

Agilent Infinity III LC System "Cradle-to-Grave" Product Carbon Footprints

Driving sustainable lab operations with product carbon footprint insights



Author

Andreas Otto, Ph.D.,
Naomi Serillo,
Lorilei Werner, Ph.D.
Agilent Technologies, Inc.

Abstract

This white paper presents a cradle-to-grave product carbon footprint (PCF) assessment of Agilent Infinity III liquid chromatography systems, including the Agilent 1260 Infinity III LC System, Agilent 1260 Infinity III Prime LC System, and the Agilent 1290 Infinity III LC System. Conducted by ERM in accordance with ISO 14067 and independently reviewed, this Agilent-commissioned study provides a transparent and data-driven evaluation of carbon emissions at every stage of the product life cycle—from raw material extraction and manufacturing through to use and end-of-life.¹ This deeper insight into the environmental impact of LC use is intended to act as a benchmark to help labs reduce their carbon footprint.

The study shows that, for Infinity III LC Systems, instrument use accounts for a significant proportion of total carbon emissions, mainly driven by electricity consumption, solvent production and disposal, and use of glass vials. This means that operational decisions—such as method optimization, reduced idle time, and increasing workflow efficiency—offer the greatest potential for lowering emissions. Agilent helps enable more sustainable laboratory operations through UHPLC systems that generate significantly lower emissions per sample than HPLC, as well as design features, including modular upgrades, that minimize inefficiencies.

Cradle-to-gate product carbon footprint

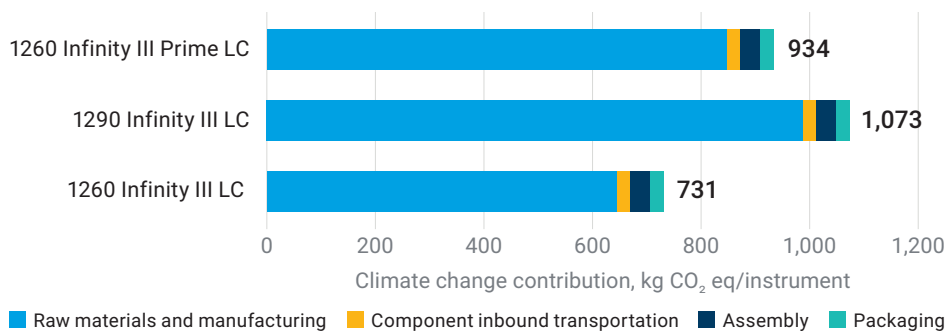


Figure 1. Cradle-to-gate product carbon footprint of the Agilent 1260 Infinity III LC System, Agilent 1260 Infinity III Prime LC System, and Agilent 1290 Infinity III LC System, broken down by life cycle contribution: raw materials and manufacturing, component inbound transportation, assembly, and packaging.

Purpose of assessment

Increasing regulatory pressure, corporate environmental, social, and governance commitments, and rising energy and waste costs are pushing laboratories to better understand and reduce their environmental impact. One of the most effective ways to do this is through the measurement and optimization of PCFs, which provide a standardized way to quantify the total carbon emissions associated with a product across its life cycle. While most products on the market are measured “cradle-to-gate”, a complete PCF uses a “cradle-to-grave” approach.

By commissioning the current study, performed by ERM according to ISO 14067 standards and with independent review, Agilent is able to provide a cradle-to-grave PCF assessment of selected Infinity III LC systems. The takeaway from the study is clear: For Infinity III LC systems, 85% to 94% of total carbon emissions come from how the instrument is used, not from how it is produced.* While it was generally presumed that the use phase contributes most significantly

to emissions over an instrument's average lifespan, these figures greatly exceeded expectations. Reducing the environmental impact of LC manufacture remains crucial, and Agilent is dedicated to improving sustainability in this area. However, the findings of this study also highlight that operational choices, such as minimizing idle time, optimizing methods, and choosing more efficient workflows, can deliver the largest reductions, often while improving throughput and lowering cost per sample.

A second key finding highlights the environmental advantage of UHPLC technology. While UHPLC systems have a 47% higher “cradle-to-gate” carbon footprint as compared to HPLC primarily due to manufacturing, they demonstrate up to 60%–63% lower emissions per sample over their full life cycle. This is due to their ability to process samples more efficiently, with shorter run times, lower solvent consumption, and higher throughput. The result is a significantly reduced carbon footprint per analysis, which also translates to lower operating costs.

