

# The National Competence Centre in HPC – Supporting Science and Business

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## Abstract

High-performance computing (HPC) has become a foundation for cutting-edge discovery and industrial innovation in Europe. The European High-Performance Computing Joint Undertaking (EuroHPC JU) funds and coordinates a continent-wide ecosystem of world-class systems, HPC software, skills, and services. Within this ecosystem, the National Competence Centre in HPC (NCC) in Poland consolidates the potential of six leading computing centers to serve researchers, enterprises - including SMEs - and public administration. This article introduces the strategic rationale of EuroHPC and the EuroCC program, explains how the Polish NCC is organized and funded, details its service portfolio, and documents representative scientific and industrial use cases. We conclude with forward-looking remarks on data-intensive research, and the role of competence centers in ensuring that compute power translates into measurable impact.

## Keywords:

Supercomputers, HPC, EuroCC, EuroHPC JU, NCC

# 1. Introduction

HPC has evolved from a niche technology into a general-purpose infrastructure for science, engineering and the data economy. Its relevance is evident in exascale-class systems, heterogeneous nodes that integrate GPUs and novel accelerators, and programming environments that increasingly couple simulation, data analytics, and AI. Europe's response is the EuroHPC JU, a long-term partnership bringing together 32 European countries (EU members and associated states), the European Commission, and private organizations to align investment in supercomputers, software, applications and skills, thereby strengthening technological sovereignty and industrial competitiveness [1, 2]. A critical pillar of the EuroHPC JU's strategy is the EuroCC project, a coordinated network of National Competence Centres in HPC that bridge research, industry and public stakeholders by providing expertise, training, access and consultancy [3].

In Poland, the National Competence Centre in HPC (NCC) operates as an inter-university initiative within the EuroCC framework, federating six supercomputing centres under PLGrid Consortium, so that users can find services, resources and expert support through a single, consistent entry point. This article expands on Poland's NCC mandate, partners and services, explains access paths to national resources, and surveys scientific and industrial use cases delivered with NCC support. The aim is to provide an overview of how a competence-center model converts HPC capacity into knowledge, productivity, and innovation.

## 2. NCC model

The concept of the National Competence Centre in HPC (NCC) originates from the EuroHPC Joint Undertaking (EuroHPC JU) – a legal and financial entity established in 2017 to develop, implement, and expand a European network of world-class supercomputers [4]. High-performance computing (HPC) infrastructure supports a wide range of computational challenges - from solving complex equations and running large-scale simulations to processing vast datasets and training AI models - enabling advances in cutting-edge technologies. These resources are available not only to the scientific community but also to businesses, particularly small and medium-sized enterprises, as well as public sector institutions.

In Poland, the development of supercomputing infrastructure is funded by the National Centre for Research and Development (NCBR) with the support of the Ministry of Science and Higher Education.

Beyond infrastructure development, EuroHPC JU

focuses on education and dissemination activities. This is the primary objective of the ongoing EuroCC2 project (National Competence Centres in HPC in the framework of EuroHPC Phase 2) and its predecessor, EuroCC [5]. Both initiatives are designed to strengthen the EuroHPC JU by fostering the exchange of specialist knowledge, expertise, and best practices across Europe.

Each participating country has established a National Competence Centre in HPC, serving as a hub that consolidates the potential of local supercomputing centers and facilitates access to services for academia, industry, and the public sector. Importantly, NCCs also provide access pathways to pan-European EuroHPC JU supercomputing systems. Through these centers, users benefit not only from computing power and dedicated software but also from expert support provided by both national and international HPC centres.

A crucial element of EuroCC2 (and the earlier EuroCC project) is the transfer of knowledge related to high-performance computing, cooperation, and best practices. These efforts aim to enhance service delivery in areas such as large-scale computations, big data processing, and artificial intelligence across Europe.

## 3. The Polish NCC: Partners, mission, and governance

In Poland, the National Competence Centre in HPC (NCC) has been established as a collaborative initiative integrating six major high-performance computing centers, which collectively form the PLGrid Consortium [6] (Figure 1):

- ▶ **ACK Cyfronet** – Academic Computer Centre CYFRONET of the AGH University, (Kraków),
- ▶ **CI TASK** – Centre of Informatics Tricity Academic Supercomputer and Network (Gdańsk),
- ▶ **WCSS** – Wrocław Centre for Networking and Supercomputing (Wrocław),
- ▶ **PCSS** – Poznan Supercomputing and Networking Center (Poznań),
- ▶ **ICM** – Interdisciplinary Centre for Mathematical and Computational Modelling of The University of Warsaw (Warsaw),
- ▶ **NCBJ** – National Centre for Nuclear Research (Otwock).

