Promoting a Circular Economy Through Shared Use of Underutilized Scientific Equipment and Energy Data Collection

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Introduction

The National High Magnetic Laboratory, (NHMFL) known for its powerful magnets houses thousands of equipment's. With such a large facility, there is a high environmental footprint, and while the NHMFL maintains a strong commitment to sustainability, for example through the laboratory's helium recycling program which recycles 85–90% of helium, additional steps can be taken to promote this further. By introducing circular economy principles, the NHMFL has the opportunity to build on its existing efforts by extending the life cycle of equipment, and making more efficient use of its resources. This project aims to (1) Promote circular-economy practices by building a website that tracks equipment reuse at NHMFL. (2) Construct and wire 3D power logger boxes that will allow for data collection of the NMR/MRI consoles.

Aim 1:- A mockup site is being built to facilitate equipment sharing across the NHMFL. We aim to minimize redundant acquisitions and promote a circular economy by gathering information on available equipment's via survey. The developed website will serve as a point for the NHMFL Web Applications Group (WAG) team to further implement. While FSU's asset management site performs a similar role, based on interdepartmental rules, a site for just the NHMFL would be able to accommodate proper reuse of capital property.

Aim 2:- Power loggers were installed on designated laboratory instruments as part of Aim 2. The 900 MHz magnet supports three distinct applications, each with specialized equipment. All configurations uses Bruker 2-bay Neo console. NMR uses the FTS Sample Chiller and MAS II unit. MRI uses Bruker Gradient Chiller BCU 20, and GREAT 60 gradient amplifier. The overall power consumption was continuously recorded over a given period while the equipment operated under different conditions. The data will show variation and allow identification of patterns in energy usage.

Establishing A Circular Economy

The NHMFL already has an existing inventory management site, as do some FSU departments. The inventory system was built through the budget management process, which involves the NHMFL staff and the information they provide when procuring new equipment. That information was then transferred into the inventory management site, resulting in over 7,000 entries.

Although comprehensive, this dataset could not be used for developing the mockup site or supporting circular-economy efforts because it contains far too many entries. However, with guidance from the WAG team, the idea of a survey emerged as a way to collect only the relevant information that would later be fed into the new site, similar to how data is entered into the inventory system, but with the benefit of listing equipment's that can be loaned and recycled.

The survey is not yet finalized or deployed. Its purpose is to collect data that will be used to populate the site. The goal is to distribute this survey periodically, likely every month, to identify which equipment faculty members are willing to lend within their departments at the NHMFL. Survey responses will be reviewed and evaluated to ensure that each item meets the lending guidelines. The survey (Figure 1) will be deployed through FSU-Qualtrics. Questions for the survey were determined based on necessary information believed that the borrower would require to make the acquisition.

A circular economy is an economic system designed to eliminate waste and promote the natural systems of reuse, repair, and recycle. The questions displayed in figure 1 demonstrate the intention to promote these ideals by providing necessary information in regards to an equipment.

An important aspect of this survey is the first question regarding asset tags. Asset tags are typically placed on equipment costing over $10,000 and allow the Asset Management team to identify the location and assigned "owner" of the equipment. This is important because the tags are scanned annually to verify that the assets remain present at the lab. If a tagged piece of equipment is sitting idle, the proper channel is to contact the Asset Management team to discuss available options if the current owner wishes to partake in this project, to ensure smooth communication and tracking with the asset management team. Additionally, equipment with an asset tag may only be relocated within the NHMFL and cannot be moved to outside departments, per NSF regulations.

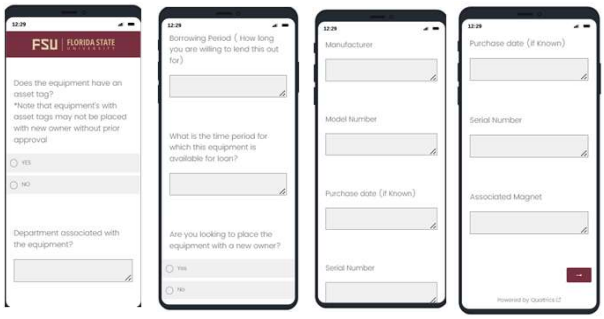

Figure 1: Qualtrics survey

Results – Aim 1

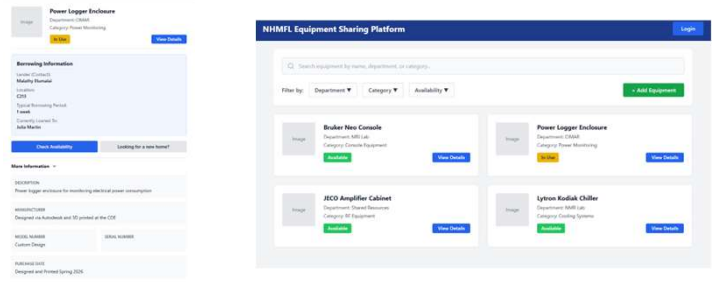

Figure 2: Equipment sharing platform initial layout

Figure 2 presents the mock-up site built in REACT JSX. The layout draws inspiration from the FSU Asset Management interface and serves as an initial reference for defining site requirements and visual structure. The Add Equipment tab illustrates how the implemented survey form will appear on screen. Overall, the mock-up reflects the intended user experience and the preliminary design direction for the final site. Implementing a centralized platform where departments can list available equipment and check its status would encourage resource sharing and minimize redundant acquisitions.

