Burners and Barriers: Decarbonizing UBC's Chemistry Labs

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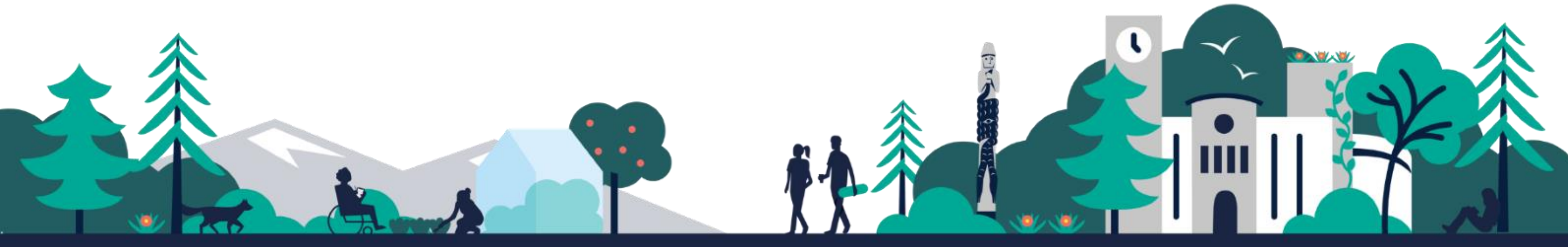

SEEDS Sustainability Program

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Executive Summary

Laboratories are among the most emissions-intensive spaces in universities, due to their reliance on energy-demanding equipment and infrastructure. At the University of British Columbia (UBC), efforts to meet Climate Action Plan 2030 (CAP2030) goals—which include an 85% reduction in operational greenhouse gas emissions by 2030—must address the continued use of natural gas in laboratory settings. This study investigates how natural gas-based equipment is used in UBC's Chemistry Buildings and examines the perspectives of laboratory users on the transition toward lower-carbon alternatives.

We partnered with UBC's Green Labs Program through the SEEDS Sustainability Program and used a mixed-methods approach consisting of site visits, semi-structured interviews, and a department-wide survey targeting staff, faculty, researchers, and graduate students. Our goal was to explore what types of equipment in the Chemistry Buildings still rely on natural gas, why it remains in use, and what forms of support users would require to facilitate a transition.

Findings show that Bunsen burners, butane torches, and gas-connected fume hoods are the most common gas-based tools still in use. Tradition, ease of use, and existing infrastructure were key reasons for continued reliance. While natural gas remains important in some contexts such as glassblowing and certain research techniques, 85% of respondents expressed support for department-wide efforts to transition to electric alternatives, contingent on proper funding, training, and policy support.

Our research highlights how user perspectives are shaped by a web of technical, institutional, and cultural factors. By applying a sociomaterial lens, we show that decarbonizing

laboratory spaces requires more than technical substitutions but also demands an understanding of how people, practices, and technologies are co-constituted.

Keywords: *Natural gas, laboratory equipment, laboratory decarbonization, UBC, sustainability, sociomateriality, user perspectives, energy transition, research infrastructure, greenhouse gas emissions, CAP2030*

Introduction

Climate change is widely recognized as one of the most urgent and complex challenges facing society today. As the crisis deepens, institutions across all sectors are under growing pressure to reduce their environmental impact. In climate action, universities serve both as drivers of sustainability research and as emitters through their operational footprints. Their responsibility extends beyond generating knowledge about sustainability; it includes taking concrete action to reduce emissions across campus systems, including the highly energy-intensive spaces of scientific research.

Laboratories are among the most emissions-intensive areas of a university, producing significantly higher emissions per square meter than classrooms or offices (Klein-Banai & Theis, 2013). While research infrastructure plays a vital role in scientific advancement, reducing emissions in these spaces poses unique challenges. In particular, the reliance on natural gas is difficult to phase out due to the technical demands of equipment, safety protocols, and research practices that depend on consistent and precise energy sources.

At the University of British Columbia (UBC), reducing reliance on natural gas is critical to meeting institutional climate targets. As outlined in its Climate Action Plan 2030 (CAP2030), UBC aims to reduce operational emissions by 85% by 2030 and reach net-zero emissions by

2035. A key part of this transition involves phasing out natural gas use in laboratories, where it remains critical for heating, equipment, and experimental processes.

Focusing on the Chemistry Buildings at UBC, our research examines how natural gas is used in laboratory settings and how the relationship between users, equipment, and institutional systems shapes perspectives and possibilities for decarbonization. Our research question asks: *How do user perspectives reveal the relationship between scientific practice and environmental responsibility in the context of laboratory decarbonization?* To explore this, we adopt a mixed-methods approach, combining surveys and interviews with laboratory users, including staff and students involved in laboratory operations for support, research and instruction. The report includes a literature review, methodology, analysis, and recommendations for supporting transitions toward natural gas-free laboratory operations.

Problem Statement

While UBC has committed to ambitious climate goals through the Climate Action Plan 2030 (CAP 2030), which targets 85% reduction in operational greenhouse gas emissions by 2030, practical steps toward achieving these reductions require a clear understanding of where and how emissions are produced. One under examined area is the use of natural gas in laboratory equipment. While the broader use of natural gas on campus is acknowledged, the specific role it plays in individual equipment remains poorly understood.

In the UBC Chemistry buildings, natural gas is still connected to equipment such as Bunsen burners, and potentially other equipment used in teaching and research. Although gas meters have recently been installed in the Chemistry buildings, equipment-level data remains unavailable. There is no centralized data identifying which equipment relies on natural gas, how frequently it is used, or whether it could be replaced with lower carbon alternatives.

Additionally, behavioral and institutional resistance to equipment change remains largely unexamined. Without a clear understanding of natural gas dependency and perspectives of those who work in these spaces, efforts to transition laboratories in Chemistry Buildings to low-carbon alternatives may overlook practical barriers and user concerns.

The research aims to address the gap by investigating specific use of natural gas-based equipment in laboratories in UBC Chemistry Buildings and explore whether it is possible to reduce or eliminate its use by evaluating alternatives and user perspectives.

Literature Review

Natural Gas

Natural gas is a fossil fuel primarily composed of methane (CH_4), formed from the decomposition of organic matter under high pressure and temperature over millions of years (Government of Canada, 2024). It has long been promoted as a cleaner alternative to coal and oil because it emits fewer pollutants and carbon dioxide (CO_2) per unit of energy when burned (EIA, n.d.).

However, the climate implications of natural gas use are more complex than initially perceived. While combustion of natural gas emits less CO_2 than other fossil fuels, its primary component, methane, is a far more potent greenhouse gas. Over a 20-year period, methane has more than 80 times the global warming potential of carbon dioxide (Howard et al., 2011). Methane can escape into the atmosphere at several points along the natural gas supply chain, including during extraction, processing, storage, and transport. These leaks pose a significant environmental risk, as even small leak rates can offset or exceed the climate benefits of fuel-switching from coal to gas (Alvarez et al., 2012).

