Project Olaf
Carbon Footprint Assessment of the Powder Watts FlexiWatt Platform

Screening-level engineering lifecycle assessment for external diligence use

Executive Summary

- Project Olaf corresponds to approximately 1,056.4 MW of controlled rooftop heat-cable load at the stated deployment volume of 556,000 smart-switch circuits and 1.9 kW controlled per switch.
- Using the embodied-carbon assumptions carried through this assessment, the base-case footprint is approximately 8.5 kg CO2e per switch when installation travel is allocated across the stated average of 2.1 switches per installation site.
- A conservative presentation that assigns the full installation-vehicle trip to each switch yields approximately 15.6 kg CO2e per switch.
- At full deployment, embedded project emissions are approximately 4,742 metric tons CO2e in the base case and 8,674 metric tons CO2e in the conservative case.
- Using a project-specific avoided-load baseline of 6,566 kWh per switch-year and the Utah eGRID2022 output emission rate of 1,514.3 lb CO2/MWh, avoided emissions are approximately 4.51 metric tons CO2e per switch-year, or about 2,507,572 metric tons CO2e in the first year at full deployment.
- Carbon payback is measured in days: approximately 0.7 day in the base case and 1.3 days in the conservative case.

This assessment is designed to support DOE and institutional diligence at the screening level. Final procurement-specific accounting should be refreshed once the bill of materials, manufacturing locations, freight lanes, packaging specification, and installation-routing profile are fixed for production deployment.

