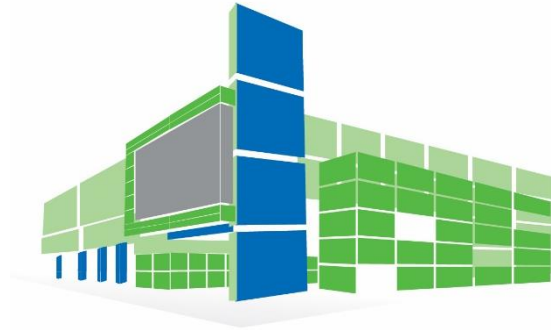

“IS IT REALLY WORKING?”
RESULTS FROM ARC FIELD EXPERIENCE



TODAY'S AGENDA

- **About ARC Technology**
- **Let's See Some Analytics**
- **Who We Are**
- **Questions & Answers**



ABOUT ARC TECHNOLOGY

ARC Stands for Advanced Rooftop Unit Control

WHAT QUALIFIES AS AN ARC TECHNOLOGY

Only the best ARCs have all of the capabilities listed below



VARIABLE FREQUENCY DRIVE

Serves as the foundation, offering up to 60% or more of the savings



PREDICTIVE ECONOMIZATION

An advanced feature that begins economizing when it is most efficient



DEMAND CONTROL VENTILATION

Based on CO2 levels, it will automatically adjust to maintain proper indoor air quality



STANDALONE OPERATION

Typically, ARCs can operate autonomously, providing independent energy savings



ADVANCED ECONOMIZATION

Intelligently leverages outside air instead of return air when the conditions are right



WEB CONNECTED

ARCs are best deployed with web connectivity for remote control & oversight




MODEL VALIDATION

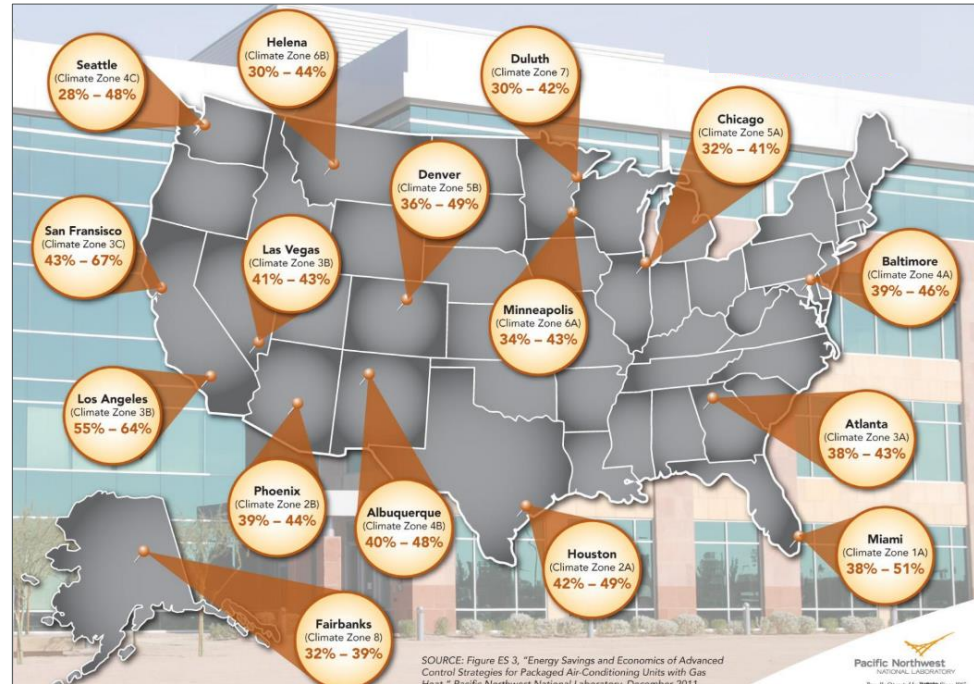
The experts have tested, measured, and evaluated the performance of ARC technology

EXPERT: DEPARTMENT OF ENERGY'S PACIFIC NORTHWEST NATIONAL LABORATORY (PNNL)

A comprehensive study was performed in across 16 U.S. climate zones to set a baseline and measure savings across constant-speed supply fan RTUs without economizers*.

