Comparative Technical Review of Advanced Energy-Saving Technologies

Comparative illustration of Powder Watts' FlexiWatt versus other energy measures.

Powder Watts

April 2026

Executive Summary

Powder Watts is presented here as a grid-edge control resource aimed at one of the largest unmanaged electric loads on the US grids: rooftop heat cable systems. The comparison set intentionally retains the broader family of technologies that commonly appear in efficiency and decarbonization discussions, including lighting, envelope measures, HVAC and water-heating upgrades, industrial motors, on-site solar, and community-solar participation.

Three conclusions dominate the comparison. First, the representative Powder Watts case produces the highest lifetime avoided energy per installation in the set at 399.2 MWh, based on 3.5 switches per home and 7,603 kWh saved per switch-year. Second, the reference-case capital intensity of that same case is approximately $5.0 per lifetime MWh, lower than every other costed measure in the comparison. Third, the full-year company MW-to-MWh yield is 5,146 MWh per MW-year, materially above the 2,278 MWh per MW-year benchmark shown for utility-scale solar at a 26% capacity factor.

The carbon basis is intentionally tied to the company's operating geography rather than to the U.S. average. The report uses the simple average of 2023 EPA eGRID state CO_2 output emission rates for Colorado, Utah, Wyoming, North Dakota, and South Dakota: 1,188 lb/MWh. That demonstrates stronger avoided-carbon outcomes for electricity-saving measures than a national-average factor would show, and it better reflects actual snow-belt operating conditions and true avoided emissions.

Methodology and Analytical Boundaries

The document uses one representative installation per technology. That means each case is sized to a realistic unit of deployment rather than forced into an artificial common scale: one LED bulb retrofit, one smart thermostat, one residential envelope retrofit, one representative industrial motor replacement, one 5-kW residential PV system, one 5-kW-equivalent community-solar subscription, and one representative snowy-climate home using Powder Watts with 3.5 switches. The purpose is comparative orientation, not a claim that all technologies are deployed at the same physical scale.

Where federal sources publish direct annual bill savings rather than annual electricity savings, the report converts those values into electric-equivalent kWh using the 2024 U.S. average residential electricity price of 16.48 cents/kWh. Where federal sources provide ranges or qualitative guidance instead of a single universal annual kWh value, the report uses transparent reference-case assumptions and labels them as modeled assumptions rather than as field-measured averages.

Generation and subscription resources remain in the graphics because they are part of the comparison set, but they are not direct behind-the-meter load-reduction measures. That distinction is made explicitly so the charts remain informative without implying false equivalence between avoided consumption, produced generation, and subscription-based bill credits.

Figure 1. Snow-belt operating-state carbon basis

State-level emission rates from EPA eGRID 2023 were used to create a snow-belt operating-grid factor for the full report. Utah, Wyoming, and North Dakota remain materially more carbon-intensive than the national average, while South Dakota is lower because of its cleaner generation mix. The simple average of the five-state set is 1,188 lb/MWh.