This issue is particularly critical in the context of shale gas, where high-volume hydraulic fracturing (fracking) is used to extract gas from deep underground. Studies estimate that between 3.6% and 7.9% of methane from shale-gas production escapes into the atmosphere, largely during the flowback phase and drilling operations (Howard et al., 2011).

Beyond its contribution to global warming, natural gas production and infrastructure have local environmental and health implications. Drilling wells and laying pipelines require significant land clearing, which can disturb ecosystems, produce air and noise pollution, and contaminate local water resources through improper handling of wastewater (EIA, n.d.). Methane flaring, used as a safety measure or when gas is uneconomical to capture, releases a mix of pollutants including CO_2, sulphur dioxide, and nitrogen oxides, further contributing to air quality concerns (EIA, n.d.). Given these risks, transitioning away from natural gas is increasingly seen as a critical step toward meaningful climate action.

Canadian Context and CAP 2030

The Intergovernmental Panel on Climate Change (IPCC, 2023) states that mitigating climate change is widely recognized as one of the most critical issues currently facing human societies. Greenhouse gas emissions from human activities have already caused an average warming of approximately 1.1°C relative to the preindustrial period (IPCC, 2023). Addressing this challenge requires urgent action. News articles emphasize the need for strong and immediate reductions in emissions to achieve carbon neutrality within the next few decades (Tollefson, 2018; Liu et al., 2023, as cited in Capet & Aumont, 2024).

Canada is committed to achieving net-zero emissions by 2050 under the Net-Zero Emissions Accountability Act and aims to reduce GHG emissions by 30% below 2005 levels by 2030 (Environment and Climate Change Canada & Government of Canada, 2020). UBC has implemented its Climate Action Plan 2030 (CAP 2030), aiming to reduce operational emissions by 85% and extend impact emissions by 45% by 2030, with net-zero operational emissions by 2035, in line with national goals. UBC's strategy incorporates past experiences, feasibility studies, and collaboration with faculty, staff, students, and experts (UBC C+CP, 2024; UBC Vancouver Climate Action Plan 2030, n.d.). Besides community engagement and collaboration with students and staff, achieving these targets requires a practical analysis towards the phasing out of fossil fuel use in campus operations (UBC Vancouver Climate Action Plan 2030, n.d.).

The higher education sector, in particular laboratory operations, has been identified as a significant contributor to carbon emissions. Klein-Banai and Theis (2013) found that laboratory spaces have ten times the impact of emissions per square meter compared to classrooms and offices, in line with UBC's situation, where many laboratory buildings currently rely on natural gas equipment, even accounting up to half of UBC's operational emissions (Green Labs Program, 2020). UBC Sustainability highlights the high energy consumption of lab facilities, where fume hoods alone account for 10% of the university's total energy use (Energy Conservation, 2020). Since such equipment has been operating for 15-20 years, replacing them with low-carbon alternatives is crucial to achieving CAP 2030 targets. However, the higher upfront costs of low-carbon alternatives require additional funding, despite long-term savings (The University of British Columbia, 2021).

Conducting a lab equipment inventory to identify energy-intensive devices that can be turned off when not in use or set on timers is another practical step toward CAP 2030 goals (Energy Conservation, 2020). An opportunity to reduce emissions is shutting off unused gas lines, or at least to measure gas usages with meters. In the Chemistry Building at UBC Vancouver, assessing current gas-powered equipment and identifying feasible alternatives can help reduce dependency while maintaining research capabilities.

Sociomateriality and Resistance

Because our research focuses on the interdependent relationship between laboratory practices, equipment, building infrastructure, policy, and sustainability initiatives, we employ sociomateriality as our guiding theoretical approach. Sociomateriality views the social and material aspects of the world as inextricably intertwined, emphasizing that technologies are not neutral tools but co-constituted through human practices, routines, and institutional arrangements (Leonardi, 2012; Orlikowski, 2010). In particular, we examine how natural gas-based equipment, such as Bunsen burners and blow torches, are intertwined with lab users' routines, teachings, policy, and infrastructure. These technologies are not merely present in labs, they are integral to the way research is conducted, how students are taught, and how they are used, as well as how lab users perceive the feasibility of shifting to other alternatives or transitioning away from natural gas-based equipment.

Extending the concept of socio-materiality to the relationship between lab equipment, institutional norms, and daily practices, Leonardi (2012) emphasizes that the term "sociomaterial" serves as a powerful reminder that when we discuss technologies or organizations, we must recognize how social practices shape the materiality of technology and its effects. Tying this concept to the resistance encountered when transitioning away from natural gas, socio-materiality highlights how humans and equipment are deeply intertwined and mutually dependent. This mutual reliance leads to resistance from both individuals and institutions when long-standing relationships, such as those between UBC's natural gas users and lab equipment like Bunsen burners, are disrupted.

As Orlikowski (2010, as cited in Egyedi & Spirco, 2011) notes, infrastructures are difficult to change in response to new societal demands because they are entrenched materially and socio-institutionally, and seem to be “locked-in.” This insight emphasizes the tight coupling of social and material relationships and helps explain the challenges of shifting away from long-established, rigid systems. Similarly, Collingridge (1980, as cited in Egyedi & Spirco, 2011) explains that “gradually, more connections form between people and technologies. These connections solidify as routines, procedures, and relationships become formalized and standardized. As these practices take hold, the system becomes deeply embedded in both social and technical contexts, leaving little room for major changes” (p. 47). This insight underscores the substantial effort and disruption required to enact change within systems that have relied on established technologies for decades.

In the context of UBC’s Chemistry Buildings, the long-standing use of natural gas-based equipment, such as Bunsen burners and other lab tools, has shaped not only technical practices but also institutional routines and educational methods. These technologies have become integral to how work is organized, how research is conducted, and how knowledge is produced and taught. The shift away from them is not merely a matter of replacing one tool with another; it challenges a deeply rooted network of relationships, assumptions, and workflows.

Egyedi and Spirco (2011) expand on this idea, noting that “resistance is likely to take place if change is expected to upset markets (e.g., radically change value chains, severely increase competition) and turnover dominant technology regimes (i.e., challenging existing technology knowledge, practices, and policies).” In other words, resistance is not merely a matter of personal preference or stubbornness, it is often a systemic response to perceived threats to stability, familiarity, and institutional efficiency. To illustrate this point, Egyedi & Spirco provide the example of the Dutch Wobbe band. Despite its potential to enable the use of hydrogen via the existing natural gas infrastructure, its implementation has been limited due to anticipated competition between fuels, market uncertainties, and institutional hesitation. This case shows how transitions, even when technically feasible, may fail due to socio-material entrenchment and the structural inertia of existing systems.