Its mission is to promote knowledge about supercomputers and HPC technologies, provide user training, ensure access to computing resources, and deliver expert support for researchers, businesses and the public sector across HPC, HPDA (High-Performance Data Analytics) and AI (Figure 2).

## 4. National Infrastructure

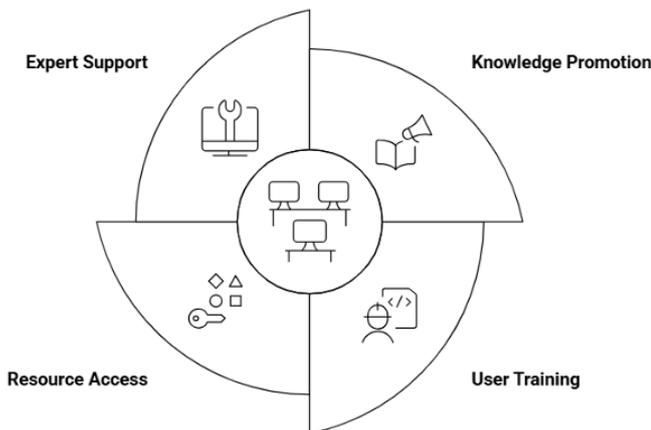
Currently, users can access several Polish supercomputers hosted by the six participating centers. These include:

- ▶ Helios and Athena at Cyfronet AGH, Kraków,
- ▶ Proxima and Altair at PCSS, Poznań,
- ▶ Kraken and Tryton Plus at CI TASK, Gdańsk,
- ▶ LEM and BEM2 at WCSS, Wrocław,
- ▶ Okeanos at ICM, Warsaw,
- ▶ The HPC cluster operated by NCBJ, Otwock.



**Figure 1:** Map of Polish supercomputing centers

Funding for national infrastructure and services has historically combined national instruments (e.g. NCBR and ministerial programs) with European initiatives that supported PLGrid’s emergence and evolution [7, 8]. In the PLGrid federation, each center contributes hardware, software stacks, domain expertise and local user communities while adhering to common access and identity-management mechanisms. The competence-center layer adds coordinated training, outreach, industrial liaison and expert consultancy to ensure that compute capacity translates into outcomes.



**Figure 2:** Summary of NCC’s tasks

This consortium-based approach leverages the strengths of six institutions under unified governance, providing flexibility and scale.



**Figure 3:** Polish supercomputers on the TOP500 list. Source: <https://top500.org/>, June 2025

Access to Polish supercomputers is coordinated through the PLGrid Portal [6], which integrates resources from all six centers and provides a unified application pathway. This enables researchers to apply for computing time for simulations, modeling, and use of specialized scientific software. Academic users can submit applications for free computing grants via the PLGrid access portal, with grant activation occurring within an hour of submission. The PLGrid portal, already serving over 11,000 active users, also provides access to the Polish share of the LUMI supercomputer (Large Unified Modern Infrastructure).

The National Competence Centre in HPC facilitates access, not only to national computing resources, but also to European infrastructure, including one of EuroHPC JU’s flagship systems - the LUMI supercomputer [9], located in Kajaani, Finland. LUMI was built by a consortium of 10 European countries, including Poland.

The NCC’s service portfolio also includes solutions for data storage, management, and processing, cloud services, as well as AI and machine learning technologies. As a central contact point and expert hub, NCC, on the one hand, enables access to Polish and European supercomputers, but also conveys the knowledge necessary to use this infrastructure effectively.

## 5. Training and skills development

As part of its knowledge-sharing mission, the National Competence Centre in HPC offers free-of-charge, systematic training and skills development for researchers, industry representatives, and public sector users. These include workshops, courses, webinars, and training programs tailored to both beginners and experienced users. The training curriculum covers essential skills for operating HPC infrastructure and performing large-scale computations using advanced scientific software for modeling, simulation, and data analysis. In line with the EuroCC education strategy, which emphasizes multi-level curricula and hands-on formats [10–12], NCC Poland has implemented an extensive training program. Training announcements and materials from past sessions are available at <https://cc.eurohpc.pl/> under the "Trainings" section [13] and are regularly published on NCC's social media channels (LinkedIn, Facebook, X, Bluesky, Youtube) [14].

