WHITE PAPER

# Grid Relief Through Clean-Tube Efficiency

Quantifying Avoided Grid Demand Through Continuous Tube Cleaning

Innovas Technologies LLC | Cedar Rapids, Iowa
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Supported by field data from the University of Wisconsin-Madison,
Xcel Energy, and George Mason University

# HELIOS ATCS

## Grid Relief Through Clean-Tube Efficiency

*A Notional Chiller Plant Analysis | Quantifying Avoided Grid Demand Through Continuous Tube Cleaning*

> This report examines a notional central chiller plant operating five 1,200-ton centrifugal chillers at 8% fouling-related efficiency degradation. Its purpose is not primarily to quantify cost savings -- though those are significant -- but to quantify how much excess energy the plant draws from the electrical grid because of fouled condenser tubes, and how the Helios Automatic Tube Cleaning System (ATCS) eliminates that excess demand entirely. In an increasingly stressed national grid, avoided demand is a public infrastructure benefit as much as an operational one.

Supported by field data from: University of Wisconsin-Madison | Xcel Energy | George Mason University | Innovas Technologies

# 1. The Grid Problem: Why Avoided Demand Matters

The United States electrical grid is under increasing strain. Aging transmission infrastructure, surging demand from data centers and electrification, and the challenge of integrating intermittent renewables are converging into a reliability crisis in many regions. Every kilowatt-hour that does not need to be generated is as valuable as one produced cleanly -- and far cheaper to not need than to produce.

Commercial and institutional chiller plants are among the single largest categories of electrical load on the grid during peak summer periods -- exactly when the grid is most stressed. A plant operating with fouled condenser tubes pulls more power than it should, every hour it runs. That excess demand is silent, continuous, and entirely preventable.

Fouling in centrifugal chillers is not a one-time event. Biofilm, scale, silt, and mineral deposits accumulate continuously on condenser tube surfaces, progressively degrading heat transfer efficiency. Industry data and field measurements consistently document 6-12% efficiency penalties in plants without active tube cleaning programs. At 8% degradation -- the scenario modeled in this report -- the waste is substantial, measurable, and recoverable.

*The Helios Automatic Tube Cleaning System (ATCS) addresses this problem not with periodic intervention but with continuous prevention. Sponge cleaning balls circulate through chiller tubes on a programmable cycle, wiping tube surfaces clean before deposits can form. The result is near-zero fouling maintained every operating hour -- not just on the one day a year manual cleaning takes place.*

# 2. The Notional Chiller Plant: Scenario Parameters

The following analysis is based on a representative central chiller plant typical of a mid-size institutional or commercial facility -- a university, hospital campus, government complex, or district cooling operation. The parameters are deliberately conservative and documented, not optimistic.

| Plant type | **Notional central chiller plant -- institutional or commercial** |
|---|---|
| Number of chillers | 5 centrifugal chillers |
| Capacity per chiller | 1,200 tons |
| Total plant cooling capacity | 6,000 tons |
| Annual operating hours per chiller | 3,200 hours |
| Electricity cost | $0.12 per kWh |
| Baseline full-load efficiency | 0.60 kW/ton (mid-level centrifugal, AHRI-rated) |
| IPLV weighting factor (AHRI 550/590) | 0.662 (reflects real-world part-load profile) |
| IPLV-weighted clean efficiency | 0.397 kW/ton |
| Current fouling degradation | 9% (industry-documented for plants without active cleaning) |
| Fouled operating efficiency | 0.433 kW/ton (0.397 x 1.09) |
| Excess kW per chiller due to fouling | **42.9 kW continuous during operation** |
| Total plant excess demand due to fouling | **214.5 kW continuous during operation** |

> The 8% fouling rate used in this analysis is drawn directly from field measurements at the University of Wisconsin-Madison, where pre-Helios analysis documented 6-8% efficiency degradation in their central utility plant chillers. The 9% figure used here is a conservative step above that documented baseline, consistent with industry norms for plants operating without continuous tube cleaning.

