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# Energy Savings Potential of DLC Commercial Lighting and Networked Lighting Controls

July 2018

DesignLights Consortium®  
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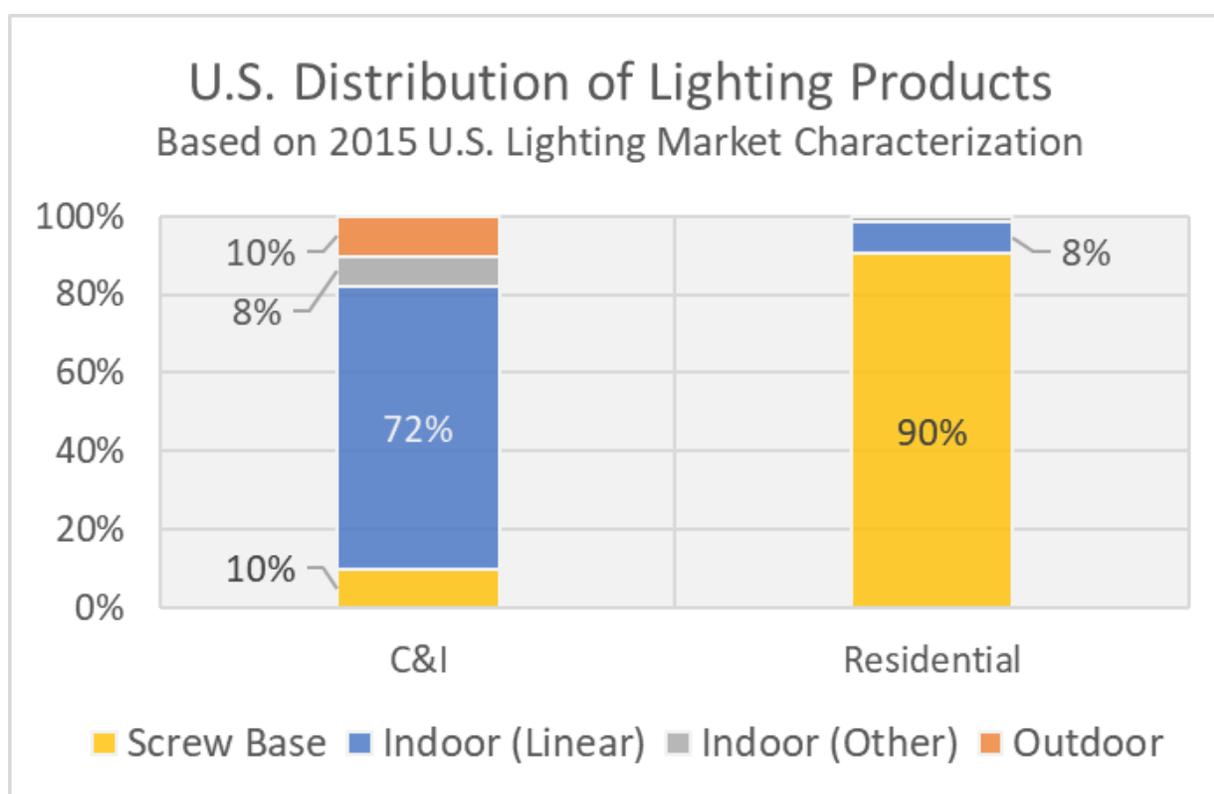
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## INTRODUCTION

Energy saving opportunities for residential utility lighting programs will soon be largely exhausted due to growing market saturation and EISA federal standards set to take effect in 2020.<sup>1</sup> Commercial and industrial (C&I) utility lighting programs, however, face a very different fate. While C&I lighting will also be affected by the EISA standard, the impact will be far less pronounced than in the residential sector. The type of product addressed by EISA - screw base lighting – accounts for only 10% of fixtures and sockets installed in C&I buildings versus 90% of residential, as shown in Figure 1. Lighting product types used by C&I facilities are primarily indoor linear fixtures (72% of installed products) followed by outdoor fixtures (10%) and indoor non-linear products (8%). In each of these C&I product categories, the large installed base coupled with relatively low LED market saturation offers significant potential for future energy savings, particularly when paired with networked lighting controls.

