An Empirical Refutation of Green Energy Claims for Dyson and Xlerator Hand Dryers in Use in Public Restrooms

Ronald A. Blouch Jr.
December 2025
DOI: 10.5281/zenodo.17859198

AI Contribution Statement: The lifecycle calculations in this paper were independently verified by three large language models—Claude (Anthropic), ChatGPT (OpenAI), and Grok (xAI)—each working from primary sources without access to the others' outputs. The human author provided empirical drying time data, directed the analysis, and takes full responsibility for the conclusions.

Abstract

Hand dryer manufacturers and their certifying agencies claim dryers use 3-4 watt-hours and produce approximately 2 grams of CO_2 per individual hand drying cycle across the total life of the product. These claims are based on drying times of 8-12 seconds, claims made by the manufacturers and certified by testing and standards companies in the industry. Our empirical testing done with 430 individual trials completed on 29 unique dryers demonstrates that hands require 70-90 seconds to reach manufacturer-specified dryness levels—not 8-12 seconds. Zero units achieved compliance at claimed times. To ensure these calculations are defensible and free from confirmation bias, identical analyses were conducted independently by three AI systems. A conservative analysis (Claude, ChatGPT) using only manufacturer-commissioned lifecycle assessments shows dryers—when drying to manufacturers' own certified thresholds at verified times—use 25-37 Wh and produce 12-18 g CO_2 per use, 600%-900% and 500%-800% increases respectively. Claimed CO_2 advantages (85-90% reduction) collapse entirely—the products are statistically equivalent under conservative assumptions and dryers are 2-3× worse under expansive assumptions. A broader analysis (Grok) incorporating independent academic studies and primary energy accounting shows dryers produce 30-50 g CO_2 per use (1400%-2400%)—2-3× worse than paper towels (12-20 g). Claimed per-use energy advantages over paper towels are overstated (95%) but directionally accurate (~65% actual). Scaled globally, the discrepancy represents approximately 5.8-45 TWh of excess energy and 2.85-20 million metric tons of excess CO_2 annually—equivalent to powering 550,000 to 4.3 million American homes, or the annual carbon output of entire nations ranging in size from Iceland to Mongolia.

This paper is part of an eleven-study series examining hand hygiene practices in public restrooms. The papers were written in chronological order as testing evolved. Earlier papers are left largely as they were written at the time for detail, historicity, and clarity. Studies in this series may be referenced in each document by series number (Paper 1-11) or by citation number in the reference list:

Transmission of Bacteria and Fungus via Dyson and Xlerator Hand Dryers in Starbucks, Home Depot and Whole Foods Restrooms: A Comparative Analysis; Blouch, R. A. Jr. (2025) MAIN STUDY [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.15504115 PAPER [1]

Testing the Validity of Hand Dryer Drying Time Specifications: A Quantitative Study of Residual Water on Dyson and Xlerator Dryers in Retail Store Environments; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.15503698 PAPER [2]

Visual Analysis of Water Dispersion Patterns During Hand Drying: A Qualitative Comparison of High-Speed Air Dryers and Paper Towels; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.15503304 PAPER [3]

Bacterial and Fungal Contamination Assessment of Paper Towel Types: A Quantitative Analysis of White versus Brown Varieties in Retail Restrooms; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.15504144 PAPER [4]

Systematic Performance Failure in Commercial Hand Dryers: A Large-Scale Quantitative Analysis of Time-To-Dry on Hands in Dyson and Xlerator Hand Dryers in Public Restrooms; Blouch, R.A Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17858443 PAPER [5]

Baseline Water Mass on Freshly Washed Hands: Establishing Reference Values; Blouch R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17858834 PAPER [6]

An Empirical Refutation of Green Energy Claims for Dyson and Xlerator Hand Dryers in Use in Public Restrooms; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17859198 PAPER [7]

Catastrophic Time-To-Dry Failures by Dyson, Excel and World Dryer Hand Dryers via the Bi-Modal Loose Water and Bound Water Mechanism: A Comprehensive Definitive Analysis; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17869567 PAPER [8]

Validation of Hand Dryer Microbial Amplification Using Broad-Spectrum Growth Media: A Replication Study with Enhanced Detection Methodology; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17859894 PAPER [9]

The Wandering Plume of Filth: A Randomized, Empirical Assessment of Visible Wall Contamination Radiating from Commercial Hand Dryers Versus Paper Towel Dispensers in Functioning Public Restrooms; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17860971 PAPER [10]

Performance Failures in Commercial Hand Dryers: An Historical Synthesis and Sequential Summary Review of an Eleven-Study Research Program; Blouch, R. A. Jr. (2025) [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.18322481 PAPER [11]

1. Introduction

Every energy and environmental claim made by hand dryer manufacturers is conditional on a single assumption: that hands reach specified dryness thresholds in 8-12 seconds. The number of hands that have reached specified moisture levels of 0.25g or 0.1g within claimed dry times of 15 seconds or less in production hand dryers is zero. [15]

Life cycle assessments (LCAs) evaluate environmental impact across a product's lifespan. For hand dryers, use-phase electricity consumption dominates total lifecycle impact at 87-92% of cradle-to-grave emissions [1]. Use-phase consumption equals power multiplied by time. If operating time assumptions are wrong, all downstream calculations inherit that error.

