

# Experiences Commercializing FDD in the Northwest

Danny Miller, President – Transformative Wave



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# Our Background

- Transformative Wave is the manufacturer of the leading HVAC retrofit solution for constant volume HVAC systems, the CATALYST.
- Subsidiary of a 30-year-old HVAC commercial service company in the Pacific Northwest.
- Team has surveyed, serviced, and/or applied our technology to over 5,000 unique RTUs in the U.S. and Canada.
- Have been collecting and analyzing RTU data for the last five years.
- Our approach and views are driven by real-life experience and HVAC expertise.

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# Our Technology

- The CATALYST is proven to reduce HVAC overall energy use by 25-50% in multiple DOE and utility field trials.  
[http://www.pnl.gov/main/publications/external/technical\\_reports/PNNL-22656.pdf](http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf)
- The energy savings provides the economic “fuel” to finance our web-enabled advanced features included in the eIQ Platform. <http://transformativewave.com/eiq>
- RTU’s are connected wirelessly with 40-points of data collected and stored in a SQL database at 1-minute interval histories.
- Features include fault detection and diagnostic capabilities that focus on RTU efficiency and performance from a whole-unit perspective. Annunciated via smart phones, tablets, & browsers.
- Automated Demand Response (ADR) capable


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# Our FDD Features

## Unit03 Health Status

- Drive Communication ●
- Drive Fault ●
- Fan Run ●
- Fan Belt ●
- Heating Fail ●
- Cooling Fail ●
- Damper Fail ●
- Space Sensor ●
- Supply Sensor ●
- Return Sensor ●
- OSA Sensor ●
- CO2 Sensor ●
- Service Off ●


72.0 °F  
Clear

**Scottsdale**  
 7111 E. Mayo Blvd.

Unit Name	Serves	Comm Mode	Health	Occ	Fan Call	Comfort Status	Space Temp	Actual Heat S/P	Actual Cool S/P	Fan Status	Fan Speed	Fan Power	Cooling		Heating		Supply	Return	OSA	CO2	OSA Volume
													1	2	1	2					
Unit01	Sales Seafood	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	71.6 °F	70 °F	73 °F	<span style="color: green;">●</span>	40 %	0.34 kW	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	80.3 °F	77.5 °F	87.9 °F	446 ppm	-
Unit02	Main Sales Cntr	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	72.3 °F	70 °F	73 °F	<span style="color: green;">●</span>	40 %	0.33 kW	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	80.7 °F	77.8 °F	88.7 °F	450 ppm	-
Unit03	Sales Tapas	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	72.8 °F	70 °F	73 °F	<span style="color: green;">●</span>	40 %	0.36 kW	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	79.7 °F	76.7 °F	88.0 °F	473 ppm	-
Unit04	Loading Dock	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	70.3 °F	68 °F	71 °F	<span style="color: green;">●</span>	90 %	1.80 kW	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	53.0 °F	72.1 °F	84.2 °F	412 ppm	-
Unit05	Food Prep	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	71.0 °F	68 °F	71 °F	<span style="color: green;">●</span>	40 %	0.13 kW	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	82.7 °F	77.8 °F	82.7 °F	392 ppm	-
Unit06	Checkstands	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	70.6 °F	68 °F	73 °F	<span style="color: green;">●</span>	40 %	0.14 kW	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	82.8 °F	78.1 °F	80.3 °F	442 ppm	-
Unit07	Bakery	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	71.5 °F	68 °F	71 °F	<span style="color: green;">●</span>	40 %	0.14 kW	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	<span style="color: grey;">●</span>	81.4 °F	77.6 °F	80.6 °F	472 ppm	-
Unit08	Vestibule	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: red;">●</span>	74.0 °F	68 °F	71 °F	<span style="color: green;">●</span>	90 %	0.84 kW	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	45.2 °F	74.0 °F	82.4 °F	-	-
Unit09	Produce	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	<span style="color: green;">●</span>	72.3 °F	68 °F	71 °F	<span style="color: green;">●</span>	90 %	0.46 kW	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	<span style="color: blue;">●</span>	46.3 °F	76.8 °F	47.6 °F	443 ppm	-

Site Data	Unit	Space Humidity	Space Humidity Setpoint		Dehumidification		Dehumidification Su	Dehumidification Fan Speed Setpoint		Space Dewpoint
			Cool	Reheat	Cool	Reheat				
OSA Humidity 20.5 %RH	Unit01	31.3 %RH	50.0 %				80.0 %	39.7 °F		
	Unit02	28.8 %RH	50.0 %				80.0 %	38.1 °F		
	Unit03	35.7 %RH	50.0 %				80.0 %	44.7 °F		
OSA Dewpoint 39.4 °F	Unit04	-	-	-	-	-	-	-		
	Unit05	-	-	-	-	-	-	-		
Space Static 0.02 in/wc	Unit06	34.4 %RH	50.0 %			55.0 °F	75.0 %	41.3 °F		
	Unit07	34.9 %RH	50.0 %			55.0 °F	75.0 %	42.5 °F		
	Unit08	-	-	-	-	-	-	-		
	Unit09	32.7 %RH	50.0 %			55.0 °F	75.0 %	41.4 °F		



