Energy Efficiency and Energy Savings in Scientific Laboratories

Report on the results of the workshop on energy efficiency and energy savings in scientific laboratories held in JRC Ispra

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Abstract

This report gathers insights from a workshop the EU Policy Lab organised on 22nd November 2023. The workshop aimed at identifying barriers and opportunities for energy savings in scientific laboratories at the JRC, with a specific focus on behavioural change in the lab. It also provided insights to define the JRC's role in promoting energy efficiency in labs across the EU. These insights include suggestions on using JRC research facilities as a regulatory sandbox for testing new energy-efficiency standards or technologies, providing training or guidelines to other scientists, and conducting behavioural studies to estimate the demand for energy efficiency by scientists and the potential barriers to energy efficiency among laboratories in the EU.

The workshop resulted in concrete actions to address pressing issues, such as energy monitoring, coordination across laboratories, equipment purchasing and maintenance, and behavioural incentives to save energy. The main actions are the following:

(1) Allocate dedicated budgets for trainings and energy monitoring tools, including an ad-hoc IT platform for test programming across labs,

(2) Implement targeted incentive programs and mandate energy cost estimation in public procurement,

(3) Foster 'Communities of Practice' and create a professional role bridging labs and infrastructure team,

(4) Launch a survey directed to lab users across the EU to understand their barriers and opportunities, and further evaluate JRC's added value.

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1 Introduction

Studies show that laboratories have the highest energy and water consumption compared to office buildings of comparable size. This poses two fundamental questions related to energy savings and energy efficiency. The first is about how to maintain the current levels of research output as the energy cost rises or, relatedly, how to do more research with less energy. The second issue is how to ensure the environmental sustainability of research in the long run, including understanding the steps necessary to reach net-zero labs in some fields.

Despite a varying degree of automation in labs, scientists and lab technicians still largely influence lab energy consumption (about 35% according to studies). Therefore, like any other individual in the workplace, scientists may need to be more attentive to energy waste (they only partially internalise the cost of energy waste). However, unlike ordinary workers, scientists' energy use is affected by various other critical considerations, such as the desire to minimise the risk of interrupting experimental operations or altering the conditions of experiments, causing a malfunction to expensive equipment, etc. This poses significant challenges for many organisations, including the JRC, that must incentivise scientists or provide adequate information to make optimal choices.

Behavioural solutions can either (1) help scientists internalise the cost of their energy waste or (2) help them make better decisions on energy use in research. For example, lab scientists do not directly pay for the energy bill but receive funding for their research. Aligning the lab funding with energy consumption via "energy credits" could help scientists internalise the cost of energy from their operations. Beyond operational costs, scientists may generate energy savings when purchasing the equipment. Encouraging the demand for specific energy-efficiency requirements in procurement contracts could help align scientists' behaviour with energy savings objectives.

Several studies show that better energy monitoring and information via feedback on consumption can promote energy savings in a wide range of settings. However, within the context of lab operations, it is necessary to understand how scientists can perform the same activities with less energy. To do so, energy monitoring must be sufficiently granular to allow scientists to experiment with different operations to select the most efficient setup (while preserving the scientific validity of findings). Scientists must be trained to use their equipment efficiently. This training may help scientists make better energy consumption decisions and increase productivity. However, granular information is often unavailable or collected at the building level and training on energy efficiency practices is not conducted systematically.

Another broad set of issues involves coordination both across laboratories and buildings. Coordination presents at least two kinds of opportunities for energy saving. First, energy needs sometimes overlap, and labs might save energy by sharing research facilities with other labs or making testing operations available to other needs. This would require better communication across labs, which simple interventions could improve or facilitate. From another perspective, labs could plan research activities in parts of the day with low demand for energy or lower energy costs for the JRC.

Why should it matter to the JRC? The activities of the JRC include experimental research that encompasses chemical, biological, and physical testing and analysis in dedicated laboratories onsite. Only considering the JRC Ispra, the major lab facilities onsite include (non-exhaustive list):

- European Union Reference Laboratory for alternatives to animal testing (EURL ECVAM)

- European Crisis Management Laboratory (ECML)
- European Interoperability Centre for Electric Vehicles and Smart Grids
- European Laboratory for Structural Assessment (ELSA)
- European Microwave Signature Laboratory (EMSL)
- European Nuclear Security Training Centre (EUSECTRA)
- European Reference Laboratory for Air Pollution (ERLAP)
- European Solar Test Installation (ESTI)
- Greenhouse gas monitoring facilities
- JRC Air Pollution Observatory
- Marine Optical Laboratory
- Nanobiotechnology Laboratory
- NGS-Bioinformatics infrastructure
- Vehicle Emissions Laboratory (VELA)

In terms of energy consumption, we estimate that the share of the 2022 energy bill attributed to scientific labs accounts for more than half of the expenses of the JRC Ispra. Despite adopting several strong technical measures to reduce energy in that period, this high impact on the energy bill was reached, and two reports on energy savings written by the JRC working group outline these measures. Overall, the situation suggests that any improvement in energy savings and efficiency in our laboratories will have significant positive consequences on the activity of the JRC.