Over the course of the project, more than 80 training events were organized, representing a wide spectrum of topics and formats:

- ▶ Introductory training for new HPC users. A recurring series of courses introduced participants to the Linux command line, Bash shell, and basic HPC usage. These sessions were designed as on-ramp training, enabling first-time users to access and utilize the national supercomputing infrastructure confidently.
- ▶ Programming and parallel computing. Advanced workshops covered C++ for scientific computing, MPI programming, workflow management with Slurm, application development in HPC environments, and specialized deployment of software packages such as SIESTA. These activities addressed the core computational competencies required for efficient scientific research at scale.
- ▶ GPU computing and AI-focused training. A major emphasis was placed on GPU acceleration and artificial intelligence integration. This included GPU bootcamps and hackathons (e.g., N-Ways to GPU Programming Bootcamp, Multi-GPU Programming Bootcamp, Profiling AI Software Bootcamp), as well as workshops on CUDA, oneAPI, AMD GPU optimisation, and machine learning workflows in HPC environments. Notably, NCC Poland organized AI for Science Bootcamps and specialized events on Large Language Models (LLMs), addressing emerging needs in scientific AI and data-intensive research.
- ▶ LUMI training. Events such as LUMI Day Poland 2023 and comprehensive LUMI training courses introduced participants to the EuroHPC JU pre-exascale flagship system, with a focus on efficient utilization of

GPU-accelerated resources and programming models adapted to heterogeneous architectures.

This training portfolio reflects NCC Poland's strategic commitment to building a robust, multi-stage learning path: from initial exposure through advanced technical skills to domain-focused and industry-relevant applications. It aligns well with scholarly findings which emphasize that effective HPC training requires layered education, practical engagement, and alignment with industrial needs [10–12].

## 6. Proof-of-Concepts (PoCs) and SME engagement

A core pillar of the EuroHPC JU strategy is ensuring that high-performance computing technologies - traditionally concentrated in academia and large research laboratories - are made accessible and usable for small and medium-sized enterprises (SMEs). In this context, proof-of-concept (PoC) projects are an essential instrument, allowing SMEs and public stakeholders to test and validate HPC-enabled workflows in a controlled, low-risk environment before committing significant financial or organizational resources [11].

The PoC model provides a structured framework in which an enterprise or research partner collaborates with the National Competence Centre in HPC to (i) identify computational bottlenecks, (ii) assess feasibility of migrating existing workflows to HPC platforms, (iii) benchmark performance on heterogeneous architectures (CPU/GPU clusters, cloud-HPC hybrids), and (iv) quantify the expected return on investment (ROI) (Figure 4).

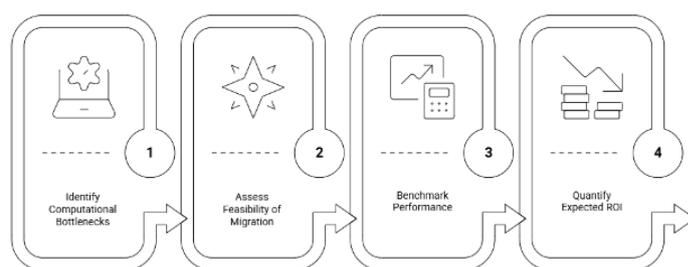


Figure 4: The PoC model - process flow

This methodology reflects best practices highlighted in recent studies of digital transformation in SMEs, which show that competence-center-led assessments combined with mentoring and training significantly accelerate adoption and mitigate perceived risks [11, 12].

Within the HPC paradigm - where simulation, data analytics, and machine learning are integrated - PoCs also play a transformative role in applied science and indus-

try. A 2023 survey of HPC+ applications in medicine illustrates how NCC-mediated PoCs have successfully supported medical image analysis, pediatric dosimetry simulations, and cloud-based decision-support tools, offering both scientific insights and clinically relevant outcomes [15]. These case studies emphasize that short-cycle prototyping, guided by domain experts and HPC consultants, is crucial for translating computational power into tangible value.

The Polish National Competence Centre in HPC mirrors this European approach by implementing PoC projects across multiple domains:

- ▶ In manufacturing, PoCs demonstrate how HPC-enabled computational fluid dynamics (CFD) simulations can optimize aerodynamics and reduce design costs.
- ▶ In pharmaceutical and biomedical research, pilot projects explore AI-accelerated molecular simulations and predictive modeling, highlighting synergies between HPC, HPDA, and machine learning.
- ▶ In energy and environmental sciences, PoCs address renewable-energy integration, grid stability, and climate modeling, offering SMEs tools to evaluate scenarios otherwise unattainable with in-house resources.