Across all technologies, three primary contributors to emissions dominate: electricity consumption, solvent production and disposal, and the use of consumables such as sample glass vials. Together, these insights provide laboratories with a clear roadmap: the main opportunity for meaningful sustainability improvements—and cost reductions—is optimizing system usage, which can include using UHPLC.

For many organizations, especially in pharmaceutical, environmental, and chemical industries, PCF-related emissions fall within Scope 3 reporting requirements. Without accurate product-level data, these emissions are often estimated using spend-based models that can significantly overstate carbon impact. By contrast, product-specific PCF data can provide a more representative, science-based estimate.

Because cradle-to-gate carbon emissions remain important in Scope 3 reporting, this data is presented for three different Infinity III LC systems in Figure 1. Across all three platforms, raw materials and manufacturing account for more than 90% of the embedded footprint, which is the relevant value for Scope 3 category 2 (capital goods) corporate reporting.

By applying internationally recognized LCA methodologies, we not only quantified emissions but also identified actionable opportunities for reduction. The goal is not simply to report carbon data, but to empower laboratories to operate more sustainably without sacrificing performance.

* Based on 10-year lifespan

Life cycle assessment framework: How is a product carbon footprint measured?

To ensure robustness and comparability, the life cycle assessment was conducted according to ISO 14067 standards and modeled using SimaPro software with the ecoinvent Life Cycle Inventory database. The cradle-to-grave study focuses on a single functional unit: one sample analyzed. This approach allows emissions to be normalized to a meaningful and comparable output, rather than evaluated solely at the instrument level.

The system boundaries include all major life cycle stages: raw materials, manufacturing and assembly, packaging, distribution, use phase, and end-of-life. By adopting this cradle-to-grave perspective, the assessment captures the full carbon footprint impact of the instrument over its lifetime (Figure 2A).

Data quality was a key priority throughout the study. Primary data—such as energy consumption and bill-of-material details—were sourced directly from Agilent's engineering teams, while secondary data were drawn from widely accepted databases. The study was also independently reviewed to ensure methodological accuracy and credibility.

The results of the study provide a detailed breakdown of carbon emissions per sample across different global markets. Variations in emissions are primarily driven by regional differences in electricity generation, with higher emissions observed in markets where energy production relies more heavily on fossil fuels.

Despite these regional differences, a consistent pattern emerges: the use phase overwhelmingly dominates the total carbon footprint. Manufacturing, distribution, and end-of-life stages contribute only a small fraction when emissions are normalized per sample. This finding reinforces the importance of operational efficiency as the primary driver of sustainability performance in the lab.

From a procurement perspective, these insights show that traditional spend-based carbon accounting methods can overestimate emissions by a factor of up to 3.7. While this figure is derived from the present study and orders of magnitude may vary, it is generally accepted that material-based methods generate much more accurate results than spend-based models. By using product-specific PCF data, organizations can make more accurate Scope 3 assessments and make better informed purchasing decisions.

The specific use phase method was drawn from an Agilent technical overview² and involved measuring the energy consumption

of the 1260 and 1290 Infinity III LC Systems, using settings and run times representative of an average daily use case. These settings were modeled on the protocol for [ACT Ecolabel LC](#) energy testing.

With the 1260 Infinity III LC, Agilent Rapid Resolution Liquid Chromatography (RRLC) checkout sample was separated using an Agilent InfinityLab Poroshell 120 EC-C18 (4.6 × 150 mm, 2.7 µm) column in a 10.01 minute run (20% to 90% acetonitrile in 10 minutes, 20% acetonitrile at 10.01 minutes). The same sample was separated on the 1290 Infinity III LC using an Agilent ZORBAX RRHD Eclipse Plus C18 (2.1 × 50 mm, 1.8 µm) column with a 3 minute gradient (30% to 95% acetonitrile in 2 minutes, held for 1 minute). These conditions were