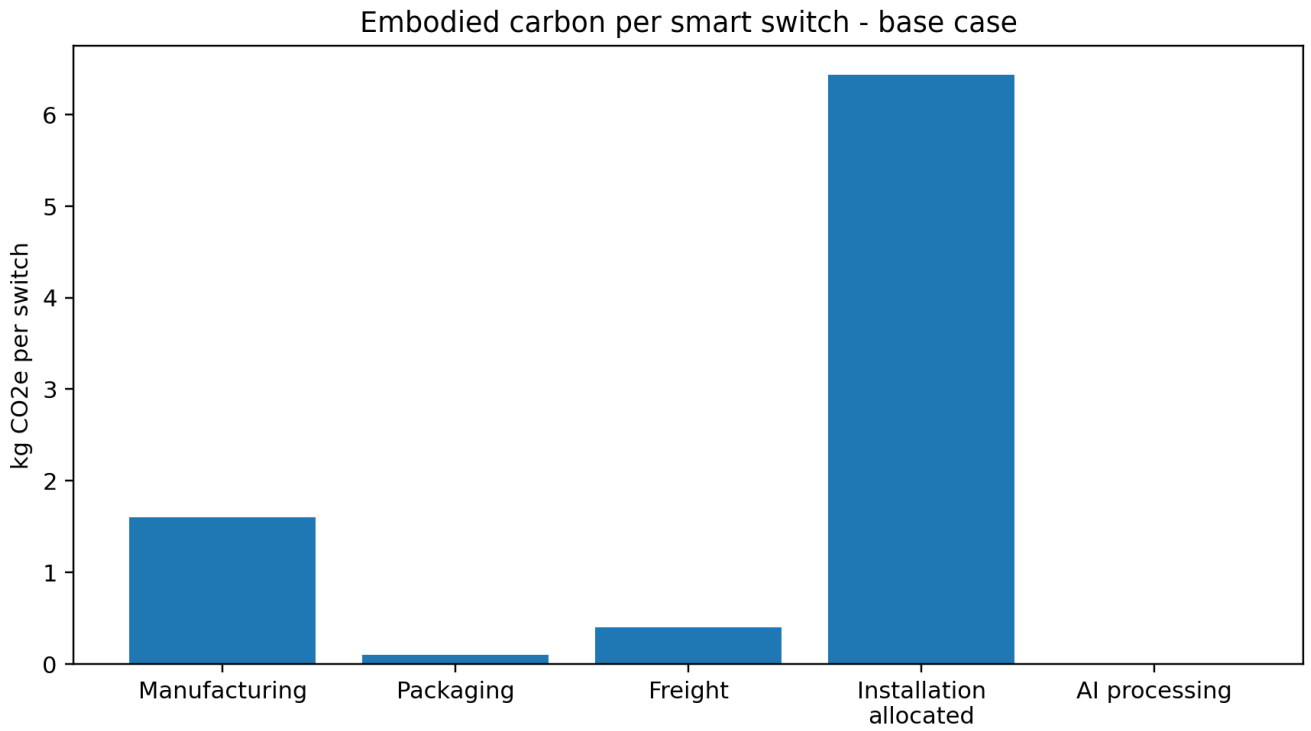

Figure 1. Base-case embodied carbon contribution by component.

1. Scope and Assessment Boundary

This report evaluates the lifecycle carbon footprint associated with the Powder Watts FlexiWatt platform proposed for Project Olaf. The assessment includes five categories: smart-switch manufacturing, packaging, freight, installation travel, and recurring AI-enabled image processing. The analysis is presented at the smart-switch level and then scaled to the stated full deployment volume of 556,000 controlled circuits.

The assessment boundary is intentionally practical rather than exhaustive. It is suitable for project screening, and program-level comparison. It is not intended to replace a procurement-specific product carbon footprint study once vendor selection and logistics are finalized.

2. Key Assumptions

Parameter	Value	Application in assessment
Deployment volume	556,000 switches	Full project scale-up
Controlled load per switch	1.9 kW	MW scaling
Manufacturing emissions	1.6 kg CO2e/switch	PCB assembly + microcontroller + housing
Packaging emissions	0.1 kg CO2e/switch	Outbound packaging
Freight emissions	0.4 kg CO2e/switch	Ocean + truck freight
Installation travel	13.5 kg CO2e/site	Diesel van trip per installation
Average switches per site	2.1	Allocation of installation travel
AI processing emissions	0.00022 kg CO2e/switch-year	Annual image inference energy
Avoided electricity	6,566 kWh/switch-year	Project-specific avoided-load baseline

Parameter	Value	Application in assessment
Grid emission factor	1,514.3 lb CO2/MWh	Utah eGRID2022 output emission rate

3. Embodied Carbon per Smart Switch

The base-case embodied footprint is 8.5 kg CO2e per smart switch. This treatment allocates installation travel across the stated average of 2.1 switches per site, which aligns the installation term with the per-switch reporting unit.

A conservative presentation yields 15.6 kg CO2e per switch by assigning a full installation trip to each switch. That conservative view can be retained as an upper-bound sensitivity, but the allocated base case is the more decision-useful measure for per-switch reporting.

Component	Base case (kg CO2e/switch)	Conservative case (kg CO2e/switch)	Treatment
Manufacturing	1.6	1.6	Direct per-switch
Packaging	0.1	0.1	Direct per-switch
Freight	0.4	0.4	Direct per-switch
Installation travel	6.4	13.5	Allocated across site vs full trip per switch
AI processing	0.000	0.000	Annual operational term; immaterial to totals
Total	8.5	15.6	Rounded presentation

