Environmental Sustainability for XLZD

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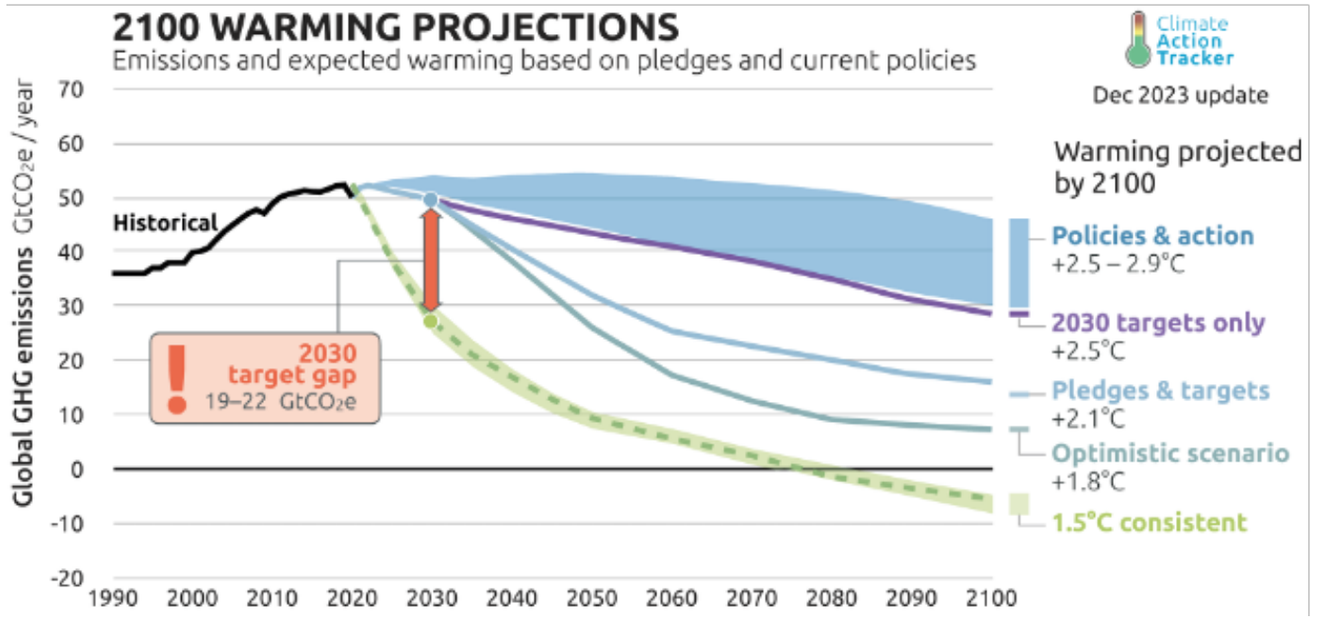
Climate Change

- Human-generated climate change is a serious problem
- Not limited to warming, but also other effects including extreme weather
- Activities in HEP can be substantial contributors to climate change