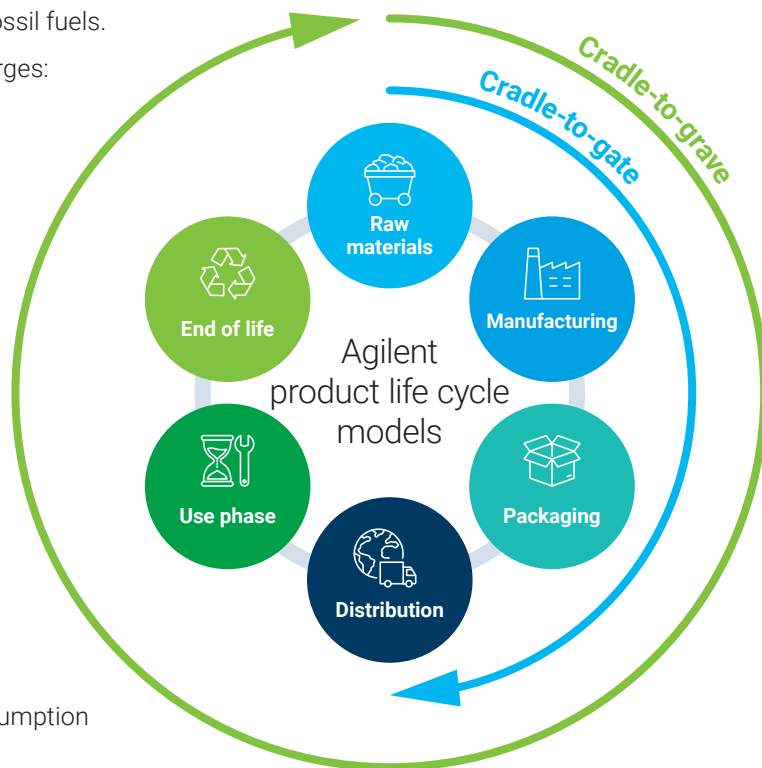


Figure 2A. Product life cycle assessment (LCA) models—two standard LCA boundaries, including cradle-to-gate and cradle-to-grave.

Disclaimer: Product carbon footprint results are based on life cycle assessment (LCA) modeling and represent estimated impacts under the specific assumptions, system boundaries, data sources, and representative operating conditions used in this study. Assumptions include, but are not limited to, instrument utilization, method parameters, electricity mix, solvent consumption and disposal, distribution scenarios, maintenance activities, product lifetime, and end-of-life treatment. Actual environmental impacts and customer-specific results may vary significantly depending on local operating conditions, laboratory practices, energy sources, analytical methods, throughput, maintenance schedules, and disposal pathways.

in the middle of the performance spectra of each system (i.e., around 300 bar on the 1260 Infinity III LC and around 650 bar on the 1290 Infinity III LC). Instrument power consumption was measured during idle, ready, and run states, and results extrapolated to the presumed daily duration of each state. End-of-life accounts for country-specific recycling, incineration, and landfill scenarios. In Figure 2B, color coding

distinguishes processes performed by Agilent (blue) from external processes (purple) and secondary-database inputs (yellow). Per ISO 14067 guidance, infrastructure, capital goods, employee commuting, and business travel are excluded as out-of-scope contributions.

