



LEAF in the Netherlands: Adopting Sustainability in our Laboratories

December 19th, 2022



Universiteit
Leiden

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Report for the Ministry of Health, Welfare and Sport

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Acknowledgements

We are grateful for the support received by the Ministry of Health, Welfare and Sport which made the LEAF pilot in the Netherlands possible. We thank all LEAF admins from the institutes taking part in the *LEAF in NL* pilot. We draw on the work of Puck Wynia (chapter 3) and Lorenzo Hogendorp (chapter 4) who studied the LEAF pilot at Erasmus MC. We are thankful for their enthusiastic engagement and valuable insights.

Please cite this document as:

Franssen, T., Giannini L. & Johnson, H. (2022) *LEAF in the Netherlands: Adopting Sustainability in our Laboratories*. Centre for Science and Technology Studies, Leiden University. DOI: 10.5281/zenodo.7457118

Chapter 1: Introduction

As society becomes increasingly aware of the significant environmental footprint of scientific research, efforts towards more sustainable laboratory practices have gained ground in recent years. The goals of reducing waste, carbon emissions and the use of raw mineral resources in laboratory work are central in driving these sustainability efforts. To achieve these goals, attention is especially focused on laboratory operating procedures, materials storage and use (for instance in the effort to reduce single-use plastics or implement toxic chemical alternatives), chemical and biological waste disposal, IT and information infrastructures, conference travelling behaviour, as well as data procurement and reproducibility. The 2022 energy crisis has added an economic incentive to reducing energy use in laboratories.

The drive to increase sustainability has been grassroots driven¹, with lab users taking the initiative in “greening up” their act at work. However, the grassroots origin of most of these sustainability efforts means that lab users often start from scratch and find a lack of guidance in how to become more sustainable.

Responding to this clear need for better guidance, Martin Farley from University College London (UCL) in the UK created the ‘Laboratory Efficiency Assessment Framework’ (LEAF)², which compiles defined actions and criteria into a user-friendly framework for lab users in public research organisations. The programme offers its criteria in a 3-tiered assessment structure granting bronze, silver or gold certification – depending on the extent of the implementation of sustainable practices in each lab. Prior to the launch of the LEAF online tool in 2021, LEAF had already been piloted in 23 different research organisations in the UK and Ireland, with a total of 235 participating research groups. The pilot resulted in a total of 648 tons of avoided CO₂ emissions and £641.000 (~€750.000) of estimated savings³. On average, research groups made an annual saving of £3.700 (~€4.300) by implementing more energy-efficient practices.

In the Netherlands, a grassroots initiative was started in early 2021 under the name Green Labs Netherlands (Green Labs NL). Green Labs NL is a non-governmental organisation that aims to build a sustainable science network in the Netherlands through resource sharing, community building and project instigation. As part of this effort, in September 2021 Green Labs NL launched the ‘LEAF in NL’ pilot, a project to encourage sustainable laboratory practices in Dutch academia. With seed funding from the Ministry of Health, Welfare and Sport, the pilot aimed to assess the usability and feasibility of the LEAF sustainable lab programme in Dutch scientific research, and was split into 2 phases. Phase 1, which ran from September 2021 to December 2021, saw the initial

¹ “Achieving sustainable transformation in science – green grassroots groups need nurturing from the top.” *Jeroen Dobbelaere, Jan B. Heidelberger, Nikoline Borgermann, Cell Science 2022*

² <https://www.ucl.ac.uk/sustainable/staff/leaf>

³ “Sustainable Science and the Laboratory Efficiency Assessment Framework (LEAF)”, available at https://www.ucl.ac.uk/sustainable/sites/sustainable/files/leaf_pilot_summary_and_review.docx

rollout of LEAF in 4 public research organisations, with the focus on getting the programme accepted and running in each of them. To this end, best practice guides for *starting a green team or initiating a sustainable lab programme* were created as publicly available resources, and barriers and facilitators were assessed and summarised in a report produced for the Ministry of Health, Welfare and Sport⁴.

Phase 2, which ran from January 2022 to October 2022, aimed to further expand the LEAF sustainable lab programme to more organisations in Dutch research. Additionally, phase 2 aimed to follow the progress of the 4 initial organisations that implemented LEAF in phase 1, as well as to assess the programme's impact in quantifiable terms of CO₂ emissions diverted and financial savings following the uptake of sustainable practices in the lab.

1.1 Phase 2 - an overview

With the start of phase 2, Green Labs NL reached out to a wide range of public research organisations – including universities, research institutes, university medical centres (UMCs) and public health organisations – regarding LEAF implementation.