1.1 Manufacturer Claims and Certification Standards

Manufacturers and certification bodies specify precise dryness thresholds: Dyson specifies ≤0.1g residual moisture per NSF P335 standard [13, NSF, 2016]. Excel/XLERATOR specifies ≤0.25g residual moisture per the UL Product Category Rules for Hand Dryers [3, UL, 2016]. Claimed dry times are 8 seconds for XLERATOR and 12 seconds for the Dyson Airblade V.

1.2 Empirical Testing Program

Two independent studies comprising 430 total trials documented systematic failure to dry hands in the allotted time 100% of the time.

Study 1 (21 trials) [9, Blouch, 2025]: Hands retained 2.83g average residual moisture at manufacturer-specified times— exceeding thresholds by mean 1,086% and mean 2,590% ($p < 0.001$).

Study 2 (409 trials) [10, Blouch, 2025]: Extended time-series testing confirmed total systematic failure at claimed drying times. Hands retained 2.29g-3.02g residual moisture (1,048% to 2,190% above thresholds, $p < 0.001$).

Study 3 (30 trials) [15, Blouch 2025]: Catastrophic Time-To-Dry Failures by Dyson, Excel and World Dryer Hand Dryers via the Bi-Modal Loose Water and Bound Water

Mechanism: A Comprehensive Definitive Analysis; Third manufacturer claimed dry time and time-to-dry tests with a prior prediction of the outcome amplified prior result certainty to

Rate Constants

$k_1 = 0.456\ s^{-1}$ (loose water)

$k_2 = 0.059\ s^{-1}$ (bound water)

Rate ratio: $k_1/k_2 = 7.7\times$

Correlation (r):

$R^2 = 0.9998$ for the bi-exponential model

$r > 0.99$ across all pairwise manufacturer comparisons (Dyson/Xlerator/World Dryer)

$r = 0.998$ when backtracking through prior raw data sets

P-values:

$p < 0.001$ for cross-manufacturer convergence (pre-registered prediction)

$p < 0.000000001$ for joint probability of three-manufacturer convergence occurring by chance

Compliance rate at manufacturer-claimed times is 0%. Best case individual trial 744% above threshold. Worst case individual trial 3,540% above threshold.

1.3 Time Required to Dry

Study 2 (409 trials) [10, Blouch, 2025] was designed specifically to determine not how much water remains on hands at the claimed times but how long it actually takes for dryers to reach their own claimed residual moisture thresholds.

Xlerator dryers claim 8-second dry times to 0.25g residual moisture. The first Xlerator Standard dryer trial to reach compliance was 50 seconds—more than 6× the claimed time. Consistent compliance across all trials required 80 seconds. Xlerator ECO performed worse: first compliance at 70 seconds, consistent compliance at 80 seconds ($p<.001$). Further, Xlerator dryers were entirely incapable of reaching the NSF <0.1g of residual water standard in all trials attempted, maximum 105 seconds.

Dyson claims a 12-second dry time to a 0.1g threshold. The first Dyson trial to achieve compliance required 80 seconds. Consistent compliance was never achieved—even at

105 seconds (the longest interval tested), mean residual moisture remained at or above the 0.1g threshold. ($p<0.001$)

Dryer Model	Claimed	Threshold	First Pass	Consistent	Multiplier
Xlerator Standard	8 sec	0.25g	50 sec	80 sec	8.75-10×
Xlerator ECO	8 sec	0.25g	70 sec	80 sec	8.75-10×
Dyson Airblade V	12 sec	0.1g	80 sec	Never	7.5×+

Table 2. Time to specification compliance. "First Pass" = earliest trial achieving threshold. "Consistent" = all trials at that interval achieving threshold. All comparisons $p < 0.001$.

For the energy and CO_2 calculations that follow, we use 70 seconds for Xlerator (8.75× the 8-second claim) and 90 seconds for Dyson (7.5× the 12-second claim). These values are conservative. Xlerator Standard achieved first compliance at 50 seconds but required 80 seconds for consistent compliance; 70 seconds represents a middle estimate. For Dyson, consistent compliance was never achieved at any interval tested—90 seconds is generous.

2. Methods

2.1 Multi-AI Verification Methodology

To ensure the energy and CO_2 calculations that follow are defensible and free from confirmation bias, identical questions were posed independently to three large language models—Claude (Anthropic), ChatGPT (OpenAI), and Grok (xAI). Each was instructed to work from primary sources without access to the others' outputs.

The goal was triangulation: where the models converge, confidence is high. Where they diverge, the methodological reason is identified—and both results are reported. This section explains the two analytical tracks so the reader can properly interpret the ranges presented throughout this paper.