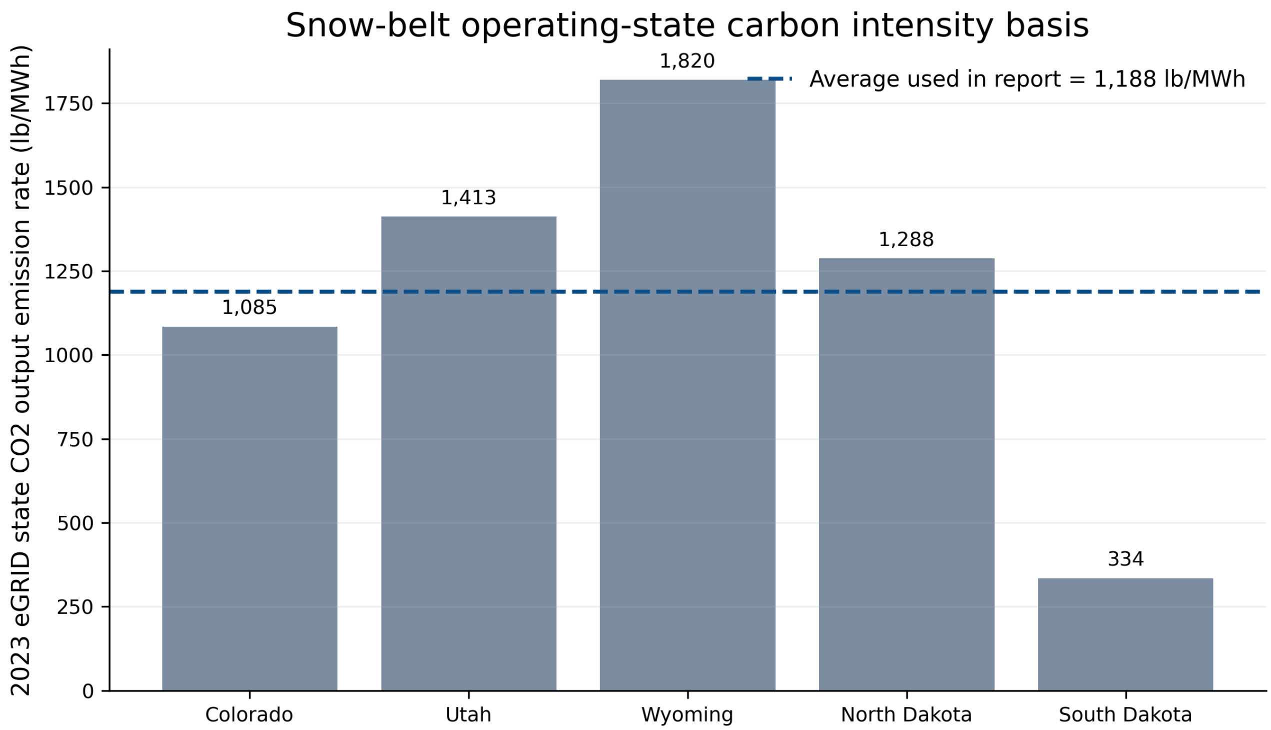

Figure 1. Snow-belt carbon basis used throughout the report. State CO2 output emission rates shown: Colorado 1,085 lb/MWh, Utah 1,413 lb/MWh, Wyoming 1,820 lb/MWh, North Dakota 1,288 lb/MWh, and South Dakota 334 lb/MWh. Average used in the report = 1,188 lb/MWh.

Figure 2. Lifetime energy impact across the full comparison set

On the representative-installation basis used here, Powder Watts leads the set with 399.2 lifetime MWh. The next-highest values come from the representative industrial motor case at 300.0 MWh, the residential solar PV case at 187.5 MWh, and the community-solar proxy at 150.0 MWh. Smaller control and plug-load measures remain important for broad adoption, but their unit-level lifetime energy impact is substantially lower.

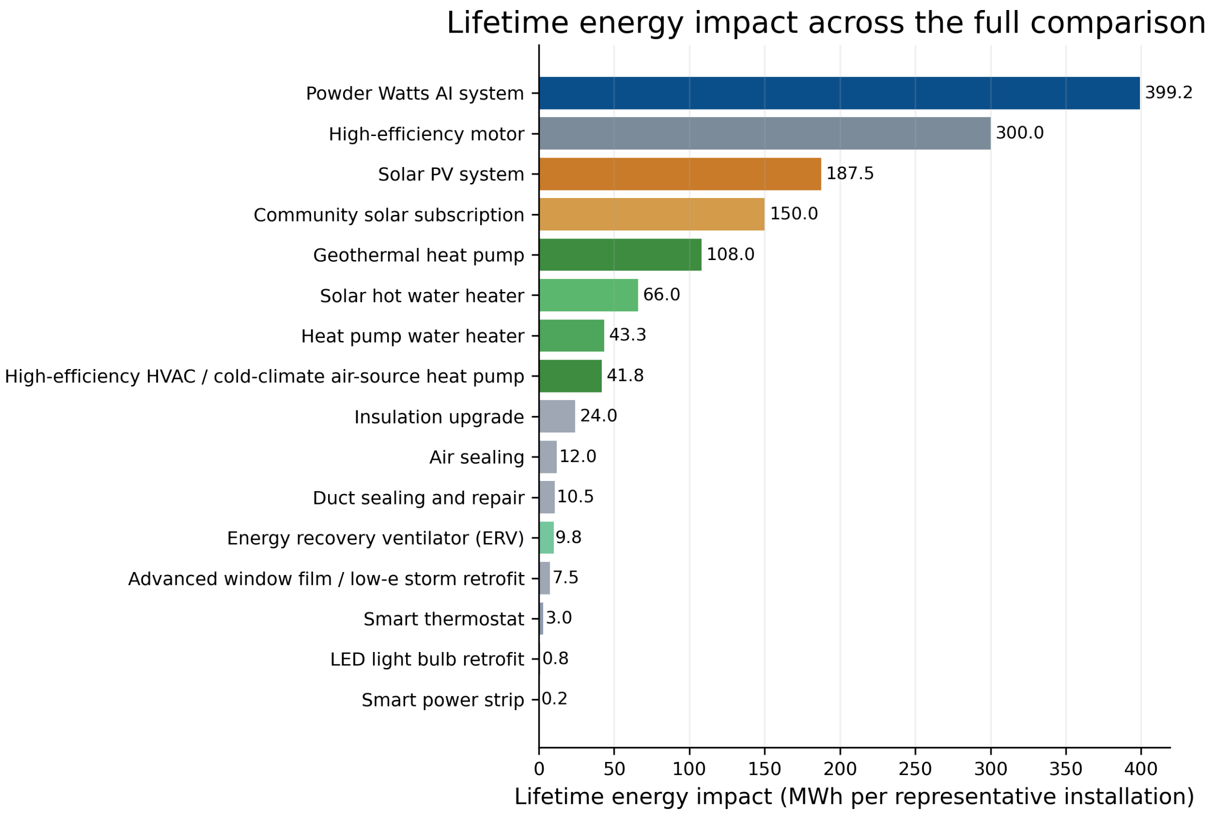

Figure 2. Lifetime energy impact per representative installation. Powder Watts leads because the representative primary-home case uses 3.5 switches per home and 7,603 kWh saved per switch-year.

