

International Development Team

LC Sustainability: ICHEP, Publication Strategy, Accelerator LCA

Benno List, DESY

LC Sustainability meeting

Apr 23, 2024



Abstract for ICHEP



Sustainability Studies for Future Linear Colliders

Benno List, Shinichiro Michizono, Takayuki Saeki, Thomas Schörner-Sadenius, Steinar Stapnes, Maxim Titov

Sustainability has become a prioritized goal in the design, planning and implementation of future accelerators; approaches to improved sustainability include overall system design, optimization of subsystems, and operational concepts. A direct quantification of the ecological footprint, is currently performed only sporadically, with Lifecycle Assessments (LCA) emerging as a more comprehensive approach.

Two large electron-positron linear colliders are currently being studied as potential future Higgs-factories, CLIC at CERN and ILC in Japan. These projects are closely collaborating on methods to reduce the power consumption of accelerator components and systems, and smart integration of future accelerator infrastructure with the surrounding site and society. In a recent, common study an LCA of the construction of tunnels, caverns and shaft of both accelerators was conducted. This contribution will present this and other current results and future activities.

Talk has been accepted for a parallel session presentation

Presenter???



LCWS Sustainability Session and Further Workshops



- Onveners list:
<https://agenda.linearcollider.org/event/10134/page/344-study-groups-and-conveners>
 Benno List (DESY)
 Takayuki Saeki (KEK)
 Brendon Bullard (SLAC)
 Maxim Titov (CEA)

- **We need to submit an abstract for LCI input to ARUP study**


parallel session schedule v1 each slot 1.5h

		sust/ind	sources	DR, BDS	Beam dyn	SCRF	NCRF	adv. acc.	applic	CFS, MDI	Higgs, EW	top. QCD, flavor, prec	BSM, glob. int.	vtx, trk, timing	calo, muon	soft, reco, comp
	#seat	→				30										
	#slot	→	3	2	2	6	3	2	2	2	3	3	3	3	3	3
	total par. rooms	↓														
Tu1	6															
Tu2	6															
Tu3	3	industry (acc. plenary)														
Tu4		sustainability (plenary)														
We1	6															
We2	6															
We3	6															
We4	7															

3

The abstract submission deadline is at the end of this week, April 26th.

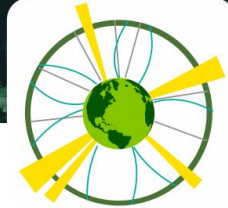
- Online workshop 10-12 June 2024
<https://indico.cern.ch/event/1355767/>
- Abstract Submission Deadline:
April 30, 2024
- Invited Talks:
 - Keynote Speech on Climate Change: Prof. (Dr.) Jyoti K Parikh
 - Psychology of Climate Change: T.B.C.
 - Intersection of HEP and the climate: Prof. Veronique Boisvert
 - Overview of computational science and sustainability: Dr. Loïc Lannelongue
 - **Overview on sustainable accelerators: Prof. Masakazu Yoshioka**
 - **Industrial scale involvement on sustainability development (Industry: ARUP): Suzanne Evans**
 - Best Practice in HECAP+: Dr. Ayan Paul



INDICO.CERN.CH/E/SUSTHEP24

SUSTAINABLE HEP 2024

3rd International Workshop on Sustainable High Energy Physics
10 - 12 June 2024



The 3rd edition of the [Sustainable High Energy Physics \(HEP\) workshop](#), will take place Monday 10th through Wednesday 12th June from 14:00 to 17:00 CET. Within three half-days, this [free, online-only](#) workshop aims to present the intersection of HEP and the climate crisis, to highlight the sustainable initiatives ongoing in HEP, and to workshop with attendees on positive tangible outcomes. The program will consist of invited talks, panel discussions, workshops and submitted talks accompanied by a discussion forum on Mattermost.


Abstract submission open!