Thanks to this outreach, the pilot successfully assisted 7 more Dutch public research organisations to get started with LEAF, in addition to the 4 research organisations already participating in phase 1. Currently, at the close of phase 2, another 4 organisations are in the process of getting the LEAF sustainable lab programme accepted for a pilot year within their structures, which brings the national total of participating organisations to 15.

As part of the phase 2 set-up, Green Labs NL held monthly meetings for all Netherlands-based LEAF administrators and hosted a communal online space. The meetings and online community were aimed at assessing the progress of LEAF implementation by all institutes as well as facilitating this process by providing assistance, sharing knowledge, tips and resources across all of the organisations and highlighting focus points for sustainable lab practices. These meetings are still ongoing – following up the continuing progress of LEAF implementation in each institution – and continue to facilitate knowledge sharing within the Dutch sustainable science community.

This report provides 1) an overview of LEAF in NL's achievements (including an overview of the implementation in the new organizations that joined in phase 2, as well as of the progress of the 4 initial organization), 2) an in-depth assessment of the changes brought about by the implementation during the pilot, as well as 3) interviews concerning the user experience of the LEAF sustainable lab programme, and 4)

⁴ "The implementation of LEAF at public research organisations in the biomedical sciences: a report on organisational dynamics." *Thomas Franssen; Hannah Johnson*
<https://zenodo.org/record/5771609#.Ybx3WFvJPZ>

foresight into how to manage sustainable progress within laboratories for the future of Dutch public research organisations.

Chapter 2: Achievements

2.1 New institutes

7 new institutes have joined the second phase of the pilot and are in various stages of implementation. Below we shortly discuss the organisation of LEAF implementation within these institutes and their progress so far.

2.1.1 University of Groningen (RUG), Faculty of Science and Engineering

Within the Faculty of Science and Engineering (FSE), the faculty-wide *Green Labs RUG FSE* team oversees LEAF implementation. The green team has members within all 11 institutes of the faculty that have laboratories. As this is the only faculty with laboratories at the University of Groningen, the *Green Labs RUG FSE* team effectively covers the entire University of Groningen.

The green team has gained full support from the university board, faculty board and green office of the university. This includes financial support provided by the faculty for investments to become 'green', for example for new equipment such as fridges or freezers with A+++ energy ratings. Moreover, funding is available for research projects on greening laboratories as well as the possibility for master and bachelor students to contribute to research on these topics.

The green team is large, consisting of around 50 staff members from the various institutes, half of which are permanent staff. An elaborate organisational structure has been developed for the green team (see figure 1). In October 2022, 1 to 3 labs from each institute began LEAF certification, and will be followed by LEAF roll-out faculty-wide. One of the green team members has been appointed as LEAF coordinator.

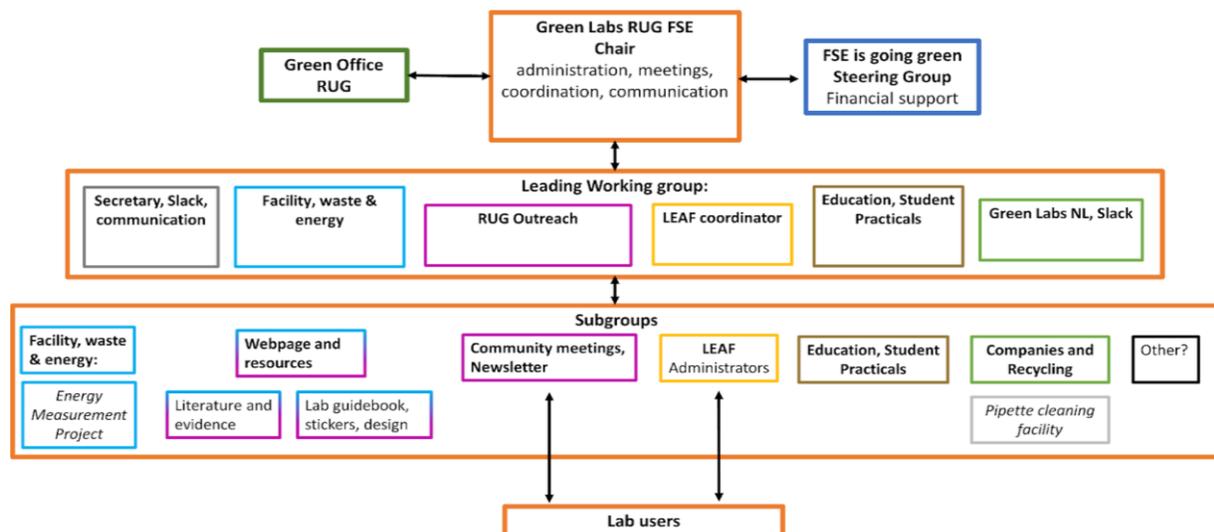


Figure 1: structure of Green Labs RUG FSE including a dedicated LEAF coordinator

2.1.2 Utrecht University (UU), Faculty of Geosciences

Within the faculty of Geosciences at Utrecht University (UU), a paid part-time coordinator was hired to implement LEAF in collaboration with the director of the Geosciences laboratory and a lab group manager. A green team was formed, involving mostly contractual (not permanent) staff members and a few students, and LEAF implementation began in July 2022. Currently, 7 research groups are signed up on LEAF, of which 2 have already achieved the bronze certification, and 2 more have just completed their submission for bronze certification and are now awaiting the internal audit.

