Sustainability Assessment of Future Accelerators: LDG Working Group Report and Discussion

Caterina Bloise (INFN Frascati), Maxim Titov (CEA Saclay)
(on behalf of the LDG Working Group)

European Laboratory Directors Group Meeting and Accelerator R&D Workshop, Brookhaven National Laboratory, USA, June 6-7, 2024

Mandate / Charge of Sustainability LDG Working Group

Charge for a Working Group on "Sustainability Assessment of Accelerators" for the next European Particle Physics Strategy Update (EPPSU)

J. Clarke, B. Heinemann, M. Seidel, June 23rd 2023

Sustainability is increasingly in the focus of public discourse. Accelerator facilities, in particular for High Energy Physics, are among the largest scientific endeavors in terms of construction and energy consumption, with lifetimes spanning decades. For this reason, and as a community representing forefront research, we have a special obligation to assess and optimize sustainability. Several next generation facilities were proposed at the last EPPSU and are expected to be proposed for the next update (likely in 2026/2027).

Recently, proponents of projects have started to report on and compare projects on the basis of Green House Gas (GHG) emissions, predominantly from electric power consumption during operation, with first efforts to quantify also embodied GHG from construction. The quoted numbers differ in terms of parameters used for comparison, methodology, considered scope, and assumptions about current and future CO2 intensity e.g. of electrical power, making it difficult to compare projects impartially in terms of their sustainability. Energy consumption and construction result in GHG emissions, or rather Global Warming Potential (GWP). Other indicators such as water consumption, Helium consumption, Ozone depletion, ecotoxitity etc., habitually used in Lifecycle Assessments (LCA), may present important aspects for the environmental sustainability of specific proposals, and these should be assessed at least qualitatively.

This working group is asked to develop guidelines and a minimum set of key indicators pertaining to the methodology and scope of the reporting of sustainability aspects for future HEP projects:

- Define key indicators to be reported, such as peak (or instantaneous?), lifetime- and performance specific (per luminosity) energy consumption, lifetime- and specific GWP including the contribution of construction. These figures should be supplemented by margins of uncertainty and possibly an assessment of the potential for improvement.
- Define the methodology and assumptions to be applied, to allow a transparent determination and comparison of these key figures across the proposals. The maturity of a proposal should be determined, for example early concept phase, CDR, TDR or TRL levels.
- Identify other high level environmental impacts that may be relevant for all or specific collider proposals.

In general, best practices determining the GWP for large projects in Europe should be followed.

The working group may comment on other aspects if deemed appropriate, for example:

- Treatment of future carbon intensity of electricity and materials: what scenarios should be assumed?
- Assessing the potential for dynamic operation of the various facilities, i.e. the ability to adapt to a fluctuating energy supply in a grid fed by renewable energy sources. This may include standby mode power consumption, recovery time to full luminosity and fraction of integrated luminosity preserved in a dynamic operation scenario.
- Treatment of regional vs global parameters: How to treat differences e.g. in carbon intensity between different host countries? (Should one compare technical merit of projects by using globally averaged carbon intensities, or site dependency by using local carbon intensity?)
- Carbon intensity / lifecycle inventory (LCI) studies of materials specific to accelerator projects: high-purity niobium, permanent magnet alloys etc.

✓ ***Definition of key indicators to be reported***

Possible examples:

- Peak / instantaneous lifetime- & specific (per luminosity) energy consumption
- Lifetime and specific Global Warming Potential (GWP), including construction
- Include margins of uncertainty and possibly an assessment of the potential for improvement

✓ ***Definition of methodology & assumptions to be applied for transparent determination of key figures across proposals***.

- The maturity of a proposal should be determined, for example, at early concept phase, CDR, TDR levels

✓ ***Identification of additional high level environmental impacts that may be relevant for all or specific collider proposals***

✓ ***Also, VERY IMPORTANT - impact on society and public appreciation of the WG report: HEP benefits and decarbonization path for the future large – scale accelerator RI's***

Some Other (More Technical) Objectives

LDG WG may comment on other aspects if deemed appropriate, for example:

- Treatment of future carbon intensity of electricity and materials:
  - what scenarios should be assumed?
- Assessing the potential for dynamic operation of the various facilities:
  - i.e. the ability to adapt to a fluctuating energy supply in a grid fed by renewables. This may include standby mode power consumption, recovery time to full luminosity and fraction of integrated luminosity per year preserved in a dynamic operation scenario.
- Treatment of regional vs global parameters:
  - how to treat differences e.g. in carbon intensity between different host countries?
- Carbon intensity / lifecycle inventory (LCI) studies of materials specific to the accelerator projects: high-purity niobium, permanent magnet alloys etc.
- How to interface with open-source LCI databases and LCA tools to potentially ease/automate the assessment for future research infrastructures
- How the recommendations for colliders can be extended to other scientific /endeavours related to HEP
- How HEP labs represented in the LDG can share/build up expertise jointly

WG Composition (Endorsed by LDG in Mar. 2024)

Panel consisting of 15 members with technical expertize in evaluation of accelerator sustainability and future collider project representatives

Ensuring broad community representation:

- *Sustainability Lab. Panels established at CERN, DESY, ESS, NIKHEF, STFC*
- *ICFA Sustainability Panel*
- *EU- Horizon Programs*
- *Future accelerator projects: FCC, ILC, CePC, CLIC/Muon, LHeC, C3*
- *Invited experts on specific topics*

- Walib Kaabi - PERLE, EU-iSAS
- Mats Lindroos - ESS (deceased May 2, 2024)
- Roberto Losito - CERN Sust. Panel
- Ben Shepherd - STFC Sust. Task Force
- Andrea Klumpp - DESY Sust. Panel, EU-iFAST
- Hannah Wakeling - ISIS-II Neutron & Muon Source
- Patrick Koppenburg - NIKHEF Sust. Panel
- Johannes Gutleber - FCC
- Yuhui Li - CePC
- Benno List - ILC
- Emilio Nanni - ICFA Sust. Panel & C3
- Vladimir Shiltsev - LHeC
- Steinar Stapnes - CLIC & Muon collider
- Caterina Bloise - Co-Chair
- Maxim Titov - Co-Chair, EU-EAJADE

LEARN, SHARE and BUILD-UP expertise with other HEP sustainability initiatives

Sustainability Assessment of Research Infrastructures

Best practices determining the GWP for large-scale infrastructures has to be considered

Sustainability is much broader than considering energy management and carbon footprints

Sustainable Accelerators and Environmental Impact of RI's: we are learning what this means

Reference for the integrated model FCC

Regulatory guiding principle

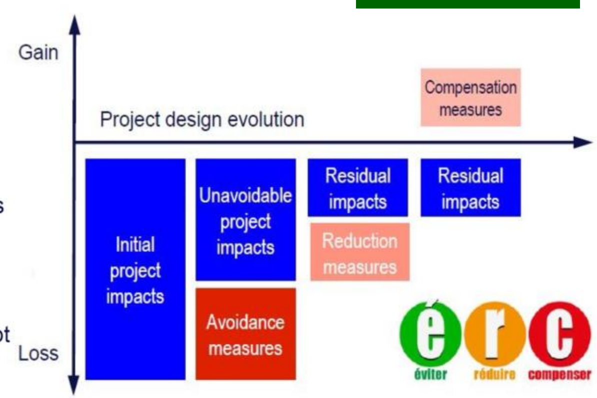
J. Gutleber

An iterative 3 step approach :

Avoid: measures taken to avoid creating impacts from the outset or set aside key conservation areas / delete a potential impact

Reduce: measures taken to reduce the intensity and/or extent of impacts that cannot be completely avoided

Compensate: measures taken to compensate for any significant residual, adverse impacts that cannot be avoided, reduced and/or restored