Key Findings:

-  **ARC Savings:** Regardless of your climate zone, ARCs produce valuable savings
-  **ARC Durability:** Regardless of the climate, ARCs were robust enough to withstand their environment
-  **ARC Performance:** The study confirmed that the technology does what it is supposed to do



*While building codes require economizers in many U.S. climates, growing consensus among our industry is that economizers are often bypassed because they are broken or an HVAC technician has either disabled it or configured it incorrectly.

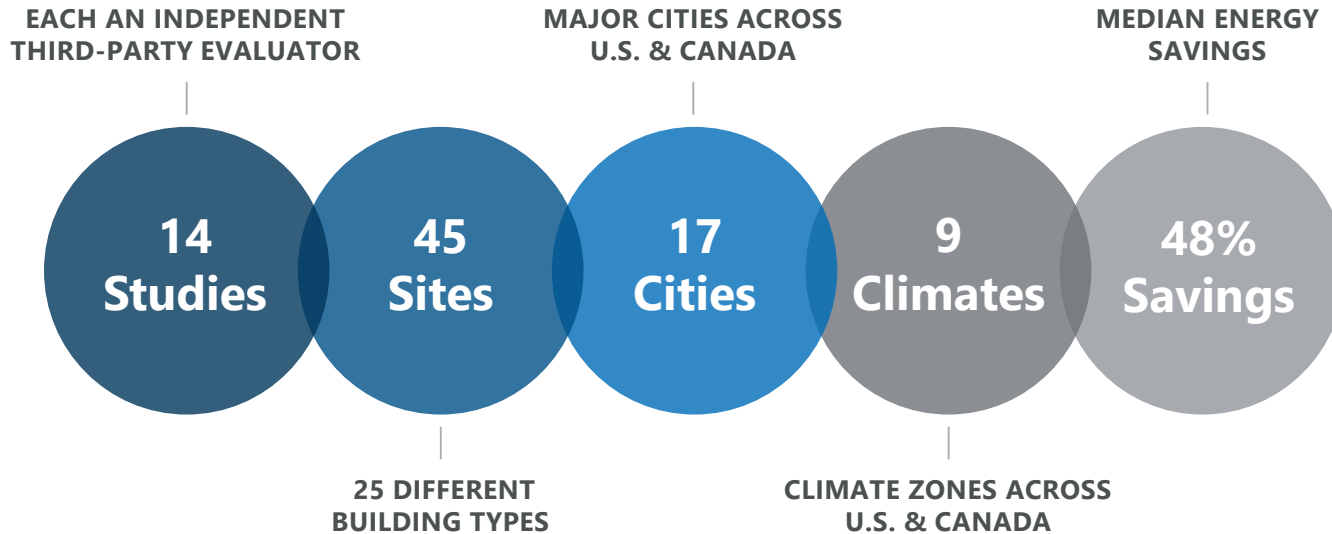


LET'S SEE SOME ANALYTICS

ARC Technology has been tested across the United States and Canada

FIELD DEMONSTRATION RESULTS

The CATALYST ARC Technology has proven its value across a significant number of third-party studies



RESULTS: ENERGY SAVINGS RANGED FROM 29%-73% WITH A 48% MEDIAN*

*Excludes the high and low outliers which are outside two standard deviations.

E SOURCE ARC VALIDATION

Field tests demonstrate significant energy savings

We're aware of over a dozen field demonstrations where rooftop unit retrofit controllers have been evaluated since 2012. The consistent positive test results indicate that these devices could be considered good candidates for inclusion in utility commercial HVAC incentive programs across the US. However, careful consideration should be given to climatic and seasonal effects on overall savings potential.

Evaluator	Products tested	Number of RTUs	Test type	Electricity savings (%)	Demand reduction (%)	Gas savings (%)
BC Hydro	Catalyst	22	Field	25–40	NA	NA
Bonneville Power Administration	Catalyst	2	Field	25–40	NA	NA
Minnesota Center for Energy and Environment	Catalyst, Digi-RTU, Premium Ventilation	62	Field	15–30	NA	Negative
National Renewable Energy Laboratory	Catalyst	11	Field	5–15 (building)	12–27	NA
Omaha Public Power District	Digi-RTU	20	Field	56	39	NA
Pacific Northwest National Laboratory	Catalyst	66	Field	22–90	NA	NA
SDG&E	Catalyst, Digi-RTU, Enerfit	1 building	Field	13–26	NA	NA
Seattle City Light	Catalyst	1 building	Field			
SMUD	Catalyst	4	Field	32–58	24	NA
Southern California Edison	Digi-RTU	1	Laboratory	NA	10–40	NA
Southern California Edison	Catalyst	4	Field	60–71	41	NA
Tacoma Power	Catalyst	1	Field	50	NA	NA
Western Cooling Efficiency Center	Catalyst	4	Field	40–65	NA	NA

Notes: NA = not available; RTU = rooftop unit.

