Meeting Slides
Freezer Roundtable

June 19 2025

Freezer use and freezer settings:

why it matters and how to be more sensible about it

teun.bousema@radboudumc.nl

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Radboudumc

A research topic with environmental impact

- Work in Africa
- Travel and transport
- Molecular epidemiology

A research topic with environmental impact

- Despite or because of impact…
- Running a lab from diesel-generators
- 20kWh per day or average household

A research topic with environmental impact

- Despite or because of impact…
- Running a lab from diesel-generators
- 20kWh per day or average household
- Considering everything else: does it matter?

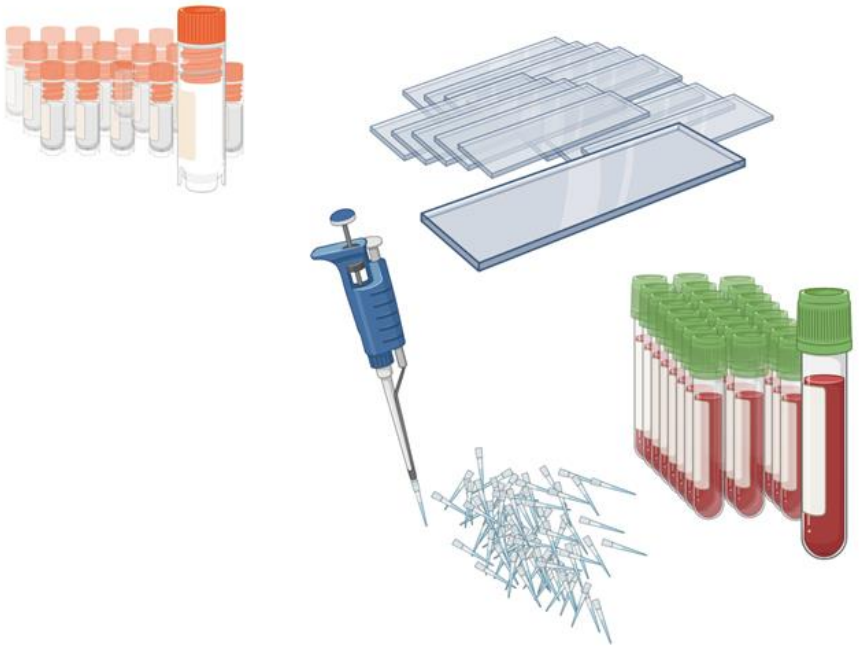
vs

Malaria trial

- Ouelessebougou, Mali
- 80 participants
- Treatment with different antimalarials
- Follow-up 28 days
- Biochemistry, hematology, molecular parasitology, mosquito feeding assays
- Analyses in Bamako and Nijmegen

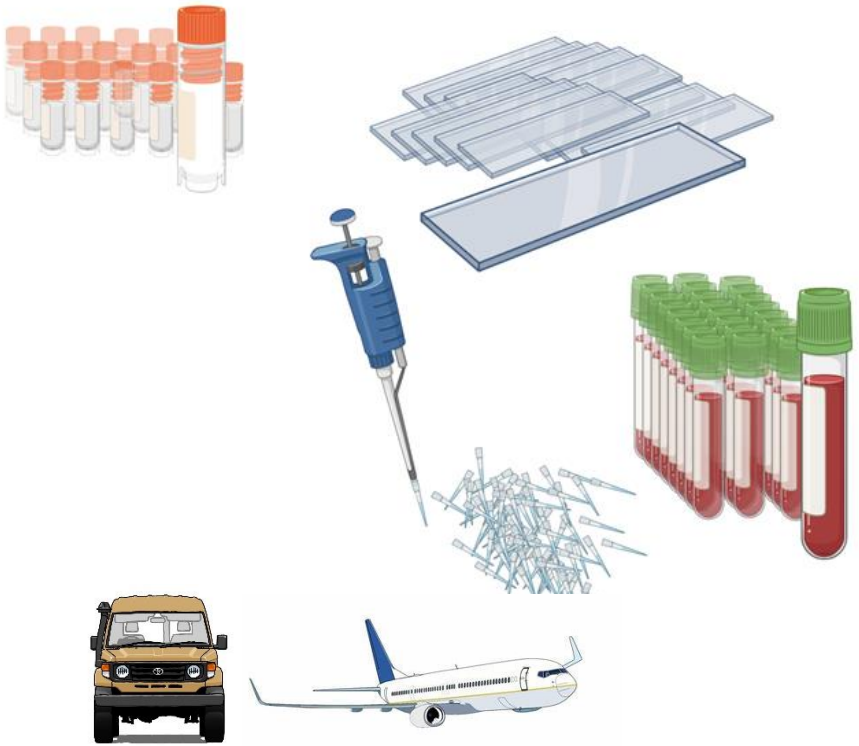
Footprint: waste, travel & transport

- 1290 participants screened
- 300 lancets
- 600 microscopy slides
- 1750 blood tubes
- 3000 plastic storage tubes
- 2,761 plastic tips



Footprint: waste, travel & transport

- 1290 participants screened
- 300 lancets
- 600 microscopy slides
- 1750 blood tubes
- 3000 plastic storage tubes
- 2,761 plastic tips
- 3,300 km by ‘road’
- 56,000 km by air

