Dupixent environmental Life Cycle Assessment (LCA) technical summary report

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Peer-reviewed study by an independent panel, following ISO 14040 and 14044 standards.

Project title	Dupixent Life Cycle Assessment (LCA) - technical summary
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ISO LCA title	DUPIXENT Life Cycle Assessment – full ISO-compliant report
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Critical Review	
Company	ERM
Reviewer name	Michael SPIELMANN
Type of review	ISO critical review by an independent panel following ISO 14040 and 14044 standards

Contents

1. References, acronyms, symbols & units

References

ISO 14040/14044	Base standards for LCA conduction & reporting
PEF method	European Commission's methodology for the LCA of products & their environmental footprint communication – based on ISO 14040/14044

Acronyms, symbols & units

1G	**DS first generation**
2G	DS second generation
ABS	Acrylonitrile butadiene styrene
CFF	Circular Footprint Formula
DP	Drug product
DS	Drug substance
EF	Environmental Footprint
eq.	Equivalent
kg	Kilogram
LCA	Life Cycle Assessment
m^3	Cubic meter
MJ	Megajoule
P	Phosphorous
PEF	Product Environmental Footprint
Sb	Antimony
UF-DF	Ultrafiltration diafiltration (also designated as TFF)
vs.	Versus

2. Context and objectives

The connection between the health of our planet and that of people is increasingly clear. As a global healthcare leader, our mission at Sanofi extends beyond developing life-changing medicines and vaccines: it encompasses our contribution to the environment and society.

As part of this commitment, we are designing our medicines and vaccines for environmental sustainability through Eco-design. At Sanofi, we have committed to an eco-design approach for 100% of our new products by 2025 and the 20 top-selling products by 2030.

Sanofi in collaboration with Regeneron has been working for years to improve the environmental profile of DUPIXENT*, a treatment against leading immune-mediated conditions, such as asthma, COPD and atopic dermatitis.

This LCA technical summary report describes the environmental Life Cycle Assessment (LCA) execution and outcomes for DUPIXENT medicine produced by Sanofi.

The goals of this LCA study are the following:

- Execute an ISO 14040/14044 compliant LCA of Dupixent full value chain, using primary data on manufacturing stages;
- Identify the major environmental impacts throughout Dupixent full value chain;
- Quantify the environmental benefits of the key improvement lever executed since 2020: first generation (1G) vs. second generation (2G) drug substance (DS) manufacturing process;
- Identify additional Eco-design levers to further improve Dupixent environmental, and quantify their potential environmental benefits;
- Communicate internally and externally on the environmental benefits from the recent executed measures implemented to optimize Dupixent environmental footprint, to support Sanofi's external environmental claims with a LCA study reviewed by an independent third party.

* Dupixent ISO-compliant Life Cycle Assessment (LCA) study conducted uses data from 2023, including a comparison of Dupixent medicine full value chain in 2020.

3. Scope of the LCA

As aligned with ISO 14040/14044 requirements environmental impacts of medicines are assessed and compared to each other according to the function they fulfil, which enables fair comparisons.

In relationship with the recommended posology of 2 injections at the beginning of the treatment, followed by one injection every two weeks (i.e. 26 doses per patient over one year), the selected functional unit is:

"One adult patient in Europe treated with the recommended dose of Dupixent during a 1-year period."

The environmental LCA impact assessment covers Dupixent full value chain: Drug Substance (DS) and Drug product (DP) manufacturing, DP filling into primary packaging, manufacturing of packaging and device, storage and distribution, use phase, packaging and device end-of-life treatment.

The base scenario uses Dupixent DS manufacturing with the latest second generation (2G) process. The Eco-design scenario compares this baseline to Dupixent full value chain with first generation (1G) DS manufacturing.

Environmental impacts are characterized using the Environmental Footprint (EF) 3.0 method from the European Product Environmental Footprint (PEF) method.[†] multi-criteria results are provided on 16 environmental impact indicators. This LCA technical summary report provides deeper analyses focusing on 6 most environmental impact relevant (following the PEF approach for prioritization)[‡]:

- Climate change (kg CO2.eq)
- Non-renewable energy resources (MJ, net calorific value)
- Mineral and metal resource use (kg Sb eq.)
- Water use (m3 world eq. deprived)
- Freshwater eutrophication (kg P eq.)
- Particulate matter formation (disease incidence)

It's important to mention that Water use, Mineral and Metal resource use impact indicators present higher uncertainty due to limitations in localized water scarcity characterization factors (related to locally available water

[†] European Platform on environmental Life Cycle Assessment. Accessed MAY 2025. https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

[‡] Process consisting in identifying top impact categories (i.e. cumulating 80%) contributing to a single score (expressed in Points) resulting from the sum of normalized and weighted results (using PEF factors) in all 16 impact categories.

for humans and ecosystems), and uncertain resource depletion potential, respectively.