Figure 3. Reference-case cost intensity

Cost values shown here are reference-case installed-cost assumptions for side-by-side comparison. They are not quoted bids, utility tariffs, or market-clearing procurement prices. The chart is useful because it reveals relative capital productivity under a common modeling framework. Under those assumptions, Powder Watts remains the strongest result at approximately $5.0 per lifetime MWh, followed by LED retrofits at $9.5 per MWh and the industrial motor case at $26.7 per MWh.

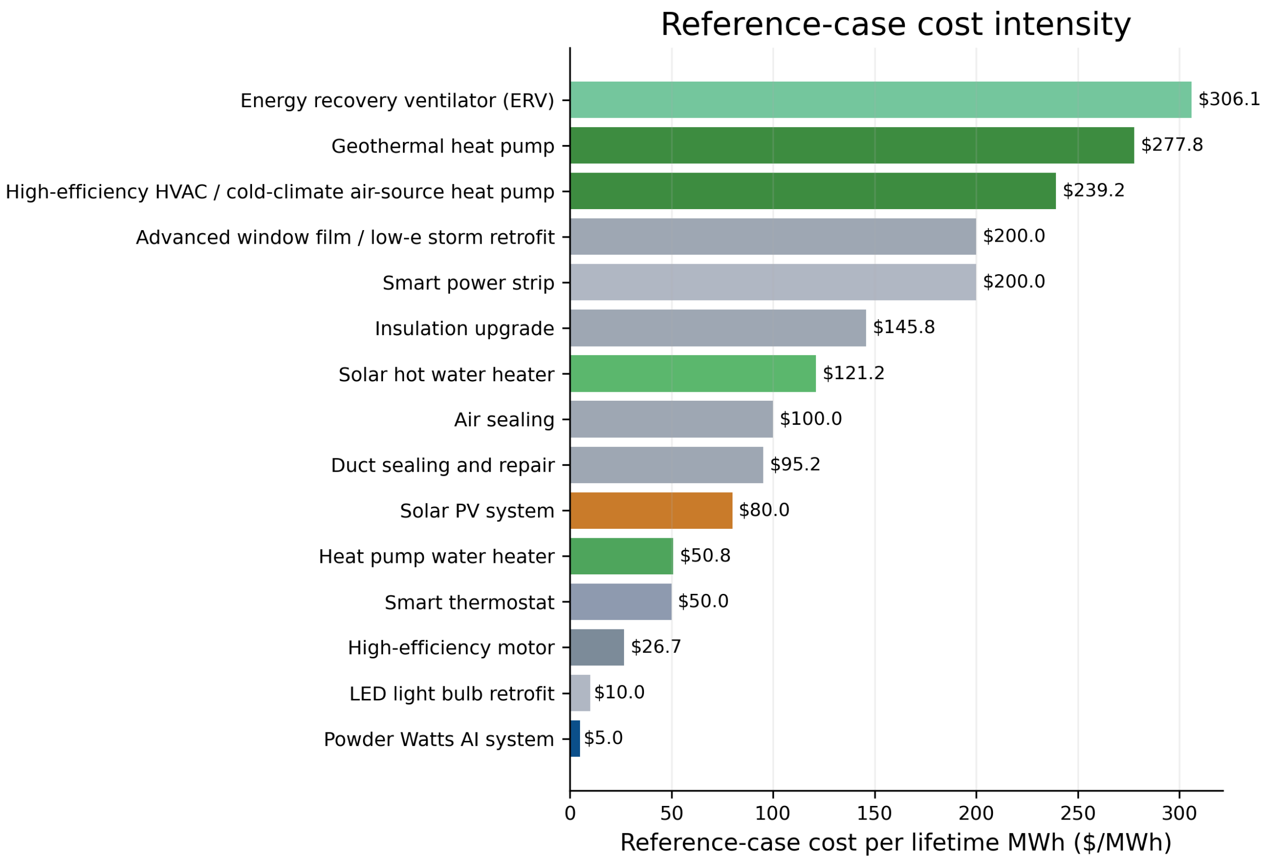

Figure 3. Reference-case cost per lifetime MWh. Community solar is excluded because no fixed upfront installed cost is assumed for the subscription case.

Figure 4. Lifetime avoided CO2 under the snow-belt grid factor

Because the report uses a snowy-state operating-grid factor rather than a U.S.-average carbon factor, electricity-saving measures demonstrate stronger avoided-carbon results than they would under a generic national model – reflecting actuals as closely as possible. The representative Powder Watts case yields 237.1 short tons of lifetime avoided CO2, ahead of the industrial motor case at 178.2 short tons and the residential solar PV case at 111.4 short tons.

