

LENS in the context of Horizon Europe

Ensuring the success of research and innovation missions through the coordinated contribution of Europe's advanced neutron sources

The innovation that gives rise to new and improved materials—from tissue scaffolds that support surgical reconstructions to wire cables that support suspension bridges—underpins many of the Pillar II clusters of the Horizon Europe programme, including health, industry, energy and food.^{1,2} This materials development is itself underpinned by the network of technical capabilities and human skills in the universities and research institutions that comprise the European Research Area. A particular strength of this network lies in the major national and European research infrastructures, which through their multi-actor, bottom-up approach enable a broad range of world-leading materials research by the expert communities that use them.

Neutron sources are one component of this innovation ecosystem, each year enabling top-level materials research by more than 5,000 scientists and engineers across many domains of the life, earth and engineering sciences.

The European network of neutron sources is comprised of a diverse user base that is intrinsically cross-disciplinary and cross-sector, and as such has benefited from decades of continuous European Commission funding within previous and current framework programmes. We have in turn leveraged this support into considerably larger pools of national funding available to the facilities.

Furthermore, the collaboration fostered by the Commission's programmes has time and again allowed for the optimisation of facility resources to target societal impact. These collaborations have contributed to the strong cross-facility relationships that have served as the basis for the 2018 establishment of the League of advanced European Neutron Sources, or LENS.

With this position paper LENS aims to make a proactive contribution to the Strategic Plan for the implementation of Horizon Europe. Success here will significantly enhance the natural alignment between the dynamic research carried out at neutron facilities and Horizon Europe's mission-oriented research and innovation actions.

Established under the guidance of the European Commission, LENS was formed to ensure the strategic coordination of the national and international facilities that comprise its membership.³ Enhanced coordination will include areas such as technical development strategy, data policy, user access, the increasing use of neutrons by industry, and the promotion and stakeholder engagement required to close the circle on the public's awareness of the socio-economic impact of European neutron science.

¹ See https://ec.europa.eu/info/sites/info/files/mazzucato_report_2018.pdf , p.15

² Mission-oriented Research & Innovation in the European Union, Mazzucato, 2018

³ LENS Goals & Objectives, <https://www.lens-initiative.org/goals-and-objectives> , 2019

LENS will act to reinforce the commitment of European neutron sources to serve society across all science domains. Only through boldly exploring new approaches can Europe maintain its place at the top of the world's science pyramid, and thereby find solutions to the Grand Challenges. Horizon Europe's vision of horizontally integrating research infrastructures with the innovation process is not only one that we share, but one that we have been practicing for several decades.

LENS maintains that European large-scale analytic facilities are a foundational pillar of Europe's highly developed academic and industrial innovation network. We therefore take this opportunity to underscore the fact that the scientific research performed at Europe's neutron facilities enables some of the most sophisticated and otherwise impossible characterisations of many materials and manufacturing processes at the core of technological innovation. As a means by which to probe materials across a staggering range of length-scales, neutron scattering is an irreplaceable tool in the advancement of science and engineering research. Moreover, LENS facilities serve as a critical actor in the education and training of the scientists, academics and technical staff that use, operate and build them. It has been recognised for many years that efforts targeted at fully unlocking the potential of the discipline pay very high dividends.

The landscape of neutron facilities in Europe has, coincidentally, reached a crossroads. We call attention to Annex 1 of this paper, which outlines the challenges and opportunities faced by European neutron sources over the next decade. In this transition period the community requires enhanced support to maintain its momentum and quickly capitalise on the unique opportunities.

In addition, we have included Annex 2 and Annex 3 to highlight the contributions neutron science is currently making to the health and energy clusters included in Pillar II of Horizon Europe's mission-oriented research and innovation plan. These serve as examples of the synergies identified between LENS facilities and Horizon Europe that will support the achievement of the European Union's key policy goals addressing global challenges.

LENS stands ready to work within Horizon Europe to increase efficiencies across our nationally and internationally funded neutron research infrastructures. LENS believes that Horizon Europe will play a key role in securing the materials research programmes of the European neutron scattering user base, the facilities they rely on and the technological knowledge base that underpins the whole enterprise. To this end, LENS aims to strategically align facility-based technological development and exploitation with the clusters and their missions as defined by Horizon Europe. The general target LENS considers of utmost importance is detailed below.

