Designing Cleanrooms for a Sustainable Future

Environmental Strategies, Embedded Carbon Reduction, and the Role of EPDs in Cleanroom Construction

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EXECUTIVE SUMMARY

Cleanrooms are vital to the integrity and performance of critical industries like pharmaceuticals, semiconductors, and nuclear energy. Yet, as these high-specification environments proliferate globally, so do their environmental footprints. Sustainable construction practices, particularly those that reduce embedded carbon and improve energy efficiency, are becoming imperative. This white paper explores key environmental considerations in cleanroom design, including the use of Environmental Product Declarations (EPDs), digital modeling, and carbon accounting practices. Drawing from global experience at GCS, it also highlights actionable strategies to create cleaner, greener cleanrooms.

INTRODUCTION: A DUAL MISSION—CLEAN AIR AND A CLEAN PLANET

Cleanrooms are designed to control airborne particulates, ensuring pristine environments for sensitive manufacturing. However, these facilities often demand high energy consumption and extensive material use, both of which contribute significantly to their carbon footprint. Steve Griffiths, Global VP of Business Development at GCS, emphasizes the urgency of aligning cleanroom construction with sustainable practices. “If we’re creating health-centric environments that harm the environment, we’re defeating our purpose,” says Griffiths.

ENVIRONMENTAL CONSIDERATIONS IN CLEANROOM CONSTRUCTION

Operational vs. Embedded Carbon

Cleanroom sustainability starts with recognizing the two main sources of carbon emissions:

- **Operational Carbon:** Emissions generated from daily energy use (e.g., HVAC systems, air changes).
- **Embedded Carbon:** The carbon footprint of materials and construction processes used to build the cleanroom.

While operational efficiency often gets attention, embedded carbon is frequently overlooked—despite its potentially high impact.

STRATEGIES TO REDUCE EMBEDDED CARBON

Sustainable Sourcing of Materials

Not all materials are created equal. Steel and concrete are notoriously carbon-intensive, but more sustainable alternatives and sourcing practices exist:

- **Use of Recycled Materials:** GCS panels, for instance, are made of 98% recyclable metal.
- **Sustainable Manufacturing:** Choosing steel suppliers who use renewable energy and efficient manufacturing processes significantly reduces embedded emissions.

Fact-Based Decision Making

Greenwashing remains a risk. To counter this, manufacturers must rely on verified data and third-party validated metrics. This is where **Environmental Product Declarations (EPDs)** come into play.

UNDERSTANDING ENVIRONMENTAL PRODUCT DECLARATIONS (EPDS)

An **EPD** is a transparent, third-party verified document that communicates the environmental impact of a product throughout its lifecycle—from raw material extraction to disposal.

Lifecycle Assessment

Often referred to as a **"cradle-to-grave"** analysis, EPDs measure:

- Raw material acquisition
- Energy use in production
- Packaging and transportation
- End-of-life recyclability

Third-Party Validation

To ensure accuracy and consistency, EPDs are governed by standards such as **ISO 14025** and validated by independent bodies. Different product categories (e.g., concrete, steel, composite panels) follow specific Product Category Rules (PCRs) during evaluation.

At GCS, regular updates to EPDs reflect changes in sourcing strategies—such as the recent adoption of more sustainable steel—to ensure transparency and accountability.

DRIVING SUSTAINABILITY THROUGH THE SUPPLY CHAIN

Griffiths highlights that up to **90% of embedded carbon** in cleanroom panels can come from **scope 3 emissions**—those originating in the supply chain.

Key Practices for Reducing Supply Chain Carbon:

- **Local Sourcing:** Reduces transportation emissions.
- **Sustainable Packaging:** Minimizes waste and energy in logistics.

- **Supplier Auditing:** Ensures adherence to energy-efficient practices.
- **Annual Carbon Accounting:** GCS tracks Scope 1 (direct emissions), Scope 2 (indirect from electricity), and Scope 3 emissions to continuously improve its carbon performance.

FUTURE OUTLOOK: DIGITAL MODELS AND AI FOR CARBON OPTIMIZATION

The next frontier in sustainable cleanroom design lies in the **integration of EPDs into digital modeling** tools. Griffiths envisions a future where:

- **Digital twins** of cleanroom facilities simulate total lifecycle carbon impact.
- **AI systems** analyze material choices, offering recommendations for lower-carbon alternatives.
- **Carbon heat maps** identify emission hotspots in real-time during the design phase.

These technologies promise a paradigm shift in how cleanroom projects are planned and executed—with sustainability at their core.

CONCLUSION: TOWARD A CLEANER CLEANROOM INDUSTRY

Sustainable cleanroom design is no longer a luxury—it's a necessity. By embracing strategies such as:

- Measuring and minimizing embedded carbon,
- Demanding credible EPDs,
- Auditing the full supply chain, and
- Leveraging digital and AI tools,

the industry can make significant strides in reducing its environmental footprint. As Griffiths aptly puts it, "We must align our health-focused environments with practices that also protect planetary health."

About the Author:

Steve Griffiths is the Global Vice President of Business Development at GCS, a leading manufacturer of hygienic environments. With over a decade of experience in cleanroom construction and a deep commitment to environmental stewardship, Griffiths is a recognized voice in sustainable infrastructure for regulated industries.

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