



PATHFINDER CHALLENGE

CLEAN AND EFFICIENT COOLING CHALLENGE GUIDE

EIC Work Programme reference: HORIZON-EIC-2023-PATHFINDERCHALLENGES-01-01

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The EIC will hold an Info Session on this Pathfinder Challenge call on 15th March 2023 between 09:30-12:00 CET. Participants can access the meeting as guests [here](#). Participation in the meeting, although encouraged, is optional and is not required for the submission of an application. A recording of this Info Session will be made available on the same URL. Notifications of additional dissemination events can be found at [Events \(europa.eu\)](#)

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1. About this document

The Challenge Guide serves as guidance and background for the common understanding, participation rules and obligations for the EIC beneficiaries that are involved in the Challenge Portfolio. Contractual Obligations are further detailed in the [EIC Work Programme](#).

The Challenge Guide is a guidance document accompanying a Pathfinder Challenge call topic for proposals to provide further information about how portfolio considerations will be taken into account in the evaluation of proposals for that topic.

The Challenge Guide is prepared by and under the responsibility of the relevant EIC Programme Manager (information about the EIC Programme Managers is available on the EIC Website https://eic.ec.europa.eu/eic-communities/eic-programme-managers_en). It complements the Scope, Specific Objectives and/or Specific Conditions set out in the EIC Work Programme by a description of the portfolio considerations and how a portfolio will be built. The presentation provided by the Programme Manager during the Info Day gives applicants a further opportunity to understand the background, rationale and motivation of the call, and to ask questions to the Programme Manager. The Challenge Guide does not contradict or supplant the Work Programme text.

Following the selection of a proposals to be funded under the Challenge, the Programme Manager will work together with the consortia of the selected projects to develop a common roadmap with a strategic plan for the Challenge. This roadmap/ strategy plan will integrate the activities and milestones of the individual projects into a shared set of objectives and activities across and beyond the projects. The roadmap serves as a common basis for the project portfolio and may affect the project implementation - including possible adjustments, reorientations or additional support to projects. The roadmap will be updated in light of emerging results or issues during the implementation.

2 Scope and objectives of the Challenge as defined in the Workprogramme

This section is a copy of the Challenge call in the EIC work programme text. Proposals to this Challenge are expected to explain how they relate to and intend to go beyond the state of the art, and how they interpret and contribute to the objectives of the Challenge.

EIC Pathfinder Challenge: Clean and efficient cooling

Background and scope

Cooling is an essential process across many areas of society, important for human wellbeing, economic growth, sustainable urbanisation, reduction of food scarcity, and for socio-economic development. It presents relevant applications in sectors such as (i) built environment, heat, ventilation and air conditioning (HVAC), building health and comfort, interoperable urban energy systems, (ii) data centers, electronics and superconductors, (iii) food production (i.e. vertical farming), processing, storage and refrigerated transport, (iv) cold energy carriers production, transport and network integration (liquid H₂, LNG, etc.), (v) chemical, metallurgical and hard to abate industries (including cryogenic carbon capture) and (vi) medical applications (e.g. vaccines that need refrigeration). In terms of cooling technologies, vapour compression is the most widely applied method for air-conditioning and refrigeration. However, a wide range of alternative methods have been developed or are under active development including thermochemical (e.g. sorption) and solid-state (e.g. magnetic, electrochemical, thermoacoustic, thermo-elastic) based cooling solutions. At the same time, the need for mechanical cooling can be mitigated by using nature-based solutions (such as trees and plants), passive cooling techniques (such as natural ventilation, shades, thermal insulation, radiative cooling etc.), the use of natural energy (e.g. winter cold for summer use, or solar cooling) and behavioural changes or other demand-based technologies. The demand for cooling is rising and cooling processes often result in significant greenhouse gas (GHG) emissions, due to the use of hydrofluorocarbons (HFCs) or fossil fuel to power cooling equipment. At the same time, the global energy market disruption and increasing costs of energy supply are threatening the competitiveness of several high cooling demand sectors, so that the availability of super-efficient and low cost cold technologies is crucial. These needs call for novel solutions as they cannot be addressed by simply adapting conventional cooling processes and solutions, nor relying on existing supply chains for components and devices. The alternative cooling technologies under development are either for small scale (e.g. solid-state refrigeration) or for a limited temperature range (e.g. sorption based refrigeration). This Challenge is strategic for the European Green Deal¹ and the REPowerEU² plan, Renewable Energy Directive (RED II), and Energy Efficiency Directive (EED) EU policy objectives, transforming the EU into a resource-efficient and competitive economy, increasing Europe's autonomy on energy and critical materials, preserving Europe's natural environment, tackling climate change and adaptation to

¹ https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

² https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowerEU-affordable-secure-and-sustainable-energy-europe_en

it, food security and health protection, and strengthening the EU technological leadership in this strategic sector.