On the wider UU level, a student-driven green office and sustainability programme with additional sustainability experts is part of the facility service centre. This office has shown interest in encouraging other faculties to take up LEAF for their laboratory spaces, and the Geosciences faculty green team is in contact with the green office regarding their efforts on a quarterly basis.

2.1.3 Hubrecht Institute

At the Hubrecht Institute LEAF is implemented collaboratively by a green team that was established in December 2021. The green team consists of members of the technical department, PhDs, postdocs and technicians, as well as the head of domestic/logistics services and a Principal investigator (PI), who act as ambassadors to help the green team reach group leaders and the board of the organisation.

The Hubrecht Institute joined LEAF in March 2022, and the online environment became available to all researchers in June. So far, 15 research groups and the service department have signed up on LEAF, and 5 of these groups are actively using the online tool, with 1 group that has already submitted for bronze certification. While the green team is large enough to be able to manage and coordinate LEAF implementation, green team members suggest that it would be beneficial to consider the creation of a sustainability office at the institute, to drive sustainability forward in a more permanent and systematic manner (the Hubrecht Institute currently does not have a sustainability manager). This is all the more important because the green team consists mainly of staff on temporary contracts and has therefore seen a decline in members already in the past 9 months.

2.1.4 Amsterdam University Medical Center (Amsterdam UMC)

At Amsterdam UMC, LEAF is implemented by green teams consisting of PhD-students, postdocs and technicians across 6 departments. In particular, the green teams are located in the laboratory of experimental bacteriology, of experimental virology, of

medical microbiology and infection control, of molecular cell biology and immunology, as well as the Netherlands laboratory for bacterial meningitis and the Tytgat institute.

To date, 8 research groups have signed up to LEAF and are currently working towards submitting for bronze certification.

Within the Amsterdam UMC, each department works individually on their own LEAF progress and there is currently no coordination across the whole institute. The green teams however are in contact with the sustainability manager, waste segregation unit and the 'green care' initiative.

2.1.5 Wageningen University and Research (WUR)

At Wageningen University and Research, LEAF implementation has mainly been spearheaded by a PhD student who is involved in the institute's sustainable practices. With support from the director of Facilities and Services, WUR signed up to LEAF at the end of August and is currently gathering interest from the individual labs within the institution.

Many labs have shown interest so far and LEAF coordination will be run by the mentioned PhD student in collaboration with the Safety and Environment team from the Facilities and Services department.

2.1.6 University of Twente (UT)

The University of Twente came into the LEAF pilot early on and signed the LEAF service agreement in March 2022. The Sustainability, Energy and Environment (SEE) committee of the university initiated the pilot and signed the agreement, and are keen to support its roll out across UT. A green team focused on lab practices was set up at the start of 2022, consisting of postdocs, lab technicians, support staff and a sustainability officer; the team works towards implementing a range of initiatives to make the labs more sustainable. There is regular communication between the green team and the campus facility management (including sustainability managers), local building management, safety officers and lab managers, as well as lab users. Even though there is no official budget for the green team, they are supported by the institution and are given occasional funds for small projects such as replacing waste bins in the labs.

There are a few dedicated LEAF administrators, but members of the green team are responsible for driving up LEAF participation within their own group. Only 1 lab is officially signed up to the LEAF tool, with a few more also actively working on LEAF related criteria, which will soon join the LEAF platform with their research groups. The aim of the green team is to have at least 1 member of each group who participates on a

regular basis and can be responsible for LEAF criteria implementation across their lab spaces.

2.1.7 University Medical Center Utrecht (UMCU)

As of September 1st 2022, the University Medical Center Utrecht (UMCU) has hired a dedicated part-time LEAF coordinator to roll out the sustainable lab programme across the organisation. There are currently 7 green teams within the UMCU, ranging from student/education level to department based for the laboratories and Intensive Care Unit (ICU).

The green team focusing on labs consists of various staff in different roles such as technicians, PhD students, quality officers, medical specialists and professors. The LEAF coordinator is working with the lab-dedicated green team for LEAF implementation.