© E Source

PUBLISHED PUBLIC FIELD DEMONSTRATIONS

Summarized savings from 9 completed third-party field demonstrations covering 19 buildings

ASHRAE Climate	Nearest City	Evaluator	Building Type	Annual Operation (hours)	RTU #	Total Capacity (tons)	Avg RTU size (tons)	Normalized Savings (kWh/ton per 1,000 hrs)	% HVAC savings
6B, cold-dry	Vancouver, Can	BC Hydro	indoor mall	3,765	3	75	25	110	42%
6A, cold-humid	St. Paul, MN	CEE	office & manufacturing	3,120	6	68	11	163	29%
5B, cool-dry	Fort Collins, CO	PRPA	small office	6,025	1	6	6	246	62%
5B, cool-dry	Fort Collins, CO	PRPA	fitness center	8,760	1	15	15	158	55%
5B, cool-dry	Fort Collins, CO	PRPA	retail	5,840	1	10	10	160	88%
5A, cool-humid	Cleveland, OH	PNNL	healthcare clinic	7,904	2	38	19	189	55%
4C mild-marine	Tacoma, WA	BPA	drug store	5,408	2	30	15	140	45%
4C, mild-marine	Seattle, WA	PNNL	indoor mall	5,175	25	321	13	183	67%
4C, mild-marine	Seattle, WA	PNNL	bank	4,368	1	13	13	164	43%
4C, mild-marine	Seattle, WA	PNNL	medium office	4,004	6	61	10	139	38%
4C, mild-marine	Seattle, WA	PNNL	indoor mall	6,916	9	140	16	135	37%
4C, mild-marine	Seattle, WA	PNNL	medium-box retail	4,420	5	50	10	192	73%
4A, mixed-humid	Philadelphia, PA	PNNL	big-box retail with grocery	7,917	8	200	25	159	52%
3B, warm-dry	Sacramento, CA	SMUD	manufacturing (electronics)	8,760	4	80	20	138	39%
3B, warm-dry	Los Angeles, CA	PNNL	supermarket	8,736	5	83	17	107	48%
3B, warm-dry	Los Angeles, CA	CEC	recreation facility	4,750	1	10	10	148	51%
3B, warm-dry	San Diego, CA	CEC	recreation facility	3,450	1	8	8	160	29%
3B, warm-dry	Los Angeles, CA	SCE	indoor mall	4,004	3	50	17	114	66%
1A, very hot-humid	Oahu, HI	NREL	big-box retail	5,840	9	175	19	94	15%

RESULTS: ENERGY SAVINGS RANGED FROM 29%-73% WITH A 48% MEDIAN*

*Excludes the high and low outliers which are outside two standard deviations.