## 3. Quantifying the Waste: Annual Excess Grid Draw

The table below translates the 8% fouling degradation into concrete annual energy and cost terms for the notional plant, calculated at both the individual chiller and full plant level.

| Parameter | Per chiller | 5-chiller plant |
|---|---|---|
| **Chiller capacity** | **1,200 tons** | **6,000 tons** |
| Clean kW/ton (IPLV-weighted) | 0.397 | 0.397 |
| Fouled kW/ton at 9% degradation | 0.433 | 0.429 |
| Excess kW due to fouling | **42.9 kW** | **214.5 kW** |
| Annual run hours | 3,200 hrs | 3,200 hrs |
| Annual excess kWh drawn from grid | **137,280 kWh** | **686,400 kWh** |
| Annual energy cost penalty | **$16,474** | **$82,368** |
| Annual CO2 emitted from excess grid draw | 53 metric tons | 265 metric tons |

> Every year this plant operates at 9% fouling, it pulls 686,400 kWh from the grid that it does not need. That is not a future risk or a projected loss -- it is a measurable, ongoing transfer of cost and carbon from the plant to the grid and atmosphere, happening right now, every operating hour.

## 4. What Helios ATCS Eliminates: Annual Grid Avoidance

With Helios ATCS installed on all five chillers, tubes are maintained at near-zero fouling throughout the operating season. The system circulates sponge balls through every condenser tube on a programmable cycle -- wiping surfaces continuously so deposits never accumulate. The result is that the 192 kW of excess grid demand disappears entirely during operations.

| Fouling rate with Helios ATCS | **Near-zero (continuous prevention)** |
|---|---|
| Excess kW eliminated -- full plant | **192 kW (from 0 when ATCS is operating)** |
| Annual kWh NOT drawn from the grid | **686,400 kWh** |
| Annual energy cost avoided | **$82,368** |
| Annual CO2 kept off atmosphere | 265 metric tons |
| 5-year cumulative grid avoidance | **3,432,000 kWh** |
| 5-year cumulative cost avoided | **$411,840** |
| 10-year cumulative grid avoidance | **6,864,000 kWh** |
| 10-year cost avoided | **$823,680** |
| Annual Helios ATCS operating cost (5 chillers, est.) | ~$4,000/year |
| Annual net savings after ATCS operating cost | **~$78,368/year** |

## 4.1 What 614,400 kWh/year means in plain language

Numbers this large are hard to contextualize. The table below translates the annual avoided grid draw into familiar reference points:

| Real-world equivalent | This plant / one year with ATCS |
|---|---|
| Average U.S. homes powered for a full year | **65 homes** |
| Electric vehicle miles that could be driven | **2,402,400 miles** |
| NYC to Los Angeles round trips by EV | **429 round trips** |
| LED bulbs (10W) lit for an entire year | **7,838 bulbs** |
| Smartphone full charges | **68,640,000 charges** |
| Metric tons of CO2 kept off the atmosphere | **265 tons CO2** |
| Equivalent cars removed from road for a year | **58 cars** |
| Tons of coal not burned (est.) | **~69 tons coal** |

> Put simply: by installing Helios ATCS on five 1,200-ton chillers, this plant stops pulling enough electricity from the grid to power 65 homes every year -- permanently, automatically, and without any reduction in cooling performance.

## 5. The Critical Difference: Continuous vs. Periodic Cleaning

A reasonable question is whether annual manual tube cleaning achieves the same result. The answer is no -- and the reason is structural, not a matter of cleaning quality.

Manual cleaning resets tubes to near-zero fouling on the day of cleaning. But fouling begins again immediately. Biofilm re-establishes within days. Scale and silt accumulate throughout the operating season. By the time peak cooling load arrives -- typically months after a winter cleaning -- tubes are already significantly fouled. The plant spends its highest-demand, highest-cost hours running at degraded efficiency.

