Sustainability Projects Fund

FINAL REPORT

PROJECT TITLE: SP0242 Helium Recovery Project

Please answer the following questions and return the completed form to the SPF Staff via e-mail.

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Actual Project Start Date 2020-03-01 Actual Project End Date 2021-04-30

Questions

1. Please summarize the project and its key accomplishments to date. In your answer, consider the impact your project has had so far on McGill's campus(es).
   Unlimited characters, suggested minimum ½ page or ~250 words.

Liquid helium is a non-renewable natural resource that is heavily used in the McGill Magnetic Resonance Facilities (MMRF). Helium is generally obtained as a byproduct of natural gas extraction, and its extraction and transport are energy-intensive. At the McGill Magnetic Resonance Facilities (MMRF), liquid helium cools superconducting magnets that are used to identify and characterize molecular identities, structures and interactions and are essential to research in many disciplines. Normally after use in the MMRF, the helium boils off into the atmosphere and from there into space. The helium recovery project has installed a helium recovery system to recycle up to 90% of the liquid helium used in the eight superconducting magnets at the MMRF, and to encourage users of the instruments, and chemistry students in general, to think about sustainability.

The project began on March 1, 2020 and included preparing a call for tender, bid evaluation, purchase, building work in Otto Maass and Pulp and Paper, and finally, commissioning of the system, which took place from April 12-21, 2021. Since that date, we have already collected over 80 L of liquid helium that would otherwise have evaporated away forever. For comparison, we use up to 3000 L of liquid helium annually. We are still in the process of optimizing the system and evaluating its capacity, so we will be able to report on long-term savings of liquid helium (including the percentage recovered and the associated savings in GHG) in early 2022.

Besides the physical installation of the helium recovery system and associated building work (door widening between Pulp and Paper and Otto Maass, installation of copper piping in both buildings), the main impact on McGill's campuses has been involvement with students in chemistry courses in Fall 2019, Fall 2020, and Winter 2021, via term papers and presentations to students.

2. Please describe the key successes and challenges of your project. Include a minimum of two examples for each.
   Unlimited characters, suggested minimum ½ page or ~250 words.

The biggest success is recuperating helium. In the few days since the equipment was installed, approximately 4 L per day has been recovered. This already accounts for about 50% of the helium we normally use, and this has been achieved with an absolute minimum of optimization.

The other key successes are obtaining funding from multiple sources and educating students and colleagues. Our second major funding source is the NSERC Research Through Innovation (RTI), which awarded PI Youla Tsantrizos in the chemistry department $150k for this project. We were also pledged $50k from the Faculty of Science, $47k from the Department of Chemistry, and $23k from our own MMRF funds. With the additional RTI funds, this allowed us to redistribute our planned spending, and purchase some warranty and service options from the HRS manufacturer that we had not initially budgeted for.

As for educating students and colleagues, we have worked particularly closely with two courses (CHEM 429 (Chemistry of Energy, Storage, and Utilization) and CHEM 462 (Green Chemistry)) to help with term papers and give

presentations, and we have also introduced the system to students in CHEM 493 (physical chemistry), as well as made many informal presentations to other members of the chemistry department, particularly those who use the MMRF. We have emphasized that sustainability is a concept which can be applied to many materials, not those directly related to traditional areas such as waste management or natural environments.

On the other hand, we have had the most difficulty with ensuring that all work related to McGill Facilities has been coordinated with the appropriate building manager, project manager, and contractors. We underestimated the extent of work required and this led to a delay in installation. Our next greatest challenge has been ensuring that our spending has met the requirements of the diverse bodies funding the project. The RTI grant, in particular, has strict rules, requiring us to pay particular attention to the attribution of funds to particular components of the project. Finally, we will spend the next several months optimizing the system to improve the rate of helium recovery. This is already presenting a technical challenge, but as we work on improving the system, we learn more about it, which will help us to maintain it for years to come.

3. What key points of advice or lessons learned would you give to other SPF teams either regarding your experience managing your project or the project itself?
   Unlimited characters, suggested minimum ½ page or ~250 words.

Our major lesson was that the better prepared we were for each step of the project, the more quickly and satisfactorily we completed it. We knew ahead of time that we had to educate ourselves about helium recovery systems for NMR labs, so we spoke to six or seven NMR managers across North America and even Scotland about their systems. We had visits from two helium recovery system vendors and spoke to one other in some detail. Thus, when it came time for the call for tender, we were able to ensure that we would obtain the system we thought would work best for us, at the most reasonable price, and we were successful in this. However, we significantly underestimated the extent of building work that would be required for the installation, nor did we really know who to talk to to find this out. This led to difficulty in budgeting for all components of the work and complications in completing the work on time. In retrospect, perhaps we could have done better if we had spoken with the building manager in more detail earlier in the project cycle, or possibly gone directly to McGill Facilities for advice. We would recommend that other teams speak with as many relevant people in the university as possible for each step of their project that requires work with the university.