2.2 The Conservative Track (Claude and ChatGPT)

Claude was instructed to build his analysis exclusively from manufacturer-commissioned, third-party verified lifecycle assessments. ChatGPT was given latitude to source from anywhere but chose on his own to use manufacturer-commissioned, third-party verified lifecycle assessments. The logic: use the manufacturers' own certified data to refute their own claims. One AI started from those principles, the other arrived there by himself. No external assumptions were introduced.

Sources: TrueNorth Collective LCA [1, TrueNorth, 2023], commissioned by Excel Dryer, ISO 14040/14044 verified; SmartEPD Environmental Product Declaration for XLERATOR [2, Excel Dryer, 2023]; Dyson Carbon Trust Product Footprint Certification [4, Dyson, n.d.]; UL Product Category Rules for Hand Dryers [3, UL, 2016].

Method: Scale the use-phase (B1) emissions by the empirical time multiplier (7-10×) while holding non-use phases constant. This follows the LCAs' own methodology—changing only the input parameter (dry time) that was empirically falsified.

Key finding: Hand dryers at actual times produce 12-18 g CO_2 per use, roughly equivalent to paper towels (17-19.5 g). The claimed 90% advantage collapses to ~0-18%—within typical LCA uncertainty (±20-30%). The products are statistically indistinguishable.

2.3 The Expansive Track (Grok)

Grok was instructed to conduct a wide source search and incorporated independent academic LCAs and used full ISO 14044 methodology, including primary energy accounting.

Additional sources: MIT Materials Systems Laboratory [5, MIT, 2011]; Swedish University of Agricultural Sciences [6, Swedish University, 2023]; Joseph et al. [7, Joseph et al., 2015].

Method: Average across sources to reduce manufacturer-funding bias. Use primary energy (MJ) rather than wall electricity to account for grid generation and transmission losses (~3× factor) per full ISO 14044 lifecycle standards.

Key finding: Hand dryers at actual times produce 30-50 g CO_2 per use, versus 12-20 g for paper towels. Dryers are 2-3× worse than the product they claim to replace.

2.4 Why the Tracks Diverge

Factor	**Conservative**	**Expansive**
Sources	Manufacturer LCAs only	+ Independent academic
Energy metric	Wall electricity (Wh)	Primary energy (MJ)
Grid losses	Excluded	Included (~3× factor)
Dryer CO_2 at actual time	12-18 g	30-50 g
vs. Paper Towels	≈ Equivalent	2-3× Worse

Table 3. Methodological differences explain the range in results. Both tracks agree the claimed 90% advantage does not exist.

The divergence is methodological, not contradictory. Both tracks agree that manufacturer claims are false. The conservative track establishes this as a floor (at minimum, products are equivalent). The expansive track suggests the ceiling may be substantially worse. All calculations that follow present both ends of this range.

3. Results

3.1 Energy Consequences

Energy consumption is power multiplied by time. When time increases 7-10×, energy increases 7-10×. The math is inescapable—the only question is which energy metric to use.

3.1.1 Wall Electricity (Conservative)

XLERATOR (1,450W rated power): Claimed (8 sec): 1,450W × 8s ÷ 3,600 = 3.22 Wh. Actual (70 sec): 1,450W × 70s ÷ 3,600 = 28.2 Wh.

Dyson Airblade V (1,000W rated power): Claimed (12 sec): 1,000W × 12s ÷ 3,600 = 3.33 Wh. Actual (90 sec): 1,000W × 90s ÷ 3,600 = 25.0 Wh.

3.1.2 Primary Energy (Expansive)

Primary energy accounts for losses in electricity generation and transmission. The US grid operates at approximately 33% efficiency (3× factor) [11, EPA, 2024]. Per ISO 14044 full lifecycle methodology:

XLERATOR actual: 28.2 Wh × 3 = ~85 Wh primary (0.30 MJ). Dyson actual: 25.0 Wh × 3 = ~75 Wh primary (0.27 MJ).

Scenario	**Wall (Wh)**	**Primary (Wh)**	**×**
Claimed (8-12 sec)	3.2-3.3	~10	—
Actual (70-90 sec)	25-28	75-85	7-10×

Table 4. Energy consumption at claimed versus actual drying times, showing both wall electricity (conservative) and primary energy (expansive).

3.2 Why This Matters

Manufacturer-commissioned LCAs confirm that use-phase electricity dominates total environmental impact (87-92% of lifecycle) [1, TrueNorth, 2023]. The time discrepancy therefore propagates directly to total lifecycle impact. This is not a minor adjustment—it is the controlling variable.

3.3 CO_2 Consequences

Carbon emissions from hand dryers are dominated by electricity consumption. The range in CO_2 estimates (12-50 g at actual times) reflects the methodological choices described in Part 2.

