Packaging LED & Advanced Rooftop-Unit Control (ARC) Retrofits for Maximum Performance

transformativewave

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"THE ARGUMENT FOR A BUNDLED LED AND ADVANCED ROOFTOP-UNIT CONTROL (ARC) RETROFIT PACKAGE **IS STRONG**"

INTRODUCTION

LED lighting and Advanced Rooftop-Unit[1] Control (ARC) retrofits have been making significant headway into the market over the past three years. They have both benefited from advancements in technologies, reduced material costs, third-party validation, and increased consumer confidence from broad market adoption. Compared to your current lighting (e.g., fluorescents, ceramic metal halide (CMH), etc.), LEDs reduce your annual lighting energy by 40-60% while improving light distribution (i.e., 'pop' for retailers and uniformity for offices) and color temperature. With controls including occupancy sensors and dimming, LEDs can reduce your annual lighting energy by 80-90%.

ARCs enhance your building's thermal comfort along with exceptional heating, ventilating and air-conditioning (HVAC) energy savings. ARCs reduce HVAC annual energy by 46% on average based on fourteen third-party field demonstrations by the Department of Energy (DOE), Department of Defense (DOD) and utilities across the country (ARC Retrofits: Field Demonstrations Validate Significant Energy Savings **White Paper**[2]).

Beyond improved performance coupled with significant energy savings, LEDs and ARCs have another feature in common. They increasingly have web-connected smarts in their DNA. Their inherent controllability and web integration empowers facility managers with remote control and oversight through smart phones, tablets and laptops.

If you're looking to cost-effectively improve lighting performance and thermal comfort while significantly reducing energy and peak demand, the argument for a bundled LED and ARC retrofit package is strong for several reasons:

1. ARCs offset the negative impact on your building's heating demands after an LED retrofit.
2. ARCs solve the humidity control problems that LED retrofits can cause.
3. A packaged solution enables you to claim all the cooling energy savings from an LED retrofit, increasing your utility rebates and helping you realize your energy goals.

Yet, surprisingly, LED and ARC retrofits are rarely packaged into a single project. As we dive into this article, there are energy and non-energy (performance) benefits to be gained. The reason they haven't

1 Rooftop-Unit (RTU) is a packaged heating, ventilating, and air-conditioning (HVAC) system.
2 http://info.transformativewave.com/arc-wp

is twofold. First and foremost, the lighting world is siloed from the HVAC world. The manufacturers are different, the contractors are different, they speak different languages. For new construction, we have started to see the two interact in exciting new ways, optimizing from a whole building perspective. In the retrofit market, lighting and HVAC technologies are competitors, vying for the same capital expenditure funding that companies make available each year.

The second part of the fold is limited bandwidth of a company's internal resources. As a facility manager, it's enough work juggling your day-to-day commitments. Now add coordinating electrical and mechanical contractors simultaneously.

"ENERGY PERFORMANCE CONTRACTING (EPC) IS AN INNOVATIVE FINANCING TECHNIQUE THAT LEVERAGES UTILITY BILL SAVINGS FROM REDUCED ENERGY CONSUMPTION **TO REPAY THE COST OF INSTALLING LEDs AND ARCs.**"

Fortunately, there is an improved Energy Performance Contracting (EPC) solution that enables you to overcome your capital budget constraints and avoid burdening internal resources with managing retrofit projects. EPC is an innovative financing technique that leverages utility bill savings from reduced energy consumption to repay the cost of installing LEDs and ARCs. Your monthly payments are based on a percentage of the measured energy savings. You keep the remaining percentage which enables you to be cash-flow positive from day-one. Another way to think about it is that you and the EPC company share the savings during the term. After the contract term, you own everything outright but never had to report it on your company's balance sheet because it's a service (energy savings-as-a-service), not a capital improvement. EPC integrates project management to oversee the installation so your internal resources need only to coordinate when work can be performed. Once installed, the EPC company even covers the full maintenance on the LED and ARC assets during the term, freeing up your internal resources even further.