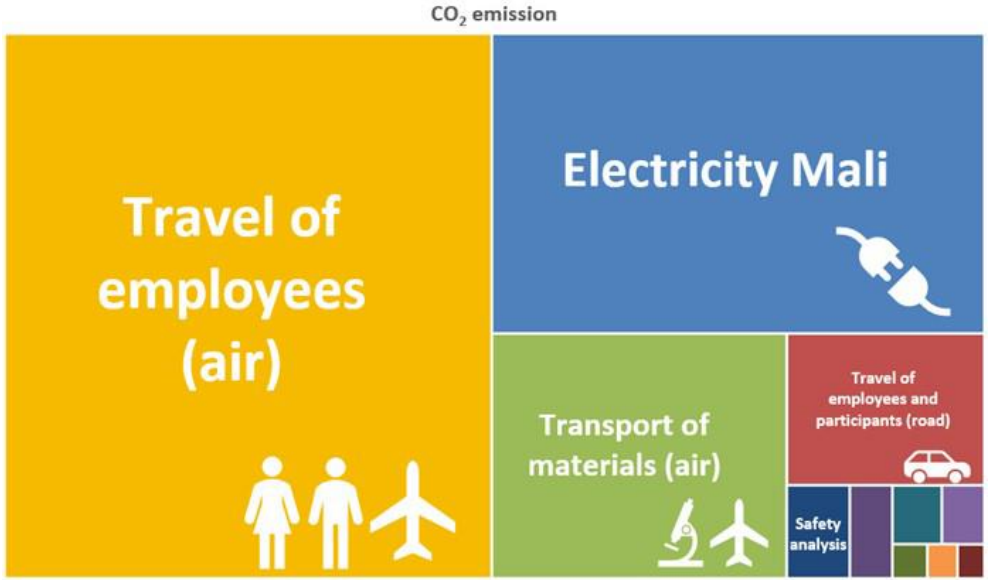


Footprint: electricity

- 7,200 kWh of electricity in Mali
  - mix fossil, hydroelectric, solar power
- Freezers accounted for ~65%
- Rest related to airconditioners, extractors, PCR

Weighing the most important contributors

- Electricity relevant source of emissions
- Even in the context of a ‘carbon-heavy project



From Ouelessebougou to Nijmegen

- 186 ULT-freezers in Nijmegen
- Many >10 years old

Radboud freezer challenge 2020

1. Clean out freezers and ensure good maintenance
2. Retire old freezers
3. Change temperature setting from -86/-80 to -70°C

1. Cleaning freezers and discarding old samples

- >100,000 samples discarded
- Retiring 12 freezers without replacing them

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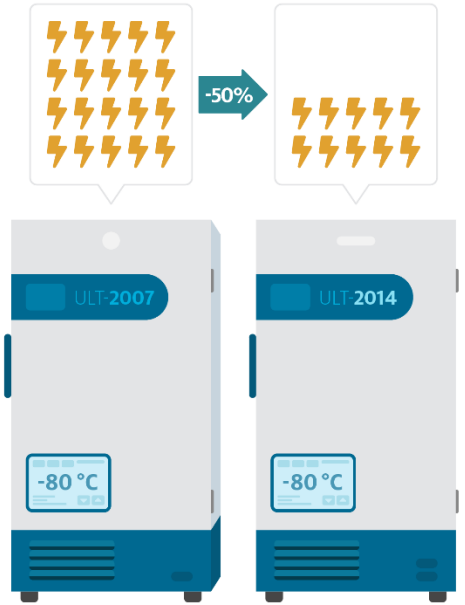
- >100,000 samples discarded
- Retiring 12 freezers without replacing them

2. Replacing energy inefficient models

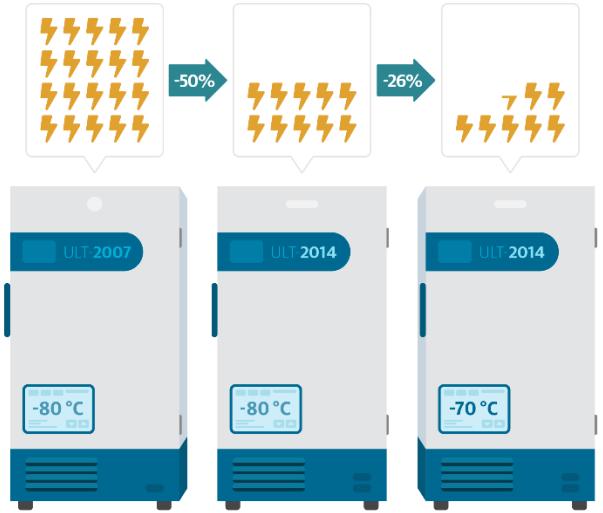
- Considerable variation in energy use
- Incentivised replacement of old models
- Central storage facility



3. Changing temperature settings

Two hurdles

1. No time or know-how to change settings
2. Concerns about sample integrity



3. Changing temperature settings

Two hurdles

1. No time or know-how to change settings
2. Concerns about sample integrity

Additionally, CU Green Labs began an effort in 2016 to provide campus researchers with shared ULT freezers where scientists pay a small fee to rent space.

We have 4 energy efficient ULT freezers set at -70°C serving about 80 researchers from 20 different research groups with a wide range of different sample types. It has been inspiring to me to see so many CU Boulder scientists choose to store their samples at -70°C. Some labs even changed the temperature of their freezers without letting CU Green Labs know. I discovered they had made the switch years later.'

Jessica Henley has been the lab manager of the Noah Fierer Lab since 2012 in Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder in the US. The Fierer lab studies environmental microbiology with a focus on soil microbiome communities. 'We haven't noticed any change since switching our ultra-low temperature freezer from -80°C to -70°C. We have been storing reagents and culture stocks at -70°C since 2013 and have had no problems. Happy to be lowering our energy usage without changing the quality of our work!'

Rachel Tapp of Charles River Laboratories is a senior research scientist and the chair for the sustainability

the demands of a GLP environment in our laboratory.'

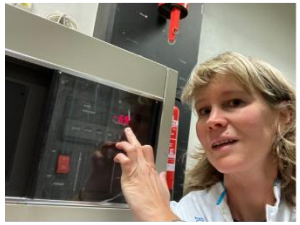
Arjo Meijering is an engineer responsible for energy, safety and sustainability at Wageningen University & Research (WUR) in The Netherlands. With colleagues, he has developed a new approach to ULT sample storage at his university. For samples that are not used on a weekly basis, central freezing facilities are provided. The system that is in place in Wageningen saves up to 70% energy compared to storage in individual ULT freezers set to -80°C.

