Fonds de recherche du Québec

Nature et Technologies Santé Société et Culture

Environmental responsibility in Research: Findings, Solutions and Impacts

Intersectoral Student Committee

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The English version of the report is a translation of the official French version.

The Intersectoral Student Committee

The Intersectoral Student Committee (CIE) is a statutory committee common to the boards of directors of the Fonds de recherche du Québec (FRQ) – Nature et technologies, Santé and Société et culture. The committee's mandate is to advise the Chief Scientist of Québec and the boards of directors of the FRQ by identifying strategies to promote the accessibility of research funding, optimize the potential of the next generation of researchers, and enhance their influence and impact on society.

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Executive summary

In the face of the climate emergency, the research community has a duty to adapt its research practices in order to minimize their impact on the environment. This report presents the main findings of a reflection on environmental responsibility in research carried out by the CIE. It is intended for the Fonds de recherche du Québec and research institutions.

The vast majority of greenhouse gas (GHG) emissions associated with research are linked to travel, particularly air travel, often to attend conferences. Although some travel is very useful for members of the research community, especially for the next generation of researchers, some researchers say they travel to meet the demands imposed by the academic culture, which places a high value on travel. Many of the trips made by plane could also easily be made by more environmentally friendly means of ground transport.

Research can also be associated with high energy use (e.g., computational resources in artificial intelligence or modelling, as well as certain laboratory equipment) and resource use (e.g., the use of single-use items in natural science or health laboratories, which generate a significant amount of waste). In these cases as well, the obstacles to changing practices are often cultural or systemic in nature, particularly with regard to the rules governing procurement and eligible expenses.

This report looks at a number of alternatives to these practices, focusing on reducing barriers to environmentally friendly practices rather than introducing new constraints. Carbon offsets should only be used as a last resort, given their low net impact. Granting agencies and universities are particularly well placed to help bring about the necessary changes and position themselves as leaders on the issue, in addition to playing an important role in raising awareness and encouraging changes in behaviour.

The CIE also notes that younger researchers who make sustainable choices are at risk of being penalised. For example, reducing international travel could result in poorer assessments of their academic record, and using slower but more environmentally friendly analysis methods reduces the rate at which results are produced.

In light of these findings, the CIE is proposing a number of recommendations for the FRQ and research and teaching establishments that are aimed at improving the environmental performance of research in Québec while limiting the impact on the next generation of researchers and the research community.

Summary of recommendations

★★★ - *high priority* | ★★ - *medium priority* | ★ - *low priority*
🎓 - *postsecondary institutions* | $ - *FRQ*

1. Carry out a general reflection on making the ecological choice the default choice for researchers.	★★ 🎓 $
2. Launch a research initiative on sustainable research practices through the creation of an observatory or dedicated funding.	★ $
3. Provide a tool for calculating greenhouse gas (GHG) emissions for each research project funded by the FRQ.	★ $
4. Add to Section 8.1 of the FRQ Common General Rules (*Eligible Expenses, General Principles*) that the research community must consider the environmental impact of its expenses.	★★★ $
5. Initiate a concerted reflection on transforming the research community's travel habits: a. In eligible expenses, allow the use of ground transport and direct flights, even if they are more costly. b. Establish a distribution of responsibilities for establishing and monitoring environmental responsibility standards. c. Educate the research community about its environmental impact, along with granting agencies, universities, research centres and research teams. d. After an education phase, seek to implement environmentally responsible transport policies. For example, as is done by many institutions elsewhere in the world, only reimburse ground travel when travel time is below a certain threshold by public transport (bus or train) or by car, and when public transport is available and easily accessible. This rule would apply, for example, for travel between Montreal and Toronto. In continental Europe, it would apply to all destinations.	★★★ 🎓 $
6. Initiate reflection on ways of using the evaluation criteria for grant and award applications to prioritize the quality of publications and knowledge mobilization activities rather than their number, thereby encouraging research that is less production-driven and of higher quality.	★★★ $
7. Review the way in which carbon offsetting is used by the research community: a. Make the research community aware that carbon credits should only be used as a last resort, for emissions that are impossible to avoid and absolutely necessary. b. Provide accessible, simple and reliable information on the various offsetting programs, including a list of recommended programs. The FRQ could even offer to handle the purchase of carbon credits for researchers.	★★★ 🎓 $

8. Offer greater flexibility in the use of grant funding. This includes reducing constraints on the type of expenditures associated with each grant (e.g., allowing funding intended for travel or the purchase of equipment to be used for other purposes).	★★ 🎓 $
9. Promote and facilitate sustainable spending of research funds. For example: a. Lower-impact equipment, including the use of used equipment; b. Combining multiple air travel trips into a single trip, including personal travel; c. Transferring grant balances to a subsequent year.	★★ 🎓 $
10. In programs offering funding for the organization of events, amend the program rules to strongly encourage recipients to organize these events in accordance with high sustainability standards. a. Add a list of criteria for making an event sustainable and establish a threshold to be respected (e.g., offer a hybrid format in order to reduce participant travel, provide low-waste meals).	★★★ $
11. Educate researchers about the environmental impacts of their research activities.	★★★ 🎓 $
12. Encourage grant and award applicants to indicate in the “Other circumstances” section the ways in which their application is impacted by environmentally responsible choices. a. Improve the list of examples of circumstances accordingly. b. Improve existing training and documentation for evaluation committees to ensure that the evaluation process is consistent with this change. This includes training to correct researcher bias.	★★★ $

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Glossary

Research community: All researchers, in universities or elsewhere.

Environmental responsibility: Awareness of the environmental impact of certain actions and the conscious adoption of behaviours to reduce that impact.

CO_2 equivalent emissions (CO_2-eq): The amount of carbon dioxide emission that would cause the same temperature change, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. Most typically, the CO_2 equivalent emission is obtained by multiplying the emission of a GHG by its global warming potential for a 100-year time horizon (IPCC, 2018). For example, 1 kg of methane emissions has the same warming effect as 28 kg of CO_2 (MyClimate, 2023).

Environment: Set of natural conditions (biological, chemical and physical) likely to affect living organisms and human activities.

Greenhouse gas (GHG): Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself and by clouds, trapping the radiation and increasing the global mean surface temperature (IPCC, 2018).

Research practices: All the activities that make up a research process, such as data collection, data analysis and the dissemination of research. We exclude the normal operations of university infrastructures and daily travel (e.g., to reach the laboratory where data are collected).

Next generation of researchers: College, undergraduate and graduate students carrying out research activities or showing an interest in research training; postdoctoral fellows; people who have recently ceased to be included in the preceding categories.

List of Acronyms

CIE	Intersectoral Student Committee
CV	Curriculum vitae
EDI	Equity, diversity and inclusion
FRQ	Fonds de recherche du Québec
IPCC	Intergovernmental panel on climate change
J2R	Acfas Journées de la relève en recherche
SDG	United Nations Sustainable Development Goals
UN	United Nations

Introduction

Scientific research, the driving force behind discovery and innovation, plays a vital role in meeting the major challenges facing society. The ecological crisis (decline in biodiversity, global warming, etc.) is now a key issue for the research community. The Fonds de recherche du Québec (FRQ) have positioned themselves as leaders in environmental science research. Objective 3.3 of their 2022-2025 strategic plan aims to leverage research to help achieve the UN's sustainable development goals. To that end, the FRQ offer grants and scholarships on environmental themes. Since 2021, they have been asking researchers to consider the environmental impacts of their research in their funding applications. This latter measure stems from the FRQ's *Action Plan for Environmental Responsibility in Research*, which is groundbreaking for a funding agency.