This may sound too good to be true. But it's not and the reason why is because of the cost effectiveness of LED and ARC retrofits. After utility rebates that range from 20% to over 50% of the installed cost, a packaged LED and ARC retrofit often achieves a simple payback in two to five years depending on the building configuration, hours of operation, climate, and utility rate. Simple paybacks of two to five years typically translate to an Internal Rate of Return (IRR) around 50% to 10%, respectively, over a seven-year term. Companies with sufficient internal funding and resources can implement these retrofits and realize significant rates of return. Unfortunately, many facility managers are in a catch-22 scenario, asked to reduce energy spends with constrained budgets. In this case, EPC might be a great avenue for you to realize dramatic lighting and HVAC energy savings, be cash-flow positive from day-one, and be free of maintaining these assets during the contract term.

In the following article, we explore a packaged LED and ARC retrofit in more detail. First, we summarize what an ARC retrofit is since many of you may not be familiar with this technology, unlike LEDs. We then summarize how ARCs can improve the performance and realized energy savings from an LED retrofit. We wrap up with how EPC provides a great financing avenue for rolling-out an LED and ARC retrofit across multiple buildings within a company's portfolio.

WHAT ARE ADVANCED RTU CONTROLLERS?

LEDs have become common place across the residential, commercial and industrial markets so we will jump to the more unknown side of this paired retrofit package. ARCs, despite their dramatic push into the retrofit market, are still less familiar. So we want to give a brief description of ARC technology.

The best way to describe them is through the DOE's ARC Campaign[3] that advocates for cost effective technologies targeting the nation's vast Rooftop-Unit (RTU) market. The DOE established an entire RTU

3 http://www.advancedrtu.org/

campaign because they are everywhere, heating and cooling over 60% of our nation's commercial floor space[4]. And they are notorious for wasting energy, sitting on rooftops, out of sight, out of mind, guzzling energy to the detriment of your bottom line.

According to the DOE's specification[5], ARCs retrofit constant-volume RTUs to provide energy savings through multi-speed fan control, demand control ventilation (DCV) and advanced economizing. These features provide energy savings in the following ways.

Multi-Speed Fan Control – Replacing the existing constant speed fan control, ARCs adjust the supply fan's speed according to the RTU's operation (heating, cooling or ventilating). For most RTUs, the majority of their operational hours are in ventilation mode. Here, ARCs reduce the fan speed to 40% which drives the fan power down by 90%. During part-load (stage-1) heating or cooling, ARCs reduce fan power by 40%. In fact, in many commercial buildings, the constant speed fan consumes more energy than the compressors during the year. Therefore, multi-speed fan control saves significantly more energy than technologies that focus on improving compressor performance.

Demand Control Ventilation (DCV) – Some ARCs monitor the carbon dioxide (CO_2) concentration in the return air to infer the ventilation needs of the space. When the CO_2 is below a pre-programmed threshold, typically 1,000 parts per million (ppm), the ARC will provide a lower ventilation rate. When the CO_2 exceeds that threshold, the ARC will bring in more outdoor air to drive that CO_2 concentration down. DCV meets building code ventilation requirements (ASHRAE 62.1) while eliminating the need to heat, cool and dehumidify outdoor air your space never needed.

Advanced Economizing – More advanced ARC solutions enhance the code-minimum economizer logic. Using differential dry-bulb control logic, ARCs can leverage the outdoor air significantly more to offset energy intensive compressors. And with dew-point lock-out, ARCs avoid bringing in humid air that code-minimum economizers have a tendency to do which causes comfort complaints and demands more energy for dehumidification. One ARC solution on the market also implements predictive control. By recognizing when the space is starting to warm-up during the morning hours, this solution begins economizing early, delaying the need for compressor based cooling until later in the day.

