Draft cover

Sartorius Lab Water

Final title TBD by Sartorius

Expert Insights

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Contents

Introduction

Scientific research addresses many pressing challenges in society. However, scientific research also consumes many resources and energy. Governments and organizations are urging actions towards sustainability to diminish the frequency of extreme weather events, lower transmission of infectious diseases, and maintain water security. In comparison to the same-sized office space, research laboratories have a large environmental footprint, consuming 5- to 100-fold greater amounts of energy.

Life science research laboratories also consume 1% to 2% of global plastics, as well as many chemicals and consumables such as purified water while running equipment. Numerous concerned researchers and senior-level management are implementing strategies that conserve energy and resources while maintaining the health of workers and the quality of research. Increasing energy efficiency and reducing waste also provide cost savings which are repurposed to support research activities. The main topics for increasing the sustainability of laboratories include water conservation during the purification or sterilizing of equipment, efficient energy usage, waste reduction beyond common recycling programs, decreased impact of procurement, and moderation of the carbon impact of annual international conferences. In addition, improving sustainability also involves motivating coworkers to reduce their laboratories' environmental footprints and sharing the knowledge with the scientific community. Furthermore, research facilities can promote sustainability in the entire facility with adjustments in one or more of the six areas such as energy generation or repurposing lab supplies and equipment. For example, they may provide a database of surplus equipment and/or reagents for laboratories to procure items, save capital, and reduce waste.

The accompanying article from Durgan et al. initially describes the environmental impacts of humans including pollution, climate change, biodiversity reduction, and habitat destruction. It subsequently highlights the large environmental footprint of scientific research due to the high energy usage and resource-intensive activities of laboratories. Because scientists understand these complex interactions and seek solutions, scientists and their facilities can reduce their environmental footprint in their own laboratories and experience cost savings. This accompanying article provides strategies and resources to encourage scientific colleagues to initiate, plan, discuss, and implement one or more readily available measures to increase sustainability in their laboratories.

Durgan *et al*. share insights on initiating a sustainability program at a research facility and implementing one or more of the numerous available solutions that can reduce energy usage and/or waste. They discuss how several scientists organized and motivated teams at their three laboratories, inspired suggestions from colleagues, and implemented several improvements. The main topics ranged from increasing energy efficiency to reducing waste, water usage, and the impact of procurement. In addition, they discussed the engagement of senior-level management and provided references to numerous resources. Additional strategies to promote sustainability in the entire facility were also presented.

Through the methods and insights presented in this article, we hope to educate researchers on new technologies, techniques, and approaches to sustainability. Considerations for choosing corporate vendors can include their ambitions and progress in improving water and resource utilization, efficiency of their manufacturing and designed end-products, sustainability of consumables, reduced impact of procurement, corporate mission statement, and commitment to continual improvement. To gain a deeper understanding of available options for improving the sustainability of your research, we encourage you to visit Sartorius.

Kathy Molnar-Kimber, Ph.D
Scientific Writer at Wiley

Green Labs: A Guide to Developing Sustainable Science in your Organization

Adapted from Durgan *et al.*, 2023

Scientific research benefits society by investigating many fundamental issues and providing a spectrum of approaches that can diminish or solve many of the challenges. However, research also consumes much energy and resources. This article explores various ways for research organizations to make scientific research more sustainable by sharing useful resources and reducing energy usage. These efforts can ultimately lower environmental footprints.

Introduction

Society and the environment are impacted by pollution, habitat destruction, climate change, and loss of biodiversity. Predictions of food shortages, extreme weather events, increased transmission of infectious diseases, and water insecurity are motivating governments and organizations to work towards sustainability. Many scientists are realizing that research laboratories with their equipment can consume 5- to 100-fold greater amounts of energy than the same-sized office space. Furthermore, yearly plasticware consumption by life science research is approx. 5.5 million tons and represents 1% to 2% of global plastic use. Laboratories also use and deplete chemicals, various materials, and consumables such as purified water. Many modifications that reduce emissions, pollution, and energy usage also provide cost savings [1]. Here Durgan *et al*. share insights on initiating sustainability programs at three lab facilities and implementing one or more of the numerous available solutions that can reduce energy usage and/or waste.

