain a more energy efficient built environment, the field of application has been expanded to include circularity as a necessary means to reduce the environmental impact of building over its total lifetime and to reduce the dependence on non-European material supplies. The need for digital tools, as for example necessary digital product passports by 2028, is also addressed in the new Construction Products Regulation.
For this, digital planning and operational optimisation, on short-term & long-term basis from a Whole Life Cycle perspective is necessary. The flexibility potential of buildings also provides energy system solutions.

However, in order to use the full potential of digitalisation of buildings, a number of challenges still have to be addressed. First and foremost, in order to use the potential of buildings reliable and timely data must be available. The digitalisation of information provides a chance to develop dedicated rule-based or model-based control algorithms, and building analytics combined with the possibilities of Artificial Intelligence (AI), offer a huge potential, but also present a risk.

Further challenges are:

- Reliability of predictions, due to lack of qualitative data and accurate and/or operationalised prediction methods and digital twins;
- Harmonisation (data sharing, data requirements, openBIM, LCA methods, databases, etc.);
- Engagement of the entire construction value chain ecosystem;
- Widespread adoption, cultural preferences & skills.

Alignment with EU strategies and structural investments stemming from clear innovation pathways are needed for the upcoming 5 years to fully exploit the potential of digitalisation for the built environment. The activities will also closely follow the priorities mentioned in the SET Plan revision focusing on cross cutting issues, digitalisation and energy.[10] Whereas specific investments in innovation of the construction sector are needed, strong leverage can be found by alignment with data related initiatives in related sectors, like transport, energy and climate.

Circular economy: sustainability and resource efficiency

The topic of circularity and sustainability has already been addressed in IWG5's Implementation Plan of November 2018. However, with the Circular Economy Action Plan (CEAP) and with the Critical Raw Materials Act it became even more important. The SET Plan revision stresses the need for the support of circularity principles as well as the substitution of critical raw materials, too[11].

Given the limited raw materials production in Europe which is progressively transitioning to climate-neutrality[12], research should focus on sustainable durable materials, with a significant service life, supporting resource preservation and guaranteeing lower embodied energy. Materials for the energy efficiency of buildings must be sustainable, they should have low-embodied energy/environmental impacts and prevent waste. They should also comply with the fundamental principles of the circular economy which is design for durability, adaptability and disassembly, and design for maintain and repair. It means creating products and buildings that can be easily repaired, reused, and that can be disassembled and recycled at the end of their life, allowing a second life for most of them, both in same and different application contexts. Thus, research on (new) energy efficient and low-carbon sustainable materials should provide broader spectrum material-centred solutions, taking up current challenges and achieving circularity and sustainability targets, as well as supporting digital, energy, and green transitions. Strategies such as Ecodesign and Design for Disassembly (DfD), life cycle assessment (LCA) and end-of-life approaches must be adopted for all materials used in the built environment.

Processes should support circularity and sustainability.

[10] EU: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions on the revision of the Strategic Energy Technology (SET) Plan (2023), https://research-and-innovation.ec.europa.eu/system/files/2023-10/com_2023_634_1_en_act_part1.pdf (assessed, June 10, 2024)

[11] See above

[12] EC, A secure and sustainable supply of critical raw materials in support of the twin transition, (2023). https://circabc.europa.eu/rest/download/7ce37e41-1d9a-4f96-a24b-4f89207700bf (assessed June 10, 2024).

For example, active modules can play a crucial role to lower sustainability impacts in its declinations. Its adaptability to user experience, improvement of indoor environmental quality (IEQ) occupant comfort, overall energy efficiency and enhanced control integrated in a LCC and LCA design framework can dramatically improve its impact. Overall, renovation approaches in the building sector must be aligned with circular approaches.

The Implementation Plan of November 2018 also took into consideration the whole cycle of energy and carbon and the embodied energy in construction materials. With the new EPBD, shifting from zero-energy to zero-emission, the ETS2 and the new CPR, a profound knowledge of GHG emission reduction factors for buildings will become essential. In addition, companies have also to consider the EU Taxonomy, for sustainable investments. Therefore, LCA, LCCA and respective instruments and tools will become crucial in order to explore the full potential of the whole life carbon potential of buildings.

Standardisation

Standards and norms support entering markets and gathering wider acceptance of stakeholders. Therefore, standardisation plays an important role in pushing forward green technologies and supporting the clean green transition. Apart from energy efficiency, this is highly relevant for the circularity and resource efficiency of buildings. For example, there is still **huge potential for the standardisation and certifications of low carbon, reused, recycled materials and products** for the clean energy transition. For this, existing standards have to be revised in order to include new findings on the use of materials, incl. recycled, circular, biobased materials (and their performance characterisation) for the clean energy transition.[13]

New common frameworks and norms are also needed for tools covering a wide range of applicability and embedded technologies, such as Active Modules and they are essential for setting up open data architectures for the digitalisation of buildings.[14] For all new elements supporting the green transition of buildings, setting up quality frameworks and quality control is essential, ensuring safety, high and specialised performance, and interoperability. In addition, due to changing climate conditions existing standards have to be refined.

[13] ECTP, Strategic Research & Innovation Agenda, 2024-2030,https://www.ectp.org/fileadmin/user_upload/documents/ECTP/ECTP_Position-papers_and_SRIA/ECTP_SRIA_2030_final_version.pdf (assessed June 14, 2024

3. Innovation Targets

3.1. Innovation targets 5.1

Action 5.1	Sustainable materials and technologies for energy-efficient solutions for buildings
Target 5.1-T1	Reduce the energy use of buildings by 16% in 2030 with respect to 2020
Target 5.1-T2	Develop and demonstrate solutions for zero-emission buildings by 2030 while retaining cost-efficiency
Target 5.1-T3	Develop and demonstrate market ready solutions to reduce the average duration of energy-related construction works by more than 40% for renovation and for new buildings compared to current national standard practices
Target 5.1-T4	Develop and demonstrate market ready solutions to reduce the difference between the predicted and the measured energy performance to maximum 15% after the commissioning period with the ambition to reach 10%
Target 5.1-T5	Develop and demonstrate interoperable and data-driven applications with the ability to maximise the use of the flexibility-potential of buildings (minimum of 20% flexibility capacity, without unacceptable impairments for users, of a minimum of 20% of all buildings on district level)
Target 5.1-T6	Develop and demonstrate data-driven solutions to maximise the reusability and high-value recyclability of materials and building elements at end-of-life (50% upcycling in 2030)

Table 3: Specific targets Action 5.1

The targets of subgroup 5.1 have been updated and two new targets have been added (5.1-T5 and 5.1-T6). The new targets were developed with the support of three task forces covering topics such as active modules, sustainable materials and digitalisation of buildings which provided input in the form of white papers. The respective white papers have been published.

The reasons for the target changes and the introduction of new targets are as follows:

Updated targets:

- Target 5.1.1: The target was aligned with the revised EPBD, especially Article 9
- Target 5.1.2: The target was aligned with the revised EPBD, especially Article 11
- Target 5.1.3: The target is addressing the deep renovation. In order to support the Renovation Wave and the targets of the revised EPBD, there was an increase in the percentages for the renovation going from 20% to more than 40% for renovation.

No changes:

- Target 5.1.4: No changes were made, the target is still valid

New targets:

- Target 5.1.5: The scope of this target is on developing the technologies to enable energy flexibility at building and district level, helping to align energy efficient buildings with the energy system as a whole.
- Target 5.1.6: This target was added for using data driven applications to maximise the reusability and high-value recyclability of materials and building elements at the end-of-life. It integrates the requirements of the Green Industrial Plan, especially the Circular Action Plan and the Critical Raw Materials Act, and links the energy efficiency of buildings with circularity issues. In doing so, it fulfils some of the requirements of the SET Plan revision on cross-cutting issues and circularity.

3.2. Innovation targets 5.2

Action 5.2	Cross-cutting heating and cooling technologies
Target 5.2-T1	Heat Pump Systems • Development of prefabricated, fully-integrated 'plug in and play' hybrid/multisource heat pump systems and integrated compact heating/cooling plants based on modular heat pump • Full-scale demonstration of heat upgrade technologies for district heating networks with supply temperatures in the range 90 - 160°C • Increase the number of heat pumps across Europe to 10 million by 2030
Target 5.2-T2	District heating and cooling: • Increase the share of district heating in the EU's heat demand to 20% by 2030 preferably using low temperature waste heat and renewable sources • Integration of 8 million households into the district heating/cooling networks across Europe
Target 5.2-T3	Micro CHP/CCHP • Integration of highly flexible CCHP systems with heat storage, heat pumps and renewable heat sources with the aim of reducing annual fuel consumption • Development of CCHP technologies running on renewable gases (hydrogen, ammonia, methanol, synthetic gas, etc.) with comparable performances as running on natural gas • Development of CCHP solutions with post combustion treatments to reduce emissions by >50% and keeping operational flexibility
Target 5.2-T4	Thermal Energy Storage

Action 5.2	Cross-cutting heating and cooling technologies
	• 100 new large thermal energy storages in district heating and cooling networks in progress in 2030 • 10 new demo systems with sensible thermal energy storage with a usage of RES and waste heat to more than 60% of the yearly heat demand • 20 systems for compact thermal energy storage demonstrated at TRL 6/7 with a storage density at system level increased to 120 kWh/m3
Target 5.2-T5	Solar Thermal Systems and PVT • Cost reduction for solar thermal combi-systems with high solar fraction (min. 60%), towards a range of 12-16 €ct/kWh • Development of standardised solutions for easier integration of solar thermal in building renovation, in particular in active prefabricated building elements • Cost reduction of PVT panels by a factor of 1.5 to 2 from the 2020 reference value of €1000/m², also by ensuring easier installation

Table 4: Specific targets Action 5.2

The updated and new targets for the subgroup 5.2 were developed with the support of respective IWG5 stakeholders and the task force on clean heating and cooling technologies. The white paper of this task force will be published in September 2024.

The following changes have been made:

Updated targets:

- Target 5.2.1: Heat pumps: The target was updated to reflect the changed market conditions for heat pumps
- Target 5.2.2: District heating and cooling: The target was updated to increase the share of district heating in the EU's heat demand by 2030.
- Target 5.2.3: Micro CHP/CCHP: The aim of the target is to increase CHP electricity share in thermal power generation from 27% today to at least 40% by 2040 and at least 50% by 2050, as well as ensuring that at least 50% of non-electrified heat is delivered via CHP.
- Target 5.2.4: Thermal Energy Storage. The target was adapted to reflect better the goals for the different thermal storage technologies.

New target:

- Target 5.2.5: Solar Thermal Systems and PVT: The new target is taking into account the Solar Readiness level mentioned in the new EBPD.

4. Conclusion

The Implementation Plan addresses the new elements mentioned in the Revision of the SET Plan, with a particular focus on cross-cutting issues, such as circularity and digitalisation. It takes into account the Green Deal and respective strategies, such as the Renovation Wave as well as the changes made by the revised EPBD and other regulations linked to topics of IWG5. It also supports EU's innovation and manufacturing capacities for relevant new technologies concerning heating and cooling (e.g. heat pumps). It supports the EU in reducing GHG emissions by 2030 and reaching European climate neutrality. The timeframe of most targets and activities is 2030, so the Implementation Plan has to be updated in the next 5-6 years. The monitoring tool for the activities are flagship projects, which have been provided by IWG5 members and respective experts.

The Implementation Plan outlines 11 Targets and **9 key Research and Innovation** (R&I) Activities, required to achieve the ambitious targets for the building sector:

- **Sustainable materials for buildings**
- **Prefabricated active modules for façades and roofs or Key Enabling Technologies for active building skins**
- **Digitalisation of buildings**
- **Heat Pumps**
- **Cogeneration of (Cooling), Heat and Power**
- **District Heating and Cooling**
- **Thermal Energy Storage (sensible, PCM and TCM)**
- **Solar Thermal and PVT**
- **Technology combination and integration**

5. Annex

Comment on the activity fiches 5.1: To better address circularity and sustainability issues in subgroup 5.1, two of the subgroups' activities have been renamed: the activity new materials and technologies for energy efficient solutions for buildings has been renamed sustainable materials and technologies for energy efficient solutions, and digital planning and operational optimisation has been renamed digitalisation on buildings to better use the full digital potential of buildings for the green transition.

5.1. R&I Activity 5.1-1: Sustainable Materials

Activity Fiche	Sustainable Materials
EU target(s), policies, and goals it addresses	• EU Green Deal, European Climate Law, SET Plan revision • Energy Performance of Buildings Directive (EPBD) • Construction Product Regulation (CPR)
Activity Fiche No.	1
Reference to IP/targets	Targets: 5.1-T1: Reduce the energy use of buildings by 16% in 2030 with respect to 2020 5.1-T2: Develop and demonstrate solutions for zero-emission buildings by 2030 while retaining cost-efficiency 5.1-T6: Develop and demonstrate data-driven solutions to maximise the reusability and high-value recyclability of materials and building elements at end-of-life (50% upcycling in 2030)
Description (challenge, scope) White paper on sustainable materials, Link	As 40% of Europe's energy consumption comes from buildings, and they generate 36% of GHG emissions in the EU, the construction sector will be one of the key stakeholders for the road to net zero in Europe. In addition, construction and operation of buildings requires enormous resources and generates waste. Indeed, Construction and demolition waste (CDW) accounts for almost 40% of all waste generated in the EU. Keeping in mind that there is only a limited raw materials production in Europe and that the energy transition is dependent on materials (often critical raw materials), circularity and resource efficiency are also of vital importance. Thus, materials for the energy efficiency of buildings must be sustainable, they must have low-embodied energy/environmental impacts, preventing waste and maintaining materials within the EU economy for as long as possible. Research on (new) energy efficient and low-carbon sustainable materials should therefore adopt a holistic approach and provide broader spectrum material-centred solutions, taking up current challenges and achieving circularity and sustainability targets, as well as supporting digital, energy, and green transitions. The focus is placed upon materials with a relevant potential in terms of energy efficiency and carbon footprint reduction. In addition, research activities should also focus on sustainable durable materials, with a significant service life, supporting resource preservation and guaranteeing lower embodied energy/environmental impacts from cradle to grave according to the principles of life cycle thinking. For this, it is fundamental to define new durability criteria together with standardised test protocols for their assessment, guaranteeing the performance of newly developed materials. An alignment with similar R&I activities in the material R&I community is also highly relevant. In addition, it is essential to adopt a holistic approach, in order to develop multi-domain solutions, centred on materials but involving transversal technologies that can foster innovation in the construction sector and speed

Activity Fiche	Sustainable Materials
	up green, energy, and digital transitions. The focus is on the following transversal topics: • Digitalisation: Digital tools contribute to achieve this objective and improve the materials life cycle in a circular economy perspective, supporting their validation and performance assessment • Standardised Life Cycle Assessment (LCA) and harmonisation with existing initiatives (e.g. PEF) while optimizing maintenance and enhancing potentiality in terms of energy efficiency and flexibility, decarbonisation, and circularity. • Industrialization: Industrialization can optimise both the fabrication and the use/reuse of materials, in a view of circular economy • Standardisation and certifications of innovative construction materials, dealing also with safety and health issues. This is required both to enter the construction market and to gather a wide acceptance by stakeholders.
R&I Activities	Whole life-cycle approach: • Develop advanced and sustainable materials/systems for smart and zero-emission buildings synergizing with the EPBD requirements and targets, e.g. thermal insulation systems and efficient heat radiation or cooling solutions and/or flexible design for repurposing and recycling • Develop materials for short, medium and long-term thermal storage over a wide temperature range (e.g., ranging from short-term low temperature home storage systems to large seasonal borehole-based solutions with higher temperature / cold storage solutions). • Develop materials and energy efficient processes and solutions that facilitate optimal and innovative combinations of construction products and systems with minimal life cycle impacts at the single building level. The innovative combinations of products and systems must also account for relevant aspects of performance such as thermal, acoustic and hygrometric performance, durability, potential for deconstruction and preparation for reuse at end of life, and potential for automated or industrialised installation. • Increased integration of circular approaches for building and renovation works, with the aim of minimising life-cycle energy and environmental impacts • Design for adaptability, reuse and deconstruction of buildings, in line with the principles of circular economy • Characterisation methods for material performance as well as material and product traceability during the whole life-cycle of buildings with the aim of reducing the environmental impact while synergizing with existing EU solutions and efforts (e.g. digital passports). Methods and tools for design optimisation (e.g. for additive manufacturing) • Methods and tools for resource optimisation, including use of secondary materials and lifetime extension • Research on recycling of materials used for energy transition (production, conversion, recovery and storage) • Research on bio-based materials to reduce the use of fossil raw materials • Contribute to the development of European standards, where relevant • Development of digital learning tools addressing resource efficiency, circularity, and recycled materials.
Expected Impact Short term impact (2030) Long term impact (2050)	Short term impact: • Development of indicators for circularity and material efficiency, standardisation and certification (norms) for more sustainable and low-carbon materials, alignment with similar R&I activities of the material community • More sustainable buildings with reduced embodied energy / carbon; high life-cycle performance and reduced life-cycle costs