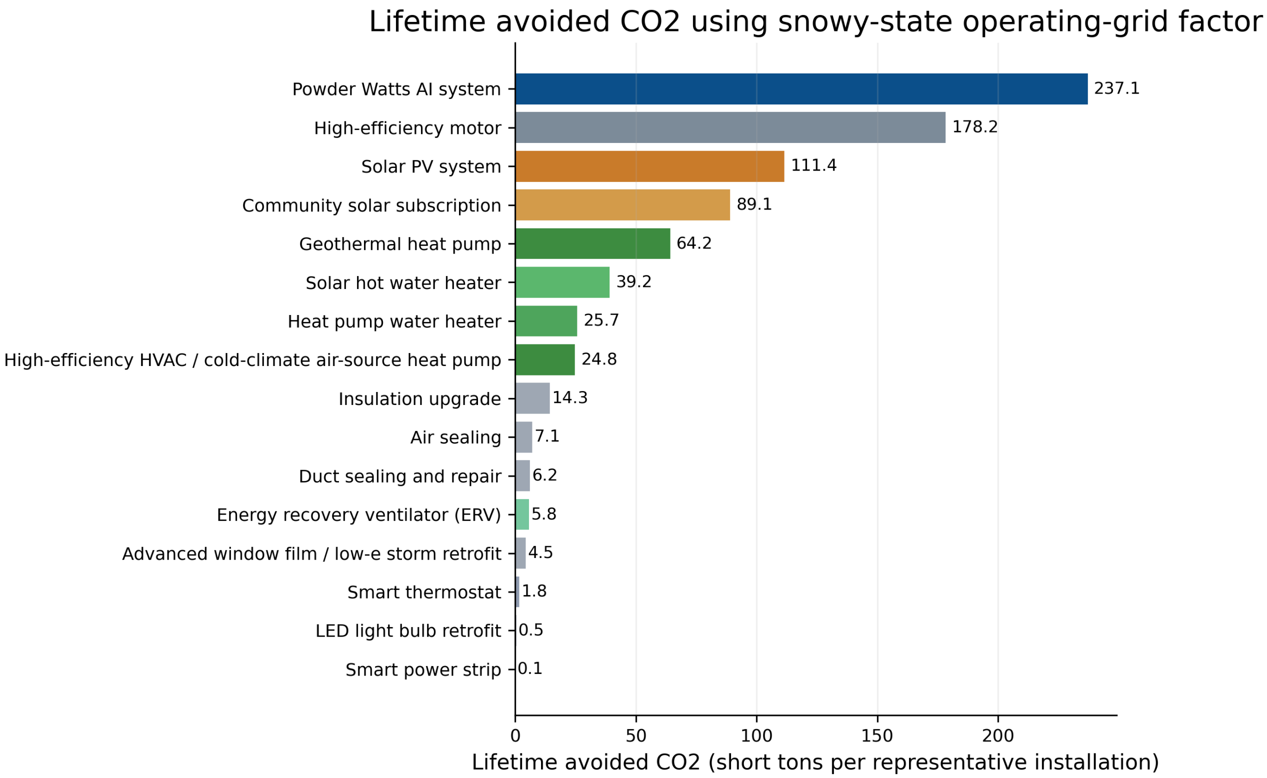

Figure 4. Lifetime avoided CO2 per representative installation using 1,188 lb/MWh as the report-wide carbon basis.

Figure 5. Carbon productivity of capital

For grant reviewers, utilities, and investors, the most useful single lens is often avoided CO2 per dollar deployed. That view combines engineering effect with capital efficiency. Under the reference-case assumptions, Powder Watts leads the costed set at 237.1 lb of avoided CO2 per invested dollar, materially above LED retrofits at 125.0 lb per dollar and the industrial motor case at 44.6 lb per dollar.