The UMCU is in the initial phase of LEAF implementation and plans to roll out the certification throughout the whole lab division within a year. The first phase consists of informing lab employees at all levels, forming departmental LEAF teams and registering labs for LEAF, at first within 2 or 3 of the 8 interested departments, like the Center for Molecular Medicine and the Department of Genetics.

Although there are several green teams and green team members are given dedicated time (1 hr per month) to attend meetings, they have indicated that more dedicated professional support is needed. The lab division's leadership team supports sustainability through LEAF and has mandated that employees in the roll-out spend time on LEAF implementation (on average 2 hours per week). In practice however, the laboratories still face challenges in dedicating time to this. Due to varying specialisations in the different lab spaces, individual support for each department would be preferred to ensure each lab space is able to progress effectively towards lab-specific sustainable practices.

2.1.8 Other organisations

Vrije University, Leiden University, Netherlands Cancer Institute (NKI) and GGD Amsterdam are in the progress of gaining internal managerial support for the use of LEAF in their organisations. Members of the different organisations are already in contact with Green Labs NL and the central LEAF coordination team to sign up and begin rolling out LEAF by the end of 2022. Some members have already joined the monthly meetings held by Green Labs NL for the *LEAF in NL* pilot, to get ahead regarding knowledge for sustainable practice implementation in their labs.

2.2 The four pilot institutes that started in phase 1

2.2.1 Erasmus Medical Center (Erasmus MC)

In the Erasmus MC, LEAF has been instigated thanks to the collaborative efforts of the Green Team Biomedical Research, a group of approximately 15 lab-based employees (mainly PhD students) working in research across different departments. The green team was initiated in March 2021, and since then it has been active with several initiatives dedicated to the sustainability of research activities (e.g. events, recycling pilots, survey). Of this group, one main LEAF coordinator and 4 LEAF sub-administrators have been responsible for LEAF project management and coordination. The project has been well supported within the Erasmus MC by the Sustainability Taskforce 'Een Duurzaam Erasmus MC', which has been helping in promoting the initiative and securing contacts for LEAF-related interventions (e.g. setting up new recycling streams). Next to this, the sustainability efforts and ambitions of the Erasmus MC are gradually expanding, comprising >10 (departmental) green teams across the entire hospital and several cross-departmental projects.

The Erasmus MC joined the LEAF pilot in September 2021, when the first labs and departments were approached. The Erasmus MC kick-off meeting (October 2021) included approximately 40

participants. Subsequently, during phase 1 of the project (until December 2021), 10 labs across 9 departments signed up on the LEAF platform. The number of participating labs gradually increased during phase 2, as more people heard about the availability of this sustainability program. Approximately 25 LEAF users participated in a LEAF roundtable meeting organised in March 2022, which was meant to share experiences, issues and ongoing initiatives within the Erasmus MC LEAF pilot.

Currently, 23 laboratories are signed up on LEAF. These laboratories vary in size, as some correspond to full departments, while others are single units within a department. The total number of users signed up on LEAF from these laboratories is 49 (2.1 user per lab on average). Of laboratories signed up on LEAF, 2 had been awarded LEAF bronze certification in 2021 (which was re-confirmed in 2022), and an additional 10 have attained the award in 2022. Most labs have worked relatively independently on LEAF implementation within their own spaces and have received dedicated feedback and/or a lab audit from the LEAF coordinating team upon submission for the certification. One exception is the Cell Biology department, where 2 LEAF sub-administrators drove the process forward at the departmental level through internal meetings and email newsletters.

2.2.2 Princess Máxima Center for Paediatric Oncology (Máxima)

The prospect to use the LEAF tool had been one of the core strategies and founding blocks of the 'Máxima Green Labs' committee, which was launched in the research department in June 2021. At the onset of the *LEAF in NL* pilot in September 2021, the committee had already begun to discuss its uptake at the Máxima, and the organisation was officially signed up in October 2021 after an internal kick-off meeting for LEAF users. Approximately 25 staff members representing 10 different research groups, from 2 different departments, attended the meeting. During phase 1 of the pilot, 6 research groups signed up to implement LEAF criteria within their labs, which has now increased to 8 during phase 2. LEAF users currently signed up on the tool amount to 12, making an average of 1.5 users per lab responsible for filling in LEAF criteria. Of the participating 8 labs, 3 have achieved bronze certification in 2022.

Considering all research groups of the Máxima share laboratory spaces, LEAF criteria were commonly assessed and actions to address and complete criteria were divided across members of the Máxima Green Labs committee. Due to the shared organisation of the laboratories and the need to get approval for any changes at a central level, implementation of criteria such as on/off switching of equipment and waste bin signage and policies has been slow. However, now that actions have begun to take place, many implemented criteria have become applicable for all (approximately 25) pre-clinical research groups in the department, whether they are participating in the LEAF pilot or not. One group that achieved bronze LEAF certification has shared their submission criteria with all Máxima LEAF users, to enable them to input information that is centrally organised. Assessment of LEAF progress for each participating group and targeted criteria achievement and progression are discussed at the monthly Máxima Green Labs committee meetings. Additionally, the committee has organised a 'Freezer challenge' across the organisation to take place from October to December 2022 to help tackle usage of the high energy-consuming pieces of equipment.

