Renewable Heating & Cooling

European Technology and Innovation Platform

RHC-ETIP's priority topics for the Horizon Europe's Work Programme 2025

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Introduction

The need for funding renewable heating and cooling technologies has never been greater. With rising energy costs and the rapidly worsening effects of climate change, it is imperative that new and/or improved ways to heat and cool homes, cities, and industries are developed.

This document presents priority topics for the renewable heating and cooling sectors to be considered for the drafting process of the Horizon Europe Work Programme 2025. The goal of the document is to identify those topics that will have a significant impact on the sectors if supported. The needs of RHC stakeholders were carefully considered, and they identified key areas where Horizon Europe funding will make a meaningful difference.

The priority topics are listed according to RHC-ETIP's Horizontal Working Groups and Technology Panels:

- 100% RE Individually Heated & Cooled **Buildings**
- 100% RE **Districts**
- 100% RE **Cities**
- 100% RE **Industries**
- **Social sciences and humanities** for RHC
- **Solar Thermal**
- **Biomass**
- **Geothermal**
- **Heat pumps**
- **District Heating & cooling** and **thermal energy storage**

The presented topics were proposed based on the understanding that all horizontal areas and technologies represented by RHC-ETIP are equal and need adequate support.

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100% RE Buildings

Topic title	[B-1] Renewable Heating and Cooling Technologies and Systems for Cost-effective Retrofitting of Old Buildings
Link to RHC-ETIP SRIA	***RE H&C technologies and systems for cost-effective retrofitting of old buildings***
Brief description of the topic & justification	The topic involves the development and implementation of renewable heating and cooling (H&C) technologies and systems specifically tailored for the cost-effective retrofitting of old buildings. The existing renewable H&C technologies and systems are reasonably mature in the new buildings market of the H&C generation, but requires further development in different example for H&C distribution and application (e.g. radiators, fan assisted emitters and radiant floor etc.) at the building level. The focus is on enhancing energy efficiency, reducing environmental impact, and systems easier to be installed, promoting sustainable solutions in the building sector. With assumed improvement in the insulation of the buildings to reduce the overall energy demand and, the different applications of retrofitting the H&C system with renewable H&C energies should be considered and investigated. It would be expected that multiple Projects would be required throughout all EU Member states to illustrate different examples of Installation, as each would expect to detail the various design characteristics due different location and application. Therefore, it will be important that each Installation, of each Project, will take into consideration the multiple of variables that will define the Design Criteria. Examples of typical Criteria variables would be: Building(s) Construction characteristics, Environmental Conditions, Solar Array size/output, ground conditions, Energy output distribution and characteristics, and Energy Storage characteristics. All these variables would be expected to be different throughout the EU States, with the expected wide geographical meteorological conditions, with varying financial and environmental returns. Digital solutions to enable system monitoring and optimisation would be expected, to enable consumer acceptance and perception e.g. weather forecasts, should be included in each project. The technologies to be developed can be single renewable heat generation technologies or hybrid systems (e.g. heat pump with PV, biomass and/or geothermal with solar thermal, heat pump with solar thermal, etc.). The topic directly aligns with the Renovation Wave Strategy, which aims to improve the energy performance of buildings in the EU. In addition, retrofitting old buildings with renewable H&C technologies aligns with the Green Deal's objectives by promoting energy efficiency and the use of renewable energy sources.

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Required budget	€ 2,000,000
Desired TRL at the end of project(s)	8-9

Topic title	[B-2] Renewable Heating and Cooling Technologies and Systems for Cost-effective Retrofitting of Historical and Special Buildings
Link to RHC-ETIP SRIA	***RE H&C technologies and systems and systems for cost-effective retrofitting of historical and special buildings***
Brief description of the topic & justification	The topic focuses on the development and implementation of renewable heating and cooling (H&C) technologies and systems designed specifically for the cost-effective retrofitting of historical and special buildings. This targeted approach considers the unique challenges posed by preserving the cultural and architectural heritage of such structures while enhancing their energy efficiency. Historical buildings have different needs energy systems and for restoration and conservation requirements. Therefore, they need to consider completely different boundary conditions, even more if these are under cultural heritage protection rules with consideration of retrofit of Historical buildings and guidelines. Establishing common standards and regulations at the EU level is necessary for the retrofitting of historical and special buildings with renewable H&C technologies. Standardization ensures that preservation efforts adhere to consistent guidelines, with respect to installation and usage and safety measures that can be replicated across member states. This topic also directly addresses Renovation wave and Green Deal objectives.
Required budget	€ 2,000,000
Desired TRL at the end of project(s)	8-9

Topic title	[B-3] H&C Systems Education, Training and Certification for Different Building Categories
Link to RHC-ETIP SRIA	***Energy systems education, training and certification for different building categories***
Brief description of the topic & justification	The topic involves the development of educational programs, training initiatives, and certification processes tailored to different building categories, with a focus on energy systems. This approach aims to enhance knowledge, skills, and certification standards to meet the

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	specific H&C needs and challenges associated with diverse building types. In Germany, new legislation emphasizes the importance of heating in buildings, and the training of installers is considered crucial. New installers need to be equipped and recruited to support the integration of renewables into new force training. They must be educated on all relevant renewable H&C energies. The renovation of buildings poses a bigger challenge and is connected with other training topics. The technologies have to be combined, and installers are needed who are able to install also hybrid and more complex technologies. An important part of the training is the use of digital tools for system management and integration as well as on meeting the consumer's expectations. An EU-level focus is essential to establish standardized educational curricula, training modules, and certification standards. This ensures consistency and quality across member states, promoting standardized approaches to energy systems in diverse building categories. In addition to the Green Deal, this topic is also linked to EU initiation "the Skills Agenda for Sustainable Europe", which emphasizes the importance of developing skills that contribute to a green and digital transition. Education, training, and certification programs for energy systems align with the agenda's goal of fostering a skilled workforce capable of addressing sustainability challenges.
Required budget	€ 2,000,000
Desired TRL at the end of project(s)	9

100% RE Districts

Topic title	[D-1] Low-Temperature and Ultra-Low Temperature District Heating and Cooling Networks
Link to RHC-ETIP SRIA	***Efficiency gain and temperature reduction***
Brief description of the topic & justification	District Heating and Cooling (DHC) is included among the EU priorities for the energy transition and decarbonization of energy systems and the increase of security of supply (e.g.: EU EED, RED, EPBD, Fit for 55 and RepowerEU packages). Recent projects on the topic (completed after 2020 or ongoing as of November 2023) include: RELaTED, REWARDHeat, KeepWarm, THERMOSS, Planheat, PLANET, TEMPO, UpgradeDH, COOL DH, D2GRIDS, HYPERGRID.