Overall goal and specific objectives

This EIC Pathfinder Challenge aims at advancing scientific knowledge and technological development of novel, clean and efficient cooling solutions that fully underpin “cold economy” vision. For this purpose, the portfolio of projects supported under this Challenge should explore the potentials of new devices, processes, components and materials for clean cooling generation, storage and/or transport, such as:

- Generation of clean cooling which may integrate the use of renewable energy, waste heat/ cold harvesting, passive and radiative cooling, thermochemical and hybrid heat pumps, heat transformers, waste heat recovery, heat pipes); solutions for a wide range of applications ranging from vaccine storage temperature (-80 to 4°C), food (-40 to 12°C), data centres and air-conditioning (6 – 12°C) are eligible; Store and/or transport of cooling (spatially and/or temporally decoupling demand and generation), clean cold chain transportation, thermal energy carriers, interseasonal storage, including charging/discharging dynamics where relevant (i.e. short charging times and mid to long duration storage). Utilization and/or management of cooling, such as cascade use of cold energy for different temperature requirements, integration of innovative and low/ net zero cooling concepts in critical demand segments (i.e. data-centre, hard-to-abate industrial sectors, buildings, specific solutions for food processing or medical applications) or other demand side related technologies).

Specific objectives of the Challenge are to explore new devices, processes, components and materials for cooling. Technologies to be integrated in products and services shall demonstrate their potential to (i) reduce investment/operational costs, (ii) increase efficiency, operational reliability and interoperability, (iii) avoid the use of critical raw materials³ or harmful refrigerants and (iv) pursue circularity by design approaches, low environmental impact and low carbon footprint. The proposals should refer the expected COP (coefficient of performance) to the max theoretical COP of the inverse Carnot cycle and describe how the proposed solution can be competitive with the state of art at the proposed operating range. The proposed solutions should aim to achieve single stage temperature gradients higher than 5 °C at a competitive COP.

The proposals submitted in response to this Challenge may address fields such as:

- unconventional refrigeration technologies and systems including but not limited to functionalised Phase Change Materials (PCM), thermochemical materials, thermophotonic, elastomeric, barocaloric, magnetocaloric or thermally regenerative

³ https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en

electrochemical cycles; new compression-expander mechanisms (i.e. electrochemical compression), use of mixed refrigerants or other novel cycles configurations;

- computational modelling and validation of energy-intensive low-temperature heat transfer processes, materials and components including their design, manufacturing, optimisation and dynamic performance (i.e. novel heat exchangers, compressors etc.);
- ultra-energy efficient operations and logistics along the cooling supply chain and final use, decoupling supply and demand via thermal carriers (PCMs, thermochemical materials, ice slurries, liquid air, molecular storage etc.) or systems integration, including mobile cold energy storage and associated charging solutions; interoperability of district networks, reversible heating and cooling infrastructures, or cold-to-power solutions;
- new designs and concepts for food processing and medical applications; unconventional refrigeration principles (such as thermoelectric, magnetocaloric, electrocaloric, elastomeric or barocaloric, photonic cooling conversion) or new compression-expander mechanisms (scroll, electrochemical compression), mixed refrigerants, novel cycles configurations.

The proposals may include smart interoperability solutions for electricity, heating and cooling networks integration, including reversible heating and cooling infrastructures, or cold-to-power solutions with waste heat and cold energy streams recovery from industrial processes, data centres and/or air conditioning of buildings.