Activity Fiche	Sustainable Materials
	• Measurable reduction in whole life-cycle greenhouse gas emissions and uptake of carbon removals in buildings and renovations Long term impact: Circularity and decarbonisation of buildings
Expected Deliverables	Expected Deliverables: Projects in this activity should contribute to the following topics: • Digitalisation of technologies to maximise the utility of information from buildings and support the circularity of the developed solutions (e.g., materials passport) • Low-energy demand production technologies and digitalised manufacturing methods (e.g., additive manufacturing, 3D printing) • Prefabrication, modularity, and design to reuse/recycle technologies • Innovative insulation construction systems with thermal performance (with respect to heating and cooling requirements) equal or better than contemporary state of the art level • Innovative thermal insulation system for building walls with regenerative and bio-based materials • Compliance with existing structural, thermal, seismic and fire safety regulations with a particular focus on seismic protection • Development of materials circularity indicators to assess the adequacy of the solution to circular economy principles • Development of indicators of the impact of materials on Indoor Air Quality (IAQ) • Common assessment methodology for durability and related indicators, solutions for durability enhancement, extension of materials/systems useful life, reuse and repurposing • Circular solutions for low-carbon and low environmental impacts renovation of buildings • Assessment of the carbon handprint of innovative solutions • Standardisation and certification (including norms) for more low-carbon materials
TRL-levels or Society readiness levels	2-6
Monitoring mechanism	Annual report summarising the progress
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	100m€
Parties involved countries/ stakeholders*	Countries: Austria, Belgium, Bulgaria, Czechia, Denmark, Estonia, Hungary, Germany, Greece, Finland, France, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, United Kingdom/ Colombia Stakeholders: Czech Technical University in Prague, RINA Consulting, National Technical University of Athens (NTUA), Vision on technology for a better world (VITO)
Indicative financing contribution and source	EC Contribution: 53.905m€ Co-funding (M-ERA-Net): 1.67m€ Member states: 4.29m € (Germany, Norway, Czechia, Slovenia) Other member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **

Activity Fiche	Sustainable Materials			
	Possible additional co-funding options via ERA-MIN, M-ERA NET and upcoming partnerships on materials.			
*Countries/stakeholders involved in projects, IWG5 members ** Will be aligned in summer 2025 (with the final IP-Update).				
Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
RECONSTRUCT Developing circular, eco-friendly, and innovative solutions to reduce emissions from the construction industry Grant agreement ID: 101082265 Link	This project aims to develop low-carbon alternatives to OPC for renovations and new buildings, incorporating CDW and other waste as much as possible to enhance sustainability and circularity in the construction sector. Moreover, it aims at realizing modular construction components in a view of construct-to-deconstruct and reuse. Moreover, it develops sensing and digital techniques supporting monitoring and digitalization in buildings and construction process.	06/23-05/27	ITeC,Spain (Coordinator), Netherlands, Italy, Belgium, Greece, United Kingdom	6.69m€
MULTICLIMACT MULTI-faceted CLIMate adaptation ACTions to improve resilience, preparedness and responsiveness of the built environment against multiple hazards at multiple scales Grant agreement ID: 101123538 Link	This project aims to develop a mainstreamed framework, innovative sustainable materials, and sensing and digital solutions to enhance the resilience of the built environment and its people at multiple scales against locally relevant natural and climatic hazards.	10/23-12/27	RINA Consulting, Italy (Coordinator) Germany, Netherlands, Spain, Sweden, Finland, Latvia, Greece, Portugal	7.49m€
DRASTIC Demonstrating Real and Affordable Sustainable Building Solutions with Top-level whole life-cycle performance and Improved Circularity	DRASTIC will pave the way for significant whole life-cycle GHG emission reduction in new construction and (deep-energy) retrofit by demonstrating affordable innovative circular solutions in 5 different geographical zones, covering different building layers. To assess and validate the solutions, an innovative multi-cyclic performance assessment framework will be developed and applied, integrating multi-cycle LCA, multi-cycle LCC, circularity and sufficiency for construction and building related products and components. The DRASTIC project	10/23-09/27	VITO, Belgium (Coordinator)France, Sweden, Germany, Spain, Estonia, Norway, Netherlands	7.85m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
Grant agreement ID: 101123330 Link	will contribute to the objectives of the EU by demonstrating the feasibility of promising and affordable new technologies, processes and products combined with new business models for faster market uptake, leading towards more sustainable buildings with reduced life-cycle carbon, high life-cycle performance and reduced life-cycle costs.			
INBUILT Innovative bio/geo-sourced, reused and recycled Products coupled with BIM-based digital platform for very low carbon construction, circular economy, energy and resource efficiency Grant agreement ID: 101123412 Link	INBUILT will introduce sustainable materials, such as large-sized rammed earth blocks, recycled bricks, straw-clay boards and smart windows. A digital platform will facilitate the integration of these sustainable materials into buildings. By promoting innovative construction techniques based on locally sourced bio- and geo-materials, the project aims to transform the construction sector, aligning it with Europe's carbon neutrality and zero emissions targets. INBUILT aims to boost European competitiveness, reduce carbon emissions, enhance digitalisation, and foster resilience through circular economy practices and eco-design.	12/23-05/27	Université Côte d'Azur, France (Coordinator) Germany, Spain, Latvia, Portugal, Luxembourg ,Belgium, United Kingdom	9.40m€
CO2NSTRUCT Modelling the role of circular economy construction value chains for a carbon-neutral Europe Grant agreement ID: 101056862 Link	An energy system optimisation model called TIMES could be used to help decision-makers understand the complex system interactions related to energy use. TIMES energy-climate mitigation models detail the use of technology and technological advances in greenhouse gas abatement pathways. The EU-funded CO2NSTRUCT project will apply TIMES as a proxy model to shift climate mitigation models from linear to circular. The focus will be on six carbon-intensive construction materials – steel, cement, brick, glass, wood, and insulation – to map six value chains with explicit feedback loops and quantified rebound effects, key to circular economy practices. TIMES will run several circular scenarios. Outcomes will be translated into useful and effective policy support information.	06/22-05/26	Danish Technical University (DTU), Denmark (Coordinator)Greece, Germany, Portugal, Spain, Italy United Kingdom	4.38m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
BIO4EEB BIO insulation materials for Enhancing the Energy performance of Buildings. Grant agreement ID: 101091967 Link	The EU-funded BIO4EEB project will use non-hazardous bio-based materials such as the seagrass Posidonia oceanica and various bio-based foams to develop smart components for external and internal use. Marketability will include demonstration of a short seven-year return on investment. The bio-based materials will significantly reduce environmental impact relative to current solutions while enabling tremendous energy (and cost) savings for building owners and occupants.	01/23-12/26	Lenze-Luig 3-L-Plan GBR, Germany (Coordinator),Italy, France, Belgium, Hungary, Netherlands, Spain, Lithuania, Czechia, Austria, Colombia	8.83m€
GreeNest Nest Ingrained Ecosystem for Zero Emission Buildings Grant agreement ID: 101138242 Link	The EU-funded GreeNest project will pioneer a transformative approach to sustainable building practices. By integrating CO2-neutral materials, renewable energy and circular construction methods, GreeNest aims to slash embodied emissions, setting the stage for a greener, carbon-free future in construction. Specifically, it aims for 100 % carbon-free construction. With biogenic materials storing carbon, the project targets a 50 % reduction in embodied emissions, surpassing NZEB and ZEB standards. Embracing circular construction practices, GreeNest will enhance productivity by over 30 %, delivering solutions from design to disposal stages. Demonstrated in real and virtual projects across five countries, GreeNest's approach marks a step towards a greener construction industry.	01/24-12/27	National Technical University of Athens, Greece, (Coordinator) Germany, Italy, Poland, Spain, Luxembourg, Lithuania, Czechia, Switzerland	6.55m€
MOBICCON-PRO MOBile and Innovative Circularity for CONstruction PROducts Grant agreement ID: 101091679 Link	MOBICCON-PRO will improve the recovery and recycling of construction and demolition waste (CDW) in south-east Europe. It will combine physical solutions adapted to the ground (a mobile CDW treatment plant) with innovative selective separation and deconstruction technologies to scale up the treatment of CDW and the production of recycled construction materials. The project will also design innovative equipment and mobile technical solutions. In addition to demonstrating sustainability, it will also pave the way for policy measures to	12/22-11/27	Glavbolg Arstroy Holding, Bulgaria (Coordinator),Denmark, Belgium, France, Serbia	12.97m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
	improve the overall legislative framework of construction products.			
Wood-wastePanels Wood waste containing composites for high performance nearly zero energy building panels Link M-ERA NET Project	The project's objective is a novel manufacturing technology of building products – multi-layered panels – made of high-performance natural fiber composites, which will be developed using production wood wool cement board (WWCB) waste from project partner CEWOOD Ltd, as well as construction demolition waste of WWCB. These panels will be cost-effective and have high hygro-thermal properties, which will give them the advantage of being used as enclosures and thermal insulation for buildings, including passive and nearly zero energy buildings (NZEB). The main benefits of the proposed building products are a rational use of local resources and sustainability, as significant CO2 savings can be achieved by avoiding bio-fibers material landfilling and encapsulating it in new materials. They will also be energy-efficient, ecological, easy to recycle, and with low energy intensity. WWCB recycling methods will also include binder re-activation and separation of wood wool for secondary use.	09/23-08/26	Riga Technical University, Latvia (Coordinator)LV/ Cewood Ltd,; PL/WUT, Budynki z konopi FR/USMB	1.33m€
CirCon4Climate - Strengthening Circular Construction Practices Funded by EUKI https://www.euki.de/en/euki-projects/circon4climate/ (national funding)	The mission of the project is to contribute to climate change mitigation and supply security in the construction sector by strengthening circular construction in the Czech Republic, Poland, and Slovenia, using best practices from Germany. Currently, policymakers lack awareness of the potential for reducing greenhouse gas emissions and resource consumption through circular construction. Investors lack local guidance on circular procurement. Architects and urban planning authorities lack good examples, support, and quality assurance when designing buildings with recycled materials. Contractors lack awareness of actual take-back and recycling practices, and the recycling industry is missing robust key figures based on the fact that they	12/22 - 03/25	Czech Technical University in Prague, Czechia (Coordinator), Poland, Germany, Slovenia	0.85 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
	can guarantee the security of supply for secondary raw materials. The project aims to increase the representation of circular building principles in public procurement, to encourage key players in the construction industry to use secondary materials and, finally, to increase the scale and volume of collection of materials for reuse and recycling, for example, through regional material cadastres			
KARMA Circular Economy in the Construction Sector - Acting Today for a Better Future Link	KARMA is an interregional cooperation project (Interreg Europe). It aims to improve local climate policies through circular construction actions organized by seven partners across the European Union. It aspires to increase resource efficiency, optimise waste management and improve recycling practices in the participating partner regions for public and private construction projects.	03/23-03/27	City of Hamburg Germany (DE) (Lead partner), DE/County Bergstraße, BE/Circular Flanders, HU/Pannon Business Network Association, IT/Regione Calabria, EUROKOM, RO/ Suceava Municipality	1.67m€
Possibilities of using natural fibers for the production of hybrid textile reinforcement in concrete Funded by Czech Science Foundation (GAČR) and Slovenian Research Agency (ARRS) https://old.starfos.tacr.cz/en/project/GF22-14942K#project-main	Concrete production remains as one of the highest CO2 contributors using steel rebars as a reinforcement. Due to the concrete cover to protect steel from corrosion higher amount of concrete is consumed, as well as the overall cost and environmental impact associated with material provision is higher. Textile reinforced concrete (TRC) is a silicate material in which reinforcement consists of one or multiple mesh structured layers typically manufactured from inorganic fibres. Due to the use of a noncorrosive reinforcement, additional cover requirements can be limited, reducing the amount of cement and resulting in a higher sustainable potential. Recent research has been directed towards the use of more sustainable alternative materials. Natural fibres are renewable,	03/22 - 02/25	Czech Technical University in Prague, Czechia (Coordinator), Slovenia	0.64 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
	widespread and accessible in both developing and developed countries and can be recycled and biodegraded. Moreover, some plant fibres have high specific mechanical properties. Hence natural fibres start to be considered as potential sustainable replacements to steel and synthetic reinforcements of concrete matrices. Project will focus on development of a concrete matrix compatible with fibers, development of hybrid reinforcement with resistance to alkaline environments. It will study the time influence on mechanical properties of TRC with natural fibers and its durability. Fire safety of natural fibers TRC, environmental and economic impact will be assessed.			
Sutracrete 03EI5012A Sustainable traceable concrete Link	The aim of the project is to produce a 'Sutracrete' with individual material fit through a microstructure based design. The Sutracrete is to be produced by recycling broken masonry in the form of brick dust and brick aggregate. The novel sorting process will, for the first time, enable the separation of low-fired, reactive brick powder from high-fired, non-reactive brick aggregate. The microstructure-based design specifically exploits the properties to produce a sustainable and traceable concrete. The production of Sutracrete results in a lower total energy consumption compared to primary building materials and thus in a reduction of greenhouse gas emissions. The use of markers enables for the first time the physical correlation between building materials and a digital twin or 'material passport' stored in a database.	06/22-05/25	Germany, Materialforschungs- und -prüfanstalt an der Bauhaus-Universität Weimar (Coordinator), VDZ Technology gGmbH, Polysecure GmbH, Informbeton GmbH, T.B.R. Teltower Baustoffrecyling GmbH	1m€
Dare2C2 Durable Aluminium Reinforced Environmentally-friendly Concrete **Construction – Phase 2** Project Number: 327863	This is a continuation of the project DARE2C (2017-2021), based on the idea that using aluminium as reinforcement in concrete could enable the use of more environmentally friendly cements. Aluminium cannot be used as reinforcement in today's commercially available concretes because it corrodes in the highly alkaline environment. Likewise, the development of more environmentally friendly clay-substituted cements is	21-24	Norway Norsk Hydro (owner), Dr.Techn.Olav Olsen, Nordic Architecture, Christie&Opsahl, Oshaug Metall, Heidelberg Materials,	1.8m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
Link	hampered by the resulting low alkalinity of these concretes, which is not compatible with regular steel reinforcement. Thus, DARE2C ambitiously aimed at hitting two birds with one stone by combining Al reinforcement with low-CO2 concrete. Now, four years later, new low-CO2 concretes have been developed with good mechanical properties and Al compatibility, and several possible Al alloys have been identified as suitable for concrete reinforcement, including some which may be produced by recycling. In this project, the focus is on evolving, generalising and enabling commercialisation of the Al-reinforced concrete that was developed in the DARE2C project.		Sika Norway, SINTEF	

5.2. R&I Activity 5.1-2: Active Modules

Activity Fiche	Active Modules
EU target(s), policies, and goals it addresses	• EU Green Deal, European Climate Law, SET Plan revision • Energy Performance of Buildings Directive (EPBD) • Construction Product Regulation (CPR)
Activity Fiche No.	2
Reference to IP/targets	Targets: 5.1-T1: Reduce the energy use of buildings by 16% in 2030 with respect to 2020 5.1-T2: Develop and demonstrate solutions for zero-emission buildings by 2030 while retaining cost-efficiency 5.1-T3: Develop and demonstrate market ready solutions to reduce the average duration of energy-related construction works by more than 40% for renovation and for new buildings compared to current national standard practice 5.1-T4: Develop and demonstrate solutions to reduce the difference between the predicted and the measured energy performance to maximum 15% after the commissioning period with the ambition to reach 10% 5.1-T5: Develop and demonstrate interoperable and data-driven applications with the ability to maximise the use of the flexibility-potential of buildings (minimum of 20% flexibility capacity, without unacceptable impairments for users, of a minimum of 20% of all buildings on district level) 5.1-T6: Develop and demonstrate data-driven solutions to maximise the reusability and high-value recyclability of materials and building elements at end-of-life (50% upcycling in 2030)