More concretely, their *Common General Rules* state that "the FRQ support sustainable development. The reuse of equipment and the purchase of used material are therefore permitted, where appropriate". The *FRQ Policy for the Responsible Conduct of Research*[1] stipulates that researchers must

> "Show respect for […] the environment — Research projects should be developed and conducted with consideration for [...] environmental responsibilities in research. The inclusion of the UN sustainable development principles in the design and conduct of research projects enriches those projects."

This policy also states that public fonds must be used in a *responsible* manner. In our view, this should include minimizing the harmful effects of research on the planet, in order to preserve it for future generations. The policy further stipulates that research must promote a climate that "maintains public trust", which also requires a minimal impact on the environment, particularly in environment-related fields. In this context, it seems essential to examine the **environmental impact of research practices in Québec.**

As we shall see in this report, the ecological impact of research is significant, from the use of plastic in laboratories to greenhouse gas (GHG) emissions associated with professional travel. Completing a doctoral degree is estimated to generate an average of 21.5 t CO_2-eq in 4 years, which is more than the average annual per capita emissions in Canada (Hertwich and Peters, 2009).

The necessary changes in practices may have an impact on the next generation of researchers. Returning to the previous examples, cleaning reusable items can slow down the rate at which results are produced, while reducing travel decreases networking opportunities and shortens the *curriculum vitae* of next-generation researchers. As well as looking at sustainable research practices, the Intersectoral Student Committee (CIE) believes that it is also important to consider the **impact of the implementation of such practices on the next generation of researchers.**

Responsibility for implementing sustainable research practices must lie not only with individuals, but above all with institutions and organizations. Granting bodies are particularly well placed to bring about a change in culture, particularly with regard to the definition of research excellence.

[1] https://frq.gouv.qc.ca/la-conduite-responsable-en-recherche/

The change in attitudes and practices that is currently underway is a further opportunity for the FRQ to show leadership on these issues, following on from the impetus given by its *Action Plan for Environmental Responsibility in Research,* implemented in 2019.

In this report, we at the CIE will present a review of the scientific and grey literature on environmental responsibility in research, incorporating the findings of interviews and consultations we carried out with the research community, including the next generation of researchers. We will also present recommendations based on these findings and on our own reflections. Our recommendations are aimed above all at *enabling* the research community to adapt or even modify its research practices to make them more environmentally responsible, by removing existing constraints and by reducing the potential impacts of the adoption of sustainable practices on members of the community.

Whenever possible, we want to avoid imposing new rules. In this regard, granting agencies can help to ensure that environmental responsibility is recognized as an inherent responsibility of all researchers. In addition, several of the stakeholders we consulted pointed out that contexts vary from one setting or field to another, meaning that the most sustainable practice is not necessarily the same everywhere. Thus, while sharing and disseminating good practices is beneficial, sustainable initiatives can be difficult to transpose from one milieu to another and should not be imposed unilaterally on the whole community.

This report is structured by theme. For each theme, an assessment of the environmental impacts and a review of existing initiatives are presented, followed by our recommendations in relation to each theme. Several sections apply mainly to research in the natural and health sciences (such as Sections 4 and 5), while others concern all disciplines (Sections 1 to 3).

This report is intended for the research community as a whole and, more specifically, for the FRQ, which have the power to implement our recommendations. However, some recommendations are also of relevance to universities and colleges and will be clearly identified as such. Finally, it is hoped that this report will inform and educate the research community about environmental responsibility issues, since it is directly affected by them. The literature review also refers to initiatives that could inspire the community and institutions to develop innovative sustainable solutions.

Overview

This section describes the steps that led to the production of this report.

1. **Review of the FRQ's position.** In 2021, the CIE carried out a review of the measures implemented by the FRQ in relation to environmental responsibility in research, as well as their levers for action on environmental protection. In particular, it took note of the *Action Plan for Environmental Responsibility in Research* announced by the FRQ in June 2019.

2. **Literature review.** The CIE then carried out a review of the scientific literature and institutional documentation on environmental responsibility in research. In particular, the following sources were consulted:
    a. Scientific articles on the environmental impacts of research;
    b. Scientific articles on solutions to these problems and their implementation;
    c. Documents describing practices implemented in academic institutions and research-related organizations (including granting agencies) in Canada and abroad.

3. **Interviews with experts.** To help align the literature review with the Québec context, the CIE conducted one-hour interviews in the summer and autumn of 2022, with (see Table 1):
    a. Québec researchers with expertise in sustainability (four experts in four institutions in two administrative regions of Québec);
    b. Project managers and environmental bodies at Québec universities (four groups, for a total of nine stakeholders at three universities in three administrative regions).

The questions asked during these interviews are detailed in Annex II. They were formulated on the basis of the literature review. They relate to the role of the various bodies in the research community in implementing sustainable practices, existing sustainable practices, obstacles to the implementation of these practices, and the possible impact of their adoption on the next generation of researchers. The findings from these interviews are presented with the literature review in each section and informed the reflections that led to the recommendations.

4. **Consultation with next-generation researchers**. The CIE consulted next-generation researchers at the Acfas Journées de la relève en recherche (J2R) in October 2022. The one-hour consultations took the form of discussion groups. Around thirty next-generation researchers took part, divided into five groups. The interview questions can be found in Annex III.

5. **Reflection and development of recommendations.** Finally, the CIE drew on these sources of information to develop the recommendations presented in this report. The recommendations are assigned a level of priority based on their ease of implementation and effectiveness. Ease of implementation was assessed on the basis of CIE members' judgment and knowledge of the milieu, while effectiveness was assessed by means of a literature review.

Table 1: Members of the scientific community interviewed by the CIE

Experts

- Professor of environmental economics
- Professor of environmental economics
- Postdoctoral fellow in climate change mitigation

Environmental managers

- Sustainable development advisor
- Professor and special advisor to the vice-chancellor of research
- Coordinator of a sustainable laboratory initiative
- Coordinator of a sustainable laboratory initiative
- Student engagement coordinator
- Sustainable mobility advisor
- Environmental Management Advisor
- Eco-advisor
- Sustainable development activities coordinator

1. Changing environmental responsibility practices

A. Literature review and findings

The environment is a subject that greatly affects the next generation of researchers. During our consultations with next-generation researchers, we found that they are reporting increasing ecoanxiety and discouragement in the face of inaction on the part of decision-makers. This is prompting many next-generation researchers to choose research topics related to the environment, but environmental considerations are not always reflected in their research practices. It even appears that a section of the community is prepared to see restrictive measures implemented, justified by the urgency of climate change, as long as the crucial balance with academic freedom is maintained.