4. Data and assumptions

Environmental Life Cycle Assessment (LCA) modelling is performed with an internal Sanofi LCA software[§], using Ecoinvent v3.8 (cut-off version) as background database.

The figure below illustrates the boundaries of Dupixent environmental LCA study over its value chain:

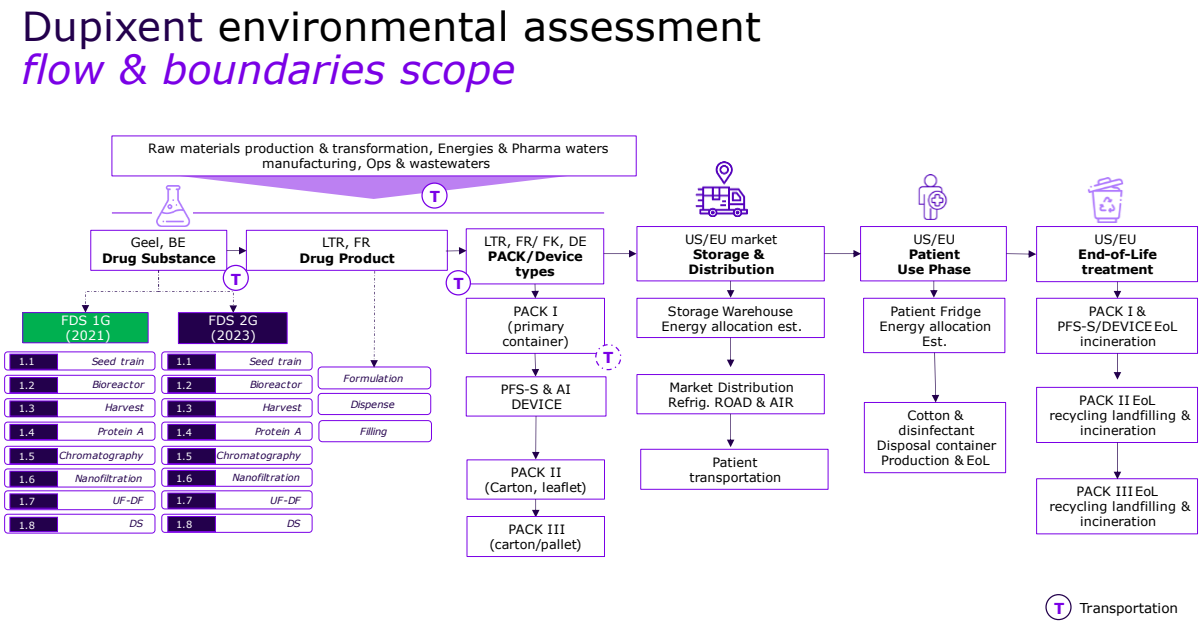

Figure 1 – Dupixent environmental LCA system boundaries

Only Sanofi manufacturing sites for Dupixent full value chain are considered in the scope of this environmental LCA study.

The table below summarizes the key data included in the LCA modelling, depending on primary data obtained and secondary data availability:

Life cycle stage		Included inputs/outputs
Manufacturing	DS	▪ Raw material production and supply (incl. transport, and packaging of consumables) ▪ Operational waste losses treatment ▪ Energy consumption (electricity, natural gas) ▪ Waste treatment (wastewater, hazardous waste, consumables) • Formulated DS transportation to DP manufacturing site

[§] Sanofi Eco-design tool, EDDi was certified in 2024 by Bureau Veritas, a world leader independent in certification services, as compliant with ISO 14040 & ISO 14044 standards.