Developing technological solutions to urgent societal problems is a complex multi-stage process:

- Horizon Europe intends to boost research and innovation impact through a mission-oriented research and innovation approach. It is important for European competitiveness that whenever neutron facilities are able to accelerate the research required by the clusters, their potential is fully exploited by including appropriate research and development activities in the respective calls.
- This demands that the researchers working on the respective scientific or technological developments in the clusters are aware of the capability of the tools and techniques offered by the facilities. They need to have appropriate access to the corresponding services and these services must be adapted to the needs of their development projects.

From its earliest days, research with neutrons has played a role in finding scientific and technical solutions to societal challenges. It is self-evident to the members of LENS that neutron facilities will increasingly fill this need going forward. It is therefore the first priority of the Consortium to capitalise on the opportunity presented by Horizon Europe to advance and improve on this contribution. **LENS will outline clearly and in a timely manner how it can best contribute to Horizon Europe in parallel with the Commission's own process of defining how its missions will be accomplished.** European neutron facilities will thus be enabled to make the measurable and direct impact required for the collective success of Horizon Europe's mission-based goals.

ANNEX 1: THE EUROPEAN NEUTRON LANDSCAPE

Challenges and opportunities

The European neutron science user community is widely acknowledged as the largest and the most diverse in the world.^{4,5} It includes more than 5,000 researchers with over 32,000 instrument days annually across a network of international and national neutron sources.⁶ It has been the global leader in scientific output for four decades, led by [Institut Laue Langevin \(ILL\)](#) in Grenoble and the [ISIS Neutron and Muon Source](#) near Oxford. The world's newest and most powerful accelerator-based source is under construction in Lund, Sweden, where the [European Spallation Source \(ESS\)](#) is scheduled to begin operations in 2023.

The challenges and opportunities facing Europe's neutron community in the coming decade have been well-documented in recent years. The reports make clear that the opportunities inherent in Europe's world-leading status and the construction of ESS are self-evident and must be optimised. [The League of advanced European Neutron Sources \(LENS\)](#), a consortium of national and international large-scale European neutron facilities, was established in September 2018 to bring new coherence to this mission. Scarcity of beam time and a drop off in funding are the most immediate challenges facing the neutron community. Two of Europe's major neutron sources will cease operations by the end of the year, but the user program for ESS will only be ramping up between 2024-2028. The growing number of scientists requiring neutrons to advance their research means that even with the addition of ESS to the European landscape, capacity will be strained to its limits. LENS will target a more efficient use of existing resources through enhanced cross-facility coordination in order to address both the impending neutron gap and to ensure sufficient capacity going forward.⁷

Neutrons are special and must be made increasingly available to science and industry

The neutron is a unique probe with characteristics that cannot be supplanted by other methods. Neutrons allow scientists to understand the world at the atomic and molecular level in a non-destructive manner. This makes neutron science one of the most useful analytical techniques deployed across numerous science and technology disciplines.

Due to the characteristics of neutrons—well suited to investigate magnetic properties, light elements, thin films or large samples—they are an essential tool used in support of the science addressing society's Grand Challenges and have a legacy of significant socio-economic impact.

Europe's world-leading position in neutron science has been achieved and is sustained thanks to its rich and storied legacy in the development of neutron research techniques, along with the related expertise of facility staff and supplier companies. The relationship to European industry is a long-standing one that is both self-perpetuating and reciprocal.

The use of neutrons by industry, which currently accounts for 15% of European beam time, serves to strengthen the knowledge transfer from basic science to applied research, and accelerates the development of novel products and services.⁸ Moreover, development of the cutting-edge technology associated with European neutron sources provides their suppliers with a sound reference, allowing them to successfully compete in other high-tech fields⁹.

⁴ ESFRI Physical Sciences and Engineering Strategy Working Group, Neutron Landscape Group. [Neutron scattering facilities in Europe: Present status and future perspectives](#), 2016.

⁵ A Report by the APS Panel on Public Affairs. [Neutrons for the Nation: Discovery and Applications while Minimizing the Risk of Nuclear Proliferation](#), p. 10, 2018.

⁶ European Spallation Source ERIC. [Neutron Users in Europe: Facility-Based Insights and Scientific Trends](#), 2018.

⁷ LENS website, [Goals and Objectives](#), 2019.

⁸ European Spallation Source ERIC. [Neutron Users in Europe: Facility-Based Insights and Scientific Trends](#), p. 10, 2018.