The experts consulted noted that the motivation to improve research practices comes mainly from the new generations, but pointed out that the responsibility for initiating these changes should not fall to them. These generations do not yet have the power to change things on a systemic scale, nor do they have the material or immaterial resources to do so. Yet they will suffer the consequences of climate change far more severely than previous generations.

A large body of scientific literature focuses on how to encourage individuals to adopt new behaviours and on the influence of organizations on this process, particularly in relation to the environment. First, it must be recognised that many environmentally damaging practices involve unregulated actions the control of which is perceived as intrusive (Yuriev et al., 2020; Babcock, 2009). Changing behaviours or practices therefore often has to be voluntary (for example, using reusable glassware and recycling; Jiang, Wang and Li, 2019; Yuriev et al., 2018). At an organizational level, however, these behaviours have a considerable cumulative impact. So, despite the daunting challenge it represents, universities wishing to reduce the environmental impact of their activities should not focus solely on their own infrastructure. They must also implement policies to influence the individual behaviour of their staff (Yuriev et al., 2020; Achten, Almeda and Muys, 2013).

Sustainable innovations are most successful when they are led by a member of staff or, in other words, by someone working hands-on, while being supported by an institutional commitment (Yuriev et al., 2021). At the organizational level, three factors seem particularly important for ensuring the long-term adoption of innovations: staff leadership, managerial support and access to financial and human resources (Yuriev, et al., 2021). Targeted support ensures that new practices are implemented, while rigorous monitoring supports their sustainability.

The scientific literature clearly indicates that organizations should strive to reduce barriers to sustainable practices rather than adding new constraints (Yuriev et al., 2020). In other words, the ecological option must become the easiest, most accessible and least expensive option. This principle is entirely consistent with the opinions of the members of the university community we consulted.

Finally, awareness is an important key to the adoption of new individual and organizational behaviours. The fact that there is a debate on an issue, such as the environmental impact of air travel, helps to change practices (Kreil, 2021). For everyday actions, such as recycling or reducing water and energy consumption, raising awareness through posters and events is effective (Torres-Pereda et al., 2020; Tangwanichagapong et al., 2017; Tiew et al., 2019; Kiran et al., 2015). That said, as we shall see, most of the environmental damage associated with research is not due to these routine gestures, but rather to sporadic actions with a significant impact, often legitimized by academic culture (e.g., intercontinental flights). So, to quote one

of the experts consulted, “to take the best possible actions, it is crucial to start by tackling the heart of the problem”, i.e., actions with a high environmental impact.

B. Recommendations

1. Carry out a general reflection on making the ecological choice the default choice for researchers.

Medium priority
Directed to the **FRQ** and **postsecondary institutions**

Here are some questions that could help guide this reflection: how can the purchase and use of laboratory equipment be made more environmentally friendly (for example, opting for used equipment, centralizing laboratory equipment, making group purchases)? How can researchers be made more aware of the carbon cost of their practices and their external impacts (i.e., the negative effects on the environment that are not included in the cost of the object or activity)?

2. Launch a research initiative on environmentally responsible research practices through the creation of an observatory or dedicated funding.

Low priority
Directed to the **FRQ**

3. Provide a tool for calculating greenhouse gas (GHG) emissions for each research project funded by the FRQ.

Low priority
Directed to the **FRQ**

4. Add to Section 8.1 of the FRQ Common General Rules (*Eligible expenses*, *General Principles*) that the research community must consider the environmental impact of its expenses.

High priority
Directed to the **FRQ**

2. Transport

A. Environmental impacts

Travel accounts for up to 84% of the GHG emissions generated by research activities, whether for conferences, fieldwork, or other research-related activities (e.g., thesis defense, administrative tasks, etc.; Burtscher et al., 2021; Cluzel et al., 2020; Achten et al., 2013; Fox et al., 2009). The majority of these emissions—between 40% and 60%—are associated with conference attendance (Arsenault et al., 2019; Labos1point5, 2022; Achten et al., 2013). And yet, air travel is left out of 34% of the GHG reduction plans of research institutions in the United States (Schmidt, 2022), as information on travel distances and means of transport is very poorly recorded by universities.

Emissions caused by air travel are particularly damaging for the environment because of their magnitude and the consequences of releasing these gases into the upper atmosphere (Lee, 2009). In Canada, graduate students generate an average of 2.4 tonnes of CO_2 per year as a result of travel for research purposes. Average emissions then increase with seniority

(Arsenault et al., 2019). Professors make an average of three professional trips per year, and some individuals make more than ten (Arsenault et al., 2019). These air travel trips emit an average of 7.5 to 9 t CO_2-eq annually (Arsenault et al., 2019; Wynes et al., 2019), which is equivalent to about half the average total annual emissions of a person living in Canada. By comparison, to meet the Paris Agreement targets, total per capita emissions would have to be reduced to 2 or 3 tonnes per year, all offset (2tonnes.org, 2022).

Academic travel is certainly beneficial for disseminating research, exchanging ideas and networking, particularly for next-generation researchers (Achten et al., 2013). However, the research community notes that the academic culture imposes a strong pressure to travel. This pressure can be seen in the peer review of grant and award applications, in hiring decisions, and simply in the general perception of peers (Cigana, 2023; Cohen et al., 2020; Jutras, 2020). Travel is also seen as one of the benefits of academia, particularly for next-generation researchers, who are poorly remunerated. The appeal of the destination sometimes motivates the choice of conference (Jutras, 2020; CIE, 2020). Studies have also shown that individuals tend not to take responsibility for the GHG emissions generated in the course of their work, even when their discipline relates to the environment (Schrems and Upham, 2020). This observation is emerging at a time when the carbon footprint of climate experts is undermining their credibility and the scope of their recommendations (Attari, Krantz and Weber, 2016).

Furthermore, studies show that many trips could easily be avoided with no impact on career. Wynes et al. (2019) noted that 5% to 10% of professional travel at the University of British Columbia is associated with same-day travel, which could be replaced with virtual attendance, or to destinations that are easily accessible by ground transport. It even appears that beyond one trip per year, there is no link between professional success and the number of additional trips (Wynes et al., 2019). This annual trip is especially advantageous for next-generation researchers, since these opportunities to meet and exchange ideas are difficult to replace by remote attendance.

Several studies have shown that beyond the environmental impacts, travel disadvantages certain groups and minorities, particularly women and researchers from low- and middle-income countries (Sarabipour et al., 2021). Female researchers generally travel less than their male counterparts (Cohen et al., 2020) and caregivers even less. People doing research in developing countries also travel much less, for financial reasons and because of visa constraints (Pasek, 2020). Virtual conferences are an interesting alternative with, for example, 60% to 260% more women attending (Skiles et al., 2021).

B. Solutions and initiatives

While fieldwork is essential for research, the dissemination of research through presentations and conferences can be rethought to be more environmentally responsible. Here are some possible solutions:

Making careful travel choices

- Reducing the number of research dissemination events attended by members of the research community. The following factors should be considered: the impact of the dissemination exercise, the potential for networking, and the potential for learning that would not be achieved through virtual attendance (Wynes et al., 2019).

