Öko-Institut

Google in Luxembourg

Current Planning Status and Opportunities for Improvement in Bissen

KEY MESSAGES

- The current planning status does not reflect the state of the art in several key areas
- Annual greenhouse gas emissions could be reduced by up to **97%** through technical optimization.
- Waste heat has the potential to supply heating to at least **20,000 residents**, as well as industrial and commercial users.
- Replacing diesel generators with battery energy storage systems can significantly reduce noise, diesel soot emissions, and other air pollutants.
- The use of natural refrigerants can eliminate the need for PFAS-containing refrigerants and help prevent the release of persistent environmental pollutants.
- The use of nuclear electricity does not constitute an environmentally sustainable solution.

Current Status of the Data Centre Planning

Google is planning to build and operate a hyperscale data centre in central Luxembourg. The facility is to be located in the Canton of Mersch, near the major electrical substation in Bissen. The project will cover approximately **34 hectares** of currently agricultural land.

With an IT power capacity of **100 megawatts (MW)**, the data centre is expected to consume around **950 gigawatt-hours (GWh)** of electricity per year. This is equivalent to the annual electricity consumption of all private households in Luxembourg and approximately **15%** of the country's current total electricity demand.

The current plans specify a **Power Usage Effectiveness (PUE)** of **1.3**, meaning that approximately **30%** additional energy is required for supporting infrastructure such as cooling and power distribution. At present, no use of the facility's waste heat for district heating or other heating purposes is planned.

Backup power in the event of grid outages is to be provided by **46 diesel generators**, each with an engine output of approximately **7 MW** — equivalent to the combined power of around **19 heavy-duty trucks with 500 horsepower each**. The generators will be supplied from an on-site fuel storage facility with a capacity of approximately **1 million litres**.

The cooling system is planned to use the refrigerant R-1234ze, with an estimated charge of approximately 30 tonnes in a closed-loop cooling circuit. Annual water consumption for the cooling system is expected to be approximately 3,800 cubic metres.

Environmental Impacts of the Current Technical Concept

The project's most significant environmental impacts result from its electricity consumption. Google has not disclosed the origin of the electricity needed for its data centre. It is therefore reasonable to assume that this electricity would be imported from Germany, Belgium, or France.

If the imported electricity were supplied from the average German electricity mix, its generation would result in annual greenhouse gas emissions of approximately **315,000 metric tonnes of CO_2 equivalent (CO_2e)**.

Google has announced its intention to use **"carbon-free energy" (CFE)**. Within the industry, this term is frequently associated with electricity generated from nuclear power. If the electricity were sourced from Belgium, where approximately **33%** of electricity generation comes from nuclear energy, annual greenhouse gas emissions would be reduced to around **145,000 metric tonnes CO_2e**. However, electricity generation would also produce nearly **1 metric tonne of high-level radioactive waste** (spent nuclear fuel) per year.

If the electricity were imported from France, where nuclear power accounts for approximately **69%** of electricity generation, annual greenhouse gas emissions would fall further to around **42,000 metric tonnes CO_2e**. At the same time, the amount of high-level radioactive waste attributable to the data centre would increase to nearly **2 metric tonnes per year**. Thus, the lower greenhouse gas emissions associated with nuclear electricity come at the cost of generating hazardous radioactive waste that requires management over millennia, while also creating geopolitical dependencies related to nuclear fuel supply.

Refrigerant losses also contribute to the facility's greenhouse gas emissions. The planned fluorinated refrigerant, **R-1234ze**, has a relatively low global warming potential. Assuming an annual leakage rate of **5%** — equivalent to **1.5 metric tonnes** from the estimated total refrigerant charge of **30 metric tonnes** — direct emissions would amount to approximately **2 metric tonnes CO_2e per year**. However, the refrigerant also has additional environmental impacts. In the atmosphere, R-1234ze degrades into several substances, including **trifluoroacetic acid (TFA)**, a persistent PFAS ("forever chemical") that accumulates in aquatic environments through precipitation and is increasingly recognised as an environmental contaminant.

The **46 diesel generators** are scheduled to undergo routine maintenance testing on a rotating monthly basis, meaning that generators operate under partial load every day. At least once a year, all generators are tested simultaneously at full load. Under normal operating conditions, approximately **200,000 litres of diesel fuel** are consumed annually. This results in significant noise pollution for nearby communities, diesel soot emissions, and additional local greenhouse gas emissions of approximately **520 tonnes CO_2e per year**.

Best Available Technology

The proposed Google data centre does not yet reflect the current state of best available technology (BAT) in several key aspects of its design.

Industry initiatives such as the **Climate Neutral Data Centre Pact**[1] and the **EU Code of Conduct on Data Centre Energy Efficiency**[2], as well as the **European Commission's Rating Scheme for Data Centres**[3] and national environmental certification schemes such as the **German Blue Angel ecolabel (DE-UZ 228)**[4], demonstrate the levels of energy efficiency and environmental performance that can already be achieved by modern data centres. Google meets several of these standards at other facilities — but not in the current plans for Bissen.