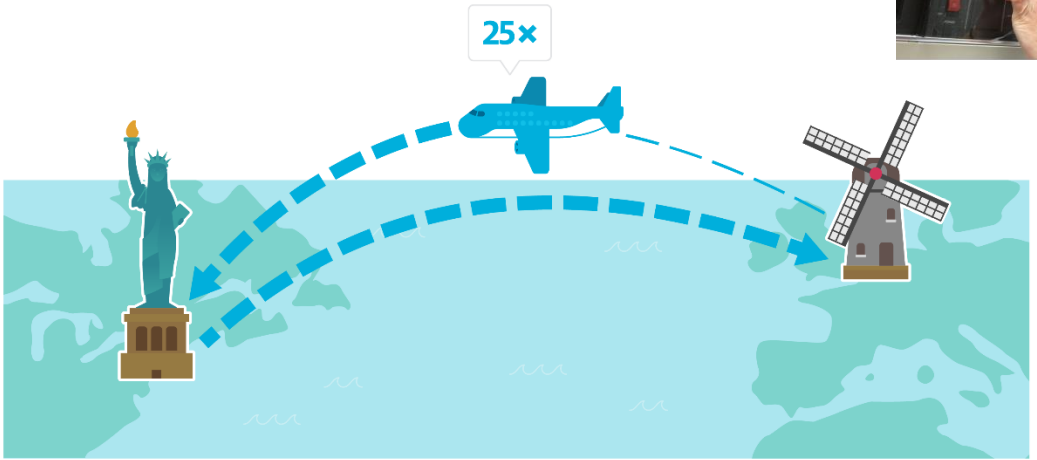
The most recent ULT central storage facility (45 m^3 with place for 2.000.000 eppendorf tubes) is set to -70°C to save energy. Whilst he acknowledges that there are no studies that directly compare sample integrity between storage at -70°C versus -80°C, he

Unexpected blackout took away my own concerns

The impact

- ~45 ton of CO2e avoided per year
- >50% of freezers not touched





Success factors and future plans

+ Support board of directors
+ Webinar to ask questions
+ Technical support
+ ‘Annoying’ perseverance of the initiator
- No financial incentive department
- Hesitation to impose ‘-70 unless…’

Re-run in 2025/6

Rethinking Ultra-Low Temperature Freezer Use

-70°C Storage as new global standard

Joep Sprangers
Sustainable Lab Coordinator
& Green Labs NL
19-06-2025

NEWS | 27 January 2025

Extreme heat will kill millions of people in Europe without rapid action

Climate models predict that the number of heat-related deaths could soar in cities over the coming century, even when efforts are made to keep people safe.

Leaders | In the line of fire

The world is losing the war against climate change

Rising energy demand means use of fossil fuels is heading in the wrong direction

Vandaag, 06:36

Meer uitstoot van broeikasgassen dan vorig jaar

De toegenomen uitstoot werd voornamelijk veroorzaakt door de energiesector.

2024 first year to pass 1.5C global warming limit

10 January 2025

Global sea levels are rising faster and faster. It spells catastrophe for coastal towns and cities

UPDATED MAY 9, 2025

Publication

Natural catastrophes

Insured losses on trend to USD 145 billion in 2025

More than 80% of world's coral reefs hit by worst bleaching event in history

'We're looking at something that's completely changing the face of our planet,' scientists warn

Laboratories have a large footprint

Single-use plastics

Water

Data storage

Animal-derived products

Lab ventilation

Procurement

Cold storage

Air travel to conferences

Equipment


-70
is the new -80
Going back to -70

Green Labs NL

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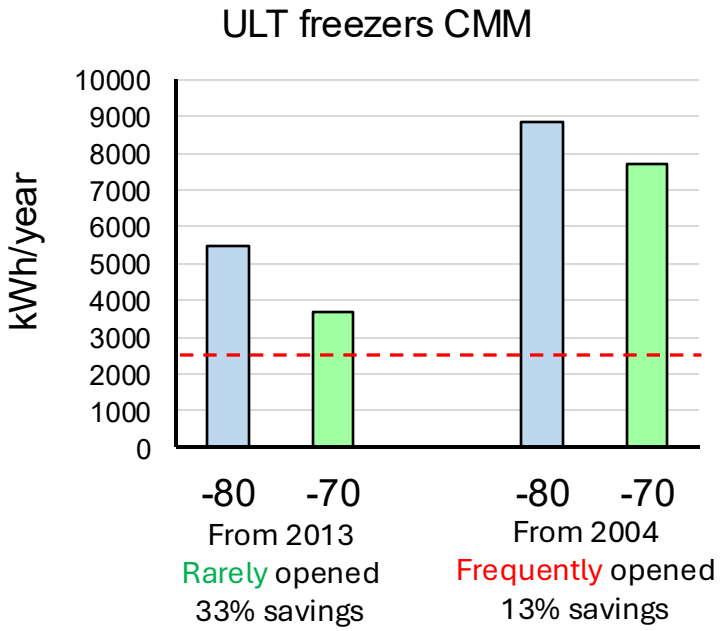
Electicity Savings at -70
No investment, big impact

- One ULT freezer uses 8-14 kWh/day (3000-5000 kWh/year)
  - Equals ~2x an average NL household
- Switching to -70 saves on average **28%** of energy consumption
  - (Graham *et al.*, 2024; Farley *et al.*, 2015, Freese *et al.*, 2024; Evans, 2022; own measurements)