Regulatory impact and visibility across the EU are additional reasons the JRC should engage in a broader discussion on laboratory energy efficiency. First, the European Union is Europe's biggest funder of research, with hundreds of new laboratories funded by the European Research Council every year. Scientists leading these labs may welcome training programs or guidance on operating or setting up their labs more efficiently as it can free more resources for their research. Creating synergies between the JRC and laboratories across the EU could promote the energy transition and help the JRC position itself even more at the frontier of scientific research in Europe.

2 Workshop organisation

The EU Policy Lab (JRC S.1) organised a one-day in-person workshop to explore barriers and solutions for energy savings and efficiency in JRC laboratories. The workshop occurred at the JRC Collaborative Space on November 22nd, 2023. The workshop idea and design were by Marion Dupoux and Andrea Blasco (EU Policy Lab, S.1) in collaboration with Stefano Tarantola and the Living Lab for Testing Digital Energy Solutions (C.3), Paolo Castello (R.I.4) and members of the Working Group on Energy Efficiency and Energy Savings at the JRC, Thierry Stievenart (JRC R.8), Luca Pirinu (JRC R.8) and Paolo Di Ianni (JRC R.I.4).

2.1 Participants

A diverse group of 25 people --lab managers, scientists, and technicians-- from 10 different JRC laboratories participated in the workshop (Table 1). The workshop also included nine facilitators and observers from other departments of the JRC, including EMAS Management Representative and Deputy Head of Unit (HR D.7), Celso Sanchez Martinez. This event created a safe and open environment for reflection and dialogue on enhancing energy savings and efficiency in laboratories, focusing on behavioural aspects.

Table 1. List of laboratories that participated in the workshop.

Lab name	JRC Unit	Lab activity description
Vela 8	C.4	Hybrid and electric vehicle testing
Vela 9	C.4	Electro-magnetic compatibility assessment
Vela 10-11	C.4	Market surveillance of vehicle emissions
Air Pollution Lab	C.5	Air pollution measurement
Marine Optical Lab	D.2	Test, characterization and calibration of optical instruments Biochemical and optical measurements on natural biological samples
Water Lab	D.2	Assessment both the chemical status of water bodies and technology for water purification
Nanobiotechnology Lab	F.2	Instrumental analysis of chemicals such as microplastics and food additives.
Genetically Modified Food and Feed Lab	F.5	Understanding the physico-chemical properties of nano- and micro-materials and their interactions with biological systems
Food Contact Material Lab	F.5	Testing materials that come in contact with our food for safe chemical leaching
Makerspace	S.2	Promoting active participation, knowledge sharing, and scientific research through open-ended exploration and experimentation

2.2 Activities

The workshop consisted of six main group activities aimed at promoting an in-depth discussion of several energy issues from different angles (see Table 2). After an icebreaker where participants paired up to discuss their lab activities, backgrounds, and their most significant energy use challenges, the workshop's first activity asked participants about their **"hopes" and "fears"** about further activities increasing energy savings and energy efficiency in their labs.

The second activity focused on mapping participants' knowledge of energy consumption in their daily activities, their views on energy monitoring, and discussing desired behavioural changes in the lab for energy savings and their impact on productivity.

In the third activity, participants reflected on the **JRC's role in promoting energy efficiency in** scientific laboratories across the EU and brainstormed strategies to fulfil this role.

The fourth activity was a speed-up gamification exercise, developed and led by the Living Lab for Testing Digital Energy Solutions, where participants identified barriers to three different issues—energy monitoring, behavioural change, and cross-lab coordination—and ideated solutions to address these challenges.

Finally, we invited U.S.-based external speakers specialised in developing programs and toolkits to increase and ensure the sustainability of scientific labs to present their insights on the topic.

Table 2. Workshop activities and objectives.