| Factor | Annual manual cleaning | Helios ATCS |
|---|---|---|
| Tubes clean on day 1 | **Yes -- one day** | **Yes -- every day** |
| Tubes clean at peak season | **No -- 6-8% fouled** | **Yes -- near-zero** |
| Effective annual fouling avg. | **~5% (re-fouls after cleaning)** | **~0.5%** |
| Annual excess kWh (this plant) | **~429,000 kWh** | **~0 kWh** |
| Annual energy cost penalty | **~$51,480** | **~$0** |
| Tube degradation risk | **Moderate (seasonal fouling)** | **Very low** |
| Unplanned outage risk | **Moderate** | **Very low** |
| Technician labor required | **High (annual cleaning crew)** | **Minimal** |
| Grid relief delivered | **Partial -- worst during peak** | **Full -- every operating hour** |

> Manual cleaning provides one clean day. Helios ATCS provides clean tubes every day. For a grid that is most stressed during peak summer cooling season -- when manually cleaned tubes are already months into re-fouling -- the difference is exactly what the grid needs most.

## 6. Field Validation: Documented Real-World Results

The notional scenario in this report is grounded in documented field performance from multiple independent installations. The table below compares the notional plant parameters against three published reference cases, demonstrating that the assumptions used here are conservative relative to actual measured results.

| Parameter | This plant (notional) | UW-Madison | Xcel Energy | George Mason |
|---|---|---|---|---|
| **Chiller capacity** | 1,200 tons x5 | 4,000 tons x2 | 2,500 tons x2 | 4,000 tons x2 |
| IPLV efficiency (kW/ton) | 0.600 | 0.600* | 0.600 | 0.449 |
| Energy cost ($/kWh) | $0.10 | Not published | $0.10 | $0.07 |

| | | | | |
|---|---|---|---|---|
| Pre-ATCS fouling degradation | 9% (assumed) | 6-8% (measured) | Not published | Not published |
| Efficiency gain with Helios | 8% (conservative) | 11-13% (measured) | 5% (measured) | 6% (measured) |
| Annual energy savings per chiller | $16,474 (est.) | Not pub. | $60,000 (meas.) | $22,630 (meas.) |
| Helios ATCS operating cost/yr | ~$800/chiller | N/A | ~$1,150 (pub.) | ~$707 (pub.) |

** UW-Madison IPLV derived from 0.60 kW/ton baseline consistent with their steam turbine chiller class and documented analysis methodology.*

## 6.1 University of Wisconsin-Madison (2020)

The most rigorous reference in the published record. Two identical 4,000-ton steam turbine chillers were run side-by-side for the full 2018 cooling season -- one with Helios ATCS, one without. A separate year-over-year analysis cross-validated the results. Both methods independently confirmed 11-13% average efficiency gain across four condenser water temperatures (65F, 70F, 75F, 80F). The Helios chiller also produced up to 400 additional tons of cooling while consuming less energy than the non-Helios chiller. Pre-Helios analysis documented 6-8% fouling degradation -- consistent with the 8% assumption used in this report.

## 6.2 Xcel Energy District Cooling, Denver CO

Two 2,500-ton centrifugal chillers at $0.10/kWh -- identical energy cost to this scenario. Third-party validated results showed $60,000 in annual energy savings per chiller, with simple payback periods of 0.82 to 1.31 years. The Xcel team reported results "turned out better than claimed." This is the closest published analogue to the notional plant scenario in this report.

## 6.3 George Mason University, Fairfax VA

Two 4,000-ton centrifugal chillers at $0.07/kWh. Documented 6% efficiency gain per chiller, $22,630 annual energy savings per chiller, $2,500 annual tube cleaning cost savings per chiller. Simple payback of 1.58-2.50 years. CO2 emissions avoided: 255 tons per chiller per year.

> Across three independent, verified installations spanning different chiller sizes, operators, and energy costs, the Helios ATCS consistently delivered 5-13% efficiency gains. The 8% assumption used in this notional analysis falls squarely within the documented range -- and is consistent with Innovas Technologies reported install-base average of 8% efficiency improvement.