Total of ~350 ULT freezers at UMCU

Estimated savings of -70 switch:
at least **€80.000** and **~135tCO2** per year



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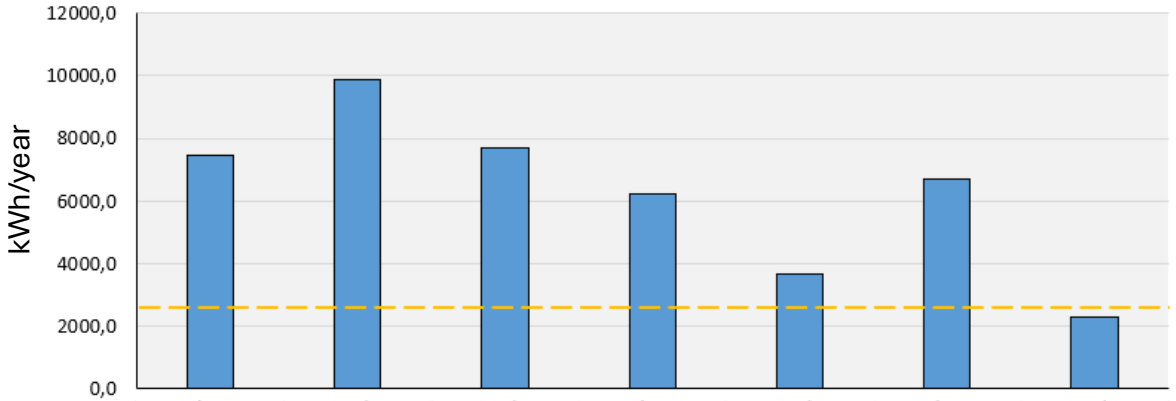
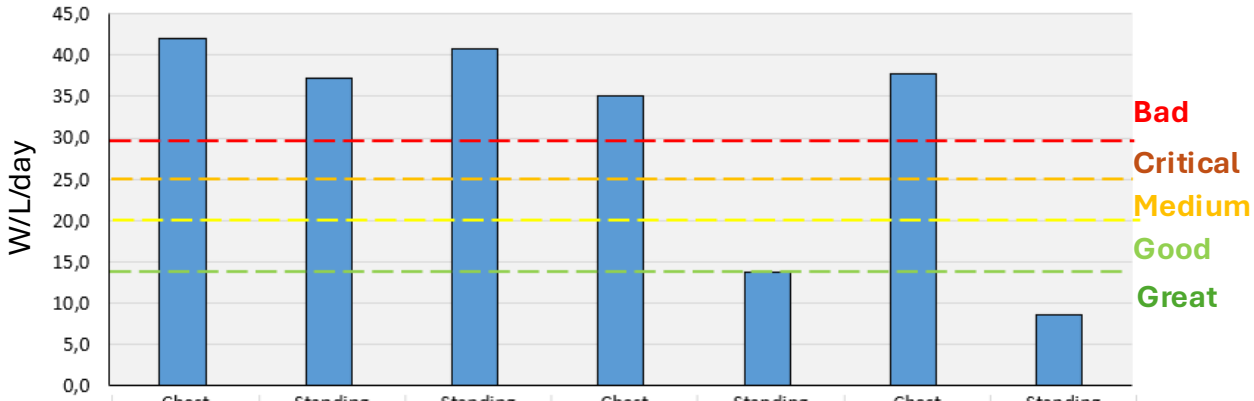
ULT freezer yearly kWh consumption (UMC Utrecht, CMM department)



	Chest	Standing	Standing	Chest	Standing	Chest	Standing
Capacity	487	728	519	487	728	487	729
# of Boxes	300	528	352	300	528	300	528
Year	2000	2001	2004	2006	2013	2013	2018

ULT freezer energy measurements (UMC Utrecht, CMM department)



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Year	2000	2001	2004	2006	2013	2013	2018

All at -70C since December 2023

Sample safety at -70

Companies that recommend -70 as storage temperature

Thermo Fisher SCIENTIFIC

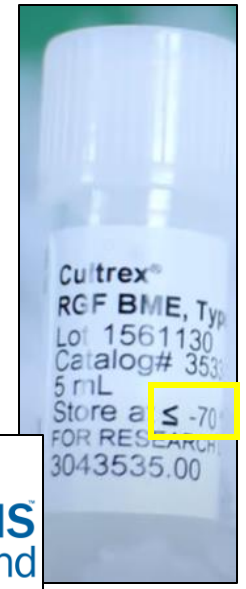
each freeze/thaw cycle lowers transformation efficiency by about half. Competent cells should remain stable for approximately 6–12 months when stored at –70°C with minimal temperature fluctuations. Cells should *not* be frozen or stored in liquid nitrogen, as this practice drastically reduces viability.

Purified RNA shoud be stored at –20oC or –70oC in RNase-free water. When isolated using QIAGEN systems, no degradation of RNA is detectable for at least 1 year under these conditions.

QIAGEN

NEW ENGLAND BioLabs Inc.

Most proteins can be stored for at least a few days at 4°C without denaturing. For long term storage, one can either freeze at -70°C or dialyze into 50% glycerol and store at -20°C. When storing at -70°C, aliquot the protein so only the portion to be used must be thawed – repeated freeze/thaw cycles denature many proteins.



MERCK

Preparation Note

After opening, aliquot into smaller quantities and store at -70 °C. Avoid repeating handling and multiple freeze/thaw cycles.

R&D SYSTEMS a bio-techne brand

-70 Database
Reveals the global transition

Global transition to -70 already started 10+ years ago, as indicated by the -70 database:

- 200+ entries of samples -70
- ~100 different research groups
- Spread over 30+ universities/institutes

Includes RNA (41x), bacteria (40x), virus (9x), C. elegans (5x), yeast (13x), plasma (6x) human/mouse/plant tissue…

