OPRACELL

Optimisation of Refrigerating Panels for small Environments using Peltier CELLs

Dissemination Plan — English version

Cohesion Italy 21-27 Calabria — Co-funded by the European Union

03/11/2025 – 31/10/2027 (24 months)

Unofficial translation of the Italian Dissemination Plan. In case of discrepancies, the Italian original prevails.

1. Regional Action

Action 1.1.1 – Support for research, development and innovation projects, also in collaboration with research organisations, in the priority Areas and trajectories of the S3

This Action promotes research, development and innovation by companies in the Areas and development trajectories of the Smart Specialisation Strategy (S3) 2021-2027, adopting a broad definition of innovation that considers both technological aspects and social benefits. It supports business innovation, collaborative activities and knowledge exchange between companies of different sizes and between companies and Research Organisations.

- Promoting innovation projects that include industrial research and experimental development.
- Supporting collaborative research and innovation between companies of different sizes and with regional, national and foreign Research Organisations.
- Strengthening research and technology infrastructures, only in close partnership with the business sector.
- Developing national, European and international networks, including synergies with Horizon 2020 / Horizon Europe (Seal of Excellence).
- Supporting innovation in the production system through industrial validation, industrialisation projects and innovation services.

2. The project

2.1 Overview

The project aims to develop and refine an innovative thermoelectric cooling system, offering efficient, flexible and sustainable solutions where conventional technologies are inadequate. Through a structured research and development path, it will create a modular and adaptable system for both mobile environments, such as vehicles and means of transport, and static spaces with structural constraints or specific air-conditioning needs.

A prototype multifunction panel has already been successfully tested in a controlled environment, showing good cooling capacity and operational stability. The project starts with a comparative analysis of the latest Peltier cells on the market, in order to select those that outperform the traditional models used in the existing prototype. The selected cells will then be experimentally characterised under different operating conditions.

The design of the panels and their control systems will be accompanied by prototypes with different configurations for specific demonstrators. These solutions will be validated through energy simulations and thermal analyses on representative case studies.

The prototypes will then be tested at full scale — in a glass room with a cooled ceiling and in a camper van — to verify their performance and optimise the system by comparing experimental data with simulations. Energy efficiency, ease of installation and maintenance, and operational reliability in critical conditions are priority objectives. Advanced technologies and smart control strategies will ensure an optimal balance between thermal comfort and energy consumption.

2.2 State of the art

Thermoelectric cooling is an evolving technology that uses the Peltier effect to transfer heat by passing an electric current through semiconductor materials. Compared with traditional refrigeration systems, such as heat pumps or vapour-compression cycles, thermoelectric systems offer advantages such as no moving parts, greater reliability, silent operation, compactness and the possibility of miniaturisation. However, they still have significant limitations in terms of energy efficiency and large-scale cooling capacity.

In recent years, interest in alternative cooling solutions with low environmental impact and high flexibility has driven the research and development of new generations of Peltier cells. The latest cells use advanced materials, such as optimised bismuth telluride alloys or nanostructured semiconductors, which improve thermoelectric performance, in particular the figure of merit ZT, a key parameter for assessing the efficiency of thermoelectric devices. At the same time, hybrid construction architectures and solutions integrated with active thermal control systems are being explored. Despite this progress, the use of Peltier cells in real room-cooling applications is still limited by low efficiency and non-optimal heat dissipation. In particular, managing the heat on the hot side of the cell is a critical challenge: failing to remove it effectively can drastically reduce performance. For this reason, coupling with passive or active cooling systems, such as heat-pipe heat sinks, air or liquid radiators, is essential to ensure stable and efficient operation.

In terms of applications, promising developments can be seen in the use of Peltier cells in portable or mobile systems, such as medical devices, technical clothing and small household appliances. However, their use in buildings or vehicles, where space, noise and energy consumption constraints are critical, is still a frontier.

This is the context of the OPRACELL project, which aims to overcome existing barriers with an integrated, modular approach. The idea of developing multifunctional cooling panels able to adapt to different application scenarios, including mobile environments such as camper vans and static spaces with architectural constraints, is a significant innovation. The technical and scientific literature shows growing interest in customisable and adaptive solutions, including the use of intelligent control systems and distributed sensors, which allow fine temperature regulation and real-time monitoring of operating conditions.

Finally, the OPRACELL approach, which combines numerical simulations, laboratory tests and experiments on real prototypes, is in line with the most effective methodologies currently used in the sector to validate performance and optimise the design of thermal systems. In particular, the use of controlled test environments (e.g. glass rooms, instrumented mobile environments) allows an in-depth assessment of thermal dynamics and perceived comfort, two key parameters for validating emerging technologies.