- Considering virtual attendance when an in-person presence is not particularly beneficial. Virtual conference attendance produces 97 to 3,000 times fewer GHG emissions than in-person attendance (Jäckle, 2021). Many institutions are including better support for the use of videoconferencing systems in their GHG reduction plans (Schmidt, 2021).
- Recognizing the value of local conferences, which also offer many of the advantages associated with international conferences (Chalvatzis and Ormosi, 2020).
- Calculating emissions, in order to increase awareness. This measure is supported by the research community (Schrems and Upham, 2020).

A number of institutions offer decision support trees to aid in making these decisions (see Fig. 1; Université de Neuchâtel, 2023; Le Quéré et al., 2015; LUCSUS, 2018).

Changing the method of travel

- Using ground transportation. These modes of transport are less polluting than air travel (see Table 2) over distances of several thousand kilometres. Using ground transport, combined with virtual attendance, could reduce the GHG emissions associated with an international conference by 90% (Jäckle, 2021; van Ewijk, 2021). There is currently no incentive to use these modes of transport in Québec. On the contrary, the often lower cost of plane tickets and the fact that they require shorter travel times may compel researchers to opt for air travel in order to meet eligible expense rules imposed by their institution or granting agency.
- Prioritizing direct flights rather than flights with connections. This would significantly reduce the GHG emissions associated with air travel (Kalmus, 2017).

Changing the academic culture

- Revising the evaluation criteria for grant, award and promotion applications to avoid placing value on the amount of travel. Proposals include adding carbon emissions to evaluation criteria (Zeferina and Hoolohan, 2022) and justifying every trip (Schrems and Upham, 2020).

Table 2: GHG emissions associated with various means of transportation (Kalmus, 2017)

Mean of transportation	CO_2-eq (kg) emissions per passenger-km
Flight	0.50
Car	0.30
Train (North America)	0.09
Voyageur bus	0.04

To date, the measures put in place by Québec and Canadian institutions to reduce the GHG emissions associated with the mobility of researchers essentially focus on raising awareness. Such is the case with the self-assessment of environmental impacts added to grant applications by the FRQ. A number of Canadian universities also offer guides to good practice.

However, some groups are looking to go further. At the Université de Montréal, professors sent a letter to management calling for a reduction in the carbon footprint of research, particularly that associated with travel. The results of a survey conducted at Polytechnique Montréal shows that researchers are ready to change their travel habits, and even to impose obligations regarding the use of ground transport (Cigana, 2023). In addition, the Department of Geography, Planning and Environment at Concordia University has adopted a *Flying Less Policy* (Concordia, 2019) which encourages researchers to prioritize collective ground travel for all trips under 12 hours, prioritize less frequent and longer-term stays, and decline long-distance trips with low academic benefit. This policy has been adopted at the departmental level but is not binding.

Outside Québec, many universities are beginning to implement binding or incentivizing initiatives in relation to transport. Several European and American institutions no longer reimburse air travel below a certain distance or travel time (often 10 to 12 hours), encouraging people to take the train (e.g., University of Georgia, Swiss Federal Institute of Technology in Zürich, Institut LOCEAN in Paris, Université d'Anvers and Université de Neuchâtel). Through this measure and others not affecting mobility (e.g., banning first-class air travel, prioritizing direct flights), the École polytechnique fédérale de Lausanne reduced its total GHG emissions by 36% between 2014 and 2016 (Ciers et al., 2018). The LOCEAN climate research institute in Paris applies a particularly bold policy, which requires GHG accounting and imposes an emissions quota that will decrease over time. Certain exclusions apply to next-generation researchers (LOCEAN, personal communication). At the Swiss Federal Institute of Technology in Zürich, CO_2 emissions are taken into account in the assessment of reimbursement requests, which encourages lower-emission options even when they are more costly. There is also a limit of 1 to 2 intercontinental trips per year for doctoral students, authorized only for oral presentations.

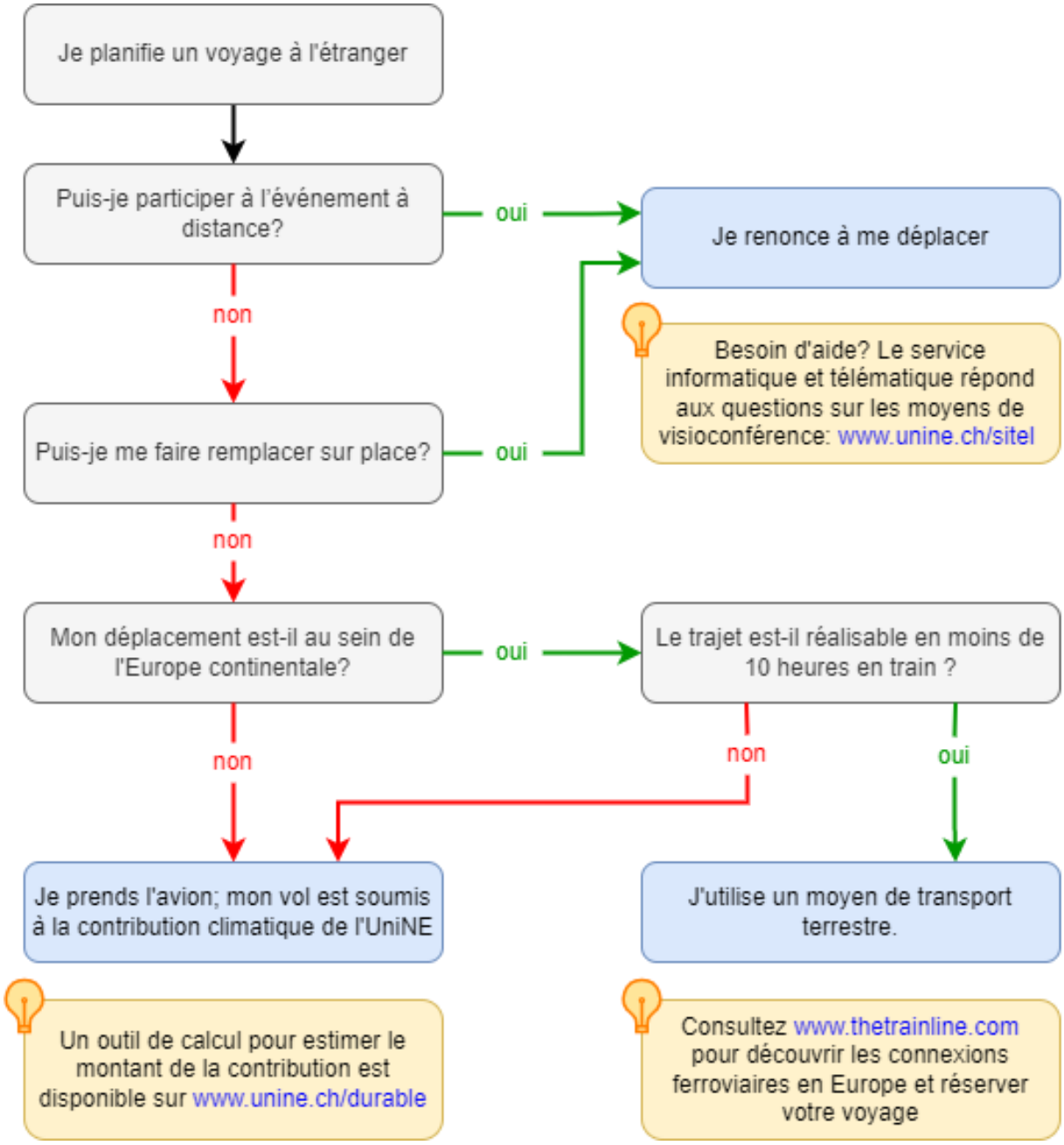

Fig. 1: Decision tree from Université de Neuchâtel, Switzerland (Université de Neuchâtel, 2023)