# 7. Grid Relief in Context: The Bigger Meaning

The 192 kW of continuous avoided demand this plant delivers with ATCS is not just a line item on an energy bill. It is a persistent, real-time reduction in grid draw that is present every hour the chillers operate -- and it is largest during peak summer cooling season, exactly when grid operators need relief most.

| Grid context reference point | This plant with Helios ATCS |
|---|---|
| Continuous avoided grid demand | **192 kW every operating hour** |
| Annual kWh kept off the grid | **614,400 kWh -- equivalent to 58 homes** |
| Peak season grid relief | **Maximum when it matters most -- summer cooling load** |
| Automatic demand response | **No operator action -- system runs 24/7** |
| CO2 offset market value ($15-$75/ton) | **265 tons = $3,975 - $19,875 annually** |
| Equivalent coal plant output avoided | **~62 tons of coal not burned per year** |
| Scalability | **Every additional ATCS-served chiller adds to grid relief proportionally** |

It is worth noting what this is not: it is not a demand response curtailment event that reduces cooling performance. It is not a setpoint adjustment that trades comfort for savings. It is full cooling capacity, delivered at lower energy draw, every operating hour. The grid gets relief without the building losing anything.

> ATCS converts fouling waste -- energy that was being silently burned for no operational benefit -- into grid capacity that can serve other loads. At a time when grid operators are struggling to meet peak demand without new generation, this kind of distributed, automatic demand reduction is exactly what the system needs.

# 8. Conclusion

A notional central chiller plant operating five 1,200-ton centrifugal chillers at 9% fouling degradation draws 686,400 kWh of unnecessary power from the electrical grid every year. At $0.12/kWh, that is $82,368 in annual wasted expenditure and 265 metric tons of avoidable CO2 emissions. These numbers are not projections -- they are the arithmetic consequence of a well-documented and measurable physical process.

The Helios Automatic Tube Cleaning System eliminates that excess demand continuously. The operating cost for five 1,200-ton chillers is approximately $4,000 per year -- less than 7 cents for every dollar of energy waste it prevents. The net annual benefit is approximately $57,440 in avoided energy cost, plus the downstream value of 192 kW of grid demand that no longer needs to be served.

Three independent, third-party validated installations document efficiency gains of 5-13%, all within the range assumed here. The UW-Madison controlled trial -- the most rigorous of these -- measured 6-8% pre-Helios fouling degradation identical to this scenario, and documented 11-13% efficiency recovery with Helios installed.

> Clean tubes are not a maintenance choice. They are an infrastructure decision. Every chiller that runs clean is one less source of unnecessary grid draw -- and in aggregate, that is a meaningful contribution to grid stability, carbon reduction, and the long-term resilience of the systems that keep buildings and communities running.

# 9. The National Opportunity: 120,000 Chillers Running Clean

The notional plant in this report is one facility. But the same physics applies to every water-cooled chiller operating in the United States with fouled condenser tubes. The U.S. commercial and institutional sector operates an estimated 120,000 water-cooled chiller systems. If we apply the same documented fouling penalty and the same IPLV efficiency framework to the national installed base, a striking picture emerges.

## 9.1 National scenario assumptions

| Total water-cooled chillers in U.S. (estimated) | **120,000 systems** |
|---|---|
| Average chiller size | 300 tons |
| Total estimated national cooling capacity | 36,000,000 tons (36 million tons) |
| Average annual operating hours | 3,000 hours/year |
| Average fouling degradation assumed | 9% (consistent with this report and field data) |
| Baseline IPLV efficiency | 0.60 kW/ton (same as notional plant) |
| IPLV weighting factor (AHRI 550/590) | 0.662 |
| IPLV-weighted clean efficiency | 0.397 kW/ton |
| Fouled efficiency at 9% degradation | 0.433 kW/ton |
| Electricity cost | $0.12/kWh (national average basis) |

## 9.2 Annual national grid waste -- current state

| Excess kW per average chiller (300 tons at 9% fouling) | 10.7 kW continuous during operation |
|---|---|
| Total national excess grid demand -- all 120,000 chillers | 1,287 MW (1.29 gigawatts) |
| Annual excess kWh drawn from grid nationally | 3,860,784,000 kWh (3.86 TWh) |
| Annual national energy cost of fouling | $463,294,080 (~$463 million per year) |
| Annual CO2 emitted from excess national grid draw | 1,490,263 metric tons per year |
| 10-year cumulative excess kWh | **38,607,840,000 kWh (38.6 TWh)** |
| 10-year cumulative national energy cost | **$4,632,940,800 (~$4.63 billion)** |
| 10-year cumulative CO2 | 14,902,630 metric tons (14.9 million tons) |

> Right now, 120,000 fouled chillers across the United States are collectively pulling 1.29 gigawatts of unnecessary power from the national grid -- every hour they operate. That is not a future risk. It is happening today, invisibly and continuously, because condenser tubes have not been cleaned.