Deciding to Act

Implementing energy and waste reduction measures is easier in familiar environments, including workplaces. Numerous opportunities exist for enhancing sustainability and achieving cost savings in the laboratory setting by implementing available solutions. For example, actions for the lab can focus on energy and water conservation, waste reduction, local procurement of reagents whenever possible, and use of less toxic chemical precursors, reagents, and reactions (Fig. 1) [2–4]. In addition, the employer can help promote sustainability by encouraging low-input commuting activities such as public transportation and cycling, choosing local and central venues for conferencing or video conferencing [5], cafeteria meals using local foods, larger areas of natural landscaping, and energy-efficient communication formats (Fig. 1). Your insights combined with your existing network may help identify promising sustainable practices.

Figure 1

Key areas for improving sustainability in research laboratories (left) and the broader workplace (right).

Although many biomedical scientists may consider a side journey into sustainability as daunting, they can find many resources in articles, reports, schemes, podcasts, and books (Fig. 2). Networks such as Lean Efficiency Action Network (LEAN), Sustainable European Laboratories network (SELs) and Green Labs [6] also offer excellent training opportunities and courses on enabling increased sustainability in scientific laboratories. Since businesses and organizations often vary in their management structure and functions, employees who desire to increase the sustainability of their organization should consider adjusting the persuasive arguments to fit the personalities, culture, and decision-makers in their organization.

Figure 2

ARTICLES

- Sustainability (1. 2, 3, 9, 15, 16)
- Sustainable science (18. 19, 20, 24, 27, 53)
- Lab waste (22, 54, 55, 56, 67)
- Computing (57)
- Conference Travel (58, 68, 69)

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- Silent Spring, Rachel Carson (40)
- The Limits to Growth, Meadows, Randall & Meadows (41)
- This Changes Everything by Naomi Klein (42)
- The Great Derangement by Amitav Ghosh (43)
- There is No Planet B. by Mike Berners Lee (44)
- The Uninhabitable Earth by David Wallace-Wells (45)
- The Future We Choose by Figueres & Rivett-Carnac (46)
- The New Climate War by Michael Mann (47)
- How to Save our Planet by Mark Maslin (17)
- Reconsidering Reparations by Olúfémi O. Táíwò (48)
- A Bigger Picture by Vanessa Nakate (49)
- The Nutmeg's Curse by Amitav Ghosh (50)
- The Climate Book edited by Greta Thunberg (51)
- The Ministry for the Future by Kim Stanley Robinson (52)

NETWORKS

- Sustainable European Laboratories network (SELs), Laboratory Efficiency Action Network (LEAN). GreenLabs ND, Green Labs Austria. Labos 1point5. MPI Sustainability, Green Labs Portugal. Green Labs Ireland

Selected resources for learning about environmental issues and sustainable scientific research. Reference numbers refer to the reference list of the original article by Durgan *et al*.

Recognizing employee actions that enhance sustainability often increases the engagement of these employees who then provide additional suggestions. For example, the kitchens at EMBL Heidelberg routinely prepare sterile reagents, thereby avoiding the transport and procurement of 350 bottles per week from outside vendors. After recognition, they recently initiated a new recycling program. Secondly, the EMBL Scientific Instrument Maintenance Team salvages and fixes laboratory equipment, reducing landfill waste. Since acknowledgment, they have begun several energy-saving programs in their group. Governments may also provide incentives, and journalists may amplify goodwill news articles that encourage businesses to implement sustainable practices and install new equipment.