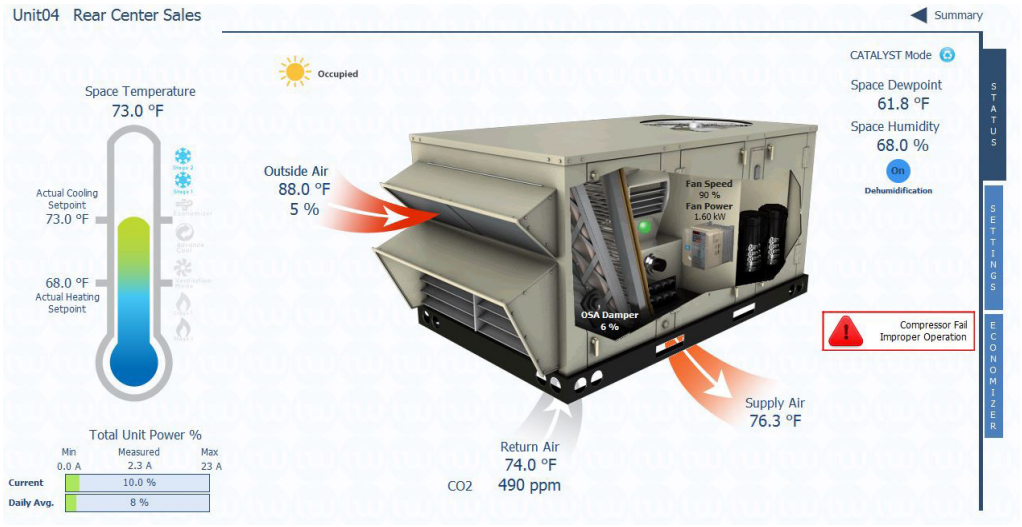
The Advanced RTU Campaign's specification also identifies an essential feature in which the outdoor air damper must modulate open when the supply fan speed reduces. This ensures sufficient ventilation air during occupied times. If the outdoor air damper did not open at lower fan speeds, then the RTU would be starving the space of fresh air and not abiding by the local building code.

"ACCORDING TO THE DOE'S SPECIFICATION, ARCs RETROFIT CONSTANT-VOLUME RTUs TO PROVIDE ENERGY SAVINGS THROUGH **MULTI-SPEED FAN CONTROL, DEMAND CONTROL VENTILATION AND ADVANCED ECONOMIZING.**"

Figure 1 provides a visual of an ARC. A variable frequency drive (VFD) on the supply fan enables multi-speed control. The ARC monitors the outdoor temperature and relative humidity to know when to economize. A CO_2 sensor keeps an eye on the space's ventilation needs while the ARC maintains the outdoor air damper at a minimum position to avoid over ventilation. More advanced ARCs provide automated Fault Detection and Diagnostics (Automated FDD). Here you see the space is asking the RTU to provide dehumidification. The ARC is commanding both compressors to be on, but the RTU is not cooling and dehumidifying the air. The ARC's Automated FDD is alerting of an issue and warrants further investigation (Automated FDD **eBook**[6]).

4 EIA. 2003. Commercial Buildings Energy Consumption Survey. Energy Information Administration, U.S. Department of Energy. www.eia.doe.gov/emeu/cbecs/contents.html.
5 http://www.advancedrtu.org/uploads/7/4/8/7/7487823/bba_advanced_rtu_controller_spec_v0.3_2015-01-07.docx
6 http://info.transformativewave.com/EBook_Automated_Fault_Detection_and_Diagnostics_by_TW

Figure 1. Example Dashboard of an RTU with an Advanced ARC Installation



AVOID INCREASED HEATING BILLS WITH LED RETROFITS

All the power consumed by lighting, whether it be fluorescents, metal halide, or LED, eventually turns into heat. The type of heat that lighting emits to a space is sensible heat meaning that it increases the space's temperature (dry-bulb). The other type is latent heat which increases how much moisture is in the air, but we'll cover that in the next section. For now, we just need to know that lighting power increases the space temperature.

In the winter, the heat gain from lights will offset how much natural gas, oil or electric heat your building needs to stay comfortable. Depending on your current lighting type (e.g., fluorescent, CMH, etc.), an LED retrofit can reduce your lighting power by 40-60%. When you reduce the power by 40%-60%, you also reduce the heat generated from the lights by 40-60%. This reduces your cooling load in the summer but increases your heating load in the winter. So your RTUs need to make up the difference.

"ARCs NOT ONLY ELIMINATE THE INCREASED HEATING DEMAND FROM AN LED RETROFIT, THEY WILL PROVIDE HEATING SAVINGS ON TOP OF THAT."

Fortunately, ARCs not only eliminate the increased heating demand from an LED retrofit, they will provide heating savings on top of that. ARCs reduce your building's heating demands in two ways. First, through DCV, they only provide the fresh air a space needs, rather than over-ventilating which is likely your current operation. When it's cold outside, ARCs bring in less ventilation unless it's necessary. In fact, ARCs rarely see the return air CO_2 concentration exceed the threshold except for extremely high occupancy periods like Black Friday for retailers or big events at a venue. In other words, ARCs are maintaining the outdoor air damper at a minimum position 99% of the occupied hours while meeting the ventilation needs of your spaces.