Biological Samples Stored Long Term at -70C or Warmer

ULTs at -70 | Freezers at -20 | Refrigs at 4

Entry Date	Sample Type	Temp (°C)	Duration sample stored in freezer	Duration freezer at indicated temp	University	Dept	Lab PI	Lab Contact	Freezer Type	Specific Sample Information
2015- Feb	Growth Chambers, LED lights	-70	0-4 years	3-4 years	CU-Boulder	Ecology and Evolutionary Biology	Adams, William	Jared Stewart		
2015- Feb	DNA and RNA samples	-70	1-3 years	since 2010	CU- Boulder	Ecology and Evolutionary Biology	Schmidt, Steve	Ryan Lynch	Revco/Thermo	
2015- Feb	DNA samples	-60	0.5-8 years	since 1998	CU- Boulder	Ecology and Evolutionary Biology	Martin, Andy	Kyle Keepers	Forma Scientific	
2015- Feb	DNA, antibodies, peptides,	-70	2-7 years	since purchase	CU- Boulder	Ecology and Evolutionary Biology	Tsai, Pei		Forma Scientific	
2015- Feb	bacteria, leaf disks	-70	<6 years	since purchase	CU- Boulder	Ecology and Evolutionary Biology	Tsai, Pei			
2015- Feb	RNA	-70	0-2 years	since purchase	CU- Boulder	Ecology and Evolutionary Biology	Tsai, Pei			
2015- March	DNA and RNA Tissue samples, enzymes	-70	2-10 years	since purchase	CU-Boulder	Ecology and Evolutionary Biology	Mederios/Stock			
2015- March	Viral protein, human sera, humans cells, competent lentivirus stocks	-70	0.5-4 years	since 2010	CU-Boulder	Biofrontiers	Garcea, Robert			
2015- March	DNA, RNA, proteins, enzyme tissues	-70	1-3 years	since 2010	CU-Boulder	Biofrontiers	Anseth, Kristi			
2015- March	Ligands drugs, anti-cancer, frozen cells	-70	0.5-2 years	2 years and up	CU-Boulder	Biochemistry	Liu, Xuedong			
2011- June	Plant tissues	-70	6-12 months	since 6/2011	UC Davis	Viticulture and Enology	Andrew Walker	Daniel Ng		
2011- June	Bacteria	-70	1-3 years	since 6/2011	UC Davis	Viticulture and Enology	Andrew Walker	Daniel Ng		
2011- June	Glycerol suspensions	-70	3-10 years	since 6/2011	UC Davis	Viticulture and Enology	Andrew Walker	Daniel Ng		
2011- June	DNA	-70	3-10 years	since 6/2011	UC Davis	Anatomy, CNPRC	Dallas Hyde	Lei Putney		
2011- June	RNA	-70	0-6 months	since 6/2011	UC Davis	Anatomy, CNPRC	Dallas Hyde	Lei Putney		
2011- June	Proteins, incl enzymes	-70	3-10 years	since 6/2011	UC Davis	Anatomy, CNPRC	Dallas Hyde	Lei Putney		
2011- June	Physiological fluids	-70	3-10 years	since 6/2011	UC Davis	Anatomy, CNPRC	Dallas Hyde	Lei Putney		
2011- June	Animal tissues	-70	3-10 years	since 6/2011	UC Davis	Anatomy, CNPRC	Dallas Hyde	Lei Putney		
2011- June	Reagents & Extraction Kits	-70	1-3 years	since 6/2011	UC Davis	Anatomy, CNPRC	Dallas Hyde	Lei Putney		
2011- June	Proteins, incl enzymes	-70		since 6/2011	UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Competent cells	-70		since 6/2011	UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Plant tissues	-70		since 6/2011	UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Bacteria	-70		since 6/2011	UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Yeast/Fungi	-70		since 6/2011	UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Glycerol suspensions	-70	>10 years	>10 years	UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Dried tissues/extracts	-70			UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	Reagents & Extraction Kits	-70			UC Davis	LAWR	Kate Scow	Dianna Louie		
2011- June	DNA	-70	1-3 years	since 6/2011	UC Davis	Plant Science	Paul Gepts	Jim Kami		
2011- June	RNA	-70	6-12 months	since 6/2011	UC Davis	Plant Science	Paul Gepts	Jim Kami		
2011- June	Plant tissues	-70	1-3 years	since 6/2011	UC Davis	Plant Science	Paul Gepts	Jim Kami		

my green lab.

International Institute for Sustainable Laboratories

Freezer Challenge

View The -70 C Database

12/16/2024

Case Study | Freezer Challenge | Energy Efficiency | Industry Reference

In 2011 the University of Colorado Boulder Green Labs Program began the first database cataloging scientific samples stored at -70 °C. With permission from the CU Green Labs Program, since 2023 My Green Lab and I2SL have been facilitating updates to this database with additions from Freezer Challenge participants. **When you view the database, note the different tabs along the bottom of the spreadsheet.** The left-most tab is data that has been added since 2023. Other tabs denote older versions of the -70 °C database as built by the University of Colorado Boulder and collaborating institutions. If you have questions for a lab that are not answered by the database, you can reach out via email to kindly request additional information from the lab team about sample preparation, more specifics about the samples stored, etc.

→ **You can view finalized submissions to this new database here.**

→ **Contribute your lab's own experience to the -70 °C database with this Google Form.**

www.freezerchallenge.mygreenlab.org

Sample safety at -70
Publications

Long term stability of paraoxonase-1 and high-density lipoprotein in human serum

Piet K Beekhof[1], Maryana Gorshunska[2] and Eugène HJM Jansen[1*]

"It can be concluded that −70°C is the right temperature for storage to maintain the PON1 activity for at least one year. Storage at a lower temperature in liquid nitrogen (−196°C) is not necessary."

Frozen tissue biobanks. Tissue handling, cryopreservation, extraction, and use for proteomic analysis

CHRISTER ERICSSON[1], BO FRANZÉN[2] & MONICA NISTÉR[1]

[1]*Department of Oncology – Pathology, Karolinska Institutet, CCK R8:05, Karolinska University Hospital, Solna, 171 76 Stockholm, Sweden and* [2]*DMPK Research & Biomarkers, Local Discovery, Research Area CNS & Pain Control, AstraZeneca R&D Södertälje, SE-15185 Södertälje, Sweden*

"These common observations indicate that the proteome of frozen tissue may remain intact for years if stored at, or below -70C."