Activity Fiche	Active Modules
Description (challenge, scope) White paper on Active Modules, Link	In the context of facade and roof solutions, active modules refer to technological and construction components or systems within a building envelope that are equipped with dynamic, interactive and adaptive features and capabilities. These modules incorporate various technologies, sensors, and control systems to actively control and optimise aspects such as energy efficiency, thermal comfort, glaring, daylighting, ventilation, and aesthetics. They can be integrated into different types of building envelope components, such as windows, louvres, shades, glazing, cladding systems, as well as renewable energy sources and systems to facilitate easy integration in the building. Unlike passive facade elements that remain static, active modules can respond and adapt to changing environmental conditions or user needs. Therefore, the active modules have the potential to enhance energy-efficient and sustainable construction practices and to contribute to the European Green Deal and the European Climate law. However, active modules, at this moment, do not seem fully ready to disrupt the construction industry as expected. While the integration of single active systems such as energy production, particularly with PV products, has been successful, further improvements are needed for the wider applicability of active modules. The scope of the activities will therefore cover the following activities: synergy among different construction players, holistic and lifecycle analysis of the costs and benefits of active modules, exploiting digital opportunities and engagement from the entire construction value chain ecosystem. The suggested actions and updated targets align with key aspects of EU strategies where active modules can contribute, such as cost reduction, energy efficiency, energy load management, and environmental sustainability.
R&I Activities	• Define Multiple evaluation parameters for active modules • Develop multi-criteria-decision matrix and analysis for active modules • Explore and develop principles of circularity and sustainability in active modules in building facades, The integration of multiple technologies in prefabricated systems needs to consider the end-of-life step from the design stage to enable such a strategy. • Developing industry standards, testing protocols, and certification processes specific to active modules in order to provide a quality assurance framework • Developing clear guidelines and regulations that address safety, energy efficiency, sustainability of active modules • Adopt Life Cycle Assessment and anticipate end-of-life • Adopt Cost-Benefit Analysis • Identify Standardisation of norms • Define methods for formulating data-driven digital twin
Expected Impact Short term impact (2030) Long term impact (2050)	Short term impact: supporting the goal of 55% GHG emission by 2030, aligned with the EPBD, the European Climate Law Long term impact: Green Deal, Climate neutrality by 2050 and transformation of the construction industry towards more sustainable and smart practices.
Expected Deliverables	• Life Cycle Assessment method for Active Modules • Cost-Benefit Analysis for Active Modules • Standardisation and quality framework for Active Modules • Clear guidelines and regulations that address safety, energy efficiency and sustainability for Active Modules • Market acceptance of Active Modules

Activity Fiche	Active Modules
TRL-levels or Society readiness levels	TRL-level 6-8 SRL-level 5-6
Monitoring mechanism	Annual report summarising the progress
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	60 m€
Parties involved countries/ stakeholders*	Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, France, Germany, Greece, Italy, Luxembourg, Netherlands, Norway, Montenegro, Poland, Spain, Switzerland Stakeholders: National Technical University of Athens
Indicative financing contribution and source	EC Contribution: 40.57m€ Member states: 2.36m€ (Germany) Other member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **
*Countries/stakeholders involved in projects, IWG5 members ** Will be aligned in summer 2025 (with the final IP-Update).	

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal

Name	Description	Time-line	Location/ Party	Budget
PLURAL Plug-and-use renovation with adaptable lightweight systems Grant agreement ID: 958218 Link	PLURAL demonstrates the integration of hybrid, passive and active, systems into one kit and their ability to work together in synergy for façade retrofitting, reaching NZEB. The project aims to create best practice renovation examples for the residential sector based on innovation and competitiveness, with benefits for the citizens and the environment; to develop training tools for main stakeholders (planners, installers, building owners and end users); to improve the life cycle based (LCA, LCC) performance standards applied in the building sector.	10/20-09/24	National Technical University of Athens, Greece (Coordinator), Czechia, Poland, Italy, Luxembourg, Switzerland, Spain, Germany	9.66m€
RE-SKIN New roof and façade for energy-efficient buildings Grant agreement ID: 101079957 Link	The EU-funded RE-SKIN project will develop an integrated and multifunctional system for the energy retrofit of existing buildings. Specifically, the new system's roof will be equipped with a hybrid photovoltaic-thermal configuration, which will produce electricity and heat at the same time. Electricity from retrofitted photovoltaic modules will power the buildings' loads. Solar modules will form the	01/23-06/26	Politecnico di Milano, Italy (Coordinator) France, Spain, Belgium, Austria, Netherlands, Luxembourg, Denmark, Bulgaria, Croatia	13.16m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
	outer skin of the roof. As for the façade, it will comprise a thermal cladding with self-supporting panels and bio-based insulation, inside which the wiring for the new installations and earthquake sensors will be housed.			
EASI ZERo Envelope mAterial System with low Impact for Zero Energy buildings and Renovation Grant agreement ID: 101091531 Link	The ambitious EU-funded EASI ZERo project will use bio-sourced and recycled materials to enhance the thermal performance of new and existing buildings' envelopes by 20%. The diverse materials include grown mycelium, wood fibres, low carbon foam, recycled raw material. The team will optimise the materials combinations for maximum sustainability and minimum payback time with the help of design tools and a numerical database.	12/22-05/26	Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), France, (Coordinator), Denmark, Spain, Norway, Germany, Italy, Belgium	8.09m€
Infinite Industrialised durable building envelope retrofitting by all-in-one interconnected technology solutions Grant agreement ID: 958397, Link	The EU-funded INFINITE project will pave the way for the decarbonisation of the EU building stock by facilitating the uptake of all-in-one industrialised envelope technologies by the market. INFINITE's approach for deep renovation of buildings will result in both cost and time reduction, with attention to the life cycle perspective and the design for assembly and disassembly, including end-of-life residual value as well as construction and demolition waste.	11/20-04/26	Accademia Europea di Bolzano, Italy, (Coordinator), Austria, France, Germany, Netherlands, Slovenia, Spain, Switzerland	10.15m€
Fronterm Project ID: 03EN6036A-E	Facade heating and cooling unit for serial refurbishment of existing buildings	07/24-06/27	Germany, Consolar, ME Wohnungsverwaltungs GmbH, Uni Stuttgart, KIT	2.36m€
Increase effectIve advaNCements towaRds uptakE of PV integrAted in buildingS & infrastructure	The EU-funded Increase project will focus on delivering IPV innovations at the module and system-level. Specifically, Increase aims to enhance aesthetics, reduce environmental impacts and improve functionality. Innovations include new encapsulants and coatings, integrated facades and	10/23-03/28	TH!NKE Belgium (Coordinator) Spain, France, Estonia, Italy, Germany, Montenegro, Switzerland	9.62m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time-line**	**Location/ Party**	**Budget**
Grant agreement ID: 101136112 Link	roof and sound barrier concepts. Through extensive testing and implementation in nine demonstration projects across Europe, Increase seeks to optimise IPV systems for maximum efficiency and ease of installation. Engagement, communication and co-creation actions with local stakeholders are integral to fostering market acceptance and developing business models for implementation across Europe.			

5.3. R&I Activity 5.1-3: Digitalisation in buildings

Activity Fiche	Digitalisation in buildings
EU target(s), policies, and goals it addresses	• EU Green Deal, EU Green Deal Industrial Plan • European Climate Law, SET Plan revision • Energy Performance of Buildings Directive (EPBD) • Construction Product Regulation (CPR)
Activity Fiche No.	3
Reference to IP/targets	Targets 5.1-T2: Develop and demonstrate solutions for zero-emission buildings by 2030 while retaining cost-efficiency 5.1-T3: Develop and demonstrate market ready solutions to reduce the average duration of energy-related construction works by more than 40% for renovation and for new buildings compared to current national standard practices 5.1-T4: Develop and demonstrate solutions to reduce the difference between the predicted and the measured energy performance to maximum 15% after the commissioning period with the ambition to reach 10% 5.1-T5: Develop and demonstrate interoperable and data-driven applications with the ability to maximise the use of the flexibility-potential of buildings (minimum of 20% flexibility capacity, without unacceptable impairments for users, of a minimum of 20% of all buildings on district level) 5.1-T6: Develop and demonstrate data-driven solutions to maximise the reusability and high-value recyclability of materials and building elements at end-of-life (50% upcycling in 2030)
Description (challenge, scope) White paper on digitalization of buildings, Link	Digitalisation is an enabler of many operational processes and makes buildings part of the solution of a number of current days issues like energy inefficiency and carbon footprint of buildings, net congestion and shortage of materials. Whilst reduction of energy use in the operational phase of buildings is prime (energy efficiency), the importance of embedded CO_2 in new-built and renovation of buildings increases. In

Activity Fiche	Digitalisation in buildings
	addition, circularity is a necessary means to reduce the environmental impact of a building over its total lifetime and to reduce the dependence on non-European material supplies. Only a sustainable growth in the construction industry is pivotal to achieve the EU's 2050 target of climate neutrality, supported also by the revision of the Energy Performance of Buildings Directive (EPBD). Therefore, digitalisation of buildings covers digital planning and operational optimalisation, on short term & long-term basis from a whole life cycle perspective. In order to reach EU'S target of climate neutrality, the "full potential" of buildings in terms of carbon removal, energy efficiency and sustainability is needed. The scope of the activities covers nearly all targets of the subgroup 5.1 with TRL-Levels 3-8. The scope of those activities is focusing on: - Data collection: setting-up and securing qualitative data on the whole life cycle of buildings in order to secure the reliability of predictions - Securing harmonisation (data sharing, data requirements, openBIM, LCA methods, databases, ...) - Securing alignment with EU strategies and structural investments stemming from clear innovation pathways are needed for the upcoming 5 years to fully exploit the potential of digitalisation for the built environment.
R&I Activities	Target 5.1-T2-Innovation projects to: - Develop digital tools and multistakeholder design methodologies to integrate whole life cycle costings as an integral part of the design, production and maintenance process - Harmonise automated and standardised calculation and data sharing methods, using openBIM (IFC 4.3) as basis - Development of Easy-to-Use digital tools and focus on skills developments (enhance market-readiness) - Develop digital tools to provide more accurate benchmarking and calculation of typical buildings' whole life cycle greenhouse gas emissions and carbon removals, consistent with the life-cycle global warming potential under the Energy Performance (and in preparation for ETS2) - Demonstration projects, with focus on large scale market adoption Target 5.1-T3- Activities - Analysis of regional obstacles that are slowing the process and subsequent (regional) workflow development, coping with unification in diversity - Development of new and innovative processes and market solutions for all different stages of the process, to be able to collect data from the different stages of the process - Digital tools and digital twin development, integrating the design for prefabrication, testing, prototyping, monitoring and large-scale demonstration (incl. innovative economic funding mechanisms) - Showcase performance-based prescriptions and data driven verifications. Use data on district and city, building and component level and develop methodologies to connect these data streams. - Benchmarking (building level) Target 5.1-T4- Activities - Collection and sharing of measured data, development of simplified digital twin models to assist in the wide adoption and the development

Activity Fiche	Digitalisation in buildings
	of empirical models of user behaviour (real setpoints for HVAC, window opening, …) based on the data collected - Automated model development based on smart meter data and development of predictive twins, including AI assisted proposed renovation alternatives (link to target 5.1-T2 and 5.1-T3) and assessment of flex potential (Link to Target 5.1-T5) - The short periodical (second-minutes) energy predictive twin capability, based on monitoring data, predicted weather conditions, and automated HVAC control could significantly improve the flex-potential of building. The longer term (weeks-months) predictive twin capability, based on monitoring data, predicted weather conditions, building characteristics and possible renovation measures, could significantly improve the efficiently of renovation measures and reduce costs - Development of automation HVAC systems based on other inputs: window opening, presence of occupants and predictive HVAC systems - Development of Easy-to-Use digital tools and focus on skills developments (enhance market-readiness) Target 5.1-T5- Innovation projects to: - Develop the technologies and business models to enable energy flexibility on a building and district level (number of buildings together in a smart grid, smart districts, smart neighbourhood, etc.) - Evaluate required maximum and minimum flex capability levels on building and district level, versus cost optimisation on building, grid and district - Investigate data sharing solutions, ensuring data sharing amongst large number of actors, data transfer security and privacy amongst multiple stakeholders - Develop cross-sectoral digital solutions and deploy supporting building grid-interactivity, small-size flexibility aggregation and community models - Develop new business models for building energy flexibility as service (e.g., energy sharing within local communities and markets for long-term seasonal storage) and extending existing business models such as dynamic “spot” price response, short-term market arbitrage, grid balancing services for short-term storage and real-time interaction - Develop easy to use flexibility tools. The flexibility tool could be used prior the building phase and during the operation of the building - Demonstration projects, with focus on large scale market adoption and fostering coordination of stakeholder’s ecosystems and their regulation - Target 5.1-T6: Innovation projects to: - Develop data collection, life re-assessing and storage methodologies - Harmonise or cross-reference national databases of building and material passports and assess possible combinations of centralised and decentralised databases with a distinguished focus on building passport on the one hand and material passports on the other hand (which will integrate different data fields) - Develop material cadastres to describe material stock and their possible reuse, and prepare market for new value chains - Harmonise legislation that support the reuse and high-value recycling - Research on reusability of materials, including AI assisted data driven methodologies, with focus on upcycling - Explore the value chains for a circular economy (construction industry) and development of easy-to-use digital tools to enable this - Demonstration projects, with focus on large scale market adoption, exchange of good practices/tools and skills development for the full supply chain, including buyers, contractors, legislators

Activity Fiche	Digitalisation in buildings
Expected Impact Short term impact (2030) Long term impact (2050)	Short term impact: • Digital tools to support more energy efficient and sustainable buildings with reduced embodied energy / carbon; high life-cycle performance and reduced life-cycle costs • Supporting the goal of 55% GHG emission by 2030, aligned with the EPBD and the European Climate Law Long term impact: Green Deal, Climate neutrality by 2050, 50 % reuse of materials target for the construction industry)
Expected Deliverables	- More accurate benchmarking and calculation of typical buildings' life cycle costs - A data driven and harmonised whole-life-cycle approach supporting the use of data dictionaries, data templates and open standards - Definition of Zero Emission Targets in detail, incl. calculation procedures and Life Carbon costs using EU ETS scenarios and the use of the flexibility index for the life-cycle costs - Definition of the flexibility index, harmonisation with other sectors and creation of an EU-wide Community of Practice, CoP, network for sharing best practices - Clear definition what a material passport and a building passport are, how they are linked and contributing to a revised construction demolition waste protocol
TRL-levels or Society readiness levels	TRL-level 6-8 SRL-level 5-6
Monitoring mechanism	Annual report summarising the progress
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	100m€
Parties involved countries/ stakeholders*	Countries: Austria, Belgium, Czechia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Romania, Spain, Sweden, Serbia, Switzerland Stakeholder: Rina Consulting, TalTech
Indicative financing contribution and source	EU: 47.78m€ Member states: 3.98m€ Other member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. ** Additional co-funding options: CETPartnership (TRI 7).