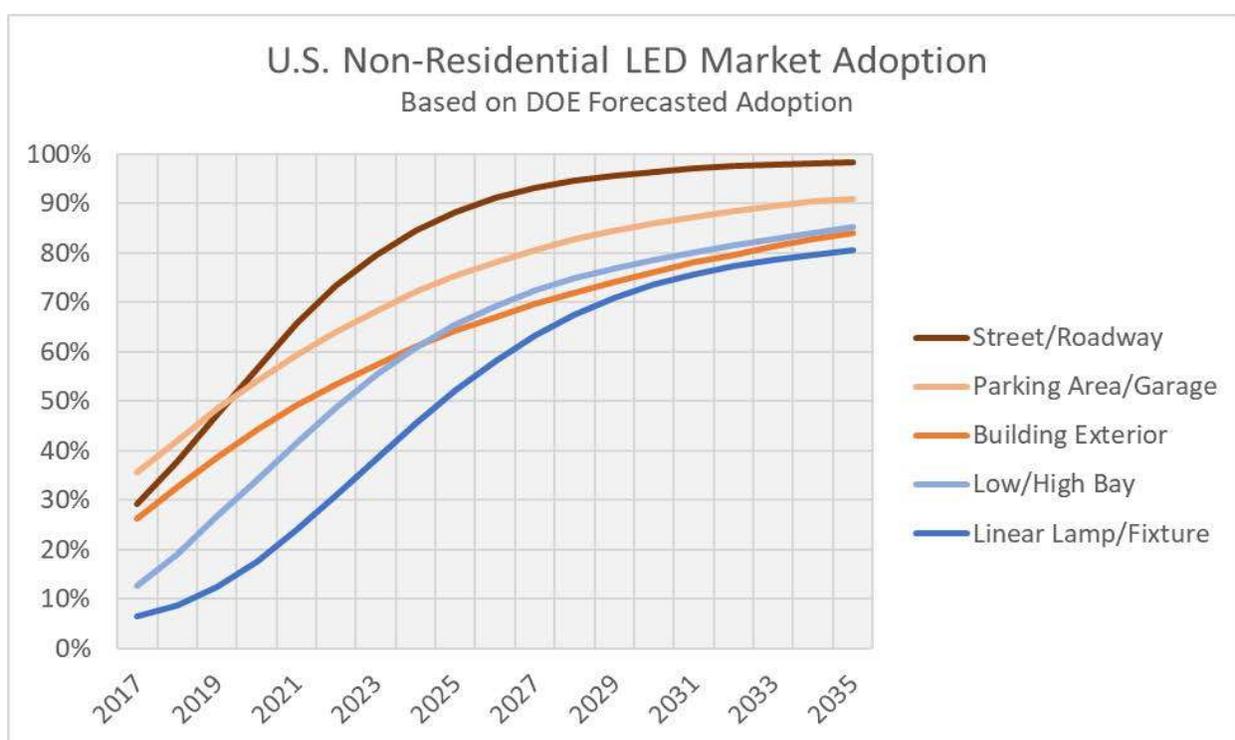


**Figure 1: U.S. distribution of lighting products (U.S. DOE 2017)**

<sup>1</sup> The Energy Independence and Security Act (EISA) requires general service lighting products sold as of January 1, 2020 to have an efficacy of at least 45 lumens per watt.

## LED LAMP AND FIXTURE POTENTIAL

The adoption of C&I LED lighting products has grown rapidly in recent years. The portion of installed lighting stock that has been converted to LED in 2017, with a projection through 2035, is shown in Figure 2.<sup>2</sup> Adoption accelerates across the board as prices continue to fall and product performance steadily improves. All product categories have entered their growth phase, although none have surpassed 50% market adoption as of 2018. Outdoor products, such as parking area and street lights, have achieved higher levels of adoption due to earlier market introductions and greater savings potential compared to incumbent technologies, among other factors. Indoor products, such as linear troffers and high/low bay fixtures, are much lower on the adoption curve. These products were slower to mature and compete against a reasonably efficient fluorescent incumbent technology. Linear products, which represent the largest portion of the installed base, have achieved only 6.5% LED adoption as of 2017.