System boundaries

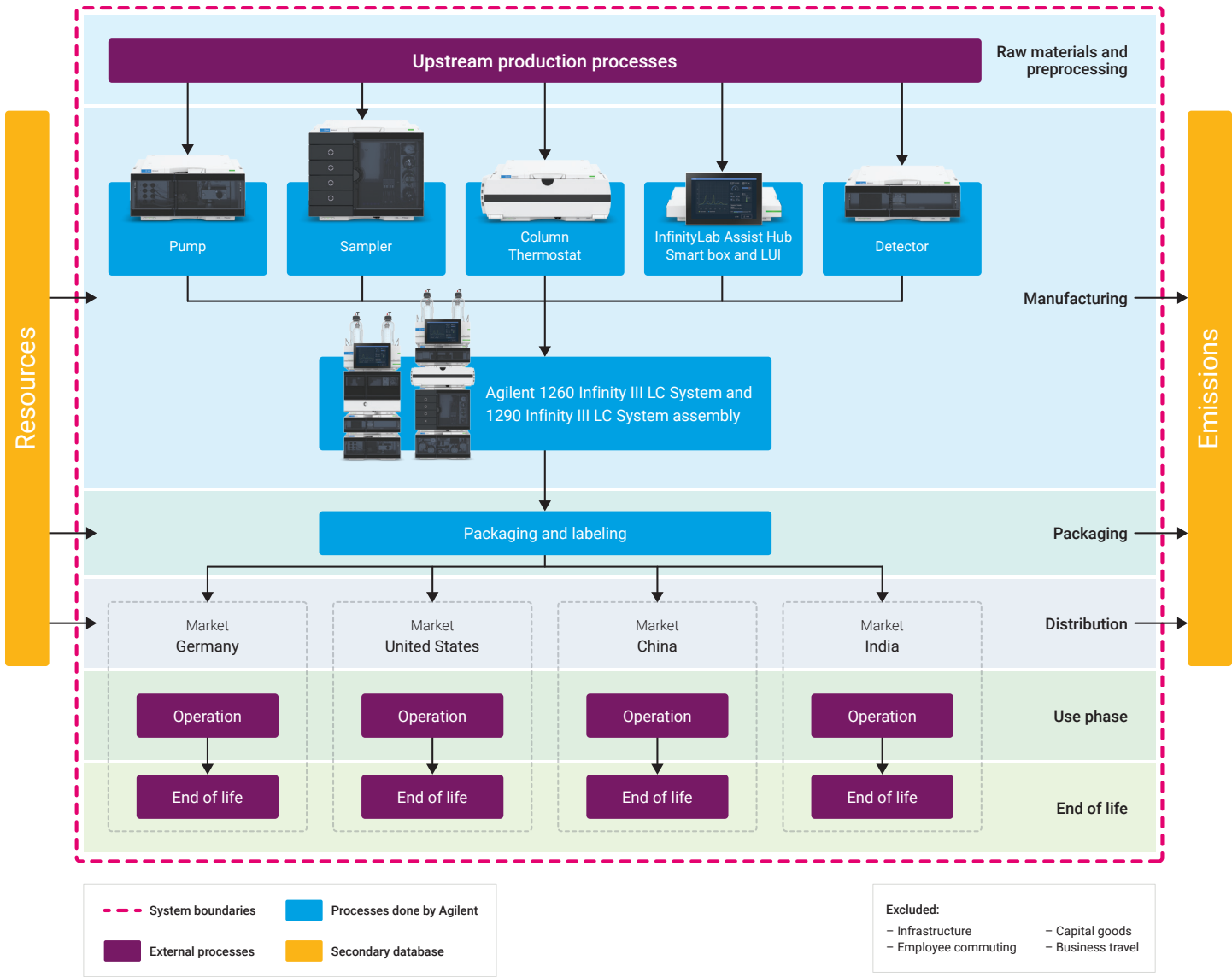


Figure 2B. System boundary diagram for the cradle-to-grave PCF study of the Agilent 1260 Infinity III LC System and Agilent 1290 Infinity III LC System, modeled in SimaPro 9.6 with ecoinvent 3.10, in compliance with ISO 14067:2018. All material and energy flows are tracked from upstream production of raw materials through manufacture of five core modules (pump, sampler, column thermostat, Agilent InfinityLab Assist Hub with local user interface, detector), system assembly at the Agilent Waldbronn (Germany) factory, packaging, and global distribution to four representative markets, including Germany, the United States, China, and India.

Product transparency and reporting

The assessment generated a comprehensive breakdown of the factors contributing to PCF per sample for the 1260 Infinity III LC and 1290 Infinity III LC in different markets, from raw materials processing to end of life (Figure 3).