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## Our FDD Features

- **Controller-level “real-time” faults include:**
  - Sensor failures including values out of range and loss of connectivity
  - Drive faults involving numerous fault codes generated by the variable frequency drive and communicated via a ModBus IP interface.
  - Communication faults
  - Inadequate airflow
  - Lack of cooling performance
  - Lack of heating performance
  - Economizer actuator and damper failure
  - Fan belt slippage indicating need for replacement or adjustment.
  - Proper functionality of the CATALYST and its individual components.

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## Our FDD Features

- Time-based degradation faults using historic data:
  - Improper schedules
  - Excessive use of after-hours override functions
  - Disproportionate runtime between RTUs
  - Changes in the economizer performance
  - Degraded cooling output
  - Comparative RTU energy use analytics for outlier identification

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## Our FDD Features

- **California Title 24 Compliant:**
  - Air temperature sensor failure/fault
  - Not economizing when it should
  - Economizing when it should not
  - Damper not modulating
  - Excess outdoor air

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## Pending FDD Features

- Under contract with PNNL/DOE on refrigerant side rooftop unit embedded diagnostics using Purdue's virtual sensor method:
  - Fouled condenser Coil
  - Fouled evaporator coil
  - Low refrigerant charge
  - Excessive refrigerant charge
  - Liquid line restriction
  - Compressor valve leakage
  - Non-condensable gas present

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## Our Findings

- Things are worse than we think
- Most of it is preventable
- Reliance on Building Management Control systems is inadequate
- Remarkably, even those paying for a facility monitoring service are subject to much of the same.
- The majority of deployed RTUs lack advanced features and those that do have FDD are not leveraging it.
- Customers are rarely interested in investing in features that cannot be cost justified in the short term.

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## Our Challenges

- Getting customers to avoid taking low-cost short cuts to the fan energy savings. The trend is that retailers, who control the majority of RTUs, opt for simple drive products or VFD's. This is shortsighted and misses the larger opportunity.
- Convincing customers to buy into the CATALYST with eIQ offering where higher incentives and savings will pay for FDD.
- Getting multi-site customers to properly consider the value of these robust tools and the positive impact they will have.
- Overcoming customer's belief that they have inadequate staff to handle information they already receive.
- Consultants, contractors and technicians have not yet bought into advanced FDD tools.

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# Our Recommendations

## 1. Promote tools that “make smart – simple” to deal with the information overload that currently exists.

- We believe customers need a robust tool set that does not prescribe the priority or messaging conditions. When the customer understands that they will not be overwhelmed with emails or alerts, their resistance subsides.
- FDD can be very complex “under the hood” but customers want simple intuitive tools that are easily customizable.

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## Our Recommendations

### 2. Invest more into validating and quantifying the cost of “not knowing”.

- The case must be made using data on a customer-specific basis. General cost justification numbers don't create the kind of confidence and buy-in necessary for AFDD to gain traction. If we can create cost-avoidance tables or demonstrate an accumulated value for the FDD, the customer will be able to justify it. Everyone answers to someone and those recommending capital investment need to be armed with hard evidence that supports the value of FDD as an enterprise priority.

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# Our Recommendations

## 3. Consider radical alternatives:

- Should the utilities take on the cost and management of FDD for ratepayers if the benefit is so great and the resistance so formidable?
- Should the major national and regional accounts be required to invest in the deployment and use of FDD by retrofitting existing equipment and in the purchase of new equipment?

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# Questions??

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transformativewave  
CATALYST

## North America's Leading Retrofit Solution for Rooftop Packaged HVAC Systems



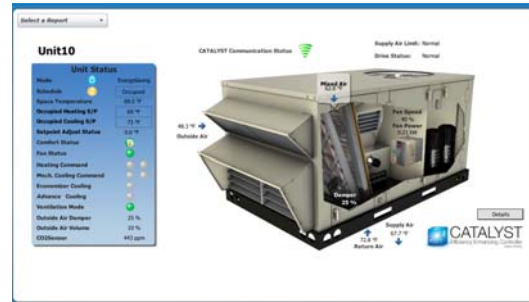
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PERFORMANCE & EFFICIENCY VERIFICATION  
RETROFIT KIT COMPREHENSIVE  
PORTFOLIO ASSET MANAGEMENT  
30-50% ENERGY SAVINGS  
PRE-PROGRAMMED 70% FAN SAVINGS  
PREDICTABLE COST EFFECTIVE  
70% FAN SAVINGS  
DOE VALIDATED  
ADVANCED  
DATA  
DCV  
DEMAND CONTROL  
CONTROL