2.3 Objectives

The project addresses situations where traditional cooling solutions, such as heat pumps, are limited or impractical: independent work cabins inside large spaces, parked vehicles, covered bus stops, factories, warehouses, railway stations and airports. Heat pumps require complex, expensive infrastructure and, when oversized, work at partial load with reduced efficiency. The project objectives aim to fill this gap with an innovative, efficient solution based on thermoelectric technology.

Develop a tailor-made solution

A flexible thermoelectric cooling system, easily adaptable to mobile applications, small spaces and settings where air cooling cannot be used; highly scalable and easy to install and extend.

Maximise efficiency

A target of +20% energy efficiency compared with the current product thanks to the new devices, and a final target of +25% through innovative monitoring and control systems that cool only where strictly required.

Ensure reliability and durability

Efficient operation even in adverse environmental conditions and with high recirculating air flows.

Simplify installation and maintenance

A practical and convenient solution for a wide range of applications.

Environmental sustainability

A low-impact cooling system that minimises the use of natural resources and greenhouse gas emissions.

2.4 Professionals involved

- Project manager: Eng. Giuseppe Camarca
- Scientific manager: Prof. Natale Arcuri

3. Work Packages

WP1 – Study of the state of the art and of the characteristics of the Peltier cells available on the market

- Type: Industrial Research
- Lead: University of Calabria
- Other participants: Z Lab S.r.l. (Company)
- Period: November – January

This Work Package is the preliminary research and technology analysis phase, aimed at identifying the most innovative thermoelectric solutions available on the market. It involves an in-depth study of the state of the art of Peltier cells, with particular attention to new generations of devices offering greater energy efficiency, better cooling performance and greater operational reliability.

The analysis will include collecting and evaluating the technical documentation, performance data and construction specifications of the main commercial products. The different cooling architectures associated with the cells (air-air, air-water, water-water) will also be examined in order to understand their advantages, application limits and possible integration into the refrigerating panels developed by the project.

At the same time, research will be carried out on emerging applications of Peltier technology in the industrial, civil and mobility sectors, identifying critical issues, risk factors and development opportunities.

Objectives

- Identify the most innovative and high-performing Peltier cells.
- Analyse the different cooling technologies available.
- Identify the critical factors affecting efficiency and lifetime.
- Provide the technical basis for the following design activities.

Deliverables

- Technical report on the state of the art of Peltier cells.
- Comparative analysis of the technologies identified.
- Recommendations for selecting the solutions to be developed in the following WPs.

Roles and tasks of the participants

- University of Calabria: analyses, through documentary research, the technological progress of the Peltier cells on the market.
- Z Lab S.r.l.: provides electronics consultancy in analysing the optimal configuration and use of the hardware identified.

Tasks

- A.1.1 – Evaluation of the characteristics of innovative Peltier cells according to their technology and cooling system (air-air, air-water, water-water).

- A.1.2 – Market research on the best-performing commercial Peltier cells.
- A.1.3 – State of the art of further applications based on Peltier cells and identification of the related issues.
- A.1.4 – Analysis of the factors affecting the efficiency and lifetime of Peltier cells and study of their characteristics to optimise their use.

Expected results

D1.1 – Report documenting the technical characteristics, performance and operating specifications of the different Peltier cell options available on the market for the various applications, in order to understand the available solutions and guide the subsequent design decisions.

WP2 – Experimental characterisation of Peltier cells and performance analysis

- Type: Experimental Development
- Lead: Z Lab S.r.l.
- Other participants: University of Calabria (Research organisation), FD S.r.l. (Company), Vedlab s.n.c. di Vitale e Fazio (Company)
- Period: January – April

This WP is dedicated to the experimental validation of the solutions identified in WP1. Laboratory activities will analyse the thermoelectric performance of both the current multifunction panel and the newly selected cells.

An experimental platform will be set up, consisting of power supply systems, sensors, measuring instruments and monitoring devices, to acquire data under different operating conditions. The tests will assess parameters such as cooling capacity, energy efficiency, thermal stability, reliability and behaviour under varying thermal loads.

Particular attention will be paid to the analysis of heat dissipation systems, a crucial element for maximising the performance of Peltier cells.

Objectives

- Measure and compare the performance of the different cells.
- Evaluate the efficiency of the associated cooling systems.
- Define the design parameters for building the prototypes.
- Identify the most promising configurations.