C. Recommendations

5. Initiate a concerted reflection on transforming the research community's travel habits: **High** priority Directed to the **FRQ**	a. In eligible expenses, allow the use of ground transport and direct flights, even if they are more costly.
	b. Establish a distribution of responsibilities for establishing and monitoring environmental responsibility standards.
	c. Educate the research community about its environmental impact, along with granting agencies, universities, research centres and research teams.
	d. After an education phase, seek to implement environmentally responsible transport policies. For example, as is done by many institutions elsewhere in the world, only reimburse ground travel when travel time is below a certain threshold by public transport (bus or train) or by car, and when public transport is available and easily accessible. This rule would apply, for example, for travel between Montreal and Toronto. In continental Europe, it would apply to all destinations.

6. Initiate reflection on ways of using the evaluation criteria for grant and award applications to prioritize the quality of publications and knowledge mobilization activities rather than their number, thereby encouraging research that is less production-driven and of higher quality.

High priority
Directed to the **FRQ**

Here are some ideas that could help guide reflection on Recommendation 6:

- In grant applications, a description of the applicant's most significant contributions, as currently requested in some FRQ competitions, is more in line with these priorities than an exhaustive nominal list of contributions.
- An emphasis on the "quality" of conferences could be encouraging individuals to choose international conferences rather than local conferences. Effective communication of the objectives and expectations of the FRQ would ensure that the community does not place less value on local activities.

D. Comments on carbon offsetting

For some years, a number of universities and research institutions have been encouraging their communities to offset their GHG emissions with a view to reducing the environmental impact of their research. Carbon offsetting is based on the idea that a given quantity of GHG emitted in one place can be offset by reducing or sequestering an equivalent quantity of GHGs elsewhere. The aim is to reduce GHG emissions or to move towards a sort of carbon neutrality.

In Québec, there are two offset systems. First, the carbon market is regulated by a cap-and-trade system for greenhouse gas emission allowances (C&T system, or SPEDE in French[1]), which is intended for major emitters (Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs, 2022). Since universities are not subject to the C&T system, they must offset their emissions through a voluntary, unregulated market (Perron, Leroux and Tanguay, 2020).

Professor Marc Jaccard, co-author of the 6th IPCC report published in 2019, stresses that only the direct capture of CO_2 followed by its permanent underground storage would be truly effective in the voluntary market. This can be done by capturing CO_2 directly from the atmosphere, or by capturing GHGs produced by the incineration of biological materials to generate electricity, thereby producing clean energy. It should be noted that the use of these technologies is recent and that the price of these offsets remains very high (Vernet, 2022).

Members of the research community therefore tend to purchase their carbon offsets from less costly or more widespread programs, such as tree planting, a typical example. However, if the forest burns—a scenario that is increasingly common with the rise in extreme weather events—or dies—which is part of the natural forest cycle— the captured carbon is released (Natural Resources Canada, 2022).

The scientific literature identifies numerous additional problems specific to the various carbon offset programs. For example, it is not easy to establish a baseline scenario against which to compare offsets, and the methodologies for calculating indirect emissions are still uncertain (Ducoulombier, 2021).

The absence of a standardized measure of carbon emissions, coupled with a lack of common agreement on the scope to be taken into account, can lead to misleading conclusions. For example, a 2017 study found that potential emissions reductions are likely to be overestimated in 73% of the programs available in the European Union Emissions Trading System (DG CLIMA, 2017).

Some offset programs also offer to finance projects that reduce GHG emissions (renewable energies, infrastructure, etc.). However, many of these projects would have been financed even without funding from the sale of carbon offsets (Struck, 2010). Some projects also have negative impacts on local populations, such as the construction of a wind farm that forced the displacement of local farmers and failed to produce the expected amount of energy (Struck, 2010).

Finally, carbon offsets have a counterproductive effect on real GHG reduction measures. Their use reduces the incentive to reduce emissions at the source by allowing polluters to buy credits and continue their activities. A study by the Stockholm Environment Institute estimated that the purchase of carbon credits under the *Joint Implementation* program may have led to 600 million more tonnes of CO_2-eq emissions than would have occurred had countries simply complied with their emissions quotas (Kollmuss, Schneider and Zhezherin, 2015). The use of carbon credits could therefore be a barrier to behavioural change.

To add to the complexity of the carbon offsetting process, it is important to note that once GHGs have been emitted, they end up in the atmosphere. While offsets can reduce future emissions, they will not remove what has already been emitted.

E. Recommendation

7. Review the way in which carbon offsetting is used by the research community:	a. Make the research community aware that carbon credits should only be used as a last resort, for emissions that are impossible to avoid and absolutely necessary.
High priority Directed to the **FRQ** and **postsecondary institutions**	b. Provide accessible, simple and reliable information on the various offsetting program, including a list of recommended programs. The FRQ could even offer to cover the cost of carbon credits for researchers.

3. Digital activities

A. Environmental impact

Digital activities have an impact on the environment, both in terms of the energy used and the ecological footprint of computer hardware. While the electricity consumed in Québec comes from renewable energy sources, researchers sometimes use servers located abroad to store and transmit data (including emails), often without even realizing it. These servers may be powered by gas or coal-fired power stations. What's more, in a context where the electrification of many activities will sharply increase Québec's electricity demand (Hydro-Québec, 2022), reducing the energy needs of research infrastructures is highly relevant.

There are two types of digital activity: office activities and computationally intensive research activities. In the first category, videoconferencing is the activity that requires the most resources. Yet virtual conferences emit 97 to 3,000 times less GHGs than in-person conferences (Burtscher et al., 2020 and Jäckle, 2021). Many are suggesting that the lessons learned from the research practices put in place during COVID-19 should be used to help design a new research model (Zeferina and Hoolohan, 2022). While the research community was quite reticent about virtual interaction before the pandemic, 67% are now in favour of the use of video technologies (Labos1point5, 2022). The next-generation researchers we consulted at the J2R said they use videoconferencing to avoid unnecessary travel and the associated GHG emissions.

The second type of activity concerns computational resources that require high-performance computing, such as modelling or data analysis. Artificial intelligence is associated with a significant carbon footprint (Schwartz et al., 2020) which is growing exponentially (Amodei and Hernandez, 2018). According to a study published in 2019, training the most energy-intensive artificial intelligence models can require 0.28 tonnes of CO2-eq, or five times the entire life cycle of a car (Strubell et al., 2020). Those who use high-performance computing are rarely aware of the environmental impact of their activities (Portegies Zwart et al., 2020).