Activity	Objective
Hopes and Fears	Discuss hopes and fears about new activities increasing energy savings and energy efficiency in their labs
Mapping energy consumption	Discuss knowledge of energy consumption and status of energy monitoring of key lab activities
Identifying desired behavioural changes	Discuss desired behavioural changes & possible behavioural barriers or enablers
JRC role for EU laboratories	Discuss role of the JRC in promoting energy efficiency in laboratories across the EU.
Barriers and solutions (speed-up gamification)	Identify barriers and solutions for: • Energy monitoring • Behavioural change • Cross-lab coordination
External experts	Presentation on best practices, smart labs toolkit, energy certification for scientific labs, and net-zero labs by domain experts from three organisations (International Institute for Sustainable Laboratories, My Green Lab, and National Renewable Energy Laboratory)

3 Workshop results

3.1 Hopes and fears from JRC laboratories

The workshop participants expressed their hopes and fears about additional work on energy efficiency and energy savings at the JRC. The hopes can be summarised as follows:

- More budget for upgrades. Obtain additional financial resources to upgrade instruments and buildings for energy efficiency measures.
- More awareness and understanding: Increase awareness 1) among senior management about the specific needs and activities within labs to ensure adequate energy efficiency strategies and 2) among lab users, including newcomers, about energy consumption.
- Improved energy monitoring: Improve energy monitoring, including greater granularity in monitoring energy use and distinguishing between research and building management of energy consumption.
- More availability of green energy sources: Diversify the energy sources used in labs, emphasising the importance of green and sustainable options such as solar power.
- Improved coordination across labs and with buildings: Improve coordination across labs and buildings, particularly in coordination with building management. For example, energy consumption is not directly controlled by lab scientists but by building management. The decision-making process needs improvement to enhance overall efficiency. New measures could improve coordination.

The participants also reported the following concerns:

- Higher maintenance cost. Implementing short-term energy-saving measures, such as limiting or staggering the use of specific scientific equipment, may inadvertently elevate the risk of malfunctions or necessitate frequent maintenance or replacements, ultimately resulting in elevated operational costs.
- Increased constraints on lab activity: High energy consumption and, therefore, costs might lead to the decision to reduce lab activities or even close labs. It might also impact the autonomy scientists benefit from in their daily activities.
- Increased organisational complexity and operational cost. Adopting energy-saving measures might lead to heightened organisational complexity and operational costs, such as additional disclosure requirements or reporting of energy consumption. These additional constraints could reduce the overall operational efficiency of labs.
- Underestimation of added value. While energy savings are quantifiable, the immeasurable nature of research findings raises concerns among lab scientists that the assessment of cost benefits might undervalue the genuine contribution of specific research activities to the JRC.
- Long-term sustainability. Some energy savings measures may put labs at risk of shutting down essential functions or operations long term.

3.2 Mapping energy monitoring and desired behavioural changes

A cross-cutting issue was that the energy consumption of several key activities in JRC labs was not adequately tracked. This problem emerged strongly from the group discussion.

Indeed, researchers know the high- or low-energy intensity machines well. Still, they usually do not have the means to separate the energy consumption of these machines from other lab activities. Second, energy consumption is often tracked at the building level, and lab managers have only limited information or direct control of the energy consumed by their laboratories.

There was consensus on demanding a better and more granular energy monitoring system, especially for labs with little or no monitoring. Some concrete first steps in this direction could be implementing more effective information sharing and coordination with building management, aiming at real-time feedback on energy consumption. Investing in technological solutions, such as smart meters, for specific activities would be ideal. At the same time, more energy monitoring and real-time data must be accompanied by data analysis and processing resources, perhaps identifying specific expertise for this activity.

Changing behaviour in the lab involves more than just motivating lab users (Ölander and Thøgersen, 1995). Motivation is fundamental to initiating behaviour change in the lab, influenced by users' willingness to adopt new behaviour, hopes, and potentially hindered by their fears. However, enhancing their ability to understand energy consumption and overcome deeply anchored habits, such as the 'always-on' mindset for equipment, is equally crucial. Providing opportunities help facilitate these changes. Actions like offering training programs, ensuring accessibility to energy monitoring tools, and creating effective incentive systems are key in supporting and reinforcing the adoption of new, more energy-efficient habits and practices (see Figure 1).

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Figure 1. Motivation-Opportunity-Ability (MOA) model applied to energy savings in laboratories.

The discussion on desired behavioural changes explored the trade-off between limiting lab productivity and the potential for saving energy. Teams identified several feasible interventions and then categorised these interventions into “high” vs “low” potential for energy savings (x-axis) and “negative” vs “positive” impact on lab operations (y-axis). Results are summarised in Table 3).

Table 3. Trade-off between potential impact on lab productivity and energy savings.