Countries: 17
Institutions: 79 → 5 new groups joined recently
Members: 450+

xlzd.org

Sustainability in HEP

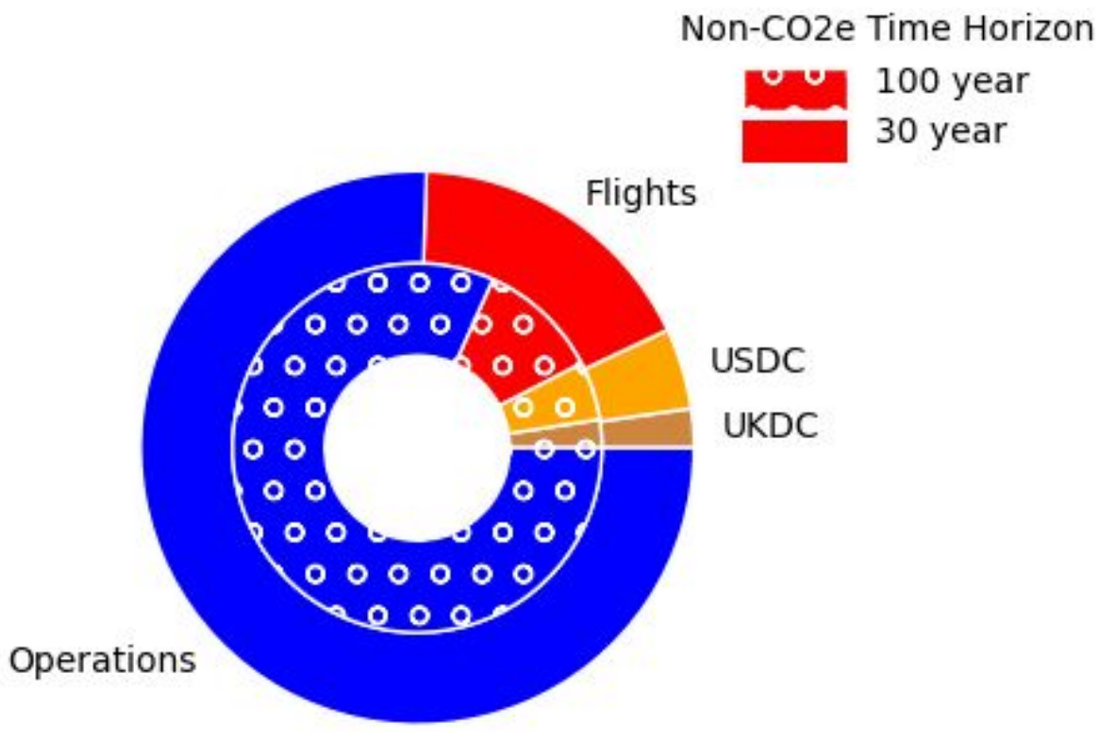
- Growing effort from the community to understand impact of our science on climate sustainability
- Sustainable HEP workshop series
- Input to EPPSU
- Local workshops and efforts, e.g. in the UK
- Calculations and targets from labs (e.g. CERN) and experiments (e.g. LZ)

CERN

GROUP	GASES	tCO_2e 2021	tCO_2e 2022
Perfluorocarbons (PFCs)	CF_4, C_2F_6, C_3F_8, C_4F_{10}, C_6F_{14}	55 921	68 989
Hydrochlorofluorocarbons (HFCs)	HFC-23 (CHF_3) HFC-32 (CH_2F_2) HFC-134a ($C_2H_2F_4$) HFC-404a HFC-407c HFC-410a HFC-507	36 557	86 211
Other F-gases	SF_6, NF_3	16 838	18 355
Hydrofluoroolefins (HFO)/HFCs	R-449 R1234ze NOVEC 649	86	199
	CO_2	13 771	10 419
Total Scope 1		123 174	184 173

- CERN has done a <u>huge amount of work</u> on sustainability
- Yesterday's miracles can be today's problems: CERN emissions are dominated by gas leakages

LZ



910 (840) tCO2eq/year for
30 (100) year horizon

- An LZ sustainability group undertook estimating one year of LZ carbon impact
- Focused on power, computing, and travel

Credit to Sam Eriksen and Josh Green

XLZD@Boulby

- Set two major goals
  - Track and measure the footprint of the UK project
  - Be carbon neutral in operations
- Requirements for sustainability targets are increasingly coming from our funding agency and our government
- Important relationship with Boulby & STFC/UKRI to achieve goals

Model
Monitor
Measure
Mitigate
Memory

Key Performance Indicators

KPIs: Carbon

- Greenhouse gases are the drivers of global climate change
- kgCO2eq
  - Scope 1: direct emissions
  - Scope 2: emissions from electricity
  - Scope 3: indirect emissions
- Total energy usage in kWh

KPIs: Waste

- Waste to landfill can have harmful environmental effects, as well as delayed carbon emission
- Recycle and reuse helps prevent waste to landfill
- kg waste to landfill
- % waste recycled

KPIs: Water Usage

- Climate change is putting pressure on water supply
- Water abstraction in L

	2016/17	2017/18	2018/19	2019/20
UTILITIES (tonnes CO2e)				
Electricity	56,460	50,384	35,340	33,885
Natural Gas	1,630	3,324	3,116	4,031
Propane (LPG)	6	1.32	3	2
UK UTILITIES TOTAL	**58,096**	**53,710**	**38,459**	**37,918**
UK TRANSPORT (tonnes CO2e)				
Air Travel (Domestic)	142	141	104	83
Rail Travel	59	73	73	61
Expenses Travel & Car Hire	263	257	269	202
STFC Owned Vehicles	81	75	72	0
Taxi	9	13	48	50
TRANSPORT TOTAL	**554**	**559**	**566**	**396**
UK TOTAL	**58,650**	**55,786**	**40,550**	**39,841**