PUBLISHED PRIVATE FIELD DEMONSTRATIONS

Summarized savings from 5 third-party field demonstrations covering 26 buildings

ASHRAE Climate	Nearest City	Evaluator	Building Type	Annual Operation (hours)	RTU #	Total Capacity (tons)	Avg RTU size (tons)	Normalized Savings (kWh/ton per 1,000 hrs)	% HVAC savings
6A, cold-humid	Toronto, Can	Pending #1	indoor mall	4,796	4	55	14	118	66%
6A, cold-humid	Toronto, Can	Pending #1	outlet mall	5,466	3	45	15	161	38%
6A, cold-humid	Toronto, Can	Pending #1	supermarket	8,760	4	85	21	133	55%
6A, cold-humid	Toronto, Can	Pending #1	indoor mall	3,493	4	50	13	126	41%
6A, cold-humid	Toronto, Can	Pending #1	recreation facility	8,662	4	35	9	151	48%
6A, cold-humid	Toronto, Can	Pending #1	indoor mall	4,691	3	55	18	122	48%
6A, cold-humid	Toronto, Can	Pending #1	medium office	3,438	4	70	18	118	46%
6A, cold-humid	Toronto, Can	Pending #1	recreation facility	8,677	4	48	12	100	49%
6A, cold-humid	Toronto, Can	Pending #1	strip mall	5,187	4	45	11	193	56%
6A, cold-humid	Toronto, Can	Pending #1	strip mall	6,345	3	65	22	191	66%
6A, cold-humid	Toronto, Can	Pending #1	indoor mall	5,415	4	38	9	140	31%
6A, cold-humid	Toronto, Can	Pending #1	indoor mall	4,149	3	28	9	219	75%
6A, cold-humid	Binghamton, NY	Pending #2	library	3,857	14	175	12	143	50%
6A, cold-humid	Ithaca, NY	Pending #2	manufacturing (process)	3,883	4	60	15	114	43%
6A, cold-humid	Ithaca, NY	Pending #2	manufacturing (healthcare)	3,120	5	61	12	108	55%
6A, cold-humid	Bainbridge, NY	Pending #2	manufacturing(machining)	3,285	2	40	20	125	21%
6A, cold-humid	Ithaca, NY	Pending #2	recreation facility	5,110	5	68	14	105	50%
5A, cool-humid	Detroit, MI	Pending #5	medium-box retail	3,190	6	58	10	140	48%
5A, cool-humid	Detroit, MI	Pending #5	travel center	8,760	2	25	13	194	46%
5A, cool-humid	Detroit, MI	Pending #5	recreational facility	8,760	2	10	5	117	47%
3B, warm-dry	Sacramento, CA	Pending #3	medium-box retail	4,911	7	86	12	107	32%
3B, warm-dry	Sacramento, CA	Pending #3	medium-box retail	5,555	8	76	9	169	43%
3B, warm-dry	Sacramento, CA	Pending #3	medium-box retail	6,030	7	85	12	96	29%
3B, warm-dry	Sacramento, CA	Pending #3	medium-box retail	4,954	3	19	6	194	43%
3B, warm-dry	Sacramento, CA	Pending #3	medium-box retail	4,323	5	63	13	137	33%
2A, hot-humid	San Antonio, TX	Pending #4	community center	5,265	1	25	25	223	50%

RESULTS: ENERGY SAVINGS RANGED FROM 29%-66% WITH A 47% MEDIAN*

*Excludes the high and low outliers which are outside two standard deviations.

ARC REBATES ACROSS THE COUNTRY

Based on the significant savings from these field results, utilities have begun and continue to provide prescriptive rebates for ARC solutions