2.2.3 Radboud University Medical Center (Radboud UMC)

Radboud UMC was one of the four pilot organisations that got involved in the LEAF pilot at the start. Initially, four departments were approached by the 'Green Lab Initiative' group with the request to take part in the pilot. The signing of the service agreement with UCL for LEAF usage turned out to be quite a hurdle, as support from the top of the organisation was lacking. For this reason, the team decided to keep the pilot small, only within the four departments that were initially approached. Of the four departments, 2 have implemented LEAF at the departmental level and 2 departments have had individual research groups sign up. In these departments, a total of 8 people are actively implementing LEAF, and two LEAF bronze certificates have been awarded. Changes in

the Green Lab Initiative group as well as a large-scale move to new buildings for most laboratory sciences has resulted in less progress in the past months.

However, support from the sustainability manager and from the top of the organisation, including future financial support to continue LEAF and to involve many more departments, is now emerging. Hopefully, this will give a new impulse towards the increase in research sustainability in terms of reduced energy consumption and improved waste management from laboratories at Radboud UMC.

2.2.4 Sanquin Research

Sanquin has a corporate social responsibility policy that includes a number of sustainability targets, including a reduction of carbon emissions and a reduction of waste (plastics). The policy is upheld with a cross-departmental team and is traditionally embedded in occupational health, safety and environment (EHS).

Participation of Sanquin in the 'LEAF in NL' pilot was spearheaded by a postdoc within the green team who found quick support from research managers and other staff to implement sustainable lab practices. Due to the departure of the postdoc who initiated the programme, progress of LEAF implementation was reported as slow at the start of 2022. However, in October 2022 the Sustainability Coordinator (EHS) and a member of the Sanquin Research green team were able to pick up where previous coordination had left off and aim to continue the efforts made.

In the first phase of the pilot, 8 research groups signed up to use LEAF, with 4 already achieving bronze and 1 silver in 2021. A further 3 went on to achieve bronze again in 2022 and 1 is awaiting internal audit of the silver certification. This means that, despite a lack of coordination, research groups seem to have continued the implementation of LEAF which is a positive sign.

Currently, Sanquin is planning to review how LEAF was used by the participating research groups and assess its potential for continued use into 2023. In addition, the EHS department have formulated goals for 2023 which include the optimisation of plastic waste separation, energy savings through lower building temperatures and assessing cooling and freezing installations, as well as paying attention to sustainable procurement practices. These goals are in line with the LEAF framework.

Chapter 3: Changes induced by LEAF implementation

3.1 Changes observed during the pilot year

Through implementing the LEAF bronze criteria, small but important changes towards sustainable work practices in laboratories have been made, which shift the behaviour of the employees most frequently using lab facilities, such as technicians, PhD students and master/bachelor students. At Erasmus MC and Máxima, we have examined the submission forms filed by the research groups to understand the most important changes made in the participating labs, which were the following:

- Energy-efficient practices surrounding the use of equipment, computers and lights, through organised usage strategies as well as signage to encourage switching off during relevant downtimes;
- The implementation of soft and hard plastic recycling throughout all LEAF-participating laboratories at Erasmus MC, and the optimisation, when necessary, of existing waste streams (paper, glass, sharps, hazardous, residual waste);
- A (further) development of introduction documents and general organisation of the laboratory with more attention to sustainability, including equipment cleaning schedules, improved maintenance of freezers and efficiency of sample/material storage, better labelling of chemicals, and sharing of materials and protocols among laboratory members;
- The appointment of at least one person per group to drive sustainability changes forward.

These changes are important as they signify that sustainability is slowly becoming an integral part of the work culture of these research groups and laboratories. It also shows that becoming sustainable is not done through a single action, but rather it needs to be integrated in a variety of ways across the laboratory. Practising sustainable science implies a mindset shift in each practice in the lab, from turning lights and equipment on and off, to shared chemical usage and proper labelling protocols, and to the way new researchers are introduced to the lab space and expected to behave when leaving the lab, e.g., completing exit protocol documents to reduce unnecessary long-term storage of samples in high energy-consuming freezers.

Erasmus MC was taken as a case study for more in-depth assessment of the use of the LEAF tool.

3.2 Quantification of CO₂ and costs savings at Erasmus MC

To assess tangible outcomes when using the LEAF sustainable lab programme, we quantified CO₂ emissions reductions as well as financial savings through LEAF

calculators in a subset of 5 laboratories that attained the LEAF bronze criteria in the Erasmus MC.