*Countries/stakeholders involved in projects, IWG5 members

** Will be aligned in summer 2025 (with the final IP-Update).

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal

Name	Description	Time line	Location/ Party	Budget
SIRCULAR Sustainable and Integrated people centRiC solUtions for	SIRCULAR intends to create digital tools, technological solutions and non-technical services for the decarbonisation of the built environment, as well as a ready-to-use	06/24-11/27	RINA Consulting, Italy (Coordinator),Greece,	7.01m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time line**	**Location/ Party**	**Budget**
buiLding decArbonisation and circularity Grant agreement ID: 101147412 Link	methodology for assessing the circularity of a given building capable of evaluating the impact of the developed construction technologies in the demos. SIRCULAR plans to consider four national clusters which will focus on Estonia and Spain, followed by Germany and Greece. The clusters will involve construction companies, housing companies, universities, and local administrative entities, and will include buildings owned or occupied by fragile population groups, in line with the SIRCULAR just and affordable transition approach.		Germany, Spain, Estonia, Ireland	
EVELIXIA **Smart Grid-Efficient Interactive Buildings** Grant agreement ID: 101123238 Link	Smart technologies can significantly advance the energy efficiency of the EU building stock. The EU-funded EVELIXIA project will study European buildings as active utility nodes, aiming to increase their energy efficiency and interconnectivity. The project will enable two-way communication between the grid and occupants, leveraging flexible technologies. EVELIXIA also seeks to make buildings more innovative and flexible by utilising analytics supported by sensors and controls, thus optimising efficiency, flexibility, and occupant preferences while considering utility signals. The project will advance solutions through government-to-business and business-to-government services, human-to-building interfaces, system interoperability, and innovative hardware. These solutions will be integrated, deployed, and validated in seven real-life pilots across the EU.	10/23-09/27	CERTH, Centre for Research and Technology, Hellas, Greece (Coordinator)Italy, France, Spain, Belgium, Ireland, Cyprus, Austria, Romania, Denmark, Finland, Switzerland	10.32m €

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time line**	**Location/ Party**	**Budget**
SmartLiving **EPC** Advanced Energy Performance Assessment towards Smart Living in Building and District Level Grant agreement ID: 101069639 Link	Future energy performance assessment and certification schemes must support the transition to climate-neutral buildings over their complete life cycle. The EU-funded SmartLivingEPC project aims to introduce a certificate that will be supplied by using digitised tools and retrieve the required assessment information for the building shell and building systems. Information will be given on a building's operation by delivering a new rating scale. The new certificate will be completely in line with digital logbooks and building renovation passports so that building energy performance information can be integrated into digital databases. The certificate will be applied to building complexes for energy certification at neighbourhood level.	07/22-06/25	Centre for Research and Technology, Hellas, Greece (Coordinator),Cyprus, Belgium, Romania, Ireland, Netherlands, Italy, Spain, Estonia, Germany, Austria, Ireland	4.75m€
REN+HOMES Renewable ENergy-based Positive Homes Grant agreement ID: 101103450 Link	REN+HOMES tackle the sustainable transition not only by reducing carbon emissions, but also resource scarcity, energy poverty and focusing on education/participation of stakeholders.	06/23-11/26	RINA Consulting, Italy (Coordinator),Greece, France, Romania, Austria, Germany Romania, Estonia, Spain	7.14m€
SUM4RE Creating materials banks from digital urban mining Grant agreement ID: 101129961 Link	SUM4Re proposes a comprehensive approach to creating material banks from the built environment by combining urban mining and technologies for automated on-site data acquisition and building materials identification and asset components.	05/24-11/27	Universidad de Vigo, Spain (Coordinator) Germany, Netherlands, Norway, France, Finland, Belgium, Switzerland	6m€
MODERATE Marketable Open Data Solutions for Optimized Building-Related Energy Services	MODERATE will formalize a set of procedures and techniques that enable building owners, policymakers, facility managers, utility companies, etc., to openly share their data, gain insights, and make decisions while complying with regulations such as the General Data Protection Regulation (GDPR). Moreover, MODERATE will	06/22-06/26	Accademia Europea di Bolzano, Italy (Coordinator), Austria, Belgium,Germany, Italy,	5.4m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time line**	**Location/ Party**	**Budget**
Grant agreement ID: 101069834 Link	enable uniform access to heterogeneous data sources on buildings' performance, usually dispersed in several non-interoperable data silos.		Netherlands, Spain	
GLocalFlex A Global as well as Local Flexibility Marketplace to Demonstrate Grid Balancing Mechanisms through Cross-sectoral Interconnected and Integrated Energy Ecosystems enabling Automatic Flexibility Trading Grant agreement ID: 101096399 Link	Demand-response solutions and services are essential for horizontal scaling of flexible local energy systems (LES). Since LES projects aim to decarbonise across supply, storage and demand resources, it is possible to lower barriers to energy flexibility markets. In this context, the EU-funded GLocalFlex project will develop interoperable solutions and products at all levels of the grid (consumers, producers, retailers, aggregators and market) by selecting modular standards and tools. It will introduce flexibility in terms of energy use in order to provide quality services to grid. The project will also allow any size LES to evolve and provide flexibility by using hardware add-ons. Overall, it will promote the integration of disruptive renewable technologies.	01/23 - 12/26	VTT, Finland (Coordinator), Germany, Czechia, Spain, France, Serbia, Sweden, Switzerland	10.75 m€
Onto-DESIDE Ontology-based Decentralized Sharing of Industry Data in the European Circular Economy Grant agreement ID: 101058682 Link	The Onto-DESIDE project supports acceleration of the digital and green transitions, automating the discovery and formation of new collaborations in the circular economy.	06/22-05/25	Linkoping Universitet, Sweden (Coordinator)Belgium, Germany, Luxembourg ,Netherlands ,Italy, Czechia	3.53m€
DynOpt-San Project ID: 03EN6024A-G Link	Development of a holistic approach for modular and step-by-step energy-efficient refurbishment of multi-family houses and residential quarters, including an easy-to-use, manufacturer-independent digital refurbishment assistant for concrete planning and commissioning, a standardised, efficient integration of heat pumps with innovative collector and storage technology, and a self-learning energy management system with integrated operation monitoring	01/24-12/24	Germany: Uni Paderborn, ESDA Axiotherm, Consolar GmbH, Fraunhofer IOSB, Solares Bauen GmbH	3.33 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Time line**	**Location/ Party**	**Budget**
OUR-E Project ID: 03EN6023A-B Link	Development of a user-friendly model-based control system for complex buildings including a central stratified storage tank	01/23-12/25	Germany: University of Applied Sciences Hof, OAG mbH	0.65 m€

5.4. R&I Activity 5.2-1: Heat pumps as an alternative for fossil fuel heating in the built environment

Activity Fiche Name	Heat pumps as an alternative for fossil fuel heating in the built environment
EU target(s), policies, and goals it addresses	• Policies mentioned in the Revision of the SET Plan communication • Green Deal, REPowerEU • Energy Performance of Buildings Directive (EPBD)
Activity Fiche No.	4
Reference to IP/targets	5.2-T1: Heat Pump Systems - Development of prefabricated, fully-integrated 'plug in and play' hybrid/multisource heat pump systems and integrated compact heating/cooling plants based on modular heat pump - Full-scale demonstration of heat upgrade technologies for district heating networks with supply temperatures in the range 90 - 160°C - Increase the number of heat pumps across Europe to 10 million by 2030
Description (challenge, scope)	As a heating system, heat pumps driven by compressors are a mature technology. However, some challenges remain: **Safe and efficient operation** with low GWP refrigerants: F-gas regulations mean that hydrocarbons (highly flammable) and other mildly flammable refrigerants become a viable replacement for conventional synthetic refrigerants. It is important to implement this is in a safe, efficient but also practical way. CO_2 as a refrigerant is also interesting, especially for domestic hot water heating, which is increasing relatively to space heating. However, conventional use of CO_2 for space heating often results in low efficiency. **High efficiency at higher heating system temperatures** (extending operating range): Although basic laws of thermodynamics result in lower efficiency at higher temperature lifts, it is still of importance to enhance the efficiency at such applications to be able to replace fossil fuel boilers in some buildings. Heat pumps are not only a suitable solution for individual buildings but also for district heating and industrial applications. In these applications, heat pump solutions which could work at higher heat source and heat sink temperatures, could contribute to phasing out of fossil fuels and a higher degree of

Activity Fiche Name	Heat pumps as an alternative for fossil fuel heating in the built environment
	waste heat recovery. Such solutions could include traditional vapor compression technologies as well as non-traditional heat pump technologies (magneto caloric, elasto-caloric, adsorption technologies etc). **Smart operation** in combination with other technologies: Besides heating, a lot of activities in our daily life, such as driving, are electrified. These, together with onsite electricity production by solar PV, can all put strain on the electrical systems. Besides strengthening the grid, being flexible when using electricity can help with avoiding grid problems. Since PV, car batteries and heat pump inverters use DC at a few-hundred volts, it could be cost-effective to use a local DC-grid. **Self-optimising control**: Heat pumps contain a variety of sensors, used for internal control and monitoring. These data are valuable as they can be used for optimising the control. For example, by creating a predictive model, based on weather forecast, price, behaviour or a heating curve, which is auto detected in a robust manner. Automatic fault detection should be part of this predictive model as well. **Ease of installation**: While the physical installation of heat pumps is generally not very complicated, an installer base which is used to installing fossil fuel fired boiler might struggle with heat pumps' sensitivity to settings, of temperatures and flow rates, and placement of outdoor unit/borehole. A lot of those aspects can be made easier by adapting the product or providing tools and guidelines for installers as well as digital systems for self-commissioning. **Sustainable and affordable value chain** As the production volume of heat pumps increases, the sustainability and efficiency along the entire value chain need focus. Modularization and integration of components in a heat pump and other HVAC/R equipment could lead to faster development. A high degree of repairability and recovery of components as well as materials should be assured.
R&I Activities including TRL-levels and timeframe for R&I Activities	**Safe and efficient refrigerants 2025-2030** Research in safe and efficient operation with low GWP refrigerants. The extent to which hydrocarbon refrigerants can be used in split systems or indoor applications with manageable risks should be investigated. This includes design of safety systems, including sensors etc, but also miniaturization of components to contain small refrigerant charges. **High temperatures 2025 onwards** High temperatures: For retrofitting heat pumps to share the existing properties for a considerable extent, high temperatures are desirable for two reasons: working with existing heating systems and being able to heat up domestic hot water to high temperatures and thus reducing the amount of space required for hot water cylinders. Also, high temperatures can be enablers for storing heat and quick heat-up of dwellings and can provide flexibility. Glide refrigerants should also be considered for this. To ensure efficient and robust operation also at higher temperatures than today, extended R&I efforts on this topic, can contribute to having heat pumps suitable for more and more dwellings. Large heat pumps that can work efficiently and flexibly in industrial as well as district heating systems, often at higher source as well as sink temperatures, are a promising but less developed solution. Research and innovation on how to design and optimise the heat pump system and optimise the process integration will be needed. . **Smart operation 2025-2030**

Activity Fiche Name	Heat pumps as an alternative for fossil fuel heating in the built environment
	Smart operation: Heat pumps should predict in advance what their energy requirements are, based on house type, user demand and weather forecast. The heat pump should be able to calculate how to best fulfil the heating demand of the building, based on different optimizing criteria (price, emissions, power constraints etc, comfort etc. This information can be used by whatever entity is controlling the grid, if this is a Home Energy Management System (HEMS) optimizing for onsite PV consumption, running cost, or aggregated party keeping the grid in balance. Algorithms learning the properties of buildings and installations, and the users, should be researched to accelerate this process. **Ease of installation 2025-2027** Ease of installation: heat pumps are generally more complex to install than fossil fuel boilers. The selection and setup phase has more impact on performance and comfort of the end user. Overengineering the set up to be *on the safe side* does not contribute to high number roll-out of heating systems. Research must be done in developing tools and methods for installing parties to: 1) select appropriate equipment, 2) keep installations as simple as viable and 3) configure correctly, 4) make fault detection and identification of measures to be taken.
Expected Impact Short term impact (2030) Long term impact (2050)	Short term impact (2030) - Since the installation companies gain more experience with heat pumps, the cost of an average installation reduces and is feasible for more and more building types. Net congestion is avoided by controlling heat pumps in a smart way, either according to price signals etc. or by cluster control of a larger population (aggregator). - The cost and material efficiency for producing heat pumps has improved considerably, the whole value chain is adapted to a circular economy. - Heat pumps are proved to be a viable, sustainable and cost efficient multi-vectoral (heat, cold, electricity, system services) solution for more and more industrial processes as well for district heating systems or thermal grids. Long term impact (2050) - There is realistically no need for fossil fuel burning for space heating and domestic hot water generation. - Heat pumps cover a majority of the heating demand up to 200°C and, to some extent, at even higher temperatures. - Heat pumps cover at least 25% of the heating demand in thermal networks for heating of buildings and industries, operates flexibly to a very large extent on renewable electricity produced by wind and PV.
Expected Deliverables	The deployment of heat pumps exceeds/follows the ambitions of REPowerEU: The number of installed heat pumps increases from 3 million in 2022[15] to 10 million in 2027, deployment of at least 30 million additional /hydronic) heat pumps in 2030 compared to 2020. The life cycle cost of a heat pump system is beneficial/competitive compared to fossil fuel heating. Alternative business models reduce the upfront cost for the end consumer for installing a heat pump system. **Sustainable and affordable value chain**

Activity Fiche Name	Heat pumps as an alternative for fossil fuel heating in the built environment
	Research and innovation should focus on how to design products considering the whole life cycle, from manufacturing the components to end-of-life, ensuring a high energy as well as material efficiency. Collaborative heat modelling tool aimed at innovating systems as to increase the speed and manufacturing of new innovations and tools for designing heat pumps directly into energy systems (thermal, and multi-vector) should be developed.
TRL-Level	8-9 for flagship projects, demonstration innovation in the market
Monitoring mechanism	Annual report summarising the progress Monitoring can be done by individual countries. Based on executed projects an assessment can be made on how each project can contribute to the deployment of heat pumps within Europe.
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	10-15 m€ per flagship project, with at least 10 projects in the period until 2030
Parties involved countries/ stakeholders*	Austria, Belgium, Denmark, Estonia, Germany, Greece, Italy, Netherlands, Poland, Spain, Sweden, United Kingdom Stakeholders: EHPA, Technische Universität München (TUM)
Indicative financing contribution and source	EU Contribution : 4.27m€ Member states : 1.17 m€ (Austria) Several member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **

*Countries/stakeholders involved in projects, IWG5 members

** Will be aligned in summer 2025 (with the final IP-Update).

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal

Name	Description	Timeline	Location/Party	Budget
GEOBOOST Boosting geothermal heat pumps to mainstream cost-effective and efficient renewable heating and cooling in buildings Grant agreement number 101077613 LIFE Link	The project will support the implementation of the Renewable Energy Directive and the Energy Efficiency Directive in the EU, by allowing a market uptake of geothermal heating and cooling technologies. GeoBOOST will seek to unlock market barriers for geothermal heat pumps, as they are the most energy efficiency and cost-effective RES HC solution but have often been neglected by policy makers and also by the dedicated market uptake research proposals.	01/23 – 12/25	BE/European Geothermal Energy Council (EGEC), (Coordinator) AT/ Geosphere Austria - Bundesanstalt fur Geologie, Geophysik, Klimatologie und Meteorologie, DE/ Geoenergie Konzept Gmbh, Technische Universitaet Muenchen, de; ES/Universitat Politecnica de Valencia, UK/Terra Geoserv Limited, NL/Groenholland Geo Energiesystemen Bv, PL/Polska organizacja	2 m€

Activity Fiche Name	Heat pumps as an alternative for fossil fuel heating in the built environment			
			rozwoju technologii pomp ciepla, SE/ Rototec ab, se.	
ITS4ZEB Integrated Thermal energy Storages for Zero Emission Buildings Grant agreement number 101113714 LIFE Link	LIFE iTS4ZEB project will develop and demonstrate novel next generation long- and short-term, compact, high-performing, cost-effective, modular and integrated latent Thermal Energy Storage (TES) technologies. They are based on the exploitation of modern Phase Change Materials (PCM) storage system combined with high-efficiency heat pumps for heating and cooling of residential space and domestic hot water. At the heart of the solution lies an innovative multi-source heat pump combined with PCM optimised by novel control algorithms to maximise performance, renewable energy fraction, GHG reduction, cost savings, and energy system integration.	09/23 – 02/27	IT/Innova SRL It (Coordinator) DE/Panasonic marketing europe gmbh, de; IT/Studio fieschi & soci srl, Innova engineering srl, Accademia Europea di Bolzano, Universita Degli Studi di Padova, Sunservice srl,	3.3 m€

AbSolut Integration of absorption technologies in district heating and cooling systems Link Flagship Region Energy (Austrian initative)	The AbSolut project examines the integration of absorption technologies in district heating and cooling systems. These technologies use thermally driven absorption processes to provide diverse solutions for thermal energy systems. These range from classic absorption heat pumps and cooling systems to absorption heat exchangers. In contrast to conventional compression heat pumps, absorption technologies are driven thermally rather than electrically. In addition, the refrigerants used have no global warming potential. In addition to relieving the load on the power grid, this opens up numerous new system concepts, such as the use of solar thermal energy or waste heat as sustainable drive energy. Despite these unique properties and the technical maturity at the technology level, such technologies have only been used as niche solutions in Austria and Europe to date. AbSolut faces this challenge and develops innovative system concepts for the efficient integration of these technologies into Austrian district heating and cooling systems.	01/24-09/24	AT/ AEE - Institut für Nachhaltige Technologien (Coordinator), EQUANS Energie GmbH, Linz Strom Gas Wärme GmbH, STEPSAHEAD Energiesysteme GmbH, Wien Energie GmbH	1.17 m€

5.5. R&I Activity 5.2-2: District Heating and Cooling

Activity Fiche Name	District Heating and Cooling (DHC)
EU target(s), policies, and goals it addresses	• Policies mentioned in the Revision of the SET Plan communication • Green Deal, REPowerEU Plan • Energy Performance of Buildings Directive (EPBD) • Renewable Energy Directive (RED)
Activity Fiche No.	5
Reference to IP targets	Target 5.2-T2 District heating and cooling: - Increase the share of district heating in the EU's heat demand to 20% by 2030 preferably using low temperature waste heat and renewable sources - Integration of 8 million households into the district heating/cooling networks across Europe
Description (challenge,scope)	District heating and cooling is part of the ready-to-deploy solutions to phase out fossil fuels in heating and cooling. It currently represents 13% of the heat market, providing heat to more than 68 million EU citizens, while 140 million citizens live in cities already equipped with a DHC network.