⁹ <https://stfc.ukri.org/files/impact-publications/isis-neutron-and-muon-source-lifetime-impact-report/>

ANNEX 2: HEALTH science case

Fundamental science solves fundamental problems

At the core of medical research related to drug development, healthy living and the ageing process is the need to understand the extremely complex mechanisms of biological systems at the molecular level. Some promising advances in this area of fundamental science are coming from advances in neutron scattering methods and instrumentation. Additionally, neutron scattering is responsible for recent innovations in targeted drug delivery, next-generation biomedical devices and strategies to combat the viruses and diseases that threaten large-scale public health.

The successful structural characterisation of proteins, for example, is at the forefront of diagnostic and pharmaceutical research, and has applications in the treatment of Alzheimer's, diabetes and other intractable public health epidemics. More concretely, recent neutron studies have directly contributed to improvements in breast cancer therapies, anti-fungal drugs, anaesthetics, transplant recovery and our understanding of the elusive hepatitis C virus.

Innovation and device development

Apart from the many ongoing studies on drug delivery and metabolic processes, neutron scattering research on quantum phenomena, polymers and 3D printing technologies promises to contribute to some of the most important breakthroughs in the evolution of everyday medical devices.

The staggering financial burden of health care can be traced clear through the supply chain. The use of neutrons in health science can reduce these costs through improved outcomes generally, but can also accelerate the time it takes medical R&D to reach the market. This can lead to substantial societal cost savings.

The use of medical implants and prosthetics, for example, has become increasingly routine, but there remain several limitations. Neutron reflectometry studies of polymer coatings for metal implants have led to functionalised coatings that promote bone regeneration, granting the devices a longer life span. Neutron imaging studies into advanced 3D printing techniques is another area of research that can deliver on the promise of stronger, more durable and less expensive implants used to treat degenerative diseases.

One albatross hanging from the neck of the world's public health system is the extraordinary cost of the 80 million MRI scans performed annually. Research into the complex interplay of superconductivity and magnetism is one of the most promising areas of neutron spectroscopy research, and one that has the potential to scale down the cost per scan and the complexity of MRI technology.

The increasingly sophisticated use of neutrons in biology and medical research, including in the development of pharmaceutical and device technology, is an important component in securing the well-being and productivity of the world's ageing population.

ANNEX 3: ENERGY science case

Neutrons are highly suited to energy research

The unique character of neutrons makes them an important probe for energy materials, and neutron scattering is leading the way to ground-breaking technologies aimed at reducing the global reliance on fossil fuels. This is an objective that will only be achieved through the discovery and development of new materials.

Aside from the direct impact of research on alternative energy technologies that would be impossible without neutrons, neutron scattering is used across the complementary disciplines of materials science, engineering, quantum and classical information technology, nuclear science and chemistry. Research with neutrons in each of these disciplines will make critical contributions to the multi-faceted approach essential to solving such a broad-based societal challenge.

Ongoing and proposed research with neutrons promises progress in frontier energy areas, including scalable hydrogen power (fuel cells and storage methods); alternative energy vectors such as ammonia; more powerful and longer lasting batteries; next-generation solar cells (organic and self-assembling); and the development of superconducting and magnetic materials that could revolutionise energy transportation and distribution. Neutron scattering research impacts decarbonisation throughout the production chain, the supply chain and across all sectors through direct contributions on research into new materials for carbon capture and storage, how to reduce energy use through improved catalysis, and the continual development of lightweight materials for transport applications.

Together, this matrix of renewable, high-performing and sustainable energy innovations will underpin the coming transformation of the global energy sector.

Research and innovation, neutrons and industry

The industrial development of new materials and novel applications is a knowledge-based design process predicated on the understanding of the structure and dynamics of matter at the molecular and even atomic scale. While neutron scattering is widely used to provide this information complementary to other techniques, it is frequently the only method able to deliver this critical knowledge.

Because neutrons have no electrical charge and are non-destructive, they are in several cases the only probe available to scientific and industrial researchers to investigate delicate processes without interfering in those processes. This means they can characterise materials *in situ*—materials installed, for example, in their operational context and integrated with real components—and/or *in operando*—detailing a material's behaviour while it or its component parts are in operation. Such studies can answer questions like why a promising energy storage solution fails under some conditions and not others; or which molecular processes determine the efficiency of a particular battery technology, and how these can be manipulated for better performance.

Altogether, neutron research contributes in a unique and indispensable way to the knowledge and technology required to move the energy sector toward responsible resource management, as well as to transform it in ways society has not yet dared to imagine.