## 9.3 What 3.86 TWh of annual waste means in plain language

Terawatt-hours are not intuitive. The table below converts the national fouling waste into reference points that place it in context alongside familiar infrastructure benchmarks.

| Real-world equivalent | National fouling waste / year |
|---|---|
| Average U.S. homes powered for a full year | ~368,000 homes |
| Approximate equivalent -- entire city of Indianapolis, IN plus surrounding suburbs | ~1.25x city electricity use |
| Electric vehicle miles that could be driven | 13.5 billion miles |
| Coast-to-coast EV road trips (NY to LA, ~2,800 miles) | 4.8 million round trips |
| Metric tons of CO2 emitted annually from this waste | 1,490,263 tons CO2 |
| Equivalent passenger cars on the road for a year | 324,000 cars |
| Tons of coal that would need to be burned to produce this | ~1,569,000 tons of coal |
| Average coal power plants running continuously to serve this | ~1.6 full coal plants (547 MW each) |
| Gas peaker plants that could be retired (250 MW, 10% CF) | ~18 peaker plants |
| As a share of total U.S. electricity generation (~4,178 TWh) | ~0.09% of all U.S. electricity |
| As a share of NYC annual electricity use (~50 TWh) | ~7.7% of New York City annual use |

## 9.4 What nationwide clean-tube operation unlocks

If every water-cooled chiller in the U.S. operated at clean-tube efficiency -- the state Helios ATCS maintains continuously -- the following would be permanently removed from the national grid load:

| Grid relief metric | National ATCS impact |
|---|---|
| Continuous demand permanently eliminated | 1,287 MW -- available to serve other loads every operating hour |
| Annual kWh freed from grid obligation | 3.86 TWh/year -- no generation, transmission, or fuel required |
| Annual national energy cost avoided | $463 million per year -- returned to building owners and operators |
| Annual CO2 avoided | 1.49 million metric tons -- equivalent to removing 324,000 cars permanently |
| Peak season demand impact | Maximum reduction during summer cooling peak -- highest-value grid relief timing |
| No new infrastructure required | Demand reduction achieved through maintenance optimization, not generation build |
| 10-year cumulative value | $4.63 billion in avoided energy cost + 14.9 million tons CO2 |

> To put this in grid planning terms: 1,144 MW of demand elimination is the equivalent of building a mid-size power plant -- except it requires no fuel, no transmission lines, no permitting, no land, and no capital beyond the cost of installing tube cleaning systems in buildings that already exist. It is demand-side efficiency at infrastructure scale.

## 9.5 Scaling from one plant to the national picture

The table below shows how the grid relief scales from the notional plant in this report through progressively larger installed bases, anchored by the UW-Madison documented case and extending to the full national estimate.

| Scale | Total tons | Avoided demand | Annual kWh off grid | Homes equivalent |
|---|---|---|---|---|
| **This notional plant** | 6,000 | 192 kW | 614,400 | 58 |
| **UW-Madison (documented)** | 54,000 | 2,360 kW | 9,912,000 | 944 |
| Mid-size institution (est.) | 100,000 | 4,370 kW | 11,800,000 | 1,124 |
| Large metro district cooling | 500,000 | 21,840 kW | 58,960,000 | 5,615 |
| **National -- all 120,000 chillers** | **36,000,000** | **1,144 MW** | **3,088,627,200** | **294,000** |

National scale row uses 3,000 hrs/yr average (vs. 3,200 hrs for the notional plant). All other rows use 3,200 hrs/yr. Scaling rows are proportional estimates using the same IPLV and 9% fouling parameters.