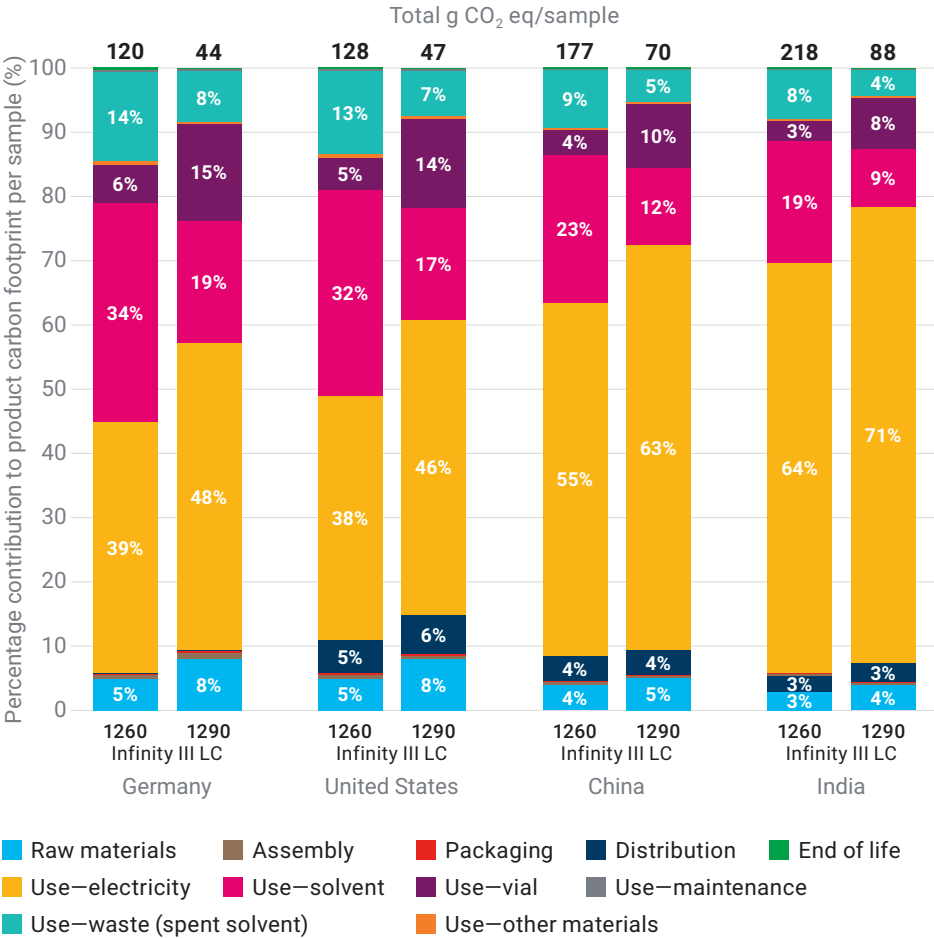
The cradle-to-grave impact of using a 1260 Infinity III LC increased across markets in the following order: Germany, the United States, China, then India. Naturally, precise results would vary greatly depending on which method is used, among other factors (e.g., Figure 4 illustrates the impact that renewable energy use can have on carbon footprints). Use-phase contributions dominate in every market: variations such as greater electricity use in India than in Germany can be explained by increased grid carbon intensity (a key aspect leading to differences between all four markets), while solvent production and spent-solvent incineration remain the next-largest contributors. Airfreight emissions from instrument distribution from Germany to the United States, China, and India also contribute to PCF differences between regions, though in a more minor way.

Conversely, the non-use stages of raw materials, assembly, packaging, distribution, and end of life account for less than 10% of the per-sample footprint of the 1260 Infinity III LC. This pattern confirms the central insight of the PCF study: how the instrument is operated impacts sustainability more significantly than how it is built.

For the 1290 Infinity III LC, the cradle-to-grave carbon footprint grew across markets in the same order as with the 1260 Infinity III LC. Use-phase electricity is also the largest contributor and rises sharply with grid carbon intensity. Solvent production falls, reflecting smaller injection volumes, and spent-solvent incineration also drops relative to the 1260 Infinity III LC. Notably, the vial share grows in Germany and the United States, not because vial emissions have increased, but because other contributions are smaller.

The per-sample footprint is 60%–63% lower than the 1260 Infinity III LC across all four markets, confirming an environmental advantage despite the higher embedded cradle-to-gate footprint. In every market, the non-use phases of the 1290 Infinity III LC contributed more to the PCF than those of the 1260 Infinity III LC—and yet over the course of the instrument’s lifetime, it is evident that its increased efficiency in the use phase pays off.

Cradle-to-grave product carbon footprint per sample



Disclaimer: Product carbon footprint values are based on life cycle inventory data available during the 2024 assessment and may not reflect conditions at the time of publication. Changes in energy generation, transportation, manufacturing, waste management, and other background datasets may influence future results.

Figure 3. Relative contributions of life-cycle stages to cradle-to-grave product carbon footprint per sample for the Agilent 1260 Infinity III LC System and the Agilent 1290 Infinity III LC System, shown for the four representative markets—Germany, United States, China, and India. “Use—maintenance” figures are based on typical components replaced during preventative maintenance.

Carbon hotspot analysis

A deeper analysis of the data reveals three major hotspots that account for the majority of emissions.



UHPLC efficiency and environmental benefits

UHPLC technology represents a significant advancement in both analytical performance and sustainability. By enabling faster run times, higher throughput, and reduced solvent consumption, UHPLC systems

dramatically lower emissions per sample.

Although UHPLC systems may have a slightly higher manufacturing footprint due to additional components and capabilities, this initial impact is quickly offset during operation. The increased efficiency of UHPLC means that more samples can be processed in less time, using fewer resources. As a result, the total life cycle emissions are substantially lower compared to traditional HPLC systems. The lower costs associated with accelerated throughput and minimized resource use means that the total cost of ownership of a UHPLC system reduced compared to a standard HPLC system.