B. Solutions and initiatives

Several measures can be implemented to encourage the use of videoconferencing systems. These include improving the quality and accessibility of the infrastructure needed for virtual communication (Zeferina and Hoolohan, 2022; Schrems and Upham, 2020), and the promotion of virtual exchanges by institutions (Ligozat et al., 2020).

When it comes to computational resources, there are a number of technical solutions that can reduce energy consumption. The use of GPUs (*Graphics Processing Units*) rather than desktop workstations makes calculations much more energy-efficient, as does the use of non-interpreted programming languages (Portegies Zwart et al., 2020). Second, certain practices can reduce electricity use, such as efficient and intelligent coding, which also reduces calculation times (Portegies Zwart et al., 2020). Overly easy access to computational resources is an obstacle to implementing these good practices.

C. Recommendation

Recommendation 11 addresses the issues raised in this section.

4. Energy consumption

A. Environmental impacts

On average, laboratories consume 5 to 10 times more energy than a standard office space of similar size (USEPA, 2008). The energy used by equipment that is plugged into an outlet (plug load) is up to 20 times higher (USEPA, 2008). However, much of the energy consumed by research institutions is attributable to the building itself and is therefore beyond the control of the researcher (USEPA, 2008).

A number of individual actions can nevertheless significantly reduce the energy consumption associated with research. In general, switching off countertop equipment when it is not in use can halve its energy consumption (Gilly, 2010). The use of fume hoods is a prime example: by operating continuously, they emit no less than 5 tonnes of CO2-eq per year in Québec, running on fossil fuel heating systems (U. Sherbrooke, n.d.), and account for 10% of all the electricity consumed on the campuses of the University of British Columbia. Consumption is exacerbated by the fact that fume hoods often operate at higher intensities than necessary. The Université de Sherbrooke has 400 fume hoods on its campus (UEQ, 2021), while McGill University has no fewer than 800 (Neseliler, 2013).

Another compelling example is the case of ultra-low temperature freezers, whose standard temperature is -80˚C. This standard is based more on user habits than on scientific evidence. Raising the temperature of these freezers by 10˚C would be inconsequential in the vast majority of cases and would save an average of 20% to 50% of the appliance's electricity consumption (Freezer Challenge, 2023). Moreover, this change in practice would have a positive effect on freezer lifespan (UBC, 2021).

B. Solutions and initiatives

At McGill University, the *Shut your Sash!* campaign encourages the users of 25 laboratories to turn off their fume hood sashes during periods of inactivity, which resulted in a 77% reduction in energy consumption of the hoods (Neseliler, 2013). With regard to freezers, an international initiative, the *North American Laboratory Freezer Challenge*, attracted the

participation of more than 200 laboratories and saved 2.7 million kWh in 2017 (Freezer Challenge, 2023), equivalent to the annual consumption of 150 people living in Québec.

C. Recommendations

Recommendations 1, 4 and 9 address the issues raised in this section.

5. Equipment, supplies and waste

A. Environmental impacts

Research activities, particularly in the health and natural sciences, require the use of sophisticated technologies and large quantities of laboratory equipment and supplies, including many single-use items. A number of the next-generation researchers we consulted deplored the omnipresence of single-use lab materials.

For example, a study conducted at the University of Exeter (UK) showed that their bioscience department consumed 267 tonnes of plastic in 2014. This is the equivalent of 5.7 million 2-litre plastic bottles. The team that conducted the study also estimated that the world's biomedical and agricultural science laboratories could produce 5.5 million tonnes of plastic waste in 2014, an amount equal to 83% of all plastic recycled worldwide in 2012 (Urbina et al., 2015).

In addition to the impact of the degradation of plastics in the environment, a study published in 2020 showed that 60% to 95% of the carbon footprint of tests carried out in pathology laboratories was due to the energy consumption incurred in the production of the materials used to collect samples, as well as the consumption of electricity and water for laboratory analyses (McAlister et al., 2020).

Plastic labware is generally perceived as inexpensive and more practical than glassware. It is often impossible to recycle plastics because they come into contact with biological or chemical substances and because they are often not identified by a number indicating the type of plastic they are made of, which means that they cannot be recycled by sorting centres (Choi, 2021). Currently, contaminated plastics are autoclaved and thrown away (Kuntin, 2018).

In Québec, various institutional rules (notably the lowest bidder rule) stand in the way of choosing more sustainable suppliers and products. But the pressure to produce scientific results is the biggest obstacle to recycling plastics in the laboratory, as recycling and cleaning glassware are perceived as being too time-consuming, which is a hurdle to changing practices (Kuntin, 2018). However, the next-generation researchers we consulted pointed out that washing labware often takes less time than many people think.

Finally, we should also note the ecological impact associated with the high-tech laboratory equipment used in the natural and health sciences. Some members of the research community remarked that unnecessary material is often purchased simply to use all the funds of a grant that is coming to an end. They also noted a certain protectionism with regard to the equipment procured by each research group from their grants. Scientists sometimes insist on keeping their equipment in their own laboratory, even when it is not being used, which makes it difficult for colleagues to share, even though this would be more environmentally responsible.

B. Solutions and initiatives

The *Guide d'écoresponsabilité en recherche* published in 2020 by the Université de Sherbrooke prioritizes the use of reusable materials (glassware rather than plastic). As environmentally friendly labware (reusable, recyclable or compostable) is often more expensive than its traditional counterpart, the guide encourages laboratories to place group orders in order to benefit from lower prices and reduce the frequency of deliveries. However, group purchases can sometimes have the opposite effect, as the compromises required to accommodate all the laboratories can lower sustainable standards.

When it comes to laboratory equipment, centralizing the resources of several laboratories could enable the implementation of an efficient glassware management and maintenance system. Some initiatives, such as the Second Cycle platform, facilitate the reuse of old research equipment between institutions.

C. Recommendations

8. Offer greater flexibility in the use of grant funding. This includes reducing constraints on the type of expenditures associated with each grant (e.g., allowing funding intended for travel or the purchase of equipment to be used for other purposes).

Medium priority

Directed to the **FRQ** and **postsecondary institutions**

9. Promote and facilitate environmentally responsible spending of research funds.

For example:

a. Lower-impact equipment, including the use of used equipment;

b. Combining multiple air travel trips into a single trip, including personal travel;

c. Transferring grant balances to a subsequent year.

Medium priority

Directed to the **FRQ** and **postsecondary institutions**

Recommendations 1, 4 and 6 also address this issue.

6. Education

We would like to conclude these findings on the environmental impacts of research activities by presenting a series of recommendations for raising awareness. As a reminder, the importance of awareness and education in encouraging changes in practice was identified in Section 2.

A. Recommendations

10. In programs offering funding for the organization of events, amend the program rules to strongly encourage recipients to organize these events in accordance with high environmental responsibility standards. **High** priority Directed to the **FRQ**	a. Add a list of criteria for making an event environmentally responsible and establish a threshold to be respected (e.g., offer a hybrid format in order to reduce participant travel, provide low-waste meals).