Build a Diverse Team

A diverse team can tap the expertise of engineers, health and safety professionals, waste managers, finance, communication, and scientists of different disciplines and roles (research assistants, department chairs, postdocs, and students). Due to its diverse perspectives and interests, the team can propose, plan, and implement multiple activities that enhance sustainability. Evolving the volunteer team into an organized committee with quarterly meetings, structured agendas, minutes, and action points can facilitate decision-making, initiation of sustainable actions throughout the facility, and promote effective interactions with senior staff that influence business policies. On a practical level, the involvement of senior staff can help secure the needed expertise and investment funds for new actions.

Organize and Plan your Action

Many groups insist that actionable modifications maintain or improve the health and safety of workers, and conserve research quality including data interpretation and adequate statistical power calculations. Figure 1 summarizes the research laboratory and other work-related activities considered for improvement of sustainability by Green Labs and analogous organizations. The important topics for sustainability in laboratories include (i) energy efficiency (generation, temperature settings, switching off of lights, equipment); (ii) waste (reducing, reusing, recycling of chemicals, consumables, organic waste; repairing equipment); (iii) water (reducing consumption, matching water quality to task, responsible contaminant disposal); (iv) procurement (managing impact of the supply chain, choosing local suppliers when possible); and (v) engagement (establishing a team of knowledgeable colleagues and coworkers, sharing wisdom with the wider community).

In addition to online resources, the team's expertise, and networks' advice, Durgan *et al*. recommend encouraging suggestions from all staff, as staff often propose novel actionable solutions for their area. Rigorous monitoring is most informative but is often too costly or time-consuming. Durgan *et al*. use simple energy monitors whenever feasible and extrapolate the estimated cost savings. Challenges that may need to be resolved include time constraints due to current team members' primary roles, funding for new equipment, and logistics (e.g., space for new equipment to facilitate recycling).

An alternative or additional strategy is to develop a Materiality Assessment that identifies the business' 10 most significant environmental issues by using an established process such as the Delphi Method with internal and external stakeholders.

Examples of Action

Energy

The Trigeneration system at Babraham Institute (BI) (Cambridge UK) produces heating, cooling, and power, saving more than £1 million in 3 years and reducing emissions by almost 2500 tCO_2. At EMBL, the ambient temperature in data centers, where heat-generating computers are kept at constant temperatures, was increased from 20°C to 24°C to reduce cooling costs.

Water

Heavily used autoclaves at BI were retrofitted with a system that provides recirculating chilled water and saves approx. 32,000 L water each week. Installation of water misers for autoclaves reduced water usage by up to 90% [3].

Generating the needed purity of water for the application with in-house water purification systems avoids transport and saves energy. Water purification systems for Type 1 ultrapure water (mass spectroscopy, chromatography); Type 2 water (media and buffer preparation); and Type 3 water (standard laboratory applications) can be obtained from Sartorius [7]. Using the lowest grade water appropriate for the task saves energy. The Arium advance reverse osmosis system uses iJust software which monitors feed water and adjusts the process, saving between 13,000 to 48,000 liters of reverse osmosis water per year.

Waste

Reducing the volume of packaging, reusing lab furniture, repairing equipment whenever possible, composting non-toxic shellfish waste, and recycling paper, glass, metal, wood, and printer cartridges reduces landfill costs [1,2]. Implementing green analytical chemistry procedures reduced hazardous waste by 23% [2]. A surplus equipment and reagent database can enable laboratories to reduce waste and save capital [1].

Consumables

Recyclable consumables and minimal packaging are preferred. Since transportation and generation of reagents consume energy, supply chains with local suppliers are favored over those with distant suppliers.

Communicate Effectively

After discussions, a good approach for requesting procurement of sustainability-enhancing equipment is to submit a clear, concise, evidence-based justification in the relevant document format for your organization.