Activity Fiche Name	District Heating and Cooling (DHC)
	DHC fosters a robust decarbonization pathway for the heating and cooling sector, on the road to 2050, harnessing local renewable heat, such as sustainable bioenergy, geothermal, solar thermal and enables harvesting waste heat from industrial and tertiary sources, such as heat from data centres, wastewater treatment plants, manufacturing processes, metro stations, food retails, and so on. DHC networks could also play an essential role in balancing the electricity grid while integrating a significant amount of renewable electricity, which is a new, innovative way of sector coupling. This has been recognized within the latest revision of the Renewable Energy Directive (RED III), where the institutions agreed that DHC systems increasingly contribute to the balancing of the electricity grid. Together with additional thermal storages DHC systems, using e-boilers (electric water heaters) and large-scale heat pumps can provide flexibility in terms of utilizing and integrating renewable-based electricity otherwise to be curtailed. District heating systems could also contribute in terms of electricity production through high-efficiency and renewable CHP plants. The demand for cooling is rapidly increasing, mostly in business and public buildings but also in households. DHC systems can furnish cooling power, with a number of network topologies and with conversion technologies that use renewable sources. Past Objectives of the Implementation Plan: The 2015 targets were achieved by taking into consideration the data from selected countries. Between 2011 and 2024, renewables grew by more than 100%. Currently, renewable energy sources account for 39% of the power used in District Heating across Europe (2022). Current EU objectives EED, Art. 26.1 – Efficient district heating and cooling systems definition: From 2028 HDC systems, wishing to be classified as efficient district heating and cooling systems should use at least 50% renewable energy, 50% waste heat, 50% renewable energy and waste heat, 80% of high-efficiency cogenerated heat or at least a combination of such thermal energy going into the network where the share of renewable energy is at least 5% and the total share of renewable energy, waste heat or high-efficiency cogenerated heat is at least 50%. Throughout 2035, 2040 and 2045 the share of renewables and waste heat sources has to gradually increase, while reaching 100% renewable energy and/or waste heat by 2050. Art. 26.2 also provides an alternative efficient district heating and cooling definition, which limits DHC networks to a maximum amount of GHG emissions per unit of heat or cold delivered to the customers, reaching 0 grams of CO2/kWh by 2050. Additionally, in order for a DHC system to quality as efficient, Member States shall ensure that when a district heating and cooling system is built or its supply units are substantially refurbished any new heat sources in that system do not use fossil fuels, except natural gas until 2030. From 1 January 2025, and every five years thereafter, operators of all existing district heating and cooling systems not complying with the efficient district heating and cooling systems definition with a total heat and cold output exceeding 5 MW will be required to develop plans that outline how the definition will be met. There is no legislative requirement for district heating and cooling

Activity Fiche Name	District Heating and Cooling (DHC)
	systems to meet the efficient district heating and cooling systems definition, however other EU legislations present limitations, for example: • According to the Energy Performance of Buildings Directive (EPBD) all newly built buildings after 2030 have to be Zero Emission Buildings (ZEBs). ZEBs by default are allowed to connect only to EDHC systems, and as an exception to a DHC system in cases where it is technically or economically not feasible to connect to an EDHC system. • According to the State Aid rules only EDHC networks are allowed to receive financial support, and DHC networks only in order to meet the EDHC requirements. RED, Art. 24(4) – Renewable targets for DHC: Member States are urged to increase the share of energy from renewable sources and waste heat in district heating and cooling by an indicative 2.2 percentage points annually, calculated from 2021 to 2030. Notably, Member States can incorporate renewable electricity used in district heating and cooling toward the annual increase, provided they inform the Commission about their intentions. Integrated national energy and climate plans of Member States should encompass estimated renewable electricity capacities for district heating and cooling, along with measures to augment the renewable energy share in DHC. • Recital 27 also justifies that waste heat and cold should contribute to the renewable targets for DHC, heating and cooling, industry, and buildings. While the primary goal is to boost the deployment of renewable energy sources (RES), waste heat is viewed as a complementary solution supporting the transition to a low-carbon energy system. • Compared to RED II, the RED III final DHC target for 2030 has been increased from 1 to 2.2 percentage points. Importantly, this adjustment maintains the indicative nature of the increase, acknowledging the varied development of such networks across the Union. New IWG5 focus areas for district heating are: 1. Multi-source District Heating integrating renewable and recovered sources – develop and implement measures to better integrate RES and Renewable Energy Certificates (REC) heat sources to develop more efficient; digital DH systems, while also developing, implementing, and sharing business models for multi- source DH networks 2. Higher temperature District Cooling for the integration of more natural cooling and increased efficiency – increase the temperature of the grid would lower peak loads and open new sources and technologies 3. Optimisation of building heating system, to minimize the temperature levels in district heating networks – reduce losses, increase the efficiency of operation and control of the indoor heating system elements of the buildings, allowing the system to run on lower supply and return temperatures
Expected Impact Short term impact (2030)Long term impact (2050)	Short-term impact (2030) The activities are being developed in the Research and Innovation field and the uptake of green energy and waste heat for providing useful heat. In the R&D&I area, there are a series of projects focusing on investigating novel ways of harnessing heat from renewable sources like data centres, and the use of low-grade renewable energy and waste heat. There are projects aimed at developing skills and increasing the qualifications of professionals working in the heating

Activity Fiche Name	District Heating and Cooling (DHC)	
	sector, and other aimed at developing new heat storage technologies. Another key action for 2030 is increasing the district heating systems' flexibility, digitalisation, and efficiency increase through heating water temperature reduction. For the short-term impact, renewables and waste heat sources are expected to account for 50% of the energy used to provide heat for district heating systems. Long-term impact (2050) The long-term impact is the complete decarbonisation of the district heating and cooling sector in the European Union. By adopting and further enhancing the policies developed before regarding R&D&I and breakthrough technologies, it is expected that the district heating systems are developed in new areas where it is required and further ameliorated, where it is already in place. The aim is to reach 48% market share for DHC in Europe's heating sector.	
Expected Deliverables	Multi-source District Heating integrating renewable, and waste heat sources: • Overview over specific solutions • System analyses and simulations • Analysis of the potential to use close to zero cost electricity in 5 existing DH networks in different countries • Realization of a 25% increase of renewable sources using a combination of solutions in 5 existing DH networks in different countriescovering different load conditions. Higher temperature District Cooling for the integration of more natural cooling and increased efficiency: • Technological developments • Overview over design solutions for buildings adjusted to higher flow temperatures • Realization of an 25% increase of renewable sources using a combination of solutions supplying higher temperatures in 5 existing or new DC networks in different countries covering differentload conditions. Optimisation of building heating system, to minimize the heating water temperature levels in district heating networks: • Large scale demonstration of the technical feasibility and economic competitiveness of low temperature grids combining the above-described aspects • Demonstration of buildings delivering heat or cold to DHC networks	
Monitoring mechanism	Annual report summarising the progress	
TRL-Levels	6-9	
Implementation instruments	Flagship projects	
Timeline	36 months	
Total budget required	145 m€	
Parties involved countries/ stakeholders* *Countries/stakeholders involved in projects, IWG5 members	**Implementation financing / Funding instruments**	**Indicative Financing contribution**

Austria	National funding: Federal Ministry for Transport, Innovation and Technology viaresearch program “City of Tomorrow” and industry resources	1 m€/year (still to be confirmed)
Belgium	National funding: Flemish agency “Flanders Innovation & Entrepreneurship” and the Research Foundation Flanders	9.5 m€/5 years (estimation, since bottom up non thematic funding programmes)
Germany	National funding (Federal Ministry of Economics and Energy) and industry resources	30 m€/6 years
Sweden	Swedish Energy AgencyNational R&I funding programme TERMO	Sweden is interested in the activity, but currently cannot provide an indicative level of financial contribution per each AF.
Italy	Ministry of Economic Development (MISE), Ministry of Education, University, and Research (MIUR), funding fromRegions	substantial financing contribution is intended but cannot be specified at present
Stakeholders	RINA Consulting, Euroheat&Power, DHC, RHC ETIP	
Indicative financing contribution and source	EC Contribution : 15, 5m€ (Horizon Europe) Life projects (not yet available in the project database) Member states: 49,5m€ (see above)	

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal

Name	Description	Timeline	Location/Party	Budget (€)
EnableDHC Enabling strategies and investment plans for efficient, multi-energy and digitalized DHC Grant Agreement No. 101167576 LIFE Link	Fostering the switch of DHC networks towards efficient DHC as defined in the EED	04/24-03/27	AEE – Institut für Nachhaltige Technologien, Austria (Coordinator), Belgium (Euroheat & Power-EHP) Croatia, Germany, Ireland, Italy, Latvia, Slovenia,Ukraine	1.467 m€
Skills4DHC Grant Agreement No. 101167576 LIFE, Link	Develop skills and qualification of professionals but also recruiting enough professionals for the DHC sector.	04/24-03/27	AEE, Austria (Coordinator); Belgium (EHP), Denmark, Estonia, Germany, Ireland, Italy, Netherlands	1.44m€
Thunder THermochemical storage Utilization eNabling Data centre seasonal Energy Recovery Grant agreement	Recover waste heat from data centres’ cooling processes.	2024-2028	RINA-Consulting, Italy (Coordinator) EHP, UBE, ABILIX, SETECHCO, 3SI STEELTECH, UNIFI, UNIGE, HIREF, Veolia	7.2 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget (€)**
ID: 101136186 Link Horizon Europe			Spain, Cartif, IVL UK: PCM (AP)	
Treasure Grant agreement ID: 101136095 Horizon Europe Link	Demonstration of 7 Pit Thermal Energy Storages for Dixstrict Heating. Bridge the gap between research and practice to ensure robust, safe, cost effective, and sustainable large-scale thermal energy storage	01/24-12/ 27	AEE INTEC, Austria, (Coordinator) Energieinstitut (Linz University), Solid Solar Energy Systems, Porr Bau, WIEN ENERGIE, EHP, FENIX TNT, Planenergi Fond, Aalborg CSP, Geo, Communaute d'agglomeration Pau Bearn Pyrenee; NEWHEAT, ENGIE; Steinbeis Innovation, HIR, Glapor Werk Mitterteich, Technische Universitaet Dresden; Hansestadt Rostock, Rafako Innovation, SECSOO,	11.4m€
ruralHeat	The aim of the project is the scientific monitoring of the planning and implementation of solar local heating in two rural settlements and the potential applicability to other rural settlements. The innovation lies in the fact that more than 70% of the heat demand is covered by solar heat in combination with a seasonal heat storage system. This means that solar thermal is no longer a 'fuel saver' but the main heat source. The system is complemented by a large heat pump to discharge the storage tank and two wood-fired boilers for peak loads. The 100% renewable local heating concept is cheaper and can be implemented much faster than measures on individual buildings (energy renovation, change of heating system). The results will be used to develop a web-based pre-selection tool that will enable interested municipalities or citizens' initiatives to pre-select possible local heating solutions based on renewable heat at an early stage (i.e. with little input data).	06/2023-05/2026	University Kassel (Germany)	0.7 m€

5.6. R&I Activity 5.2-3: Combined (Cooling) Heat and Power generation

Activity Fiche Name	Combined (Cooling) Heat and Power generation
EU target(s), policies, and goals it addresses	• Green Deal, SET Plan revision •
Activity Fiche No.	6
Reference to IP/targets	5.2-T3 Micro: CHP/CCHP - Integration of highly flexible CCHP systems with heat storage, heat pumps and renewable heat sources with the aim of reducing annual fuel consumption - Development of CCHP technologies running on renewable gases (hydrogen, ammonia, methanol, synthetic gas, etc.) with comparable performances as running on natural gas
Description (challenge, scope)	Buildings account for a substantial portion of global energy consumption and greenhouse gas emissions, primarily due to the widespread use of gas and oil boilers for heating. These conventional systems are not only carbon-intensive but also contribute to air pollution and resource depletion. Replacing them with renewable energy sources and more efficient technologies is crucial and it may require substantial investments and infrastructure changes, depending on the characteristics of the specific area considered. For instance, the integration of electric heat pumps, which are highly efficient, can be limited by the capacity of local electrical grids. Further, not always a direct connection of the heat pumps and renewable energy sources is possible. In regions where grids require high network investments to avoid congestions, adding significant electrical load of heat pumps could lead to reliability issues and increased costs. Cooling systems too, predominantly powered by electricity, face similar challenges. As global temperatures rise, the demand for air conditioning is expected to increase, further straining electrical distribution systems. Furthermore, the intermittent nature of renewable energy sources such as wind and solar power necessitates the development of energy storage solutions and grid management strategies. Without these, ensuring a consistent and reliable energy supply for heating and cooling remains a significant hurdle. Innovative solutions like the proposed microcogeneration systems using microgasturbines powered by green fuels (or e-fuels) will have an important role in this context. By generating both heat and power on-site and utilizing clean energy sources in form of green fuels, these systems can contribute to alleviate electricity grid congestion and provide a reliable and dispatchable energy supply. Additionally, they offer the flexibility to adapt to different fuels and evolving energy landscapes, making them a versatile solution for the decarbonized energy scenario. While microgasturbines themselves are not a new technology, their application in building heating and cooling systems fed by green fuels represents a novel and potentially transformative approach.
R&I Activities	**Broad spectrum development and experimentation for hydrogen combustion system** (from TRL6 to TRL7, time frame 2025 - 2028) Develop high flexible dual fuel (hydrogen/natural gas) combustion systems for microturbines to burn any concentration of mixtures of hydrogen in natural gas from 0% hydrogen (100% natural gas) to 100% hydrogen. Review state of the art, simulation and modelling, hydrogen / natural gas combustion chamber and fuel system design, combustion system prototype detailed design and procurement, combustion system prototype testing, data processing and emissions evaluation, enhanced design.