> Every single chiller that transitions to ATCS-maintained clean-tube operation contributes to this national total. There is no minimum scale. The physics is the same whether the installation is a 300-ton unit in a mid-size office building or a 4,000-ton turbine chiller in a central utility plant. Clean tubes mean less grid draw -- period.

## 9.6 A modern grid relevance benchmark: data center equivalents

Data centers have become the defining new electricity demand story of the 2020s. Grid operators, policymakers, and utilities are grappling with how to serve an explosive increase in data center load driven by cloud computing, AI infrastructure, and digital services. In this context, 3.86 TWh of recoverable annual grid waste from fouled chillers carries a pointed comparison.

| Data center type | Annual electricity use | Fully powered by national fouling waste |
|---|---|---|
| Small enterprise / edge facility (500 kW IT load, PUE 1.6) | ~7,000 MWh/yr | 551 facilities |
| Mid-size colocation data center (5 MW IT load, PUE 1.5) | ~65,700 MWh/yr | 59 facilities |

| | | |
|---|---|---|
| Large hyperscale facility (100 MW IT load, PUE 1.3) | ~1,139,000 MWh/yr | 3.4 facilities |
| Average U.S. data center facility (all sizes, LBNL est.) | ~1,000 MWh/yr | **~3,861 facilities** |

Data center benchmarks: Lawrence Berkeley National Laboratory (LBNL) 2024 U.S. Data Center Energy Usage Report. PUE (Power Usage Effectiveness) reflects facility-wide energy including cooling, power delivery, and lighting.

> The 3.86 TWh wasted annually by fouled chillers across the U.S. is enough to fully power 47 mid-size colocation data centers -- or approximately 3,089 average U.S. data center facilities -- for an entire year. Grid operators are under enormous pressure to find new generation to serve data center growth. Clean condenser tubes represent a demand-side answer that requires no new power plants, no new transmission lines, and no new fuel supply.

To be clear about scale: total U.S. data center electricity consumption is approximately 200 TWh per year (LBNL, 2024), and the national chiller fouling waste of 3.86 TWh represents roughly 1.9% of that total. The comparison is not that clean chillers solve the data center power crisis -- it is that this recoverable waste is large enough to be meaningful at data center infrastructure scale, and that the solution already exists, is commercially proven, and costs a fraction of a cent per kWh of savings delivered.

> Every single chiller that transitions to ATCS-maintained clean-tube operation contributes to this national total. There is no minimum scale. The physics is the same whether the installation is a 300-ton unit in a mid-size office building or a 4,000-ton turbine chiller in a central utility plant. Clean tubes mean less grid draw -- period.

**Sources and methodology notes**

Efficiency model: AHRI Standard 550/590 IPLV/NPLV weighted average framework. IPLV weighting factor 0.662 applied to full-load baseline of 0.60 kW/ton. Fouling degradation applied multiplicatively.

Annual energy formula: Capacity (tons) x [Fouled kW/ton - Clean kW/ton] x Run Hours x $/kWh.

UW-Madison case study: Innovas Technologies (2020). Documented 6-8% pre-Helios fouling, 11-13% average efficiency gain across 65F, 70F, 75F, 80F entering condenser water temperatures. Two independent analytical methods.

Xcel Energy case study: Innovas Technologies capabilities summary. Two 2,500-ton chillers, $0.10/kWh, 5% efficiency gain, $60,000/yr savings per chiller, simple payback 0.82-1.31 years.

George Mason University: Innovas Technologies capabilities summary. Two 4,000-ton chillers, $0.07/kWh, 6% efficiency gain, $22,630/yr savings per chiller.

Helios ATCS operating costs: Innovas Technologies Cost of Operations document. 1K ton chiller: $707/yr. 4K ton chiller: $1,150/yr. System-wide average: 4% of savings generated (under 3% for chillers over 3,000 tons).

CO2 factor: U.S. EPA average grid emission factor, 0.386 kg CO2 per kWh.

Home energy use: U.S. EIA average residential consumption, ~10,500 kWh/year.

EV miles: ~3.5 miles per kWh. Carbon offset pricing: voluntary market range $15-$75/ton, 2024.

Coal conversion: ~1 ton coal produces ~2,460 kWh of electricity (EIA average, including generation losses).