Lane (2007) also identifies the “conservative characteristics of faculties in the ‘hard’ scientific disciplines,” noting their “fierce protection of current practices” and resistance to change. This insight is particularly relevant when examining the continued reliance on natural gas-based lab equipment, as such technologies could be entangled with longstanding pedagogical routines and disciplinary expectations. From a sociomaterial perspective, this resistance reflects how the material properties of natural gas infrastructure (e.g., open flames, gas lines) are co-constituted with social practices, such as curriculum and experiment design, and lab safety protocols.

While such dynamics have been documented in other contexts, similar discussions at UBC remain largely undocumented or unexplored. Applying the lens of sociomateriality, our research seeks to investigate whether and how such entanglements exist in UBC’s laboratories, specifically in the Chemistry Buildings, and to what extent they shape perceptions of, and potential resistance to, transitioning away from natural gas-based equipment.

Methodology

To understand the relationships between laboratory users and natural gas-based equipment, we first had to identify who used natural gas, what type of equipment they used, and how it was used within the Department of Chemistry. As geography students, we were not involved in university departmental operations or the teaching and research processes. Furthermore, we were conducting research in an academic department within the Faculty of Science, which we had not previously engaged with much as Arts students.

Due to our positionality and limited interactions with Chemistry, we designed a three-step, mixed-methods approach for an in-depth understanding and investigation of Chemistry operations and practices. An initial site visit was conducted in January to determine the scope and selection of buildings for our research, followed by a 6-week data collection period in late March to mid-April. This step-by-step approach allowed a holistic understanding and perspectives from back-end operational staff to front-end laboratory users.

Step 1: Site Visit

As a first step, our group conducted a preliminary site visit to the Chemistry Complex in late January. This included a thorough walk-through of Chemistry Wings A to E, where we identified laboratories and facilities based on name plates and paired our field observations with information from the Chemistry website. By matching laboratories in the buildings with their respective lab websites and staff contacts, and using deductive reasoning, we established a preliminary list of contacts who potentially used natural gas in their laboratories.

Step 2: Interviews

Considering our target population was both known and relatively small, alongside the unique and diverse laboratory practices that occur within the Department, we opted for a non-random selection method for interview participants, whereas interviewees selected were "on the basis of [our] own judgement about which ones will be the most useful" (Babbie & Benaquisto, 2013, p. 163). These interviews were conducted on an individual-basis and semi-structured in nature, focusing on higher level, operational and organisational relationship with natural gas equipment.

Interviewees were contacted through three rounds of email outreach, prioritised by staff's roles based on Step 1 findings. We also aimed to use these interviews to inform our survey design, prioritising outreach to support facilities and staff in managerial or director-level roles, followed by Faculty involved in Chemistry courses with lab components, and research lab representatives.

We designed sets of interview questions, each covering five key themes and approximately nine to eleven core questions. Depending on whether the interviewee was a "Staff", "Faculty" or "Graduate Student", as denoted on the People Directory on the Department website, questions were selected either from Set 1 (Operational/Research Staff) or Set 2 (Teaching Staff in Lab Courses). Each set of questions included guiding sub-questions for more in-depth discussion as needed. While both addressed key themes on existing equipment relationships and transition perceptions, Set 1 emphasised procurement and the decision-making process, while Set 2 emphasised equipment for teaching and curricula delivery. These questions and themes can be accessed in Appendix A.

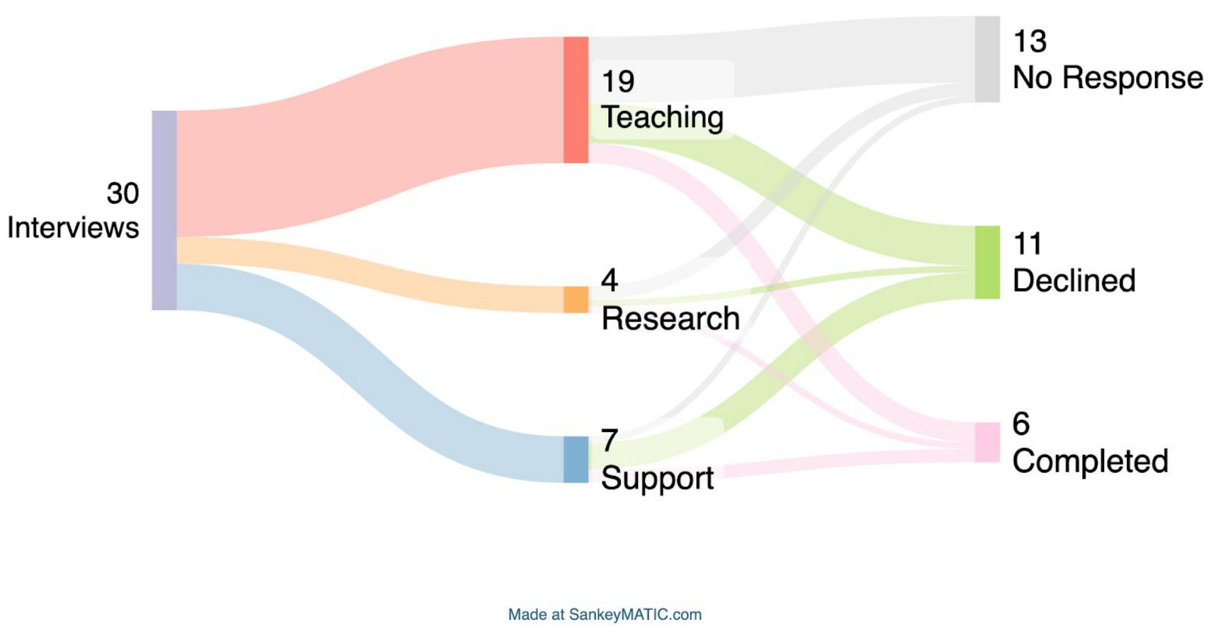

Figure 1 - Interview Outreach, Response Rates and Outcomes

Adopting a subjective sampling of interview participants, we reached out to a total of 30 interviewees via Outlook, including 19 staff and faculty members involved in laboratory teaching processes, 4 members involved in research laboratories, and 7 members on the Support facilities in the Chemistry Building. While we received 11 declined responses, their declines were primarily due to not using natural gas in their laboratories, which contributed towards narrowing down and identifying who does use natural gas.

The six completed interviews included a mix of three virtual Zoom interviews, two in-person interviews at the interviewee's labs, and one conducted via email correspondence. Of the six interviewees, five were directly invited via Outlook, while one was referred through our Green Labs program partner. Please refer to Appendix B for a list of interviewees and their lab affiliations.