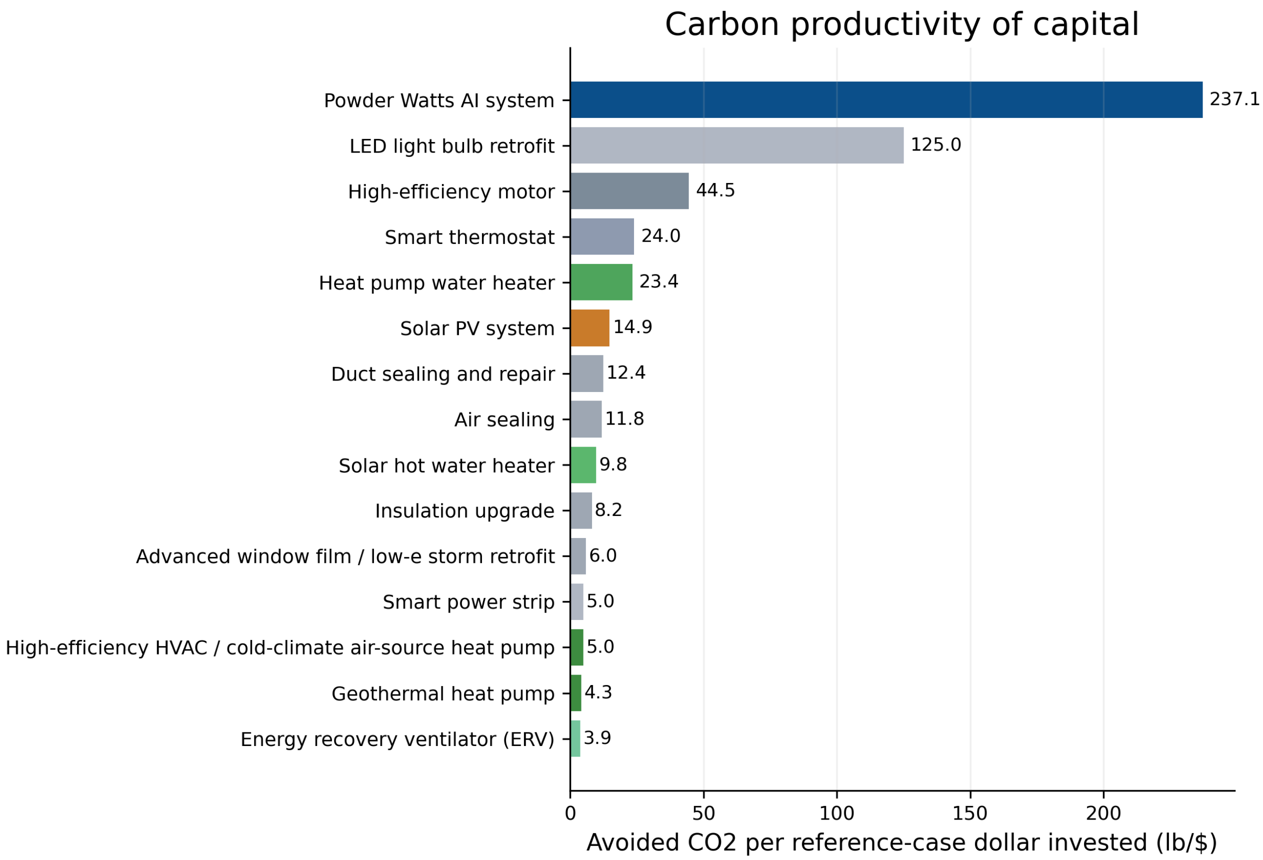

Figure 5. Carbon productivity of invested dollars. Values shown in lb of avoided CO2 per reference-case dollar invested.

Figure 6. Grid-value framing on an MW basis

The most important strategic point in the document is not simply that Powder Watts saves a large number of MWh at the home level. It is that the company's modeled resource converts an accredited megawatt of controlled load into a larger annual MWh yield than a megawatt of intermittent utility-scale solar while remaining shapeable during winter stress windows. Using a 26% utility-scale solar capacity factor produces a benchmark of 2,278 MWh per MW-year. The company winter-only Powder Watts model yields 4,633 MWh per MW-year, while the full-year model yields 5,146 MWh per MW-year.