	High flexibility development and experimentation for methanol and hydrogen combustion systems (from TRL6 to TRL7, time frame 2025 - 2028) From combustion systems state of the art define flexible operating concepts (for different use context) able to cope with high variability of trigeneration demand, minimizing emissions. Testing transient operations, minimum load and part loads, assess capabilities and emissions in a wide spectrum of cases.
Expected Impact Short term impact (2030) Long term impact (2050)	Short term impact (by 2030): - By completion of several demonstration projects, reach a proven technological and economic viability for the application of Micro CCHP to buildings based on renewable fuels in distributed energy applications. - The deployment of microgeneration systems powered by green hydrogen or other green fuels will contribute to significant reductions in greenhouse gas emissions from the building sector, meeting the EU's target of reducing emissions by at least 55% by 2030 compared to 1990 levels. - In regions facing electrical grid congestion, microgeneration systems offer a reliable alternative to traditional heating and cooling solutions. By generating energy on-site, these systems can alleviate stress on the grid, enhancing overall grid stability and resilience, which is crucial for accommodating the increasing share of renewable energy sources. - The increased efficiency and reduced energy costs associated with microgeneration systems can drive economic benefits for building owners and occupants. This supports the SET PLAN's objective of fostering a competitive European energy market that delivers affordable energy to consumers. Long term (by 2050): - By 2050, the widespread implementation of microgeneration systems can support the complete decarbonization of the building sector. Utilizing hydrogen and other green fuels aligns with the EU's vision of achieving net-zero greenhouse gas emissions by 2050. These systems will reduce reliance on fossil fuels and significantly cut emissions from heating and cooling. The widespread implementation will also support the exploitation of economies of scale and reach cost reduction objectives for equipment and installation, and support achieving the carbon-neutrality targets for buildings. - Microgeneration systems can be seamlessly integrated into smart grids and advanced energy management systems, enhancing the overall efficiency and flexibility of energy networks. This integration will support the SET PLAN's goal of creating a smart, efficient, and sustainable energy system across Europe. - The development and deployment of advanced microgeneration technologies will position Europe as a leader in clean energy innovation. By fostering research and development, the EU can drive global advancements in energy technologies, contributing to the SET PLAN's objective of maintaining Europe's technological leadership. - In the long term, the adoption of microgeneration systems will support sustainable urban development by providing decentralized and resilient energy solutions. This aligns with broader EU objectives of creating sustainable cities and communities, reducing urban carbon footprints, and enhancing the quality of life for residents. - By deploying Micro CCHP systems in areas where other technologies are not feasible, economies of scale and experience in the supply chain will be leveraged to reach cost

	reduction objectives for equipment and installation and support the achievement of carbon-neutrality targets for buildings.
Expected Deliverables	- Demonstration of ultra-low emission combustor design for hydrogen and methanol and its endurance behaviour - Definition of techno-economic and environmental key performance indicators (KPIs) for characterising and comparing CHP-CCHP systems with traditional energy production systems (e.g. boilers, heat pumps etc. associated with electricity from the grid) - Consolidation of data and experience from demonstration projects, tracking of defined KPIs over the first years of operation - Assessment of the scalability and replicability of the technology, for broader adoption across different applications, building types and locations - Assessment of enhancements brought to potentially congested local electrical grids in terms of avoidance of interrupted energy supply - Facilitation and dissemination of the know-how on the design of the developed solutions - System digital twin and model to be integrated in building energy management systems
TRL-Level	6-9
Monitoring mechanism	Annual report summarising the progress
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	Cannot be estimated at this stage as projects are still in the draft phase
Parties involved countries/ stakeholders*	Countries: Belgium, Denmark, Germany, Italy, Netherlands Stakeholders: Cogen Europe
Indicative financing contribution and source	EC Contribution: 4.99m€ Member states: Member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **

*Countries/stakeholders involved in projects, IWG5 members

** Will be aligned in summer 2025 (with the final IP-Update).

Planned/ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal

Name	**Description**	**Timeline**	**Location/ Party**	**Bud get**
Planned project 1	Demonstration of installation with Combined Heat and Cooling with microgasturbine fed with **green hydrogen** (potentially selecting a location nearby an available green hydrogen infrastructure) in the temperature-controlled fruit stevedoring application. This particular application will use both heat and cooling loads at the same time without		Site not yet identified	

Planned/ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/ Party**	**Budget**
	a determined seasonality. The aim is to reduce the carbon footprint of the logistics of the fruit distribution chain, with no additional demand on local electrical distribution grid. Object of the demonstration is to ascertain the endurance reliability of the microgasturbine system while working with hydrogen fuel. Other objectives will include assessment on carbon savings, overall efficiency, running costs, need of optimisation/addition of heat/cool storage. Sizing of the potential application, electrical power 100 kW, cooling power 105 kW, heat power 165 kW. Start: TRL8, end of project: TRL9			
Planned project 2	Demonstration of installation with Combined Heat and Cooling with microgasturbine fed with **green methanol** in the residential buildings and /or tourist reception in remote areas, with no or limited possibility of expanding electrical distribution grid and or installation of additional renewable sources. The aim is to reduce the carbon footprint of the thermal and cooling loads required by the application. Object of the demonstration is to ascertain the endurance reliability of the microgasturbine system while working with methanol fuel and very low NOx emissions. Others objectives will include assessment on carbon savings, overall efficiency, running costs, need of optimisation/addition of heat/cool storage. Sizing of the potential application, electrical power 100 kW, cooling power 105 kW, heat power 165 kW. Start: TRL8, end of project: TRL9		Site not yet identified	
FIT4MICRO Grant agreement ID: 101083536 Horizon Europe Link : https://www.fit4micro.eu/the-project/	Micro combined heat and power (micro-CHP) systems, also known as cogeneration systems, generate heat and electricity simultaneously. The EU-funded Fit4Micro project plans to develop a hybrid micro-CHP unit running on sustainable liquid biofuels. The envisaged technology will be designed for multi-family homes, especially for stand-alone (off-grid) applications. The system will comprise a double shaft micro gas turbine and a humidification unit. This unique combination is expected to drive high electrical efficiencies (>40 %) and have a very flexible heat-to-power ratio. A flameless combustion system will reduce carbon emission levels. Furthermore, the Fit4Micro	10/22-09/26	BE/MITIS (Coordinator) BE/University of Mons BE/Cogen Europe DK/University of Aalborg DE/Fraunhofer ISE, OWI Aachen FAHREN	4.99 m €

Planned/ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/ Party**	**Budget**
	unit will be integrated with a compression heat pump, an adsorption system and a photovoltaic array that will work in parallel to produce electric and thermal energy.		HEIT NL/BTG IT/ ETA	

5.7. R&I Activity 5.2-4: Thermal Energy Storage (TES)

Activity Fiche Name	Thermal Energy Storage (TES)
EU target(s), policies, and goals it addresses	• Policies mentioned in the Revision of the SET Plan communication • Green Deal, REPowerEU Plan • EPBD
Activity Fiche No.	7
Reference to IP/targets	5.2-T4 Thermal Energy Storage: - 100 new large thermal energy storages in district heating and cooling networks in progress in 2030 - 10 new demo systems with sensible thermal energy storage with a usage of RES and waste heat to more than 60% of the yearly heat demand - 20 systems for compact thermal energy storage demonstrated at TRL 6/7 with a storage density at system level increased to 120 kWh/m3
Description (challenge, scope)	More than 50% of final energy is globally used for heating & cooling. A significant decarbonization of this demand is enabled by thermal energy storage (TES), providing peak shaving, load shifting, energy efficiency improvements, increased use of renewable sources, increased waste heat recovery, and flexible sector coupling services to both thermal and electrical sectors. The three basic classes of TES are sensible, phase change and thermochemical. **Sensible thermal energy storage** is the most developed and applied presently in the built environment, in the form of hot water boilers for individual homes and larger tanks, pits, boreholes, aquifers or caverns for thermal energy storage for larger demands such as district heating/cooling systems, hospitals, airports and greenhouses. Higher temperature sensible storages, using sand, molten salt, stone or metals are being developed for power-to-heat purposes, both in small and in large thermal systems. They will play an important role in flexible sector coupling, with smaller systems also relevant for the built environment. Challenges are the cost reduction of sensible TES, the exploration and demonstration of new business models for sector coupling and the system integration. **Phase change materials (PCMs)** are the compact TES type that also has a high technology readiness level (TRL) today, with many market-ready systems with ice and some with other materials. Despite these successes, PCM design has many techno-economic challenges to overcome, at material, component and system level, to realize their widespread and particularly large-scale deployment.

Activity Fiche Name	Thermal Energy Storage (TES)
	Thermochemical storage materials (TCM) have the potential for the highest compactness and are still in a lower TRL, with a few startup companies working on market introduction of specific TCM technologies. The challenges here are on material, component and system level and by using recyclable, sustainable and low-cost reagents For PCM storage and TCM storage, the challenges broadly are: - At material level, supercooling, hysteresis, phase separation, low thermal conductivity, unsatisfactory thermal and chemical stability for repeated cycling, finding renewable alternatives at effective costs etc. still must be further explored. Furthermore, costs can be reduced by improvement of material production methods. - At component level, effective heat exchangers or reactors, including incorporation of heat recovery systems, for satisfactory charging/discharging powers without significant compromises on effective TES size and costs, as well as application-scale long-term cycling testing of materials in the components are key challenges. - At system level, optimised and smart (including digitalized) operation and control of systems in-combination with building energy systems as well as both the thermal and electrical systems for flexible sector coupling services remain challenges. Furthermore, enhancing the system energy storage density is important to reduce system cost. - A passive PCM application in buildings aims at incorporating it into building materials to increase the thermal mass of buildings thus reducing outdoor temperature effects and therefore decrease the building energy demand during the heating and/or cooling season, respectively. In this context, the scope of this activity fiche on PCM-TES covers materials, components and systems, and in this IWG5, both heating and cooling applications in buildings. A general challenge for all TES technologies is to find good business cases for the storage options. A financial justification should be found for any TES on the market, peak shaving, load shifting, energy efficiency improvements, increased use of renewable sources, increased waste heat recovery, and flexible sector coupling services to both thermal and electrical sectors. Another general challenge is the safety of higher-temperature TES systems in the built environment.
R&I Activities	General: - Studies into the business cases for TES technologies Sensible TES: - Further cost reduction through technology improvements, through manufacturing/building process improvements, through build-up of practical experience with demonstration and monitoring projects and through standardisation. PCM TES: - PCM and PCM encapsulation design and optimisation (novel composites, biomaterials, renewable, robust with low supercooling & hysteresis and good cycling stability, cost-effective) - PCM encapsulation design (biomaterials, renewable, robust, a variety of compatibility, cost-effective, … - PCM-TES heat exchanger design (novel, compact, more cost-effective, a variety of compatibility, improved charging & discharging powers…)

Activity Fiche Name	Thermal Energy Storage (TES)
	- PCM-TES system design (compact at system level, cost-effective, good charging and discharging powers, large storage capacity per volume and mass, improved operational control, …) - Pilot- and application-scale system studies, numerical & real (experimental) - Monitoring of real installations for long-term performance & comparison for design versus real performance - Standardisation of interfaces / ports for the connection between TES and energy system - PCM-TES Design and prediction tools. All funded projects should attempt to provide open science tools to broaden the application and impact of knowledge generated with public funds. TCM TES: - Development, refinement and design of novel, affordable, environment friendly, nontoxic, noncorrosive shaped (granulated or coatings) TCMs (good cycling stability, adequate thermal conductivity, good kinetics, without hysteresis in sorption isotherms) and enhanced components (TRL 1-3). - Integration and testing within complete storage systems to validate these advancements (TRL 3-5). - Establishing an open platform incorporating data from previous projects to facilitate collaboration and accelerate progress in the field. This would provide a comprehensive repository of knowledge, enabling stakeholders to build upon existing research and drive the development of more efficient and economical TCM-based energy storage solutions. - Setting up networks of experts for effective collaboration, through initiatives like COST actions (TRL 1-3). - Establishment of training programs is to nurture experts with a comprehensive understanding across diverse disciplines of material science and engineering (TRL 1-3). - Demonstration of TES technology for weekly, monthly and seasonal storage and possibility of coupling with other thermal energy storage solution, taking to account the life cycle analysis and economic and social aspects (TRL 5-7).
Expected Impact Short term impact (2030) Long term impact (2050)	**Short term (by 2030):** - Large-scale TES systems integrated into DHC and industrial heat networks - Integrated monitoring of materials in LTES systems to determine long term performance - PCMs with robust long-term functionality and techno-economic feasibility, and with preferably renewable or sustainable sources (life cycle analysis) - An online/live database compiling data from previous national and international projects to support data-driven design approaches - Techno-economically effective heat exchangers with compatibility for both organic and inorganic PCMs. - Novel, smart thermochemical materials and systems with minimized temperature difference between charging and discharging phases. - Novel, optimised TCM reactors - System integration compact TES for optimal energy benefits (flexible sector coupling) - Successfully demonstrated innovative thermochemical heat storage systems within neighbourhoods (shared between buildings) or micro heat networks. **Long term (by 2050):**

Activity Fiche Name	Thermal Energy Storage (TES)
	- Large-scale incorporation of PCM in lightweight buildings to increase thermal mass - Favourable market and policy frameworks to recognize, monetize and promote flexibility and grid services of PCM TES - TRL 9 compact TES systems with widespread market deployment, enabling carbon neutral energy systems (both thermal and power sectors)
Expected Deliverables	A series of demonstration projects for large scale sensible TES system integrated in DHC and industrial heat networks. Knowledge on long term performance of materials for LTES. The expected deliverables concern R&I on materials, components (heat exchangers) and systems using PCM TES, such as: - Providing representative techno-economic and environmental key performance indicators (KPIs) for characterising and comparing PCM TES systems with other TES and energy storage types for similar applications - Facilitation and dissemination of the know-how on the design of 'plug-and-play' PCM-TES solutions - More robust PCMs* with: no supercooling and phase separation; low hysteresis; good thermal and chemical stability at 10 000+ cycles, - Many renewable and cost-competitive PCMs alternatives in both pure and blend materials - Prediction tools to choose proper PCM material, position, and quantity in lightweight buildings depending on local climate - Cost-effective thermal conductivity enhancement techniques for PCMs, in both as composites and other alternatives - Improved thermo-physical and chemical characterization of PCMs and most importantly, achieving international standardisation of their analysis methods - Cost-effective and technically robust, novel compact heat exchanger designs and compatible heat exchanger materials - Competitive and smart LHTES system operational and control systems and strategies. - State-of-charge characterization, enhancement and benchmark - Digitalization of PCM-TES systems and their integration in building energy systems - Enabling flexibility and grid services to the power grid through cost-effective and robust LHTES linked to thermal and power sectors - Enabling considerable waste/surplus thermal energy recovery (both heat and cold) and thereby energy efficiency improvements through LHTES-integrated energy system TCM: - Smart, sustainable and multifunctional thermochemical heat storage materials and systems - Cheap and fast production route for thermochemical heat storage reactors and heat exchangers (e.g. through additive manufacturing) - Design tools for reactors - Open data base - Publications - Patenting innovative methods, as well as establishing start-ups and SMEs to commercialize these innovations.
TRL-levels	5-9 (see also above)
Monitoring mechanism	Annual report summarising the progress

Activity Fiche Name	Thermal Energy Storage (TES)
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	100-150 m€ **Total budget required** €9-10 million per project. Additional budget is required to achieve TRL7-9.
Parties involved countries/ stakeholders*	Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Poland, Romania, Slovenia, Spain, Sweden, United Kingdom Stakeholders:
Indicative financing contribution and source	EC Contribution: 43,79m€ Member states: 5,2 m€ (Germany, Slovenia/ Switzerland) Other member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **
*Countries/stakeholders involved in projects, IWG5 members ** Will be aligned in summer 2025 (with the final IP-Update).	

