**Sustainable Science and the**

**Laboratory Efficiency Assessment Framework (LEAF)**

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As the need for action to tackle the climate and ecological crises intensifies there has been an increasing focus on sustainability in science. UCL’s LEAF programme provides a proven framework for delivering sustainable and reproducible laboratory based research. Adoption of the LEAF framework by UK universities could deliver an estimated £50m saving annually and reduce carbon emissions by 42,000 tonnes/yr (equivalent to planting over 600,000 trees).

**Introduction: Sustainability in Science**

Society relies on the research and innovation sector for solutions to address global challenges, from the climate emergency to biodiversity loss and pandemics. Much of this vital research takes place in laboratories within research institutes and Higher Education Institutions (HEI). However, with the growing urgency to mitigate our impact on the natural environment, we must also recognise the significant environmental impacts of laboratory-based research.

In 2019, the UK made the commitment to achieve net-zero emissions by 20503. Alongside this it has committed to increasing investment in research and development (R&D) from 1.7% of GDP (2016) to 2.4% (2027), representing an increase in public and private R&D investment by as much as £80 billion over the next 10 years4. As part of the upscaling of UK R&D research we have the opportunity to adopt sustainable science methods, making efficient research the norm.

Environmental Impact of Laboratories

Laboratories are resource intensive; utilising significant amounts of energy and water to operate equipment and maintain environmental conditions (a typical lab will consume 3-10 times more energy per m2 than standard office spaces2). As an example; one typical ultra-low temperature freezer used to store samples will consume as much energy as the average household, and institutions can possess hundreds if not thousands of these freezers.

Sustainable science though is not just about reducing energy and water use, the embodied carbon from manufacturing lab consumables and equipment is the largest source of laboratory carbon emissions5. In 2014 it was estimated that 1.8% of the world’s plastic waste1 originated from lab spaces; a single researcher in a tissue culture lab can easily use over 200 kg of single-use plastics a year. Furthermore, laboratories are constantly being constructed and refurbished for new and alternative uses, which in itself is extremely carbon-intensive.

Likely the largest but most undiscussed environmental impact of science relates to the reproducibility of research. “The Crisis in Reproducibility” is a challenge to research methods and communications, as publications are undergoing renewed scrutiny for their replicability. This crisis though also represents a massive sustainability challenge, as unreproducible work is essentially a waste of resources. Unused data and samples also may represent waste in terms of server space and cold storage. Thankfully both research quality and sustainability issues can be largely addressed by simple good-practice measures.

**Why isn’t sustainable science common practice?**

A key challenge to integrating sustainable practices into laboratory environments is the lack of incentives. In most laboratories energy and water costs are typically embedded into wider institutional space charges, removing both transparency and the financial incentive for choosing equipment with the lowest life cycle cost but higher upfront costs. In the grant application process, there are currently no environmental requirements to drive the modernisation and integration of sustainable laboratory practices, though some are being investigated.

Unlike carbon-intensive domestic equipment like refrigerators, there are no standards or means of comparing the sustainability performance of science equipment. Manufacturers provide data but regularly vary their testing protocols making comparisons challenging. In terms of consumables (such as pipettes, test tubes and petri-dishes) single-use plastic items have become the norm. Crucially, almost no life-cycle carbon assessments are conducted on any materials entering a lab, presenting a challenge to making informed purchasing decisions.

**LEAF – A standard for sustainable science**

The Laboratory Efficiency Assessment Framework (LEAF), developed by UCL, is a programme to drive sustainability within laboratories. Initiated in 2018 as a 2-year pilot programme, LEAF was developed through the collective input of at least 20 institutions. Hundreds of researchers and technical staff were engaged in developing LEAF’s contents, honing the requirements to maximise impacts. Participants in the programme can strive to achieve a Bronze, Silver or Gold level depending on how many sustainability changes they implement in their laboratory.

The LEAF programme comprises the following:

1. ***The Framework (online)*:** This consists of actions relating to reducing waste, travel, energy, water, procurement and consumables, and improving research quality which laboratory users can implement. Each action is supported by a rationale and evidenced guidance.
2. ***Calculators (online):*** These tools enable lab users to roughly calculate the current sustainability performance of their lab and track improvements as they implement changes.
3. ***Toolkit***: To support and optimise the implementation of LEAF, a toolkit of materials has been developed:

* LEAF Process Guide: Outlining a process of supporting LEAF with minimal facilitation for institutions unfamiliar with sustainable lab operations.
* LEAF Auditing Guide: Providing recommended processes for assessing laboratories against the LEAF criteria.
* LEAF Auditing Form: Providing a pass/fail target for each criteria.
* Technical Guides: Sustainable Equipment and Consumables Guides. These provide the necessary technical guidance on how to operate equipment and utilise consumables in as sustainable manner as possible.
* Further Supporting Resources: Users will find further supporting resources including posters, stickers, inductions and departure form templates.