Step 3: Surveys

We conducted our survey using purposive sampling, targeting Faculty, Staff, and Graduate Students within the Chemistry Department. The survey was primarily distributed through internal communications, a poster on the Chemistry Graduate Student Board, word-of-mouth through our partner's contact, and direct email outreach to 32 Research Faculty members. While the outreach email focused on natural gas usage, the survey was designed so respondents without natural gas usage in their labs could still participate. As we were unable to carry out initial interviews in time to fully inform our survey design, our survey featured some overlapping themes with our interview, such as identifying natural gas-based equipment and its use frequency. Additionally, the survey also served as an outreach tool to the 30+ research laboratories in Chemistry that we could not reach out for interviews within our data collection timeframe. We received a total of 21 responses, out of which 14 responses were fully completed.

As our interview also focused more on the back-end operational staff, our objective was to reach graduate students and researchers, who were the front-end users of equipment and engaged in laboratory processes on a day-to-day basis.

To minimise survey fatigue, the survey was designed to take no more than five minutes while still allowing "maximum opportunity [for participants] to respond" (Parfitt, 2005). We achieved this through a mix of binary and multiple-choice questions, one Likert scale question, and optional open-ended responses. Classification questions, such as an individual's primary role, were designed as multiple-choice questions based on the organisational structure identified in Step 1. The full survey can be found in Appendix C.

Ethics Considerations

As we were conducting our research on behalf of the Green Labs Program, we were mindful that "ethical behaviour helps assure a favourable climate for the continued conduct of scientific inquiry" (Hay, 2003). Given that our client continues to work closely with laboratory users, it was important for us to build trust and maintain transparent communication throughout our data collection process. To do so, we clearly communicated our research objectives, ethics ID, and consent form in our survey, and ensured that interviewees had time to ask questions about our goals and consent form prior to each interview.

As UBC students, we are also privileged to engage in research on campus. During our site visit, we were careful not to interrupt day-to-day operations or trespass restricted areas, respecting existing physical boundaries. Particularly, when invited into laboratory spaces for interviews, we adhered to all laboratory safety regulations and wore all required personal protective equipment, as well as maintaining an appropriate volume when talking near offices and classrooms.

Since our target population was limited to the Department of Chemistry, participant contacts and information were easily accessible online. Especially in some labs with very few staff members, or even just one, it was essential to carefully filter identifying details to preserve participant anonymity.

Limitations

As we opted for a non-probability sampling method, we were unable to obtain a representative sample of the Department of Chemistry. Although the target population was known, it was not feasible within our limited timeframe to engage with all 30+ research laboratories. With the diverse research, teaching and support activities occurring in the Department, any generalisations from our data would not reflect the full complexity and diversity of the Department's operations.

Our positionality as Arts students and outsiders to the Department also may have posed a limitation. With a deductive approach, we went in assuming most contacts were using natural gas, framing our research focus on existing natural gas usages. By focusing only on existing natural gas use, we missed an opportunity to connect with individuals who had historical usage of natural gas equipment or have already transitioned away from natural gas-based practices, limiting the perspectives and responses we gathered.

Analysis

This section showcases what we learned from both our survey results and interview findings, which provide insights into the persistent use of natural gas-based equipment in UBC's Chemistry Complex. Through a combined qualitative and quantitative lens, we examine the material systems in place and the social, teaching, and institutional practices that shape them. By framing this analysis through a sociomaterial perspective, it helps reveal how decarbonization in laboratory contexts is not just a matter of technological substitution but an entangled process of cultural, infrastructural, and institutional transformation.

Survey Results

Looking at the survey responses, it was revealed that the most commonly used natural gas-dependent equipment in the Chemistry Complex laboratories is Bunsen burners shown in Figure 2. This is followed by blow torches, which were used occasionally for specific research needs such as spot-drying glassware. Natural gas lines embedded in fume hoods were also installed by default, but are the least frequently used. These findings indicate that while not all natural gas lines are consistently active, old systems tend to stick around and keep influencing how things are done because they have already been implemented for a long duration.

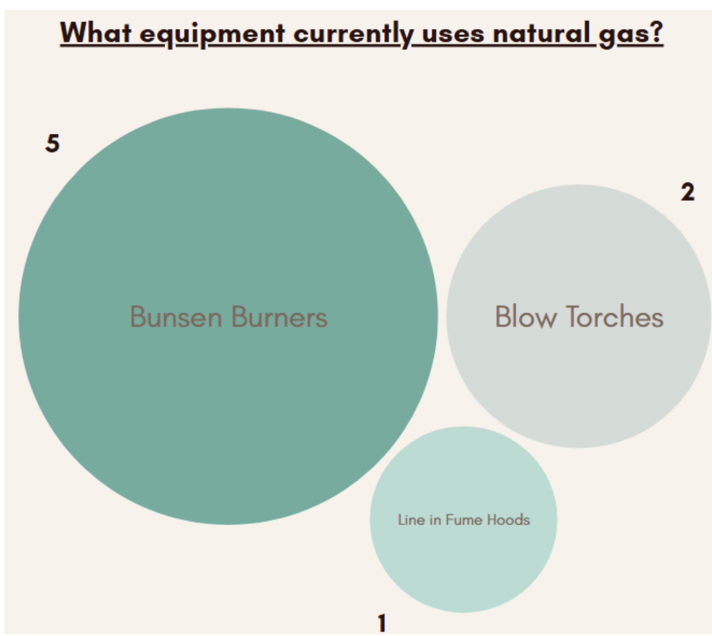

Figure 2 - Types of Equipment That Rely on Natural Gas

We further asked why natural gas-based equipment is still being used, and participants were asked to identify factors that influence their use. Figure 3 shows the most frequently cited reason was tradition, with 60% of respondents indicating that it is what they are used to. This was closely followed by factors such as equipment performance, existing infrastructure, and ease of use, each selected by around half of the respondents. Interestingly, cost-effectiveness was mentioned less often, suggesting that economic rationale plays a more secondary role compared to established norms and operational convenience. 30% of the respondents selected “Other,” providing qualitative comments that referenced teaching routines in introductory lab courses and a general lack of awareness about electric alternatives.