Deliverables

- Experimental characterisation report.
- Guidelines for selecting the cells to be used in the project.
- Evidence of an expected performance improvement of at least 20%.

Roles and tasks of the participants

- Z Lab S.r.l.: together with FD S.r.l., sets up the control and monitoring electronics to carry out a series of experimental studies on the current multifunction panel.
- University of Calabria: sets up the solutions identified in WP1.
- FD S.r.l.: together with Z Lab S.r.l., sets up the control and monitoring electronics for the experimental studies on the current multifunction panel.
- Vedlab s.n.c. di Vitale e Fazio: supports the prototyping of the systems to be characterised.

Tasks

- A.2.1 – Set-up of the instrumentation for powering the Peltier cells and monitoring their performance.
- A.2.2 – Experimental characterisation of the current multifunction panel and of the identified Peltier cells, in the laboratory, under different operating conditions.
- A.2.3 – Evaluation of the thermoelectric performance of the current multifunction panel and of the Peltier cells with different cooling systems.

Expected results

D2.1 – Report on the characterisation of the Peltier cells: identification and installation of the necessary instrumentation and analysis of the tests carried out.

WP3 – Integrated design of the refrigerating panels and of the data acquisition and control system

- Type: Industrial Research
- Lead: Z Lab S.r.l. (Company)
- Other participants: University of Calabria (Research organisation), FD S.r.l. (Company), Vedlab s.n.c. di Vitale e Fazio (Company)
- Period: March – August

In this phase the new refrigerating panels will be designed on the basis of the technologies validated in the previous WPs. The activity will include defining the mechanical layout, the construction layers, the arrangement of the Peltier cells and the choice of insulating materials.

At the same time, the electronic architecture of the monitoring and control system will be developed. Based on IoT technologies, it will acquire data in real time and optimise the operation of the cooling system.

Control algorithms and strategies will also be studied to reduce energy consumption and improve the overall efficiency of the system.

Objectives

- Define the optimal configuration of the refrigerating panels.
- Develop the monitoring and control system.
- Optimise the operating parameters to maximise energy efficiency.
- Ensure the scalability and replicability of the solution.

Deliverables

- Detailed design of the refrigerating panels.
- Design of the data acquisition and control system.
- Design and optimisation report.
- Expected additional performance increase of 5%.

Roles and tasks of the participants

- Z Lab S.r.l.: shares the current electronic power supply system of the multifunction panel.
- University of Calabria: supports the evaluation of the thermal insulation to be used.
- FD S.r.l.: starts designing the IoT-based control and monitoring system of the individual multifunction panel.
- Vedlab s.n.c. di Vitale e Fazio: handles the prototyping of the new multifunction panels.

Tasks

- A.3.1 – Design of different types of Peltier-cell refrigerating panels.
- A.3.2 – Design of the acquisition and control system.
- A.3.3 – Optimisation of the control parameters to maximise the energy efficiency of the panel.

Expected results

D3.1 – Design and optimisation report of the cooling and control system.

WP4 – Thermodynamic analysis of case studies using Peltier-cell refrigerated panels

- Type: Industrial Research
- Lead: University of Calabria
- Other participants: Z Lab S.r.l., FD S.r.l. (Company), Vedlab s.n.c. di Vitale e Fazio (Company)
- Period: July – December

This WP aims to validate the designed solutions through numerical simulations and thermodynamic modelling of real applications. Energy models will be developed for two representative case studies: a refrigerated camper van and a glass room located inside a large space.

The simulations will make it possible to study the thermal behaviour of the spaces, estimate energy needs, assess comfort conditions and identify the optimal configuration of the refrigerating panels.

The results will also be used to build a predictive model to guide the subsequent prototyping activities.

Objectives

- Simulate the thermal behaviour of the selected applications.
- Determine energy consumption and expected performance.
- Identify the most efficient configurations.

- Support the design of the real prototypes.

Deliverables

- Thermal models of the case studies.
- Energy simulation report.
- Expected efficiency increase of at least 25% compared with the current solution.

Roles and tasks of the participants

- University of Calabria: starting from the analyses and results of the previous WPs, simulates different fields of application of the multifunction panel in order to assess potential further applications, in industry and elsewhere.
- Z Lab S.r.l., FD S.r.l. and Vedlab s.n.c. di Vitale e Fazio: support the University of Calabria in identifying the models/systems to be simulated and in assessing how the electronic control system could affect the simulations, so as to make them as realistic as possible.