	2016/17	2017/18	2018/19	2019/20
WASTE (tonnes)				
Waste recycled externally (excl WEEE)	632	856	455	392
WEEE waste	12	19	5	4
Waste composted	25	26	53	64
Waste incinerated with energy recovery	35	23	168	132
Waste incinerated without energy recovery	0	0	0	0
Hazardous Waste		53	34	48
WASTE ANALYSIS				
Total waste not to landfill	704	923	682	593
Total waste to landfill	90	10	19	14
Total UK STFC Waste (excl. hazardous)	**794**	**933**	**701**	**607**
% recycled	81	99	97	98

STFC CO2 Information

	2016/17	2017/18	2018/19	2019/20
WATER (m3)				
UK Water usage	127,440	104,000	142,444	171,205

https://www.she.stfc.ac.uk/Pages/Sustainability-and-Carbon-Management.aspx

EMISSIONS

184 173 tCO_2e

CERN's objective is to reduce direct emissions by 28% by the end of Run 3 compared to the 2018 baseline year, which corresponds to a maximum target of 138 300 tCO_2e.

The scope 1 emissions in 2021 and 2022 were 123 174 and 184 173 tonnes of CO_2 equivalent (tCO_2e) respectively.

The total amount of scope 2 greenhouse gas emissions due to CERN's electricity consumption was 56 382 and 63 161 tCO_2e in 2021 and 2022 respectively.

Total scope 3 emissions arising from business travel, personnel commuting, catering, waste treatment and water purification amounted to 7813 and 8956 tCO_2e in 2021 and 2022 respectively.

Scope 3 emissions arising from procurement, which are reported for the first time, amounted to 98 030 tCO_2 and 104 974 tCO_2 in 2021 and 2022 respectively.

https://hse.cern/environment-report-2021-2022

WATER AND EFFLUENTS

3234 ML

The Laboratory is committed to keeping the increase in its water consumption below 5% up to the end of Run 3 compared to the 2018 baseline year, which corresponds to a maximum target of 3651 ML, despite a growing demand for water cooling at the upgraded facilities.

WASTE

69% recycled

CERN's aim has been to increase its recycling rate for non-hazardous waste. The recycling rate rose from 56% in 2018 to 69% in 2022.

KPI Tracking

- Starting with a very rough, spreadsheet-based estimate of our KPIs
- Intend to develop into more sophisticated database
- Release annual reports on KPIs

Case Study: XAQ

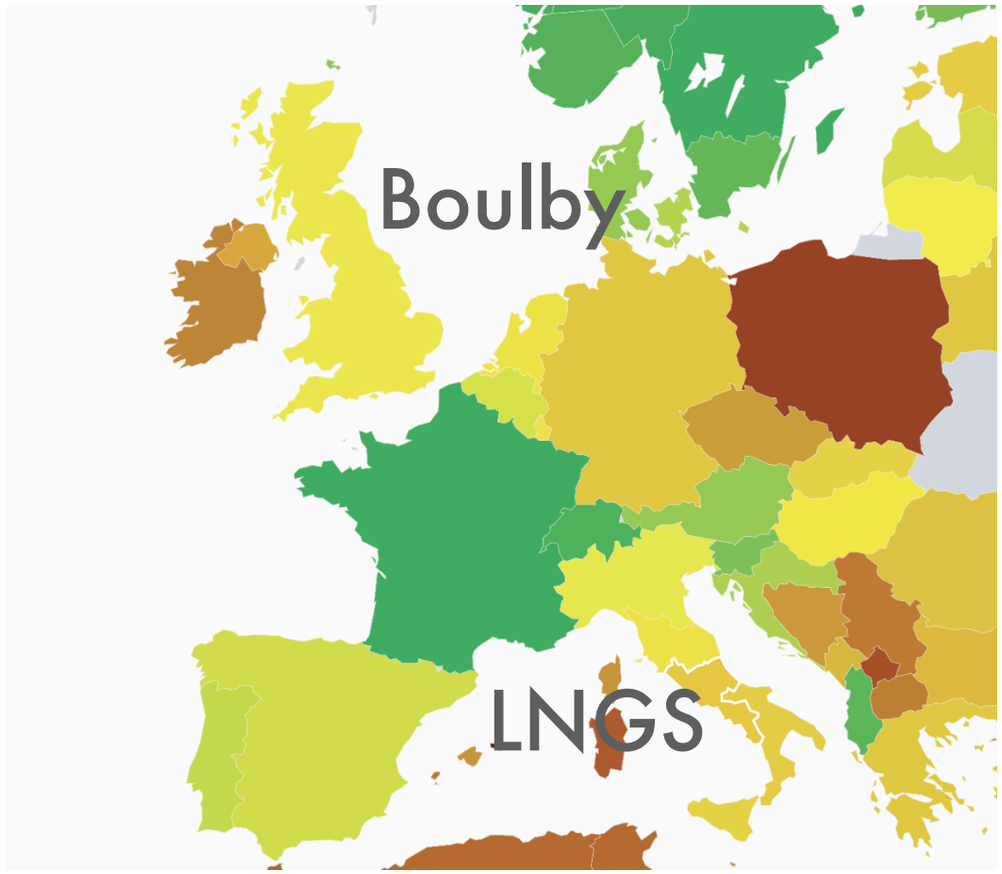
Activity	Description	Status	Total Energy Usage (kWh)	Uncertainty Category	Verification Method	Notes	Scope 1 Emissions (kg CO2)	Uncertainty Category	Verification Method	Notes
Example activity	Brief description of example activity.	With WPX	100.00	Calculated Estimate	Initial Estimate		0.00	Measured	To Be Measured	
Storage packs pre-production	Fabrication and preparation of ultra-clean storage packs for xenon pre-deployment	To Be Reviewed by WP8	50.00	WAG	Initial Estimate	~0.5 kWh per pack × 100 packs (sealing, prep)	0.00	Measured	To Be Measured	No direct fuel use
Purity Sampling system and compressor setup	Xenon sampling and transfer systems at intermediate storage	To Be Reviewed by WP8	5000.00	Calculated Estimate	Initial Estimate	2h per storage pack, 25kW average power consumption, 100 Storage packs	0.00	Measured	To Be Measured	No direct fuel use