ARCs also reduce heating demands by ensuring the outdoor air damper is closed during unoccupied times. While code minimum RTUs should provide this level of control using a typical programmable thermostat, many do not. Often modulating outdoor air dampers are bypassed and set to some fixed position. This not only keeps the damper open during night time RTU operation, bringing in outdoor air that isn't needed, it also eliminates the RTU's ability to economize.

ARCs ensure the outdoor air damper is modulating properly and according to the correct occupied/unoccupied schedule. This ties into the web-connected smarts inherent in ARCs. Their internet connectivity enables users to ensure long-term performance and energy savings.

ARCs SOLVE HUMIDITY ISSUES FROM LED RETROFITS

Unfortunately, an LED retrofit may cause or exacerbate humidity control issues. This may seem counterintuitive so we'll use an example. A typical retail store with T8 fluorescents has a lighting power density (LPD) of 1.0 watt per square foot. The RTU's cooling capacity (tonnage) is sized for that internal sensible load – remember as we summarized above, all lighting power ends up as sensible heat to the space. The store receives an LED retrofit which reduces its LPD to 0.5 watts per square foot, a 50% reduction.

The internal sensible heat has reduced. Yet the latent heat gains, which are adding moisture to the space, do not change. The same amount of humid air is infiltrating into your building. The same number of occupants are still evaporating sweat into the air. An LED retrofit doesn't impact these latent loads.

Therefore, after an LED retrofit, with the latent heat remaining the same and the sensible heat reducing, the ratio of latent to sensible has increased. When this happens, RTUs will have greater difficulty managing humidity. And for many buildings, the RTUs won't be able to maintain the proper humidity levels – typically 55% or below according to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)[7].

"AFTER AN LED RETROFIT… RTUs WILL HAVE GREATER DIFFICULTY MANAGING HUMIDITY. AND FOR MANY BUILDINGS, THE RTUs WON'T BE ABLE TO MAINTAIN THE PROPER HUMIDITY LEVELS."

There are two reasons for this difficulty. First, is excessively oversized RTUs and Figure 2 explains why. When a thermostat demands cooling, the RTU turns on compressors. The light blue area in Figure 2 represents water slowly starting to accumulate onto the evaporator coil in the air stream. At this stage, the RTU is providing both sensible cooling (reducing the air temperature) and latent cooling (taking moisture out of the air).

Here is where it gets tricky. The compressor has to be run for a sufficient amount of time until "useful moisture removal" occurs, signified by the dark blue area. During this phase of the compressor operation, condensed water on the evaporator coil drops to the condensate pan and goes down the drain.

So why is all the water that has accumulated on the coil not useful latent cooling? Because as soon as the compressor turns off, all that water on the coil gets re-evaporated into the air stream. The time right after the compressor kicks off (green area) shows the RTU essentially operating as a swamp cooler. Here the RTU is doing negative latent cooling (adding moisture back into the air) and positive sensible cooling.

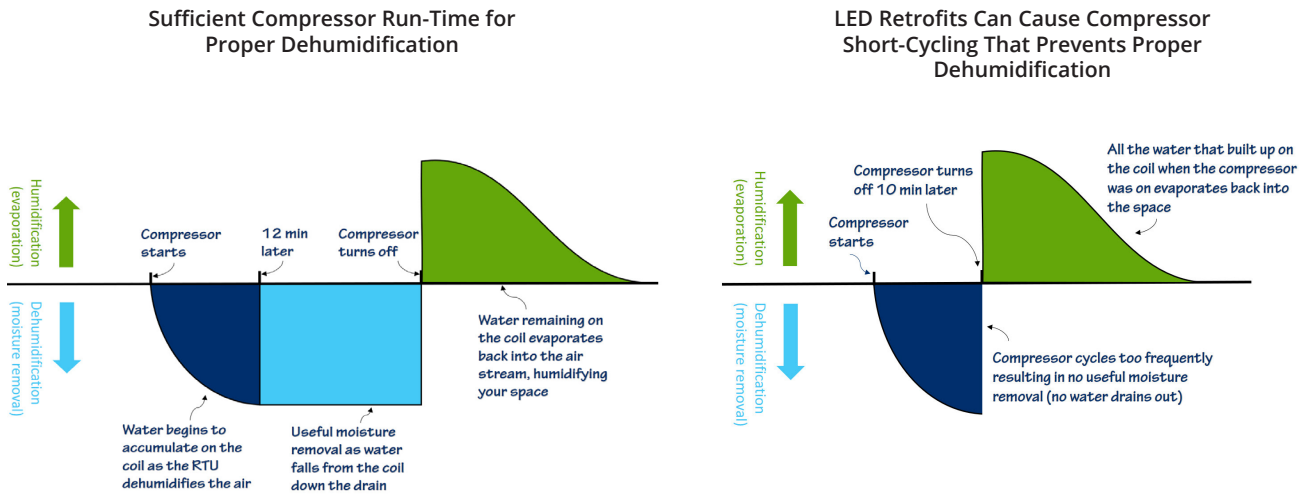
A great analogy is your car's air-conditioning (AC) on a humid day. When you turn the AC off but the fan keeps blowing, you feel cool, wet air coming out. And it normally has a musty smell to it. Your car's AC turned into a swamp cooler as soon as you turned the AC off. All that water that had collected inside your car's AC system is being evaporated back into the vehicle.