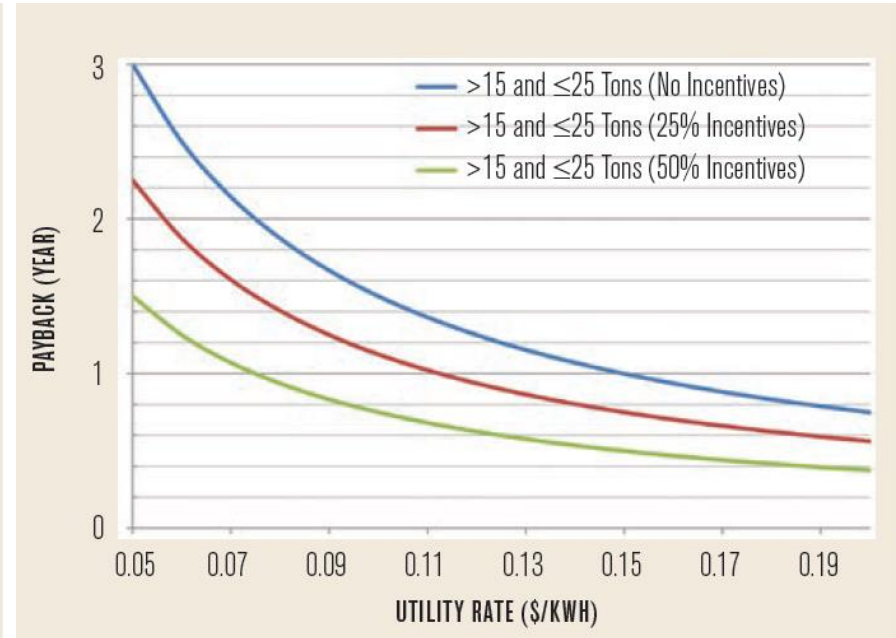
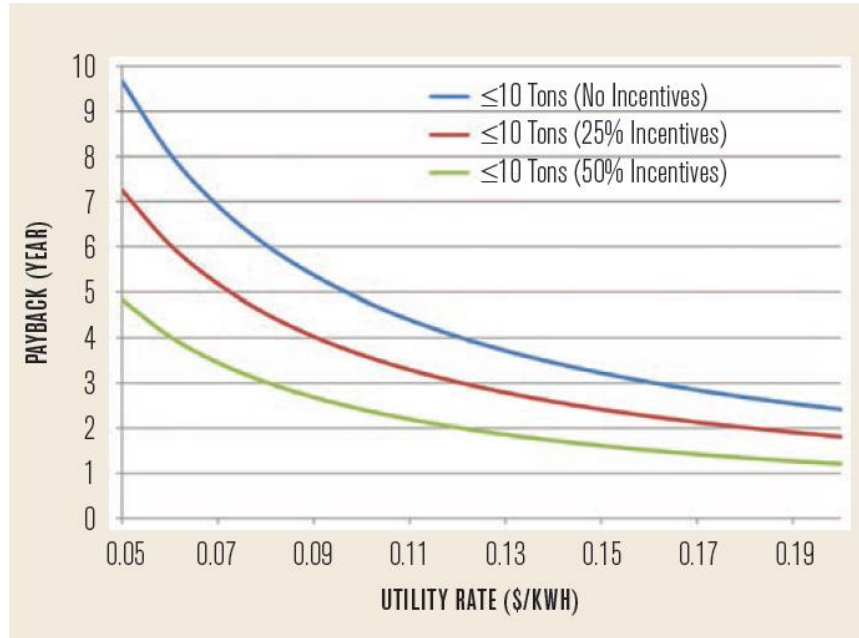
Available Rebates

AR	Entergy	\$80/ton for <i>Lite</i>
AZ	APS & SRP - Bldg Controls	\$0.15 - \$0.25/sqft
CA	PG&E	\$155/ton
CA	SCE	\$200/ton
CA	Silicon Valley Power	\$160/ton
CO	PRPA/Fort Collins	\$2,000 per RTU
IL	ComEd (<100kW demand)	\$300/ton + \$250/hp
IN	Duke Energy	up to \$288/ton
KY	Duke Energy	\$0.10/sqft for DCV
MA	Mass Save*	\$0.13/kWh
MI	Consumers Energy	\$100/ton
MO	Kansas City Power & Light	\$0.345 - \$.0379/kWh
NC	Duke Energy	up to \$288/ton
NY	ConEd	\$0.16/kWh
OH	Duke Energy	\$0.10/sqft for DCV
SC	Duke Energy	up to \$288/ton
UT	Rocky Mountain Power	up to \$4,800 per RTU
WA	Washington Utilities**	\$225/ton
WA	PSE Gas	\$50/ton
WA	Pacific Power	up to \$4,800 per RTU
WA	Cascade Natural Gas	\$20/ton

*Mass Save includes National Grid, Cape Light, Eversource, Unitil,
 **Washington Utilities include: Clark Public Utilities, BPA, Seattle City Light, SnoPUD, Tacoma Power, Peninsula Light, Puget Sound Energy, Cowlitz County PUD

POSITIVE CONCLUSION FOR ARCS

Field demonstrations prove that ARC solutions can provide significant HVAC electrical energy savings for many different building types



RESULTS: WITH UTILITY INCENTIVES GROWING, ARCS TYPICALLY REALIZE A SIMPLE PAYBACK BETWEEN 1 TO 4 YEARS

CASE STUDY: CLEVELAND CLINIC

The Cleveland Clinic is an American academic medical center based in Cleveland, Ohio.

SCENARIO: PARTICIPATED IN PNNL ARC STUDY

This healthcare clinic was operating 7,904 hours annually, with (2) 20-ton RTUs. The units were under the control of an existing BMS, we integrated behind those controls.

SOLUTION: CATALYST ARC + eIQ PLATFORM

The Cleveland Clinic was part of our landmark study with the DOE. Clinic management liked their existing controls, but were frustrated that they were unable to use them to explore efficiency. We gave them that power!

