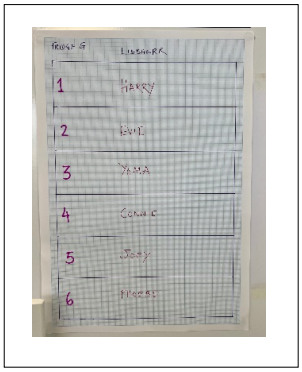
Cold Storage: Usage and Performance Study

Impacts of loading, inventory, and set temperature on energy consumption



Cold storage is mandatory for many laboratories, with researchers requiring that their samples and reagents are stored at a specific temperature. Typically, lab fridges will be set to maintain a chamber temperature of 4 °C. Their performance at these set points will vary between models and will be impacted by usage and organisation, such as the employment of an inventory system.

A recent study[1] by independent laboratory sustainability specialist, Green Light Laboratories demonstrates the positive impact of inventory usage in typical laboratory conditions.[2] This case study investigated the impact of loading, and of inventory usage upon fridge door opening times and energy consumption.

The full case study is available on request, but we have summarised the key findings for you.

Here's what we've learnt...

The impact of loading:

1. **Loaded fridges use more energy to recover from a door opening compared to when unloaded.**

Using a basic inventory (i.e. fridge map):

1. **Shortens door opening times, saving 50% in time.**
2. **Reduces energy consumed by up to 57% for timed door openings.**

Using a detailed inventory (i.e. detailed fridge map and internal shelf labelling):

1. **Shortens door opening times, saving 67% in time.**
2. **Reduces energy consumption by up to 62% for timed door openings.**

Independent Case Study

Please contact us at enquiriesuk@calibrescientific.com, if you would like more information on this case study or wish to discuss your cold storage requirements.

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Independent study data supplied by Green Light Laboratories Limited.

GREEN LIGHT LABORATORIES LIMITED

The impact of loading on fridge performance

Testing conditions

All units were tested at the Learning and Research Centre, University of Bristol. A multi-probe wireless monitoring system was used to measure temperature data. The energy monitors employed had an accuracy of ±1%.[3]

Three new upright/tall fridges were tested from three different manufacturers. The energy consumption and temperature performance of each fridge at the set temperature of 4 °C was measured. All fridges were first tested empty. The three fridges were then loaded with the same variety of labelled storage containers, including cryoboxes, tubes in racks, and Duran bottles.[3]

The effect of loading on door opening energy usage:

Timed (60s) door openings were carried out on the empty and then loaded fridges. The door opening recovery times, temperature performance and energy consumption were recorded.

- With no door openings the energy consumption for each model was almost identical when loaded and empty.

Two timed door openings were carried out on the loaded fridges (Figure 1).

- Door opening recovery energy increased for two models when loaded.
- The energy required to recover from two door openings varied between the 3 models.
- The difference in energy requirement varied between the three different units: Manufacturer A: ↓13%; B: ↑188% and C: ↑100% in energy consumption.

Figure 1)

Loaded fridge door opening performance and energy data. Timed door openings of 60 seconds and 90 seconds were carried out with the energy consumed measured. The table below shows the combined energy used for a single 60-second and a single 90-second door opening.

Manufacturer	Unloaded (kWh)	Loaded (kWh)
A	0.015	0.013
B	0.017	0.049
C	0.006	0.012

Data supplied by Green Light Laboratories

The impact of inventory management on energy consumption

Testing conditions

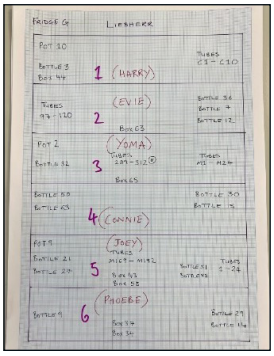
End users from the Learning and Research Centre, University of Bristol were tasked with retrieving and returning items from the three fridges.[3]

Three scenarios were investigated with the access times measured:

- **Unorganised:** No inventory. Labelled items were retrieved and replaced with no inventory or shelf labelling.
- **Organised:** Basic fridge map (diagram 1). Labelled items were retrieved and replaced with the aid of a basic inventory fixed to the outer door indicating the owner of each shelf.
- **Highly Organised:** Detailed inventory (diagram 2). Labelled items were retrieved and replaced with the aid of a detailed inventory fixed to the outer door indicating ownership of each shelf space and the exact location of all contents. In chamber, each shelf was also labelled to indicate the owner.