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	The latest generation of DHC works at low- or ultra-low temperature (i.e. below 45°C or less – based on the national/regional context), to reduce heat distribution losses and enable the integration of low-carbon heat sources. This requires the identification of high-efficiency, cost-effective and socially just solutions/technologies to lower network temperatures in existing DHC systems and to realize greenfield and brownfield (conversion from individual fossil fuel heating) LTDHC projects. This topic focuses on research and innovation actions aimed at increasing from TRL 3-5 to TRL 7-8 technical solutions for greenfield and brownfield LTDHC and for the transformation of existing high-temperature networks towards LTDHC. The target solutions include innovative technologies for heat/cold distribution (e.g.: piping, substations, storage), building retrofitting to increase suitability for LTDHC including booster solutions and conversions from individual heating and/or cooling to DHC, digital solutions to optimize and achieve more flexible operations, data analytics for fault detection and diagnosis, as well as strategic planning tools to enable municipalities, local authorities and DHC operators to transition to LTDHC. The target solutions shall take into consideration costs and benefits (especially considering effects and contributions of low temperatures to the fully decarbonized DHC network) as well as social aspects such as applicable business models for DHC operators and end-users, engagement of all the involved stakeholders and the re-skilling of workers currently employed in sectors competing with LTDHC. Special consideration should be given to the data requirements for implementing digital solutions.
Required budget	40 million € (4 projects with 6-7 million € budget each)
Desired TRL at the end of project(s)	7-8

Topic title	[D-2] Decarbonisation of Heat and Cold Production for DHC Networks
Link to RHC-ETIP SRIA	***Decarbonisation – Scenario evaluations and decarbonisation strategies***
Brief description of the topic & justification	The heating and cooling sector is responsible of approximately a half of EU energy needs, and actions for the reduction of energy uses and GHG emissions in this sector are included among the EU priorities for energy and climate (e.g.: EU EED, RED, EPBD, Fit for 55 and RepowerEU packages). Recent projects on the topic (completed after 2020 or ongoing as of November 2023) include: WEDISTRICT, ReUseHeat, Envision, COUPLE, RES-DHC, EnergyMatching, SupportDHC, HeatMineDH, ConnectHeat, REDI4Heat, SENERGY NETS, D2GRIDS, PUSH-IT, DENSE.

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	The decarbonization of the heating and cooling sector in line with the EU targets requires the identification and application of technologies producing low-carbon heat/cold, both for residential and commercial buildings as well as for their integration into DHC networks. This topic focuses on research and innovation actions aimed at increasing from TRL 4-5 to TRL 7-8 technical solutions for sustainable heat/cold generation. The target innovative solutions include renewable heat production (e.g.: from solar, geothermal), low-carbon cold production, excess heat recovery from industrial and tertiary sources, heat pumps fed with renewable power, as well as hybrid solutions and energy storage systems. Digital solutions to optimize and increase the flexibility of the DHC networks both in terms of operation and capacity to uptake heat from various sources, data analytics for fault detection and diagnosis as well as strategic planning tools to enable municipalities, local authorities and DHC operators to transition to a resilient low-carbon DHC system, considering various uncertainties of the development of key factors are also included. The target solutions shall take into consideration economic and social aspects. Applicable business models for DHC operators and sustainable heat producers, engagement of all the involved stakeholders and the re-skilling of workers currently employed in sectors competing with sustainable heat production could be involved.
Required budget	40 million € (4 projects with 6-7 million € budget each)
Desired TRL at the end of project(s)	7-8

100% RE Cities

Topic title	[C-1] Advanced integration of thermal storage systems with DH systems, buildings and industrial environments in cities
Link to RHC-ETIP SRIA	***Technologies for integrated system solutions of decarbonised energy systems of cities***
Brief description of the topic & justification	Scope: • Integrated control of thermal storage systems to include ground side, heat pumps, building or network circuits and characteristics; multiple input – multiple output control approaches, real-time optimization procedures and adaption to weather forecast (linking to R&D in IT) • High efficiency H&C systems with thermal storage systems for small and medium sized H & C networks. • Demonstrate the practical feasibility, reliability and efficiency as well as economic advantages of wider introduction of thermal storage for seasonal storage of energy.

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	• Optimum integration of thermal storage systems in thermal energy supply for municipalities Expected impact: Utilised waste/surplus heat, replacement of fossil fuel, recovery efficiency, €/recovered GJ, District heating network efficiency improvement, 20% Financial risk reduction (Risk of Success)
Required budget	€40,000,000 for 3 demo sites
Desired TRL at the end of project(s)	From TRL 6 to TRL 8-9

Topic title	[C-2] Innovative integration of RHC in urban planning concepts
Link to RHC-ETIP SRIA	***Tools and guidelines for the planning of climate-neutral energy systems for cities***
Brief description of the topic & justification	Scope: • Subsurface characterization methods and integration • Planning tool for optimisation of the use of RHC • Optimal utilization of RHC resources and thermal energy storage in urban settings. • Subsurface underground models for a sustainable RHC use in cities; • Studying the impact of Subsurface Urban Heat Islands (SUHI) on the potential of RHC use in Cities; • Mutual interactions between systems, effect on efficiency of storage, and energy performance. Expected impact: Increasing acceptance level of RHC in Cities and dense urban areas. Increasing number of systems and share of renewable energy utilization in Cities. Incorporation of RHC resources into local energy and climate Plans and Climate Change Mitigation measures in European Municipalities.
Required budget	€30,000,000 for 2 demo sites
Desired TRL at the end of project(s)	From TRL 6 to TRL 9

Topic title	[C-3] Advanced integration of RHC resources in Cities
Link to RHC-ETIP SRIA	***Tools and guidelines for the planning of climate-neutral energy systems for cities / Tools and guidelines for the development of transformation strategies and roadmaps to achieve decarbonised energy systems of cities***

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Brief description of the topic & justification	Scope: • Integration of RHC into the long-term energy planning in cities • Tools to easily and accurately assess existing RHC potential and resources and Planning tool for optimisation of the use of RHC • Tools for an accurate assessment of Green House Gas Emissions reductions in comparison with alternative fossil based technologies for H&C • Best practices strategies for subsurface land-use plans in European cities. • Pre-normative templates to ease deployment and roll-out based on best practice examples across Europe. • Templates for an efficient integration of RHC Resources into the City Planning under different scenarios representing most of European Cities (from the point of view of geology, legislative and political framework, administrative boundaries, etc..)
Required budget	€10,000,000 for 2 projects
Desired TRL at the end of project(s)	From TRL 6 to TRL 9

100% RE Industries

Topic title	[I-1] Multisectoral approach of RES for H&C decarbonisation
Link to RHC-ETIP SRIA	***Hybridization of RES***
Brief description of the topic & justification	An EU-level focus on the hybridization of renewable energy and innovative technologies is crucial to address cross-border implications and ensure harmonized solutions compliant with EU standards. This collective approach aligns with the European Green Deal and the Clean Energy for All Europeans package, emphasizing the need for decarbonization and increased use of renewable energy in industrial processes. The topic is highly relevant to EU goals, and ongoing Horizon Europe projects contribute significantly to research and development in this field. These projects aim to foster collaboration, innovation, and the development of cutting-edge technologies to optimize the system integration of renewable energy in industrial applications, supporting a greener and more energy-efficient industrial landscape across the European Union.
Required budget	€3,000,000
Desired TRL at the end of project(s)	9