EU: Europe-Horizon Sustainability-Supporting Programs

- ✓ *Innovation Fostering in Accelerator Science and Technology (I.FAST): https://ifast-project.eu*
- ✓ *Europe-America-Japan Accelerator Development Exchange Programme (EAJADE): https://www.eajade.eu/*
- ✓ *Innovate for Sustainable Accelerating Systems (iSAS): https://indico.ijclab.in2p3.fr/event/9521/*

iSAS Objectives – *Technology Areas*

- **TA#1: energy-savings from RF power** – *While great strides are being made in the energy efficiency of various RF power generators, the objective of iSAS is to ensure additional impactful energy savings through coherent integration of the RF power source with smart digital control systems and with novel tuners that compensate rapidly cavity detuning from mechanical vibrations, resulting in a further reduction of power demands by up to a factor of 3.*
- **TA#2: energy-savings from cryogenics** – *While major progress is being made in reusing the heat produced in cryogenics systems, the objective of iSAS is to develop superconducting cavities that operate with high performance at 4.2 K (i.e., up to 4.5 K depending on the cryogenic overpressure) instead of 2 K, thereby reducing the grid-power to operate the cryogenic system by a factor of 3 and requiring less capital investment to build the cryogenic plant.*
- **TA#3: energy-savings from the beam** – *Significant progress has been achieved in maintaining the brightness of recirculating beams to provide high-intensity collisions to experiments, but most of the particles lose their power through radiation or in the beam dump system. The objective of iSAS is to develop dedicated power couplers for damping the so-called Higher-Order Modes (HOMs) excited by the passage of high-current beams in the superconducting cavities, enabling efficient recovery of the energy of recirculating beams back into the cavities before it is dumped, resulting in energy reduction for operating, high-energy, high-intensity accelerators by a factor ten.*

https://indico.cern.ch/event/1326603/timetable/#20240215.detailed

Discussion about possibility to organize joint iFAST / EAJADE workshop in Fall 2024

https://indico.cern.ch/event/1326603/timetable/#20240215.detailed

WP11 Overview

task 1: Sustainable Concepts for RIs: networking, workshops on selected topics
deliverable: report

1) System Efficiency of Accelerator Concepts (N.Catalan Lasheras, CERN)
2) Key Technologies and Components for High Efficiency (A.Sunesson [C.Martins], ESS)
3) Cross Linking Accelerator R&D with Industrial Approaches (P.Spiller, GSI)
4) Ecological Concepts (D. Voelker, DESY)

task 2: High Efficiency Klystron (O.Brunner CERN, THALES, ULANC)

- deliverable: industrial prototype
- replacing klystrons in LHC

iFAST

task 3: Permanent Combined Function Magnets for Light Sources (B.Shepherd, UKRI, DLS, KYMA, DESY)

- deliverable: magnet prototype, applicable for Diamond upgrade
- several advantages of permanent magnets, not just power consumption

EAJADE Workshop on Sustainability on Future Accelerators (WSFA2023)

MORIOKA, JAPAN, SEPTEMBER 25-27, 2023
Aiina Center, the same venue as LCWS2016, hosted by Iwate University

https://wsfa2023.huhep.org/ ; https://indico.desy.de/event/39980/

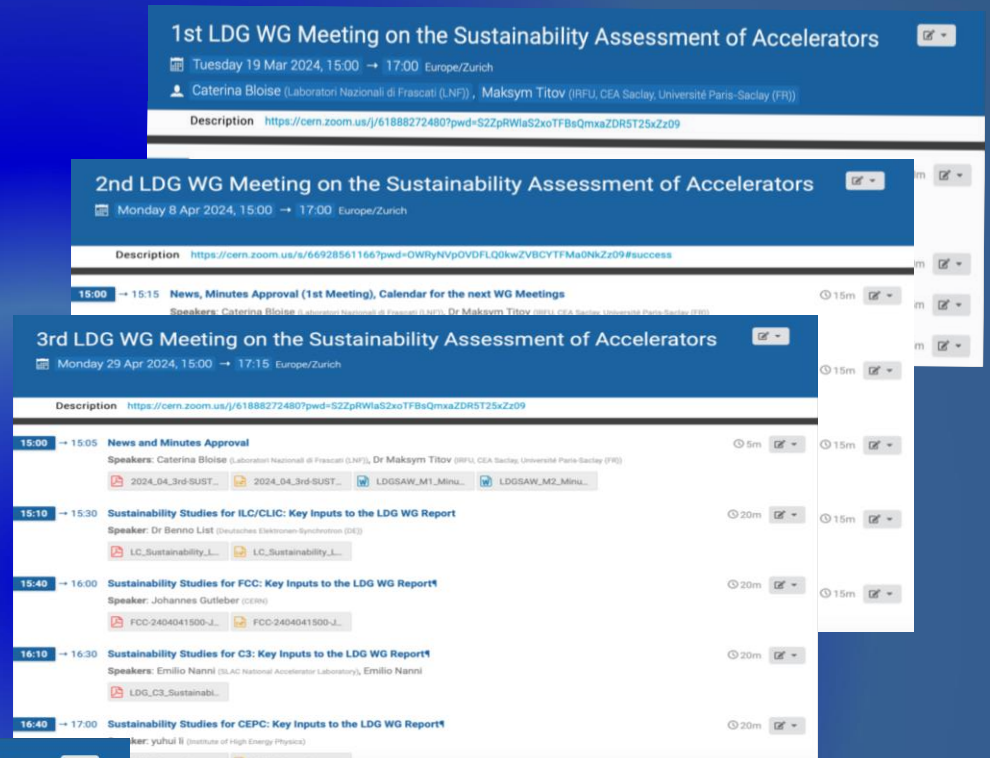
Four blocks (not limited to future Higgs Factores and to Linear Colliders):

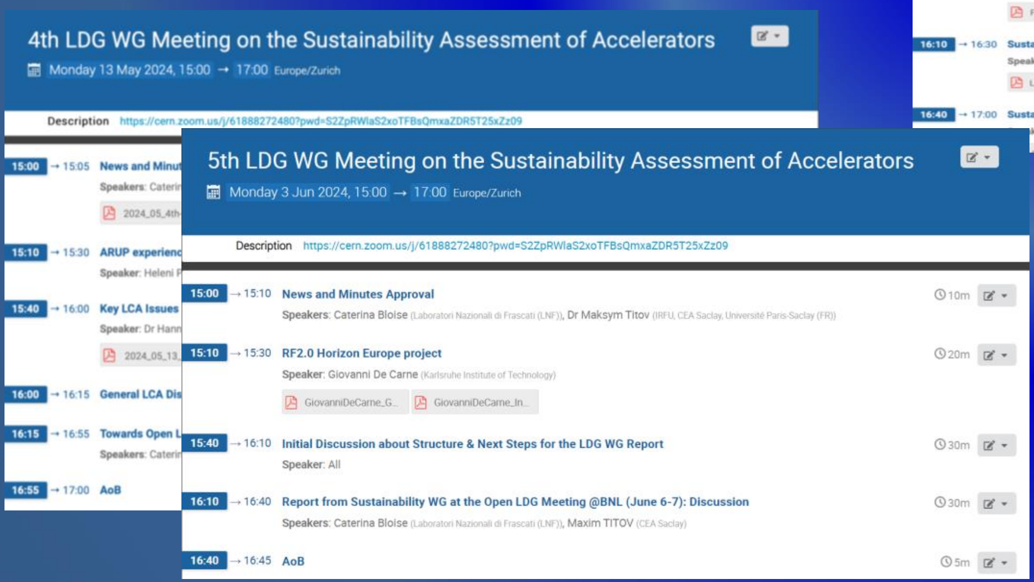
- ***I. Large-Scale Research Facilities & Sustainability / Life Cycle Assessment(LCA)***
- ***II. Sustainable Accelerator Technologies***
- ***III. Europe-Horizon and National Sustainability-Supporting Programmes***
- ***IV. Green ILC and Local Industries***

https://wsfa2023.huhep.org/

LDG Working Group Activities (5 Meetings So Far)