Beyond technical validation, PoCs contribute to raising awareness among SMEs about the opportunities that HPC provides. They foster a cultural shift, showing that supercomputing is not reserved for large corporations or academic institutions, but can be an accessible enabler of innovation when accompanied by expert support and targeted funding instruments. Indeed, evaluations of European competence-center networks demonstrate that hands-on pilot projects with measurable business outcomes are the most effective mechanism to convince SMEs to continue engagement after the initial project phase [11, 12].

In this way, NCC Poland's PoC and SME engagement activities are not only aligned with EuroHPC policy but also serve as catalysts for industrial competitiveness, ensuring that public investments in HPC infrastructure translate into measurable socio-economic benefits.

## 7. NCC Poland use cases

HPC is indispensable for solving complex, computation-intensive problems across a diverse range of domains. Globally, common HPC use cases include:

- ▶ Engineering and manufacturing, such as aerodynamic simulations, structural mechanics, computational fluid dynamics (CFD) for product design and

optimization.

- ▶ Life sciences and medicine, including genomics, drug discovery, medical imaging, and precision healthcare.
- ▶ Energy and environment, covering climate and weather modeling, renewable energy optimization, nuclear safety, and ecosystem simulations.
- ▶ Public safety and epidemiology, with agent-based and compartmental models for epidemic forecasting and disaster prediction.
- ▶ Data-intensive AI and machine learning, encompassing large-scale model training, natural language processing, and digital twin simulations.

These categories reflect patterns documented in both scientific literature and European strategic documentation - for instance, a EuroHPC brochure highlights how HPC underlies simulations for digital twins, real-time analytics, and AI-integrated applications across sectors such as healthcare, manufacturing, environment, and agriculture [16, 17].

Below are a few illustrative use cases supported by NCC Poland, exemplifying how national HPC infrastructure enables impactful research:

- ▶ Aerodynamic and Aeroacoustic Analysis of Flow Control Methods – Large-scale CFD simulations of streamlined structures were carried out on the CI TASK supercomputer, enabling reductions in simulation times from months to days and supporting the development of flow control techniques in aerodynamics [18].
- ▶ Numerical Analysis of Vertical Axis Wind Turbines – Simulations of transient airflow around Darrieus-type rotors on the ICM UW supercomputer provided insights into turbulence modeling and rotor efficiency, advancing renewable energy research [19].
- ▶ Preparation of Reference Databases for Nuclear Technologies and Safety – Using the Świerk cluster at NCBJ, researchers generated Direct Numerical Simulation (DNS) datasets for pressurized thermal shock and coolant mixing, producing terabytes of reference data essential for nuclear safety [20].
- ▶ Agent-Based Modeling for COVID-19 Epidemic Spread – Large-scale simulations on the WCSS supercomputer supported epidemic forecasting for entire national populations, providing timely recommendations during the COVID-19 crisis [21].
- ▶ Mortality Prediction and Pathology Detection in Thoracic Imaging – Deep learning methods applied to chest X-rays and CT scans required processing terabytes of medical data on the Rysy cluster at ICM UW, demonstrating how HPC accelerates AI applications in early disease detection [22].

## 7.1. SME use case - Industrial mixer optimization through HPC-enabled CFD simulations

Among the use cases accomplished by NCC Poland, the optimization of large-scale industrial mixers illustrates how supercomputing transforms traditional manufacturing workflows into data-driven design processes. The design and optimization of large-scale industrial mixers - particularly those exceeding  $6m^3$  in volume - poses substantial challenges for manufacturers. Traditional design approaches often fail to capture the complex interactions between fluid dynamics and thermal processes in mixing operations, resulting in suboptimal energy efficiency and extended production cycles. A proof-of-concept project was initiated to address these limitations by applying advanced Computational Fluid Dynamics (CFD) simulations supported by high-performance computing infrastructure.

**Challenge:** A manufacturing company sought to optimize the design of industrial mixing equipment used across multiple sectors, including paints, pharmaceuticals, construction materials, and food production. The primary objectives were to reduce mixing and heating times while minimizing energy consumption. Conventional computational methods were insufficient to model the complex behavior of non-Newtonian fluids under realistic operating conditions, as they could not handle the computational demands of fine-resolution simulations.

**Solution:** In collaboration with the Wrocław Centre for Networking and Supercomputing (WCSS), the project employed HPC resources to perform large-scale CFD simulations. The numerical models incorporated full equations for continuity, momentum, and energy conservation, accounting for the specific rheological properties of industrial fluids. Simulations were executed on computational grids containing at least 70 million elements, utilizing parallel computing across multiple compute nodes. Both commercial software packages (Ansys CFX, Ansys Fluent) and open-source tools (OpenFOAM) were deployed to validate results and ensure robustness.