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Topic title	[I-2] Interconnect to enhance flexibility
Link to RHC-ETIP SRIA	***Innovative technologies for optimized system integration of RE***
Brief description of the topic & justification	To address the intermittency of renewable energy sources concerning industrial demand, a focus on innovative technologies for the optimized system integration of renewable energy (RE) becomes imperative. This involves the concept of "sector coupling," aiming to interconnect different sectors to enhance flexibility and align energy consumption with availability. The development targets two main aspects. Firstly, there is a push for process flexibilization and a departure from traditional consumption patterns to better match energy availability. Secondly, the emphasis is on advancing technologies capable of utilizing fluctuating renewable energy sources (such as solar thermal, excess heat) in tandem with base load production from geothermal and storable RE sources (biogas, hydrogen, ammonia, HT heat). The goal is to provide continuous, on-demand (high-temperature) heat and electricity to industrial processes. Technological solutions include integrating (high-temperature) solar collectors, deep geothermal, heat pumps, and thermal storage for heat integration. Fluctuating waste streams can be incorporated through low-temperature heat, low-calorific gases, and gasification of biogenic materials (organic industrial waste, sewage sludge, municipal waste). Furthermore, the reuse of high-temperature residual heat by other plants in an industrial zone, facilitated by steam-condensate systems, enhances overall energy efficiency. This topic aligns with EU objectives, particularly in the context of the European Green Deal and the Clean Energy for All Europeans package. It emphasizes the need for advanced technologies that contribute to a more sustainable and resilient industrial landscape, effectively utilizing renewable energy sources and fostering sector coupling for increased flexibility and efficiency. Ongoing Horizon Europe projects are expected to play a vital role in driving research and development in this crucial area of renewable energy integration.
Required budget	€3,000,000
Desired TRL at the end of project(s)	9

Topic title	[I-3] Improve energy storage
Link to RHC-ETIP SRIA	***Technologies of heat and cold storage and distribution***

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Brief description of the topic & justification	Thermal energy storage will be a key enabler for the deployment of RHC in cities, districts, industries, and buildings, at small or large scale. TES can effectively contribute to energy savings (storage of excess heat), peak load shaving and sector coupling. One way is to aggregate many small/medium-size TES through intelligent, high level control systems with predictive control algorithms. Another way is to deploy high-capacity underground storage solution shared by several heat or cold generation systems. Depending on the industrial process, the requirements on the TES are given by the output temperature, the transportability of the heat, the store's dissipation rate and its compactness. Therefore, the full range of technologies needs to be developed further; from sensible storage (molten salts, molten metals) to phase change stores (paraffins, salt hydrates, polymers, salts, metals) to sorption and hydration (zeolites, salt hydrates) to chemical reactions (metal oxides/hydroxides, chemical looping, other processes) and to underground thermal. Also, innovative hybrid storage solutions using different storage materials increase the applicability. Outcomes: • Increased energy storage densities in thermal solids and fluids • Reduced thermal losses during storage and distribution ○ Decreased response times in charging and discharging to contribute to grid balancing and to recover excess heat whenever available • Use of safe, sustainable and environmentally friendly materials, preferably in a circular economy approach (e.g. reusing waste material) • Adaptable storage cycles (daily, weekly, monthly or seasonal) • Easy-to-install TES • TES-ready heating systems
Required budget	€3,000,000
Desired TRL at the end of project(s)	7-9

Topic title	[I-4] Standardisation of industrial processes
Link to RHC-ETIP SRIA	***Research and innovation priorities for RHC in industries***
Brief description of the topic & justification	Standardisation of industrial processes (waste heat/cold recovery in industrial processes, fossil fuels replaced with RHC technologies) and deployment of renewable H&C technologies to respond to them (meaning no more bespoke, expensive solutions, but standardized/cheaper ones).

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	There is an example of ongoing EHPA and CEPI collaboration in the sector of paper and pulp. This example illustrates that such collaborations are plentiful, offer a lot of opportunities (with small, medium and large industries realising their potential), but are also time consuming and would need additional resources for their replicability, business model development, dissemination and exploitation. There have been no bespoke EU funded initiatives on this topic.
Required budget	€3,000,000 (split into 3 grants of 1 million)
Desired TRL at the end of project(s)	9

Social sciences and humanities for RHC

Topic title	[SSH-1] Unveiling Social Acceptance and Consumer Behaviour for Achieving 100% Renewable Heating and Cooling
Link to RHC-ETIP SRIA	*Topic* ***Policy and social innovation*** mentions that studies are needed to better understand consumer behaviour, especially regarding large purchases related to heating. It is also mentioned as a desired result that consumer behaviour enables effective marketing, information campaigns and sales tools for people in the RE sales chain.
Brief description of the topic & justification	Achieving 100% Renewable Heating and Cooling (RHC) in the EU by 2050 is fundamental, and it requires assessing the diverse perspectives of potential users and their behaviours. In general, there is an apparent contraction between general public support for renewable energy innovation and the challenging realisation of specific projects. Furthermore, innovations bringing a change in people's habits often require the acceptance of a new vision and lifestyle organization while competing with other innovations to prevail. In a scarcity of resources, this competition may, at best, cause a non-optimal allocation of resources. The more innovations are perceived as disruptive and expensive, the more they can have a negative effect on public opinion, with possible adverse effects on their adoption and diffusion. Therefore, evaluating the social/political acceptance and the economic availability to every citizen must be seriously taken into consideration by policymakers. Despite the common practice of conducting market analyses in the development of new technologies, there is an urgent need for a systematic study on user behaviours and consumption in present and future economic scenarios.

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	At the end of the projects, it is expected that quantitative indicators will be provided to categorise users' acceptance of different RHC technologies. There has not been a call for consumer behaviour or social acceptance topics in the recent Horizon Europe Innovation Fund work program. Suggestions on the aspects, methodologies that can be covered in the call: 1. Social Acceptance and Consumer Behaviour: • How does social acceptance influence consumer behaviour? • What are the key factors contributing to social acceptance? • How do consumers perceive and interact with the products or services under consideration? 1. Behavioural Change in the RHC Sector: • How can behavioural change be stimulated within the RHC (Residential Healthcare) sector? • How can the findings inform the development of a replication guide and policy recommendations for implementing behavioural change strategies? Methodologies: **Transformative User-Centric Co-Creation:** • Conduct co-creation sessions spanning a two-year period. • • Utilize desk research, qualitative interviews, and workshops. • Examine social acceptance and consumer behaviour. **Incorporation of Relevant Social Science Studies and Methodologies:** • Integrate qualitative studies of everyday experiences and behaviours. • Apply human-centred approaches (Participatory Design and Design Anthropology). • Use ethnographic studies, codesign, and prototyping with citizens, communities, and stakeholders. • Explore possible sustainable futures through co-creation sessions. • Employ a social science approach with both quantitative and qualitative methodologies. ○ Utilize methods like interviews, workshops, questionnaires, and seminars.

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Required budget	€3,000,000
Desired TRL at the end of project(s)	All considered technologies are at TRL 9, which means deployed in the market. With this project(s), no further advancement in TRL is expected, but rather advancement in the Societal Readiness Level (SRL) (see https://innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf). The expected final SRL of the project is 8-9

Topic title	**[SSH-2] Empowering Vulnerable Households: Capacity Building and Community Energy Support for Combatting Energy Poverty**
Link to RHC-ETIP SRIA	*Topic* ***Policy and social innovation*** mentions that studies are needed to better understand the role of re in alleviating energy poverty. Also, as a desired result the importance of supporting the emergence of energy communities is mentioned which is aligning with the aims of the proposed topic.
Brief description of the topic & justification	Energy is a prerequisite for the realisation of human rights for billions of people. However, in some cases, energy bills represent a high percentage of consumers' income, and consumers need to reduce their household's energy consumption to a degree that negatively impacts their health and well-being. According to Eurostat's figures, about 35 million EU citizens (approximately 8% of the EU population) were unable to keep their homes adequately warm in 2020. Without adequate social and political measures, the ongoing Renewable Heating and Cooling (RHC) transition might distribute benefits, costs, and risks unevenly, exacerbating existing inequalities. Therefore, it is fundamental that this transition results in a just and fair energy transition. In addition, despite figures showing a larger involvement of women in renewable energy-related jobs rather than in the oil and gas sector, the energy sector remains male-dominated due to several barriers that exist in empowering women in the use and management of Renewable Heating and Cooling (RHC) technologies in households. Therefore, projects in this area should evaluate strategies aimed at promoting regional values and synergistic actions to empower the low-