*Who is LEAF applicable to and how?*

LEAF is applicable to individual laboratories as well as entire institutes, and can be implemented by lab users such as technical staff, lab management, researchers and students. It is user-friendly and not time-intensive. According to those surveyed, LEAF takes only 1-10 hours on average per year to complete.

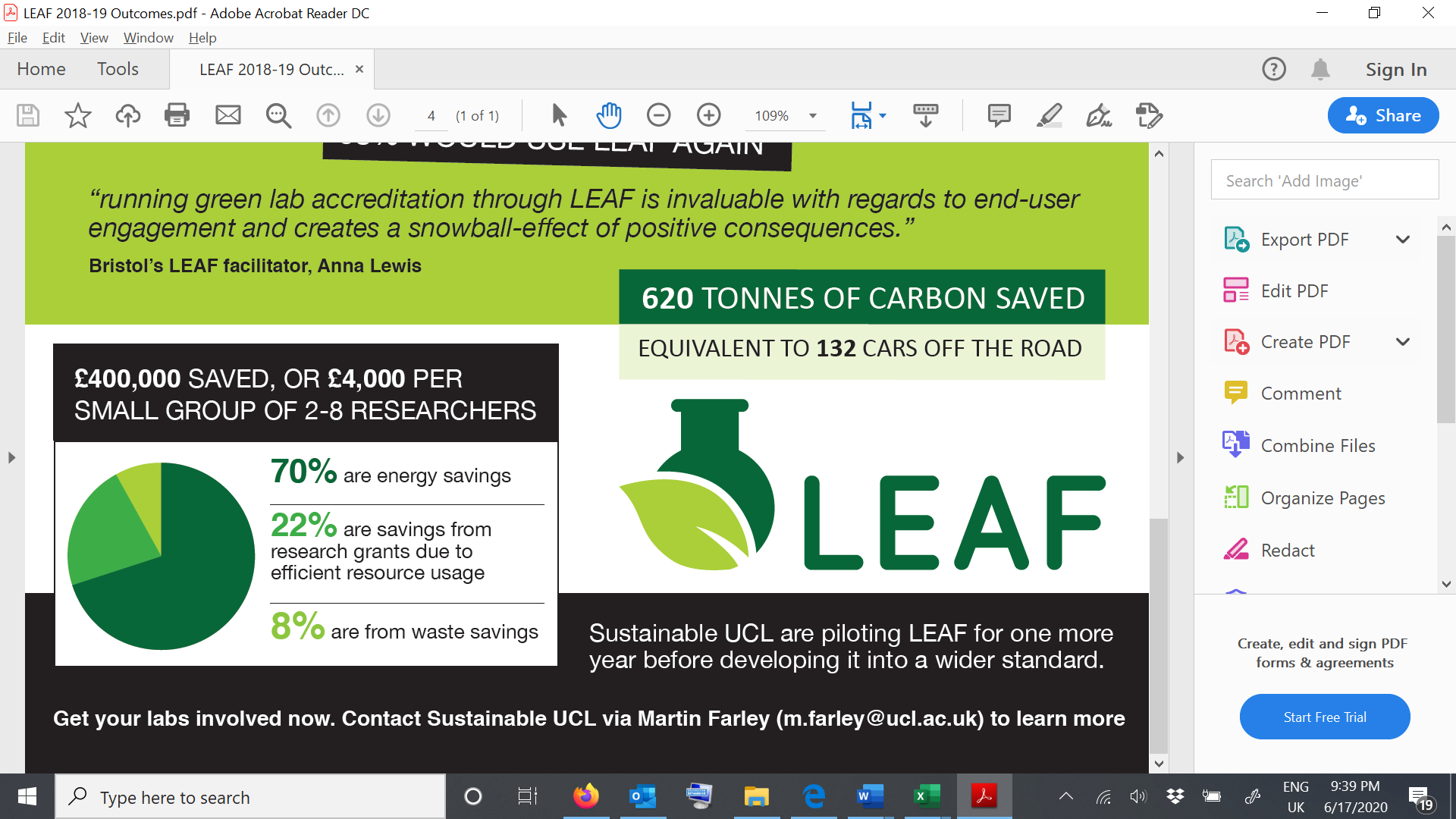
To implement LEAF, each institution should:

* Select liaison(s) to act as points of contact internally and to communicate with UCL.
* Enrol onto the online tool, individual labs register to access the framework and calculators. Labs complete the actions for their sought award level (Bronze, Silver or Gold).
* To assess what sustainability improvement has been made each institution decides on an audit process which suits their setting (e.g. utilising peer-to-peer audits, or having an audit group).
* Certificates are provided to successful laboratories. While most institutions implement LEAF on an annual basis, this may be varied as institutions see fit.