Table 1. Daily material flows of different adjustments to the USP method ceftizoxime sodium isocratic method, assuming eight hours of analysis per day.

Method Variation	Column	Throughput (samples/day)	Acetonitrile (mL/day)	Buffer (mL/day)	Impact (g CO ₂ eq/sample)	Difference with the Original USP Method
Original	L1, 4 × 300 mm, 10 µm	37	96	866	85	0%
USP 1	Agilent ZORBAX Eclipse Plus C18, 4.6 × 150 mm, 5 µm	74	125	1,123	49	-42%
USP 2	Agilent ZORBAX Eclipse Plus C18, 3.0 × 150 mm, 3.5 µm	114	77	689	31	-63%
USP 3	Agilent ZORBAX Eclipse Plus C18, 2.1 × 100 mm, 3.5 µm	155	39	348	23	-72%
USP 4	Agilent InfinityLab Poroshell 120 EC-C18, 4.6 × 100 mm, 4 µm	150	159	1,431	29	-66%
USP 5	Agilent InfinityLab Poroshell 120 EC-C18, 3 × 75 mm, 2.7 µm	369	100	897	15	-83%
USP 6	Agilent InfinityLab Poroshell 120 EC-C18, 2.1 × 50 mm, 2.7 µm	436	100	903	13	-84%

Importantly, these efficiency gains do not come at the expense of regulatory compliance or analytical quality. Studies based on [USP <621>](#) demonstrate that optimized UHPLC methods can achieve equivalent results while significantly reducing environmental impact, without the need for revalidation.⁶ Specifically, six adjustments were made to an isocratic USP method, and the carbon footprint of each adjusted method compared with that of the original. It was found that using columns with reduced lengths, smaller particle sizes, or smaller IDs led to significantly lower carbon footprints per sample, as shortened analysis times meant that both energy and solvent use were reduced (Table 1).

Sustainable operation: Practical actions for laboratories

By adopting best practices in instrument use, laboratories can significantly reduce both their carbon footprint and operating costs.

One of the simplest and most effective actions is reducing idle time. Ensuring that systems are powered down or placed in energy-saving modes when not in use can substantially decrease Scope 2 electricity-related emissions. Similarly, optimizing methods to reduce run times and solvent usage can deliver measurable improvements in both sustainability and throughput.

Another important strategy is the use of partial re-equilibration, which minimizes the time and resources

Table 2. Carbon footprint comparison of alternative HPLC and UHPLC flows with full and partial re-equilibration in the German market.

Case	Impact (g CO ₂ eq/sample)		Difference
	Full Re-Equilibration	Partial Re-Equilibration	
Standard HPLC	374	290	-23%
Standard UHPLC	111	84	-24%
Fast HPLC	280	243	-13%
Fast UHPLC	67	53	-22%

Table 3. Carbon footprint of UHPLC under a scenario where well plates are used in the multisampler instead of vials.

Market	UHPLC Impact (g CO ₂ eq/sample)		Difference
	Base Case	Well Plate Use	
Germany	44	39	-10%
United States	47	43	-10%
China	70	65	-6%
India	88	83	-5%

Comparison of carbon footprint of HPLC and UHPLC where **30% and 100% of electricity consumption** during analysis is **renewable**