# transformative wave eIQ Platform



Mor Furniture - Kent Site Report

34.0 °F

Connection Status: Online

Unit Name	Series	Comm	Mode	Health	Oct	Fan Coil	Comfort	Space	Actual	Actual	Fan	Fan	Coilng	Wdng	Supply	Return	CO2	Volume
UNIT01	Control Panel	✓	✓	✓	✓	✓	86.3 °F	68.7 °F	72 °F	72 °F	100 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT02	Unit 2	✓	✓	✓	✓	✓	71.2 °F	71 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT03	Unit 3	✓	✓	✓	✓	✓	71.5 °F	72 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT04	Unit 4	✓	✓	✓	✓	✓	68.8 °F	68 °F	72 °F	72 °F	100 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT05	Unit 5	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT06	Unit 6	✓	✓	✓	✓	✓	67.4 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT07	Unit 7	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT08	Unit 8	✓	✓	✓	✓	✓	68.7 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT09	Unit 9	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT10	Unit 10	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT11	Unit 11	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT12	Unit 12	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT13	Unit 13	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT14	Unit 14	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT15	Unit 15	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT16	Unit 16	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT17	Unit 17	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT18	Unit 18	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT19	Unit 19	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm
UNIT20	Unit 20	✓	✓	✓	✓	✓	68.5 °F	68 °F	72 °F	72 °F	75 %	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm	0.00 gpm

## Web Accessible Control, Visualization, & Fault Detection

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DEMAND RESPONSE PERFORMANCE & EFFICIENCY VERIFICATION  
RTU RETROFIT KIT COMPREHENSIVE VERIFICATION  
PORTFOLIO ASSET MANAGEMENT ADVANCED  
30-50% ENERGY SAVINGS 70% FAN SAVINGS  
PRE-PROGRAMMED 70% FAN SAVINGS  
PREDICTABLE COST EFFECTIVE  
70% FAN SAVINGS

Advanced  
Fault  
Detection &  
Remote  
Diagnostics

Energy  
Saving  
Hardware  
Upgrade

Efficiency &  
Performance  
Verification  
Tools

**CATALYST** *with eIQ*  
comprehensive solution

M&V Data  
Collection  
Mechanism

Demand  
Response  
Technology

Building  
Control  
System

DEMAND CONTROL PORTFOLIO  
DATA  
30-50% ENERGY  
PRE-PR  
PREDICTABLE  
70% FAN SAVING  
EFFICIENCY  
COMPREHENSIVE  
IMPLEMENT  
70% FAN SAVING  
DOE VALIDATED  
ADVANCED

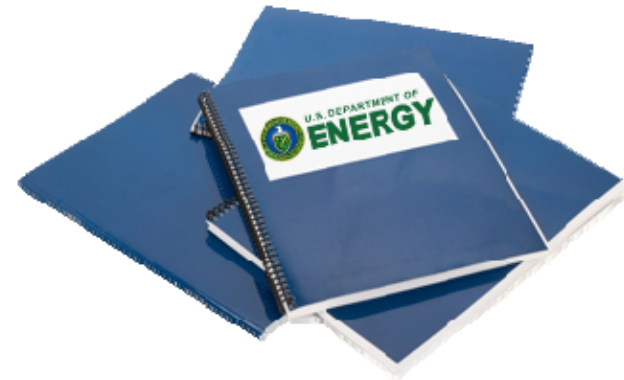
# Third-party Validated Savings

- New study by PNNL shows CATALYST saved an average energy savings of 57% on 66 RTUs across four US climate zones.



**Pacific Northwest**  
NATIONAL LABORATORY

*Proudly Operated by **Battelle** Since 1965*



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## Three Applications to Choose from



### CATALYST *BMS*

Full-featured CATALYST with Tridium BMS for control of HVAC and lighting with portfolio asset management tool.



### CATALYST *eIQ*

Full-featured CATALYST with web-based live views, fault detection, and energy accountability overlay to existing BMS.



### CATALYST *lite*

Smart VFD for those looking for supply fan control. Includes CATALYST ventilation and equipment protection features.





# transformativewave eIQ Platform

Live Demonstrations Available



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DEMAND RESPONSE PERFORMANCE & EFFICIENCY VERIFICATION  
RTU RETROFIT KIT COMPREHENSIVE REAL-TIME MONITORING  
PORTFOLIO ASSET MANAGEMENT  
30-50% ENERGY SAVINGS  
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