Life cycle stage		Included inputs/outputs
	DP	▪ Raw material production and supply (incl. transport) ▪ Operational waste losses treatment ▪ Energy consumption (electricity, natural gas) ▪ Waste treatment (wastewater, hazardous waste, consumables) ▪ DP (filled in cartridge - primary packaging) transportation to secondary packaging site
	Packaging & Device	▪ Primary (cartridge) to tertiary packaging types: Raw material production and supply (incl. transport) and transformation (e.g. molding material) • Device (auto-injector): Raw material production and supply (incl. transport) + energy for transformation & assembly
Storage & distribution	Storage	▪ Energy consumption for storage in Sanofi warehouses, and at the distribution centers (DCs) and at the pharmacy
	Distribution	▪ Transportation (refrigerated truck) from warehouses to DCs ▪ Transportation (refrigerated truck or plane) within local destination country ▪ Patient travel from home to pharmacy for medicine pick-up
Use	Use phase	▪ Energy consumption for storage in patient's fridge • Consumables production and disposal treatment (for injection: cotton, antiseptic, medical plaster)
End-of-life	Packaging & Device	▪ Waste collection & transport (default) ▪ End-of-life treatments of primary, secondary, tertiary packaging types and device components (default European average recycling, incineration and landfilling rates per material type)

Table 1- Dupixent LCA study perimeter

For this environmental LCA study 2023 primary data on Sanofi's manufacturing processes was collected, including energy consumption for Sanofi DS manufacturing building in Geel Belgium and DP manufacturing site in Le-Trait France, raw materials, consumables, waste generation and treatment. Dupixent DS and DP manufacturing sites were provisioned with 100% renewable electricity in 2023.

Details on packaging materials and medical device (auto-injector) components were collected by Sanofi experts:

- The glass cartridge is the primary packaging type (in contact with the DP). It is inserted in the device (Molly auto-injector) which sub-components are assembled in Frankfurt (Germany)
- Secondary packaging consists in the carton box containing 2 devices and the leaflet.
- The tertiary transportation packaging includes the cardboard box, the plastic film and a wood pallet considered reused 20 times.

For product distribution default scenarios from the European Product Environmental Footprint (PEF) were used to represent average transport modes and distances within local markets. The European market assessed represents average distribution in Belgium, Finland, France, Italy, Portugal, Spain, and Sweden (countries with largest sales volumes).

Self-administration at home was exclusively modelled as representative of the main administration mode (vs. in healthcare facility). Default roundtrip distance and modes (e.g. car, public transport, foot…) are assumed for patient personal travel to the pharmacy.

End-of-life disposal of device, primary and secondary packaging is modelled according to European average recycling, incineration and landfilling rates. The PEF's Circular Footprint Formula (CFF)[**] was used to allocate shares of material and energy recovery impacts and benefits (avoided virgin materials or conventional energy sources) to the product.[††]

[**] The Circular Footprint Formula methodology article. Accessed MAY 2025. https://www.eu4environment.org/news/circular-footprint-formula-or-how-to-calculate-the-emissions-associated-with-the-recycled-content/

5. Environmental impact assessment results

Baseline environmental LCA results

The figure below details the environmental impact contributions of Dupixent 2G full value chain in the most relevant impact indicators.

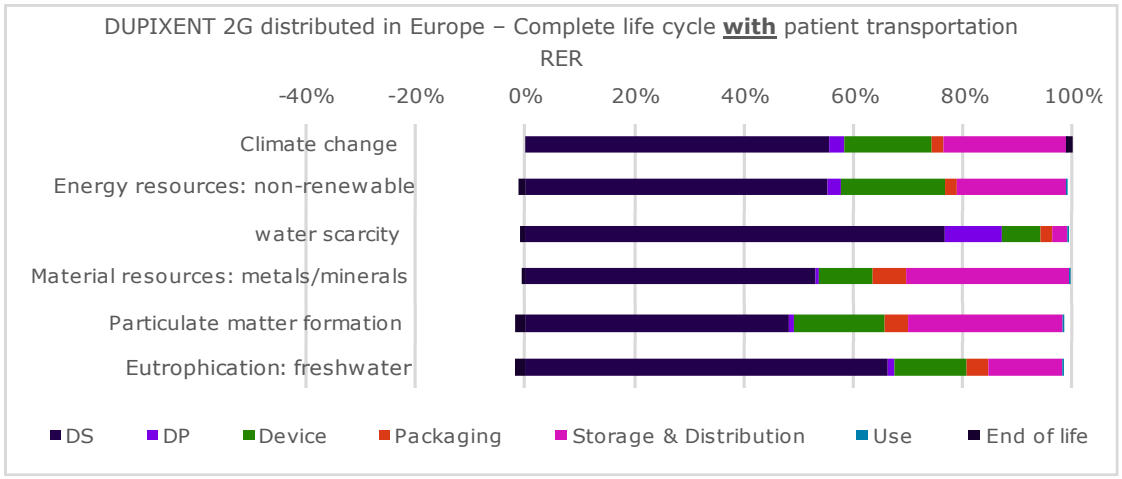

Figure 2 – Dupixent 2G distributed in Europe full value chain environmental profile, for one dose

