# AR ${AR}: Switch to LED Lighting

**Recommended Action**

Replace ${AREAS} lights with high-efficiency LED lights which provide equivalent lighting.

**Summary of Estimated Savings and Implementation Costs**

|  |  |
| --- | --- |
| Annual Cost Saving | ${ACS} |
| Implementation Cost | ${MIC} |
| Payback Period | ${PB} |
| Annual Electricity Savings | ${ES} kWh |
| Annual Demand Savings | ${DS} kW |
| ARC Number | 2.7142.3 |

**Current Practice and Observations**

Replacing the old lights with new light emitting diode (LED) lights inside the plant will save energy. This AR will indicate the additional savings realized by replacing all existing old lights with new, reliable, and highly-efficient LED technology lights.

Higher efficiency lighting has been a focus for many lighting manufacturers in recent years. New technology has led to light emitting diode lights that have a longer rated life, require less wattage for use, and do not use toxic chemicals, such as ${PREV1} do. First introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness. Also, the measure of light per watt from new LED lights on the market is quickly surpassing current ${PREV1}, and accounting for the higher rate of lumen degradation with time of existing lighting fixtures versus LED lighting oftentimes less LED bulbs/fixtures can provide the same level of lighting as the existing system.

**Light-Emitting Diode (LED) Lighting**

LED technology is currently the primary focus of research and manufacturing for lighting companies, such as General Electric and Phillips. This research and development is leading to LED lighting products that are more efficient converting electrical energy to light, use less power, and have a much longer lifespan, while supplying a comparable amount of light. Since LED lights are solid state, they can be cycled on and off very frequently, and they reach their lighting potential within microseconds, unlike T-8 bulbs, which can take minutes to reach full brightness. Additionally, high frequency cycling does not cause damage to LED lighting, unlike fluorescent lighting, which will burn out faster. The amount of lumens from LED lights has been shown to decay less over the operational lifecycle versus traditional metal halides or fluorescent bulbs, see figure below.

Chart

Description automatically generated

**Figure 1:** **Lumen Depreciation for Conventional Sources[[1]](#footnote-1)**

Color improvements with a blue-white light and improved uniformity cause the overall visibility to improve through LED bulbs, even though as much as 43% less foot-candles may be present. All these advantages make indoor LED lighting solutions ideal for the plant area applications requested by your plant.

**Anticipated savings for ${AREA1} lighting:**

The savings results from replacing the ${PREV1} in ${AREA1} with LED bulbs are outlined in this section. The estimated energy savings, ES1, for replacing all of these lights with LED bulbs is calculated as follows:

ES1=

where:

CN1 = Current number of ${PREV1}; ${CN1}

CFW1 = Power rating of current ${PREV1} in ${AREA1}; ${CFW1} W

COH1 = Current Operating hours of lights in ${AREA1}; ${COH1} hrs/yr

PN1 = Proposed number of LED bulbs; ${PN1}

PFW1 = Power rating of proposed LED bulbs in ${AREA1}; ${PFW1} W

POH1 = Proposed operating hours of lights in ${AREA1}; ${POH1} hrs/yr

C1 = Conversion constant; 1,000 W/kW

The estimated energy savings, ES1, by replacing ${PREV1} with LED bulbs is calculated as:

ES1 = ${ES1Eqn}

= ${ES1} kWh/yr.

The following relation gives the demand savings, DS1, if the lights in a specific area were replaced with LED bulbs:

DS1 =

where

CF1 = Coincidence factor − probability that the equipment contributes to the facility peak demand, per month, assumed to be ${CF1}

The lights will likely be operating at their rated power when the peak demand is set each month, so CF1 = ${CF1}/month. Thus, the demand savings is calculated as follows:

DS1 = ${DS1Eqn}

= ${DS1} kW/yr.

<area2>**Anticipated savings for ${AREA2} lighting:**

The savings results from replacing the ${PREV2} in ${AREA2} with LED bulbs are outlined in this section. The estimated energy savings, ES2, for replacing these lights with LED bulbs is calculated as follows:

ES2=

where:

CN2 = Current number of ${PREV2}; ${CN2}

CFW2 = Power rating of current ${PREV2} in ${AREA2}; ${CFW2} W

COH2 = Current Operating hours of lights in ${AREA2}; ${COH2} hrs/yr

PN2 = Proposed number of LED bulbs; ${PN2}

PFW2 = Power rating of proposed LED bulbs in ${AREA2}; ${PFW2} W

POH2 = Proposed operating hours of lights in ${AREA2; ${POH2} hrs/yr

C1 = Conversion constant; 1,000 W/kW

The estimated energy savings, ES2, for replacing ${PREV2} with LED bulbs is calculated as:

ES2 = ${ES2Eqn}

= ${ES2} kWh/yr

The following relation gives the demand savings, DS2, if the lights in a specific area were replaced with LED bulbs:

DS2 =

where

CF = Coincidence factor − probability that the equipment contributes to the facility peak demand, per month, assumed to be 1.0