Diagram 1

Diagram 2



Benefit 1: Shortened door opening times

The effect of inventory on door opening time:

The use of basic inventory management (exterior fridge map) had a clear positive effect on both the time taken to locate/relocate samples, and therefore on the energy used. See figure 2.

- **50%** reduction in time taken by introducing basic inventory (Organised Access) versus no inventory (Unorganised).
- **67%** reduction in time taken by introducing detailed inventory (Highly Organised Access) versus no inventory (Unorganised).

Figure 2)

Access procedure door opening times. The table below shows the combined time taken for three access procedures to be completed.

Manufacturer	Unorganised (s)	Organised (s)	Highly Organised (s)
A	137	75	51
B	192	110	67
C	169	62	48
Total	498	247	166

Data supplied by Green Light Laboratories

Insight

Reducing the door opening times saves end users' time. If used 240 days/year, the basic inventory would save 16.7 hours in door openings per fridge. Accessing fridges using the more detailed inventory would save 22.1 hours in door openings per fridge.

Benefit 2: Reduced energy consumption of door openings

The effect of inventory on door opening energy usage:

The use of a simple fridge inventory had a significant positive impact upon energy consumption, highlighting the impacts that even simple action can have upon lab running costs. See figures 3 and 4.

- **57%** reduction in energy consumption by introducing basic inventory (Organised Access) versus no inventory (Unorganised).
- **62%** reduction in energy consumption by introducing detailed inventory (Highly Organised Access) versus no inventory (Unorganised).

Figure 3)

Access procedure door opening times. The table below shows the combined energy used for three access procedures to be completed.

Manufacturer	Unorganised (kWh)	Organised (kWh)	Highly Organised (kWh)
A	0.024	0.005	0.004
B	0.050	0.030	0.027
C	0.007	0.000	0.000
Total	0.081	0.035	0.031

Data supplied by Green Light Laboratories

Insight

Creating a basic inventory requires very little effort, simply naming who owns each shelf saved ≥50% in door opening times and energy consumption. As energy consumption falls so does the heat output into the laboratory, reducing air conditioning costs.

Figure 4)

Unorganised, Organised and Highly Organised access data at setpoint 4 °C. Total time taken for three access procedures to be carried, for all three fridges.

Access procedure	Total Door Opening (s)	Door Opening Recovery Energy (kWh)
Unorganised (UA)	498	0.081
Organised Access (saving versus UA)	247 (↓ 50%)	0.035 (↓ 57%)
Highly Organised Access (saving versus UA)	166 (↓ 67%)	0.031 (↓ 62%)

Data supplied by Green Light Laboratories

In Conclusion

The impact of using simple fridge inventory is evident. Employing a simple, basic inventory which indicated shelf ownership halved door opening times and reduced the recovery energy by 57% (figure 4). More detailed inventory usage decreased the door opening times by two thirds and the recovery energy by 62%. As energy consumption falls so does the heat output into the laboratory, reducing air conditioning costs.

In the case of the Manufacturer model C, using Highly Organised Access instead of Organised did save time, but did not show any additional energy saving. The Organised Access procedure resulted in the door being open for a grand total of 62 seconds. The Highly Organised Access procedure resulted in the door being open for a grand total of 48 seconds. In both cases, these total times are the result of very short door openings, as brief as 4 seconds, and the small rises in temperature were recovered without any additional compressor activity being required. Reducing the fridge door opening times saves end user's valuable time; in this study, the time saved over a working year[4] would have amounted to 22.1 hours when using the more detailed inventory.

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1. Green Light Laboratories study: COLD STORAGE: USAGE & PERFORMANCE, 2024: Full Case Study available on request.

2. Location: Learning and Research Centre, University of Bristol.
The laboratory space used was air conditioned with an ambient temperature of 23°C (±1.5 °C).

3. Full protocol available on request.

4. Calculating using 240 days/year.

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