<p>ORGANIZING COMMITTEE</p> <p>SHREYASI ACHARYA (INFN BABO) JULIETTE ALIMENA (DESY) DANIEL BRITZGER (MPP) BRENDON BILLARD (SLAC) SHREYA SAHA (ADELAIDE) HANNAH WAKELING (OXFORD)</p>	<p>ADVISORY COMMITTEE</p> <p>SHANKHA BANERJEE (IMSC CHENNAI) NIKLAS BEISERT (ETHZ) VALERIE DOMCKE (CERN) VALERIE LANG (FRIEBURG) PETER MILLINGTON (MANCHESTER) AYAN PAUL (NORTHEASTERN)</p>
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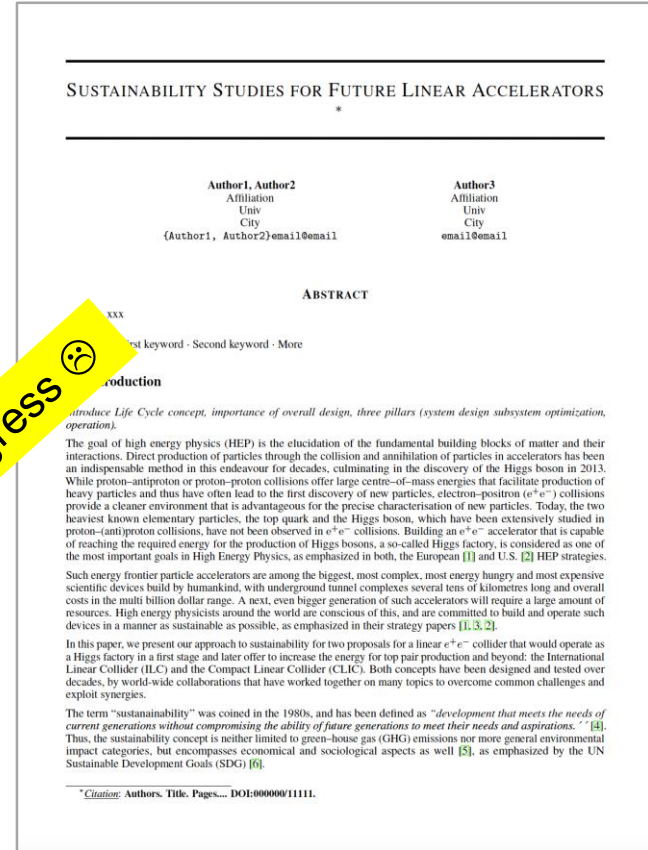
CONTACT
indico.cern.ch/e/susthep24
susthep24@physics.ox.ac.uk

10 - 12 JUNE 2024
14:00 - 17:00 CET
ONLINE VIA ZOOM

SCAN ME



- Introduction
- Accelerator Design
- Construction
- Operation
- Decommissioning
- LCA Results
 - Open Questions
- Managing Sustainability
 - Construction Phase
 - Civil Engineering – Accelerator – Detector Organisation
 - Operation
 - Civil Engineering- Accelerator – Detector – Campus and Site - Computing
 - Decommissioning Phase
 - Accelerator
 - Cross Cutting Activities
- Acknowledgments





New ARUP Study on Accelerator LCA



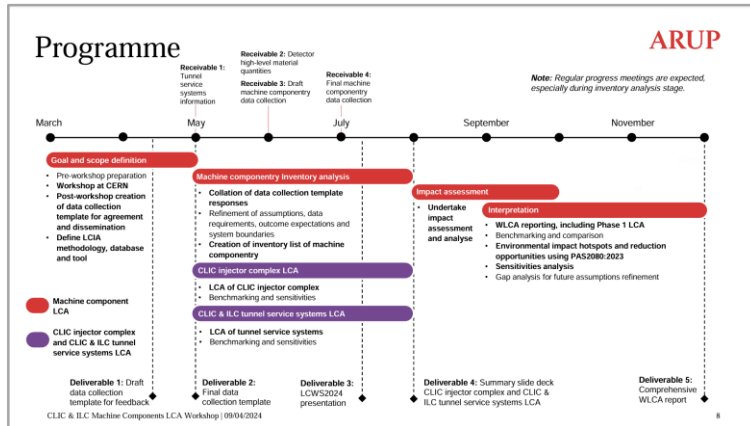
- Preparatory meeting was held on Apr 9 <https://indico.cern.ch/event/1402434/>
- Aims for LCA (Life Cycle Assessment) of both, CLIC and ILC, project: Civil (tunnel etc), accelerator, detector
- Input needed from experts: inventory data on magnets, RF system etc: materials, energy, ...
-> a lot of work

ARUP

Linear Colliders | CLIC & ILC LCA

Machine Componentry LCA Workshop with CERN and KEK

Yung Loo Heleni Pantelidou Suzanne Evans Claudia Di Noi Celia Puertas Jin Sasaki
9th April 2024



