International Development Team

LC Sustainability: ICHEP, Publication Strategy, Accelerator LCA

Benno List, DESY

LC Sustainability meeting

Feb 15, 2024

Abstract for ICHEP

Sustainability Studies for Future Linear Colliders

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Presenter???

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.

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)
- Need to get going
- Is one plenary enough?
- Further plans?

block timetable

	Mon 8 large "Ito" hall	Tue 9 smaller rooms	Wed 10 smaller rooms	Thu 11 Ito hall	Fri 12
am1	plenary 1	parallels	parallels	ECR forum	
am2	plenary 2	parallels	parallels	acc plenary phys.det plenary	satellite meetings
pm1	acc plenary phys.det plenary	industry det.phys parallels	parallels	plenary 3	
pm2	LC facility in global picture	sustainability (+parallels if needed)	parallels	plenary 4	
evening	reception / poster		dinner		

Paper on Overleaf – Have a Look, please

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

SUSTAINABILITY STUDIES FOR FUTURE LINEAR ACCELERATORS
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ABSTRACT

xxx

Keywords First keyword · Second keyword · More

1 Introduction

Introduce Life Cycle concept, importance of overall design, three pillars (system design subsystem optimization, operation).

The goal of high energy physics (HEP) is the elucidation of the fundamental building blocks of matter and their interactions. Direct production of particles through the collision and annihilation of particles in accelerators has been an indispensable method in this endeavour for decades, culminating in the discovery of the Higgs boson in 2013. While proton–antiproton or proton–proton collisions offer large centre–of–mass energies that facilitate production of heavy particles and thus have often lead to the first discovery of new particles, electron–positron (e^+e^-) collisions provide a cleaner environment that is advantageous for the precise characterisation of new particles. Today, the two heaviest known elementary particles, the top quark and the Higgs boson, which have been extensively studied in proton–(anti)proton collisions, have not been observed in e^+e^- collisions. Building an e^+e^- accelerator that is capable of reaching the required energy for the production of Higgs bosons, a so-called Higgs factory, is considered as one of the most important goals in High Energy Physics, as emphasized in both, the European [1] and U.S. [2] HEP strategies.

Such energy frontier particle accelerators are among the biggest, most complex, most energy hungry and most expensive scientific devices build by humankind, with underground tunnel complexes several tens of kilometres long and overall costs in the multi billion dollar range. A next, even bigger generation of such accelerators will require a large amount of resources. High energy physicists around the world are conscious of this, and are committed to build and operate such devices in a manner as sustainable as possible, as emphasized in their strategy papers [1, 3, 2].

In this paper, we present our approach to sustainability for two proposals for a linear e^+e^- collider that would operate as a Higgs factory in a first stage and later offer to increase the energy for top pair production and beyond: the International Linear Collider (ILC) and the Compact Linear Collider (CLIC). Both concepts have been designed and tested over decades, by world-wide collaborations that have worked together on many topics to overcome common challenges and exploit synergies.

The term "sustainability" was coined in the 1980s, and has been defined as *"development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations.''* [4]. Thus, the sustainability concept is neither limited to green–house gas (GHG) emissions nor more general environmental impact categories, but encompasses economical and sociological aspects as well [5], as emphasized by the UN Sustainable Development Goals (SDG) [6].

Citation: **Authors. Title. Pages.... DOI:000000/11111.**

Journal: Physical Review X - Energy

PRX Energy Scope

PRX Energy welcomes manuscripts on all topics relevant to the multidisciplinary energy science and technology research communities spanning physics, chemistry, materials, engineering, biology, environmental studies, and policy. Research coverage in the journal comprises: fundamental and applied science; theoretical, experimental, computational, and data-intensive research, including significant advances in methods and instrumentation; and interdisciplinary and emerging areas. The full scope statement including subject areas can be found here.