11. Educate researchers about the environmental impacts of their research activities.

High priority

Directed to the **FRQ** and **postsecondary institutions**

The following methods could be used:

- Providing examples of environmentally responsible alternatives;
- Preparing good practice guides for award holders and funded researchers, to also be made available to the research community as a whole;
- Publishing content on this subject on the FRQ media platforms (social media, newsletters) and at FRQ events.

7. Next-generation researchers

Next-generation researchers are particularly interested in adopting more environmentally responsible research practices. However, they face barriers of their own, including the impact that adopting certain practices may have on their careers. In this section, we present some thoughts on these issues specific to the next generation of researchers.

A. Obstacles to change

Academic culture

The next-generation researchers we consulted believe that the main obstacles to a more environmentally responsible research environment stem from the prevailing attitudes and narratives of the research community. Generally speaking, a lack of openness to sustainable practices is leading next-generation researchers to fear the social or professional consequences of implementing certain practices. Most of these fears are linked to the effect of these new practices on productivity, which is highly prized in research. For example, travel is highly valued by certain research departments and in certain fields, where it is seen as a way to strengthen the CVs of next-generation researchers. In the interest of competitiveness, environmental responsibility takes a back seat. The creation of an environmental responsibility committee within research centres or departments is one solution proposed by next-generation researchers to normalize the discourse on sustainable research practices.

A major obstacle identified by the next-generation researchers we consulted is at an institutional level. Several reported that the rules governing reimbursements often prevent them from making environmentally responsible choices, for instance when they are more costly, as in the case of ground versus air travel. With regard to laboratories, it was noted that, while glassware is initially expensive to purchase, it pays for itself after a certain period of use.

Despite this, the use of plastic is often justified by its lower purchase cost. In general, it was observed that the lack of flexibility in institutional policies often discourages researchers wishing to make their practices more environmentally responsible.

Habits

According to some of those consulted, the biggest obstacle to making research more environmentally responsible is the comfort level and ingrained habits of researchers, which points to a greater need for education. Many question the environmental consequences of their various research activities, including the use of computational resources and cutting-edge technologies. In this respect, next-generation researchers mention that the resources available within institutions to help laboratories change their practices are not well known.

The real or perceived efficacity of less environmentally friendly practices also makes it harder to replace them. Some people point to the time saved by using disposable supplies, while others say that maintaining reusable labware takes much less time than it might seem.

Reducing travel

When it comes to travel, the next-generation researchers we consulted seem motivated to take action. However, several stressed the importance of networking at conferences, which they feel should not all be replaced by virtual attendance. Some next-generation researchers also pointed out that it is difficult to avoid travelling to collect data, while others proposed that international or local collaborations should be used to share data rather than constantly collecting new data. However, the next-generation researchers emphasized that they do not have the necessary authority to initiate such a change in their research group. Finally, some noted that the time saved by air travel makes it easier to reconcile travel and family responsibilities.

B. Impacts

In summary, adopting environmentally responsible practices could affect next-generation researchers in a number of ways:

1. Reducing international travel could lead to:
    a. Fewer networking opportunities, which may lead to fewer opportunities for future collaborations and employment;
    b. More limited data collection;
    c. A reduction in the number and international nature of knowledge mobilization events in their CV, with the effects described in Point 3.

2. Using slower but more environmentally friendly laboratory methods (washing and recycling of lab materials, etc.) slows down the rate at which results are produced, with the effects described in Point 3.

3. Points 1c and 2 could:
    a. Negatively affect the evaluation of grant and award applications and hiring or promotion outcomes;
    b. Affect the way supervisory committees and collaborators perceive the research skills and academic ambitions of next-generation researchers, which could lead to less support and fewer opportunities being given.

While next-generation researchers are more motivated to make environmentally responsible choices, they still have a number of evaluation processes to go through. They are therefore more affected by these impacts than more established members of the research community. The impacts on next-generation researchers mentioned above can be divided into two categories: those that affect the quality of their research, and those, more systemic and linked to the academic culture, that affect their career advancement. Our recommendations focus on practices that have an impact in the second category. It will be necessary to reconsider the notion of research excellence so as not to penalize researchers who take into account the environmental impact of their activities. This revision is in line with steps taken by the FRQ in recent years to update the notion of research excellence (CIE, 2022).

C. Recommendations

12. Encourage grant and award applicants to indicate in the "Other circumstances" section the ways in which their application is impacted by environmentally responsible choices. **High** priority Directed to the **FRQ**	a. Improve the list of examples of circumstances accordingly. b. Improve existing training and documentation for evaluation committees to ensure that the evaluation process is consistent with this change. This includes training to correct researcher bias.

Recommendation 6 addresses the issues raised in this section.

Conclusion

This report looks at the significant impacts that research activities have on the environment. It demonstrates the particularly strong impact of air travel to attend conferences, of the use of single-use plastic in laboratories, and of the high energy consumption required for high-performance digital computing. We have presented ways of reducing certain impacts without affecting the quality of the research. We have also shown that a considerable proportion of the environmental impacts stem from activities that do not serve science, but rather aim to maintain a certain academic culture.

The recommendations directed to the FRQ and to Québec's research and teaching institutions focus on reducing the barriers that prevent members of the research community from improving the environmental performance of their activities, and on educating the entire community to make the changes demanded by the climate crisis.

As we have seen, both the scientific literature and the research community consider that granting agencies play a particularly important role in implementing more sustainable research practices. The members of the community we consulted believe that the rules and evaluation criteria of granting agencies have a decisive influence on the way in which the academic world perceives the merits of those who carry out research, and therefore on the ways research is done.

If next-generation researchers are adopting more environmentally responsible research practices despite the consequences of these choices on their careers, it is because they believe that preserving the environment and combating climate change should take precedence over the scientific output imperatives of the current academic culture. In a context where the climate emergency calls for a strong and rapid ecological transition in all sectors of activity, and considering the added responsibility of the research community due to its level of knowledge and public funding, we must recognize the moral value, indeed the necessity, of implementing new practices and of ensuring that we do not penalize those who are leading the way.

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Annex I – Overarching initiatives and accreditations

Certifications and international rankings for higher education institutions

Various certifications allow postsecondary institutions to assess their environmental responsibility performance, and even compare it to that of other institutions. According to one stakeholder consulted by the CIE, these certifications have the advantage of providing an external framework, whereas defining their own standards would make it easy for institutions to commend their own actions. It has been shown that such certifications encourage the establishment of concrete actions in universities, acting as a framework for the implementation of transition strategies (FAECUM, 2021). The best-known certifications and rankings include the *Association for the Advancement of Sustainability in Higher Education* (AASHE) *Sustainability Tracking, Assessment and Ranking System* (STARS) and the *Times Higher Education* (THE) *Impact Rankings*. *STARS* considers a university's built environment, curriculum, campus engagement and operations, while THE focuses on the 17 United Nations Sustainable Development Goals. Where research activities are concerned, STARS gives credit for open access and the monitoring of greenhouse gas emissions, such as those related to travel. These certifications, which for the most part do not specifically target research activities, are not very effective at assessing progress made directly in connection with these activities.