Expected outcomes and impacts

The supported projects shall individually provide proof of concepts for unconventional approaches (at materials, component, process or device level) that can convincingly impact the energy consumption, emission reduction and cost reduction of the cooling sector. The portfolio of supported projects should contribute to one or more of the following medium to long-term impacts:

- Increase the EU technological leadership in the cooling sector and in strategic productive fields strongly linked to cold production (such as food), Improve building comfort and health in living environment, Increase operational security of server and computing facilities, Reduce carbon footprint of energy systems and address climate change mitigation, Address climate change adaptation (in particular in semi-desert areas) and food security, including possibilities of international outreach, Reduce EU dependency from, and diversify EU sourcing of, critical materials supply

3 Portfolio considerations for the evaluation of applications to the Challenge

This section describes how portfolio considerations will be taken into account in the second evaluation step. For more details of the full evaluation process please refer to the EIC Work Programme pages 29-32.

Portfolio considerations

For this Challenge the portfolio building process will be based on the preliminary mapping by the evaluation committee of the proposals to one (or more) of the following categories:

- Clean cooling generation: solutions for a wide range of applications ranging from cryogenic cooling (such as LNG, CO₂ and bio-CH₄ liquefaction), vaccine storage temperature (-80 to 4°C), food (-40 to 12°C), data centres, electronic components, batteries, and air-conditioning (6 – 18°C), etc.;
- Clean cooling storage and/or transport: solutions for spatial and temporal decoupling of cold generation and demand, including cost-effective, high density cold energy storage and its charging/discharging dynamics where relevant (i.e. short charging times and mid to long duration storage), interseasonal, seasonal and daily storage and transport of cold, including the use of cooling to balance the electricity system
- Clean cooling utilisation, management and monitoring: solutions such as cascading use of cold energy for different temperature requirements, innovative integration and industrial-symbiotic solutions in cooling or other technologies related to the cooling demand management, the end user requirements and the integration of storage at systems and components level (i.e. batteries cooling for electric vehicles); advanced strategies, algorithms and tools for monitoring and maintaining high performance at system/component level in cooling generation, handling or final end use, through prediction and evaluation of faults, predictive maintenance strategies and other monitoring technologies to guarantee high systems resilience, fault tolerance, process efficiency, environmental performance and/or self-healing capabilities during the lifetime and at different operating conditions..

The evaluation committee will aim to compose a balanced and diverse portfolio covering the three aforementioned categories. Within and among these categories, the evaluation committee will look at shared components or potential complementarities among the projects to identify a clear added value for the development of synergies and collaborations among the projects in the portfolio in order to maximise the overall impact on the expected outcomes and impacts of the Challenge. Shared components or complementarities could be related to aspects such as the materials selection (e.g. two projects use the same materials for different applications), the components integration into devices and systems (e.g. two projects develop different components that could be integrated in one system or for a unique application), the proposed processes (two projects use the same process with different materials), the application ranges, the monitoring and control strategies.

Starting from the highest ranked proposal, a portfolio of proposals will be selected based on shared components/complementarities, while ensuring diversity among the selected proposals

and coverage of the three categories. This implies that if the evaluation committee considers that a highly ranked proposal does not have a shared component/complementarity with other proposals, it will not be selected for the portfolio. To ensure diversification, proposals which the evaluation committee considers to be very similar to a proposal already included in the portfolio will not be selected. Consequently, this means that the projects selected for funding after the second step is expected to differ from the ranking list established from the first step (score based ranking after assessment of each proposal separately).

The following table summarises the portfolio building approach with potential shared components and complementarities.

Categories	Elements for portfolio building	
	Complementarities	Shared components
<ul style="list-style-type: none"> • Cold energy generation • Storage/transport • Cold management, end-uses, monitoring/fault evaluation 	<ul style="list-style-type: none"> • Application range • Temperature level • Processes and technology proposed 	<ul style="list-style-type: none"> • Materials selected • Components and devices integration • Cold chain integration

4 Implementation of the Challenge portfolio

Once funded, projects will be expected to work collectively during the implementation of their projects under the guidance of an EIC Programme Manager. The proposals should allocate a specific Work Package and budget for portfolio activities. This section summarises some of the key aspects of this pro-active management which applicants should take into account in preparing their proposals.

Proposal preparation and Grant negotiations

Applicants may be requested to make amendments to their proposed project in order to take into enhance the portfolio. Such changes may for instance include additional tasks to undertake common/ joint activities (workshops, data exchanges, joint research, etc) with other projects in the portfolio.

Based on first experience, it is advised to foresee in your proposal a dedicated work package for portfolio activities and to allocate at least 10 person-months (see below for the purpose and examples of such activities. You may propose concrete activities or remain generic in your description).