Summary

Scientific research elucidates the foundational knowledge and can discover inventions that benefit society. However, laboratories consume many resources and energy. Multiple examples that improve sustainability described the practices that led to cost savings of more than £300,000 per year, energy reduction, water conservation up to 90%, and reduced waste stream. The resources and practical tips on building a team, planning actions, and requesting modifications can help increase sustainability at your facility and its laboratories. Furthermore, purchasing reagents and equipment from companies that design and manufacture products using sustainable approaches amplifies the sustainable goals of the research community. To attain a greater perspective on available options that augment the sustainability of your research, we encourage you to visit the Sartorius website [8].

References

[1] Dolgin, E. (2018). How going green can raise cash for your lab. *Nature*. DOI: 10.1038/d41586-018-01601-5.

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[8] Sartorius. (2024). Driving environmental sustainability in the biopharmaceutical industry. Accessed Mar. 14, 2024. https://www.sartorius.com/en/pr/sustainability-collection.

SARTORIUS

iJust Software

Technical Note

Scope
High product water quality obtained by balancing the needs of ecology and economy:
- More efficient recovery rates of purified water
- Economic control of cleaning cycles
- Less energy used by rium® lab water systems with an integrated electrodeionization (EDI) module.

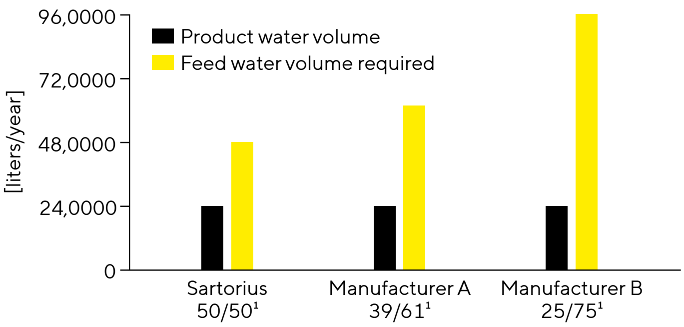
The iJust software installed in all Arium® advance and Arium® comfort systems optimizes the performance of reverse osmosis technology. To ensure the best possible performance, inlet water, also known as feed water, needs to be tested usually only once by a Sartorius technician to determine the hardness and CO_2 content. Afterwards, these values are saved in the Arium® system.

In areas where the water changes seasonally, we recommend regular testing and adjusting of the iJust settings to match the feed water chemistry. Based on the values saved, iJust selects the operating parameters that ensure not only high product water quality but also ecological use of your resources. In addition, iJust controls the cleaning cycles in the most economical way, adapting their frequency to the quality of your laboratory's feed water. As a result, 50% fewer cleaning cycles are needed per year. This has a positive impact on the ratio of product water delivered to the feed water volume required for purification.

Moreover, iJust takes the CO_2 content into account, minimizing the energy consumed by Arium® systems with an integrated electrodeionization (EDI) module.

The economic benefits that iJust provides by saving feed water usage are shown in Figure 1.

Figure 1: *Water Usage in Comparison With Other Manufacturers' Systems and Potential Savings With iJust*



[1] Ratio between product water and concentrate water

An Arium® advance RO system that requires 24,000 liters of feed water annually, or around 100 liters a day, saves between 13,538 liters and 48,000 liters of reverse osmosis water per year, depending on the particular model you use.

The technical terms important for understanding how iJust software works, such as product water recovery, rejection rate and the effects of CO_2 and water hardness, are explained in the following.

Significance of Feed Water Hardness

The water hardness of your feed water saved in an Arium® unit defines the ratio of concentrate water and product water. The softer the feed water, the less concentrate water will be rejected.

Beyond this, water hardness influences the number of cleaning cycles. The softer the feed water, the less frequently RO modules need to be cleaned. This reduces the time and effort required for care and maintenance.