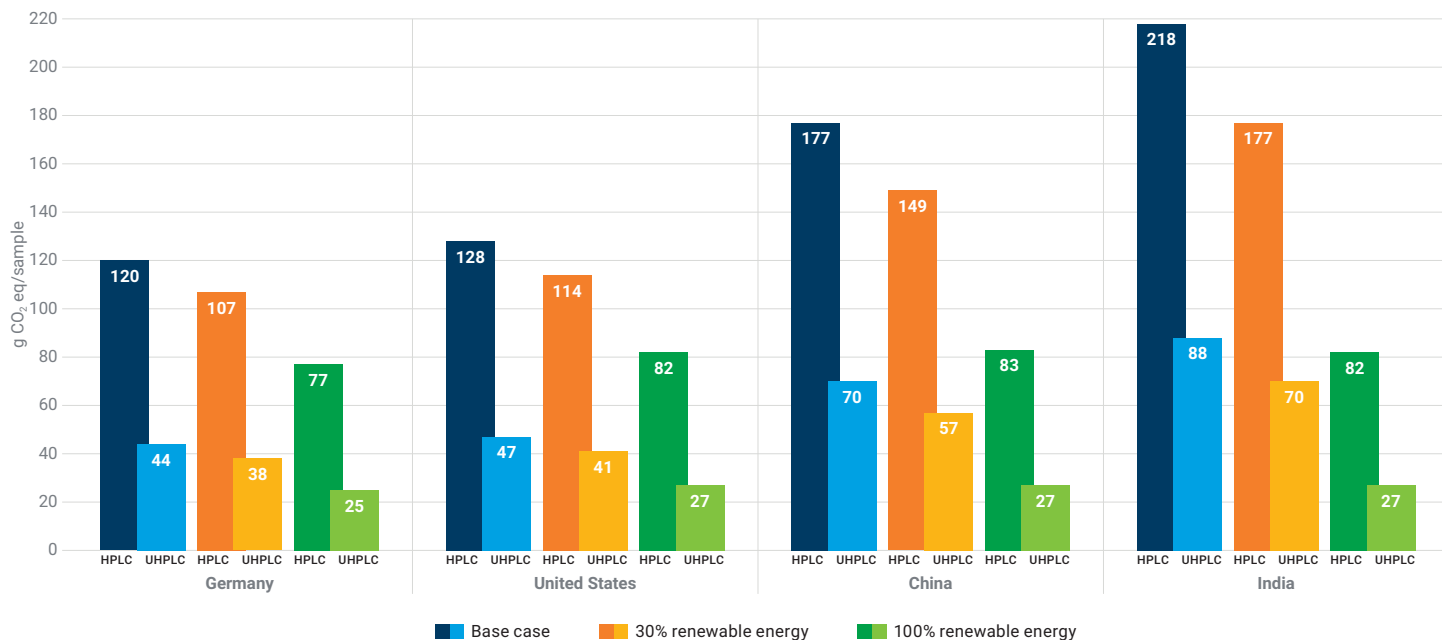


Figure 4. Carbon footprint per sample for the Agilent 1260 Infinity III LC System and the Agilent 1290 Infinity III LC System where 30% and 100% of the electricity consumption during analysis is renewable, and shown for the four representative markets—Germany, United States, China, and India.

required between runs. It has been suggested previously by Stoll et al. that two times the column volume is sufficient to recondition an LC column, and this approach was used in the assessment (Table 2).⁷ A more generous partial re-equilibration volume, which would be more likely to generate reproducible analysis, can be created by adding the system delay volume to two times the column volume.⁸

Switching to renewable electricity sources, where available, offers one of the largest potential reductions in emissions, particularly in regions with carbon-intensive energy grids (Figure 4).

Laboratories can address consumable-related emissions by transitioning from individual glass vials to polypropylene well plates (Table 3) and exploring the use of more sustainable solvent alternatives like ethanol, if their methods allow for these changes.⁹

Design features supporting sustainability

Agilent has integrated several features into the Infinity III platform to support sustainable operation. Technologies

such as Agilent [InfinityLab Assist](#) improve system usage by reducing inefficiencies and enabling smarter workflows. Agilent Intelligent System Emulation Technology (ISET) allows a single system to replicate the functionality of multiple instruments, reducing both equipment requirements and overall emissions, and helping labs optimize the size of their fleet.

As part of the current assessment, a case study compared the carbon footprint of running both HPLC and UHPLC, for five hours each, on a 1290 Infinity III LC featuring ISET with the combination of five hours of HPLC on a 1260 Infinity III LC and five hours of UHPLC on a 1290 Infinity III LC. Using ISET resulted in a total carbon footprint of 159 g CO₂ eq compared with a combined footprint of 209 g CO₂ eq when using separate instruments for HPLC and UHPLC (Figure 5).

Agilent BlendAssist optimizes solvent usage during method development, with a case study showing that it could reduce the carbon footprint of HPLC by 10% and that of UHPLC by 4%. Using BlendAssist results in lower solvent use, which in turn reduces the impact of solvent production and spent solvent incineration.