3.4 Conservative Estimate (Manufacturer LCA Data)

Following TrueNorth LCA methodology [1, TrueNorth, 2023]—scaling B1 by the time multiplier while holding non-use phases constant:

XLERATOR: Claimed (8s): 2.05 g CO_2e per use (verified from TrueNorth). Actual (70s): B1 scaled 8.75× + fixed non-use = 15.9 g CO_2e.

Dyson: Claimed (12s): 2.1 g CO_2e per use (verified from Carbon Trust [4, Dyson, n.d.]). Actual (90s): Use-phase scaled 7.5× + fixed non-use = ~14.7 g CO_2e.

3.5 Expansive Estimate (Independent + Primary Energy)

Averaging independent academic studies [5, MIT, 2011; 6, Swedish University, 2023; 7, Joseph et al., 2015] with manufacturer data, using primary energy and US grid average (0.4 kg CO_2/kWh):

Claimed (8-12s): 4-10 g CO_2e per use. Actual (70-90s): 30-50 g CO_2e per use.

Scenario	Conservative	Expansive	Range
Dryer at claimed time	~2 g	4-10 g	2-10 g
Dryer at actual time	12-18 g	30-50 g	12-50 g

Table 5. CO_2 emissions per use showing conservative (manufacturer LCA) and expansive (independent + primary energy) estimates.

3.6 The Paper Towel Comparison

The preceding analysis establishes that hand dryers consume 7-10× more energy and produce 6-9× more CO_2 than manufacturers claim. The critical question: how does this compare to the alternative they claim to replace?

3.7 Paper Towel Lifecycle CO_2

From verified sources [1, TrueNorth, 2023; 5, MIT, 2011; 6, Swedish University, 2023], paper towel lifecycle emissions for two towels per use (approximately 4g total for typical commercial restroom towels):

Conservative (TrueNorth): 17.2-19.5 g CO_2e (recycled to virgin).

Expansive (averaged independents): 12-20 g CO_2e.

3.8 The CO_2 Comparison

Hand dryers at actual drying times (12-18 g conservative; 30-50 g expansive) produce CO_2 emissions equal to or greater than paper towels (12-20 g). Manufacturers claimed an 85-90% CO_2 advantage; no such advantage exists. The products are statistically equivalent under conservative assumptions and dryers are 2-3× worse under expansive assumptions.

3.9 Paper Towel Lifecycle Energy

From the same verified sources, paper towel embodied energy derives from raw material extraction, pulping, manufacturing, transportation, and disposal. Environmental Product Declaration data indicates approximately 19-20 Wh per gram of tissue product [6]. For two towels (4g total): approximately 75-80 Wh per use.

3.10 The Energy Comparison

Hand dryers at actual drying times (25-28 Wh) consume less total lifecycle energy than paper towels (~75-80 Wh). Manufacturers claimed a 95% energy advantage; the actual advantage is approximately 65%. The energy claim is overstated but directionally accurate.

Table 6. Lifecycle comparison at actual drying times. Energy favors dryers; CO_2 does not.

Metric	Paper Towels (4g)	Dryer (Claimed)	Dryer (Actual)
Energy (Wh)	75-80	3-4	25-28
CO_2 - Conservative (g)	17-19.5	~2	12-18
CO_2 - Expansive (g)	12-20	4-10	30-50

4. Discussion

4.1 Why Energy and CO_2 Tell Different Stories

The divergence between energy and CO_2 comparisons reflects the carbon intensity of different energy sources. Paper towel manufacturing derives 40-60% of process energy from biomass combustion (lignin and wood waste). Under ISO 14040/14044 lifecycle accounting standards, biogenic carbon is classified as carbon-neutral because it was recently sequestered from the atmosphere during tree growth. This energy contributes to lifecycle energy totals but not to fossil CO_2 emissions.

Hand dryers consume 100% grid electricity, which carries full carbon intensity (~0.4 kg CO_2/kWh US average). The result: paper towels have higher total lifecycle energy but substantially lower carbon intensity per unit of energy consumed.

4.2 The Bottom Line

Hand dryer environmental marketing has centered on CO_2 reduction—claims of 85-90% lower carbon footprint than paper towels. This is the justification cited in LEED applications, corporate sustainability reports, and procurement decisions.

There is no CO_2 advantage. At empirically-verified drying times CO_2 values between dryers and paper towels are equal at best and likely as much as three times worse. The conservative analysis—using only manufacturer-commissioned, third-party verified data—shows the products are statistically equivalent. The expansive analysis—incorporating independent academic sources—shows dryers may produce 2-3× the CO_2 of paper towels.

Facilities that replaced paper towels with hand dryers based on environmental claims achieved no measurable CO_2 benefit and may have done great environmental harm.

4.3 LEED Certification False Claims

The false energy claims propagate into building certification systems, affecting over 100,000 LEED-certified projects worldwide.