The lights will likely be operating at their rated power when the peak demand is set each month, so CF = 1.0/month. Thus, the demand savings is calculated as follows:

DS2 = ${DS2Eqn}

= ${DS2} kW/yr</area2>

<area3>**Anticipated savings for ${AREA3} lighting:**

The savings results from replacing the ${PREV3} for ${AREA3} with LED bulbs are outlined in this section. The estimated energy savings, ES3, for replacing all of these lights with LED bulbs is calculated as follows:

ES3=

where:

CN3 = Current number of ${PREV3}; ${CN3}

CFW3 = Power rating of current ${PREV3} in ${AREA3}; ${CFW3} W

COH3 = Current Operating hours of lights in ${AREA3}; ${COH3} hrs/yr

PN3 = Proposed number of LED bulbs; ${PN3}

PFW3 = Power rating of proposed LED bulbs in ${AREA3}; ${PFW3} W

POH3 = Proposed operating hours of lights in ${AREA3}; ${POH3} hrs/yr

C1 = Conversion constant; 1,000 W/kW

The estimated energy savings, ES2, for replacing ${PREV3} with LED bulbs is calculated as:

ES3 = ${ES3Eqn}

= ${ES3} kWh/yr

The following relation gives the demand savings, DS2, if the lights in a specific area were replaced with LED bulbs:

DS3 =

where

CF = Coincidence factor − probability that the equipment contributes to the facility peak demand, per month, assumed to be 1.0

The lights will likely be operating at their rated power when the peak demand is set each month, so CF = 1.0/month. Thus, the demand savings is calculated as follows:

DS3 = ${DS3Eqn}

= ${DS3} kW/yr</area3>

The total energy savings, ES, and demand savings, DS, are calculated as follows:

ES = ES1<area2> + ES2</area2><area3> + ES3</area3>

= ${ES1} kWh/yr<area2> + ${ES2} kWh/yr </area2><area3>+ ${ES3} kWh/yr</area3><area1>

= ${ES} kWh/yr</area1>

DS = DS1<area2>+ DS2</area2><area3>+ DS3</area3>

= ${DS1} kW/yr<area2> + ${DS2} kW/yr </area2><area3>+ ${DS3} kW/yr</area3><area1>

= ${DS} kW/yr</area1>

The annual cost savings, ACS, are estimated as follows:

ACS = (ES × Energy cost) + (DS × Demand cost)

= (${ES} kWh/yr × ${EC}/kWh) + (${DS} kW/yr × ${DC}/kW)

= ${ECS}/yr + ${DCS}/yr

= ${ACS}/yr

**Implementation Costs**

The implementation cost for this recommendation includes the material and labor costs required for the new light replacements. A ${PFW1} W linear LED bulb costs about ${BP1} and ${BL1} to install<area2>, a ${PFW2} W linear LED bulb costs about ${BP2} and ${BL2} to install</area2><area3>, a ${PFW3} W LED bulb costs about ${BP3} and ${BL3} to install</area3>. Therefore, ${CN} LED bulbs would cost about ${BC}. Installation cost is estimated to be ${LC}.<ms> ${MSN} motion sensors need to be installed to control the light when the area is unoccupied. Each motion sensor costs ${MSPL} for parts and labor and the total is ${MSC}.</ms>

However, there could be energy efficiency rebates available through your electric utility company, which could potentially reduce the overall capital cost and thereby the payback period. The savings from the rebate is calculated below.

RB = ${RR}/kWh × ${ES} kWh/yr × 1 yr

= ${RB}

The incentives are capped at 50% of the project cost and makes the modified rebate savings MRB equals to ${MRB}. Hence, the modified implementation cost (MIC) is estimated as follows:

MIC = IC - MRB

= ${IC} - ${MRB}

= ${MIC}

The total implementation cost is ${MIC}.

**The annual electricity savings for this AR will be ${ES} kWh, and the annual demand savings is ${DS} kW. The estimated annual cost savings is ${ACS} and, with ${MIC} in implementation costs, the payback period will be about ${PB}.**

**Implementation cost references**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, in order to determine the best product for the recommended application.

* [**https://www.trutechtools.com/AccuTrak-VPE-Ultrasonic-Leak-Detector-with-Contact-Probe**](https://www.trutechtools.com/AccuTrak-VPE-Ultrasonic-Leak-Detector-with-Contact-Probe)
* [**https://www.grainger.com/product/SUPERIOR-ACCUTRAK-Ultrasonic-Leak-Detector-35LX64**](https://www.grainger.com/product/SUPERIOR-ACCUTRAK-Ultrasonic-Leak-Detector-35LX64)
* [**https://www.pce-instruments.com/us/index.htm?\_artnr=5845567**](https://www.pce-instruments.com/us/index.htm?_artnr=5845567)

1. Lumen Maintenance and Light Loss Factors: Consequences of Current Design Practices for LEDs, Pacific Northwest National Laboratory [↑](#footnote-ref-1)