	Low potential for energy savings	High potential for energy savings
Negative impact on work	• Include “cost of energy” in the budget for experiments	• Critically revise “always-on” requirement for lab equipment
Positive or neutral Impact on work	• Grant more direct control of energy consumption by labs or enable real-time coordination with building management. • Raise self-awareness of energy consumption • Mandatory training on energy savings for newcomers • “Peer pressure” across labs to save energy	• Sharing instruments across labs • Optimise use of instruments, including switch-offs

3.3 Defining the JRC's role in promoting energy efficiency and savings in labs across the EU

This activity fostered a free-range discussion on the JRC's role in promoting energy efficiency in laboratories across the EU, which revolved around several key points, each presenting challenges, and opportunities.

The primary question was whether the JRC approach should involve guiding or just stimulating a reflection among users of labs in the EU. The JRC faces unique conditions that might not necessarily apply to many labs. These exceptional circumstances may allow the JRC to take more risks and, for example, demonstrate the energy efficiency advantages of a new technology. The JRC could work as a regulatory sandbox to promote innovative solutions. One challenge to this approach is that solutions that proved well-suited for the JRC may not apply similarly to other labs or organisations under different constraints or conditions. This asymmetry may reduce the direct applicability of JRC findings and experience on energy efficiency across the EU.

The JRC could be central to promoting energy savings and energy efficiency in laboratories across the EU, and workshop participants identified several possible contributions, summarised below.

- Lead by Example. The JRC should be pioneering by exemplifying best practices in energy efficiency. This involves implementing and showcasing innovative solutions within its facilities, serving as a model for others to follow.
- Review and Apply Best Practices. Conduct a thorough review of existing best practices and actively apply them within the JRC. This reinforces the principle of leading by example and ensures that the organisation aligns itself with the latest and most effective energy efficiency measures.
- Collect Evidence for Recommendations. Undertake surveys or interviews with users in the EU to collect evidence that can be used to formulate practical recommendations and guidelines promoting energy efficiency in laboratories.
- Provide training. The JRC could offer training programs open to the broader network of laboratories in the EU. This can empower the scientific community with the knowledge and expertise to enhance energy efficiency in their respective labs.
- Sandbox for Innovative Regulatory Approaches. Establish a sandbox environment where innovative regulatory approaches to lab energy efficiency can be experimented with and tested. This includes demonstrating the energy efficiency advantages of new technologies and methods.
- Provide technical support and independent advice. Extend support by offering technical assistance and independent advice to labs seeking to improve their energy efficiency. This can include personalised consultations to address specific challenges faced by different laboratories, online training, workshops, etc.
- Energy labels for laboratories. To promote innovative regulatory approaches, the JRC can introduce a system of energy labels for scientific laboratories, providing a transparent and standardised way for labs to communicate their energy efficiency levels. This can serve as both an incentive for improvement and a benchmark for comparison.

3.4 Barriers and solutions to energy monitoring, behaviour change and cross-lab coordination

In this activity, participants were grouped into teams. Each team focused on identifying potential energy efficiency barriers across three domains or "topics": energy monitoring, behavioural change, and cross-lab coordination. Then, a different team reviewed and shortlisted the identified barriers. Next, another team brainstormed solutions. Finally, in the fourth phase, the team that identified the barriers reviewed and shortlisted the proposed solutions, bringing the activity full circle. At the end of the activity, the list of barriers and solutions for each topic was filtered by all the participants via a voting mechanism (how much resources would you invest in this solution). The resulting barriers and solutions regarding energy monitoring, coordination across labs and behavioural change are in Table 4, Table 5 and Table 6 respectively.

Table 4. Short-listed barriers and solutions regarding energy monitoring.

Energy Monitoring	
Barriers	*Solutions*
Energy monitoring equipment deficit	• Map out needs and define priorities. • Budget and HR resources for metering installation and data analysis.
Resource limitations for energy data management	• Establish a dedicated budget for energy efficiency within each scientific project.
Lack of strategic prioritisation	• Map energy needs and research outcomes
Energy consumption "blind spots"	• Provide training, implement environmental/energy efficiency requirements. • Mandate external energy reports.
Overlooked equipment life cycle energy costs	• When purchasing new equipment, include Life Cycle Assessment (LCA) as a quality parameter for equipment and factor in total cost (Purchase + O&M) in the technical specifications.

Table 5. Short-listed barriers and solutions regarding cross-lab coordination.