Excel Dryer's official LEED v4.1 Credit Contribution document [8, Excel Dryer, 2021] instructs:

> *"Project teams may input 3.68 Wh per 8 second cycle use and 3.74 VA non-use average standby mode power consumption for energy modelling purposes."*

This instruction directs teams to use energy data based on 8-second drying times that achieve 0% empirical compliance. Every LEED-certified building using this guidance contains false energy calculations.

Metric	**LEED Input**	**Empirical Reality**
Energy per use	3.68 Wh	25-85 Wh
Understatement	—	7-23×

Table 7. LEED energy modeling instructions versus empirical reality (range reflects conservative to expansive methodologies).

4.4 Global Impact Usage Estimates

The per-use discrepancy, applied to population-scale usage, produces staggering cumulative waste.

Based on market analysis [12, Mordor Intelligence, 2025]: U.S. installed base: 1.5-15 million units (conservative to expansive). Annual uses (U.S.): 55-550 billion. Global annual uses (U.S. = 20-25% of market): 220 billion - 2.2 trillion.

Annual Global Impact	**Conservative**	**Expansive**
Excess energy	~5.8 TWh	~45 TWh
Excess CO_2	~2.85 million t	~20 million t
U.S. homes equivalent	~550,000	~4.3 million
National CO_2 equivalent	Iceland	Mongolia

Table 8. *Annual global impact of the gap between claimed and actual hand dryer performance.*

At minimum, the global hand dryer discrepancy wastes enough electricity to power over half a million American homes and produces CO_2 equivalent to Iceland's entire annual emissions. At maximum, it approaches the electricity consumption of a mid-sized European country and the carbon output of Mongolia. This waste occurs annually, in perpetuity, based on a marketing claim that was never true.

5. Conclusion

This analysis demonstrates that hand dryer energy and environmental claims made by manufacturers and certifying bodies are false. Three independent AI systems, working from primary sources through different methodological paths, converge on the same conclusion:

1. Timing claims are false. Zero of 430 tested units achieved manufacturer-specified dryness at claimed times. Actual time-to-dry is 7-10× longer. The downstream effect of the false dry time claims drives actual versus claimed energy use.
2. Energy claims are false. Actual consumption is 25-85 Wh per use (depending on methodology), not 3-4 Wh.
3. CO_2 claims are false. Actual emissions are 12-50 g per use, not ~2 g.
4. In the best case, hand dryers operated until hands reach manufacturer-certified dryness thresholds are environmentally equivalent to paper towels—not 95% cleaner as claimed. In the worst case they are 2-3× worse.

Millions of dryer owners and users have relied on these claims to make informed decisions regarding the purchasing and use of hand dryers creating a vast previously unseen impact on the public health and the environment.

6. References

1. [1] TrueNorth Collective. (2023). Comparative Life Cycle Assessment of Hand Drying Systems: Excel Hand Dryers and Paper Towel Systems. Prepared for Excel Dryer, Inc. ISO 14040/14044 compliant. Retrieved from https://www.exceldryer.com/wp-content/uploads/2023/07/Excel-Hand-Dryer-Life-Cycle-Assessment-LCA.pdf

2. [2] Excel Dryer. (2023). Environmental Product Declaration: XLERATOR Hand Dryer, 120V (SmartEPD-2023-002-0006-01). EPD Program Operator: SmartEPD. Retrieved from https://www.exceldryer.com/wp-content/uploads/2023/07/EPD-XLERATOR.pdf

3. [3] Underwriters Laboratories. (2016). Product Category Rule for Preparing an Environmental Product Declaration (EPD) for the Product Category: Hand Dryers (UL PCR v.1). Document ULE_HandDryer_PCR_7-13-16. Effective July 13, 2016.

4. [4] Dyson. (2021). Carbon Trust Product Footprint Certification: Airblade Hand Dryers (Certificate CERT-13192). Verified in accordance with PAS 2050:2011 and ISO 14067. Retrieved from https://www.dyson.com/commercial/hand-dryers/sustainability-for-business

5. [5] Montalbo, T., Gregory, J., & Kirchain, R. (2011). Life Cycle Assessment of Hand Drying Systems. Materials Systems Laboratory, Massachusetts Institute of Technology. Commissioned by Dyson, Inc. Retrieved from http://msl.mit.edu/publications/HandDryingLCA-Report.pdf

6. [6] Reference Withdrawn

7. [7] Joseph, T., Baah, K., Jahanfar, A., & Dubey, B. (2015). A comparative life cycle assessment of conventional hand dryer and roll paper towel as hand drying methods. Science of the Total Environment, 515-516, 109-117.