A newly constructed hyperscale data centre can reasonably be expected to implement the following technical specifications:

- Power Usage Effectiveness (PUE) ≤ 1.1
- Use of electricity from renewable energy sources that are physically connected to the data centre and generated simultaneously with demand (24/7 renewable electricity matching)
- Recovery and beneficial use of waste heat with an **Energy Reuse Factor (ERF) of at least 20%**
- Use of **halogen-free natural refrigerants** (e.g. ammonia, propane, carbon dioxide, or water)
- Battery-based backup power systems instead of diesel generators
- No abstraction of groundwater or drinking water for cooling purposes

The following assessment examines the environmental benefits that could be achieved if these technically feasible efficiency measures were implemented at the planned data centre.

Achievable Environmental Improvements

Reducing Energy Losses

The first opportunity for improvement lies in the use of more efficient cooling technologies. Replacing conventional air cooling with **direct-to-chip liquid cooling**, in which the coolant circulates in a closed loop, can substantially reduce cooling-related energy losses. This approach enables **Power Usage Effectiveness (PUE)** values of **1.1** to be achieved, reducing the data centre's annual electricity consumption by approximately **15%**, from **950 GWh** to around **800 GWh**.

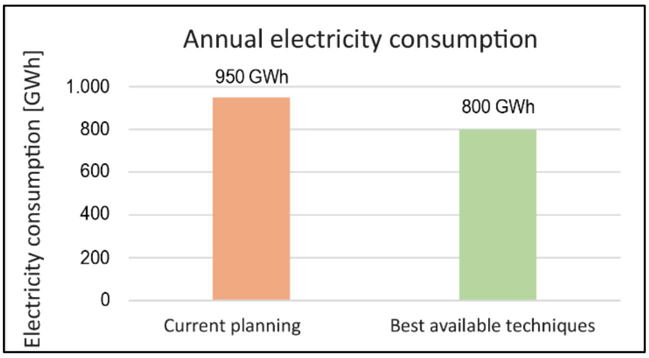

Figure 1: Electricity Savings by Efficient Cooling Technology

Renewable Energy Supply

A substantial reduction in greenhouse gas emissions can be achieved by supplying the data centre with electricity generated from **renewable energy sources**, primarily wind and solar power. To deliver genuine climate benefits, this electricity should be **additional**, generated **at the same time as it is consumed**, and physically connected to the data centre via the electricity grid.

This can be achieved through investments in new wind farms and photovoltaic installations, combined with on-site solar generation using available areas of the data centre site. Assuming the data centre is supplied with **5%** electricity from on-site photovoltaic systems, **80%** from newly developed onshore wind farms, and **15%** from the Luxembourg electricity grid — instead of importing electricity based on the average German electricity mix — annual greenhouse gas emissions could be reduced from approximately **315,000 metric tonnes CO_2e** to around **28,000 metric tonnes CO_2e**. This represents an emissions reduction of approximately **91%**.

Waste Heat Recovery

Further substantial reductions in greenhouse gas emissions can be achieved by recovering and using a portion of the data centre's waste heat for residential heating. By supplying this waste heat to district heating networks or other heating systems, heat generated from oil- and natural gas-fired boilers can be displaced, thereby avoiding the associated greenhouse gas emissions.

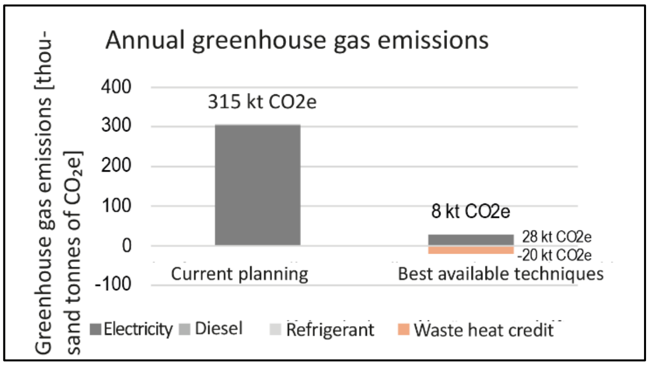

Figure 2: Renewable Electricity Supply and Waste Heat Recovery

The municipalities of **Bissen**, **Diekirch**, and **Ettelbruck** together have a population of approximately **20,000 residents**. Bissen is located immediately adjacent to the proposed data centre site, while Diekirch and Ettelbruck already operate district heating networks that could potentially be connected. We therefore assume that the planned data centre could supply at least **40 GWh of waste heat per year** to households, corresponding to an **Energy Reuse Factor (ERF)** of approximately **5%**.