- **DS manufacturing** is the main environmental impact driver over Dupixent full value chain in all key impact indicators, representing 50%-57% on the particulate matter, climate change, material and energy resource use indicators, 69% on freshwater eutrophication and up to 78% on Water use indicator.
- **Storage and distribution,** environmental contribution to Dupixent is from 3% (Water use) up to 30% (material resource use), mostly because of patient travel impacts (distance and car use share) and patient product pick-up at the pharmacy.
- **Device manufacturing** environmental contribution to Dupixent to 10% resource use, 16% carbon footprint impact and up to 19% non-renewable energy use. Main drivers of these impacts include the transport of device components from supplier over long distances, followed by material type and quantities: steel and ABS components.

Dupixent remaining life cycle steps have limited potential environmental impact contributions:

- 3% average for DP manufacturing
- 3% average for packaging manufacturing
- <1% average for the use phase

- -1% average environmental savings for the packaging and medical device end-of-life treatment mainly due to packaging cardboard recycling and the avoided production of virgin material.

Eco-design benefits of DS manufacturing optimization: 1G vs. 2G

Key optimizations in DS manufacturing specifically include:

- intensification of DS manufacturing process[‡‡] leading to productivity increase using the same raw material resources leading to a reduction in materials and energy uses.
- electricity mix change, from local grid mix to 100% renewable electricity at Geel, Le Trait and Frankfurt Sanofi manufacturing sites.

The figure 3 provides details on environmental LCA comparison of Dupixent life cycle impacts with 1G vs. 2G DS manufacturing process, breaking down the life cycle stage contributions in the key environmental indicator categories.

[‡‡] Dupixent DS - Dupilumab is being jointly developed by Sanofi and Regeneron under a global collaboration agreement.