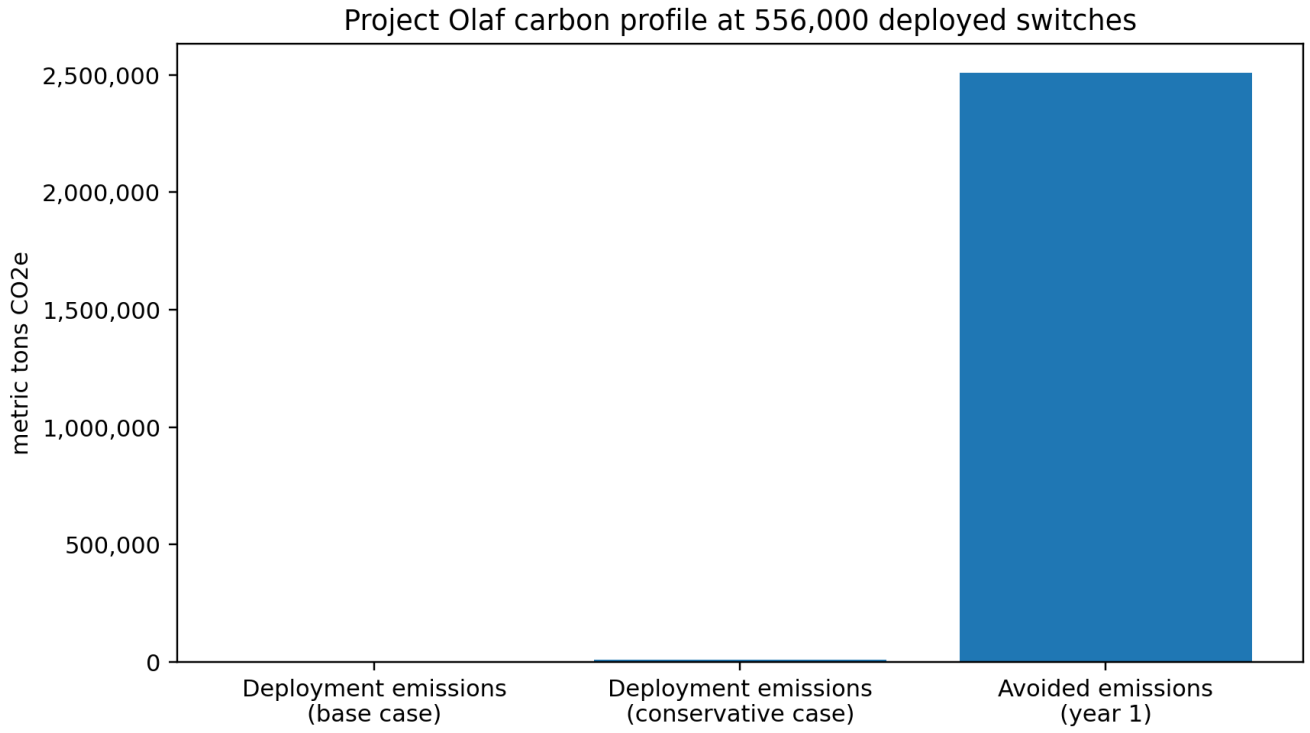

Figure 2. Project deployment emissions versus first-year avoided emissions at full scale.

4. Project-Scale Carbon Footprint

At 556,000 deployed switches, Project Olaf represents approximately 1,056.4 MW of controlled rooftop heat-cable load. Embedded deployment emissions total approximately 4,742 metric tons CO2e in the base case. Under the conservative installation treatment, embedded deployment emissions total approximately 8,674 metric tons CO2e.

These totals remain small relative to the emissions displaced through avoided electricity consumption. The scale comparison is important for external diligence because it shows that the emissions associated with deployment are de minimis relative to the operational abatement value created by the controlled-load strategy.

5. Avoided Emissions and Carbon Payback

Using an avoided-load baseline of 6,566 kWh per switch-year and a Utah grid output emission rate of 1,514.3 lb CO2/MWh, avoided emissions are approximately 4.51 metric tons CO2e per switch-year. At full deployment, this corresponds to approximately 2,507,572 metric tons CO2e of avoided emissions in the first year alone.

Carbon payback is approximately 0.7 day in the base case and 1.3 days in the conservative case. On a ten-year service-life view, net carbon abatement is approximately 45.1 metric tons CO2e per switch before considering any additional operational refinements.