Methods – Aim 2

To quantify energy usage patterns and identify opportunities for cost reduction, a comprehensive power logging infrastructure across all test equipment was implemented. This approach allows precise measurement of electrical consumption during active (ON), idle, and powered-down (OFF) states, providing the foundation needed to evaluate energy-saving interventions and calculate their financial viability.

- **Console Power Logging:** The EKM metering EKM-25XDSE (Figure 4) was installed between output of the sub-panel and the input of the Bruker 2-bay console to measure overall consumption of all equipment's (RF amplifiers, BSMS and AQS) residing in the console. This provided results in kWh data.
  Measured states:- P1- Powered-Down State*(network interface (Ethernet) connected but no system running)* ***P2*** **-** System Idle State *(Spectrometer fully powered, but no system running*)
  P3 -Experiment state (hour period in which experiment is running)

Energy Consumption Analysis: Average consumption will be calculated to estimate potential energy cost savings and assess the financial impact of implementing power-down protocols during non-operational periods.

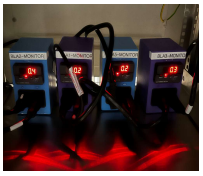

Figure 3: Installed Power Loggers

Figure 4: EKM-25XDSE Meter

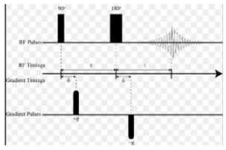

Figure 5: DOSY Pulse sequence

Results – Aim 2

RF amplifiers	R1 State	R2 State	R3 State
BLA1(BLAH500)	39.66	79.48	_
BLA2 (BLABB500)	79.36	_	79.48
BLA3 (BLABB1000)	59.58	99.5	_
BLA5 (BLA100)	39.68	_	39.76

Table 1: Power Consumption for individual RF Amplifiers

- We used "edasp" command in Topspin as shown in (Figure 8) to identify the RF amplifiers that were in use. The table (Figure 9) shows R1,R2, R3 states of the four power monitoring boxes during solid state NMR experiment in which BLA 1 /BLA 3 was in use for 1H / 57Fe nuclei experiment and BLA2/BLA5 were not in use. The monitors display voltage, current, frequency and power and we used it to calculate power consumption across all three states.
- BLA1 and BLA3 power consumption increased during active state by 40 W respectively. However, consumption levels stayed constant, indicating that despite experiments taking place, "inactive" power loggers continue to draw the same power. By turning off, inactive power loggers, we would save approximately 80W in BLA2 and 40W in BLA5 respectively.
- During any given experiment, the RF amplifiers are only used for a specific amount of time, during a pulse sequence. In NMR/MRI, the RF amplifier is not running continuously. It only transmits during discrete, very short bursts called pulses. While the installed 3D power loggers provide data with the pulses occurring in microseconds, it can be difficult to have them constantly monitored by an individual. Installing a power logger which monitors data in real time would enable pulse sequences (Figure 5) to be easily recoded and analyzed to further determine the exact timeline of RF amplifier usage.

Acknowledgements

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Future Work

This project establishes a foundation for expanded sustainability initiatives at NHMFL. The energy consumption data collected can serve as a basis for grant applications supporting larger-scale projects, such as getting access to high-tech power loggers that will allow for monitoring during an experiment without human interference.

References

[1] Laboratory, National High Magnetic Field. "Helium Recovery Bags." *MagLab*, nationalmaglab.org/about-the-maglab/around-the-lab/what-is-that/helium-recovery-bag/.

[2] Payen, Kate, et al. "53rd Southeastern Magnetic Resonance Conference." *Sustainability: Assessing Ways to Reduce Energy Consumption in NMR/MRI Systems*, 2025.

[3] *Scientific Equipment*. (2025). Fsu.edu. https://apps.its.fsu.edu/AssetManagement/app/

[4] *Diffusion Ordered Spectroscopy (DOSY)*. (2016, July 13). Chemistry LibreTexts. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Magnetic_Resonance_Spectroscopies/Nuclear_Magnetic_Resonance/NMR:_Experimental/Diffusion_Ordered_Spectroscopy_(DOSY)