ARUP

Workshop agenda

Section	Length	Time	Format
1. Introductions	10	14:00 – 14:10	
2. Machine componentry overview	30	14:10 – 14:40	CERN presentation
3. Presentation from Benno List on LCA work	10	14:40 – 14:50	CERN presentation
4. Phase 2 scope of work	10	14:50 – 15:00	Arup presentation
5. Summary of Phase 1 LCA and lessons learnt	15	15:00 – 15:15	Arup presentation
6. Approach for inventory analysis	15	15:15 – 15:30	Arup presentation
BREAK	15	15:30 – 15:45	
7. Data collection key questions	50	15:45 – 16:35	Discussion and activity
8. Impact assessment and results analysis	15	16:35 – 16:50	Arup presentation and discussion
9. Wrap-up and next steps	10	16:50 – 17:00	

CLIC & ILC Machine Components LCA Workshop | 09/04/2024



LCI Input for ARUP



- Start with PBS (Product Breakdown Structure)
- Based on overall structure of accelerator, be consistent with approach taken for civil engineering work

Please define the componentry hierarchy of the CLIC and ILC systems (an example is provided below for CLIC, to be checked and refined)

System	Sub-system	Components	Sub-components (if applicable)
CLIC Drive Beam 380GeV	Drive beam injector complex and transfer to ML tunnel	DB	?
		Delay loop and combiner ring (DL and CR)	?
		DB transfers until main linac (ML) tunnel	?
	Main beam injector complex	Injectors "active"	?
		Transfer to main linac (ML) tunnel	?
		Damping ring (DR)	?
	Main Linac (ML)	Main linac modules	?
		Post decelerators	?
	Beam delivery and post collision lines	Beam delivery system (BDS)	
		Final focus	
		Post collision lines/dumps	
	?	Detectors	



Proposed ILC Structure



- For ILC: Used established structure for accelerator areas, plus detectors
- Identify the most important components (i.e., technical systems) that contribute to the environmental impact
- Most important / biggest contributors:
 - Cryomodules (analysis by me)
 - Magnets, including power supplies and stands
-> comprehensive data on magnet yokes&coils, not much on power supplies, cabling, stands
 - Cryogenics ???
 - Vacuum (estimate mostly beampipe)
 - **Detectors**
-> need to contact detector collaborations

System	Sub-system	Components
ILC 250GeV	ES: Electron Source	Magnets with Power supplies and stands Vacuum system Cryomodules HLRF (Klystrons, Modulators) Cryogenics Area Specific: NC Accelerating Structures, Gun
	PS: Positron Source	Magnets with Power supplies and stands Vacuum system Cryomodules HLRF (Klystrons, Mmodulators) Cryogenics Dumps and Collimators Area Specific: NC Accelerating Structures, Target
	DR: Damping Rings	Magnets with Power supplies and stands Vacuum system Cryogenics Dumps and Collimators Area Specific: Cryomodules, Klystrons, Wigglers
	RTML: Ring to Main Linac	Magnets with Power supplies and stands Vacuum system Cryomodules HLRF (Klystrons, Modulators) Cryogenics Dumps and Collimators
	ML: Main Linac	Magnets with Power supplies and stands Vacuum system Cryomodules HLRF (Klystrons, Mmodulators) Cryogenics Dumps and Collimators
	BDS: Beam Delivery System	Magnets with Power supplies and stands Vacuum system Cryomodules HLRF (Klystrons, Modulators) Cryogenics Dumps and Collimators Area specific: Crab cavities
	Detectors	ILD SID Infrastructure