- *Reports from the Initiatives on Sustainability*
  - CERN & STFC Panels, ESS
  - Future Higgs Factories (FCC, ILC, C3, CEPC)
- *Topics to focus on: Key LCA issues*
- *Inputs from Invited Experts:*
  - Decarbonization for Large Infrastructures (H. Pantelidou / ARUP)
  - EU-Horizon RF2.0 Project (G. de Carne)
- *Elaboration of WG Report structure starting*





✓ *Draft report containing recommendations from the WG is expected by end of 2024*

✓ *Report will serve as an input document to the ESPPU due by March 2025*

Topics more focused on ESPPU inputs will be incrementally enlarged

WG Report ***DRAFT:*** Topics and Content (Preliminary)

Overleaf area for the WG report has been created

WG mandate :

Development of guidelines and a minimum set of key indicators pertaining to methodology and scope of reports on sustainability in future HEP projects

In what follows, the detailed outline and potential topics are presented:

- *not all of them can be addressed in a limited time by end of 2024, some might need more time to develop and to mature*
- *need to define a strategy how to roll this out in the coming years*

WG Report *DRAFT:* Topics and Content (Preliminary)

- Foreword
- Executive Summary (for wide public) and Main Recommendations
- *Social – Economical Benefits of Particle Physics* in Relation to the UN Sustainability Development Goals (environment, economy, society):
  - Fundamental Physics Knowledge
  - Accelerator and Detector R&D (context of strategic ECFA R&D Roadmaps)
  - Education, Innovation, International Cooperation, Cultural Exchange
- Setting the *basis for sustainability of the long-term accelerator infrastructures:*
  - Best practices determining GWP for large-scale infrastructures
  - EU Policies (e.g. PNIEC, …)
- *Life-Cycle Assessment* for Future Accelerators *– Methodology and Reporting:*
  - Scope and boundary: LCA for future facilities is “a MUST”
  - Overview with unified table for accelerator sustainability parameters, esp. GWP?
  - Common approach to report and evaluate the data, assessment methodologies:
    - impact categories
    - sensitivity of the footprint to the evaluation method and related uncertainties

WG Report ***DRAFT:*** Topics and Content (Preliminary)

- *Green House Gas Emissions footprint for future accelerator facilities:*

  Developing a tool and guidance for quantification could be a good recommendation for the strategy: e.g. evaluate and optimize CO2 impact in a *staged approach* at early concept phase, CDR and at TDR level over the full lifecycle

  - *civil construction:* LCA studies for accelerator infrastructure (e.g. tunnels, caverns) and Civil engineering (LCA A1-A5)
  - *accelerator construction:* carbon intensity / lifecycle inventory studies for some major accelerator components (e.g. RF and magnets); develop reference set of impact values for some commonly used accelerator materials (high-purity niobium, permanent magnet alloys etc.)
  - *accelerator operation:* Treatment of carbon intensity of electricity related to energy source - depending on future energy mixes and regions:
    - which scenarios should be assumed?
    - how to treat differences e.g. in carbon intensity between different host countries (regional vs globally averaged impacts)
    - the cost of carbon, shadow costs scenarios and associated uncertainties
  - *particle detectors:* construction, impact of detector gases, computational footprint
  - *decommissioning:* recycling and disposal of used components, site reuse; develop criteria to estimate impacts (?)

WG Report ***DRAFT:*** Topics and Content (Preliminary)

- *Mitigation and Compensation Strategies, Decarbonisation and Impact Reductions:*
  - optimization of large civil & accelerator construction footprint & better/greener materials (inventory of concrete, steel, Cu, niobium)
  - responsible procurement
  - align to future energy markets & electricity provisioning
  - energy and power optimization (improving the key technologies energy efficiency and overall design) and recuperation (ERL, waste heat management, …)

  - invest in *R&D on green technologies*
  - *sustainable operational concepts:* potential for dynamic operation of the various facilities; power purchase agreements & renewable energy sources
  - *"nature-based" interventions* for carbon removal (e.g. environmental studies)
  - integration in local environment / power grids

- *Recommendations for Future Work / Optimization:*
  - additional high-level environmental impacts (e.g. rare earth, …)
  - attribution of long-lived infrastructures to projects
  - where can large accelerator labs develop new common approaches

- Summary of Evaluations

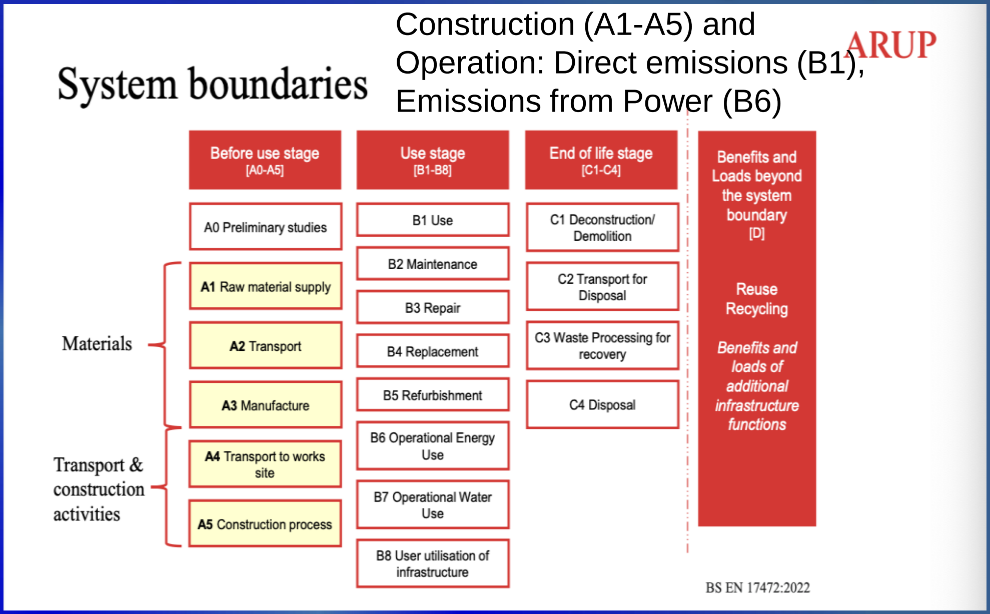
Annexes – Decarbonization Scenarios, Legislations, Standards, etc …

Sustainable Construction: Life-Cycle Assessment (LCA)

LCA is the tool to provide figures about the impact of a project / component on the environment from all points (not only CO2..):

Goal and Scope definition:

- Covering all project stages: design, construction, operation, decommissioning
- Covering all parts: accelerator, detector, civil construction, infrastructure, computing
- Covering the full scope, including raw material extraction & electricity generation



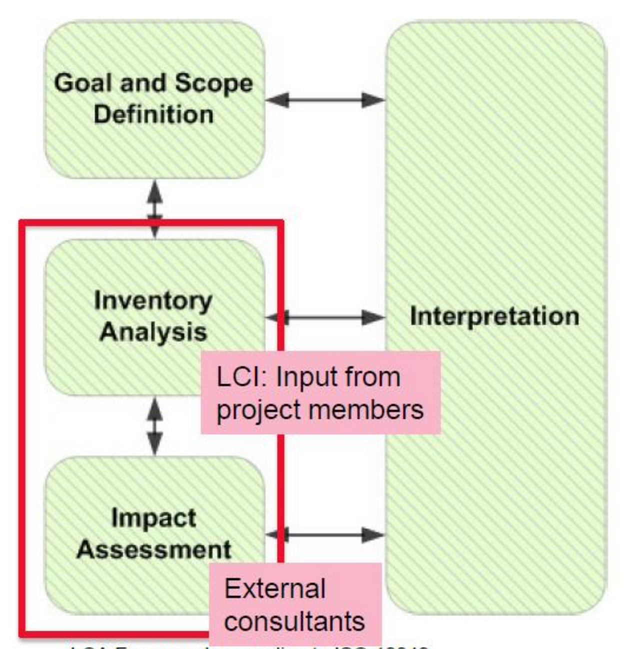
Inventory Analysis:

Materials, Energy, waste, production process
-> domain specific
-> input from accelerator, detector and CFS experts
- tunnel/cavern/shaft dimensions & type
- component types and numbers
- production of components

B. List

Impact Assessment and Interpretation:

Impact of materials on environment
-> methodology
-> based on specific software (e.g. OpanLCA, Simapro) and databases (e.g. ecoinvent)
-> external consultants (e.g. ARUP) can be quite helpful



LCA Framework according to ISO 10040
Public Domain, https://commons.wikimedia.org/w/index.php?curid=40862556

Life-Cycle Assessment: Targets and Issues

B. List,
H. Wakeling

optimize facility (internal); recommend improvements (Lab/FA); communicate to public (society)

LCA standards for the **assessment of future accelerator** infrastructures **are not set:**

- Common approach how to report and evaluate the data for accelerator RI's (which impact categories, treatment of CO2 intensities, attribution of impacts to long term projects);
- Common table for sustainability parameters, esp. GWP;
- ISO standards may be too rigid for accelerators to perform full LCA → "simplified LCA";
- Many LCA software available → different packages can give different results (data handling)
- LCA database is the most impactful element (global vs. local, age of database, accelerators use non-standard materials, often not available);
- Are there relevant differences in Standards / Methods (e.g. Midpoint ReCiPe 2016 (ILC) vs Endpoint EN 17472 (FCC)) that need to be addressed?

Ultimate Goal:
Collect and provide data in tabular form, provided and endorsed by the projects, for a figure as shown below

(E.g. metric to compare the carbon costs of Higgs factories, balancing physics reach, energy needs, and carbon footprint for both construction and operation)

E. Nanni, M. Breidenbach et al., PRX Energy 2, 047001

PRX ENERGY **2**, 047001 (2023)

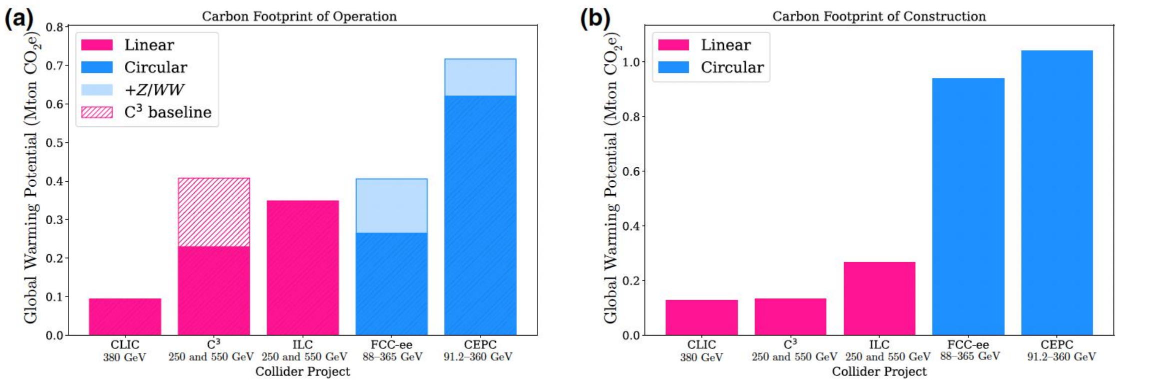
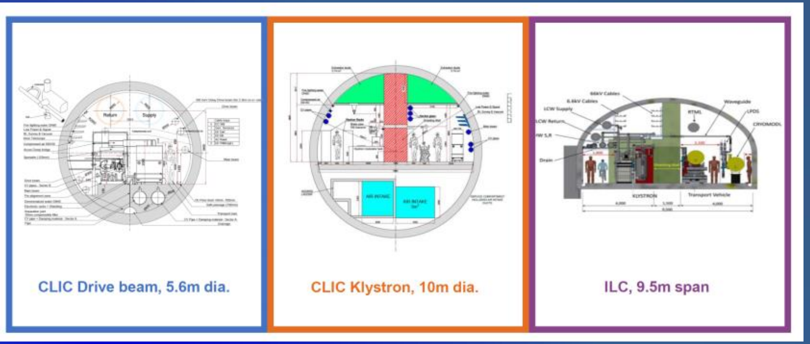


FIG. 5. Global warming potential from (a) operation and (b) construction of all collider concepts. The hashed pink component represents the additional costs of operating C^3 without power optimization, while light blue regions account for additional run modes targeting Z and WW production.

Example: ILC & CLIC LCA Studies

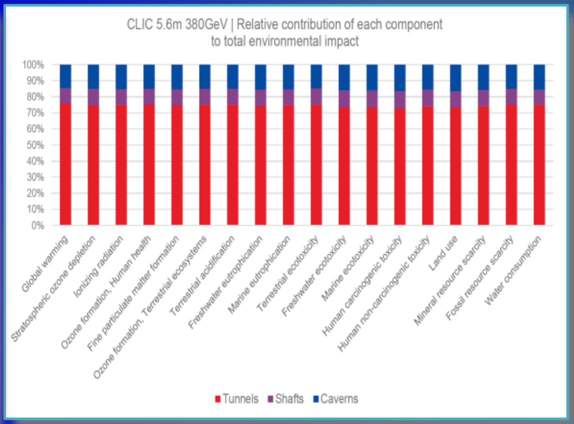
CERN commissioned a study with ARUP to perform a Lifecycle Assessment for the CLIC and ILC civil infrastructure (tunnels, shafts, caverns)

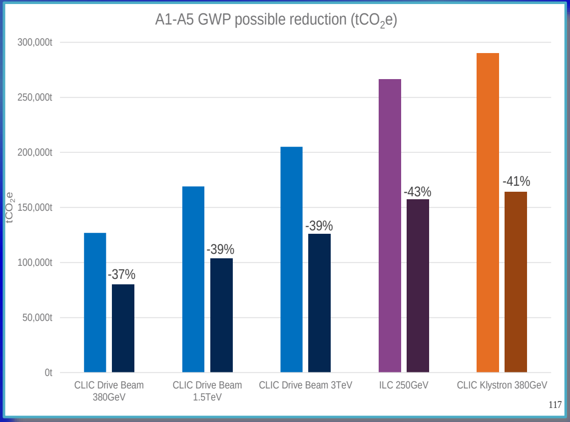


Full ARUP report:
https://edms.cern.ch/document/2917948/1

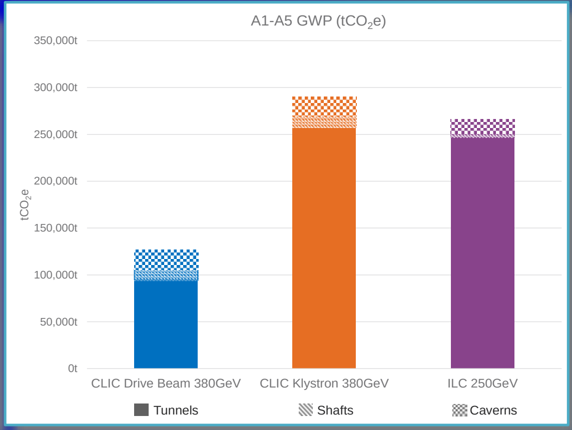
Study provided results on:

- Greenhouse gas emissions from construction
- **Full set of ReCiPe 2016 impact categories**
- Reduction potential (40%) from optimized design and use of lower carbon material





Reduction potential: 40% reduction through use of low-CO2 materials (steel, concrete) and reduction of tunnel wall thickness)



CO_2-eq from underground civil engineering and electricity for operation

New LCA study with external company (ARUP):

- Quantify LCA impact of the full projects (data inventory for ILC and CLIC accelerator & detector
- results will be available by end of 2024
- IlC/CLIC Paper in preparation (by end of 2024)

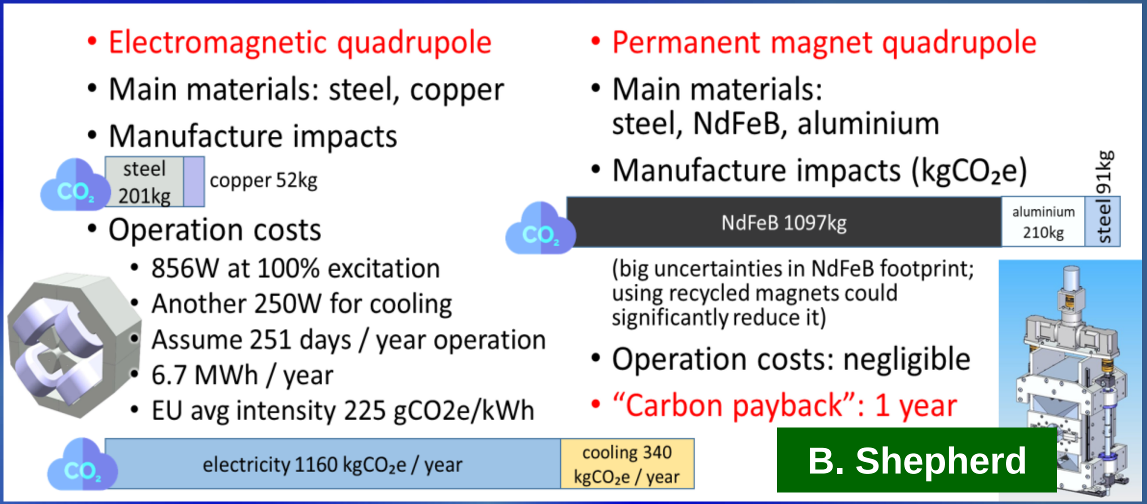
B. List

Efficient Accelerator Technologies

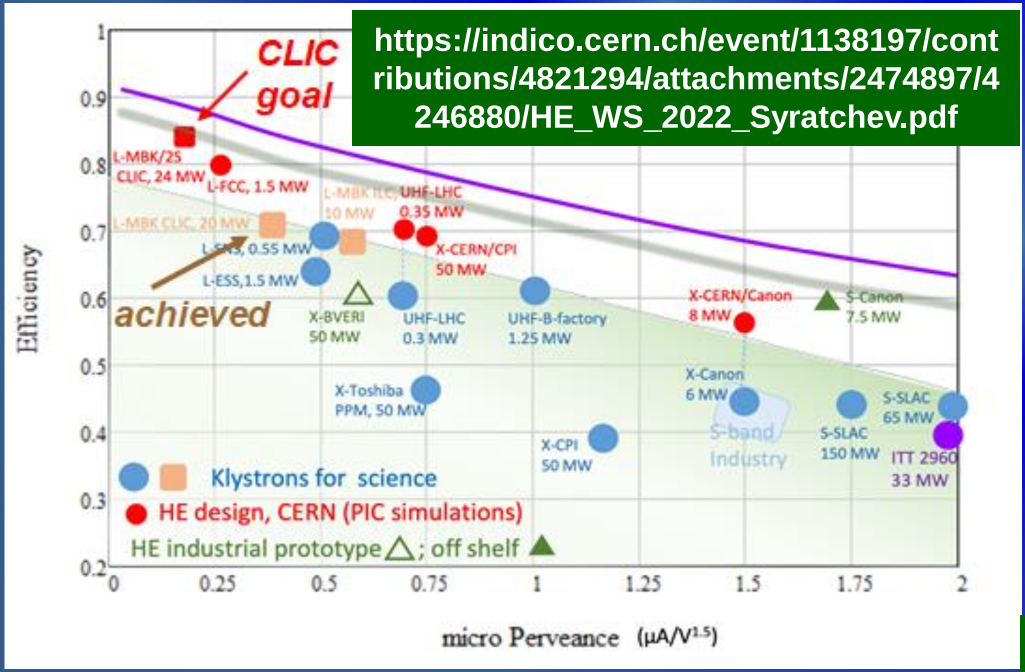
Improving the key technology for energy efficiency:

- High gradient and Q0 accelerator cavities, operation at higher T
- High efficiency RF sources (klystrons)
- Permanent magnets

ZEPTO: Electromagnet Operation vs. Manufacturing Footprint



Efficient RF Power Sources (klystrons)



https://indico.cern.ch/event/1138197/contributions/4821294/attachments/2474897/4246880/HE_WS_2022_Syratchev.pdf

Technology R&D for SRF cavities:

Major progress during past 10 years:

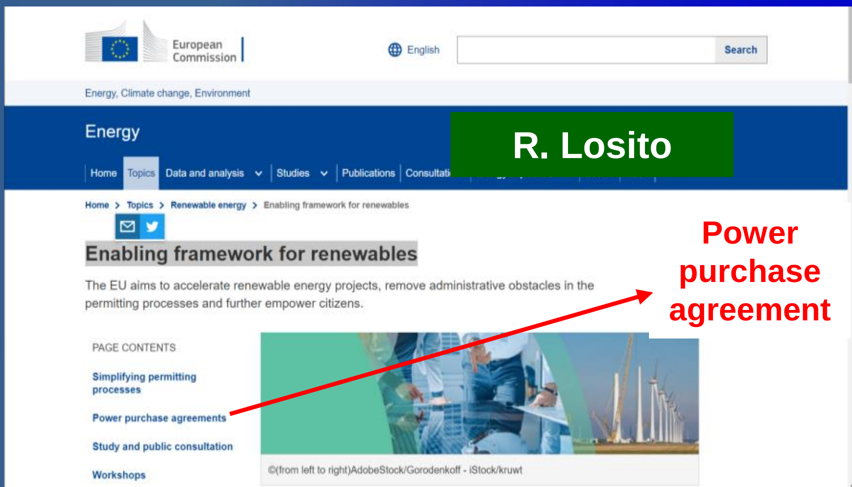
- *State-of-the-art surface treatment of bulk Nb: baking/annealing/doping, plasma processing (possibly reducing aggressive chemicals, required for electropolishing)*
- *R&D into replacement of bulk niobium cavities with Nb or Nb3Sn coated copper (beyond bulk Nb – thin-film SRF): reduce Nb consumption, increase performance, higher T operation*

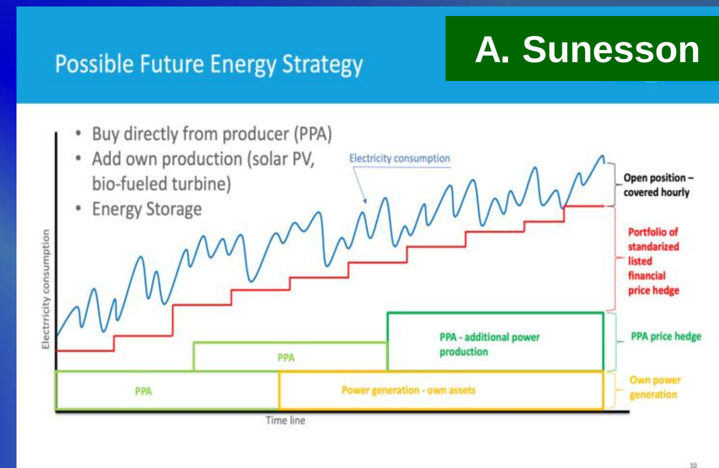
Reports from B. Shepherd (UK), Y. Li (China)

