Lecture 18: Particle Accelerator Sustainability

Evaluating the environmental impact of your HALHF design project.

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As we discussed in Lecture 18, the early conception/design stages of an accelerator project have the greatest potential to influence its lifetime environmental impacts (e.g. your design project!). The first step in the reduction of environmental impacts is through first understanding the impacts.

This thought exercise involves calculating the environmental impact of your design project in a simplified manner. Include your results in your HALHF design project final presentation.

One of the two options should align well with your work. There is a third option if the first two are not applicable.

As you work through the sub-questions, you may notice that you need to make significant assumptions to be able to answer them, e.g. the material your component is made out of, or its efficiency. Please go ahead and make these assumptions and state and justify all assumptions.

You are welcome to perform these calculations manually, or using a software of choice. As always, please show your working.

Useful Acronym: "Global Warming Impact" (GWI)[1].

[1] with units of kilograms of carbon dioxide equivalent [kg CO_2e]

Option 1: Calculating the GWI of materials used

Estimate the GWI of the construction stage of the area of HALHF you are working on for your design study. Table 1 is provided as an optional aid.

(a) Describe the design project that you are working on and what physical components it will consist of (or influence).

> Note: it is easy to start to include additional areas of the accelerator such as ancillaries, stands, casing, joints, vacuums, other connected parts etc. For now, keep the scope of components you consider to be exactly those you are designing/studying.

(b) Compile an inventory of the bulk of the materials used in its construction, and estimate the gross mass of each material used.

(c) Convert the material masses into a GWI [kg CO_2e] using material conversion factors (usually available online or in software). Ensure you cite the sources for all material conversion factors used.

(d) Discuss any assumptions you made, such as:

- the mass of material used (if unknown).
- any material substitutions (where conversion factors were not readily available).
- materials you did not consider as you deemed the mass or GWI to be negligible.

(e) Estimate the percentage of components that can be reused or recycled, and justify your estimates.

(f) Identify the opportunities to reduce the environmental impacts of your design project. Here you may consider a range of environmental impact factors outside of GWI.

(g) Which of these would you chose to implement and why? What challenges might arise in implementing the changes you propose (e.g. cost, feasibility, compatibility with existing systems, etc.)?

Material Type	Gross Mass [kg]	Material GWI conversion factor [kg CO_2e/kg]	Total GWI [kg CO_2e]

Table 1: Example table setup provided as an aid for problem option 1.

Option 2: Calculating the operational GWI

Estimate the GWI of resources consumed during the operational lifetime of the area of HALHF you are working on for your design study.

(a) Describe the design project that you are working on and what physical components it may consist of (or influence).

> Note: it is easy to start to include additional areas of the accelerator such as ancillaries, stands, casing, joints, vacuums, other connected parts etc. For now, keep the scope of components you consider to be exactly those you are designing/studying.

(b) Calculate the total energy consumption. This time, include ancillary energy consumers such as software, cryocooling, vacuum pumps, etc., where applicable. List any applicable energy consumers you have ignored and justify your reasoning.

(c) Calculate the GWI of the power consumption and justify which GWI power conversion factor you use. Assume that HALHF were to run for 40 years.

(d) List the other types of resources (e.g. water, etc.) that would likely be consumed in its lifetime and give a rough estimate their GWI.

(e) Discuss the expected lifetime of the component and whether replacements or repairs might be needed during HALHF's operational lifetime.

(f) Identify the opportunities to reduce the environmental impacts of your design project. Here you may consider a range of environmental impact factors outside of GWI.

(g) Which of these would you chose to implement and why? What challenges might arise in implementing the changes you propose (e.g. cost, feasibility, compatibility with existing systems, etc.)?

This final question is provided as an additional option, and should only be chosen if options 1 and 2 are not applicable to your design project.

Option 3: Calculating the GWI of your design project

Evaluate **in detail** the GWI of the resources that you have consumed in your design project. For group/shared impacts, calculate your proportion of the GWI.

(a) Calculate the GWI of total power consumption (e.g. modelling, report compiling, video-conferencing, Cloud use, central heating, etc.). State your assumptions.

(b) Calculate the GWI of physical resources consumed (e.g. fuel for travel, food, water, paper, ink, etc.). State your assumptions.

(c) How might the assumptions you made in your calculations affect the accuracy of your results? What additional data or research would help refine your analysis?

(d) Identify the opportunities to reduce the environmental impacts of your design project. Here you may consider a range of environmental impact factors outside of GWI.

(e) If you were to redesign your project, what changes would you make to reduce this GWI? What challenges might arise in implementing the changes you propose (e.g. cost, feasibility, compatibility with existing systems, etc.)?