Input values of the LEAF tool in-built calculators were adjusted in such a way that they would best reflect costs and figures relevant to Erasmus MC. Information on LEAF-induced changes of equipment usage was gathered through structured interviews with the lead implementer of LEAF in each laboratory, and the calculators were filled in systematically according to the changes observed. Table 1 shows in detail the changes made to freezers, fume cupboard and other equipment. Based on the reported changes, we estimated a total of €2.553 annual cost savings (based on the 2022 electricity rate of €0.061 per kwh) and a total of 21.9 tons of CO₂ emissions avoided from the 5 participating labs.

Through the interviews, we were able to determine that with additional and continued encouragement of these sustainable practices (e.g., feedback audits after LEAF submissions and more demanding criteria in the silver and gold certification levels of LEAF), further emissions reductions and costs savings can be achieved. Furthermore, while for these calculations we have mainly focused on lab equipment usage, other components of the LEAF criteria can be measured, such as waste and IT usage. The actual savings are thus higher than what we report here. These pilot results, however, demonstrate that with only a few labs participating, significant cost savings and CO₂ reductions can be achieved.

Annual electricity usage and cost savings after LEAF implementation

Equipment	Baseline annual electricity usage/cost [#]	Changes after LEAF implementation	New annual electricity usage/cost [#]	Estimated annual savings
ULT Freezers (N=31 from 5 labs)	211.364 kwh / €12.893	Defrosted freezer doors (N=5) Raised temperature to -70 (N=12)	188.971 kwh / €11.527	22.393 kwh / €1.366
Fume cupboards (N=6 from 1 lab)	42.310 kwh / €2.581	Sashes closed more often (from 25% to 50% of the time; N=6) Kept on less time (from 24 hours a day to 12 hours a day; N=6) Switched off during the weekend (N=6)	23.435 kwh / €1.430	18.875 kwh / €1.151
Miscellaneous equipment (N=6 from 2 labs, incl. 2 centrifuges, 2 PCR machines, 1 incubator, 1 water bath)	1.185 kwh / €72	Switched off after use (N=6)	591 kwh / €36	594 kwh / €36

Legend: ULT=ultra-low temperature

[#]=electricity costs were estimated using the 2022 electricity rate of €0.061 per kwh

Chapter 4: LEAF use and implementation experiences

Interviews were conducted with 8 LEAF users from 4 laboratories at Erasmus MC about their experiences with LEAF implementation and possible barriers to the ‘green team-driven approach’, which is the approach taken in most organisations in the Netherlands (i.e., all 4 organisations participating from September 2021 onwards, and 6 out of 7 of the new organisations that have joined in 2022).

4.1 What do laboratory users like about LEAF?

The interviews showed that all LEAF users recognized the environmental impact of current laboratory practices and were eager to make a change. All participants expressed positive experiences on the implementation process and would recommend LEAF to other groups and institutes.

When discussing reasons to participate in the LEAF pilot, interviewees signalled that they found sustainability important in their private life but saw a mismatch between how they behaved at home and their behaviour in the workplace. This was especially felt with regard to single-use plastics and the lack of recycling options. This mismatch was a strong driver to participate in the pilot. One interviewee explained:

“We use a lot of plastic packaging that we just throw away, as we didn’t have a separate waste stream. While at home that is something you are concerned with. At least you separate plastic waste at home. And here it was the feeling that everything ended up on a big pile. So, I think the concern was there for a while already. But the real interest in sustainability only emerged with the start of the LEAF project. Maybe for some colleagues it was a concern for longer already, but it hasn’t been a big topic in the group the past years”.

One of the main problems interviewees experienced before the pilot was that they did not know where and how to begin addressing sustainability in their work life.

Sustainability is generally a large and often abstract goal, which is hard to approach without defined concrete targets, or opportunities in the organisation to contribute to. For this purpose, the LEAF framework was found to be especially helpful, as LEAF gives structure to sustainability efforts by offering manageable and attainable concrete actions. Interviewees explain:

“I think the best thing of LEAF is that it is structured and divided in levels, and that makes it easier. And also, it gives you suggestions of what you should

actually do. Because if I would have to do it by myself, I would for sure not think about all the things that are already implemented or recommended by LEAF.”

“I think it's quite a user-friendly system. I think it's all very straightforward and quite easy to do.”