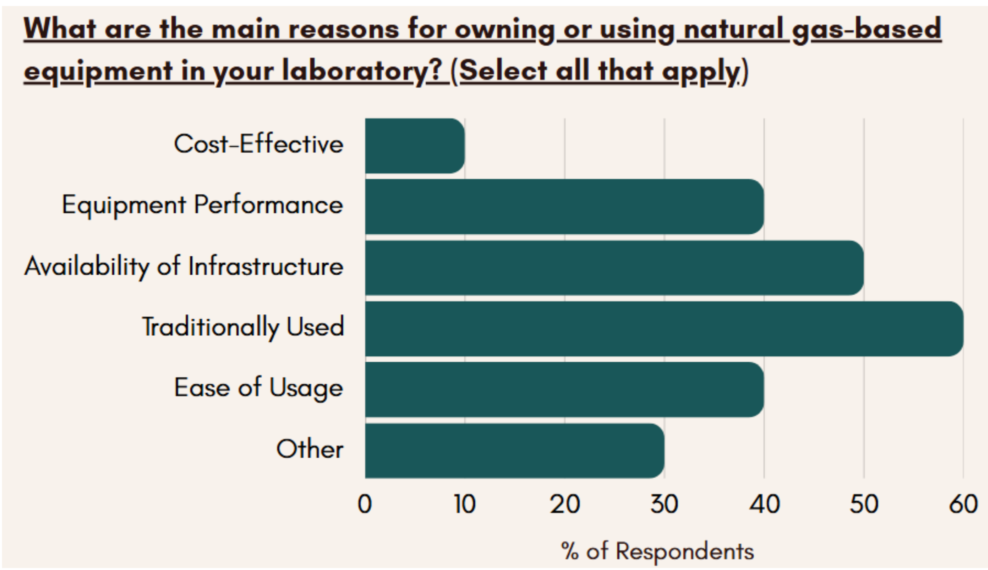

Figure 3 - Reasons for Owning or Using Natural Gas-Based Equipment in Laboratories

Despite all this, in Figure 4, illustrates that there is a clear openness towards decarbonization. When asked whether they would support department-wide efforts to phase out natural gas-based equipment in favour of electrical alternatives, 85% of respondents showed support. This suggests that people are willing to change, but they will need proper support from the institution to make a change.

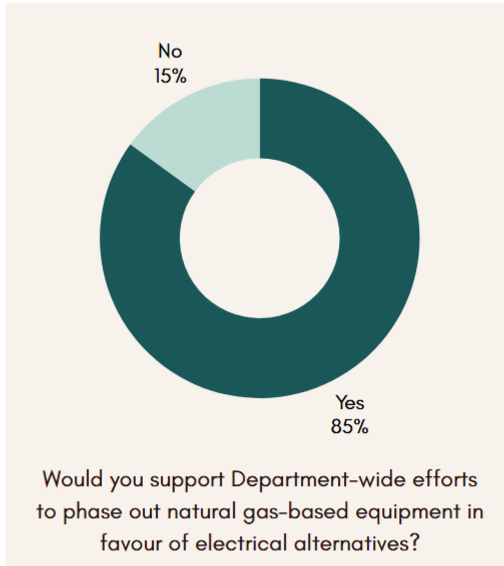

Figure 4 – Support for Phasing Out Natural Gas-Based Equipment in Laboratories

Participants were also asked what kinds of support would be necessary to facilitate such a transition. Figure 5 shows the most frequently selected options were funding for new equipment and policy incentives from the university. Over half of the respondents also indicated the need for training on how to operate alternative technologies, while others pointed out the importance of maintaining equipment inventories and ensuring access to reliable maintenance services. These findings highlight the need for not just technological upgrades, but comprehensive structural support that changes how laboratory work is resourced and maintained.

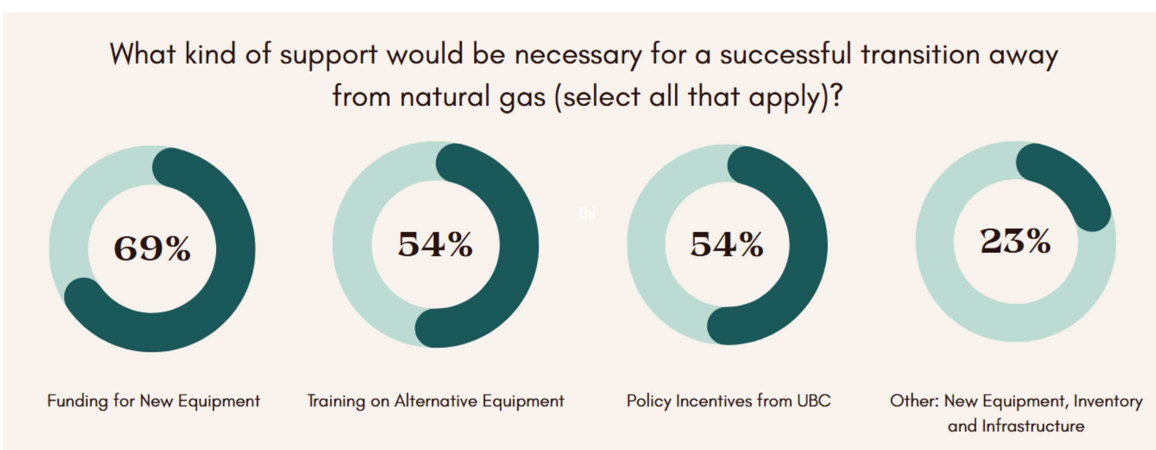

Figure 5 – Supports Needed for a Successful Transition Away from Natural Gas in Laboratories

The survey also asked participants which Chemistry Wing they primarily worked in. Figure 6 shows that most respondents reported working in either Chem D Wing or Chem A Wing, with Chem D Wing having the highest percentage of respondents. The high number of participants from Chem D Wing is important because it also aligns with the usage of natural gas. Many of the people working in Chem D mentioned that natural gas remains a major part of their daily activities.

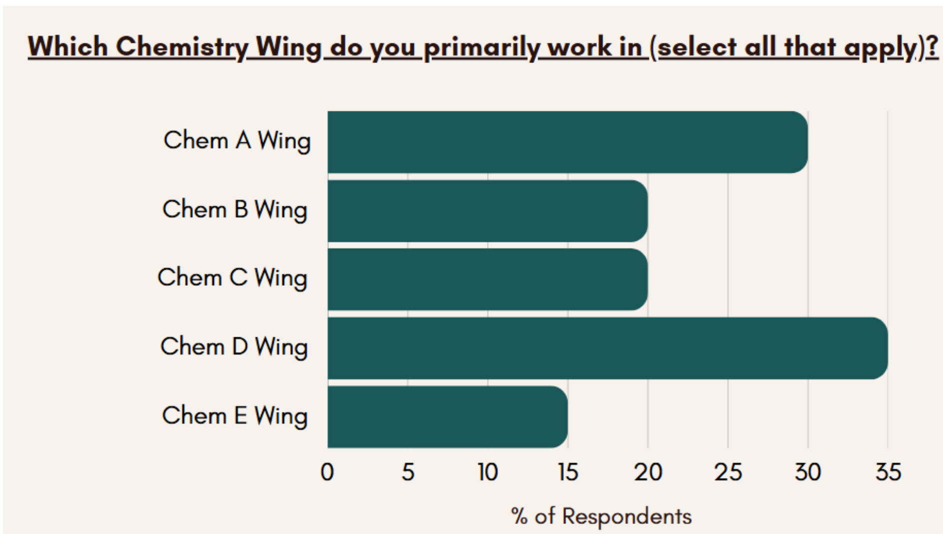

Figure 6 – Primary Chemistry Wing Work Locations of Survey Respondents

Insights from Interviews

After interviewing with lab staff and faculty, we got a better sense of why natural gas is still being used in some areas shown in Figure 7. Most interviewees noted that it's still extremely important for certain kinds of research, especially in synthesis labs. Some reactions need a steady, high-temperature flame, and electric alternatives are not suitable for that role. One interviewee also noted that natural gas is still used in first-year teaching labs and public outreach demonstrations because it's familiar and simple enough for new students, while others noted that they do not use and do not plan to use natural gas-based equipment in teaching anymore due to safety reasons and the availability of more effective alternatives.