Certifications specific to research laboratories

There are, however, certifications that are more directly linked to the research environment, and in particular to laboratory practices. In the United States, *My Green Lab*[1] certification assesses laboratories according to 14 criteria: community, recycling and waste reduction, resource management, purchasing, green chemistry and green biologics, water, plug load, fume hoods, cold storage, large equipment, infrastructure energy, fieldwork, animal research, and travel. In the UK, the LEAF (Laboratory Efficiency Assessment Framework)[2] program provides online calculators, toolkits and resources, with different certification levels depending on the number of actions taken. Drawing on these initiatives, employees at the Université de Montréal developed the MON ÉCOLABO certification in 2013. The aim of this initiative is to provide simple tools for managing laboratories in a more environmentally responsible way, without compromising their objectives. Following an assessment of the laboratory, an action plan is drawn up, taking into account the identified areas for improvement. Recommendations focus on the management of chemical products (purchase, storage, handling, waste management), infrastructure (heating and air conditioning, lighting, water) and scientific equipment (energy consumption). Classifications allow for friendly competition between laboratories, as is the case at the University of Waterloo, which created a Leaderboard honouring its three most environmentally responsible laboratories. The French collective Labos 1point5, which is dedicated to reducing the environmental impact of research, also offers laboratories and research centres a GHG emissions calculator specifically tailored to research, without giving an official score as would a certification program.

Other overarching initiatives

In an effort to move towards carbon neutrality, up to 50% of universities are turning to the purchase of carbon offsets to compensate for the emissions associated with basic building operations (heat, electricity) or professional travel (Schmidt, 2022). However, it is important to remember that carbon offsets cannot replace all current emissions, and many available credit systems are in fact unreliable, including several tree planting programs (Kalmus 2017).

When it comes to granting agencies, the FRQ are among the most avant-garde, in part because of their requirement for a self-assessment of environmental risks. For its part, the National Science Foundation (NSF) in the United States considers the environmental impacts of research before awarding grants. The environmental impact assessment is based, in part, on information provided by researchers (NSF 2021). In the UK, *UK Research and Innovation* is in the process of implementing a method for evaluating the environmental sustainability of funded projects. Its objectives include reducing the need for travel and adopting common energy management standards for outsourced IT activities. If we accept that speeding up the pace of research contributes to increasing its environmental impact, it is worth mentioning the initiative of Australia's Chief Scientist to reduce the importance of publications in the evaluation of grant applications. Greater emphasis is placed on the impact and engagement of the proposed research in order to encourage slower, higher quality research.

Best practices do not emerge on their own. One way of developing them is to encourage research into these practices. One researcher we consulted said that thinking about environmental responsibility stimulates research, leading to the emergence of new questions requiring thought and evidence. In this vein, McGill University's 2020-2025 Climate & Sustainability Strategy uses the concept of a "Living Lab" which involves, among other things, encouraging on-campus study of measures to combat climate change. The University of Waterloo's most recent environmental strategy includes the creation of a database identifying the needs to be met and the knowledge gaps relating to environmental issues. This resource is intended to encourage researchers to choose research themes that will meet these needs as effectively as possible.

Annex II – Interview guide (experts)

The interviews were conducted in French. This interview guide is a translation.

Objectives of these interviews: To obtain a more qualitative and contextualized view of environmentally responsible research practices in Québec, as a complement to the literature review.

- Essential questions are shown in bold in case there is not enough time during interviews. Sub-questions will not be asked systematically, but will be raised in order to refocus the question if necessary.

Categories (4)

A) Generally speaking, what are the roles of research entities with regard to environmentally responsible practices in research?

1. **What is the role and involvement of the various entities in the research community with regard to environmentally responsible research practices, including those related to climate change? (Universities, research centres, granting agencies, etc.)**
    a. We are interested in practices related to the research process, including knowledge mobilization activities, and not in the choice of research themes or topics as such.
2. (Profs) How do your peers perceive environmentally responsible research practices and the involvement of researchers in this area?
    a. What is the perception of your scientific community? To gauge (i) what kind of measures or level of constraint the community is prepared to accept and (ii) whether it is better if it comes from above or below.

B) Good practices

3. Are there any good environmentally responsible research practices in your institution that you would like to share?
    a. What makes them work well?
    b. What has made them sustainable over time?
    c. What makes people apply them (beyond the written plan)?
4. Have you heard about other good environmentally responsible research practices that seem relevant to you? (Same sub-questions)
    a. Are there current research practices that could be reviewed to make them more environmentally responsible, whether in universities, research groups or granting agencies?

List of aspects to consider in answering these questions:

- Travel (in general and for conferences)
- Laboratories (waste, energy, purchase of supplies)
- Computer resources
- Management of research funds (e.g., purchase of non-essential materials due to unspent grant balances)

C) Obstacles to the implementation of environmentally responsible practices

5. **What are the obstacles to implementing specific environmentally responsible practices in the research environment?**
    a. Are there rules (at the institutional, funding, organizational levels, etc.) that prevent the implementation of certain practices?
    b. Can the culture of organizations or research groups, or the climate within teams, prevent the implementation of certain

environmentally responsible practices (in general and by next-generation researchers)?

6. In your opinion, what are the impacts of adopting more environmentally responsible research practices on academic progress?
    a. What is your perception of the impact of these practices on next-generation researchers and their academic record?
    b. In your opinion, do next-generation researchers have any other concerns about adopting environmentally responsible practices?

D) Role of next-generation researchers

7. In your opinion, does the next generation of researchers have a particular role to play in the fight against climate change?
    a. What is the impact of educating them on environmentally responsible research practices from the moment they enter the research community?
    b. What changes in practice specifically affect next-generation researchers? What changes in practice could be put in place by next-generation researchers?

Annex III – Interview guide (consultation with next-generation researchers)

This interview was conducted in French. This interview guide is a translation.

OBJECTIVES

- Assess the importance of environmental issues for the next generation of researchers.
- Identify the environmentally responsible research practices that most concern next-generation researchers and how these practices affect them.

INTRODUCTION

(1) Presentation of the CIE
(2) Mention that the purpose of these consultations is to fuel reflection on environmentally responsible practices in research, which will lead to recommendations for the FRQ. The aim is to gauge the pulse of next-generation researchers on these issues.

QUESTIONS

Block 1 – Importance of environmental issues

1. In a nutshell, how do you feel about the environmental situation?

Notes: Can include personal and professional aspects.

2. Do you integrate environmental considerations when thinking about your research activities and your career path?

Block 2 – Environmentally responsible practices

1. Do you consider that your research practices have a significant impact on the environment?
2. How do you or would you like to make your research more environmentally responsible?

Notes: For example, travel, equipment and energy use, etc., across the entire research process (generation of results and dissemination).

   a. What are the obstacles to implementing some of these choices?

Block 3 – Impacts of adopting environmentally responsible practices

1. What are the impacts (positive or negative) of the adoption of environmentally responsible practices...
   a. On your academic record?
   b. On your career path?

Additional question (if time permits):

- Does the climate emergency affect your ability to do research?