



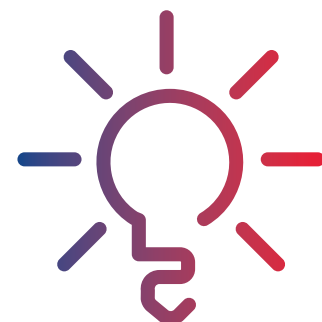
LIFE CYCLE ASSESSMENT

X-Ray vs. Gamma: Shedding Light on Sterilization Sustainability

LIFE SCIENCES

BRIGHT IDEAS FOR THE FUTURE

- Gamma sterilization is a more energy-efficient “light source.”
- X-ray is more energy intensive, its carbon footprint can be lowered with the use of renewable energy.
- This study is based on exploratory Life Cycle Assessment (LCA).



WHY THIS STUDY? LET'S ILLUMINATE THE FACTS

Single-Use Technologies (SUT) in Biopharma need irradiation sterilization before they can shine.

Gamma sterilization (Co-60) has long been the gold standard, but with growing demand, the industry is searching for another **alternative—X-ray!**

Objective: To measure the **environmental footprint** of both methods and highlight the most sustainable path forward.

- Scope of this study: Gate-to-gate LCA—covering the **sterilization process only**.
- Functional Unit: Sterilization of 1 metric ton of SUT material at 0.2 g/cm³ density to 25 kGy dose.
- Tools Used: Sphera GaBi software + Ecoinvent v3.8 database.

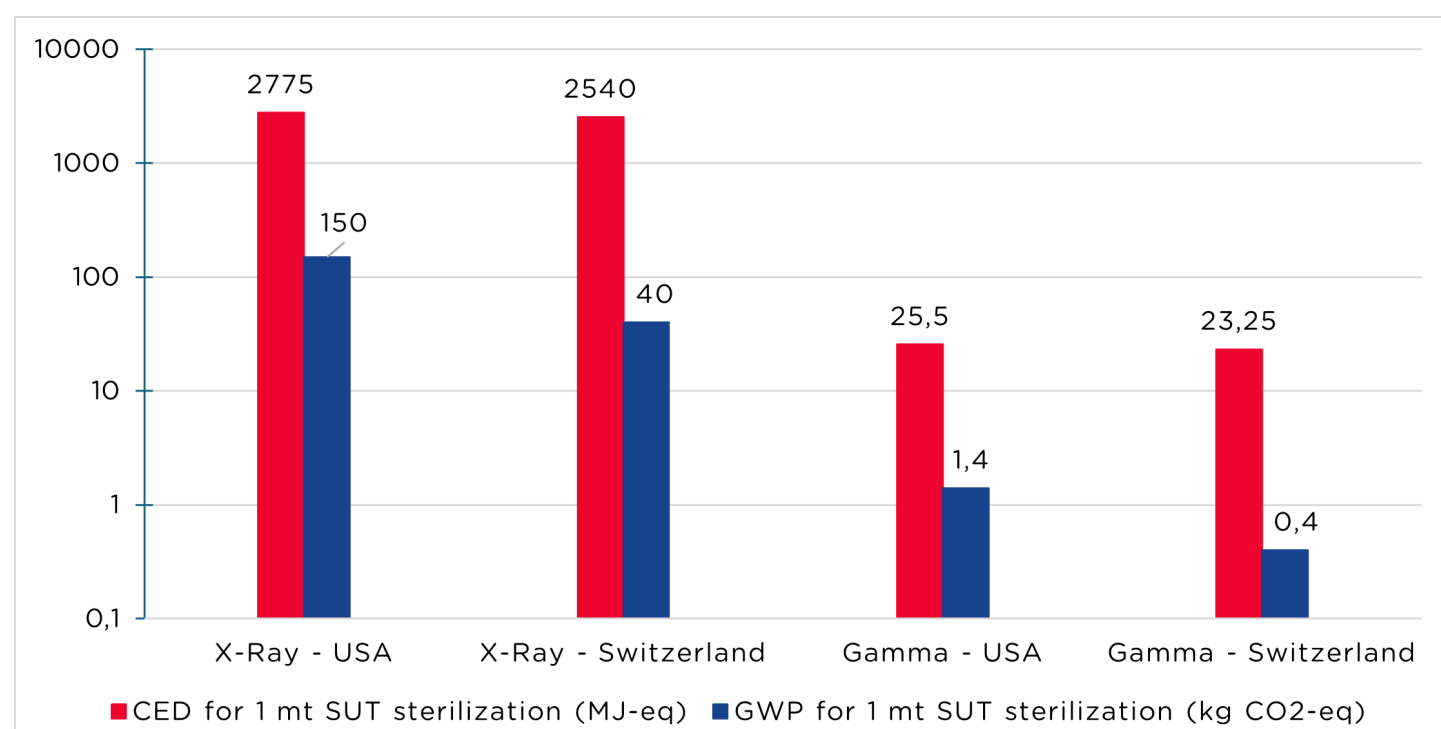
ENERGY SPOTLIGHT: WHO BURNS BRIGHTER?