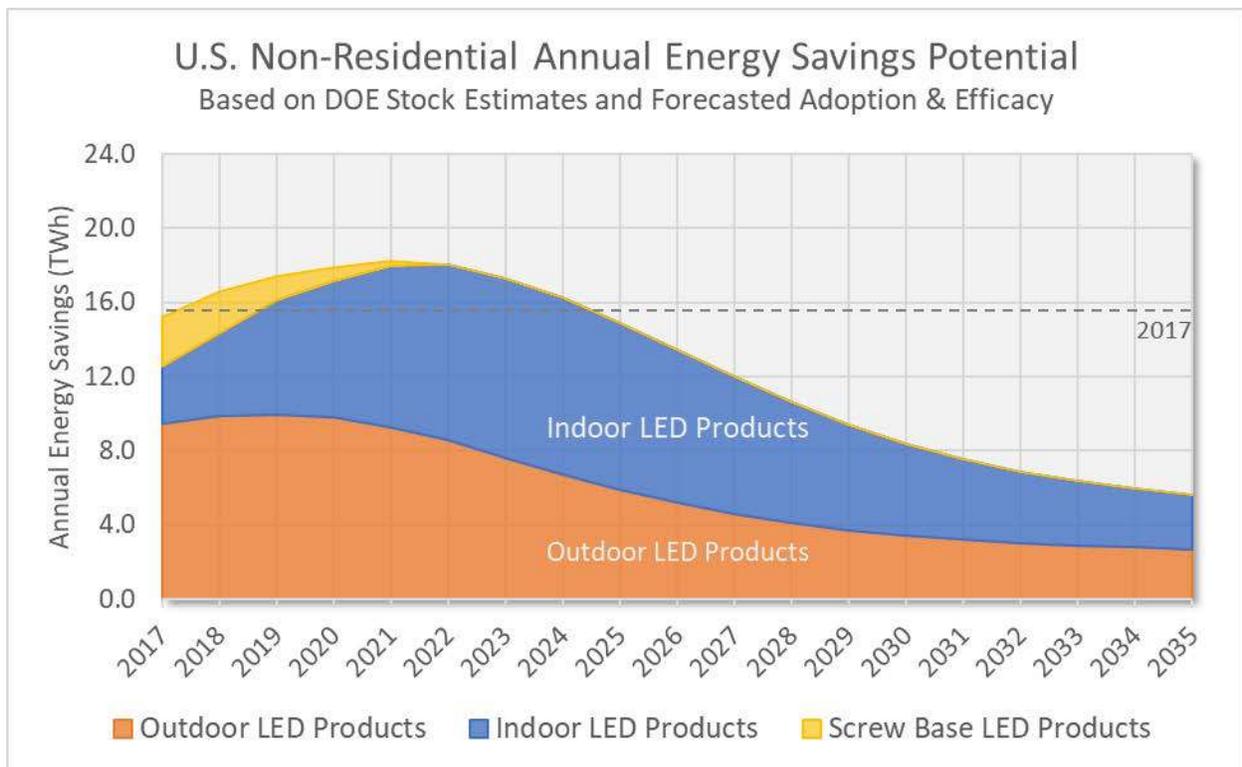


**Figure 2: Forecasted non-residential (C&I) adoption of LED lighting**

Figure 3 combines the effects of growing market adoption rates (from Figure 2) with the savings associated with each type of LED product. With continued levels of utility promotion, energy savings from C&I LED lighting will reach its highest point in 2022 and will remain at levels at least as great as those experienced in 2017 through 2024. While outdoor LED products (shaded in orange) have already achieved moderate levels of market adoption and will therefore see annual savings from new installations gradually decline starting as early as 2020, those declines will be offset for a number of

<sup>2</sup> The estimated future path for LED lamps and luminaires assumes continuation of current levels of solid-state lighting (SSL) investment and effort from industry stakeholders, including rebates and promotion by utility lighting programs.

years by rapid growth in annual savings from indoor product categories (shaded in blue). Indoor products will not reach their high point of adoption and energy savings until the mid-2020s. Screw base LED products offer very little remaining savings due to higher levels of saturation in the C&I sector and the pending implementation of the 2020 EISA federal standard.