4. How has your project helped to grow a culture of sustainability at McGill? You may consider social, economic, and/or environmental sustainability in your answer.
   Unlimited characters, suggested minimum ½ page or ~250 words.

Our project illustrates that a major research facility can improve its operations to be more sustainable, and we hope that this observation is transmitted throughout the university. Commonly used laboratory supplies such as protective gloves or single use plastics cannot easily be reused, reduced or recycled due to the need for sterile work or because of contamination with hazardous substances, making it difficult to find ways to work more sustainably. However, in our case, we were able to identify a resource that we had essentially been disposing of that could be reused.

Helium recovery is environmentally sustainable in that it greatly reduces the need for energy-intensive extraction and purification of helium from the sites at which it is found (usually natural gas reservoirs, so this also very slightly reduces the impetus to destroy those sites in order to extract natural gas and helium), and because it reduces the need to ship the helium all over the globe. It is also economically sustainable in that it reduces the need to purchase helium, although it replaces it with the need to purchase electricity to power the recovery system. However, in Quebec, the electricity is usually both cheap and relatively sustainable.

From an operations standpoint, we have identified what we believe is a major component of GHG emissions and natural resources use in the MMRF, and we hope that our discovery that we can improve sustainability by reducing our use of a non-traditional material inspires other groups to examine their environmental impact and work towards reducing it in the manner most relevant to them.

5. What recommendations do you have for the future of this project and are there any opportunities for complementary projects? Who will take responsibility for the project's future and how can interested persons be in touch? The SPF team may be in touch for updates on the project's progress in coming years, if ongoing.
Unlimited characters, suggested minimum 1 paragraph.

In the near future, the project will need to be fully completed and then optimized. As of April 28, 2021, six of eight magnets using helium are returning their helium to the recovery system. The remaining two will be connected within the next month, hopefully increasing recovery to at least 4.5 L/day. Also, we will install some kind of soundproofing because some of the helium recovery equipment is quite loud. This should then complete the project.

Optimizing the system to maximum helium recovered during both "standard boil-off" (the 4 L/day already mentioned) and helium lost during "helium transfers" (at least 20% of total usage, in events occurring about 35 times annually) will occupy the next few months, and it is in this step that we hope to improve recovery to 90% or greater. We will also be monitoring the behaviour of the NMR magnets connected to the system to ensure that they are not adversely affected.

A complementary project that we might consider is a nitrogen generator. We use even more nitrogen in our facilities than we do helium, and if we could generate it on site, it would reduce the amount of nitrogen being trucked to McGill. However, the GHG gains are nowhere near as significant as for helium, since commercial nitrogen is separated from the atmosphere in Montreal, rather than extracted from natural gas fields in the US, and the nitrogen itself is not lost to planet earth after use; it is trapped in the earth's atmosphere. So the sustainability calculation is quite different.

As for helium recovery, other helium users on McGill campus may benefit from a similar system, and most that can are already in the process of purchasing and installing equivalents. We are in touch with managers of similar facilities in other universities and are already sharing the knowledge we have gained as we have installed our system.

The project in the MMRF will continue to be managed by the managers of the MMRF facility, with support from the electronics technicians and building manager in the Chemistry Department. The equipment should easily last until the Chemistry Department moves to the Royal Vic in 7-10 years, and most of it can be transported there for continued use indefinitely, as long as individual parts are maintained and/or replaced as necessary.

6. Would you or your project team member(s) be willing to serve as a mentor to SPF project teams? Please choose one. If yes, SPF Staff will contact you with more information. ☒ Yes ☐ No

7. In your application, you listed the following additional sources of funding:

NMR/EPR Facility - $47,000; QANUC - $23,000

Please confirm if you received this funding in the space below and list the actual amount (in dollars) that you received.