Now that we know the physics, let's tie in how oversized RTUs compromise humidity control. The more oversized an RTU is relative to the space it cools, the shorter the duration of each compressor cycle. As soon as the thermostat calls for cooling, the oversized RTU will be able to drive the space temperature back down to set-point quickly. As a result, the compressor cycles frequently, meaning it is reducing its "useful moisture removal" (light blue area in Figure 2). The rule of thumb is if a compressor is on for less than 10 minutes, minimal useful latent cooling was done.

Compounding the problem, the evaporation of the water from the coil after each compressor cycle provides more sensible cooling to the space. In other words, some of the latent cooling provided when the compressor was on, transforms into sensible cooling after the compressor cycles off. This reduces the compressor on-time further, eliminating more useful moisture removal time.

7 Harriman, L. G. & Lstiburek, J. W. (2009). The ASHRAE Guide for Buildings in Hot and Humid Climates. ASHRAE. Atlanta, GA.

Figure 2. Positive and Negative Latent Cooling (Moisture Removal) Over a Compressor Cycle



LED retrofits exacerbate the problem because they eliminate sensible heat from the space. Now the RTUs are even more oversized. In some cases, buildings that did not have humidity control problems before will start experiencing humidity issues. For buildings that already had humidity issues, an LED retrofit will certainly make it worse.

Many facility mangers fight against high humidity by reducing the thermostat set-point to a temperature like 70°F or even lower. A lower set-point increases compressor run-times which drives more useful moisture removal (latent cooling). While a lower set-point can reduce the humidity, it increases comfort complaints from having too cold of a space. And it increases your electricity bill. ARCs fight high humidity without needing to resort to a cold, uncomfortable set-point.

ARCs improve humidity control in three ways. First, by implementing DCV logic, they prevent over-ventilation which keeps humid air out. Second, ARCs reduce the fan speed during the first-stage and second stage cooling. At a slower fan speed, RTUs provide a better job of drawing moisture out of the air and therefore dehumidifying the space. Third, some ARCs improve the code-minimum economizer logic sequence with an adjustable dew-point lock out which prevent the RTU from economizing when the outside air dew-point is above a pre-determined threshold. For office applications, typically 65°F dew-point is used and 55°F dew-point for grocery applications (Humidity Control **White Paper**[8]).

ENERGY PERFORMANCE CONTRACTING

In the introduction, we highlighted two obstacles to a packaged LED and ARC retrofit: lack of internal funding and lack of internal resources to manage coincident installs. EPC is a powerful solution to overcome both obstacles.

The EPC company designs, builds and operates the LED and ARC programs. For this service, you share the energy savings with them during the contract term. Every month you pay the EPC company some percentage of the measured energy savings. If the LEDs and ARCs saved you 10,000 kWh of energy last month and the contract establishes you pay 80% of that, then you pay them for 8,000 kWh. The contract term is configured such that you are either cost-neutral or cash-flow positive from day one. You can choose either scenario. We provide an example in the next section that will clarify this shared savings concept further.

It's 'energy savings-as-a-service', an all-inclusive 'pay as you save' option which includes project management during the install and full maintenance coverage of the assets during the contract term.