X-RAY

- Cumulative Energy Demand (CED)
- X-ray: ~2500 MJ-eq per kg SUT sterilized (~100x higher)
- Global Warming Potential (GWP)
- X-ray: ~100kg CO₂-eq per kg SUT sterilized (A Heavier Carbon Footprint)

GAMMA

- Cumulative Energy Demand (CED)
- Gamma: ~25 MJ-eq per kg SUT sterilized (Efficient Glow)
- Global Warming Potential (GWP)
- Gamma: Only ~1kg CO₂-eq per kg SUT sterilized (Tiny Carbon Shadow)



LCA results for cumulative energy demand (CED) and global warming potential (GWP) for sterilization methods in the United States and Switzerland locations.

Note: the gamma plot axes (right) are at 1/10th the scale of the X-ray plot axes (left).

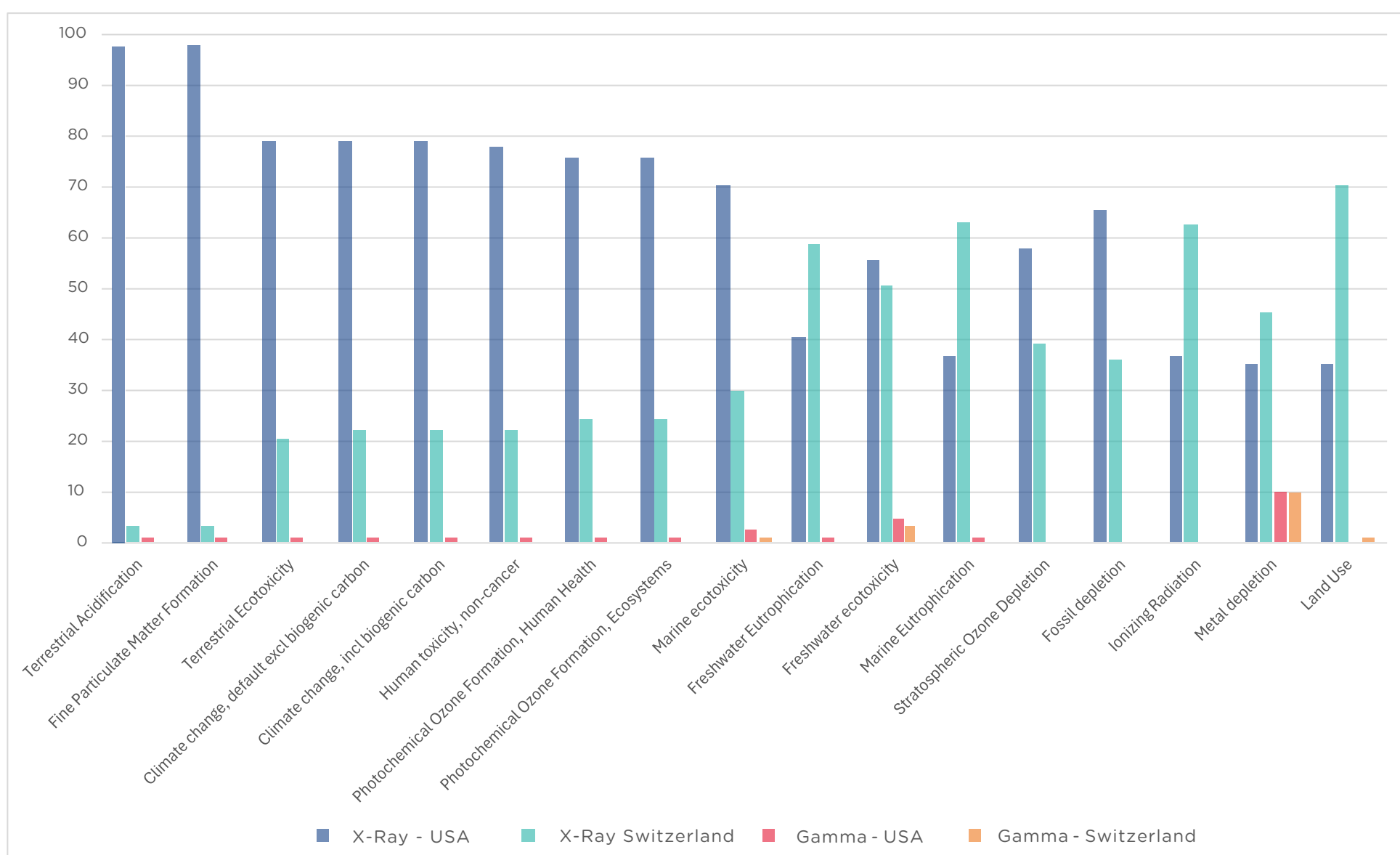
Source: Environmental Impacts of Gamma vs X-Ray Irradiation: an LCA Approach, Robert Barrentine, 2023.