RESULTS:



ANNUAL COST SAVINGS: 44%



AVERAGE ELECTRIC SAVINGS: 359,580 kWh/year



COMPRESSOR RUNTIME REDUCED BY ALMOST 50%



CASE STUDY: H&M

H&M is a national customer with several sites in Ohio.



SCENARIO: NATIONAL ACCOUNT CUSTOMER

H&M Stores approached TW in 2017 to become the whole-house controls solution for HVAC & lighting in all their U.S. Stores.

SOLUTION: CATALYST ARC + eIQ PLATFORM

The Great Northern Mall, Cleveland, OH location was installed in September of 2017. TW applied the CATALYST eIQ BMS to three 20-ton Trane units, and provides whole-house lighting control.

RESULTS:



AVERAGE DAILY ELECTRICAL SAVINGS: 51%



AVERAGE DAILY GAS SAVINGS: 3%



GREATEST DELIGHT: LIGHTING!



WHO WE ARE

At Transformative Wave, our mission is to deliver simple elegant solutions that enable our customers to reduce energy costs, improve occupant comfort, and gain operational efficiency.

FROM HVAC RETROFITS TO BUILDING AUTOMATION SOLUTIONS

No matter where you are in your journey to energy efficiency, we can meet you where you're at



VARIABLE FREQUENCY DRIVE +

The CATALYST *Lite* is more than just a VFD and offers simple fan savings



ARC TECHNOLOGY

The full CATALYST drives intelligent HVAC energy savings and operational efficiency



ENTERPRISE VISIBILITY

The eIQ Platform offers visibility through real-time monitoring

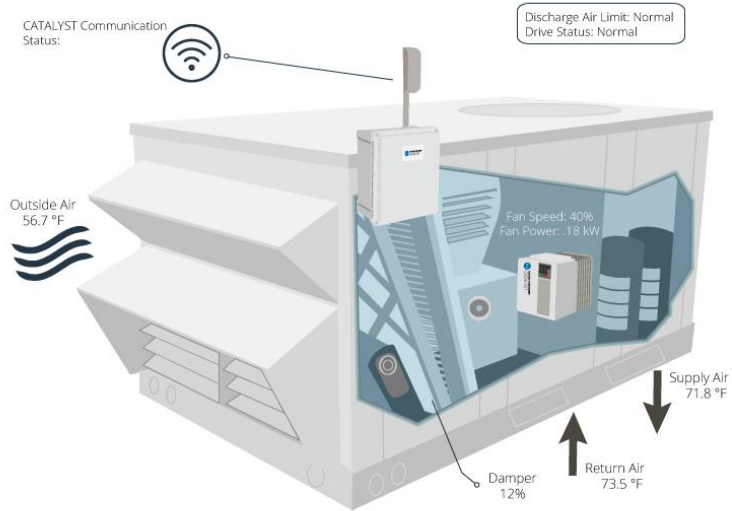


FULL BAS SOLUTION

Our portfolio of solutions enables asset control with IoT connectivity






THE CATALYST ARC TECHNOLOGY

Leading the industry in Advanced Rooftop Unit Controls (ARC)



REDUCES OVERALL HVAC ENERGY USE 25%-50%

The CATALYST transforms HVAC assets into smart machines delivering an intelligent solution for RTUs that give you greater control to extend the benefits of your current investments even further.

- 
Variable Speed Drive: The Variable Frequency Drive (VFD) provides savings through supply fan control.
- 
Advanced Economizer Control: Reduces the compressor runtime to improve efficiency and reduce wear and tear.
- 
CO₂-Based Demand Control Ventilation: Makes the most of the available outside air for cooling while ensuring proper ventilation.
- 
Multiple New Sensors & Data Points: Maintain comfort levels and indoor air quality.
- 
Qualifies for Incentives: Widespread support of ARC technology enables financial incentives to reduce capital cost.

THE CATALYST SERVICE SWITCH

Customers and contractors alike, appreciate the forethought of the service switch

THE WAY THAT WE DO WHAT WE DO, IS JUST AS IMPORTANT AS WHAT WE DO.

The service switch empowers contractors to easily perform preventative maintenance and verify economizer functions without undermining the CATALYST installation.