Item Name	Xenon Storage		Materials Carbon	3039.25
Material Component	kg	Material	Processing Level	kCO2
Storage Packs Stainless Steel (**Active option**)	500	Stainless Steel	High	3039.25
Storage Packs Composite (Alternative Option)	200	Compsites (BOC)	High	3792.7
Storage Packs Steel Classic (Alternative Option)	1000	Steel	High	4334

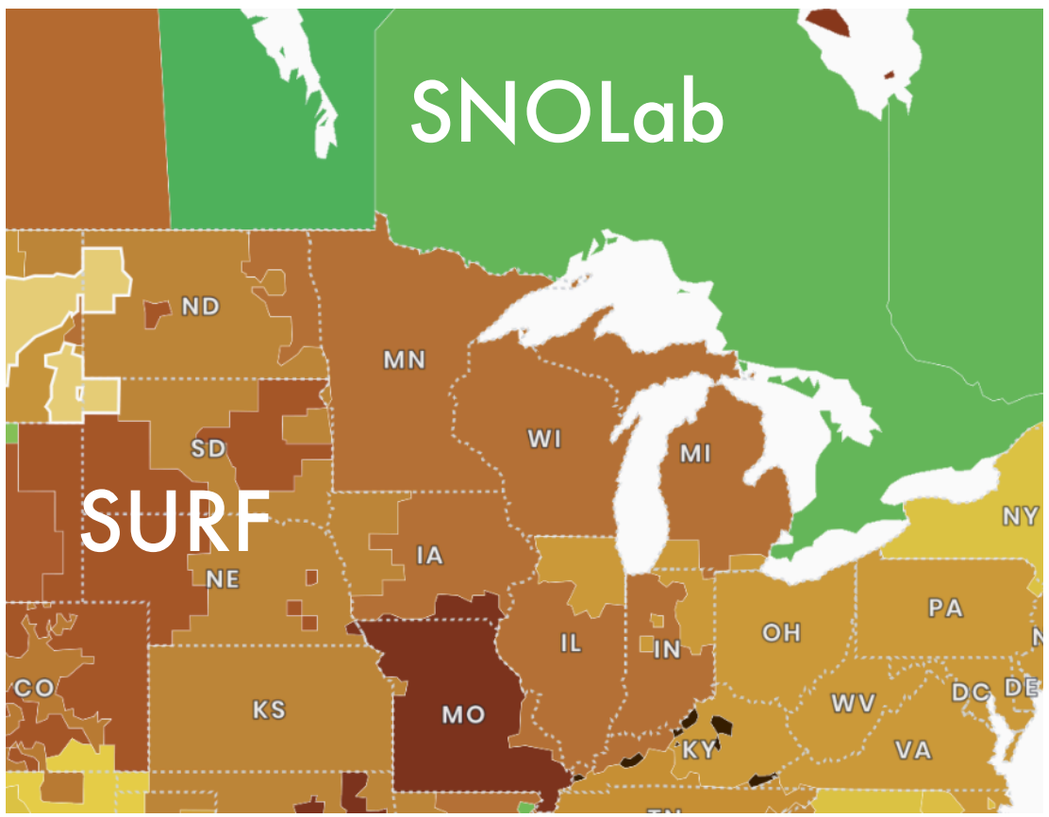
Scope 3 Emission Change	(%)	Kg CO2 eq	Notes
Office on the web Frame			
Classic Steel Storage Pack	0.87%	1316	Classic Steel cheaper but will increase emissions. Opens discussion if savings can be used for offset?
Composite Storage Pack	0.49%	741	Composite is lighter (40% weight of original stainless steel option) the processing outweights the saving during transport