This level of heat recovery would generate an annual greenhouse gas credit of approximately **20,000 metric tonnes CO_2e** by replacing fossil fuel-based heating. As a result, annual emissions from the optimized data centre concept would fall to around **8,000 metric tonnes CO_2e**, representing a **97% reduction** compared with the current planning scenario.

If additional waste heat were supplied to industrial and commercial users, the emission savings could be even greater. Under favourable conditions, the resulting greenhouse gas credits could enable the data centre to achieve a climate-positive operational balance. To realise this potential, Google should begin engaging with prospective heat users at an early stage and incorporate the necessary technical infrastructure into the project design.

Use of Natural Refrigerants

Instead of the currently proposed refrigerant R-1234ze, which poses environmental risks, the cooling system should use natural refrigerants such as propane or ammonia. These refrigerants do not generate persistent environmental pollutants and therefore avoid the long-term impacts associated with routine refrigerant leakage or accidental releases.

Battery-Based Backup Power

A further opportunity for optimization is the use of **battery energy storage systems** to provide several hours of backup power in the event of grid outages.

This approach not only eliminates local noise, diesel soot emissions, and the air pollution associated with diesel generators, but also enables the data centre to actively support the integration of renewable energy and enhance grid stability.

By charging the batteries during periods of surplus solar or wind power generation, the facility can help store renewable electricity, reduce pressure on the electricity grid, and potentially lower its own energy costs.

Use of Rainwater

The projected annual water consumption of **3,800 cubic metres** indicates that the planned data centre will not rely on large-scale **evaporative cooling**. This is a positive aspect of the current design, as it avoids the unnecessary consumption of valuable freshwater resources. However, the planned water demand could be reduced even further. The roof area and other impermeable surfaces of the data centre provide sufficient potential to harvest the required volume of **rainwater**. With appropriately sized rainwater storage tanks and collection systems, the facility's demand for **drinking water and groundwater** could be reduced to **zero**.

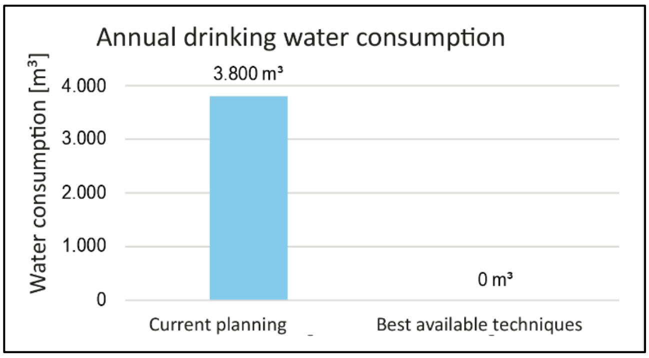

Figure 3: Use of Rainwater

Results of the Potential Analysis

The data centre currently planned by Google in **Bissen, Luxembourg**, still offers significant opportunities for technical and environmental improvement.

Given the very large amount of electricity the facility is expected to consume, together with its other environmental impacts — including noise, air pollutant emissions, waste heat generation, and land take — it is essential, from both a climate protection and environmental perspective, that only the most energy-efficient and environmentally sustainable technologies are deployed.

The potential analysis presented here identifies practical and technically feasible measures to substantially improve the project's environmental performance. Only by implementing **best available technology (BAT)** can the data centre be operated in a manner that is both **future-proof** and **environmentally sustainable**.

Potential Analysis by Öko-Institut e.V.

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Disclaimer

The estimates of environmental improvement potential presented in this report are based on the limited planning information that Google has made publicly available for the proposed data centre. These data have been extrapolated using technical parameters from comparable projects to estimate energy consumption and environmental impacts. Google has not yet provided the level of transparency necessary to enable a comprehensive public assessment of the project's environmental implications. Consequently, the environmental impacts and improvement potentials presented here should be regarded as indicative estimates rather than precise calculations. They are intended to illustrate the scale of the achievable improvements and do not replace a detailed engineering assessment or project-specific environmental evaluation.

Sources

1 **Climate Neutral Data Centre Pact (2026):** *The Green Deal Needs Green Infrastructure.* Available online at: https://www.climateneutraldatacentre.net/

2 **Acton, M.; Booth, J.; and Paci, D. (2025):** *2025 Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency.* Publications Office of the European Union, Luxembourg, 2025. Available online at: https://data.europa.eu/doi/10.2760/9449356, JRC141521.

3 **European Commission (2026):** *Energy Efficiency – Rating Scheme for Data Centres in Europe.* Available online at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/16035-Energy-efficiency-rating-scheme-for-data-centres-in-Europe_en

4 **German Environment Agency (Umweltbundesamt) (2026):** *Blue Angel Ecolabel for Data Centres (DE-UZ 228), Edition January 2023, Version 3.* Available online at: https://www.blauer-engel.de/