After our initial application, the Faculty of Science agreed to fund the project with $50,000, which was noted in our reply to the initial SPF assessment of our application. In April 2020, we were notified that we had been successful in the NSERC RTI competition. This came with an award of $150,000 from the NSERC RTI, and complementary funding from the Department of Chemistry. As a result, less of the pledged funding from the MMRF (NMR/EPR Facility and QANUC) is required. The RTI award and the change in funding distribution has been reflected in the updated budgets we have submitted to the SPF. Currently, the entire $150,000 from the NSERC RTI has been spent (encumbered) on the recovery system, and the Faculty of Science transferred the $50,000 that they awarded the project to the Department of Chemistry in June 2020. All of this will be spent when the final invoices are paid. Also, the MMRF has been invoiced for the maintenance contract (approximately $12,000). The final amounts charged to the SPF fund and to the Department of Chemistry are not yet known, as we are still purchasing small parts for the system, we may

make some final modifications to the piping (paid by Dept fund), and we will install sound abatement.

8. How did you document your project, and did you include the SPF logo on any project materials (e.g. posters, promotional materials, social media posts, webpages, decals, etc.)? Please briefly describe in the field below.

The website https://mcgill.ca/mc2/helium-recovery-system includes text and photos of the project. A note on funding is on the site. We have put SPF logo stickers on the equipment itself. An article by the SPF team is in progress.

9. Did you purchase equipment or make an installation on campus? ☒ Yes ☐ No
If yes, please briefly describe how these items will be maintained and used in the future.

The helium recovery system consists of a helium compressor, medium storage gas cylinders, a purifier, a liquefier, and a transfer dewar. All of this was purchased from Quantum Technology. In addition, copper piping linking the NMRs to the compressor, a 600V transformer, chilled water lines, and two junction boxes have been installed. The system will run continually to collect helium from NMRs as long as they are operational and in their current locations. Should the instruments be moved as part of the Royal Vic project, all five equipment components and as much of the related infrastructure as possible will be moved, as helium recovery has been planned for that building from the beginning.

As for maintenance, part of the purchase was a 2 year extended warranty and 5 years of maintenance. After this initial period, user fees collected from users of the NMR instruments will be used to maintain the system. These fees have traditionally been collected to pay for helium directly; now these fees will now be applied to maintenance of the equipment/repairs. We expect that the cost of maintenance and related purchases (including top-up helium) will be less than purchasing helium, so user fees will be reassessed on a regular basis in order to pass on cost saving to researchers as appropriate. The facility managers and electronics technicians will work together to carry out maintenance.

10. The following Key Success Indicators were indicated in your project application and selected for tracking. Please indicate the actual results that you have achieved in the "Actual" column.

Selected Key Success Indicators	Target	Actual
Quantity of helium captured/reused	90%	50%
Money saved on helium purchases	90%	50%
Additional partnerships/trainings developed with other units	2	2

If there is a significant difference in the target numbers and the actual numbers achieved, please explain. If you have any additional information to share about these success indicators, please also include it below.

In our original proposal, we proposed to optimize helium recovery rates over the year following installation. As installation only took place in April 2021, we expect to show much improved results in our final report in 2022.

11. Please report on your progress with the Standard SPF Key Success Indicators in the "Actual" column.

Standard SPF Key Success Indicators	Actual
# of people hired using SPF funding for the project	
# of volunteers directly or indirectly engaged in the project	
# of people (student, staff, or other) trained in the context of the project	4
$ raised for project activities subsequent to SPF funding	150000
# of tons of GHG emissions reduced by your project	unsure
# of partnerships or collaborations developed between the project team and other McGill administrative	2

units, student groups, community groups, other universities, and/or other groups/organizations.	

Please list the groups and/or organizations that you counted in the last Key Success Indicator. *Point form acceptable.*

Physics Department, MNI

If you have any additional information to share about the Standard SPF Key Success Indicators, please include it below.

GHG emissions calculation will be updated in 2022 final report

12. Please indicate the McGill stakeholder groups that were involved with your project as a team member or collaborator/partner. Select all that apply.

☐ Undergraduate ☐ Postgraduate ☐ Administrative Staff ☒ Academic Staff ☐ Alumni

13. Please rate your project team's overall satisfaction with the support provided by the **SPF Staff**.

☐ Very Dissatisfied ☐ Dissatisfied ☐ Neither Satisfied Nor Dissatisfied ☐ Satisfied ☒ Very Satisfied

Please provide any feedback or recommendations regarding your team's experience with the SPF Staff.

Everyone we worked with was extremely enthusiastic about the project, and very accommodating and understanding of the delays, changes in budgets and our inability to publicize the project for a long period. This, and the fact that we received news of the additional NSERC RTI funding shortly after the project was launched, meant there was absolutely no stress regarding how and when money was spent. Therefore we were able to make sure that when the installer finally came on site we were very well-prepared and the fact that there were some unexpected issues to address did not leave us with too little time for him to complete this task.