Thanks to Rob Gregorio

Power



https://app.electricitymaps.com



- Power sources will have a major impact on KPIs
- gCO2/kWh varies strongly by location
- This doesn't take into account the changes and ambitions before XLZD will turn on!

Power at Boulby

- It's the stated ambition of the UK to have UK power be 95% low-carbon by 2030
- It's difficult to add direct-connection new renewables to Boulby
- Some solar will be added to buildings on site
- Additional options being investigated

Computing Waste Heat

- Net-zero is not possible without mitigation
- Major mitigation opportunity through waste heat recovery from computing
- A system has recently been installed at QMUL to do this

A Toolkit for the Future

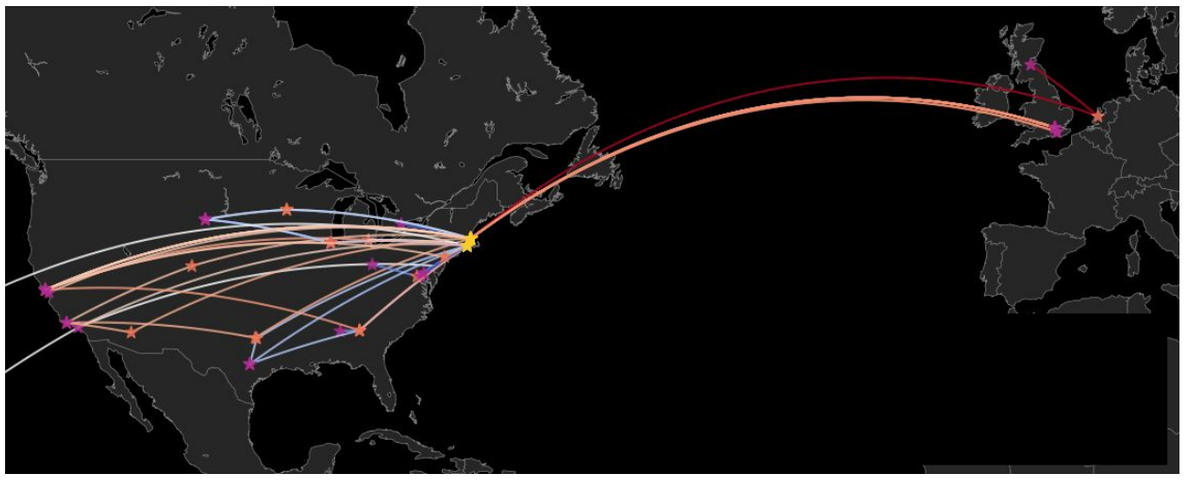
- In addition to doing the work, we want to make the work available
- We are building a toolkit for the future—other experiments & projects in the field
  - Policy
  - Documentation
- If you want to use our tools, get in contact!

Whole Collaboration

- There is a (highly infrequent!) slack channel: #sustainability
- We've met twice with interested colleagues
- There's a space for sustainability in the new WBS
  - How do we use that structure?
  - What do we do as collaboration vs national projects?
  - How do we interact with funding agencies with different requirements?

Travel Survey

- Let's start small and see what the footprint of this meeting is
- Travel survey: https://forms.gle/Tyb6L9Zr5HiarmkF7



Conclusions

- Sustainability is very important for XLZD@Boulby—and hopefully for XLZD as a whole
- Building in sustainability activities from the beginning will give us a good picture of the footprint of our experiment
- Activities are underway in the UK project—come join us!