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
Treasure Demonstrating large pit thermal energy storages and improving their components, processes and procedures for an accelerated realisation of 100% sustainable district heating networks in Europe Grant agreement ID: 101136095 Horizon Europe Link	Demonstration of 7 Pit Thermal Energy Storages for District Heating. Bridge the gap between research and practice to ensure robust, safe, cost effective, and sustainable large-scale thermal energy storage	11/24-12/27	AT/AEE INTEC(Coordinator) Energieinstitut (Linz University), SolidSolar Energy Systems, Porr Bau, WIEN ENERGIE, BE/ EHP, CZ/ FENIX TNT, DK/ Planenergi Fond, Aalborg CSP, Geo, FR/ Communaute d'agglomeration Pau Bearn Pyrenee; NEWHEAT, ENGIE DE/ Steinbeis Innovation, HIR, Glapor Werk Mitterteich, Technische Universitaet Dresden; Hansestadt Rostock, PL/SECSOO,	11.4 m€
USES4HEAT Underground Large Scale Seasonal Energy Storage for Decarbonized and Reliable	Two demo sites, in Italy and in Norway, that will demonstrate innovative large-scale seasonal thermal energy storage solutions for a future decarbonised and reliable heat supply. Aquifer	11/23-11/27	Kungliga Tekniska Hoegskolan, Svenska (Coordinator) Belgium,Bulgaria , Croatia,	12.4 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
Heat Grant agreement ID: 101136136 Link	and borehole thermal energy storage technologies are applied.		Greece, Italy, Norway, Spain	
HYSTORE Project 4 Hybrid services from advanced thermal energy storage systems Grant agreement ID: 101096789 **Link**	The mission of HYSTORE is to develop and validate an innovative set of TES concepts, based on the combination of cutting-edge technology components: ALL-IN-ONE PCM solution, LOW-TEMP PCM HEATING&COOLING solution, PCM HEATING solution and TCM HEATING&COOLING solution. The four novel concepts attain different applications on heating/cooling (H/C), DHW configurations, and further set up optimal conditions for the provision of hybrid – meaning energy and power-services thanks to the development of a smart aggregator and an open-source multi-service platform.	01/23-12/26	ARMENGOL & ROS CONSULTORS I ASSOCIATS SLP (Coordinator), Spain, Italy, Sweden, Germany, Austria, Ireland, Romania, Belgium	8.78 m€
ThumbsUp **Project 5** Project THermal energy storage solUtions to optimally Manage BuildingS and Unlock their grid balancing and flexibility potential Link	With innovative phase changing and thermo-chemical materials, this European project facilitates the development of innovative, thermal energy storage technologies that can easily be integrated into buildings to increase their energy efficiency and grid flexibility. It aims to overcome the limitations of existing building-integrated technologies by increasing energy density and reducing the intensity factors of capital investment in this sector. The project will promote complementary digital innovations aimed at simulating, optimising and maximising the technical, operational and economic benefits of the proposed storage solutions.	01/.23-12/26	SP/ Veolia Servicios Iecam Sociedad Anonima Unipersonal (Coordinator) Italy, Ireland, Greece, Netherlands, Germany, United Kingdom, Sweden	7.63m€
BIOBUILD Innovative bio-based solutions for building materials with thermal storage function	This project aims to improve energy efficiency of buildings with passive PCM-TES, by incorporating bio-based PCMs and building materials in building envelop. The project expects to decrease energy consumption in the buildings by 20%, via the bio-composite	01/24-12/27	Sveriges Lantbruksuniversitet Sweden (Coordinator) Austria, Belgium, Italy, Romania, Spain	4.94m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
Grant agreement ID: 101135629 **Link**	materials proposed in the project, while also maintaining the “strength, durability and sound insulation properties”. These composites (PCMs in building materials) are made of more than 95% “sustainable and bio-based compounds” to produce “novel wallboards and parquets” for buildings. The composites are made by incorporating bioPCMs into solid wood and recycled wood particles and fibres, bonded then with bio-binders.			
4TunaTES: For Tunable Thermochemical Energy Storage Grant agreement ID: 101130021 Link	4TunaTES will deliver a groundbreaking flexible TCES technology that can be easily adapted to different applications (variable in- and output temperatures) and thereby reduce the development costs by 90% as the R&D the process does not have be redone repeatedly. 4TunaTES develops a TCES-prototype that can be used for domestic use cases, which addresses three challenges: 1) radically new TCES materials with tunable phase diagrams by using a second gas or dopants, 2) heat exchanging components with a high degree of manufacturing flexibility, and 3) revolutionary systems with electricity adapted thermodynamic cycles.	02/ 24-01/28	EIC Pathfinder. Eindhoven University of Technology, NL (Coordinator); DE/German DE/ DE/ Aerospace Center DLR ; IT/ Consiglio Nazionale delle Ricerche, BE/ Vrije Universiteit Brussel, NL/ CELLCIUS BV.	2.8 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
New HeatIntegrated	The objective of the project is to develop an innovative and both technically and economically advantageous solution for building-integrated thermal energy storage systems, which can be configured site-specifically for applications throughout Europe. For this purpose, a modular PCM storage system is being developed, which consists of modules for surface heating (35°C) and for water heating (55°C). The storage system operates on the principle of switchable PCMs, which enable virtually loss-free heat storage over a long period of time. The second focus of the project is to link the TES system with the local energy infrastructure to form an optimised overall energy system that links all local energy sources and sinks into a holistic solution.	11/2023-04/2026	DE/ Fraunhofer, BME (Germany); UVA, NollaE (Finland); VSB-TUO (Czechia)	1.7 m€
Muspell https://www.muspell.eu/project Horizon Europe EIC Pathfinder Challenges and from the Swiss Secretariat for Education, Research and Innovation (SERI) under grant agreement No. 101114987	EIC Pathfinder Challenge project aims to transform Thermal Energy Storage Systems (TESS) by introducing a novel, efficient design featuring advanced materials and a seamless integration of heat pump capabilities.	10/23–09/27	EURAC (IT, lead); NIC (Slovenia)	3,5 m€
Nanoporous Materials	Ongoing national research programme, including heat storage TCMs for space heating.	ongoing	NIC (Slovenia)	3,5 m€

5.8. R&I Activity 5.2-5: Solar Thermal and PVT

Activity Fiche Name	Solar thermal and PVT technologies
EU target(s), policies, and goals it addresses	• Policies mentioned in the Revision of the SET Plan communication, • Green Deal, REPowerEU Plan • Renewable Energy Directive (RED 2024) • Energy Performance of Buildings Directive (EPBD, 2024) • Energy Efficiency Directive (EED, 2024) • EU Solar Energy Strategy • EU Joint Research Agenda on Solar Energy, Link
Activity Fiche No.	8
Reference to IP/targets	Target 5.2-T5: Solar Thermal Systems and PVT: - Cost reduction for solar thermal combi-systems with high solar fraction (min. 60%), towards a range of 12-16 €ct/kWh - Development of standardised solutions for easier integration of solar thermal in building renovation, in particular in active prefabricated building elements - Cost reduction of PVT panels by a factor of 1.5 to 2 from the 2020 reference value of €1000/m², also by ensuring easier installation
Description (challenge, scope)	Solar thermal systems for buildings offer a mature and efficient solution towards sustainable and energy-efficient domestic hot water, heating and cooling solutions, when combined with certain technologies (such as chillers). Despite challenges as high initial costs, space requirements, and variable solar irradiance, the scope for these systems is vast. These factors constitute important barriers in the market and also reflect another major barrier, which is the lack of awareness or the need for a better understanding of this technology. For instance, high initial costs are compensated by competitive levelised costs of energy, space requirements for solar thermal are the lowest among solar technologies due to higher performance and energy density, and variable heat generation is compensated by having thermal storage included by default in solar thermal systems. With advancements in technology, supportive policies, and integration into sustainable building and an integrated energy system, solar thermal systems can play a crucial role in reducing carbon footprints, saving energy costs, and enhancing energy security. In terms of large solar systems, solar district heating systems represent an innovative approach to supplying domestic hot water (DHW), heat and cold (as well as power in case of cogeneration with concentrated solar thermal or PVT) to communities and urban areas by utilizing solar thermal energy. While still relatively niche compared to conventional heating/cooling methods, they have seen increasing adoption, particularly when there is a stronger push for decarbonising the heat supply to DH networks. One of these examples is Denmark, with more than 100 solar heating plants in operation, collectively boasting an installed solar heat generation capacity over 1GW, exceeding 1.5 million square meters of collector area. Solar thermal water heating for single-family houses is a mature and cost-effective solution. In warmer climates, termosiphon systems are a well-developed solution, supplying 100% of the needs by means of over 90% solar fraction and the rest covered by an integrated backup. For forced circulation systems (thermal storage inside the house), the dependency from the backup is higher and the challenge is therefore to develop robust, plug and play and cost- efficient package solutions. As for space heating systems, the main challenges include system complexity and poor economics, since the relatively large collector area cannot be fully exploited in summer, when the load is low and solar irradiation is high. Additionally, there is a lack of trained installers and

Activity Fiche Name	Solar thermal and PVT technologies
	adequate support infrastructure, further hindering the deployment and maintenance of these systems. New solutions, such as hybrid solar panels (PV and thermal, PVT) are promising solutions with growing deployment. Such solutions face several development challenges, from new manufacturing processes to improvements in durability and performance.
R&I Activities including TRL-levels and timeframe for R&I Activities	**Activity 1: Large-scale solar thermal and PVT applications** To accelerate the deployment and improve the effectiveness of solar district heating systems, targeted research and development efforts are essential. Key areas for R&D include: • Cost Reduction: Developing new solar collectors and improving manufacturing processes, thermal storage systems, and installation methods that contribute to lowering the levelised cost of energy upfront investment required for solar district projects. • Integration and Optimisation: Researching optimal system configurations, sizing methodologies, and integration with existing infrastructure. • Storage Technologies: Advancing thermal storage technologies, such as seasonal storage solutions and innovative thermal energy storage (TES) materials. • Policy and Regulatory Frameworks: Researching policy instruments, legislative frameworks, and financial incentives that can effectively support the deployment of solar district systems and create favourable market conditions. • Demonstration Projects: Supporting large-scale demonstration projects (particularly in new locations) and field trials to validate new technologies, assess their performance under real-world conditions, and showcase the viability, performances and feasibility of solar district heating technologies on a larger scale, also in terms of energy management and control. • Capacity Building and Knowledge Sharing: Investing in training programs, knowledge sharing platforms, and collaboration networks to build capacity and expertise among stakeholders, including policymakers, planners, engineers, and installers. • Further development of control systems and control approaches which enable flexibility services. TRL 6-8 **Activity 2: Pre-fabricated and modularized solar thermal and PVT systems for single family houses** The key areas for R&D of solar thermal and PVT systems for single-family houses include: • Prefabricated Easy-to-Install Systems: Development of plug-and-play solar kits, streamlined installation processes to minimize time and labour, standardized components for universal application, • Modularization: Design of scalable systems that can be expanded or reduced based on household needs, Interchangeable parts for easy upgrades and repairs, Modular components to simplify logistics and inventory management • Cost Reduction: Innovations in materials to lower production costs, Efficient manufacturing techniques to reduce overall expenses, Economies of scale through mass production and widespread adoption • Installer Education and Training: Comprehensive training programs for installers to ensure proper system setup, Certification courses to standardize installer qualifications, Continuous education on new technologies and best practices • System Efficiency and Performance: Enhanced storage solutions to maximize energy use and minimize losses, Integration with smart

Activity Fiche Name	Solar thermal and PVT technologies
	home systems for optimised performance. Advances in solar collector technology for improved energy capture, • Durability and Maintenance: Development of robust systems with long lifespans, Easy maintenance procedures and self-diagnostic features, Resistant materials to withstand various environmental conditions • Aesthetic Integration: Design solutions that seamlessly blend with different architectural styles, Compact and visually appealing components, Options for customization to suit homeowners' preferences. • Sustainable and environmental-friendly components and circular economy: While most components are easier to extract and recycle or reuse (steel, copper, aluminium, glass), other elements such as insulation materials require special care and new approaches that can facilitate recycling could be relevant. Reducing the maintenance and durability needs of solar thermal systems, namely via management of stagnation temperatures or other innovative approaches. • Regulatory and Incentive Alignment: Compliance with local and national building codes and standards, Advocacy for government incentives and rebates for solar heating systems, Collaboration with policymakers to streamline approval processes. • Environmental Impact: Use of eco-friendly materials and sustainable manufacturing practices, Lifecycle analysis to minimize the environmental footprint of systems, Research into recycling and repurposing components at end of life. • User Experience and Interface: Intuitive user interfaces for monitoring and controlling the system, Mobile applications for remote access and management, Customer support systems to assist users with troubleshooting and maintenance TRL 6-8 **Activity 3: Medium-sized solar thermal systems for multi-dwelling buildings and service buildings.** Considering the scarcity of rooftop area available in urban areas, it is essential to make the most of the existing space, in particular in larger buildings, where the overall energy consumption per available rooftop area is much higher than in single-family houses. The use of solar thermal and/or PVT allows for the best use of the limited rooftop area available, considering that these systems have efficiencies that are threefold higher than solar PV systems. Therefore, the development of medium-sized solar thermal systems for multi-dwelling buildings and service buildings presents specific challenges, in terms of sizing, integration with the building energy infra-structure, management, monitoring and operation, among others. These challenges include: • Integration of solar thermal in hybrid RES solutions: development of standardised solutions integrating solar thermal with other RES and thermal storage capacity, adapted to the existing energy infrastructure of multi-dwelling and service buildings to enhance energy efficiency and reduce carbon footprint and fully replace fossil-fuel boilers. • Cost Reduction: Innovations in materials to lower production costs, Efficient manufacturing techniques to reduce overall expenses, Economies of scale through mass production and widespread adoption • Smart Control Systems: Develop intelligent control systems that can optimise the performance of solar thermal installations, increasing the solar fraction of hybrid solutions combining different RES technologies, including production and consumption forecasting

Activity Fiche Name	Solar thermal and PVT technologies
	and integrated demand-response solutions (including different heat supply technologies). • Integration and Optimisation: Researching optimal system configurations for medium sized systems, sizing methodologies, and integration with existing infrastructure and demand-response solutions. • Aesthetic Integration: Research ways to seamlessly integrate solar thermal systems into the architectural design of buildings, including the development of prefabricated multifunctional solar façade systems that integrate seamlessly with building designs, contributing to both the aesthetic and energy efficiency of buildings. • Scalability and Modularity: Ensure that the solar thermal systems are scalable and modular, allowing for a standardisation of scalable solutions, for cost-effective application in different buildings or even for an easy expansion or modification of a previous installation. • Policy and Regulatory Frameworks: Work on establishing supportive policy and regulatory frameworks that encourage the installation of solar thermal systems in multi-dwelling and service buildings. • Training and Skill Development: Implement training programs for architects, engineers, and technicians to ensure they have the necessary skills to design, install, and maintain medium-sized solar thermal systems and to plan and execute its integration with other RES and/or the existing energy infrastructure of the building. • Cross-Sector Collaboration: Encourage collaboration between the building sector, energy providers (for different RES technologies), and research institutions to foster innovation and the practical application of research findings. • Environmental Impact Assessment: Support the development of standardised environmental impact assessment methodologies applied to solar thermal, to facilitate the widespread analysis of the positive impact of medium size solar thermal installations.
Expected Impact **Short term impact (2030)** **Long term impact (2050)**	• TRL 6-8 Novel collector materials that have a high optical efficiency (95%), a good cyclic performance and a long lifetime (> 30 years). • TRL 6-8 Novel cost-effective collector/storage design, which strongly increases land efficiency and system economics. Multiple use of the land is desired. Levelized cost of heat < 40 Euro/MWh • TRL 6-8 Online monitoring and diagnosis using AI • TRL 6-8 Smart control and management of the solar heating system • Pre-fabricated and modularized system • Demand-response-ready thermal energy storage technologies for ST
Expected Deliverables	• Application of novel materials • Solar collector/Heat storage designs • Cost-effective and durable solar heating systems • Publications in scientific and professional journals; contributions to conferences; project reports. • Evolving energy storage industry with a focus on thermal energy storage i.e. start-ups and SMEs.
TRL-Level	6-8
Monitoring mechanism	Annual report summarising the progress
Implementation instruments	Flagship projects
Timeline	36 months
Estimated budget for activities	Budget of 150m€ Based on the following considerations:

Activity Fiche Name	Solar thermal and PVT technologies
	• Activity 1: at least 60 m€ corresponding to 3 R&D projects (typical medium size EU project with a budget of 5m€ each) and 3 demonstration projects (large demonstrators with a budget of 15 m€); •Activity 2: at least 30 m€ corresponding to 3 R&D projects (typical medium size EU project with a budget of 5m€ each) and 3 demonstration projects (smaller EU-level demonstration projects with a budget of 5 m€); • Activity 3: at least 40 m€ corresponding to 3 R&D projects (typical medium size EU project with a budget of approx. 5m€ each) and 3 demonstration projects (EU-level demonstration projects with a budget of 7,5 m€); • Cross-sectional activities: at least 5 m€ 3 CSA projects (with a budget of 1,5m€)
Parties involved countries/ stakeholders*	Belgium, Bulgaria, Croatia, Czechia, Cyprus, Denmark, Finland, France, Greece, Ireland, Italy, Norway, Poland, Portugal, Romania, Spain, Sweden, UK Stakeholders: Swedish Energy agency (co-financing)
Indicative financing contribution and source	EU: 17.05m€ Member states: co-financing via CETP Member states: 5.3 m€ (Germany) Associated country: 508 m$ (Turkey) Other member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **
*Countries/stakeholders involved in projects, IWG5 members ** Will be aligned in summer 2025 (with the final IP-Update).	