Tasks

- A.4.1 – Modelling of the case studies with energy simulation software.
- A.4.2 – Thermal analysis of the identified systems to find the optimal configurations and the areas for improvement.
- A.4.3 – Optimal choice of the panel to improve heat transfer and cooling uniformity.
- A.4.4 – Analysis and comparison between expected future results and current results.

Expected results

D4.1 – Report on the modelling and on the results of the thermal simulations of the case studies.

WP5 – Construction of prototypes using the designed refrigerating panels and implementation of the data acquisition and control system

- Type: Industrial Research – Experimental Development
- Lead: Z Lab S.r.l.
- Other participants: University of Calabria (Research organisation), FD S.r.l. (Company), Vedlab s.n.c. di Vitale e Fazio (Company)
- Period: November – June

In this WP the prototypes designed in the previous phases will be physically built: an experimental camper van equipped with a Peltier-cell cooling system, and a glass room cooled by an innovative cooling ceiling.

Both prototypes will be equipped with monitoring, data acquisition and automatic control systems, able to collect information on their operation and intelligently manage the operating conditions.

During construction, any issues arising from the actual integration of the components will be addressed and alternative technical solutions will be developed where necessary.

Objectives

- Build working prototypes.
- Integrate the control and monitoring system.
- Verify compliance with the design specifications.
- Prepare the systems for the testing activities.

Deliverables

- Two complete and operational prototypes.
- Installed data acquisition system.
- Construction and preliminary testing report.

Roles and tasks of the participants

- Z Lab S.r.l.: makes its facilities available for building the prototype.
- University of Calabria: provides support throughout the prototyping phase to ensure that it reflects what was simulated and studied in the previous WPs.
- FD S.r.l.: builds what was designed in WP3 for the monitoring and control of the individual panel, and also implements a control unit for managing and monitoring the system.
- Vedlab s.n.c. di Vitale e Fazio: installs any mechanical parts needed to implement the project.

Tasks

- A.5.1 – Construction of the refrigerated glass room with an innovative ceiling connected to the Peltier cells and implementation of the acquisition and control system.
- A.5.2 – Construction of the refrigerated camper van model using Peltier cells and implementation of the data acquisition and control system.

Expected results

D5.1 – Report describing how the two prototypes were built, the results obtained and the control system.

WP6 – Analysis of the experimental results obtained to optimise the technical solutions adopted, and their implementation

- Type: Experimental Development
- Lead: Z Lab S.r.l.
- Other participants: University of Calabria, FD S.r.l. (Company), Vedlab s.n.c. di Vitale e Fazio (Company)
- Period: May – October

This WP is dedicated to the final validation of the technologies developed, through the analysis of the data collected while testing the prototypes.

The results obtained will be compared with those predicted by the numerical models developed in WP4, in order to validate and calibrate the thermal models. This will make it possible to build a

reliable digital twin of the panel-environment system.

Possible corrective actions and improvements will also be identified, implemented and then tested to verify their effectiveness.

Objectives

- Validate the simulation models.
- Assess energy performance and thermo-hygrometric comfort.
- Identify and implement improvements.
- Define the final performance of the system.

Deliverables

- Experimental validation report.
- Calibrated thermal model (Digital Twin).
- Final technical specifications of the systems developed.

Roles and tasks of the participants

- Z Lab S.r.l. and University of Calabria: work together to collect, analyse and validate the experimental results of the previous WPs.
- FD S.r.l. and Vedlab s.n.c. di Vitale e Fazio: provide support if software improvements to the monitoring and control system, or mechanical improvements to the structures already built, are needed.

Tasks

- A.6.1 – Detailed analysis of the experimental data obtained for the two prototypes.
- A.6.2 – Comparison of the experimental results with those obtained when simulating the thermal model.
- A.6.3 – Validation of the thermal model by comparison with the experimental data, to calibrate suitable parameters so that it describes the physical phenomenon under real operating conditions.
- A.6.4 – Identification of improvements that increase the efficiency of the two systems.
- A.6.5 – Appropriate modifications to the prototype based on the results obtained.
- A.6.6 – Experimental tests under different operating conditions to assess the effectiveness of the improvements in terms of system performance.
- A.6.7 – Description of the two systems in terms of construction and performance as internal and external boundary conditions vary.

Expected results

D6.1 – Comparative assessment of two systems: construction, energy performance and thermal comfort as a function of the boundary conditions.