Long-term stability of parameters of antioxidant status in human serum

E. H. J. M. Jansen[1], P. K. Beekhof[1], J. W. J. M. Cremers[1], D. Viezeliene[2], V. Muzakova[3] & J. Skalicky[4]

[1]*Centre for Health Protection, National Institute of Public Health and the Environment, Bilthoven, The Netherlands,* [2]*Department of Biochemistry, Medical Academy, Lithuanian University of Health Sciences, Kaunas, Lithuania,* [3]*Department of Biological and Biochemical Sciences, Faculty of Chemical Technology, University of Pardubice, Pardubice, Czech Republic, and* [4]*Department of Clinical Biochemistry and Diagnostics, Regional Hospital of Pardubice, Pardubice, Czech Republic*

"At -70 ° C of storage, all antioxidant vitamins, such as retinol, tocopherols, ascorbic acid and also carotenoids, are stable even up to 4 – 10 years."

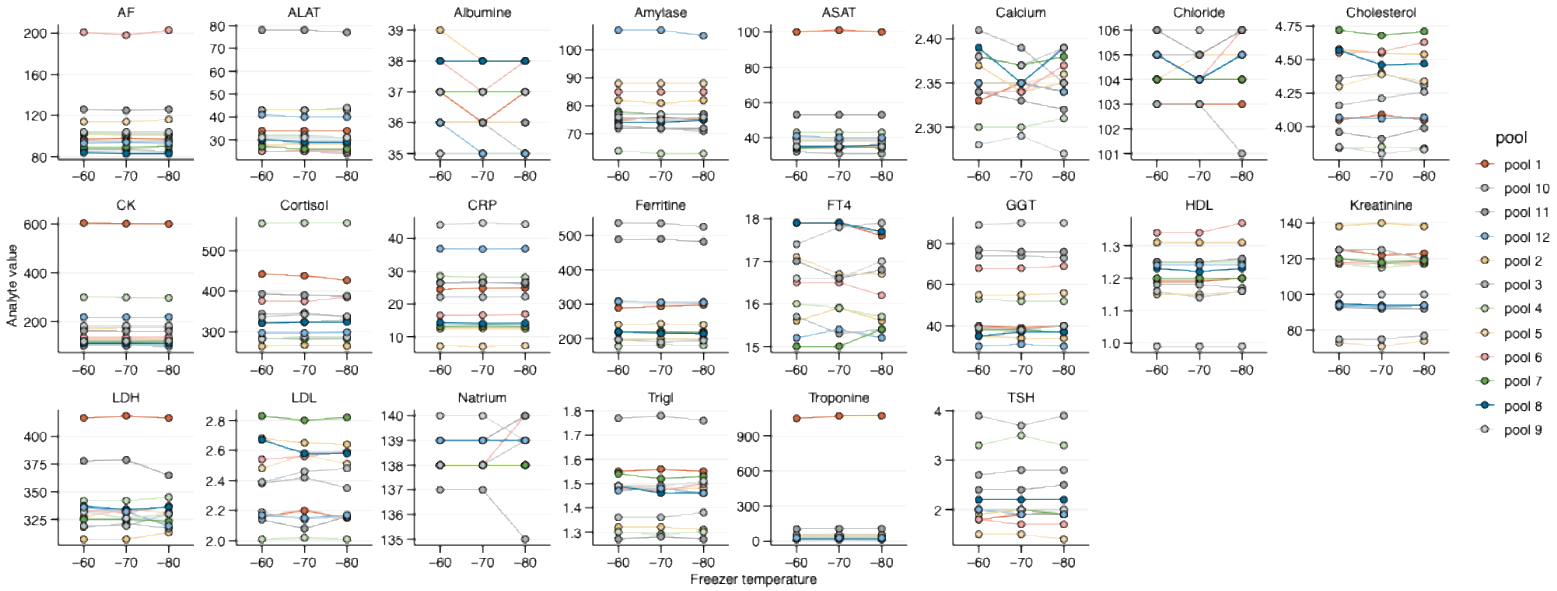
Material & method sections generally lack information about storage temperatures…

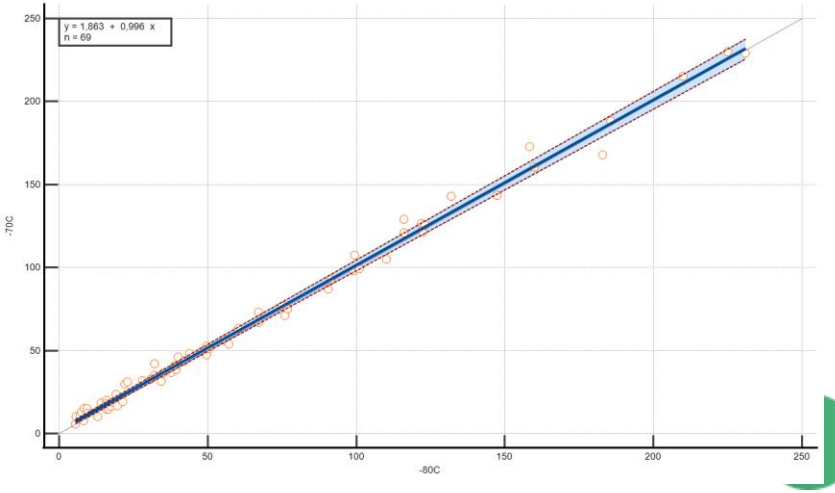
ULTRA-SAFE

Ultra **L**ow **T**emperature storage of **R**eagents:
Assessment of **S**tability **A**fter **FrE**ezing

Hannah van der Stok, Dr. Evelien Boekhout-Berends, Dr. Tom Caniels & Aram de Haas; in collaboration with Amsterdam UMC Biobank and numerous researchers at Amsterdam UMC

- Test material stored at -80, -70 and -60 across time (months to years)
- Many samples that are already included (Cerebrospinal fluid (CSF), Viruses)
- Much more will be included in the near future (cell lines, PBMCs, trimers, tissue slides, bacteria)