*Additional Benefits*

In recognition that reproducible science is sustainable science LEAF contains action criteria which address reproducibility and research quality as key efficiency targets. The UK Reproducibility Network (UKRN) supported UCL in developing these criteria, and continue to promote LEAF as a means of improving conditions for quality research. LEAF also facilitates technical career development and improved collaboration between various staff groups, and is now supported by the National Technician’s Development Centre (NTDC).

In standardising the processes, criteria, and quantifiable outcomes, the LEAF programme facilitates benchmarking and scoring for laboratory sustainability. This in turn permits organisations to identify opportunities to increase efficiency and record examples of good practice.

**LEAF Year-1 Pilot, 2018-19 - Results**

In 2018-19, LEAF was piloted in 16 institutions including Imperial College London, the University of Cambridge, King’s College London, and the University of Manchester. In total 103 individual laboratory groups submitted for accreditation under the LEAF programme.

**What were the benefits for labs taking part in LEAF?**

Across the pilot participating institutions saved £400,000 from implementing LEAF. The chart to the right provides a breakdown of the source of these savings. On average each research group saved £4,000. The majority of recorded savings derived from energy efficiencies (70%), as these savings are the most easily recorded by the calculators. 22% of savings were derived from grants and reduced purchasing, for e.g. repairing equipment as opposed to buying new.

Current estimates do not include the carbon impact of reduced purchasing, due to a lack of any life-cycle carbon reporting on laboratory consumables or equipment.

**Qualitative Feedback**

Following the first pilot year, an anonymous survey was sent to both facilitators and users of LEAF. 47 users and 12 facilitators took part, the feedback on the scheme was overwhelmingly positive; in particular:

* 98% would use LEAF again
* 68% felt using LEAF improved their career development
* 49% had never participated in a sustainable lab programme before
* 74% said LEAF drove new sustainability actions and wasn’t a validation of existing practices
* 85% users and facilitators found that LEAF required 10 or less hours per year

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**LEAF Year-2 Pilot, 2019/20 COVID-19 Response**

Due to COVID-19 pandemic the return of results for 2019/20 results were delayed until September 2020. While initially 35 institutions registered for the pilot, 12 institutions were able to submit due to facility closures associated with the pandemic. Supporting documents and guidance were reviewed and updated to facilitate a successful remote-process, and actions were adapted to suit new working arrangements.

Users from the 2nd year of piloting provided qualitative feedback via a shortened survey, with responses summarised as follows:

* 100% would use LEAF again
* 100% found the number of criteria just right
* More time was spent accomplishing LEAF this year, with 60% of users reported it taking at least 10 hours to complete. This is likely due to the increased challenges of administrating a programme during a shutdown.

**Final Pilot Results**

In summary, LEAF was piloted across 23 different institutions in over 230 different laboratory groups. On average each group reported that by taking part in LEAF they saved £3,700 and 2.9 tCO2e. In total we estimate that £641,000 and 648 tCO2e were saved, the equivalent to 140 passenger vehicles off the road in a year. With 99% reporting they would reuse LEAF, the imperative was provided to make it more widely accessible.

**LEAF 2021 – Online Launch & Update**

UCL launched an online version of LEAF in January 2021, to improve user accessibility and enable institution and sector-wide reporting. The online version will provide:

* The actions for lab users to take
* The calculators
* Reporting functionality
* Access to resources & support
* Low administration form of peer auditing

UCL is currently exploring options to support LEAF long-term. Sustainable UCL receives regular correspondence from institutions around the world (both private and public) to access LEAF. We expect LEAF to be piloted in countries beyond the UK in 2021, including Australia, Austria, Ireland, Germany, and Denmark.

**LEAF & Sustainable Science - Sector-wide impact**

When initiating LEAF at UCL in 2017, the programme outline and its potential impact was assessed and presented to the Department for Business, Energy & Industrial Strategy (BEIS). It was estimated that the UK research sector stands to annually save £50,000,000 sector-wide if sustainable lab practices were made standard. When weighing the potential impact to the sector with the low running costs of a national LEAF programme, and considering the rise in environmental challenges, we feel the time is right for the initiation of a UK standard in sustainable laboratory operations.

With support from funding bodies and research bodies, sustainable lab practices could be seamlessly integrated into research practices, saving millions and helping the UK and world achieve stated carbon targets. This could be achieved through:

1. Recognition and tracking of the sector’s sustainability strategies
2. Integration of LEAF concepts into student education and existing technical training
3. Recognition of sustainability achievements for early-career researchers
4. Uptake of the LEAF process within funded laboratories
5. Standardisation of sustainable science targets, guidance, training, and support

**References**

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