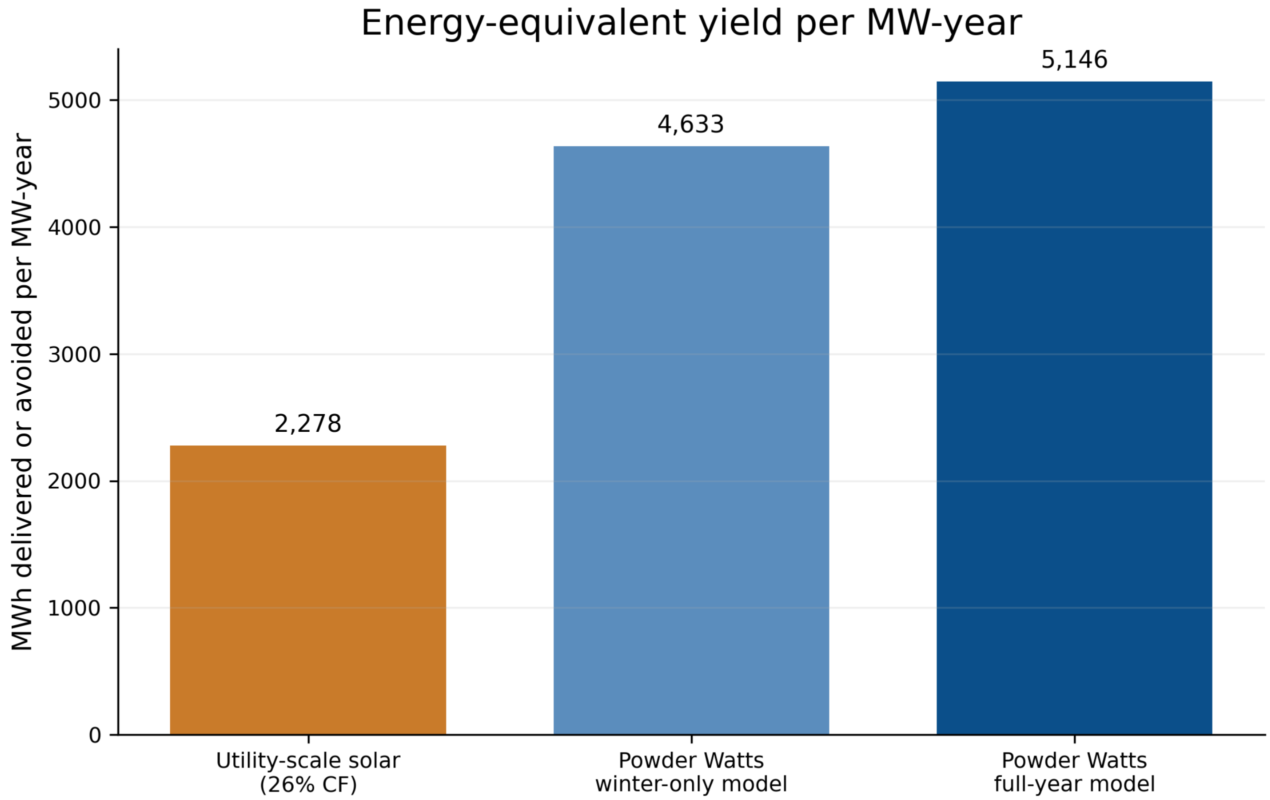

Figure 6. Energy-equivalent yield per MW-year. Utility-scale solar is shown at 26% capacity factor, inside the NREL 2024 ATB utility-scale PV range. Powder Watts winter-only and full-year values are company field-derived model inputs.

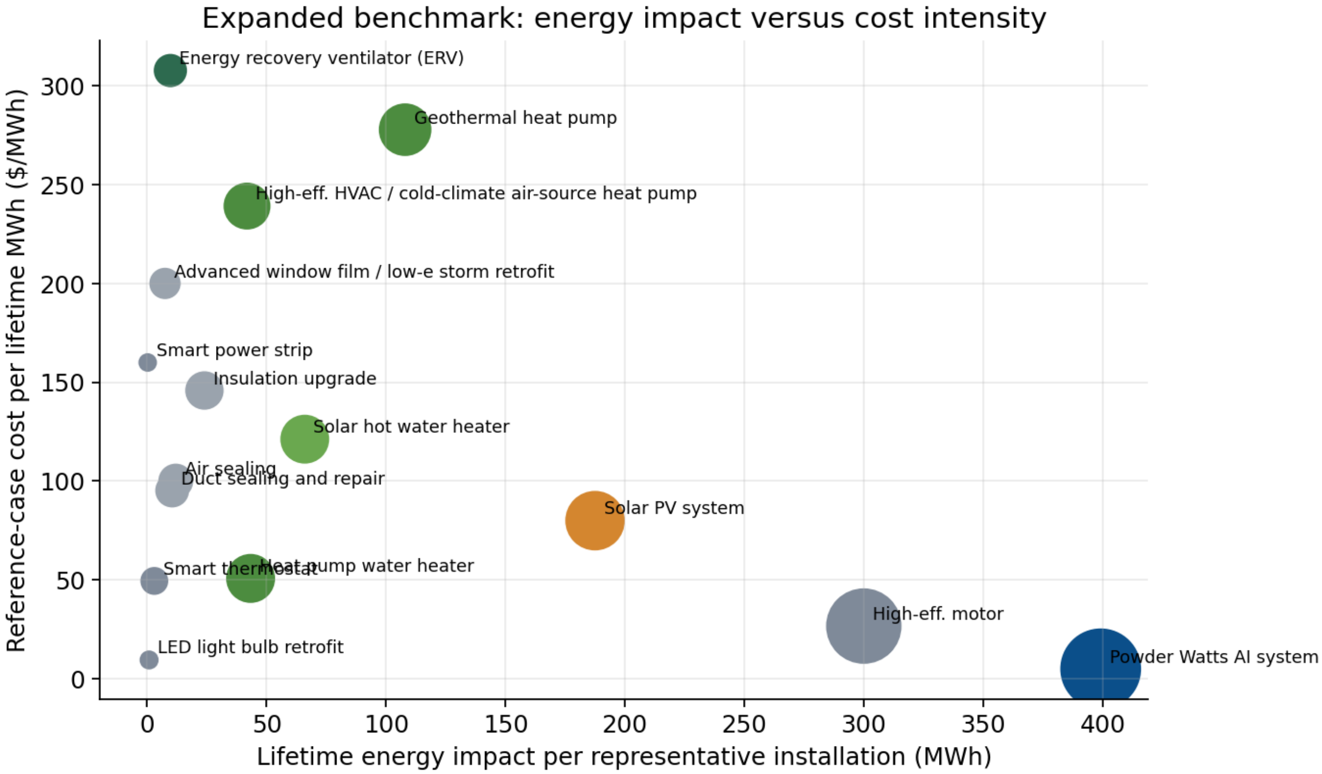

Figure 3. Expanded benchmark: lifetime energy impact versus cost intensity for the full retained set. Technologies far to the right deliver more lifetime MWh per representative installation; technologies lower on the chart have lower reference-case cost per lifetime MWh. Powder Watts sits in the lower-right corner because it combines very high avoided MWh with a low reference installed cost in the company model.[20]