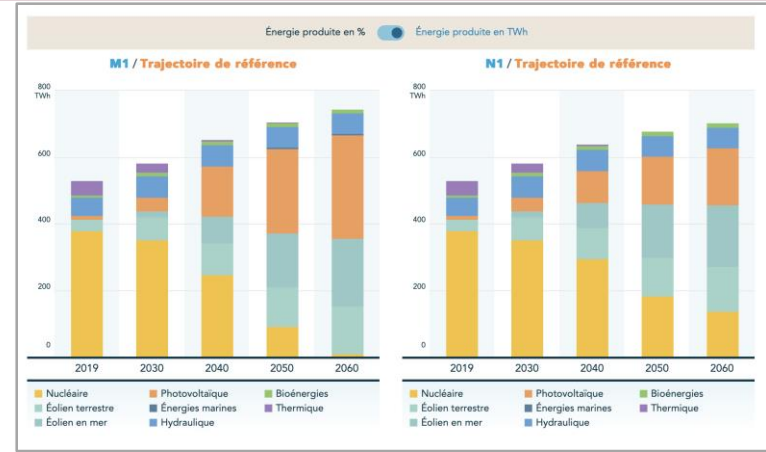
Questionnaire Format



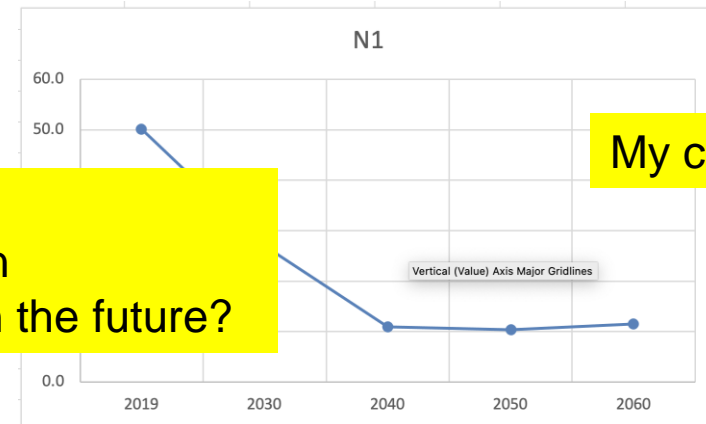
- LCI data will be collected in spread sheets
- Feeds into analysis by ARUP
- Open issue: Impact of accelerator specific material (niobium, oxygen free copper...)

Assembly/machine name	<i>A data collection template can be provided for each system (CLIC and ILC) as in the example below or data collection template can be split in different tabs to reflect different cross sections of the tunnel. Data collection can be adapted based on CERN's feedback</i>					
Date of completion						
Contact person						
Telephone						
E-Mail						
Quantitative reference and unit	<i>1 item, technical characteristics ? Physical characteristics (weight)?</i>					
Production stage	<i>DESCRIPTION: The drive beam complex includes injectors and components for frequency multiplication, add other components</i>					
Inputs	Amount	Unit	Origin (Country)	Data source	Uncertainty (high, medium, low)	Notes
Energy						
Electricity	2	kWh	Switzerland	Measurement		Electricity for production of component X
Nuclear gas	1	kWh	Switzerland	Expert judgement		Total gas consumption for drive beam complex production
Electricity	1	kWh	Asia	Supplier		Electricity for production of component X
Materials						
Steel	1	kg	France	Expert judgement		
Copper	1	kg	France	Measurement		
Aluminium	1	kg	China	Measurement		
Ti	5% overall weight	kg		Expert judgement		
Plastics	1	kg	Europe	Measurement		
Resources						
Water	1	l	Switzerland			
Packaging						
Plastics						
Wood pallets						
Outputs						
Emissions to air						
Carbon dioxide						
Emissions to water						
Emissions to soil						
Production waste						
	Amount	Unit	End of life treatment (Landfill, recycling, incineration, reuse) as %		Data source	Notes
Steel	0.5	kg	100% recycling (on site)			
Copper	1% of production		50% recycling (on site), 40% recycling (other site), 10% landfill			
Plastics	1% of production		Disposed in Switzerland			

- RTE (<https://www.rte-france.com>): réseau de transport d'électricité français - the French grid operator
- Study provides detailed scenarios with many variations for development of French electricity mix up to 2050
- Enough data to calculate CO2 emission factors
-> plan: consolidate this to have meaningful reference numbers
- Broadly in agreement with our “12.5 g/kWh”



<https://rte-futuresenergetiques2050.com>



Question to Japan:
Can you prepare a documented projection
Of Japanese CO2 intensity of electricity in the future?



LDG Group on Sustainability



- 2nd meeting of LDG WG on Sustainability Assessment of Accelerators was held Apr 8 (indico access restricted)
- 3rd meeting planned for Apr 29, 3-weekly rhythm
- Will go through a number of presentations from participants, then decide on outline of report
- Document needs to be approved by Feb 25
-> finish by end of 24
- Participation:
 - Representative from Labs (CERN, DESY, NIKHEF, ESS, UKRI, ...)
 - Representative from Projects: FCC, CLIC, ILC...