The Future: Fluctuating Energy Sources, Power Purchase Agreements, Running on Renewables

Switch to carbon-neutral energy sources &enabling framework for renewables:

- *power purchase agreement (PPA) - long-term contract* for the electricity supply (~ 20 years)



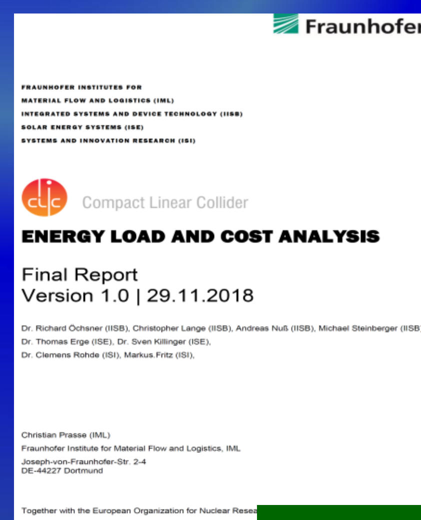


Linear Colliders

- **full collider operation at times of high grid production**
- **reduced operation or standby modes with fast L recovery otherwise**

Study by Fraunhofer institute (2018) considered running CLIC (380 GeV) for a total power of 200 MW (in reality only 110 MW needed) on renewables and participating in ***demand side flexibility:***

- *CLIC's total energy consumption could be generated from renewables (using local solar plant of 330 MWp a local wind farm of 220 MWp)*, but still needs public grid for continuity
- Operating modes with power modulation were investigated


Fraunhofer

FRAUNHOFER INSTITUTES FOR
MATERIAL FLOW AND LOGISTICS (IML)
INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY (IISB)
SOLAR ENERGY SYSTEMS (ISE)
SYSTEMS AND INNOVATION RESEARCH (ISI)

Compact Linear Collider

ENERGY LOAD AND COST ANALYSIS

Final Report
Version 1.0 | 29.11.2018

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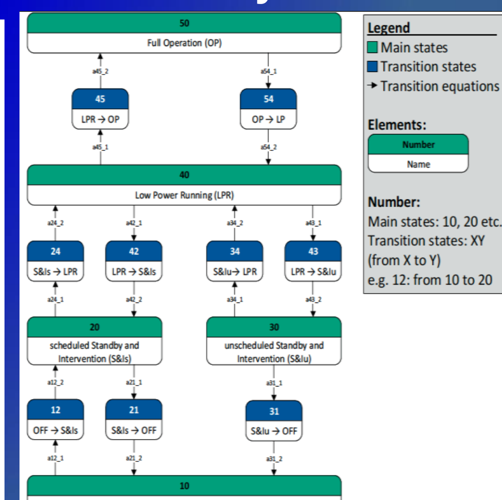


https://edms.cern.ch/document/2065162/1

Future Colliders: Running on Renewables

There will be no future large-scale collider project without an energy management component:
fluctuating sustainable energy - E management / dynamic operation → use surplus energy for RIs

Requirements for future colliders: Energy

R. Losito

Modulate power according to availability (price)

- **CERN policy on renewables:**
  - Increase share of renewables through purchase of long term PPAs (15 to 20 years commitment towards solar plants or wind farms), within the boundaries of present energy contract with EDF (and future ones)
  - Limited by the flexibility required on the total share
  - Would require massive curtailment, not necessarily technically feasible and socially acceptable.

FCC-ee: has warm magnets but a large SRF system with stable power required for cryogenics:
- Large oscillations among operational modes makes it difficult to manage the excess energy with the legal framework of today.
- Energy required in stand-by ~25% of energy during beam operation.

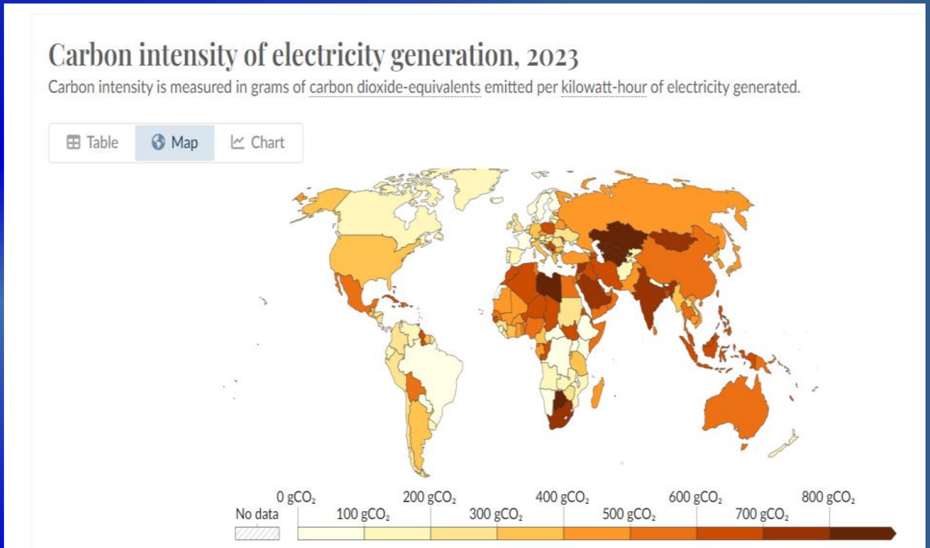
- *Two factors provide uncertainty today in a scenario fully based on renewables:*
  - ✓ Lack of one or more efficient technology to store energy in order to provide a sufficiently stable baseload → adapt to fluctuating power supply will remain a concern
  - ✓ Lack of capacity and of the possibility to reserve capacity to move energy across borders.

Open Questions: Regional versus Globally Averaged Impacts

- Carbon intensity of electricity production varies enormously across regions &countries
  → reference values for assumed CO2 intensity of electricity for relevant regions/labs
- Carbon intensity of materials also varies
  - Different local standards
  - Different geology, primary minerals, concentrations
  - Different carbon intensity for local energy, esp. electricity (-> copper, niobium)
- Civil construction: steel and cement mostly from local sources, adhere to local codes
- Result of LCA depends heavily on
  - Source of used materials
  - Construction and operation site
  - LCA Method: use local values or global averages

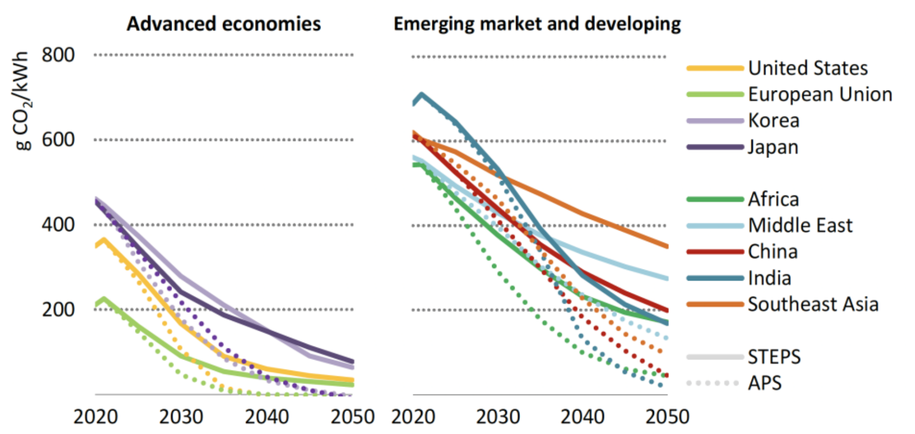
B. List

*Should one evaluate impacts using **site-specific or globally averaged impact** values?*
→ or use general LCA database and move to more local information as the project matures (for materials CO2 content) ?