From always-on winter load to utility-directed flexible load

The most important omission in fully understanding the complete value of Powder Watts' FlexiWatt is that a completely uncontrolled load not only becomes controlled, but is also able to shaped to meet utility needs. In practice that means that before the application of Powder Watts smart controls, a large fraction of circuits were energized 24/7 across the winter season, commonly modeled as **152 days**, and a meaningful share of commercial and second-home sites remain energized or inadvertently left available to run outside winter as well.[20]

Powder Watts changes the value proposition because the platform does not merely reduce annual kWh. It turns that unmanaged load into a **utility-shapeable demand-side resource**. If the utility needs peak relief, the load can be curtailed during the peak window and the melt deferred. If the grid has excess renewable output, the melt can be advanced into those hours instead. That is a different class of resource than a static efficiency retrofit.[17][18][20]

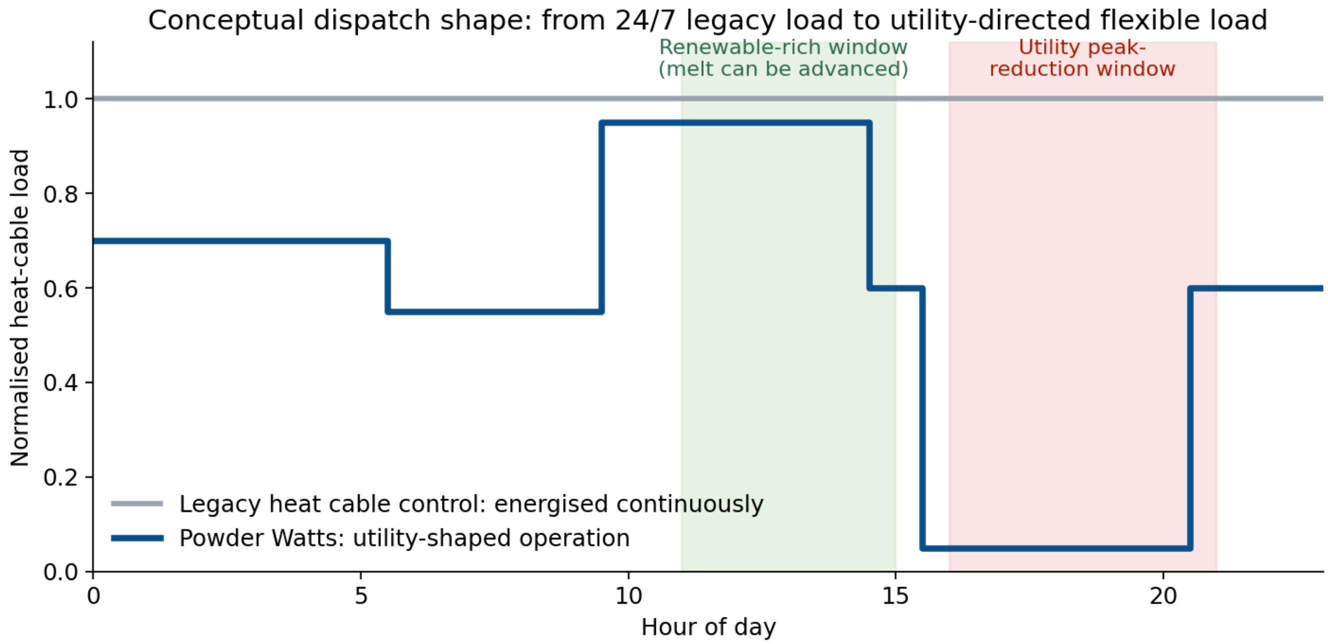

Figure 6. Conceptual dispatch shape. This is an engineering schematic, not a measured trace. It illustrates the specific operational claim relevant to Powder Watts: legacy heat-cable load that would otherwise sit on continuously can be moved into the hours the utility values, including renewable-rich windows and away from evening peaks.[17][20]

Comparative Table: All Technologies

The table below preserves the full technology family from the comparison set. Cases labeled as modeled assumptions are reference cases used to keep the review comprehensive; they are not presented as universal field averages.

Technology	Type	Annual impact (kWh)	Life (yr)	Lifetime (MWh)	Ref. cost ($)	$/MWh	Lifetime CO2 (short tons)
Smart thermostat	Controls	303	10	3.0	150	50.0	1.8
LED light bulb retrofit	Efficiency	56	15	0.8	8	10.0	0.5
Smart power strip	Efficiency	50	5	0.2	40	200.0	0.1
Advanced window film / low-e storm retrofit	Envelope	500	15	7.5	1,500	200.0	4.5
Air sealing	Envelope	800	15	12.0	1,200	100.0	7.1
Duct sealing and repair	Envelope	700	15	10.5	1,000	95.2	6.2
Insulation upgrade	Envelope	1,200	20	24.0	3,500	145.8	14.3
Solar PV system	Generation	7,500	25	187.5	15,000	80.0	111.4
Powder Watts AI system	Grid-edge Controls	26,611	15	399.2	2,000	5.0	237.1
Geothermal heat pump	HVAC	4,500	24	108.0	30,000	277.8	64.2
High-efficiency HVAC / cold-climate air-source heat pump	HVAC	2,788	15	41.8	10,000	239.2	24.8
Heat pump water heater	HVAC/Water Heating	3,333	13	43.3	2,200	50.8	25.7
High-efficiency motor	Industrial	20,000	15	300.0	8,000	26.7	178.2
Community solar subscription	Off-site Generation	7,500	20	150.0	—	—	89.1
Energy recovery ventilator (ERV)	Ventilation	650	15	9.8	3,000	306.1	5.8
Solar hot water heater	Water Heating	3,300	20	66.0	8,000	121.2	39.2