“It just gave me the tools to deal with it in an efficient way. I had abstract ideas and LEAF made them concrete”

Moreover, respondents report that LEAF made them aware of actions they could take with regard to sustainability that they had not (yet) considered themselves, or felt they would not have thought of. In this sense, LEAF allows respondents to further deepen their knowledge of sustainability in science by concretely engaging in it. Two interviewees told us:

“Since the start of LEAF, we've included the cleaning of the filters and the ventilators in the cleaning schedule. We have a weekly and a monthly cleaning for our lab. So, we've included it in there. (...) I honestly hadn't thought about it before this. But I guess if it's all blocked, it takes a lot more energy to cool the system. So yeah, by cleaning it regularly, it will change the energy use. Nobody was aware of this basically. But now people pay more attention to it.”

“I think I became more conscious of turning my equipment on/off. And I think about the way I use my materials, keeping in mind not to compromise the experiment. Is it really necessary or can I do the experiment without?”

Lastly, rather than offering strict guidelines to users, the LEAF user guide stresses that users must do what is reasonably attainable for them in their specific situation. The developers understand that sustainability measures are very specific to different fields and laboratories, and that there are important differences in what can and cannot be achieved. The openness and flexibility of the tool and the audit process were appreciated by users because this was something they were concerned about before participating. One interviewee explains:

“I think they made it really easy for everyone to implement it. The criteria are very clear. What I saw (...) was also that it's not too difficult. They are not super strict.

You can still get your certificate even if you do not meet the criteria. For instance, when you cannot meet certain criteria because your institute does not allow it. I really like that they provide you the guidelines, the handles, but they also bring you into this whole green community”.

What we thus learn from the pilot is that the LEAF framework works well in the Netherlands because it structures the sustainability effort providing realistic and concrete goals, it empowers lab users, helping them to deepen their knowledge of sustainable science and, lastly, the framework and the audit process are flexible and open to be adopted in various circumstances.

4.2 What are barriers in the implementation of LEAF?

While the overall experience with LEAF has been positive, the interviewees also recognised a few barriers to the ‘green team-driven approach’ taken for LEAF implementation in most participating organisations in the Netherlands. Drawing on the interviews with Erasmus MC participants, we identified three main barriers:\

- (1) the lack of allocated time for sustainability for staff;
- (2) the need for additional guidance and feedback moments;
- (3) the difficulty in implementing changes that require overarching efforts at the institutional level.

The first problem derives from the fact that LEAF implementation is added to the workload of staff, often technicians or PhD students/postdocs. While these individuals are usually highly motivated and have volunteered to take on the implementation of LEAF bronze criteria, there is generally a shared concern about the amount of time LEAF will take when silver and gold criteria need to be implemented.

The second problem is related to the first one, in the sense that several participants indicate that they would like additional guidance and more feedback moments from the green team on sustainable practices. The green team, however, similarly to our interviewees, is active on a voluntary basis and cannot be expected to professionalise their support for LEAF implementation. It is, however, clear that additional guidance would facilitate the implementation process.

The third problem is the difficulty local implementers encounter in changing things that require overarching efforts from the organisation. For instance, this is noted as a

problem in equipment or material purchasing decisions that are bound by contracts at the Erasmus MC, which offer limited choice in vendors. Therefore, an attempt to switch to more sustainable lab gloves would need upper-level institutional support to be implemented.

In this respect, the broader question is to what extent a bottom-up approach to sustainability is enough. A survey conducted among 354 Erasmus MC employees showed that, while most of the responders were motivated towards the implementation of sustainable practices, they also believed that the responsibility for sustainable change lies at the upper levels of the institutional structure (i.e. PIs, sustainability coordinators, upper management). The barriers foregrounded here also suggest the same thing. While a bottom-up approach to LEAF implementation works, the full potential of LEAF can only be achieved through increased professionalisation, paid support staff and more active managerial support, to assist participating laboratories in the process.

Moreover, the experiences with Radboud UMC and Sanquin Research show that a bottom-up approach can also be slower than a top-down approach, if the green team is not sufficiently large in size. This is the inherent difficulty of a volunteer-based approach to sustainability initiatives in organisations.

Chapter 5: The future of sustainability assessment frameworks in the Dutch public research sector

The pilot conducted by Green Labs NL focused on one assessment framework, LEAF, and its usability in the Dutch public research sector. The report shows that the use of this framework was met favourably by lab users and has been, in some organisations more than others, a success. From this experience, we can distil several lessons for the future of sustainability assessment in this sector. We argue that frameworks that are adopted in the Netherlands in the future for the assessment of sustainability should follow these guidelines.

This is especially important if Dutch science governance actors decide to include sustainability assessment as part of the *Strategy Evaluation Protocol*, or if sustainability assessment becomes a requirement for research funding. When this happens, one can expect new frameworks to emerge rapidly due to increased demand, including from large commercial companies. These guidelines aspire to help organisations to select a framework that is fit for their purpose and to avoid a number of pitfalls.