**Implementation:** HPC infrastructure enabled significantly finer time steps and higher spatial resolution than previously achievable, allowing detailed analysis of thermal and hydraulic boundary layers. This computational capacity was essential for achieving convergence between virtual models and experimental validation data. The technical support provided by WCSS experts facilitated efficient code porting, workflow optimization, and resource allocation.

**Results:** The application of HPC-driven simulations led to measurable improvements in mixer design. Structural components, including mixing discs and anchor elements, were optimized for enhanced performance. In

one representative case, the redesigned system achieved nearly a three-fold reduction in combined mixing and heating time compared to the baseline configuration. This improvement translates directly into lower energy costs and increased production throughput

**Impact:** The computational methodologies developed during this proof-of-concept are broadly applicable across industries reliant on mixing processes. The company has integrated these HPC-enabled design workflows into its standard engineering practice, and the techniques are being disseminated to other manufacturers in the Lower Silesia region. This case demonstrates how structured HPC engagement—combining infrastructure access, expert consultancy, and domain-specific training—can transform industrial design practices and deliver tangible economic benefits for small and medium-sized enterprises [23].

Researchers consistently highlight the benefits of HPC, including significant time savings, the ability to work on a scale otherwise unattainable, and the invaluable role of training and expert support. Thanks to the guidance provided by supercomputing resource administrators and Centre experts, scientists can carry out computational tasks and simulations precisely tailored to the specific needs of their research. For those embarking on research projects requiring large-scale computations, simulations, modeling, machine learning, or other HPC applications, the NCC's website features descriptions of numerous scientific projects completed using supercomputing infrastructure [23].

## 8. From systems to impact: Why competence centers matter

Peer-reviewed analyses done by EuroHPC emphasize that compute power alone is insufficient; impact requires skills, software and organizational interfaces that help users solve concrete problems [1, 2]. Competence centers transform heterogeneous infrastructure into an integrated service by coupling allocations with training, consultancy and communities of practice. In education, JCSE case studies document how well-designed courses and pathways raise the baseline for newcomers while offering advanced content for experienced users [10–12]. For industry, recent Springer studies show that structured assessments and PoCs can convert latent demand into adoption, particularly in SMEs that lack in-house HPC staff [11].

Aligned with these insights, the Polish NCC provides:

- ▶ Single front-door access to national systems (via

PLGrid) and to EuroHPC capacity such as LUMI, with harmonized identity and accounting.

- ▶ Training (introductory to advanced) with reusable materials and continuous updates tied to hardware and software roadmaps.
- ▶ Expert consultancy, including code porting, GPU acceleration, workflow design, data management, and reproducibility.
- ▶ PoCs that de-risk adoption for SMEs and public agencies by quantifying effort, cost, and benefit before scale-up.
- ▶ Showcases and dissemination, publishing success stories that demonstrate ROI in science and industry.

A typical journey begins with contacting the Polish NCC (e.g., for consultancy or training), followed by PLGrid account creation and a small educational or preparatory allocation. For projects needing larger or specialized resources, users submit proposals to national calls or EuroHPC calls. Upon award, NCC experts assist with environment setup, code optimization (profiling, vectorization, GPU kernels), workflow automation (job arrays, containers), and data pipelines (I/O optimization, FAIR data practices). For SMEs, a PoC establishes feasibility and economic value, after which projects can scale through national infrastructure or EuroHPC.

## 9. Conclusions

The National Competence Centre in HPC in Poland operationalizes EuroHPC's vision by making compute power useful; it couples access to national HPC systems with training, consultancy, and PoC-driven industry engagement. Peer-reviewed literature confirms that such competence-center models are essential to convert infrastructure into scientific outputs and industrial innovation [1–3, 7–12]. The Polish NCC, leveraging PLGrid and collaborations across Europe, already underpins high-impact work in chemistry, materials, life sciences, environmental modeling and algorithms engineering [15–23].

Looking ahead, the decisive factors will be: (i) software and skills that keep pace with heterogeneous hardware; (ii) robust data and AI capabilities integrated with simulation; and (iii) scalable industry on-ramps that transform pilot successes into production value. By continuing to invest in these areas, Poland's NCC will ensure that HPC capacity translates into measurable benefits for science and business, fully aligned with the EuroHPC JU's strategic objectives.

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