Figure 7 - Insights from Interviews and Survey Responses

Interviewee 6 mentions that natural gas is absolutely essential for what they do. They use it to melt and shape glass, and even the raw materials depend on fossil fuels to be made in the first place. Much of the equipment in the shop has been unchanged for decades, and although they have expressed hope that 3D printing of glass might become a solution in the future, it was doubtful within their lifetime. Natural gas is not just a convenient option but is critical to keeping the shop working. Without natural gas, the shop would have to close. Interviewee 6 also emphasizes the durability and reliability of tools like Bunsen burners and hand torches, which have been used across teaching and research labs forever. Interviewee 6 also describes natural gas as a clean, controlled, and widely accessible fuel source, stating how it even powers many of the engines that generate electricity. The interviewee's view was clear, transitioning away from natural gas without any effective alternatives in place would cause disruptions within the labs.

Interviewee 6 states that “you don’t put the cart before the horse”, illustrating that a reliable replacement must be discovered before existing systems are phased out.

Other people pointed out some examples of tools that are still relied on. Butane torches are often favoured for spot-drying glassware because they are more reliable and faster than available electric alternatives. Another person working in the glassblowing division said they still need natural gas for shaping glass, as it offers the necessary precision and intensity for manipulating glass. This showcases a continued reliance on natural gas, not just for functional reasons, but for skilled, embodied practices that have developed over years of work. There were also some concerns about switching away from gas. Cost and safety were the main focus, as many participants explained that budget constraints limit their ability to purchase newer electric equipment, particularly when grants and funding structures prioritize scientific output over operational sustainability. There was also a strong sense of uncertainty around the performance of electric tools, as people were worried about how changing equipment might affect their results with the consistency of their experiments. One interviewee explained that cost plays a major role in purchasing decisions. When buying new equipment, it is often necessary to purchase multiple identical models at once to maintain consistency across all labs. Having different models of the same tool makes it harder to run classes and train students effectively. Space is also an issue, as there simply isn’t enough room to store the large amounts of new equipment without any renovations. This ties in with the openness to purchasing more sustainable equipment and how it is not currently the top priority. The interviewee stated that the focus right now is mainly on safety, affordability, and infrastructure.

Through the Lens of Sociomateriality

Our findings suggest that perspectives among lab users at UBC vary, some individuals express more resistance to transitioning away from gas-based equipment, citing concerns over functionality and disruption to established routines, others appear indifferent, as the transition may not significantly affect their work; while a third group actively supports change, motivated by sustainability goal. These diverse responses underscore the sociomaterial complexity of the issue, where attitudes toward change are shaped not only by individual values, but also by how deeply embedded natural gas infrastructure is in the daily practices, spatial configurations, and disciplinary norms of laboratory work. Sociomateriality helps us understand that such resistance or acceptance does not occur in isolation but emerges from a web of interdependencies between people, practices, and material systems.

Combining everything together, the survey data and interview narratives reveal that decisions around laboratory equipment use are not based solely on technical specifications. These decisions are embedded in what scholars have described as sociomaterial practices, where technical systems are entangled with social processes and institutional norms. The continued use of Bunsen burners is not merely about their function as a heating tool, but it also reflects how lab users are trained, how research protocols are written, how safety protocols are structured, and how the physical space is designed. Even if electric alternatives exist, their integration into chemistry labs requires retraining, retooling, and rethinking how scientific work is done. This sociomaterial lens highlights the complexity of decarbonizing laboratory infrastructure. Without addressing these systems, traditions are unlikely to succeed. In conclusion, the findings suggest that the persistence of natural gas in university labs is not due to outright resistance but to the factors of embedded practices, institutional habits, and infrastructural path dependencies.

However, the high level of expressed support for sustainable alternatives indicates that with the right combination of training, policy support, and funding mechanisms, meaningful change is not only possible, but it is already desired by many within the community.

Significance

The findings of this research offer valuable insights into the challenges and opportunities of decarbonizing university laboratories, particularly within the context of UBC's Chemistry Buildings. Despite the longstanding presence of natural gas-based equipment such as Bunsen burners, torches, and fume hoods, this study revealed a general willingness among users to support transitions toward electrical alternatives provided that sufficient institutional support, funding, and training are in place.

This project contributes to UBC's Climate Action Plan 2030 (CAP2030) by helping illuminate how and why natural gas continues to be used in laboratory settings. While institutional efforts such as installing gas meters signal progress, there remains a lack of equipment-level data and user-oriented strategies to phase out gas use effectively. This study begins to fill that gap, offering both empirical findings and qualitative perspectives from lab users that can guide future planning.

From a scholarly perspective, the project reinforces and extends sociomaterial theories of sustainability transitions. By showing how equipment use is deeply embedded in teaching routines, research protocols, safety standards, and even user identity, it highlights that technical change cannot be achieved through top down policy alone. Transitioning away from natural gas involves reconfiguring a web of practices and relationships that demands collaboration, experimentation, and long term engagement with end users.

In particular, the research adds to the growing literature on resistance to sustainable transitions within scientific institutions. While previous studies have identified institutional inertia as a barrier, our findings specify the mechanisms by which resistance occurs: through perceived risk, embedded habits, and disciplinary conservatism. On the other hand, the data reveal points of leverage such as wide support for decarbonization, openness to alternatives, and awareness of infrastructure inefficiencies.

By foregrounding the perspectives of students, technicians, and faculty, this project offers a grounded understanding of laboratory decarbonization that can inform UBC's operational planning, policy interventions, and investment priorities. The insights are also transferable to other post-secondary institutions facing similar challenges in transitioning away from fossil fuel-reliant research infrastructure.

Recommendations

Identifying the intertwined relationships of users and equipment, our overall recommendation is that gas lines cannot be hastily shut down as many are still actively used in support, teaching and research labs. While some labs have expressed plans to completely transition away from natural gas, other processes have been deeply rooted in decades of Departmental practice and infrastructure. Additionally, with new alternatives, many expressed concerns that it may not perform at the same level as existing natural gas fed open flames, and the time and finances taken to retrofit the entire set of existing equipment is significant. Some also discussed safety as a top priority in navigating new equipment.