If you fail to do this during proposal time, your proposal will not be scored lower during the evaluation, but in case your proposal is selected for grant agreement preparation, you will be requested to add the portfolio work package to your grant agreement. Please be aware that in that case the maximum grant you receive will not change, and you will need to find the resources for portfolio activities within the foreseen project budget

Challenge portfolio roadmap/ strategy plan

This Challenge aims at:

- Enhancing the opportunities of novel clean cooling technologies and processes proposed in the individual projects to achieve their expected targets, thanks to their active participation in the portfolio activities; ensuring that portfolio members can access an higher number of **relevant applications and market segments**, and can explore key partnerships along the whole cold value chain, from generation to transport to final use, and within the whole innovation ecosystem in the specific technological areas of intervention;
- Enhancing the **commercialisation potential** of the portfolio individual project, as a result of its active participation in the portfolio activities: ensuring that portfolio members, can access the right partners to explore key partnerships

In order to accomplish the above the Programme Manager needs to develop and agree on a strategy plan for the Clean Cooling portfolio with the portfolio projects.

Portfolio Strategy Plan

Following the selection of a proposals to be funded under the Challenge, the Programme Manager will work with the selected projects to investigate and possibly develop a common strategy plan/roadmap for the Challenge. This plan will integrate the activities and milestones of the individual projects into a shared set of specific objectives and activities across and beyond the projects. The roadmap serves as a common basis for the project portfolio and may affect the project implementation - including possible adjustments, reorientations, or additional support to projects. The roadmap will be updated in light of emerging results, new opportunities, difficulties emerged during the implementation. The objectives can be revised, for instance based on projects' unexpected achievements, new technology trends, external inputs (other projects, new calls...).

In particular, the Challenge roadmap/ strategy plan will include activities on the transition to innovation and commercialisation, to stimulate business and new market opportunities and to compare different solutions for various final applications. These activities may be reinforced

during the implementation with additional funding and expertise through pro-active management.

Non-exhaustive examples of activities towards the above-mentioned aims are:

- Contributing to understand better/improve the current regulatory framework
- Effectively communicate of any key outcome of the research work of the portfolio members collectively and/or an individual project, to early stage private and corporate investors focused on the same field. Such communication might also be addressed to the general public to increase social acceptance for proposed solutions, or to other researchers and stakeholders through common dissemination activities at scientific conferences or trade-fairs.
- Market analysis: Map the targeted players in a market and exchange the market research analysis results with other the portfolio projects to identify specific players with which the entire portfolio can establish partnership(s) of much higher impact as opposed to that of the individual project.
- Discussions on IP, licensing and business models and commercialisation strategy
- Providing access to Open Innovation Test Beds and other research infrastructure
- Standardisation activities
- Providing access to new markets through multipliers like Enterprise Europe Network

These tasks require the active participation of portfolio members to a series of meetings called for and steered by the Programme Manager. Portfolio projects will be expected to exchange information on the proposed research methodologies, experimental tests, techno-economic input data and relevant results achieved, in order to collectively use the available resources. This exchange of data between portfolio members can enhance the potential of individual projects, use of results originating from the analysis of common databases, as well as their chances to establish key partnerships. The exchange of information for the purpose of EIC portfolio activities will fall under the conditions and non-disclosure obligations as specified in the EIC Work Programme 2023 (Annex 6, section 2).

Tools through which projects can receive additional support

Projects in the portfolio may be offered additional support, either individually or collectively, in order to reinforce portfolio activities or explore the transition to innovation. Such additional support includes:

- Booster grants of up to €50k (see Annex 5 of the EIC Work Programme)
- Access to additional EIC Business Acceleration Services (see https://eic.ec.europa.eu/eic-funding-opportunities/business-acceleration-services_en)
- Access to the Fast Track to the EIC Accelerator, which would follow a project review (see Annex 3 of the EIC Work Programme)

- The possibility to apply for EIC Transition if your Pathfinder project resulted in an experimental proof of concept (TRL 3), or a technology validated in the lab (TRL 4)
- Access to the EIC Market Place, once operational, to connect with innovators, investors and other selected partners
- Interactions with relevant projects and initiatives outside the portfolio, including other EU funding initiatives as well as those supported by national, regional or other international bodies.