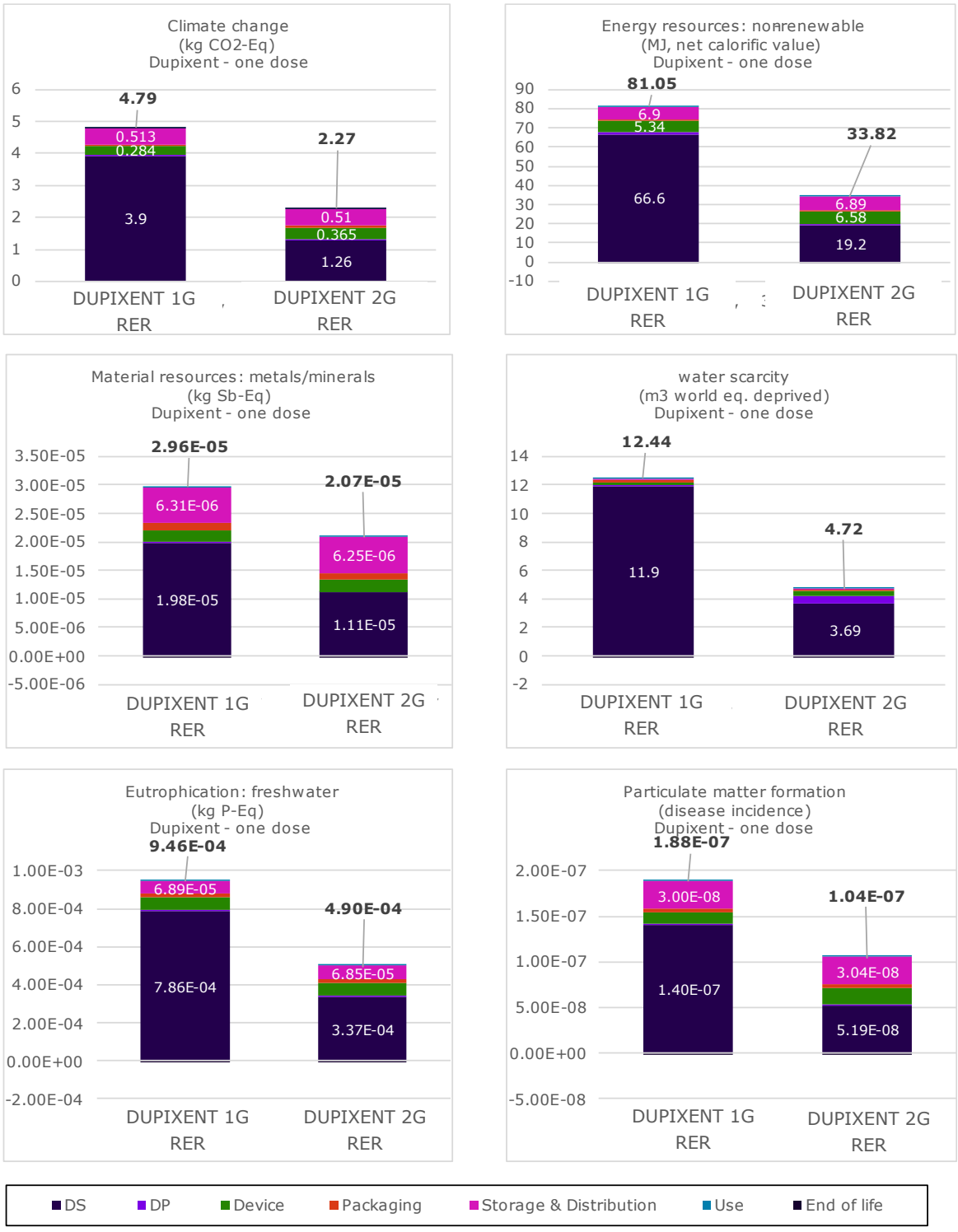

Figure 2 - Dupixent 1G vs 2G full value chain environmental profile, in key environmental indicator categories, for one dose

Thanks to the optimization of Dupixent DS manufacturing, the following impact savings are observed over its full value chain:

- 53% lower carbon footprint climate change
- 62% less water use

- 30% material less metal and mineral resource depletion

6. Conclusions

Dupixent illustrates Sanofi's[§§] commitment to design our medicines and vaccines for environmental sustainability through Eco-design. This approach involves by first conducting an ISO-compliant Life Cycle Assessment (LCA) to assess its environmental impact. This science-based EU commission method assesses the environmental footprint of each stage of a product's life cycle — from raw materials to manufacturing, packaging & device, distribution, use, and product end-of-life treatment.
This environmental multi-criteria assessment highlighted the DS manufacturing is one of Dupixent largest contributors and executed improvements contributed significantly to environmental optimization.

Through the optimization of the DS manufacturing process, each dose of Dupixent now has

- 53% lower carbon footprint climate change
- 62% less water use
- 30% Material less metal and mineral resource depletion

Furthermore, to reduce patient waste & support responsible disposal practices, we are looking for ways to reduce the amount of disposed material after Dupixent patient use. To tackle waste in Dupixent pens, Sanofi is studying with French & Danish authorities a take-back program to be validated by end-2025.
This program provides patients with a convenient way to recycle used Dupixent pens. This program builds on our commitment to reduce post-consumer waste and implement responsible disposal practices.

[§§] Dupixent DS - Dupilumab is being jointly developed by Sanofi and Regeneron under a global collaboration agreement.

Considering 1 year of treatment for 1,000 adult patients in Europe, cumulated impact reductions are equivalent to:

- 13,984 km driven by car[***]
- 1,430 glasses of water[†††]
- Metal and mineral use to produce 368 Li-ion batteries[‡‡‡]

Dupixent environmental improvements are a start in our commitments to designing our medicines to be more environmentally sustainable.

This is only the beginning to continuously minimize the environmental impacts of our medicines for people living with immune and respiratory diseases.

[***] Impact source: Ecoinvent 3.10, based on a medium-sized petrol car (EURO5), considering tailpipe emissions only.

[†††] Impact source: Ecoinvent 3.10, assuming 0.5-L of water consumed per glass and European tap water scarcity impact.

[‡‡‡] Impact source: Ecoinvent 3.10, considering average 90 g smartphone batteries.