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	income segment of the population and balance gender aspects in the development and use of RHC in households. Energy poverty is also an important topic that the EU is addressing. The concept of energy poverty was introduced by a Directive published in 2009. The topic also found a place in the revised Energy Efficiency Directive in 2023, and recently, the Commission published recommendations to tackle energy poverty across the EU. Topics related to energy poverty and energy communities are usually covered by the LIFE program, call on "Alleviating household energy poverty and vulnerability in Europe". In the Horizon Europe/Innovation Fund program, the topic is not directly mentioned, but is sometimes referred to in other topics.
Required budget	€3,000,000
Desired TRL at the end of project(s)	All considered technologies are at TRL 9, which means deployed in the market. With this project(s), no further advancement in TRL is expected, but rather advancement in the Societal Readiness Level (SRL) (see https://innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf). The expected final SRL of the project is 8-9

Topic title	**[SSH-3]** Removing barriers in legal frameworks to improve RHC market uptake
Link to RHC-ETIP SRIA	*Topic* ***Policy and Social Innovation*** mentions that Studies are needed to better understand legislation for increasing RE. Desired results are finding and understanding, if pure legislation is an effective way for increasing RE uptake. In addition, political pathways describing precise policy measures on local and regional level to improve regulatory frameworks for DHC, and the sustained awareness created in public and policy which will lead to investments in the transformation of the DHC sector contributing to 100% fossil-free supply, mentioned among the desired results in the abovementioned chapter.

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Brief description of the topic & justification	In the energy system transition, it is evident that no single technology can fit all solutions, and the Renewable Heating and Cooling (RHC) energy transition is based on various alternatives depending on local sources and needs. From a policy perspective, this results in a countless number of cases, adding bureaucracy and hindering the deployment of distributed energy sources. Additionally, recent social, economic, and political events are reflected in unstable framework conditions, putting long-term investments at risk. It is expected that social and economic policies will be able to address legal and social barriers that limit education, assets and land ownership, and access to credit for the deployment of RHC technologies. For these reasons, there is a need for projects that address the complexities of present and future scenarios to promote a shared EU policy framework that attracts both foreign and local investors, along with private citizens, to support RHC projects and solutions.
Required budget	€2,000,000
Desired TRL at the end of project(s)	All considered technologies are at TRL 9, which means deployed in the market. With this project(s), no further advancement in TRL is expected, but rather advancement in the Societal Readiness Level (SRL) (see https://innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf). The expected final SRL of the project is 8-9

Topic title	**[SSH-4]** Transitioning Energy Workforce to Renewable Energy
Link to RHC-ETIP SRIA	*Topic* ***Policy and Social Innovation*** mentions the scope to retrain workers from fossil fuels for RE. In addition, in the desired results it is mentioned that it is important to map and match future unemployment within fossil fuels with a demand for competence in RE.

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Brief description of the topic & justification	This topic focuses on retraining workers who are currently employed in the fossil fuel industry, providing them with the necessary skills and knowledge towards roles within the renewable energy sector. Alternatively, it emphasises knowledge transfer mechanisms, allowing workers to apply their existing skills in renewable energy contexts. The goal is to facilitate a smooth and sustainable shift towards cleaner energy sources, addressing both environmental concerns and the livelihoods of workers in transitioning industries. An EU-level focus is needed to standardise retraining programs and certification processes. In addition, a unified policy framework supports the creation of an enabling environment, providing incentives and regulatory support for both employers and workers involved in the transition.
Required budget	€3,000,000
Desired TRL at the end of project(s)	All considered technologies are at TRL 9, which means deployed in the market. With this project(s), no further advancement in TRL is expected, but rather advancement in the Societal Readiness Level (SRL) (see https://innovationsfonden.dk/sites/default/files/2019-03/societal_readiness_levels_-_srl.pdf). The expected final SRL of the project is 8-9

Solar Thermal TP

Topic title	**[ST-1]** Solar Thermal Hybrid Systems for Clean Energy Generation
Link to RHC-ETIP SRIA	***RE H&C technologies and systems for cost-effective retrofitting of old buildings*** ***Hybridisation of renewable energy systems***
Brief description of the topic & justification	The objective of this topic is to support the development and demonstration of innovative solar thermal hybrid systems that can provide clean, reliable and affordable energy for various applications. Solar thermal hybrid systems combine solar thermal collectors with other energy sources, such as biomass, heat pumps, waste heat, or electricity, to increase the efficiency and flexibility of the supply, with benefits for consumers and the energy system. The topic will fund projects that address the technical, economic and social challenges of integrating solar thermal hybrid systems into different sectors, such as buildings, industry, agriculture or district heating and cooling.

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	The projects should also consider the environmental and climate impacts of the systems, as well as the user acceptance and market potential. **Topic justification:** Solar thermal technology is a key component of the EU's strategy for achieving climate neutrality by 2050, as outlined in the European Green Deal, the Strategic Energy Technology Plan (SET-Plan) and the EU Solar Energy Strategy. Solar thermal technology can contribute to the decarbonisation of heating and cooling, which accounts for half of the EU's energy consumption. However, solar thermal technology faces several barriers, such as high upfront costs, low public awareness, and limited integration with other energy sources. Solar thermal hybrid systems can overcome these barriers by enhancing the performance, reliability and cost-effectiveness of solar thermal solutions. Moreover, solar thermal hybrid systems can support the integration of renewable energy sources into the energy system and increase the resilience and security of energy supply. Therefore, this topic is aligned with the Strategic Research and Innovation Agenda (SRIA) for solar thermal technology, which identifies solar thermal hybrid systems as a priority area for research and innovation. This topic also builds on the results of previous Horizon Europe projects on solar thermal technology, such as SHIP2FAIR, INSHIP, HYCOOL and SOLAR-H.
Required budget	€6,000,000 EUR for 2-3 proposals
Desired TRL at the end of project(s)	7-9

Topic title	**[ST-2]** Development of system components for solar district heating (SDH) and solar heat for industrial process (SHIP)
Link to RHC-ETIP SRIA	***Efficiency gain and temperature reduction*** ***Energy system integration*** ***Developing new process technology concepts being supplied by renewable energy***
Brief description of the topic & justification	The aim of this topic is to support the development and demonstration of innovative system components for solar thermal technology, with a focus on large scale solar thermal systems, namely applications for solar district heating (SDH) and solar heat for industrial process (SHIP).