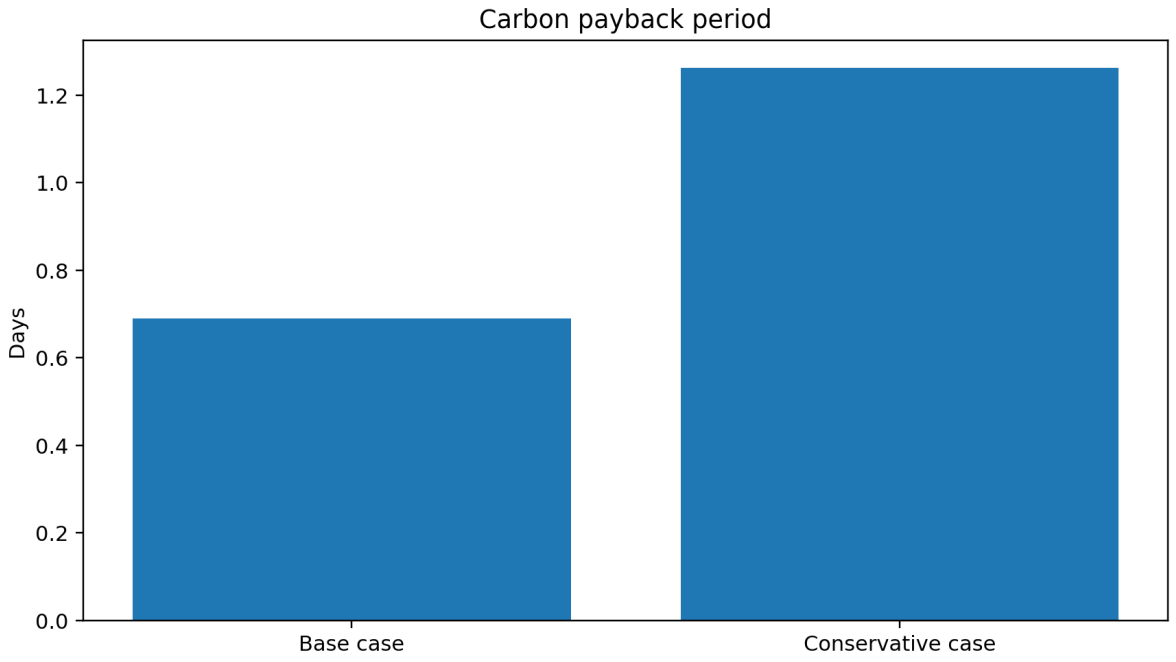

Figure 3. Carbon payback period under base-case and conservative installation treatments.

6. Interpretation

The central conclusion is straightforward: the embodied carbon associated with deployment is very small relative to the first-year avoided-emissions value created by the platform. The principal analytical discipline

required in presenting the result is to keep reporting units aligned. When installation travel is stated per site, it should be allocated consistently when totals are presented per switch.

A screening-level analysis is appropriate at the present stage. A final diligence update should be performed once production procurement is locked, including confirmed bills of materials, final packaging, actual manufacturing geography, freight lanes, and field-routing data from scaled installation operations.

7. Conclusion

Project Olaf combines approximately 1,056.4 MW of controlled load with a deployment footprint of approximately 4,742 metric tons CO2e in the base case. Against first-year avoided emissions of approximately 2,507,572 metric tons CO2e, carbon payback occurs in roughly one day. On that basis, the carbon profile is favorable by a very wide margin and supports the positioning of the Powder Watts platform as a high-leverage load-control strategy for winter-peaking regions.

Appendix A. Calculation Summary

- Controlled load = 556,000 switches x 1.9 kW/switch = 1,056.4 MW
- Base-case per-switch footprint = 1.6 + 0.1 + 0.4 + (13.5 / 2.1) + 0.00022 = 8.529 kg CO2e
- Conservative per-switch footprint = 1.6 + 0.1 + 0.4 + 13.5 + 0.00022 = 15.600 kg CO2e
- Base-case project emissions = 556,000 x 8.529 kg / 1,000 = 4,742.0 metric tons CO2e
- Avoided emissions per switch-year = (6,566 / 1,000 MWh) x 1,514.3 lb/MWh x 0.45359237 / 1,000 = 4.5100 metric tons CO2e
- First-year avoided emissions at scale = 556,000 x 4.5100 = 2,507,571.5 metric tons CO2e