About *PRX Energy*

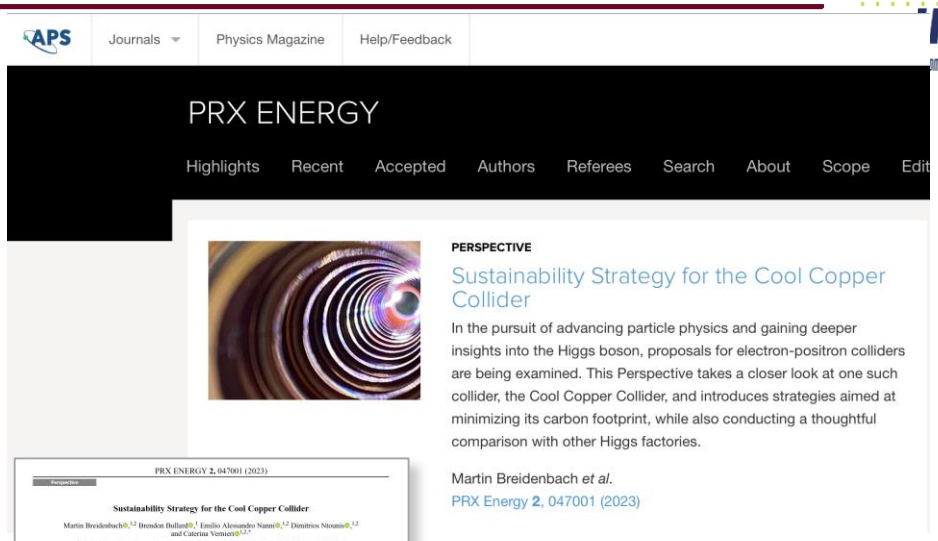
The pursuit of science and technology for renewable and sustainable energy is an urgent challenge facing society and policymakers around the world today. The physics community has long been central to fundamental energy science and many resulting applications — from defining energy as the capacity to do work, to exploring the fundamental laws, to discovering ways to harness energy and transform it between various forms, and developing innovative technologies, like steam and combustion engines, nuclear power, and solar panels.

But communication and collaboration across traditional boundaries is now critical, as researchers and stakeholders from a diverse array of disciplines and regions focus their efforts on achieving common goals.

For these reasons the American Physical Society (APS) launched *PRX Energy*, a highly selective, fully open access journal with aims to:

- provide a high-impact forum for the interdisciplinary community focused on energy research and technologies
- seamlessly connect members of the community, across all disciplines, to the physics community and to each other
- maximize dissemination of the most significant and timely results, to facilitate important advances for the benefit of humanity

Building on 10 years of excellence established by *Physical Review X* (PRX), the world's leading open access journal in multidisciplinary physics, *PRX Energy* will be a fully open access journal featuring highly selective editorial standards, but with a focus on the interests and needs of the broad and diverse energy research community. The journal's editorial team will provide fair and rigorous peer review to select high-quality and timely original research papers, perspectives, and tutorials, all with an emphasis on outstanding and lasting impact.




PRX ENERGY 2, 047001 (2023)

Sustainability Strategy for the Cool Copper Collider

https://journals.aps.org/prxenergy/

New: Launched April 22, 2 volumes

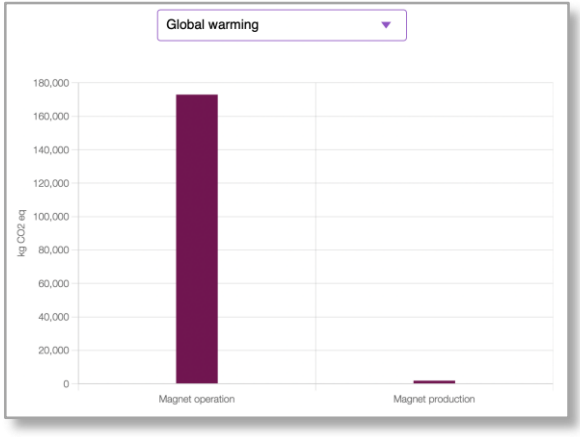
To Do

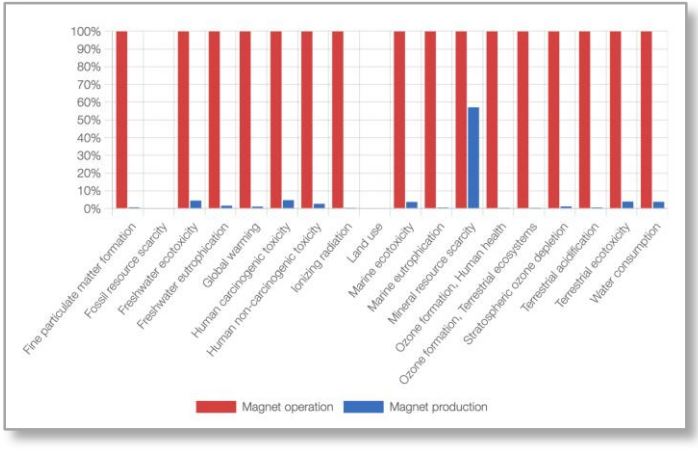
- Unify approach to running time per year, machine development, downtimes etc; refine/define ILC power estimate in down times
- Make carbon emission profile for ILC
- Revisit potential for energy storage? 100MW x 10h = 1GWh possible
- **Accelerator LCA**

Cost: ~2M$ for 3MWh according to
https://www.teslarati.com/tesla-hiring-megapack-factory/