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	The system components should address the challenges of integration, storage, distribution and control of solar thermal energy in these sectors, as well as the improvement of efficiency, reliability and cost-effectiveness. It shall focus on solutions covering a temperature ranges up to 200°C, which cover the needs for district heating networks and for a substantial part of industrial processes operating with steam as thermal energy vector. Some of the areas of improvement applicable to system components development for large scale solar thermal systems are: • Efficient hydraulics and standardized design of components (type of collector, collector area, storage size, power of other technologies) • Modular design approaches • Automated monitoring of large-scale integrated energy systems • Material and component development for high-temperature district heating networks (up to 95 °C) for (very) large PTES • The integration of decentralized cooling and air-conditioning systems into solar thermal district heating systems • Materials and component development for thermochemical technologies for temperatures up to 200°C **Topic justification:** This topic is aligned with the Strategic Research and Innovation Agenda for solar thermal technology, which identifies SDH and SHIP as two of the most promising markets for solar thermal in Europe. The topic is also relevant for the European Green Deal objectives of decarbonising the heating and cooling sector and increasing the share of renewable energy sources. The topic addresses the need for an EU-level work to foster cross-border collaboration, knowledge exchange and market development for solar thermal technology in these sectors. The topic is linked to several EU initiatives, such as the Renewable Energy Directive, the Energy Efficiency Directive, the Net-Zero Industry Act. The topic builds on the results of previous Horizon Europe projects on this topic or a similar one, such as SDHp2m, InSHIP, SHIP2FAIR and SolBioRev.
Required budget	€8,000,000 for 2-3 projects

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Desired TRL at the end of project(s)	6-8

Topic title	**[ST-3]** Integrated solutions for solar heat for industrial processes (SHIP) below 400°C
Link to RHC-ETIP SRIA	***Innovative technologies for optimised system integration of renewable energies*** ***Developing new process technology concepts being supplied by renewable energy***
Brief description of the topic & justification	The aim of this topic is to support the development and demonstration of innovative solar thermal technologies for Solar Heat for Industrial Processes (SHIP) below 400 degrees Celsius. The topic will address the technical, economic and environmental challenges of integrating solar thermal systems into industrial processes, such as heating, cooling, drying, sterilization, etc. It shall also cover the need for new technical concepts and business models to integrate decentralized solar thermal systems into heating grids and for for thermo-electrical smart grids with integrated solar thermal systems. Some of the areas for improvement on integrated SHIP solutions are the demonstration of: • the integration of SHIP into industrial processes where such integration has not yet been executed • system designs for increased solar thermal fractions in smart grids and system technology for optimised operations • sensible high temperature TES systems for SHIP (concrete, metals, minerals and other materials) • slightly over-pressurised systems, including large thermal energy storages • pre-commercial, MWh scale, steam storage at 10-20 bar The topic will also foster cross-sectoral collaboration and knowledge transfer among different industrial sectors and stakeholders. **Topic justification:** The topic is in line with the Strategic Research and Innovation Agenda (SRIA) for solar thermal technology, which identifies SHIP as one of the key applications for increasing the competitiveness and sustainability of European industry. This topic is aligned with the Strategic Research and Innovation Agenda for solar thermal technology, which identifies SHIP as one of the most promising markets for solar thermal in Europe.

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	The topic is also relevant for the European Green Deal and the EU's climate and energy targets, as SHIP can contribute to reducing greenhouse gas emissions and fossil fuel dependency in the industrial sector. It is also linked to several EU initiatives, such as the Renewable Energy Directive, the Energy Efficiency Directive, the Net-Zero Industry Act. The topic addresses the need for an EU-level work to foster cross-border collaboration, knowledge exchange and market development for solar thermal technology in these sectors. The topic will build on the results and lessons learned from previous and ongoing Horizon Europe projects on SHIP or related topics, such as INSHIP, SHIP2FAIR, etc.
Required budget	€10,000,000 for 1-3 projects
Desired TRL at the end of project(s)	8-9

Biomass TP

Topic title	**[Bio-1]** Micro-CHP and hybrid heating systems for domestic applications (Integration of biomass fired with solar heat and power systems)
Brief description of the topic & justification	Micro-CHP systems integrate the production of heat and power on a small scale, typically for residential or small commercial applications. These systems are designed to provide both electricity and heat simultaneously, often using biomass as a renewable energy source. Hybrid heating systems combine different technologies, such as heat pumps, biomass boilers, biomass CHPs, and other renewable energy sources, to optimize energy efficiency and reduce environmental impact in domestic settings. A focus at the EU level allows for the development of standardized regulations and guidelines for micro-CHP and hybrid heating systems. This ensures consistency in technology deployment, safety standards, and environmental considerations across member states. Market harmonisation, cross-border collaboration and knowledge exchange as well as economies of scale are the other factors that could benefit the technological advancement in the EU level. A similar topic `Cost-effective micro-CHP and hybrid heating systems´ was covered in HORIZON-RIA HORIZON Research and Innovation Actions: Funding & tenders (europa.eu). However, this call aimed for TRL up to 5.

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	With this new call, the focus should be on the demonstration of such systems to bring the developments to TRL 8-9.
Required budget	€2,000,000 – €3,000,000
Desired TRL at the end of project(s)	8-9

Topic title	**[Bio-2]** Accelerating the use of biomass at domestic heating systems (Adoption of advanced supply chains and new feedstock for sustainable and cheap renewable heating from biomass)
Brief description of the topic & justification	The topic centres on advancing the utilization of biomass in domestic heating systems (i.e. represent new milestone in biomass fuel flexibility) while prioritizing a crucial environmental aspect— zero or near-zero dust emissions. This involves developing technologies and systems that enhance the efficiency of biomass combustion, minimizing particulate matter and contributing to cleaner air quality. An EU-level focus is crucial for establishing common standards and regulations for biomass heating systems. In addition, coordinated efforts at the EU level are necessary to align policies related to biomass heating with environmental goals. The topic aligns with the objectives of the European Green Deal on the transition to a circular and green economy. Advancing biomass heating aligns with the Green Deal's objectives by promoting renewable energy use and addressing environmental concerns through the mitigation of dust emissions. There is no recent HE/IF call/project on this or similar topic.
Required budget	€4,000,000
Desired TRL at the end of project(s)	7

Topic title	**[Bio-3]** Negative emissions at bioenergy plants (New and cost-efficient integrated concepts for BECCUS at existing or new plants)
Brief description of the topic & justification	BECCUS is a critical technology aimed at achieving negative emissions. It involves capturing CO2 emissions produced during the combustion of biomass in bioenergy plants and utilizing the captured CO2 for various purposes, such as the production of fuels, chemicals, or other valuable products. The focus of the call should be on the development of novel

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	and in terms of energy efficiency well integrated BECC solutions for biomass combustion combined with suitable utilization options. The European Green Deal aims for climate neutrality by 2050. BECCS aligns with this goal by actively removing CO2 from the atmosphere and contributing to the transition to a low-carbon economy. The EU's focus on these topics is necessary because common EU standards and regulations are essential for the effectiveness and safety of these technologies. International collaboration, along with EU funding and research support, would benefit the advancement of this technology. There is a similar HE call, but not on the BECCUS and not taking into consideration the utilisation (only storage is covered). In addition, cost efficiency and integrated concepts are also not necessarily aimed: Horizon CL 5 call on «DACCS and BECCS for CO2 removal/negative emissions »
Required budget	€5,000,000
Desired TRL at the end of project(s)	5

Geothermal TP

Topic title	**[Geo-1]** Innovative geothermal solutions with enhanced materials and new generation robotized drilling to provide cost-efficient geothermal heating & cooling for buildings
Brief description of the topic & justification	Scope • Enhanced plastic piping and other materials for Bore Hole Exchangers (BHE) in geothermal applications. • Thermal enhancement of the borehole heat transfer by means of high-pressure grout injection and adequate materials. • Improved PCM – grout mixtures for an adequate diurnal or seasonal Borehole Thermal Energy Storage (BTES). • Improved and eco-friendly antifreeze geothermal fluid for circular economy • Development of cost-efficient solutions to increase the conductivity and thermal capacity of the underground in the vicinity of borehole heat exchangers with environmentally acceptable and stable solutions • Development of fully robotized/automatized drilling solutions for shallow and deeper borehole applications. New drilling equipment should also allow to reduce emission and noise in