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
ASTEP - Application of Solar Thermal Energy to Processes Grant agreement ID: 884411 Link	**Industrial process heating using solar energy** Heating for industrial processes accounts for most of the manufacturing sector's energy demand. However, current heating systems have a number of limitations, such as the use of fossil fuels. The EU-funded ASTEP project aims to overcome these drawbacks by developing a novel solar heating for industrial processes (SHIP) concept. It will combine a rotary Fresnel solar collector and a thermal energy storage based on PCM with passive and active heat transfer enhancement techniques, which will be integrated through a control system to maintain continuous service. This innovative system will be able to cover a significant proportion of the process industry's heat demand at temperatures and latitudes where current designs have failed. The project will provide a competitive alternative to fossil fuel consumption.	05/20 – 06/25	ES/ UNIVERSIDAD NACIONAL DE EDUCACION A DISTANCIA (Coordinator), Cyprus, France, Greece, Ireland, Italy, Poland, Romania, UK	5m€
PVT4EU Photovoltaic Thermal For Europe Link Grant agreement No.Cetp-2022-00403. (CETPartnership)	PVT4EU is a research project that aims to develop two innovative PVT collectors that could be an efficient and cost-effective solution for domestic heating and cooling demand and low—to medium-temperature industrial processes (20℃-140℃). This project has been granted by the Clean Energy Transition Partnership Programme (project ID. CETP-2022-00403). The work is supported by national funds through, Sweden: Swedish Energy Agency (P2023-00884); Denmark: Innovation Fund Denmark (3112-00010B); and Portugal: FCT-Fundação para a Ciência e a Tecnologia, I.P. (CETP/0004/2022).	10/23-09/26	SWE/ SUSTAINABLE ENGINEERING AB (Coordinator) DK/Danmarks Tekniske Universitet (DTU) PT/Laboratorio Nacional de Energia e Geologia I.P. SWE/Solarus Renewables AB, HOGSKOLAN I GAVLE, SolarPeak AB	1.1 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
RESHeat Renewable energy system for residential building heating and electricity production Grant agreement ID: 956255, Link Horizon Europe	The EU-funded RESHeat project will develop a system for the use of solar energy as the primary renewable energy source. Novelties of the system include integrated sun-tracked and cooled PV panels and solar collectors as well as advanced underground energy storage units. The latter aim to enable a high coefficient of performance COP of the heat pump over a longer period of time, thereby efficient underground energy storage, reducing the overall electrical energy consumption by the heat pump compressor, and heat storage from various sources.	12/20-05/25	PL/Politechnika Krakowska (Coordinator) Czechia, Finland, Italy	2.87m€
USES4HEAT Underground Large Scale Seasonal Energy Storage for Decarbonised and Reliable Heat Grant agreement ID: 101136136 Horizon Europe Link	Demonstration of innovative, large-scale underground seasonal thermal energy storage (UTES) solutions integrated with RES heat supply (solar thermal, heat pumps, etc.) to enable a decarbonized and reliable heating supply. The main objectives include showcasing two cost-effective seasonal UTES technologies, advancing key enabling technologies for enhanced heating sector flexibility, and implementing intelligent energy management systems using AI and big-data analytics.	12/23-11/27	Kungliga Tekniska Hoegskolan, Svenska, Sweden (Coordinator), Belgium, Bulgaria, Croatia, Greece, Italy, Norway, Spain	12.4 m€
Strawberries	Solar Thermal Agriculture with Bifacial Collectors for Farming Synergies: The core technological objective is to adapt the collector design to enable bifacial operation and to design, install and analyse an Agri-ST demonstration plant to determine the implementation potential and increase commercial readiness of this novel system. This essentially adds innovations to the focal area ‘climate-neutral thermal energy resources’ and creates synergies with the cross-cutting topics of agriculture and citizen participation. In that way, the project offers a new solution to the problem of land scarcity and contributes to innovation-based growth of the European economy.	12/23-12/26	Germany TH Ingolstadt, Bürger-Energie-Genossenschaft Neuburg-Schrobenhausen-Aichach-Eichstätt, CitrinSolar (Germany); Savosolar, Seloy (Finnland), University of Minho (Portugal)	2.2 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
Pro-Sol-Netz	The project aims to carry out the necessary developments and evaluations - also in initial pilot plants - in order to be able to use and establish concentrating collectors in the German markets for heat grids and for process heat in a technically and economically successful way. Two collector manufacturers want to reduce the investment and operating costs for parabolic trough collectors by developing new cost-efficient components. The products will be tested in commercial projects. Existing design tools for calculating and predicting system yields are being further developed for use with concentrating collectors.	05/24-04/27	Germany DLR, Solarlite CSP Technology, Protarget, Steinbeis Innovation, Fraunhofer, Rechenzentrum für Versorgungsnetze Wehr, Dornier Power and Heat (Germany)	3.1 m€
KABEV Public and Municipal Renewable Energy (KABEV) Project (PUMREP-P179867) Funded by the World Bank (WB), Implemented mainly by the Ministry of Environment, Urbanization and Climate Change under the financial guarantee of the Ministry of Treasury and Finance.	The Objective is to increase the availability and affordability of solar PV panels within the scope of energy efficiency on the rooftop, ground-mounted, and car parks for central government buildings in Türkiye. Heat pumps and efficient lighting installation will be implemented in some of these buildings as pilots. The Project activities are aligned with Türkiye's NDCs to the Paris Climate Agreement that aims to reduce up to 21 percent of GHG emissions from business-as-usual scenarios by 2030. It is aimed to renovate 500-700 public buildings in an energy efficient manner and combat climate change by providing energy savings, increased comfort and greenhouse gas reduction.	Start 2023	Türkiye / Funded by the World Bank (WB), Implemented mainly by the Ministry of Environment, Urbanization and Climate Change under the financial guarantee of the Ministry of Treasury and Finance.	508 m $

5.9. R&I Activity 5.2-6: Technology combination and integration

Activity Fiche Name	Heating & Cooling system Technology combination/integration
EU target(s), policies, and goals it addresses	• Policies mentioned in the Revision of the SET Plan communication • Green Deal, REPowerEU Plan • Energy Efficiency Directive (EED) • Energy Performance of Buildings Directive (EPBD, 2024) • Renewable Energy Directive (RED)
Activity Fiche No.	9
Reference to IP/targets	Target 5.2-T1 Heat Pump Systems: - Development of prefabricated, fully-integrated 'plug in and play' hybrid/multisource heat pump systems and integrated compact heating/cooling plants based on modular heat pump - Full-scale demonstration of heat upgrade technologies for district heating networks with supply temperatures in the range 90 - 160°C - Increase the number of heat pumps across Europe to 10 million by 2030 Target 5.2-T3 Micro CHP/CCHP: - Integration of highly flexible CCHP systems with heat storage, heat pumps and renewable heat sources with the aim of reducing annual fuel consumption - Development of CCHP technologies running on renewable gases (hydrogen, ammonia, methanol, synthetic gas, etc.) with comparable performances as running on natural gas - Development of CCHP solutions with post combustion treatments to reduce emissions by >50% and keeping operational flexibility Target 5.2-T4 Thermal Energy Storage: - 100 new large thermal energy storages in district heating and cooling networks in progress in 2030 - 10 new demo systems with sensible thermal energy storage with a usage of RES and waste heat to more than 60% of the yearly heat demand - 20 systems for compact thermal energy storage demonstrated at TRL 6/7 with a storage density at system level increased to 120 kWh/m^3 Target 5.2-T5: Solar Thermal Systems and PVT: - Cost reduction for solar thermal combi-systems with high solar fraction (min. 60%), towards a range of 12-16 €ct/kWh - Development of standardised solutions for easier integration of solar thermal in building renovation, in particular in active prefabricated building elements - Cost reduction of PVT panels by a factor of 1.5 to 2 from the 2020 reference value of €1000/m², also by ensuring easier installation
Description (challenge, scope)	Heating & Cooling Systems are considered as a holistic technical system when designed. However, not all the systems are comprised by the same elements, nor with the same complexity. The materials used, the design and layout, the types of elements, their compatibility and performance, and the boundary conditions, influence the behaviour of the system. Their combination/integration within a building, district or grid also requires the control to consider climate conditions, user behaviour, and building design/ construction.

	This requires not only to know how any of the main elements works, but also how the whole system performs, including all the potential load losses (pipelines, and ducts included) in any of the subsystems: generation, exchange circuits, transport and distribution, regulation and control, etc. Besides, combination refers to the joint design and use of subsystems that allow different thermal services, for instance, taking advantage of the energy resources or on residual heat production, as well as the smart consumption and/or production of electricity (in the case of CHP systems) etc. Integration allows diverse subsystems or even systems, previously designed as a whole, to work together, which provides more efficiency and maintenance, space saving, power system resiliency (e.g. lower seasonal peak demand, lower residual load needing centralised power back-up) and heat recovery, among other benefits. Heating and cooling engines are tested on test points with fixed and controlled lab conditions. However real systems are exposed to certain dynamics, either external, from the weather variations, for instance, or internal, such as different behaviour of users/homes, and different configurations for heating& cooling systems. This means that even the most efficiently designed technology can still benefit from performance enhancement not from the core tech (as compressors, heat exchangers etc.), but from for other subsystems, as a well laid out heat or cold distribution system, or a control system which complements that. System modelling often means combining sub models of components which are quite easy to comprehend by itself. However, due to the system interaction complex behaviour can show itself, which is not expected based on the study of individual components. In this work this is implemented to: - Develop decision making tools for sizing of heating and cooling technologies like heat pumps, C(C)HP units, solar thermal and PVT collectors, and thermal storages based on techno-economic drivers - Develop self-tuning algorithms which increase energy efficiency and decrease installation time of heating and cooling technologies - Work out monitoring strategies which gives out meaningful KPIs instead of numbers - Investigate heat/cooling emitter systems (radiators, underfloor heating/cooling etc) providing direct applicable tips/best practices for installers which increase efficiency and reduce installation time. Digitalisation of systems through smart control allows the overall efficiency, the smart use or self-production of energy, a decrease of energy losses, and a personalized management of the resources, considering (and even adjusted to) the behaviour patterns, user occupation or price signals from power grids. Some gaps or barriers: - The system is prone to be made or designed ad hoc, and then, how to assess the TRL of it, as a whole? How to systematize the assessment? - Related to this, not only the TRL of the main technologies have to be considered, but also the transport and distribution circuits have to be designed and laid out efficiently, minimizing load losses. The KPIs have to include these other elements. - Digital tools, such as Digital Twins or BIM, could be required for design, layout and performance assessment of the combined/integrated system. But first, the validity of these models has to be previously tested and compared with monitored or other real data. - The boundary conditions for testing the different technologies that are part of a system could be uneven, so the design performance values provided by manufacturers could eventually differ when installed within the system.

R&I Activities	- Define potential subsystems to be combined/integrated, and the assessment parameters to determine for each of them - Implement smart and enhanced system design, using Digital Twins, BIM or other Digital Building/Grid Modelling. - Manufacturers/ providers could facilitate combination/integration guidelines, tolerances (for instance, a maximum number of secondary elements or exchange circuits, etc), so that basic calculations based on several scenarios could be given as well to building designers or engineers. - Explore not only the usage-step when considering sustainability and circularity, and even the efficiency of the system, but also the remaining Life Cycle Assessment stages, from cradle to end-of-life - Assessment stages, from cradle to end-of-life - Develop, compare, and update when possible, industry standards, testing protocols, and certification processes, in order to harmonize assessments and boundary and testing conditions and thus, warrantying a legal framework - Evolving guidelines to provide safety, energy efficiency, and sustainability for combined/integrated heating & cooling systems - Generate Cost-Benefit Analysis according to different scenarios, and system compositions (by iterative matrix combination of elements) - Create open data bases for different elements, technologies and auxiliary components, as potential parts of a combined/integrated system, to be modelled and assessed through digital tools, such as Digital Twins or BIM, etc. - Figuring out simple solutions to complex problems which are not perfect, but still work quite well in 70-90% of the cases. For instance, the case of net congestion: maybe it helps to put DHW target temperatures of heat pumps on a schedule. Dropping a few degrees during known busy hours of the duck curve. This means that it likely will not do affect comfort but will run less during congestive hours. While this is not the ultimate solution but does not require information exchange infrastructure. - Develop algorithms for auto-adapting heat/cooling installations. This can save time and avoid losses due to avoidable wrongly set systems. Example: The thermostat which works with a temperature band instead of a hard temperature, the algorithm can then decide which setpoint it uses based on energy/congestion etc.
Expected Impact Short term impact (2030) Long term impact (2050)	Short term impact (2030): 55% GHG emission goal, according to the EPBD, the European Climate Law Integrated solutions offer: • Lower primary energy consumption • Less equipment resources and lower material resources • Faster achieving decarbonization targets Long term impact (2050): Green Deal, Climate neutrality Integrated solutions offer: • Lower primary energy consumption • Use and adaption of existing infrastructure results in less equipment resources and lower material resources • Use and adaption of existing infrastructure results in faster achieving decarbonization targets
Expected Deliverables	The Research and Innovation activities for Technology Combination/Integration are: - Systematization when implementing elements, circuits and technologies to the Heating & Cooling Systems (for instance depending on ducts/pipelines sections, lengths, number of

	elements – as emitters…). Iterative modelling could provide tabulated values for simplified pre-dimensioning to be considered when designing more complex, combined or integrated systems. - Practical/easy to use tools which help installers and installation advisors.
Monitoring mechanism	Annual report summarising the progress
Implementation instruments	Flagship projects
Estimated budget for activities	Cannot be estimated at this stage as more feedback on flagship projects is needed.
TRL-Level	5-9
Timeline	36 months
Parties involved – list the countries / stakeholders*	Countries: Germany, Netherlands Stakeholders:
Indicative financing contribution and source	EC Contribution: Member states: 9.8 m€ Member states are interested in this activity but currently cannot provide an indicative level of financial contribution to the activity. **
*Countries/stakeholders involved in projects, IWG5 members ** Will be aligned in summer 2025 (with the final IP-Update).	

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
Name	**Description**	**Timeline**	**Location/Party**	**Budget**
Team Duurzaam installeren 500	Multidisciplinary project on how to improve/speed up installing (hybrid) heat pumps in the Netherlands. (Target is to achieve 500 installations per day extra)	2022-2026	Netherlands,	~5 m€
FlexBlue	The development of energy storage and other flexibility technologies is essential for the integration of (intermittent) renewable energies. With regard to flexible electricity consumers, the cooling sector is of particular interest as its flexibility potential has hardly been tapped so far. The two demonstrators planned in the project are intended to prove the technical functionality and the economic and ecological viability of partially decarbonised and flexibly controllable cooling supply systems. The aim is to enable flexible operation through direct storage (cold/heat/battery storage). The aim is to enable players in the flexibility value chain to retrofit existing cooling systems with a view to decarbonisation and flexibility, and to optimise the design of new cooling systems accordingly.	01/24-12/26	Germany Fraunhofer, TH Ingolstadt, KIT, FZI, rütgers, kraftBoxx, SKVE	2.9 m€
saM_soL	The aim of this project is to develop and test a new type of control system based on machine learning that enables the	09/23-05/27	Samson, Steinbeis	1.9 m€

Ongoing R&I Activities (Flagship activities or not): relevant to this new activity proposal				
	control of centralised and decentralised district heating supply stations for heat generation systems with fluctuating sources to learn by optimising the parameterisation depending on external influences. The project focuses on solar thermal energy as one of the most fluctuating sources.		Innovation (Germany)	
PhoFlueK	PV-driven cooling and heating in combination with ice slurry storage systems is an energetically and economically attractive way to increase the degree of autarky and reduce grid consumption for a wide range of applications. Within the framework of the project, a forecast-based control system is to be developed, implemented and optimised. The results of the project will help to facilitate the use of ice slurry cold storage, which makes an important contribution to reducing peak loads from PV systems and reducing the need for grid expansion.	08/24-07/27	ILK, Sachsen Kälte (Germany)	1.0 m€

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