Product Water Recovery Rate (Yield)

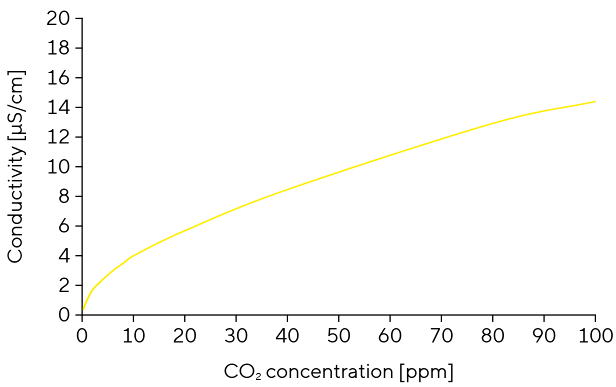
The proportion of the product water delivered to the concentrate water rejected is designated as recovery rate or yield. If iJust is not activated, the recovery rate will consistently remain at 40%; i.e., 40% of the inlet water is fed into the Arium® bagtank and 60% will be rejected as concentrate. For soft feed water with a low conductivity, the recovery rate is 50%. In the case of hard feed water, the ratio of product water to concentrate water is 25% to 75%.

The Effect of CO_2

The conductivity of water is affected by the CO_2 content, which can regionally differ. CO_2 is not retained by an RO membrane and thus has a considerable impact on the conductivity of product water (see Figure 2).

As iJust uses the conductivity of the feed and product water and the CO_2 content to calculate the salt rejection rate, this actual rate is displayed on Arium®. The formulas described below explain how the salt rejection rate is calculated.

Figure 2: *Correlation Between the CO_2 Content and the Conductivity in Water*



Considering CO_2 has a positive impact on controlling the energy consumed by the EDI module. When an Arium® system is started up, iJust uses the manually saved CO_2 value to quickly regulate the current input to an optimal value. If the CO_2 value is not saved, it will take several hours until the EDI module can operate at an optimal energy level. As a result, the module will consume more energy during this time.

Salt Rejection Rate (Retention Rate)[2]

Besides optimizing the yield of purified water, iJust ensures accurate display of the rejection rate. This term denotes the percentage of salt retained from the feed water and removed from the product water; i.e., the percentage of salt retained by an RO membrane. The effect of iJust on the salt rejection rate is illustrated by the following formulas:

Calculation of the rejection rate without iJust:

$$\frac{LEF - LER}{LEF} \times 100$$

Calculation of the rejection rate with iJust:

$$\frac{LEF - LER + CO_2\ \text{correction factor}}{LEF} \times 100$$

LFF = conductivity of feed water

LFR = conductivity of reverse osmosis water

The rejection rate usually lies between 95% and 99%, and also depends on the water temperature. The warmer the feed water, the lower the salt rejection rate.

[2] The term commonly used for describing the performance of a membrane in collecting substances on its surface is retention rate. However, this term is not used within the context of reverse osmosis for removal of salts. Retention by RO membranes is referred to as "rejection," although this word actually means to rebuff, to repel or cast off.

Health and Well-Being

One of the Most Urgent Global Sustainability Topics is at the Core of the Sartorius Business Model

Since its foundation, Sartorius' technologies have contributed to speeding up medical progress, so that more people have access to medicine.We aim to champion sustainability by implementing sustainable practices in our own operations, engaging with our business partners and providing products that help our customers to prioritize sustainability.

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Climate Action

Ambition

Sartorius aims to reduce GHG emissions in relation to turnover and gradually decouple them from economic growth.

Strategic Targets

Ø-10% CO_2eq emission intensity p.a. by 2030 (to 2019 | covering scopes 1–3).

- Scope 1 & 2 zero avoidable emissions in 2030[1]

Commitment to extending the 2030 targets with targets approved by the SBTi

Commitment to net-zero GHG emissions for scope 1, 2 and 3 by 2045

1 Process emissions generated during membrane production are currently deemed unavoidable based on the technology available at present.

Social Responsibility

Ambition

Sartorius is committed to upholding human rights and labor standards that include the UN Guiding Principles on Business and Human Rights and the International Bill of Human Rights in its sphere of influence.