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	urban areas with hybrid or full electric drill rigs and provide less invasive drilling methods in the built environment • Development of Intelligent Control solutions for a continuous monitoring of the drilling operation, supported by machine learning and artificial intelligence algorithms to improve the outcome of the drilling. • Development of very shallow closed loop geothermal HP systems allowing to develop VSGP in environments where this solution may provide a very cost competitive alternative to other systems (e.g. farms, agriculture, rural building environments, etc..) **Expected impact** Reduction in the unit cost of drilling (€/MWh), % improvement of overall conversion efficiency of geothermal installations at different thermodynamic conditions, % reduction of production costs of geothermal energy (€ct/kWhth), decrease (%) of n. of boreholes per kW energy produced, %reduction in time for the competition of a standard borehole of 100m, %increase in the thermal capacity of a unit volume of grout with PCM
Required budget	€20,000,000 (3 projects of €6,000,000 – 7,000,000 each)
Desired TRL at the end of project(s)	From TRL 5-6 to TRL 8-9

Topic title	**[Geo-2]** Demonstration of new generation of Underground thermal storage systems (UTES), with subsurface system development and planning[1]
Brief description of the topic & justification	Scope • Subsurface characterization of suitable formations (mainly for High Temperature Aquifer Thermal Energy Storage (HT-ATES)), identification of potential. Impact / water quality effects / water treatment. Coupled temperature water quality changes, desorption of heavy metals • New BTES configurations to allow an efficient high temperature heat storage at diurnal or seasonal timescale • Development of PCM based concepts to allow enhanced borehole heat exchanger BUTES applications for District Heating (DH) systems • Optimization of recovery efficiency • Integration with district heat network. Optimisation with well types / well placement.

[1] This topic is partly covered by topic DHC-TES-1 below

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Required budget	From TRL 4-5 to TRL 8-9
Desired TRL at the end of project(s)	€20,000,000 (2 projects ~€10,000,000 each)

Topic title	**[Geo-3]** Novel materials and equipment for smart operation of geothermal plants[2]
Brief description of the topic & justification	**Alternative materials for Scaling & Corrosion** • Development of effective and environmentally benign measures to prevent and control scaling and corrosion (TRL 6 – 8 by 2023, TRL 9 by 2026). • Development of safe and environmentally benign measures to remove scaling (TRL 6 – 7 by 2023, TRL 8 – 9 by 2026). • Development of materials that are resistant to corrosion and/or have anti-scaling properties. Such materials can help to reduce costs and downtime due to workovers and increase the lifetime of components such as submersible pumps and tubing (TRL 5 – 7 by 2023, TRL 8 – 9 by 2026). **Equipment** • Development of second-generation geothermal pumps with prolonged lifetimes under aggressive fluid conditions or development of alternative lifting technologies (e.g. airlift) (TRL 6 – 7 by 2023, TRL 8 – 9 by 2026. • Development of innovative efficient Heat pumps: challenges with heating systems coupled with HP. **High Temperature sensors & tools** • Development of electronics and sensors to be used in high-temperature geothermal wells during drilling operations. This will lead to better control of the drilling process, reducing the risk of wellbore instability and lost-in-hole incidents. • Development of data communication or telemetry technologies allowing fast and reliable data transfer under high-temperature conditions. • Development of electronics and sensors that can withstand temperatures up to 350°C by 2030. • Development of data communication technologies that can withstand temperatures up to 350°C by 2030. **Eco-friendly chemicals** • Development of eco-friendly drilling fluids that are stable under high-temperature and high-pressure conditions and that effectively protect drilling equipment against corrosion. (TRL 4 – 5 by 2023, TRL 6 – 7 by 2026, TRL 8 – 9 by 2030) **Eco-friendly materials**

[2] This topic is partly covered by topic DHC-TES-3 below

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	• Development of materials, including casing couplings and cements, to improve overall heat transfer and guarantee integrity and resistance to fatigue over the well's lifetime under the challenging conditions encountered in geothermal applications. Focus will be on: ○ Development and laboratory testing during the period 2020 – 2023 (TRL 5 – 6), testing under realistic conditions and in the field during the period 2023 – 2026 (TRL 7 – 8), application in one or two demonstration projects by 2030 (TRL 8 – 9)
Required budget	€10,000,000 (split into 5 grants of €2,000,000)
Desired TRL at the end of project(s)	Action aims to prolong the lifetime of geothermal wells, piping and equipment by making the materials used more resistant to the detrimental effects of temperature, fluid chemistry and flow. This can be done in a number of ways, either through materials research, the use of environmentally benign chemicals, or effective design and operating protocols.

Topic title	**[Geo-4]** Solutions and demonstration of geothermal integration in the coupling of the energy system for the heating and cooling sector
Brief description of the topic & justification	The European Commission deemed a 'Smart Sector Integration' plan essential to a successful European Green Deal. The intention is to maximise technological and policy synergies in the decarbonisation of one sector with others to accelerate attainment of zero-carbon emission buildings, mobility and power generation before 2050. Technological development includes: • Energy system modelling to definition the site-specific contribution of deep geothermal heat in complex energy systems mix and district heating networks; • Modelling on decarbonisation of the heat sector, buildings and industry; Develop methodology to define costs of Renewable H&C technologies and enabling factors, such as storage. • Integrate deep geothermal heat to agri-food production and industrial process; • optimise the production of geothermal energy together with minerals extraction. For instance, Lithium and other minerals of high strategic value could be harvested together with the energetic use of the appliances, creating a double value effect for these systems • Optimized shallow geothermal technologies as part of a combined energy system: heat supply, cold supply, thermal storage

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	• Demand load response systems and the integration of ground source heat pumps and underground thermal energy storage (BTES/ATES) to 4th generation district heating/cooling networks • Optimum integration of UTES systems in thermal energy supply for DH • Support Regional and local authorities to optimise the integration of RES H&C through the introduction of incentives and codes and/or obligations affecting the spatial planning of residential, commercial and industrial areas. • Housing associations, owners of large building stocks and consumer cooperatives adopting approaches which enable the large scale uptake of RES heating and cooling systems, together with the energy efficient retrofitting of existing buildings. This could include the initiation of new district heating and cooling networks using RES, and the modernisation and retrofitting of RES in existing networks combined with sound end use management practices. • Developing nearly-zero neighbourhoods: the concept of nearly-zero energy buildings is more easily adopted when considering several buildings in an integrated way, exploiting a combination of renewable energy sources, including renewable heating and cooling solutions.
Required budget	€24,000,000 (2 projects of €12,000,000)
Desired TRL at the end of project(s)	From TRL 5-6 to TRL 7-8

Heat pump TP

Topic title	**[HP-1]** Heat Pump value chain efficiencies
Link to RHC-ETIP SRIA	***Research and innovation priorities for RHC buildings***
Brief description of the topic & justification	Evaluation of the complete heat pump value chain with the rationale of cutting CAPEX and OPEX to further improve affordability. Reducing costs for the rest of the supply chain e.g. installers need more training and new tools for flammable refrigerants, factory design, storage and distribution, maintenance. The "Innovative heat pump components" Horizon Europe call model could serve as a model, but this time adapted to the whole or particular parts of the value chain.
Required budget	€4,500,000 (split into 3 grants of €1,500,000)
Desired TRL at the end of project(s)	7