8. [8] Excel Dryer, Inc. (2021). XLERATOR Hand Dryer LEED v4.1 Credit Contribution (Document XLT1006). Retrieved from https://www.exceldryer.com/sustainability/

9. [9] Blouch, R. A. Jr. (2025). Testing the Validity of Hand Dryer Drying Time Specifications: A Quantitative Study of Dyson and Xlerator Dryers in Retail Store Environments. [Preprint] Retrieved from www.handdryerstudy.com/. https://doi.org/10.5281/zenodo.15503698

10. [10] Blouch, R. A. Jr. (2025). Systematic Performance Failure in Commercial Hand Dryers: A Large-Scale Quantitative Analysis of Time-To-Dry on Hands in Dyson and Xlerator Hand Dryers in Public Restrooms. [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17858443

11. [11] U.S. Environmental Protection Agency. (2024). Emissions & Generation Resource Integrated Database (eGRID). https://www.epa.gov/egrid

12. [12] Mordor Intelligence. (2025). U.S. Hand Dryers Market Size & Share Analysis – Industry Research Report – Growth Trends. Retrieved from https://www.mordorintelligence.com/industry-reports/us-hand-dryers-market

13. [13] NSF International. (2007). NSF Protocol P335: Hygienic Commercial Hand Dryers. Ann Arbor, MI: NSF International. Retrieved from https://info.nsf.org/Certified/Protocols/

14. [14] Essity Australasia. (2019, revised 2023). Environmental Product Declaration: Tork Hand Towels and Handee Paper Towels. EPD Australasia. Retrieved from https://epd-australasia.com/epd/tork-hand-towels/

15. [15] Blouch, R. A. Jr. (2025). Catastrophic Time-To-Dry Failures by Dyson, Excel and World Dryer Hand Dryers via the Bi-Modal Loose Water and Bound Water Mechanism: A Comprehensive Definitive Analysis. [Preprint] Retrieved from www.handdryerstudy.com/. DOI: 10.5281/zenodo.17869567

Full series available at: www.handdryerstudy.com

Appendix A: Multi-AI Verification of Hand Dryer Lifecycle Energy and CO_2 Calculations

Abstract

This appendix documents the independent verification of hand dryer energy and CO_2 calculations by three large language model systems: Claude (Anthropic), ChatGPT (OpenAI), and Grok (xAI). Each system was provided identical empirical drying time data and instructed to calculate cradle-to-grave energy consumption and CO_2 emissions using primary sources without access to the others' outputs. All three systems confirmed that manufacturer-specified drying times produce systematic non-compliance with stated dryness thresholds, resulting in actual energy consumption of 25-28 Wh per use (versus 3-4 Wh claimed) and CO_2 emissions of 12-18 g per use (versus ~2 g claimed). The convergence of independent analyses using different methodological approaches establishes the robustness of these findings.

1. Introduction

Hand dryer manufacturers publish energy and CO_2 specifications based on drying times of 8-12 seconds [2, Excel Dryer, 2023; 4, Dyson, n.d.]. Empirical testing across 430 trials demonstrated that these drying times do not achieve manufacturer-specified dryness thresholds, with actual times to compliance ranging from 70-90 seconds [9, Blouch, 2025; 10, Blouch, 2025]. This time differential has direct implications for energy consumption and CO_2 emissions.

To ensure calculation accuracy and eliminate confirmation bias, identical analytical tasks were assigned to three independent AI systems. This appendix presents the methodology, individual results, points of convergence and divergence, and reconciled findings.

2. Methods

2.1 AI System Selection

Three large language models were selected to represent different training approaches and organizational perspectives: Claude (Anthropic), ChatGPT (OpenAI), and Grok (xAI). Each system has demonstrated capability in technical analysis and access to web-based primary sources.

2.2 Task Specification

Each system was instructed to:

(a) Calculate cradle-to-grave energy (Wh) and CO_2 (g) per hand-drying event for electric hand dryers at manufacturer-claimed drying times (8-12 seconds)

(b) Calculate the same metrics at empirically-measured drying times (70-90 seconds)

(c) Calculate equivalent metrics for two paper towels per drying event

(d) Use manufacturer-published lifecycle assessment data and third-party verified sources

(e) Work independently without access to other systems' outputs

2.3 Empirical Input Data

All systems received identical empirical drying time data from two studies:

Study 1 [9, Blouch, 2025]: 21 trials across Dyson and XLERATOR units. Mean residual moisture at claimed times: 2.83g. Threshold exceedance: 1,086-2,590%. Compliance rate: 0%.

Study 2 [10, Blouch, 2025]: 409 trials across Dyson, XLERATOR, and World Dryer units. Mean residual moisture at claimed times: 2.29-3.02g. Threshold exceedance: 1,048-2,190%. Compliance rate: 0%. Time to first compliance: 50-80 seconds. Time to consistent compliance: 70-90+ seconds.

2.4 Primary Sources Identified by AI Systems

The AI systems independently identified and utilized the following primary sources:

• TrueNorth Collective (2023). Comparative Life Cycle Assessment of Hand Drying Systems [1, TrueNorth, 2023]

• Excel Dryer SmartEPD Environmental Product Declaration [2, Excel Dryer, 2023]

• Dyson Carbon Trust Product Footprint Certification [4, Dyson, n.d.]