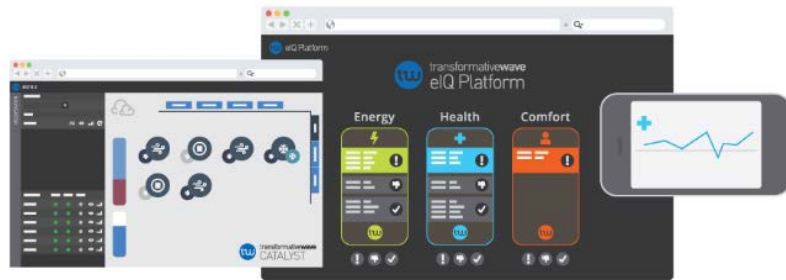
- ✓
A multi-position selectable switch for service personnel use. This will enable techs to operate the system in any mode of operation for maintenance purposes.

- ✓
The use of the service switch will suppress data collection by the eIQ Platform to avoid negative impact on fault detection and analytics.








THE CATALYST eIQ PLATFORM

The BAS that provides visibility and control of your facility assets



BUILDING AUTOMATION OFFERS ADDED SAVINGS

With the eIQ Platform, you have real-time energy consumption monitoring and control with the assurance that the CATALYST's high-tech monitoring system will give you around the clock access to your HVAC assets.

- 
Connected 24/7: The eIQ Platform provides web-based, real-time monitoring for up-to-date reporting with comprehensive diagnostics.
- 
Works with Existing HVAC Assets: Integrates with many existing HVAC and Building Management Systems (BMS).
- 
Fault Detection & Diagnostics: Actively monitor performance of equipment including abnormalities which trigger alerts.
- 
Building Management Controls: Acts as its own open-protocol BMS capable of controlling lighting, HVAC, keycard access and more to eliminate day-to-day operational pains.
- 
Preventative Maintenance / Cost Avoidance: insight to equipment conditions can enable maintenance work to be scheduled as needed.

CUSTOMER TESTIMONIALS

We're not the only ones who believe in the CATALYST. Here's what a few of our customers have to say...

“ The significant energy savings and quality installation process are just two of the reasons we selected CATALYST and Transformative Wave as our partner for RTU retrofits across the United States and Canada. ”



MIKE ELLINGER

Global Maintenance & Refrigeration
Coordinator, Whole Foods Market

“ We have been impressed with the benefits of Transformative Wave's CATALYST technology. Along with a 40% reduction in HVAC energy use, we are benefiting from the Automated Fault Detection & Diagnostics alerts which enable us to proactively schedule service calls when dampers and economizers are not working correctly, a common issue which typically goes unnoticed and contributes to higher energy costs. ”



PAUL GOODMAN

Owner/Operator, McDonald's

“ The short time we've had the CATALYST system, we've notice substantial decreases in our electric bill, more efficient units, and an array of graphs and charts that will monitor actual usage and temperatures so we can see savings immediately. ”



JIM FROIO

Franchisee, Burger King




CHECK OUT OUR WHITE PAPER

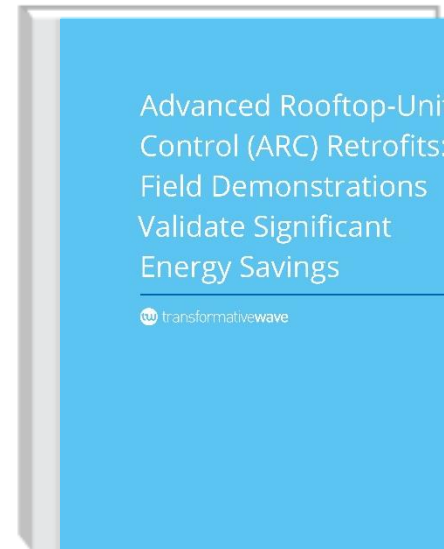
Advanced Rooftop-Unit Control (ARC) Retrofits: Field Demonstrations Validate Significant Energy Savings

ADVANCED ROOFTOP-UNIT CONTROLS (ARC)

This white paper details the extensive field demonstrations that have been completed by utilities and third-party organizations to validate the savings and outcome of ARC retrofit installations across North America.

Key Takeaways:

-  **Normalizing the Results:** Understand how the technology performs across multiple climate zones
-  **Field Demonstrations:** Review completed and pending field demonstrations across the country
-  **Realize Savings:** Available utility incentives, Automated Fault Detection & Diagnostics capabilities, as well as measured and verified savings back up the value proposition of ARC technology




[Click Here to Download the White Paper](#)

THANK YOU

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