Topic title	**[HP-2]** Innovative components and configurations for heat pumps

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Link to RHC-ETIP SRIA	***Research and innovation priorities for RHC buildings***
Brief description of the topic & justification	The Horizon Europe call with the same topic opened in 2023 (HORIZON-CL5-2023-D3-02-04) gathered a lot of interest and ideas from complementary sectors. The call combined general aspects with requirements that would push forward the state of the art, and as such encouraged a lot of different approaches. A re-issuing of the call updated for 2024 requirements would significantly assist the sector.
Required budget	€6,000,000 (split into 2 grants of €3,000,000)
Desired TRL at the end of project(s)	4-5

Topic title	**[HP-3]** Heat Pumps – Industrial synergies
Link to RHC-ETIP SRIA	***Research and Innovation priorities for RHC in industries***
Brief description of the topic & justification	The collaboration between EHPA and CEPI on the standardization of industrial processes in the paper and pulp industry can be easily replicated with other industries, indeed, large industries have already shown interest in such a process. Such standardization would be linked with the REPowerEU, the Heat Pump Accelerator and the Green Industrial Plan, having a significant replication potential in waste heat recovery as well as any process close to 200 degrees C.
Required budget	€10,000,000 (split into 2 grants of €5,000,000)
Desired TRL at the end of project(s)	4-5

Topic title	**[HP-4]** Enabling flexible heat pumps to support the grid and integrating the energy system
Link to RHC-ETIP SRIA	***Transversal topics***
Brief description of the topic & justification	A study into the advantages and use cases for the flexibility that heat pumps offer to the grid, as well as their integration (heating and cooling component) in a holistic system (e.g. with solar PV, Electric storage, electric vehicles, smart control, user interfaces (e.g. apps)).
Required budget	€3,000,000 (split into 2 grants of €1,500,000)
Desired TRL at the end of project(s)	7

DHC & TES TP

Topic title	[DHC-TES-1] Re-purposing legacy infrastructure as large-scale thermal energy storage units: Advancing sustainability and circular economy goals
Link to RHC-ETIP SRIA	***Technologies of heat and cold storage and distribution***

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	Digitalisation, operation and system flexibility ***Circularity*** ***Energy system integration (Topic 5: RESEARCH AND INNOVATION PRIORITIES FOR RHC IN DISTRICTS)***
Brief description of the topic & justification	This topic emphasizes repurposing legacy infrastructure (e.g. tunnels, bunkers, caverns, abandoned mines, former oil or gas storages, wastewater treatment plants and silos, thermal power plants) into large-scale thermal energy storage (TES) units. This innovative approach addresses the challenge of high initial capital expenditure (CAPEX) associated with implementing new underground TES while aligning with sustainable development goals and promoting a circular economy. By extending the service lifetime of existing structures, this concept minimizes the carbon footprint by avoidance of new construction and materials (e.g. pre-stressed concrete and steel). **Key focus areas:** 1. Repurposing challenges: The investigation of effective cleansing methods for different infrastructures (e.g. gas storage, caverns, thermal power plants) and addressing potential residues. The selection and development of cost-effective cleansing methods is crucial to ensure successful repurposing, 2. Designing charging/discharging mechanisms: The development of specialized devices tailored to each infrastructure type for efficient thermal energy injection/extraction. Specific systems for direct or indirect charging/discharging (e.g. caverns vs. tunnels) need customization for robust TES transformation, 3. Installation of insulation and liners: Overcoming technical challenges in installing insulation materials. The development of effective installation methods is critical for ensuring the reliability and robustness of large-scale TES via infrastructure reuse, 4. Optimal control strategy: The optimization of the thermal energy allocation based on its temperature level to the specific TES unit within a set of TES units connected with each other. The control strategy shall also consider the optimal hydraulic connections between the set of TES units (e.g. parallel, serial) based on the requirements of the district energy system and available thermal energy. **Demonstration projects shall include the following objectives:** 1. Integration into district-level heating/cooling: Showcase the impact of repurposed TES on CAPEX, OPEX, round-trip efficiency and environmental factors (e.g. CO2 footprint), 2. Industrial heat supply integration: Highlight the synergy between repurposed TES and industrial processes to meet heat demands, utilizing waste heat, and/or

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	3. Multi-vector thermal energy consideration: Explore various levels of heating and cooling applications and temperature levels within the repurposed infrastructure. **Key aspects to address:** • Usage of sustainable materials: Emphasize the use of recycled, non-toxic and durable materials for insulation and sealing leading to the minimization of environmental impact. • Impact of land footprint: Demonstrating how repurposing optimizes land use, reducing the need for new land through detailed LCA. • Utilization of local resources: Use of locally available materials for the transformation of infrastructure into large-scale TES promoting sustainability. • Predictive maintenance and control: The development of reliable digital twins for optimal system operation and establishing methodologies for predictive maintenance. • Transformation guidelines: Providing detailed planning methodologies and guidelines to facilitate the successful transformation of these infrastructures. The demonstration topics shall outline a comprehensive approach to repurpose existing infrastructure for large-scale thermal energy storage addressing technical, environmental and economic considerations. Through demonstration projects and innovative methodologies, it aims to advance sustainable energy solutions while contributing significantly to the circular economy. Recent projects on the topic (completed after 2020 or ongoing as of January 2024) include: INTERSTORES, PUSH-IT, TREASURE.
Required budget	Total budget: €15,000,000 – 18,000,000 (3 projects each with € 5 – 6 Mio.)
Desired TRL at the end of project(s)	7-9

Topic title	[DHC-TES-2] Optimizing large thermal storages
Link to RHC-ETIP SRIA	*n/a*
Brief description of the topic & justification	**Optimizing large thermal storages** Large thermal energy storages play a pivotal role in increasing the flexibility of district heating systems and industrial heating systems and enabling a 100 % renewable energy supply for these. Currently, a number of innovation and demonstration activities in the field of large thermal energy storages are ongoing, with the aim to lay a good technology and market basis for a broad, Europe-wide uptake of the technologies. The LTES are typically very capital-intensive, with a long preparation time and

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	a long target lifetime. The long lifetime of the storages generates challenges for the development of novel materials and components for LTES. Present testing methods do not yet yield the desired accuracy to predict long-term behaviour. Besides, there is a serious lack of monitoring data of performance of materials and components in actual operating LTES systems. This calls for a dedicated support for the • development of testing equipment and test procedures for the assessment of long-term performance of LTES materials (e.g. liners, concrete) and components (e.g. piping, pumps, stratifiers). • In-situ monitoring of materials and components for very long periods (several to ten years), in order to determine the effects of actual boundary conditions on the material and component quality. Dedicated monitoring, novel sensoring and data acquisition would have to be developed in order to enable the long-period monitoring. Recent projects on the topic (completed after 2020 or ongoing as of January 2024) include: HEATSTORE, PUSH-IT, USES4HEAT, TREASURE.
Required budget	Total budget: €15,000,000 - €18,000,000 (3 projects each with €5,000,000 – €6,000,000)
Desired TRL at the end of project(s)	6

Topic title	[DHC-TES-3] New technologies and materials for thermal storages
Link to RHC-ETIP SRIA	***Technologies of heat and cold storage and distribution***
Brief description of the topic & justification	**New technologies and materials for thermal energy storages** Both for compact thermal energy storages and for large thermal energy storages, material performance is deciding for the application potential of the storage technology, be it in terms of costs or in terms of lifetime or circularity. In order to further improve the storage technologies, targeted material development is necessary. At the same time, new applications fields like flexible sector coupling or carnot batteries ask for novel materials or materials with novel properties. The challenges for materials development are high and can only be tackled through international collaboration of European institutes and industries. The development challenges are: • Materials for novel application fields (e.g. flexible sector coupling, carnot batteries) • High temperature TES materials charged via direct electric charging

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- Novel or improved material synthesis and production methods, aimed at improved performance and reduced costs (e.g. sorption materials, salt hydrates, liner materials)

For all material developments, circularity, affordability and regional availability are development targets.