• Essity Environmental Product Declaration for Tork Paper Towels [14, Essity, 2023]

• MIT Materials Systems Laboratory Life Cycle Assessment (2011) [5, MIT, 2011]

• Swedish University of Agricultural Sciences (2023) [6, Swedish University, 2023]

• US EPA eGRID Emissions Database (2024) [11, EPA, 2024]

3. Results

3.1 Claude (Anthropic) Analysis

3.1.1 Sources

Claude utilized the TrueNorth Collective LCA [1, TrueNorth, 2023], SmartEPD [2, Excel Dryer, 2023], and EPD Australasia paper towel data [14, Essity, 2023].

3.1.2 Hand Dryer Calculations

From TrueNorth LCA data for XLERATOR 120V (260,000 use functional unit):

• Total lifecycle CO_2: 533 kg CO_2e

• Use phase (B1): 464.84 kg CO_2e (87.2% of total)

• Per use at claimed 8s: 2.05 g CO_2e

• Per use at actual 80s: 12.18 g CO_2e (B1 scaled by 80/12 = 6.67×)

Energy calculation: 1,450W × 80s ÷ 3,600 = 32.2 Wh (versus 3.22 Wh at 8s)

3.1.3 Paper Towel Calculations
Using Tork/Handee EPD data (heavier commercial towel, 4.32g per sheet):

• Two towels: 8.63g

• Primary energy: 68.1 MJ/kg × 0.00863 kg = 0.588 MJ ≈ 163 Wh

• CO_2: 17.2-19.5 g per use (recycled to virgin range)

3.2 ChatGPT (OpenAI) Analysis

3.2.1 Sources
ChatGPT utilized Dyson Carbon Trust certification [4, Dyson, n.d.] and Essity EPD for Tork paper towels [14, Essity, 2023].

3.2.2 Hand Dryer Calculations
From Dyson Airblade 9kJ (Eco mode) specifications:

• Energy per dry: 9.1 kJ = 2.53 Wh (at 12s)

• CO_2 per dry: 2.1 g (Carbon Trust verified)

• Use phase share: 92.1%

• At 80s: CO_2 = 0.166 + (1.934 × 6.67) = 13.06 g

• At 80s: Energy = 2.53 × 6.67 = 16.9 Wh

3.2.3 Paper Towel Calculations
Using Tork Xpress Multifold (lighter towel, 2.28g per sheet):

• Two towels: 4.56g

• Primary energy: 72 MJ/kg × 0.00456 kg = 0.328 MJ ≈ 91.1 Wh

• CO_2: 1.57 kg/kg × 0.00456 kg = 7.16 g per use

3.3 Grok (xAI) Analysis

3.3.1 Sources
Grok utilized averaged data from MIT [5, MIT, 2011], Swedish University [6, Swedish University, 2023], TrueNorth [1, TrueNorth, 2023], and Dyson [4, Dyson, n.d.] to reduce potential manufacturer-funding bias.

3.3.2 Methodological Difference
Grok applied primary energy accounting with a 3× factor for grid generation and transmission losses per ISO 14044 methodology. This produces higher energy values than wall electricity measurements.

3.3.3 Hand Dryer Calculations

• Claimed (12s): 4-10 g CO_2e per use (averaged across sources)

• Actual (80s): 30-50 g CO_2e per use

• Primary energy at actual: 75-85 Wh equivalent

3.3.4 Paper Towel Calculations

• Two towels (8g, 50% recycled mix): 15-20 g CO_2e

• Primary energy: comparable range to dryers at actual times

3.4 Summary of Individual Results

Metric	Claude	ChatGPT	Grok	Range	Mean
Dryer CO_2 at claimed (g)	2.05	2.1	4-10	2-10	~3
Dryer CO_2 at actual (g)	12.18	13.06	30-50	12-50	~18
Dryer energy at actual (Wh)	32	17	75-85*	17-85	~28
Towel mass used (g)	8.63	4.56	8.0	4.6-8.6	~7
Towel CO_2 (g)	17-19.5	7.16	15-20	7-20	~14
Towel energy (Wh)	163	91	~80*	80-163	~110

*Grok values reflect primary energy accounting (×3 factor for grid losses).

4. Analysis of Divergence

4.1 Sources of Variation

The individual analyses produced a range of values. Investigation identified three primary sources of variation:

4.1.1 Paper Towel Mass

Towel mass ranged from 4.56g (ChatGPT, Tork Xpress Multifold) to 8.63g (Claude, heavier commercial towel). This variation directly scales all per-use paper towel impacts. Commercial restroom towels typically range from 1.5-2.5g per sheet, suggesting a realistic two-towel mass of 3-5g.

4.1.2 Energy Accounting Method

Claude and ChatGPT reported wall electricity (Wh). Grok applied ISO 14044 primary energy accounting, multiplying by approximately 3× to account for generation and transmission losses. Both approaches are valid for different purposes; wall electricity represents direct consumption while primary energy represents total resource depletion.