14. Please rate your project team's overall satisfaction of your experience with the **SPF**.

☐ Very Dissatisfied ☐ Dissatisfied ☐ Neither Satisfied Nor Dissatisfied ☐ Satisfied ☒ Very Satisfied

Please provide any feedback or recommendations regarding your team's experience with the SPF.

An absolute pleasure to work with. Our initial rejection was given to us along with enough feedback that we saw a pathway towards resubmission. Then the various progress reports and budget updates helped us view our progress in terms of the bigger picture. And every time we had a question, it was answered instantly.

15. If there is additional information you would like to share about your project, please use the field below. *Unlimited characters.*

As this project was quite different from many SPF projects it has been a bit difficult to fit into some of the success indicators- especially as the timeline is much longer than usual (and expected). As a high degree of technical expertise was required to initiate the project it was difficult to involve students as team members. However we have involved a number formally, through lectures, projects, and term papers, and informally, as they ask about what they see being installed in the buildings that the work in. We have been able to educate them about the SPF and how we can find ways to do chemistry sustainability. The use of lectures and projects about helium recovery in CHEM 462, 429 and 493 are expected to remain a part of the curriculum in the courses. Additionally the next time that CHEM 180 (World of Chemistry: Environment) is offered, we will present the recovery system.

We hope that in future we can bring more students into an active role in monitoring and optimizing the system. The ability to engage with students was really the only aspect of the project that was negatively affected by the COVID19 pandemic. Otherwise, as we had already met with a Quantum Technology engineer onsite prior to our initial funding request to the SPF, all aspects of site planning were very easy to complete virtually. The high US exchange rate at the

time of the initial 50% payment did increase the amount we expected to spend on the system, but subsequent negotiation by procurement, and the favourable drop in the exchange rate since, minimized that impact. The were no direct delays in manufacturing or building work due to the pandemic. Facilities did encounter some delays in receiving parts for the electrical work, but we cannot comment on the cause of delays on the part of their suppliers. We were very lucky to have worked with the only Canadian helium recovery system manufacturer, as it meant that their installer was able to travel to our site without any quarantine restrictions. And we were happy to find that he was very meticulous in making sure he had all the correct paperwork and awareness of COVID19 restrictions when planning his trip, and felt very sure he had both his, and our, health and safety in mind.

16. Has your involvement in this SPF project positively impacted your team in the area of **professional growth**?

☒ Yes ☐ No ☐ Prefer Not to Share

If you would like to elaborate, please use the field below.

During project preparation, we increased our knowledge of the helium life cycle and learned how different recycling/capturing methods work. Once we were awarded funding, we worked on the Call for Tender with Procurement; this was the first time either of us had been so directly involved in such a process. During project implementation, we learned much more about how building management and McGill Facilities work towards implementing a major project.

17. Has your involvement in this SPF project positively impacted your team in the area of **personal growth**?

☒ Yes ☐ No ☐ Prefer Not to Share

If you would like to elaborate, please use the field below.

Most of the project took place during the COVID 19 pandemic, from the end of the Call for Tender through to installation, and it was very positive for us to have this project to work on. It was also a true team effort, requiring people from across the university to complete.

18. Which of the following skills or attributes has your team improved through involvement in your SPF project? Select all that apply.

☒ Budgeting	☐ Networking	☐ Systems Thinking
☐ Communications	☒ Planning	☒ Teamwork
☐ Conflict Resolution	☒ Problem Solving	☒ Technology
☐ Leadership	☒ Project Management	☐ Time Management
☐ Listening	☒ Public Speaking	☒ Writing
☐ Mentoring	☒ Stakeholder Engagement	☐ Other *(Please specify in the field below)*
☐ Negotiating	☐ Stakeholder Identification	

Other:

19. Since starting your SPF project, has your team improved its **knowledge of sustainability**?

☒ Yes ☐ No ☐ Prefer Not to Share

If you would like to elaborate, please use the field below.

We had no idea how to calculate GHG at the beginning. Also, we discovered accidentally that the copper piping joints used - Viega ProPress - is a recognized green technology.

20. (Optional) If applicable, please list the total number of team members voluntarily self-identifying as members of marginalized communities. Total number: _____

(Optional) Please identify the represented communities below.

THANK YOU FOR COMPLETING YOUR FINAL REPORT!

Please e-mail your report to the SPF Staff attaching any additional information that you would like to share (e.g. other reports, research, documents, photos, etc.). Please note that this Final Report will be shared publicly on your SPF Project Webpage.