WP7 – Dissemination and communication activities

- Type: Experimental Development
- Lead: University of Calabria
- Other participants: Z Lab S.r.l., FD S.r.l., Vedlab s.n.c. di Vitale e Fazio (Company)
- Period: November 2025 – October 2027

This Work Package covers all the cross-cutting activities of coordination, management and dissemination of the project results.

A communication plan will be prepared to disseminate the knowledge generated as widely as possible, involving the scientific community, companies, professionals and sector stakeholders.

Activities will include creating the project website, publishing scientific articles, organising workshops and seminars, and taking part in national and international events.

Particular attention will be paid to Open Access policies and to disseminating the results in at least three EU Member States or EEA countries, in accordance with the GBER Regulation.

Objectives

- Ensure effective project coordination.
- Disseminate the results to the scientific and industrial community.
- Foster the technology transfer of the solutions developed.
- Ensure the visibility of the project at national and European level.

Deliverables

- Communication plan.
- Project website.
- At least 2 dissemination events.
- Scientific publications and informative material.
- Final report on dissemination activities.

Roles and tasks of the participants

- University of Calabria: coordinates scientific dissemination activities and the publication of the research results.
- Z Lab S.r.l., FD S.r.l. and Vedlab s.n.c. di Vitale e Fazio: take part in communication activities, dissemination events and the production of informative material.

Tasks

- A.7.1 – Ensure that the project is well structured, with all activities planned so as to meet the established timeline and budget.
- A.7.2 – Monitor the progress of project activities and compliance with the technical and financial planning.
- A.7.3 – Prepare and publish scientific articles in specialised journals, to disseminate the project results to the scientific community, contribute to advancing knowledge in the sector and increase the project's visibility.

- A.7.4 – Plan and organise events such as conferences, workshops and seminars to present the project results.

Expected results

D7.1 – Publication of scientific articles, creation of the project website, organisation of 2 dissemination events (workshops/seminars).

4. Milestones

- Progress report I (SAL I) – 03/05/2026
- Progress report II (SAL II) – 03/11/2026
- Progress report III (SAL III) – 03/05/2027
- Final balance (SALDO) – 31/10/2027

5. Partners

Z Lab S.r.l. (Lead company)

['Engineering consultancy that brings aeronautical know-how to less advanced sectors, with 85 employees (78 graduates, 61 in Engineering). It specialises in RAMS analyses (Reliability, Availability, Maintainability and Safety) and Verification & Validation, and its Acoustics Laboratory is ACCREDIA accredited (LAB no. 1416) under UNI CEI EN ISO/IEC 17025.', 'As lead partner of the temporary association, Z Lab ensures that all project phases run on time and meet their objectives, coordinates dissemination, provides electronics consultancy, contributes to control and monitoring electronics and validates experimental results.']

FD S.r.l. (Company)

['ICT company active since 2012, based in San Giovanni in Fiore (CS), ISO 9001 certified. It designs and produces custom electronic boards in-house and integrates embedded AI, together with data organisation (knowledge graphs, RAG, semantic search) and AI agents.', 'In the project it designs and builds the IoT-based control and monitoring electronics of the panels and the control unit of the system.']

Vedlab s.n.c. di Vitale e Fazio (Company)

['Rapid prototyping for architecture and design: models, prototypes, mechanical design, 3D scanning and modelling, reverse engineering and finished products, using additive manufacturing, CNC milling and laser cutting. Among the first companies in southern Italy to offer these services.', 'In the project it supports the prototyping of the panels and installs the mechanical parts.']

University of Calabria — DIMEG (Research organisation)

['Public university established in 1968. Its Department of Mechanical, Energy and Management Engineering (DIMEG) is a national and international reference for research and technology transfer; its Applied Physics group specialises in applied thermodynamics, heat transfer, energy conversion, numerical simulation and experimental analysis.', 'In the project DIMEG studies the state of the art of Peltier cells, simulates and optimises the panels in different applications, chooses the thermal insulation, carries out experimental studies and leads scientific dissemination.']

Specialist consultants

NET S.c.a.r.l.

Manager of the "Environment and Natural Risks" Innovation Hub, connecting companies, universities and research centres (Crotone and Reggio Calabria).

CReAI — Centro Ricerche e Attività Industriali S.r.l.

Engineering company with over thirty years of experience in industrial research, FEM and CFD analyses, reverse engineering and industrialisation.

Eng. Alessandro Bonavita

Electronics engineer with over twenty years of experience; coordinates the technical activities on the Peltier cell management systems and multifunction panels.

Website created as part of the information and communication activities pursuant to Articles 46-48 and Annex X of Regulation (EU) 2021/1060.