Yet, there have also been success stories in transitioning to other heating methods, namely hot plates and thermal wells in lieu of Bunsen burners. Many also were willing to transition provided that alternative sources of fuel were available at the Chemistry Stores.

1. For a successful transition, a long-term transition plan must first be established. Our findings identify that while many laboratory users support decarbonization in principle, meaningful changes cannot occur without alignment between institutional policies, fundings, and users' needs. Strong community engagement and adequate time is required. Engagement should begin early and continue throughout implementation, with opportunities for users to voice concerns, co-design solutions, and stay informed of upcoming changes.
2. Further feasibility study of alternative equipment to compare effectiveness between equipment types and fuel types could be beneficial. As individuals requested alternatives in replacing existing equipment, with concerns on its effectiveness to conducting the same processes, there is potential to engage with Chemistry students and staff to conduct small group trials and feedback.
3. Providing comprehensive training and accessible technology guides of new equipment is essential to support a successful transition away from natural gas. These resources will help lab users become familiar with the alternative, understand how to operate it safely and efficiently, and build confidence in its ability to meet their research and teaching needs. Ensuring that users have the opportunity to learn and adjust before natural gas systems are removed helps alleviate concerns about performance and reliability. This is particularly important when replacing long-standing tools such as Bunsen burners, gas torches, or gas-connected fume hoods, which many users are accustomed to and rely on

in their daily routines. Offering hands-on demonstrations, user feedback opportunities, and ongoing technical support can further strengthen trust in the transition process and promote a smoother, more inclusive shift toward low-carbon laboratory practices.

Future Research

This project has generated useful findings and it points to several areas for further research. One major avenue involves deepening the understanding of how natural gas usage varies by discipline and lab type. While our study focused on the Chemistry Department, other departments such as Physics, Engineering, or Biological Sciences may have different energy demands, pedagogical needs, and transition challenges. Comparative studies could help identify best practices or common bottlenecks across disciplines and may lead to more efficient natural gas transitioning processes.

Future research should also pursue quantitative equipment level data collection, While our study relied primarily on user perspectives and general knowledge of lab infrastructure, integrating quantitative usage data could provide a more comprehensive view of emissions sources and help track the impact of transition efforts over time.

In addition, there is a need for more participatory and ethnographic approaches that explore user behaviour in real time. While our surveys and interviews captured important narratives, methods such as participant observation or lab based focus groups could help uncover the often invisible routines that shape equipment use. These methods would be especially useful for understanding how sociomaterial entanglements are formed and maintained in day to day lab life.

More research is also needed to explore pedagogical dimensions of decarbonization. For example, how might switching from gas to electric equipment alter student learning outcomes, safety training, or curriculum delivery in teaching labs? Addressing this could support the design of new instructional models that align sustainability goals with pedagogical excellence.

Finally, future work could examine institutional decision-making and procurement processes. Many interviewees noted that funding constraints and administrative systems shape equipment purchases more than sustainability priorities. A better understanding of how decisions are made, and by whom, would support more strategic interventions that align purchasing policies with climate commitments.

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Appendices

Appendix A

<u>Set 1 Interview Questions (Operational/Research Staff)</u>
#1 Individual and Lab Background

1) Can you tell us about yourself? What is your involvement with the Department of Chemistry and/or Chemistry Labs?
2) Do you currently have any laboratory equipment in your lab that requires natural-gas?
    a) If YES: Please tell us briefly about it.
        i) What is it?
        ii) How is it used in instructional/research/other?
        iii) Where does its source of natural gas come from? (gas lines or compressed gas cylinders?)
        iv) How often is it being used?
        v) What are some factors that might influence whether this equipment continues to be used in the future?
        vi) What kind of incentives would encourage you to transition away from this equipment?
    b) If NO: Have you had natural-gas equipment in the labs you support in the past, or maintained natural-gas equipment in the past?
        i) If yes, what was it?
        ii) If yes, how was it used in instructional/research/other?
        iii) If yes, where does its source of natural gas come from? (gas lines or compressed gas cylinders)
        iv) If yes, how often is it being used?
        v) If yes, could you share the factors that led to its decommissioning?
        vi) If NO, do you foresee purchasing any equipment that uses natural-gas in the next 10 years? Why or why not?
3) From your experience, how has the use of natural-gas lab equipment changed over time?
    a) Area 1 (Behavioural): In terms of usership and practice of students, researchers and faculty for instructional and research in Chemistry Labs, how have their relationships with equipment evolved over time?
    b) Area 2 (Material): How has technological improvements and innovative updates changed over time?
    c) Other: Anything other areas that have changed over time that the interviewee would like to share.

#2 Organisational Decision-Making

4) Are you involved in the decision-making and/or procurement process of lab equipment?
    a) If YES
        i) How do you decide what laboratory equipment to purchase? What are some factors you generally consider in this process?
        ii) How do you weigh these factors in your procurement process?

iii) Are there any department policies or budget constraints that affect the procurement process?
iv) How much flexibility do you have in choosing lab equipment, such as exploring alternative laboratory equipment options?

b) If NO: SKIP TO Q5

#3 Awareness and Transition

5) Beyond your own lab, do you know whether there is natural gas-based equipment in the Chemistry department?
6) What kind of alternatives have you looked at as alternatives to natural-gas based equipment?
   a) If YES: What is the reason that you have considered alternatives? What do you think of those alternatives?
      i) PRACTICE/DEMAND: Does the alternative have the capacity to meet existing research and teaching requirements and practice? Can it deliver the same functions as the equipment it is replacing?
      ii) MATERIAL/PRACTICAL: Is it a cost-effective alternative? Organisational constraints (department policies)? What is the durability of the alternative compared to existing equipment?
   b) If NO: Skip to Q7
7) What would be the most important factor influencing your decision to adopt alternatives to natural gas-based lab equipment?

#4 Perceptions

8) (In your role), what are your thoughts on decarbonising laboratory equipment?
   a) What do you think are some benefits or challenges in transitioning away from natural gas-based lab equipment?
   b) How do you anticipate students, researchers, and faculty responding to a shift towards new equipment?
   c) Do you anticipate challenges in re-training existing users on using the alternative equipment?
9) Have you heard any discussions (positive or negative) among your colleagues about transitioning away from natural gas-based lab equipment?
   a) If YES: Could you share any positive and/or negative comments or experiences related to electric lab equipment?
   b) How easy or difficult do you think it would be to access and implement electric alternatives in labs?
10) What would make the transition to electric lab equipment easier or more appealing for you?