Innovative Thermal-based Energy Storage Technologies for Enhanced Energy Sector Integration

Expected Outcomes:

- Novel technological solutions to decouple thermal energy generation and usage in large-scale systems, facilitating integration of energy vectors.
- Novel Materials, components and configurations specifically for large-scale applications.
- Increased scientific and technological leadership of EU in energy storage technology
- Enhanced understanding of values, roles and advantages of thermal-based energy storage in pertinent large-scale settings.

Scope: Development of innovative technological solutions for large-scale storage of thermal energy and that demonstrate significant advancements in efficiency, cost-effectiveness, ease of integration and scalability, aligning with the objectives of a future net-zero energy system. In scope are novel thermal, thermo-mechanical, and thermo-chemical energy storage solutions. Research on batteries and chemical-based storage is out of scope. Emphasis is on novel solution technologies with the potential to seamlessly integrate with large infrastructures such as industrial parks, energy districts and energy grids and promote energy sector coupling toward net-zero targets.

The following research and development areas should be to be covered:

- Development of new technology concepts and designs: clear innovations with respect of the state of the art and aimed at facilitating decoupling of thermal energy generation and usage in large-scale systems. Where appropriate, contribution to Power-to-Heat-to-Power should be explored.
- Development of materials and components: high-performance and sustainable thermal energy storage materials and thermal insulation technology, advanced heat exchangers and fluid-

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	machineries. Novel computational methods for design discovery are in scope. • Lab scale demonstration (TRL 4-5) of technological feasibility; advancement of scientific and technological knowledge beyond state-of-the-art Assessment of the expected technical, environmental and economic benefits to EU R&I strategy, as well as the EU targets of an integrated net-zero energy systems
Required budget	€25,000,000 (5 projects each ~€5,000,000)
Desired TRL at the end of project(s)	4-5

Topic title	[DHC-TES-4] Integration of renewables in DHC and sector coupling
Link to RHC-ETIP SRIA	***Technologies for integrated system solutions of decarbonised energy systems of cities)***
Brief description of the topic & justification	DHC and sector coupling are key strategies to cost-effectively realise the EU energy transition and decarbonization of energy systems, while increasing the security of supply (as targeted in EU EED, RED, EPBD, Fit for 55 and RepowerEU packages). Storage, circularity of thermal energy and demand-side flexibility have become key challenges to further increase the adoption of renewable and residual energy sources in heating and cooling networks, and to increase renewables uptake in the energy system in general. This topic focuses on research and innovation actions related to local multi-energy systems constituted of thermal and electrical distribution networks, and is aimed at: • increasing from TRL 3-4 to TRL 6-7 technical solutions for energy conversion, exchange and storage that promote renewable and residual energy adoption in local multi-energy systems, including power-to-heat and heat-to-power …. • Digital solutions up to TRL 6 to increase and optimize the flexibility of the DHC and electrical distribution networks both in terms of operation and capacity to uptake renewable energy from various sources, and to increase and optimize system stability and adequacy with respect to various uncertainties related to the development of key factors (such as evolution of demand, availability of renewable and residual heat sources, weather, energy and/or flexibility market evolutions…). • Market design solutions that facilitate and stimulate the increased coupling between power and thermal systems.

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	An open-source virtual testing framework, enabling the assessment of system integration measures on the distribution level, assists the benchmarking process of different system integrators. Recent projects on the topic (completed after 2020 or ongoing as of November 2023) include: RELaTED, REWARDHeat, PLANET, TEMPO, D2GRIDS, HYPERGRYD.
Required budget	€8,000,000 (for 2 projects)
Desired TRL at the end of project(s)	5-6

Topic title	[DHC-TES-5] Increasing efficiency in DHC
Link to RHC-ETIP SRIA	***Decarbonisation – Scenario Evaluations and Decarbonisation Strategies***
Brief description of the topic & justification	The efficiency of both existing and new DHC networks needs improvement, and sustainable energy sources should be used more efficiently. Key actions to focus on to achieve this target deal with: **Maintenance** Just as any system, DHC networks require regular maintenance. Water leakages do not only increase the amount of markup water, but also lead to degrading of the quality of the insulation, and as such to higher heat losses. Malfunctioning in substations also lead to higher than necessary return temperatures. Therefore, digital tools such as digital twins or data driven decision support software need to be developed to facilitate the maintenance strategy. **Smart control** Smart network controllers make it possible to optimize the efficiency of the network. By shifting the heat/cold demand in time through demand response or smart control of THES, and by optimizing the temperature levels in the network, significant gains can be made in terms of efficiency and OPEX. Adding smart control to DHC networks heated or cooled by devices connected to the electric grid, the intrinsic flexibility of the thermal network can be offered to balance the electric grid (sector coupling). Ongoing or recently finished project focussing on these topics include: STORM, TEMPO, D2GRIDS, REWARDHeat, OPTi, PUSH-IT, DENSE
Required budget	€20,000,000 (4 projects each ~€5,000,000)
Desired TRL at the end of project(s)	7-9

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Topic title	[DHC-TES-6] Innovative and Robust Concepts for decarbonized DHC networks
Link to RHC-ETIP SRIA	***Decarbonisation – scenario evaluations and decarbonisation strategies***
Brief description of the topic & justification	Future DHC systems with high shares of multiple and decentral renewables and waste heat sources require lower temperatures, decentralized supply, heat pumps on multiple levels, and storages. Innovative technological options for realizing such networks include • The optimal combination of old and new supply units (including e.g. data centers, waste heat from electrolysers, etc.) • The integration of BECCS technologies wherever bioenergy plants are applicable, aiming to achieve carbon negative DHC networks • Different hydraulic options for heat pump integrations, considering various electricity markets • Cascading options for optimal network capacity utilization (i.e. using the return line as a supply) • The optimization of the heat capacity of storages by maximum cooling of the storage far below return temperatures (--> 5°C) • Concepts for network expansion by increasing the building flexibility and decentralized heat supply as well as the reduction of the return temperatures • The integration of cooling networks focussing on the utilization of the waste heat from the cooling process Those systems are complex in planning and design. Thus, proposals should develop plannings, simulation and optimization tools focussing on techno-economic assessments of the above-mentioned technology options. However, investment decision for the different option depends on several uncertainties regarding the future development of key factors (e.g., influence of climate change, development of connection rates, availability of waste heat, energy price volatilities, etc.). Understanding and quantifying those uncertainties is a crucial step to overcome the limitations of currently widespread “conventional” models for investment decisions. Proposals therefore should also further develop and / or extend existing planning, simulation and optimization tools towards stochastic approaches, as well as beyond state-of-the-art algorithmic approaches to deal with the rising complexity of district heating models embedded into the overall energy system.

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Required budget	€25,000,000 (5 projects each ~€5,000,000)
Desired TRL at the end of project(s)	4-5

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