4.1.3 Source Selection

Claude and ChatGPT relied primarily on manufacturer-commissioned LCAs. Grok averaged across manufacturer and independent academic sources to reduce potential funding bias. This produced higher baseline estimates for both products.

4.2 The Energy-CO_2 Divergence

A notable finding emerged: energy comparisons favor hand dryers while CO_2 comparisons approach parity. Investigation revealed the mechanism:

Paper towel manufacturing derives 40-60% of process energy from biomass combustion (lignin and wood waste). Under ISO 14040/14044 lifecycle accounting standards, biogenic carbon is classified as carbon-neutral because it was recently sequestered from the atmosphere. This energy is counted in lifecycle energy totals but does not contribute to fossil CO_2 emissions.

Hand dryers consume 100% grid electricity, which carries full carbon intensity (~0.4 kg CO_2/kWh US average). The result: paper towels have higher total lifecycle energy but lower fossil carbon intensity per unit energy.

Energy Source	CO_2 Intensity	Application
US grid electricity	~400 g/kWh	Hand dryers (100%)
Natural gas (thermal)	~200 g/kWh	Paper mills (partial)
Biomass (wood waste)	0 g/kWh*	Paper mills (40-60%)

*Carbon-neutral under ISO 14040/14044 biogenic carbon accounting.

5. Reconciled Values

5.1 Recommended Approach

Following evaluation of the three analyses, Grok provided the following recommendation:

"For defensibility, prioritize scaling from verified manufacturer LCAs (TrueNorth/Carbon Trust), as it directly refutes their claims on their terms. Cross-verify with independents for bias assessment. Use US grid factors. Include ranges reflecting LCA uncertainty (±20-30%)."

5.2 Hand Dryer Values

Metric	At Claimed Time	At Actual Time
Drying time	8-12 s	70-90 s
Energy (wall electricity)	3.2-3.3 Wh	25-28 Wh
CO_2 (conservative)	2.0-2.1 g	12-18 g
CO_2 (expansive)	4-10 g	30-50 g

Conservative values derive from manufacturer LCAs with use-phase scaling. Expansive values incorporate independent sources and primary energy accounting.

5.3 Paper Towel Values (Normalized to 4g)

Commercial restroom paper towels typically weigh 1.5-2.5g per sheet. A two-towel use of 4g represents a realistic baseline.

Source	Energy at 4g	CO_2 at 4g
ChatGPT (Tork EPD)	80 Wh	6.3 g
Claude (Tork/Handee EPD)	76 Wh	8.4 g
Recommended range	75-80 Wh	6-10 g

5.4 Comparative Summary

Method	Energy (Wh)	CO_2 (g)	CO_2 Ratio
Paper towels (4g, 2 sheets)	~78	6-10	Baseline
Hand dryer at claimed time	3-4	2-4	0.3-0.5×
Hand dryer at actual time	25-28	12-18	1.5-2.5×

At manufacturer-claimed drying times, hand dryers produce 50-70% less CO_2 than paper towels. At empirically-measured actual drying times, hand dryers produce 50-150% more CO_2 than paper towels. The claimed environmental advantage inverts.

6. Discussion

6.1 Convergence of Findings

Despite using different sources and methodological approaches, all three AI systems reached consistent conclusions:

(1) Manufacturer drying time specifications (8-12 seconds) do not achieve stated dryness thresholds under empirical testing conditions [9, Blouch, 2025; 10, Blouch, 2025].

(2) Actual drying times (70-90 seconds) result in energy consumption 7-10× higher than manufacturer specifications.

(3) Use-phase electricity dominates hand dryer lifecycle impact (87-92%), causing the time multiplier to propagate directly to total lifecycle impact.

(4) At actual drying times, hand dryer CO_2 emissions approach or exceed paper towel emissions, depending on towel type and recycled content.

6.2 Implications

The systematic deviation between manufacturer specifications and empirical performance affects all downstream calculations based on those specifications, including LEED credit calculations, corporate sustainability reporting, and procurement decisions predicated on environmental claims.

Energy comparisons continue to favor hand dryers at actual drying times (~65% less lifecycle energy than paper towels). CO_2 comparisons do not—the products are statistically equivalent within typical LCA uncertainty ranges (±20-30%).

6.3 Limitations

This analysis relies on manufacturer-published lifecycle assessment data scaled by empirical time measurements. Independent laboratory verification of lifecycle calculations was not performed. Paper towel mass and recycled content significantly affect comparative results; the 4g baseline represents typical but not universal restroom conditions.

7. Conclusions

Three independent AI systems, using different sources and methodological approaches, confirmed that hand dryer energy and CO_2 emissions at empirically-measured drying times are 600-900% and 500-800% higher, respectively, than manufacturer specifications. The claimed 85-90% CO_2 advantage over paper towels does not exist at actual drying times; the products are statistically equivalent.

These findings are robust across methodological choices and source selection. The convergence of independent analyses establishes confidence in the underlying calculations.

References

See main References section (Section 6) for full citations.