Coordination across labs	
Barriers	*Solutions*
Inefficient test scheduling	• Develop an IT application/platform to optimise test programming, including energy saving considerations.
Absence of standardised practices	• Create Communities of Practice to exploit collective intelligence and share best practices.
Expertise shortfall in energy efficiency	• Consider creating a dedicated 'Energy Officer' role to bridge labs and infrastructure.
Energy and scientific goals misalignment	-

Table 6. Short-listed barriers and solutions regarding behaviour change.

Behavioural change	
Barriers	*Solutions*
Deeply anchored habits	• Implement incentive changes and educate through example to break habitual patterns.
Sense of personal ownership of research facilities/infrastructure	-

Energy-unconscious planning	• Provide energy use reports post-tests; encourage energy-conscious planning. Consider the impact on human resources.
Neglecting energy performance in purchasing decisions	• Mandate energy consumption estimates in public procurements. • Weight procurement decisions on energy performance alongside price and technical merit.

4 Conclusions and recommendations

Overall, involving participants from various JRC laboratories in a workshop resulted in a comprehensive list of actionable strategies to overcome challenges and foster a culture of energy efficiency in laboratories at the JRC. The workshop results underscore the significance of improving energy monitoring, behavioural practices, and coordination across laboratories to achieve substantial energy savings. The hopes and concerns expressed by participants highlighted the critical need for increased budget allocation, awareness, and improved energy monitoring without lowering productivity or creating excessive operational burdens.

Moreover, the workshop delved into defining the JRC's role in promoting energy efficiency in laboratories across the EU. The proposed contributions, ranging from leading by example and applying best practices to providing training programs and establishing a sandbox for innovative regulatory approaches, demonstrate the multifaceted role the JRC can play in advancing energy efficiency at a broader level.

Moving forward, we recommend the JRC actively pursue the roadmap we highlight in Figure 2. The proposed actions range from mandatory training for newcomers to new rules on purchasing equipment, from monitoring to IT-supported coordination for lab operations and can be considered as a starting point for a holistic energy efficiency strategy. Continuous engagement with lab staff, incorporation of innovative technologies, and collaboration with external experts can further enhance the effectiveness of these measures. Additionally, the JRC should leverage its findings and experiences to contribute to the broader European discussion on energy efficiency in laboratories, aligning with the EU's goals of fostering a sustainable future for scientific research.

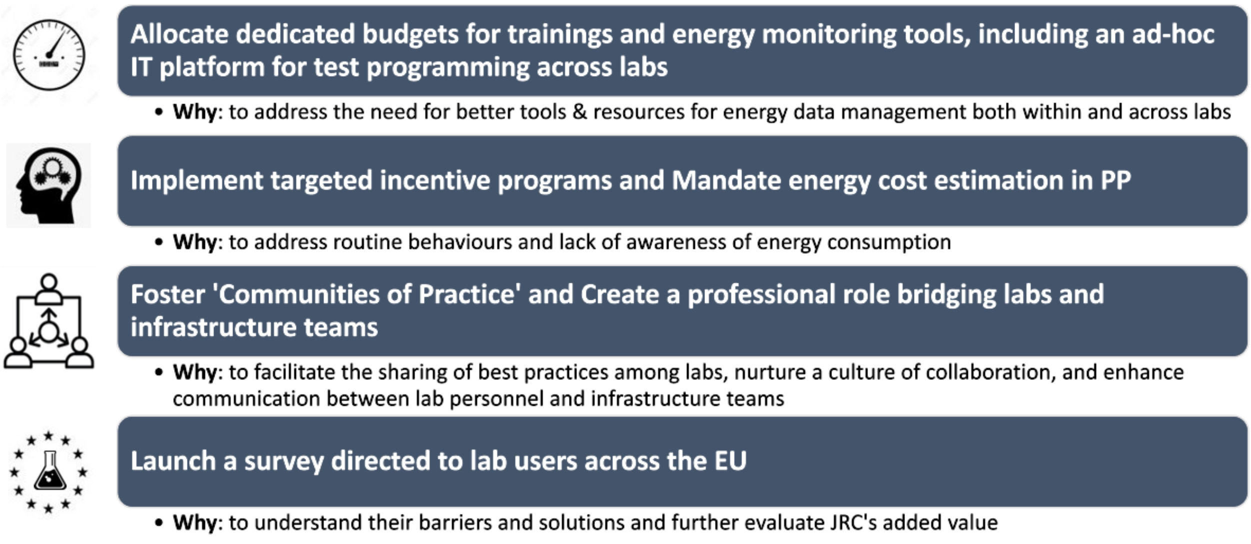

Figure 2. Post-workshop roadmap: Key actions for further energy savings and efficiency in labs.

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