POWER SOURCE: WHAT FUELS THE GLOW?

Electricity Mix Matters:

- U.S. Grid: 69% fossil-based (coal, gas), leading to higher emissions.
- Switzerland Grid: 55% hydro, 37% nuclear, meaning lower carbon footprint.

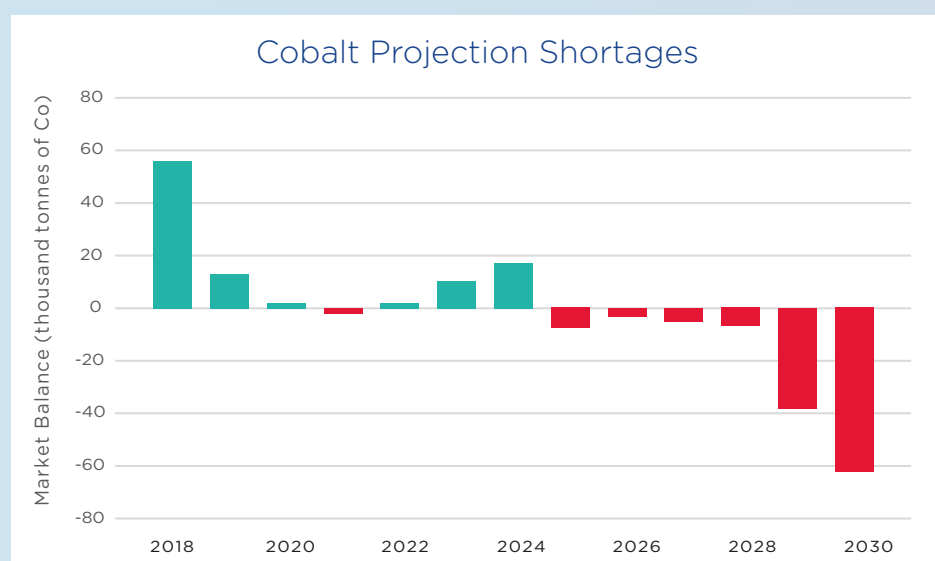
Assessment result for each scenario plotted by contribution



Source: Environmental Impacts of Gamma vs X-Ray Irradiation: an LCA Approach, Robert Barrentine, 2023.

A CLOSER LOOK AT OTHER ENVIRONMENTAL IMPACTS: WHERE DO IMPACTS COME FROM DURING STERILIZATION?

- Sterilization = Only ~1% of Total Life Cycle Impact of Single-Use Technologies (SUTs)
- While this study did not concentrate on transportation, it is still the main polluting step (Scope 3 emissions) - [Source](#).
- X-ray: Higher impacts across all categories due to its energy-hungry nature.
- Gamma: Lower impact overall, but Co-60 mining (supply consistency challenge, see graph) & radioactive waste disposal create dark spots.



Source: Cobalt: supply and demand balances in the transition to electric mobility, European Union, 2018, [link](#)

DECARBONIZING THE VALUE CHAIN: AREAS FOR IMPROVEMENT

- Optimize energy use at sterilization facilities.
- Shift to low-carbon or renewable energy sources.
- Localize production & sterilization facilities to cut transportation impacts.



LEARN MORE



- Check out the Saint-Gobain [Bioprocess Solutions](#) website sustainability section
- Environmental impact of Gamma versus X-ray irradiation [sterilization poster](#)
- Part 1: Industry Need, Requirements & Risk Evaluation BPSA [white paper](#)
- Part 2: Representative Qualification Data BPSA [white paper](#)

ENGAGE MORE



- Any questions? Contact us at bps.sustainability@saintgobain.com
- Contribute to the Biopharma decarbonization approach by engaging in the Scope 3 working group by contacting info@biophorum.com.