8 http://info.transformativewave.com/l/138811/2016-07-06/h558y/138811/19498/WHITEPAPER_Improve_Occupant_Comfort_by_Transformative_Wave.pdf

The following bullets summarize the benefits of this EPC model applied to an LED and ARC retrofit:

- You need no capital up-front.
- You can decide to be cash-flow neutral or cash-flow positive from day one.
- The capital improvement remains off the balance sheet, yet you own the LEDs and ARCs at the end of the term.
- Each month, instead of paying the utility for energy you no longer needed because of the LED and ARC upgrades, you pay the EPC company for some agreed upon percentage of the energy savings.
- You are less exposed to utility rate increases since you've eliminated a significant fraction of your monthly bill which is locked into a non-escalating payment structure for the contract term. After the contract term, you have paid off the LED and ARC assets, and now enjoy a smaller utility bill indefinitely. This is especially beneficial as utilities move toward Time-of-Use pricing which makes electricity cheaper at night when your buildings are using less energy and significantly more expensive during the day when you typically use more energy.
- The LED and ARC energy savings are quantified using well established Measurement and Verification (M&V) methods from the International Performance Measurements and Verification Protocol[9] (IPMVP) and the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) Guideline 14[10].
- During the install, your internal team only needs to coordinate times when the installation can happen. The rest of the project management is taken care of and you work directly with the EPC company rather than multiple contractors.
- Maintenance is also included so your internal team does not need to fix anything on the LED and ARC assets during the EPC term.
- Since you pay based on the energy savings each month, you have real-time knowledge of whether the LED and ARC retrofit is meeting performance expectations. And if it isn't, you can leverage the maintenance that is bundled in the EPC to address any operational issues with the assets. Often times, it's not an issue with the LED or ARC assets but improper control by building staff such as setting thermostat set-points too low or overriding lighting controls that leave the lights on during unoccupied times. Since LEDs and ARCs can easily be web-connected through a building automation system (BAS), which can come packaged with the retrofit, improper control can be quickly identified and remedied using Automated FDD.

EXAMPLE LED + ARC RETROFIT USING EPC

An example should help clarify how using an EPC financing mechanism can enable you to realize the significant energy savings and cost effectiveness of a packaged LED and ARC retrofit. Now, you can avoid having to wait for your limited capital funds to do LED and ARC retrofits separately. EPC is especially powerful for multi-site roll-outs rather than having to conduct retrofits on one building at a time when the internal funding becomes available.

"**EPC IS ESPECIALLY POWERFUL FOR MULTI-SITE ROLL-OUTS,** RATHER THAN HAVING TO CONDUCT RETROFITS ON ONE BUILDING AT A TIME WHEN INTERNAL FUNDING BECOMES AVAILABLE."

9 http://www.nrel.gov/docs/fy02osti/31505.pdf
10 ASHRAE. 2002. ASHRAE Guideline 14-2002. Measurement of Energy and Demand Savings. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA. https://gaia.lbl.gov/people/ryin/public/Ashrae_guideline14-2002_Measurement%20of%20Energy%20and%20Demand%20Saving%20.pdf

Table 1 shows an example of a 25,000 square foot standalone retail building with a $0.10 per kWh fixed utility rate. The ARC retrofit, after typical rebates, realizes a $0.67 installed cost per square foot and pays back in 3.6 years. An LED retrofit at $1.00 per square foot installed after typical rebates pays back in 4.4 years. When combined together, an additional 15,359 kWh energy savings from reduced cooling loads can be used to leverage additional rebates. At $0.12 per kWh of savings, which is a typical incentive level for many utility rebate levels, this reduces the combined installed cost to $39,858 with a 3.4 year simple payback.

Table 1. Example Energy Savings, Installed Cost and Payback on an LED and ARC Retrofit

	Annual Energy Savings	Annual Utility Savings	Installed Cost After rebates	Simple Payback
ARC	45,900 kWh	$4,590	$16,701	3.6
LED	56,713 kWh	$5,671	$25,000	4.4
Reduced Cooling from LEDs	15,359 kWh	$1,536	($1,843)	
LED + ARC	117,971 kWh	$11,797	$39,858	3.4

Instead of paying $39,858 up-front, Table 2 summarizes two different EPC options. The first option is configured to achieve the shortest contract term at 4 years. Here you are cash-flow neutral and paying the EPC company 100% of the realized savings during the term.

If you wanted to be cash-flow positive from day one, the second option would be more attractive. Here, you keep 20% of the savings each year and the contract term increases to 6 years. This shows the flexibility of the EPC model where the contract term can be changed according to how cash-flow positive you want to be.