Accelerator LCA

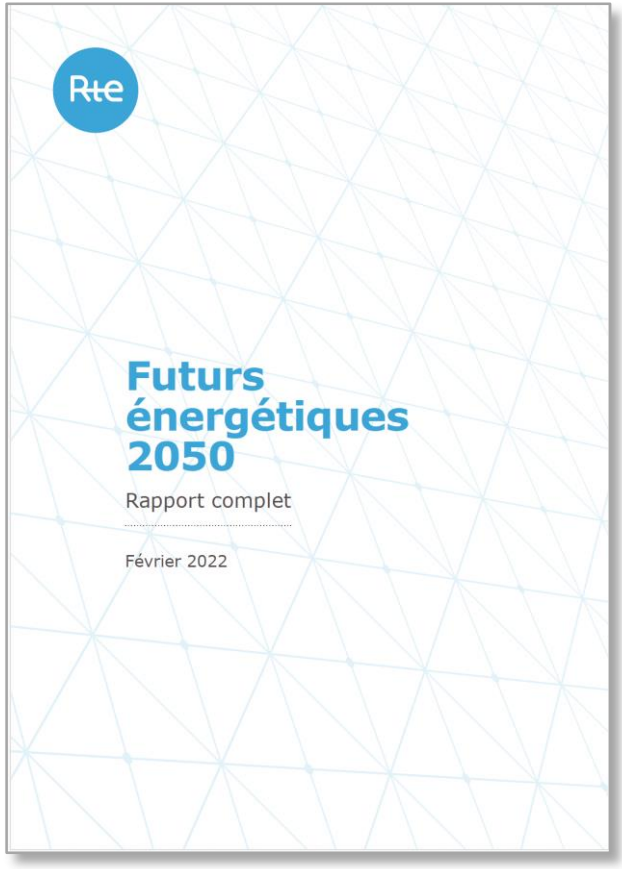
- I have re-started work on magnets:
- Following discussions with Hannah Wakeling, I work with OpenLCA (https://www.openlca.org)
- Allows to make a professional LCA of a magnet -> good, but a LOT of work
- Could be used to get impact factors (kg steel / kg copper -> GWP or other estimators) and apply that to all magnets in a list
- Restarted looking at CLIC list of magnets





Electricity Carbon Intensities in France

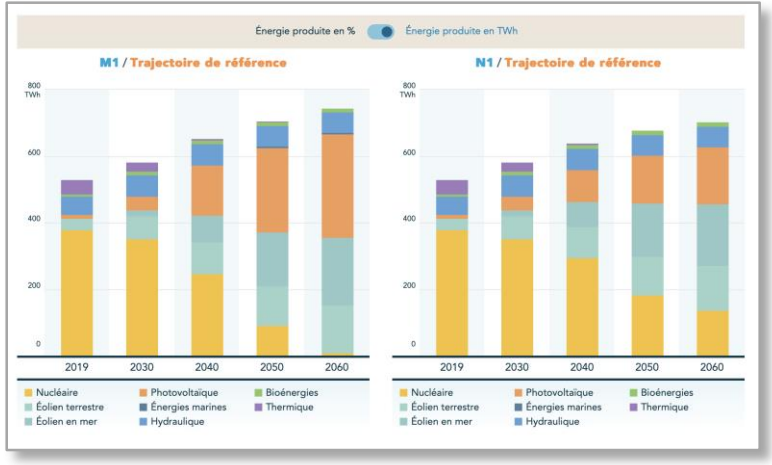
https://rte-futursenergetiques2050.com



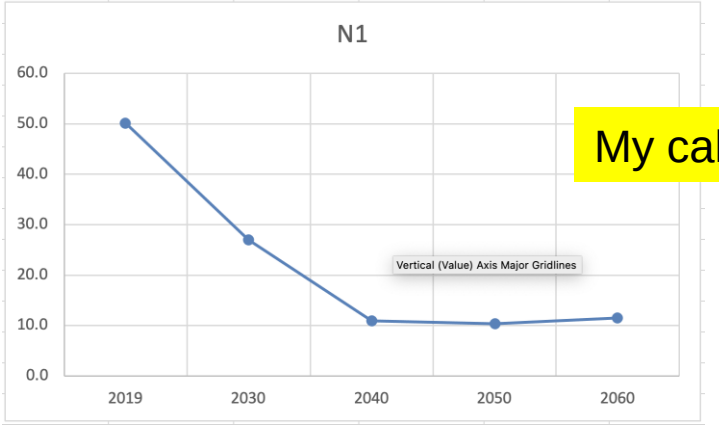
https://assets.rte-france.com/prod/2022-06/Futurs%20énergétiques%202050%20_%20rapport%20complet.zip

RTE Study

- 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-futursenergetiques2050.com



My calc