https://ourworldindata.org/grapher/carbon-intensity-electricity

Figure 6.14 ▷ Average CO_2 intensity of electricity generation for selected regions by scenario, 2020-2050



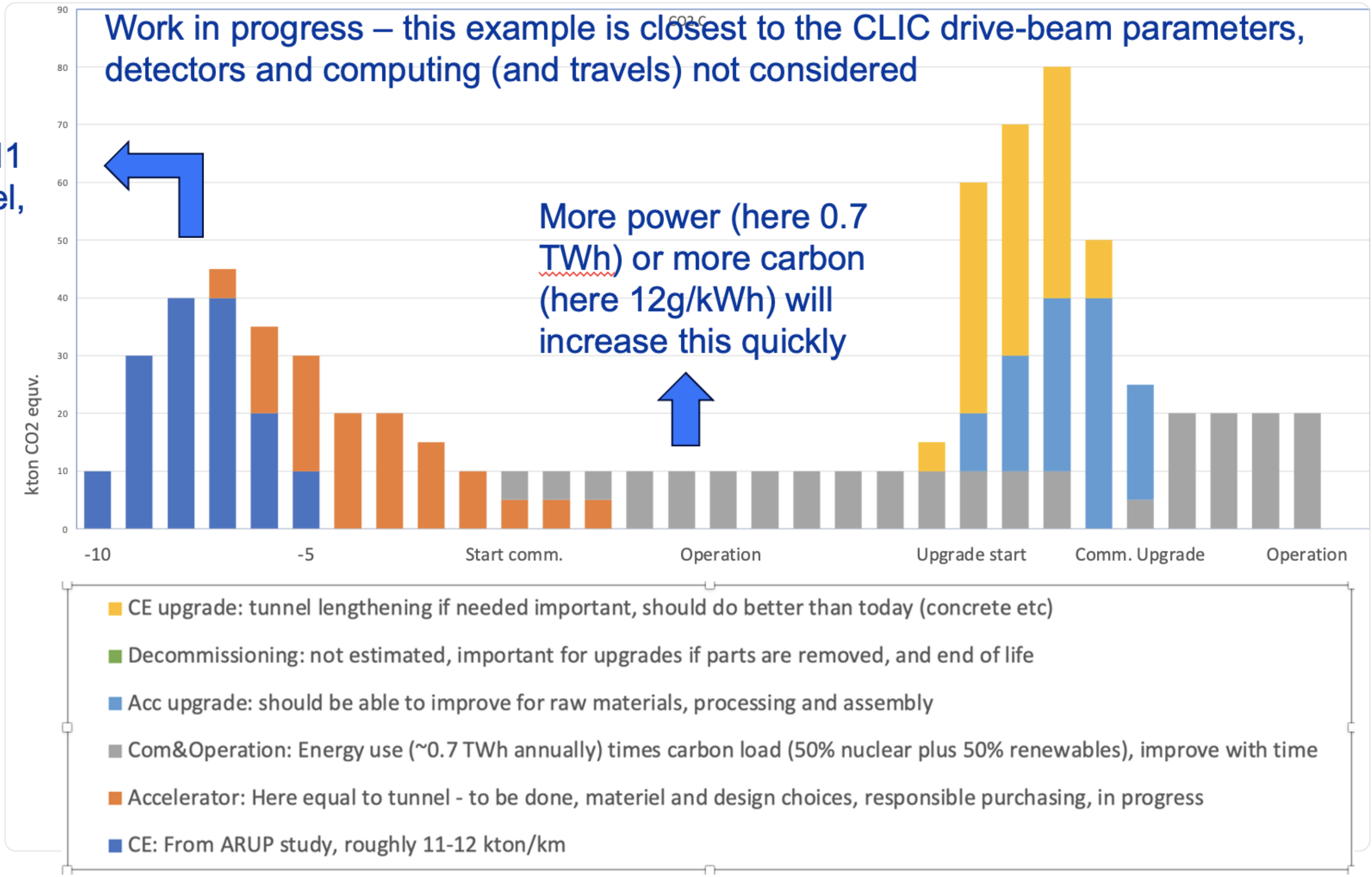
IEA (2022), World Energy Outlook 2022, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2022, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)

Carbon Emission Profile Over Full Lifecycle

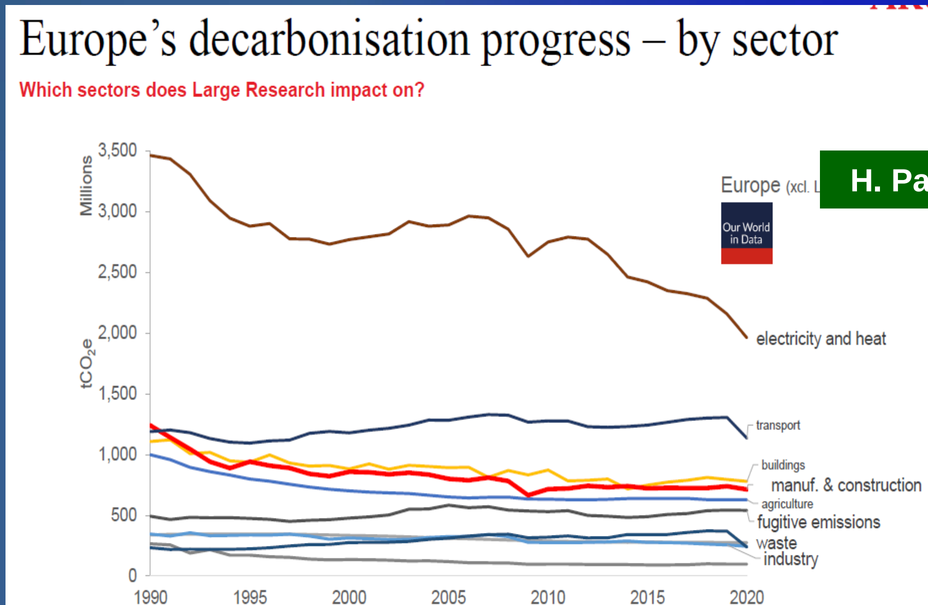
S. Stapnes

Towards Carbon Accounting with LCA

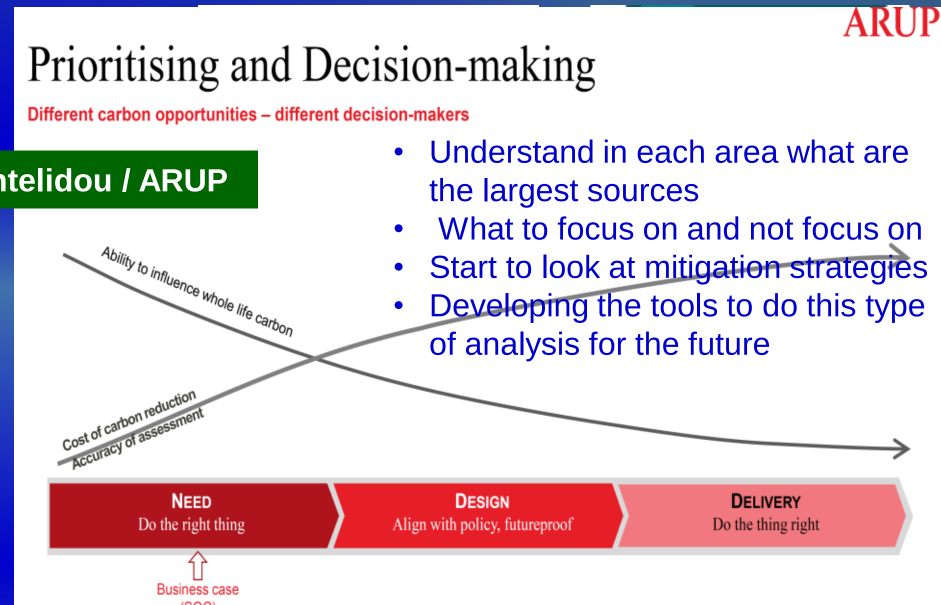
This is for 11 km of tunnel, scales with length