1. Support cultivation of sustainability as a quality of research through sustainability assessment frameworks

Sustainability within research is a relatively new concern for most members of the scientific community, beyond those involved in the green chemistry movement. There is little established knowledge about how to organise research in a more sustainable manner and sustainability is not a quality students learn to cultivate in their education. Hence, to organise science more sustainably, researchers need guidance, which sustainability assessment frameworks can offer. Respondents we interviewed have reported that a few of the bronze action points in LEAF were things they had not thought about previously, cleaning filters and heating sources of appliances being the most important one. Sustainability assessment frameworks and the guidance offered on how to approach actions are crucial for researchers to cultivate sustainability as a quality of their research. Just like we support members of the scientific community to conduct research in a rigorous manner, conducting research in a sustainable manner is a goal that needs, and deserves, support.

2. Prevent goal displacement

LEAF offers users a bronze, silver or gold certificate when the appropriate actions have been undertaken. This certificate can be used to show the outside world that the group takes sustainability seriously and might instigate other groups to do the same. As such, certification can play a positive, stimulating role in mainstreaming a more sustainable science. However, there is also a clear threat of goal displacement. Similar to the

Journal Impact Factor, the certificate itself can become the goal rather than the aim to develop a more sustainable research practice. Such goal displacement can be seen around the use of performance metrics in science (de Rijcke et al., 2016), and it might also occur when sustainability assessment becomes institutionalised. It is important to remind organisations and researchers that the certificate is not the goal of the exercise.

3. Open and inviting (local) audit process aimed at learning and not monitoring

Relatedly, the audit process of LEAF is currently an open process, conducted in the organisations themselves with the aim to support learning and provide constructive feedback. Due to the voluntary nature of adopting LEAF, which currently happens primarily in research groups that are motivated to increase their sustainability, the peer-audit process has a natural fit. When sustainability assessment becomes increasingly mandatory, it is important to continue to stress the goal of learning how to do things better through the audit process, and not to restructure the process with a more superficial aim to simply 'monitor uptake'. If engagement from the auditor is not substantive, there is a real threat that the engagement of the researcher will also not be substantive, and sustainability assessment will simply become another hoop to jump through.

4. Offer institutional support

As sustainability is a newly emerging quality of research, the knowledge base of researchers is limited. Respondents explain that they are in need of guidance on best practices and want insights into the latest research on what can and cannot be done (e.g. "do my samples survive in the freezer at -70 degrees or do I need to leave it on at -80 degrees?"). Moreover, some complex action points require institutional support to change practices across a building or faculty, and often involve other organisational departments such as facilities or waste management. As such, the introduction of sustainability assessment frameworks in an organisation requires institutional support in the form of knowledge, a dedicated sustainability manager to direct questions towards, and in the form of managerial support to take action at higher levels in the organisation when this is necessary, for instance related to waste flows, building energy maintenance or sustainable procurement.

5. Allow for community feedback and local specificity

To foster an open and reflexive engagement with sustainability, it is crucial that the assessment framework is designed to allow for feedback and local specificity. Due to the specific and varied nature of research, we find that what is possible in terms of sustainability depends on the research practices researchers engage in. LEAF offers

the opportunity for administrators to add local guidance to criteria. In this way, one could add guidance on what is possible in labs with specific safety concerns such as the ones that work with radioactive materials. Moreover, the developers of LEAF engage with administrators to update criteria, add new universal guidance, and discuss other developments of the framework and online environment. Such openness and flexibility of the assessment framework again supports an in-depth tailored engagement with sustainability, which is much more beneficial in this context than a 'one-size fits all' approach to increasing sustainability.

6. *Non-commercial providers*

Lastly, there is no reason to leave the development of sustainability assessment frameworks to commercial providers. The open science push for open-access publications shows the costs of relying on a commercial infrastructure for publishing scientific results. Concerning research information, a member of the *Universities of the Netherlands* taskforce on the *Responsible Management of Research Information and Data*⁵ has highlighted that the open access deal with Elsevier puts crucial information about Dutch research in the hands of a private company (de Rijcke, 2020⁶). It is crucial that the development of sustainability assessment frameworks for public research organisations remains in the hands of not-for-profit organisations. Science governance actors like Universities of the Netherlands, the Royal Netherlands Academy of Arts and Sciences (KNAW), research funders and the Ministry of Education, Culture and Science can enable this directly by supporting the development of a Dutch sustainability assessment framework or indirectly by providing guidance to public research organisations.

⁵<https://www.universiteitenvannederland.nl/files/documenten/Domeinen/Onderzoek/Open%20access/Engelstalige%20samenvatting%20opdracht%20werkgroep.pdf>

⁶<https://www.leidenmadtrics.nl/articles/s-de-rijcke-cwts-leidenuniv-nl>