Interpretive Notes

- Community solar and on-site solar PV remain relevant for comparison because they are part of the broader decarbonization comparison set. Their inclusion is useful for framing energy and carbon pathways, but they are not direct load-reduction measures. The compare with Powder Watts in that they deliver grid capacity measured in terms of both MW and MWh. With Powder Watts's FlexiWatt enabling 10+ hour grid capacity support and scheduling of consumption tied to utility preference it delivers significantly higher firm capacity than solar. Solar is not considered firm capacity even during daylight hours due to cloud cover, and weak winter production.
- LED retrofits remain a highly effective unit-level efficiency measure. Their lower lifetime-MWh impact here is a function of comparison scale rather than a claim of technical weakness. Much of the LED opportunity has already been realized.
- Several envelope and ventilation cases rely on transparent modeled assumptions because public federal sources typically publish ranges, bill savings, or qualitative guidance rather than a single universal annual kWh figure.

- The Powder Watts case uses company-supplied field-derived operating inputs, including 3.5 switches per home, 7,603 kWh saved per switch-year for the representative primary-home case, and company MW-to-MWh yield values of 4,633 MWh per MW-year for the winter-only case and 5,146 MWh per MW-year for the full-year case.

References

[1] U.S. Energy Information Administration. 2020 Residential Energy Consumption Survey (RECS). 90% of U.S. households reported using LED bulbs for indoor lighting.

[2] U.S. Department of Energy, Energy Saver. LED Lighting. LEDs use up to 90% less energy and can last up to 25 times longer than incandescent lighting.

[3] ENERGY STAR. Smart Thermostat FAQ. Average savings are approximately 8% of heating and cooling bills, or about $50 per year.

[4] U.S. Department of Energy, Energy Saver. Why Energy Efficiency Matters. Reducing drafts through air sealing can save roughly 5% to 30% per year.

[5] U.S. Department of Energy, Energy Saver. Minimizing Energy Losses in Ducts. Duct design, sealing, insulation, and conditioned-space placement strongly affect HVAC losses.

[6] U.S. Department of Energy, Energy Saver and related DOE materials on windows and storm windows. Storm windows and low-e attachments can materially reduce heat loss; the representative window case in this report is a modeled reference assumption.

[7] U.S. Department of Energy, Energy Saver. Estimating the Cost and Energy Efficiency of a Solar Water Heater. Solar water heaters can reduce water-heating bills by about 50% to 80%.

[8] ENERGY STAR. Heat Pump Water Heater savings guidance. ENERGY STAR certified heat pump water heaters can save a household of four approximately $550 per year and use about 70% less energy than a standard electric water heater.

[9] U.S. Department of Energy, Energy Saver. Heat Pump Systems. Modern heat pumps can reduce electricity use for heating by up to 75% compared with electric resistance heating.

[10] U.S. Department of Energy, Energy Saver. Heat Pump Systems. High-efficiency geothermal heat pumps can use 61% less energy than a standard model.

[11] U.S. Department of Energy motor-systems guidance. Significant energy savings are available from efficient motor systems; the motor case in this report is a representative modeled small commercial / industrial example.

[12] U.S. Department of Energy, Energy Saver. Save Energy in Your Household With a Smart Power Strip. Smart power strips can cut standby consumption by shutting devices off when they enter standby mode.

[13] U.S. Department of Energy, Energy Saver. Whole-House Ventilation. Energy recovery ventilation systems provide controlled ventilation while minimizing energy loss and reducing winter heating and summer cooling costs.

[14] National Renewable Energy Laboratory. 2024 Annual Technology Baseline. Utility-scale PV and residential PV capacity-factor ranges used to frame the solar cases.

[15] U.S. Environmental Protection Agency. eGRID 2023 Summary Tables and Technical Guide. State CO2 output emission rates used for the snow-belt carbon basis.

[16] U.S. Energy Information Administration. Electric Power Monthly, Table 5.3. U.S. average residential electricity price in 2024 = 16.48 cents/kWh.

[17] U.S. Department of Energy. Community Solar resources. Community solar is included as an off-site generation and bill-savings pathway, not as a direct load-reduction technology.

[18] Powder Watts company field-derived model inputs supplied for the representative home case and MW-to-MWh yield calculations.