Roadmap Highlights

- Increase percentage of women at both levels of management below the Board to around 30% was clearly exceeded:
- First level standing at 50%
- Second level at around 29%

Water & Effluents

Ambition

Sartorius aims to further improve water efficiency in its operations. Water is primarily used in the BPS Division for membrane production and modification. The manufacturing processes for membranes and membrane products are optimized to minimize the use of rinsing water. Organic solvents are processed and for the most part, recycled.

Corporate Governance

Ambition

Corporate governance aligned with the interests of stakeholders, lawful and responsible conduct, and constructive collaboration between the managerial bodies and within the company in a spirit of mutual trust constitute the essential cornerstones of Sartorius' corporate culture. The corporate governance statement and declaration of compliance can be found in the annual report.

Resources & Circularity

Ambition

Sartorius aims to continuously optimize the selection and use of all materials along the value chain and decouple economic growth from resource depletion and environmental pollution. Transforming our business following circular economy principles in minimizing waste, optimizing resource use and creating a system where products and materials are kept in circulation through processes through innovative ecodesign, responsible sourcing and collaborative partnerships.

Supply Chains

Ambition

Sartorius fosters sustainable and responsible corporate behavior not just in its own operations but all along the value chain. We engage with suppliers and expect them to comply with applicable sustainability standards.Sartorius fundamental sustainability requirements are laid out in the Code of Conduct for Business Partners which has been binding for new suppliers since 2019.

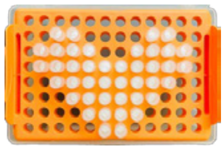
SARTORIUS

Sustainable Laboratory Essentials

Optifit and Safetyspace Pipette Tips

Sustainable Laboratory Essentials

Pipette tips are indispensable in labs. The Optifit standard tips offers versatility with various purity levels and packaging options, while Safetyspace filter tips are presterilized, featuring a unique SafetySpace gap design to prevent sample being absorbed to the filter for the high-purity demanding applications.



Innovative Manufacturing in Kajaani, Finland

- Tip production Facility operates on 100% renewable energy ever since XXXX
- LED lighting
- The plant's waste heat is used for facility heating
- Only XX% of the annual production plastic becomes waste
- Production plastic waste is locally recycled and repurposed for other plastic products
- Total recycle rate of the entire production site is 98%

Packaging with Purpose

- We offer a variety of packaging options, including eco-friendly Bulk and Refill choices that reduce waste.
- All our cardboard packaging is 100% recyclable and additionally contains up to 70% recycled content, depending on the product packaging.

Optimized Distribution

- Packaging design for better shipping efficiency, reducing the number of shipments
- We prioritize overland and maritime freight

DRAFT

The ACT Label Commitment

ACT. The Environmental Impact Factor Label

- Our Refill Tower packaging has earned the environmental Eco-label, the ACT-label
- Visit XXXX for more information about the ACT-Label

Precision Design for Reduced Waste

- Sartorius pipettes and tips are designed to work together perfectly, minimizing the need for unnecessary repetitions in pipetting thereby reducing tip usage.
- Our tip boxes and trays are suitable for repeated autoclaving.
- Tip boxes and trays are compatible across our product range ensuring seamless use of refill and bulk products

Responsible Disposal and Recyclability

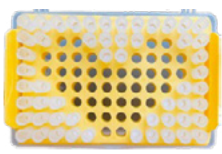
- Our cardboard packaging is fully recyclable.
- For pipette tips we encourage responsible waste management and recycling where possible.
- See product datasheet for recycling instructions: XXXXX

Commitment to Continuous Improvement

Sartorius is dedicated to ongoing sustainability efforts, ensuring our high-quality pipette tips are produced with environmental responsibility in mind.

For more information on our sustainability initiatives and products, visit the **Sartorius Website**.

Visit: XXXX for more about tips



Further Readings and Resources

Imprint

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