#5 Miscellaneous

11) Any final thoughts you would like to share about the Green Labs program, using natural-gas equipment in labs and/or transitioning away from it?

Set 2 Interview Questions (Teaching Staff in Lab Courses)

#1 Individual Background

1) Can you tell us about yourself? What is your involvement with the Department of Chemistry and/or Chemistry Labs?

#2 Natural Gas Equipment and Relationship

2) If any, can you share the name of all equipment that you currently use for instructional purposes that require natural gas?
    a. IF YES: How important is/are natural-gas based equipment towards delivering course curriculum? Would you be able to deliver course content in the absence of those equipment(s)?
        i. Are there specific experiments or processes that you believe would be challenging or impossible to conduct without natural gas-based equipment?
        ii. Have you looked into alternatives to natural gas-based equipment? What are they, if known, and what do you think about them?
        iii. Have you also explored or considered alternative methods of delivering the curriculum/experiment that currently requires the natural-gas equipment?
        iv. What kind of incentives would encourage you to transition away from natural-gas based equipment?
    b. IF NO: Do you use any lab equipment in your teaching? How important is lab equipment to delivering your course curriculum? Would you be able to deliver course content in the absence of those equipment(s)?
        i. Are there alternatives to existing equipment(s), and what are they, if known?

#3 Awareness and Transition

3) Can you share some benefits and challenges of transitioning towards non-natural gas based equipment?
4) From your knowledge, do you think electrical or non-natural gas alternatives can fully replace natural-gas based equipment?

#4 Perceptions

5) How would a change in lab equipment affect your teaching, students, and lab users?
6) What are your thoughts on the potential for alternatives to natural gas in lab settings?
    a. If suitable alternatives were available, would you consider transitioning away from natural gas-based equipment?
7) What factors might influence your willingness to transition to alternative, non-natural gas-based equipment?
8) Have you observed successful implementations of sustainable alternatives in other institutions?
    a. What factors do you think contributed to their success?

#5 Miscellaneous

9) Any final thoughts you would like to share about the Green Labs program, using natural-gas equipment in labs and/or transitioning away from it?

Appendix B

List of Interviewees

List of interviewees arranged in order of interview or email correspondence, denoted by their laboratory affiliation category (Support, Teaching and/or Research), and position category (Faculty, Staff, Graduate Students) organised on chem.ubc.ca.

Interviewee 1: Support Lab, Staff

Interviewee 2: Teaching Lab, Staff

Interviewee 3: Teaching Lab, Staff

Interviewee 4: Teaching Lab, Faculty

Interviewee 5: Research & Teaching Labs, Graduate Student

Interviewee 6: Support Lab, Staff

Appendix C

Appendix C: Survey Questions

* Denotes mandatory questions.

#1 Introduction

1. Consent Form* [Multiple Choice, One Answer]
   a. I Consent
   b. I Do Not Consent

#2 Background Information

2. What is your primary role at the University of British Columbia?* [Multiple Choice, One Answer]
   a. Research Faculty
   b. Teaching Faculty
   c. Lab Technician
   d. Graduate Student
   e. Researcher
   f. Other (Please Specify)
3. What are your area(s) of involvement in the Department of Chemistry?* [Multiple Choice, Multiple Answers]
   a. Research
   b. Teaching
   c. Lab Support
   d. Other (Please Specify)
4. Which Chemistry Wing do you primarily work in (select all that apply)?* [Multiple Choice, Multiple Answers]
   a. Chem A Wing
   b. Chem B Wing
   c. Chem C Wing
   d. Chem D Wing
   e. Chem E Wing
   f. Other (Please Specify)
5. How many years have you been involved or worked within the Department of Chemistry?* [Text Entry]

#3 Natural Gas Experience and Usage

6. Are you currently involved with any Chemistry laboratories in any capacity (such as teaching, research, or as support staff)*? [Multiple Choice, One Answer]
   a. Yes
   b. No

7. Have you used or managed natural gas-based laboratory equipment in the past? [Multiple Choice, One Answer]
    a. Yes
    b. No
    c. Unsure
8. Please specify all natural gas-based equipment you own or use in your laboratory (if none, put 'NA' and skip to next page) [Text Entry]
9. How often do you use natural gas-based equipment in your laboratory? [Multiple Choice, One Answer]

a. Daily
b. Weekly
c. Monthly
d. Yearly
e. Less than Yearly

10. What are the main reasons for owning or using natural gas-based equipment in your laboratory (select all that apply)? [Multiple Choice, Multiple Answers]
    a. Cost-Effective
    b. Equipment Performance
    c. Availability of Infrastructure
    d. Traditionally Used
    e. Ease of Usage
    f. Other (Please Specify)

#4 Natural Gas Future Usage

11. Do you plan to use and/or purchase natural gas-based lab equipment in the next 5-10 years?* [Multiple Choice, One Answer]
    a. Yes
    b. No

#5 Natural Gas in Department

12. Do you know anyone in the Department of Chemistry who uses natural gas-based lab equipment?* [Multiple Choice, One Answer]
    a. Yes
    b. No
13. If known, please list the lab equipment that they use. [Text Entry]

#6 Transition and Alternatives

14. What do you see as the challenges in transitioning away from natural-gas based lab equipment (select all that apply)?* [Multiple Choice, Multiple Answers]
    a. Budget Restraints
    b. Lack of Suitable Replacements
    c. Time Taken to Learn New Equipment
    d. Safety Concerns
    e. Other (Please Specify)

15. On a scale of 1-5, how willing would you be to transition away from natural gas-based lab equipment if viable alternatives were available? (Scale: 1 = Not Willing At All, 5 = Very Willing, Not Applicable)* [Likert Scale]
16. What kind of support would be necessary for a successful transition away from natural gas (select all that apply)?* [Multiple Choice, Multiple Answers]
    a. Funding for New Equipment
    b. Training on Alternative Equipment
    c. Policy Incentives from UBC
    d. Other (Please Specify)
17. Would you support Department-wide efforts to phase out natural gas-based equipment in favour of electrical alternatives?* [Multiple Choice, One Answer]
    a. Yes
    b. No
18. What potential alternatives do you think could replace natural gas in lab equipment? [Text Entry]

#7 Miscellaneous

19. Do you have any additional comments or concerns regarding the potential transitioning away from natural gas-based laboratory equipment and decarbonisation of laboratories? [Text Entry]

#8 Voluntary Interview

20. Thank you for taking part in our survey. Would you be interested in taking part in an interview? We'd love to hear more about your thoughts and experiences.* [Multiple Choice, One Answer]
    a. Yes
    b. No
21. Thank you for your interest! Please type below your email so we can contact you. Be aware that by giving us your email we will be able to connect your email with your responses. That way we can follow up on your answers, but your identity will remain confidential. [Text Entry]