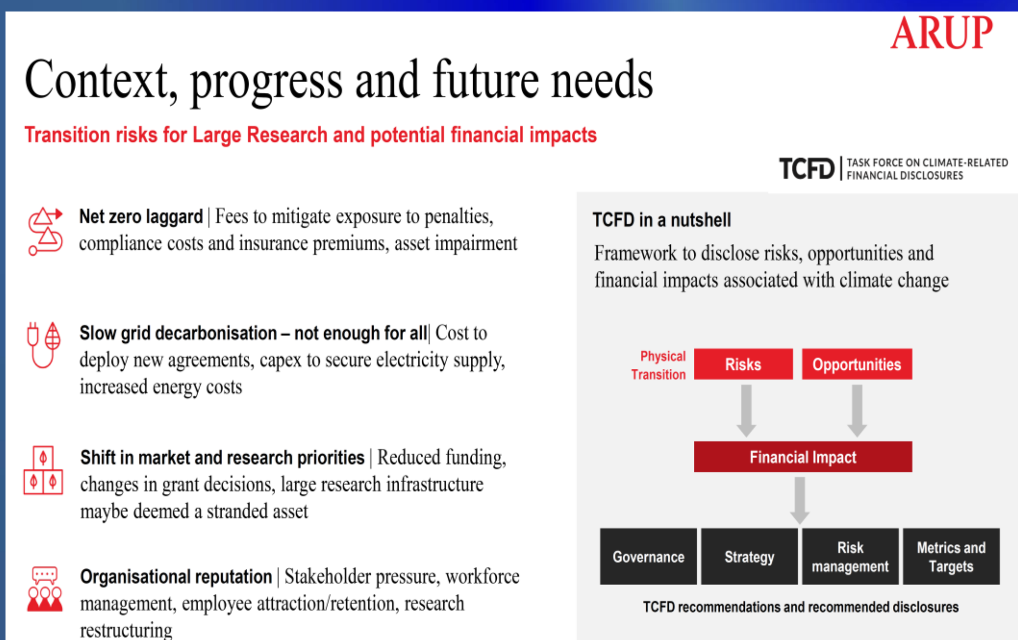
Decarbonisation and Large Research Infrastructures



H. Pantelidou / ARUP



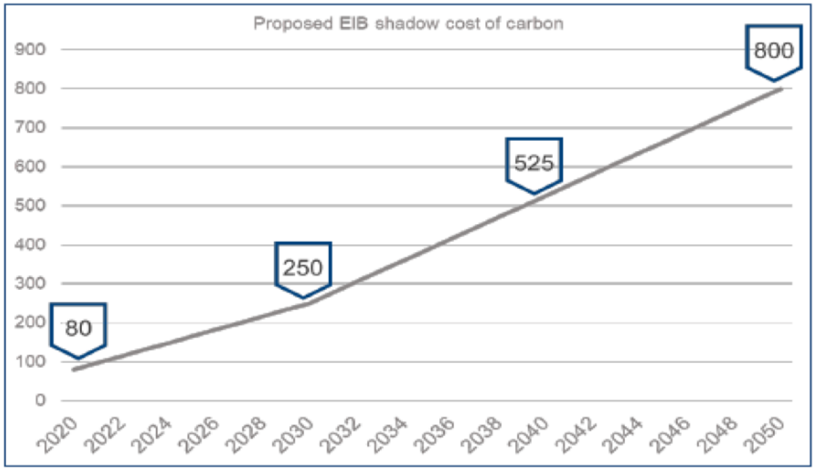
- Understand in each area what are the largest sources
- What to focus on and not focus on
- Start to look at mitigation strategies
- Developing the tools to do this type of analysis for the future



- Funding and financing landscapes are changing rapidly in Europe and beyond, which will *require addressing carbon explicitly* in the business case *for large research infrastructure*
- *Mitigation of the transition risks for RI's: this can lead to increase of costs, reduced funding – maybe* one of the future discussion topics within the WG – *start developing thinking …*

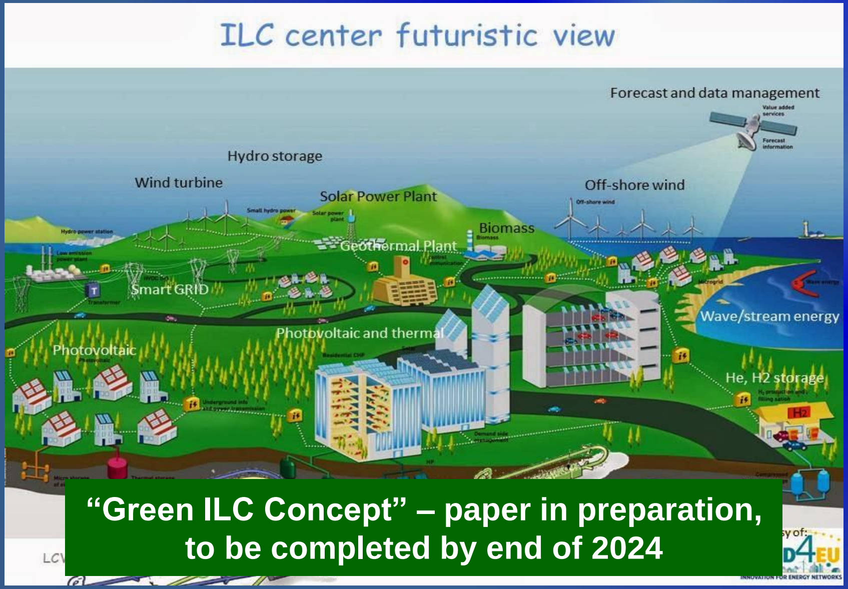
Decarbonisation: Prioritising Nature-Based Interventions

Construction of accelerator large-scale RI's has to face decarbonisation path, with the associated increase of the shadow Carbon cost over the years



https://www.eib.org/attachments/thematic/eib_group_climate_bank_roadmap_en.pdf

- Identifying relevant initiatives to complement decarbonisation efforts:
  - *prioritising nature-based interventions within and around RI's,* integration in local environment as part of the asset management (e.g. CERN generally, Green ILC concept)
  - potential to contribute towards carbon removal through environmental enhancement



"Green ILC Concept" – paper in preparation, to be completed by end of 2024

Figure 7: A single 25 MWh energy storage unit (white containers) built from used electric car batteries, deployed for a PV energy plant in Lancaster, CA (south of Los Angeles, US) put in operate by B2U Storage Solutions in early 2023. Capacities of new systems are increasing fast. A 260 MWh[25] is by now being commissioned and today's largest systems in the range of 1 400 MWh are being extended to 3 000 MWh[26].

J. Gutleber, FCC Renewable Energy Supply Fasibility Study, https://zenodo.org/records/10023947

Summary and Outlook

- The *WG mandate* is to develop a motivated list of key parameters for the sustainability assessment of future accelerators

  → *inputs* from different *sustainability initiatives* and panels are *strongly encouraged*

- *Sustainability assessment for future large-scale accelerator infrastructures is quite complex:*

  → assessment criteria needs to be properly tuned to the maturity of the project

  → differently developed for Researchers, Management and Society

- The WG aims to *elaborate a proposal* for the LDG on time to be submitted as an *input to the ESPPU in March 2025*

  → WG Report draft, containing detailed outline and potential topics, is being advanced

  → not all of them can be addressed by end of 2024, some might need more time to mature