Table 2. Example Contract Term Options for Applying EPC to an LED and ARC Retrofit

	100% of Savings to EPC During the Term	80% of Savings to EPC During the Term
Contract Term	4	6
Total Utility Annual Savings	$11,797	$11,797
Your Annual Payments to the EPC Company During the Term	$11,797	$9,438
Savings You Keep Each Year During the Term	$0	$2,359
Lighting Maintenance Savings During the Term	$1,350	$1,350
10-Year NPV at 6% Discount Rate	$67,245	$62,075

Since the EPC includes full maintenance of the LED and ARC assets, you will also realize reduced maintenance costs over the contract term. The EPC company will not charge you for those because compared to the energy savings, they are too difficult to measure each year. Only the estimated lighting maintenance savings of $1,350 per year are shown in Table 2 because these are easier to quantify based on bulb replacement frequency. While there will be HVAC maintenance savings from the Automated FDD oversight provided by the ARC's remote monitoring and control through its BAS (Automated FDD **eBook**[11]), these can vary dramatically based on the existing conditions and age of the RTUs. Therefore, the estimated HVAC maintenance savings are not included in Table 2. In summary, you pay the EPC company with energy savings as the currency and the operational savings on your lighting and HVAC assets are an added bonus at no charge to you.

11 http://info.transformativewave.com/EBook_Automated_Fault_Detection_and_Diagnostics_by_TW

CONCLUSION

If you are evaluating LED retrofits for your building(s) to realize significant 40-60% lighting energy savings and improved lighting performance, you should also look into packaging an ARC retrofit with it. ARCs provide significant HVAC energy savings with advanced control of your RTU assets including multi-speed fan control, DCV and enhanced economizer logic. ARC technology has been validated by fourteen third-party field demonstrations which found that ARCs reduce you HVAC annual energy by 46% on average. And a couple of the more advanced ARCs on the market come integrated within a web-based BAS for remote control and oversight using your preferred smart device.

You will realize improved performance and larger energy savings by packaging an LED and ARC retrofit together. On the energy side, ARCs will reduce your heating energy needs more than the increased heating needs caused by an LED retrofit. On the performance side, ARCs will ensure your building has proper humidity control which can become an issue after an LED retrofit. Finally, an ARC retrofit lets you claim the reduced cooling energy as a result of an LED retrofit for greater utility incentives.

For most facility managers who do not have sufficient capital funding nor internal resources to implement simultaneous LED and ARC retrofits, financing using EPC may be a good fit for your company. With no capital needed up-front, the EPC company designs, builds and operates the LED and ARC programs for the agreed upon contract term. You only pay the EPC company each month based on the realized energy savings. The EPC also includes project management to oversee the installation process so you do not need to coordinate with multiple contractors.

"YOU WILL REALIZE IMPROVED PERFORMANCE AND LARGER ENERGY SAVINGS PACKAGING AN LED AND ARC RETROFIT TOGETHER."

Because it's a service, the capital improvements remain off your balance sheet, yet you own the LEDs and ARCs at the end of the term. Depending on whether you want to be cash-flow neutral or cash-flow positive, you can adjust the contract term to fit your company's goals. Finally, during the term, the EPC company covers all the maintenance of the LED and ARC assets, freeing up your internal resources further.

Bundled together, an LED and ARC retrofit package, especially when financed through an EPC, can help your company hit your energy savings goals, improve the lighting and thermal comfort within your buildings and be cash-flow neutral or positive from day one.

ABOUT TRANSFORMATIVE WAVE

Transformative Wave is a leading energy efficiency innovator in HVAC retrofit and building automation solutions, developing and bringing to market a growing line of game-changing technologies that are transforming the commercial building energy landscape.

With the most advanced ARC product on the market today, Transformative Wave's CATALYST is validated by the DOE to save an average of 57% (PNNL 2013) in energy savings. It is a complete HVAC energy efficiency upgrade and retrofit kit that converts RTUs into smart machines. More than just a variable frequency drive, the CATALYST delivers advanced and predictive economization, demand control ventilation, and fault detection and diagnostics capabilities, while also enabling RTUs to become Smart Grid and Demand Response enabled assets.

The CATALYST provides live interaction via the eIQ Platform, a completely wireless solution that allows real-time monitoring and building automation control over the Internet using computers, laptops or smart phones, along with advanced fault detection diagnostics and troubleshooting capabilities, remote notifications and performance reporting.

For more information on our revolutionary products, including the CATALYST and eIQ Platform, visit www.transformativewave.com.

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