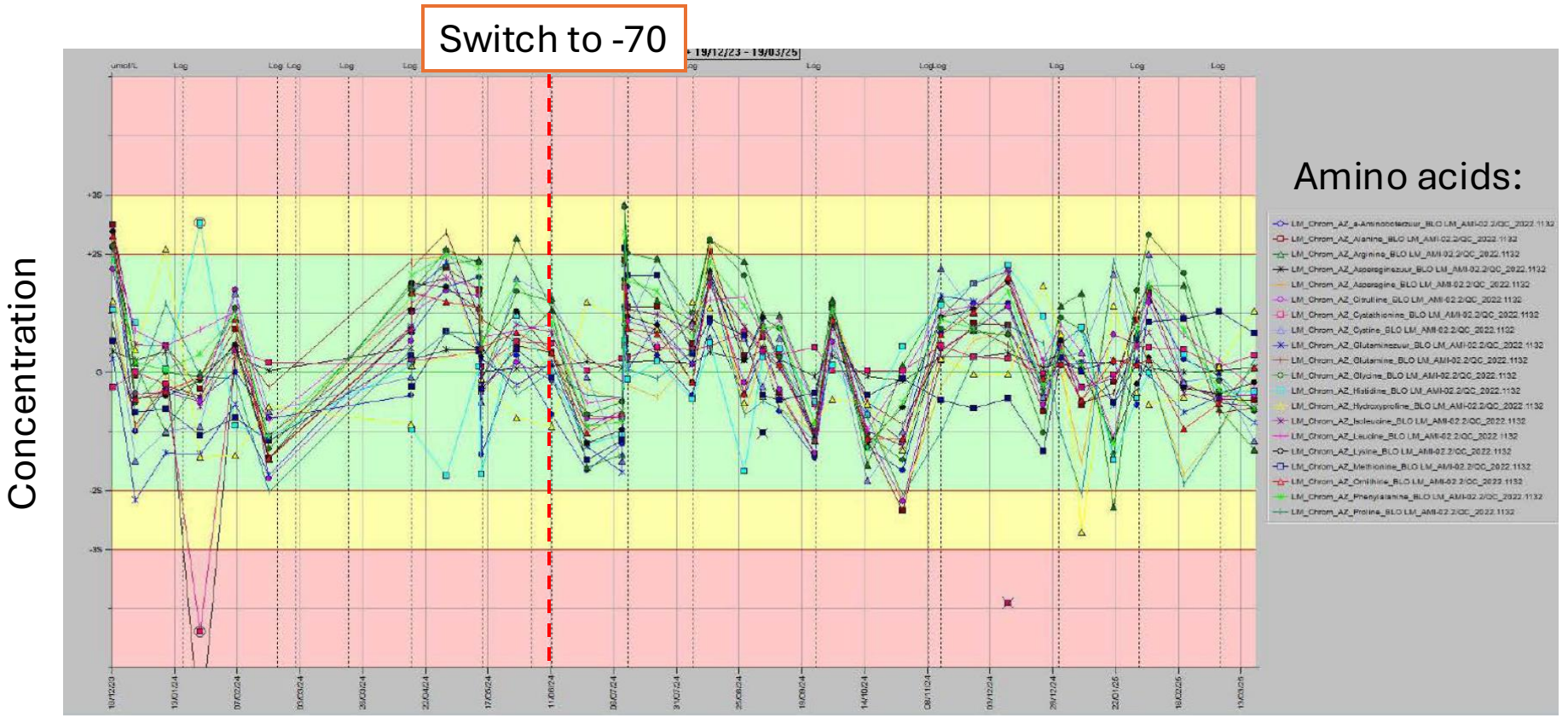




Data from diagnostic labs

UMC Groningen

- One ULT at -70 for almost a year in diagnostic laboratory
- Weekly measurements on standardized control samples
- Amino acids, organic acids, bile acids: no changes in concentration observed since the switch to -70C



Anouk de Boer-Poelstra
Metabolic Diseases department
University Medical Center Groningen

Sample safety at -70

Internal freezer temperature

- ULT freezer temperature stability and uniformity were generally not adversely affected by a -70C set point
- Operating temperatures has an effect on possible warm up times during power failures for ULT freezers, but the variation between -80 °C and -70 °C was minimal.

3. Warm-rate at Various Set Operating Temperatures Post-Power Cut.

Time to -50 °C	Bottom Shelf	Middle Shelf	Top Shelf
-60 °C	1 hr 25min	2hrs 15min	55min
-70 °C	3hrs 25min	5hrs 25min	4hrs 25min
-80 °C	4hrs 50min	5hrs 50min	5hrs

Time to -20 °C	Bottom Shelf	Middle Shelf	Top Shelf
-60 °C	9hrs 25min	9hrs 50min	8hrs 45min
-70 °C	14hrs 50min	19hrs 10min	18hrs 10min
-80 °C	16hrs 25min	19hrs 45min	18hrs 25min

Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories

ET Project Numbers: ET14PGE1721, ET16SCE1060, ET15SDG1092

THE UNIVERSITY of EDINBURGH
Social Responsibility & Sustainability

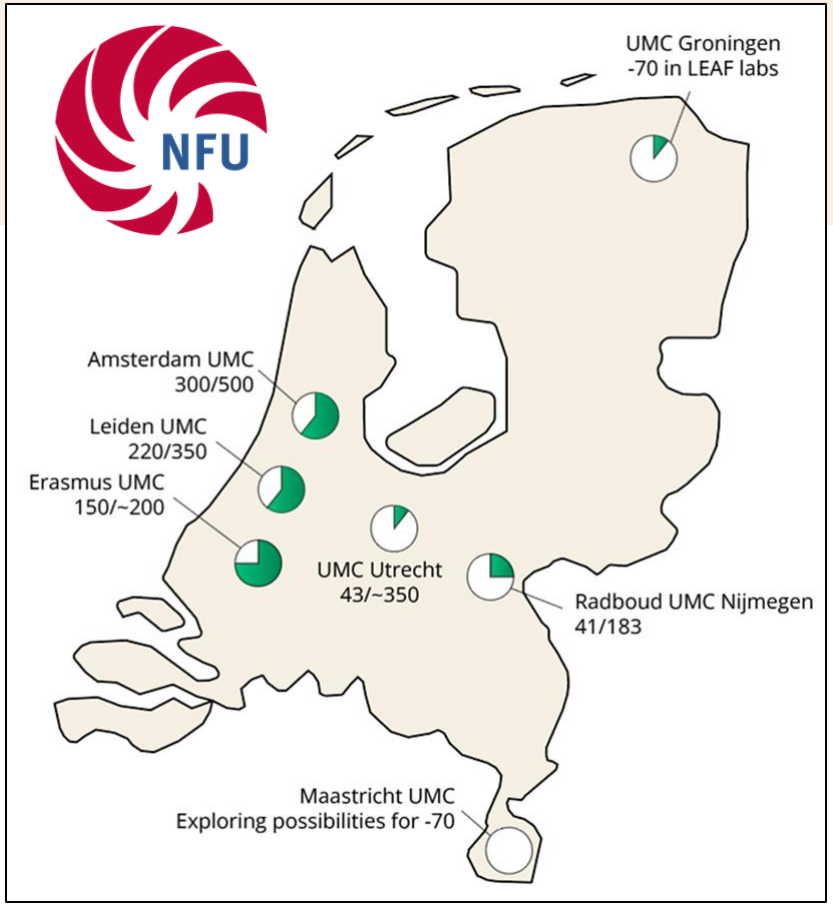
Author: Martin Farley (King's College London)
Brian McTeir (University of Edinburgh), Andrew Arnott (University of Edinburgh), Andy Evans (VWR), July 2015

Efficient ULT freezer storage

An Investigation of ULT freezer energy and temperature dynamics

Transition of -70 in NL

- UMC's in NL:
  - In total an estimated ~2000 ULTs
  - Of which ~750 already at -70
- Universities/Hogescholen
- Research Institutes
- …



Freezer Challenge: Amsterdam UMC vier keer in de prijzen

Prijs en Geld | Duurzaamheid | Maatschappelijke impact

Biobank saves 650.000 kWh per year

ENERGY TRANSITION COORDINATING COUNCIL

Correct Freezer Maintenance

and the impact when done wrong

1. Clean the filters
2. Promote proper spacing
3. Remove door seal obstructions

Make sure you discard samples that are no longer needed

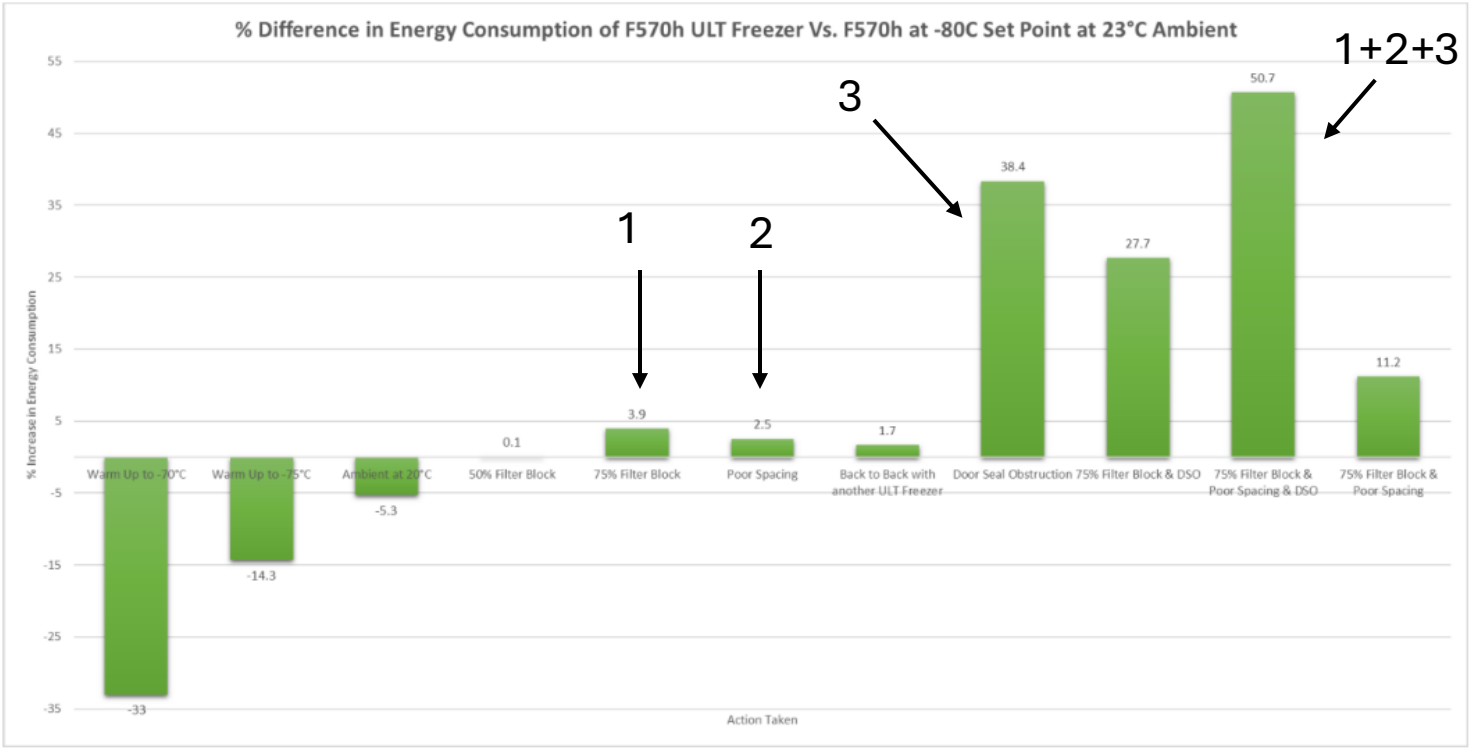


Figure 13. Impacts of actions and bad practice upon ULT freezer energy consumption.

Evans, 2022; Gumapas & Simons, 2012

j.sprangers-4@umcutrecht.nl

www.greenlabs-nl.eu