Carbon footprint of HPLC and UHPLC under scenarios with and without the ISET functionality

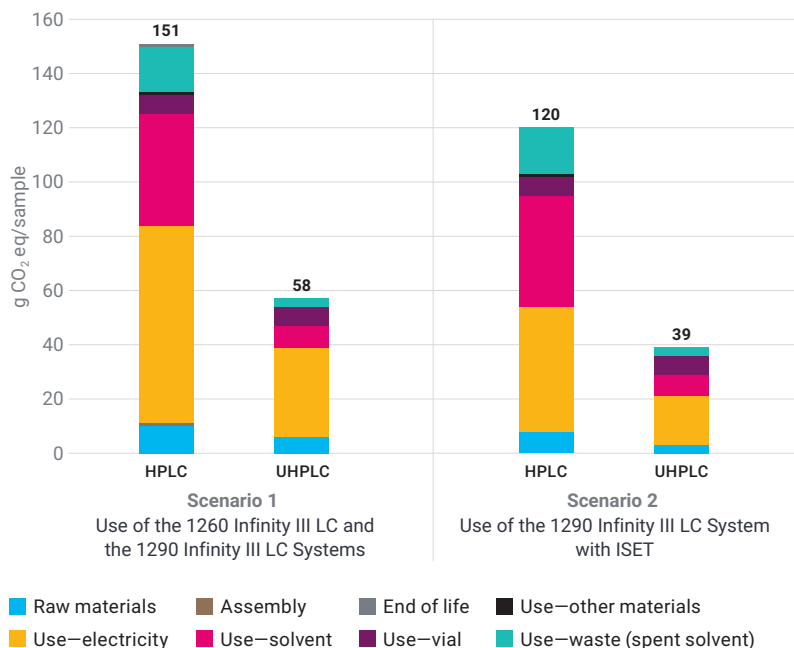


Figure 5. Carbon footprint per sample for the Agilent 1260 Infinity III LC System and the Agilent 1290 Infinity III LC System with and without ISET, as modeled for a lab setting in Germany.

The modular design of the platform allows for upgrades rather than full system replacement. This extends the life cycle of the instrument and reduces material waste.

These features demonstrate how thoughtful engineering can directly enable more sustainable laboratory practices, providing both environmental and economic benefits.

Conclusion and future outlook

The results of this assessment highlight a shift in how laboratories should approach sustainability for analytical instruments. Agilent is working to reduce the environmental impacts associated with manufacturing. However, this study demonstrates that how instruments are operated significantly influences carbon emissions, especially given that most systems have an expected lifetime of at least 8 to 10 years in the lab.

UHPLC technology, combined with smart operational practices and energy-conscious decisions, offers a powerful pathway toward more sustainable laboratory workflows by lowering carbon footprint per sample. At the same time, these improvements align closely with

cost reduction and productivity gains, reinforcing the strong connection between sustainability and business performance.

Agilent remains committed to advancing sustainability through innovation, transparency, and partnership. By providing robust carbon footprint data and enabling smarter laboratory solutions, the company aims to support customers in achieving their environmental goals while maintaining the highest standards of analytical performance.

References

1. ERM GmbH. 2024–2026. Product Carbon Footprint of Agilent Infinity III LC Systems: Final Report for Review. Version 02, Project No. 721755. Prepared for Agilent. Neu-Isenburg, Germany: ERM International Group Limited.
2. Rieck, F. Do You Know the Environmental Impact of your HPLC? Agilent Technologies technical overview, publication number 5994-2335EN, 2022.
3. Maguire, G. India's Power System Just Passed a Historic Tipping Point. Reuters, 17 August 2026.
4. Silva Freitas, I.; Lima, A. M. O.; Alves, E. P.; Souza, G. M.; Pontes, L. A. M. Evaluation of the Technical and Environmental Viability of a Bioethanol, Propene, and Green Ammonia Process for Acetonitrile Production through a Comprehensive Life Cycle Assessment. *ACS Sustainable Chem. Eng.* 2025, 13(14), 5190–5200.
5. Colangelo, S. Reducing the Environmental Footprint of Glass Manufacturing. *Int. J. Appl. Glass Sci.* 2024, 15, 350–366.
6. Modernizing the USP Ceftizoxime Sodium HPLC Method Following the Revised USP <621> Guidelines. Agilent Technologies application note, publication number 5994-7819EN, 2024.
7. Seidl, C.; Stoll, D. R. Column Re-equilibration Following Gradient Elution: How Long Is Long Enough?, LCGC 2019.
8. Beyond the Initial Cost: Achieving the Full Lifecycle Value of LC Investments. Agilent Technologies brochure, publication number 994-8725EN, 2026.
9. The CHEM21 Solvent Selection Guide. *ACS GCI Pharmaceutical Roundtable*.

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