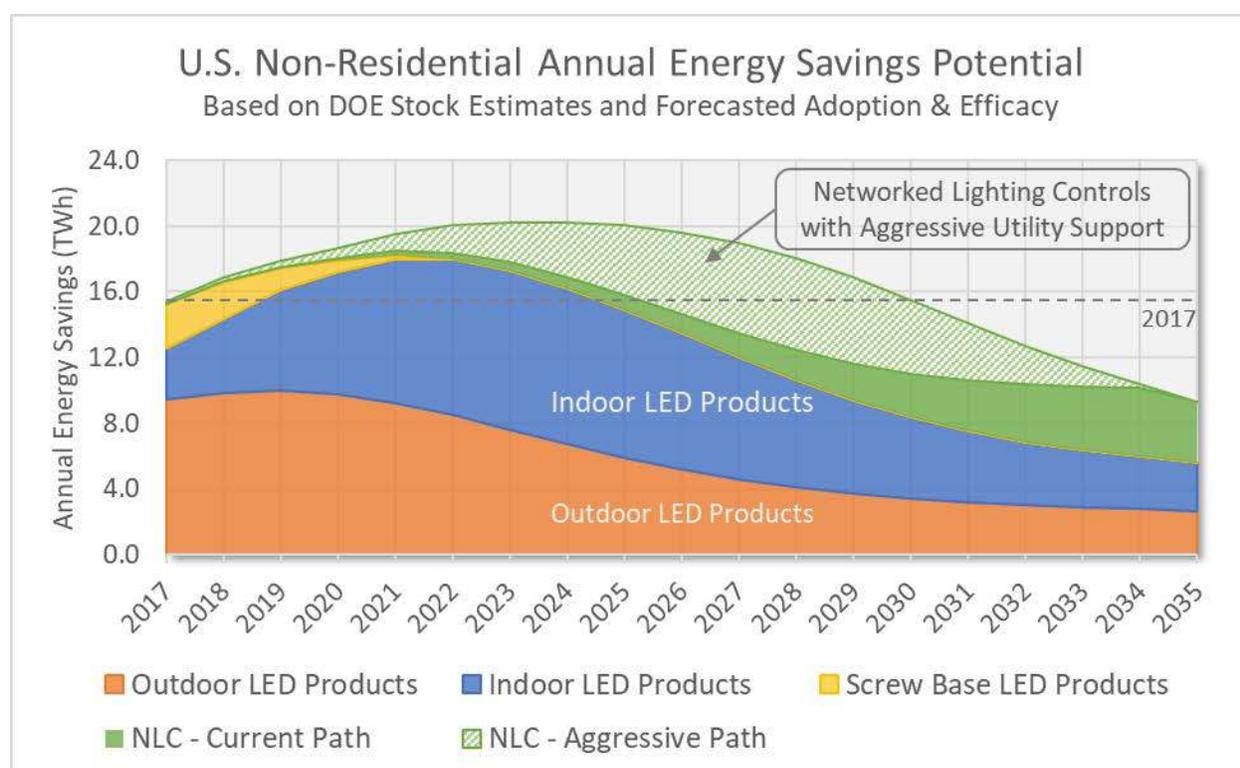


**Figure 3: Non-residential (C&I) annual energy savings potential from LED**

It should be noted that the savings potential presented here includes adoption that will occur naturally due to market forces beyond utility interventions. Due to more stringent building codes and decreasing availability of traditional technologies, LEDs may soon be considered baseline for new construction projects. Additionally, the savings forecast does not account for any net savings adjustments that are often applied to utility programs. For example, savings may be reduced to account for program participants who are considered to be free riders. As LED technology continues to mature, and on-going adoption results in higher levels of saturation, it is likely that free ridership will become an increasingly relevant factor for utility programs. The impact of future net savings adjustments will likely vary by product category, with the greatest impact applied to the most mature and/or saturated categories such as replacement lamps and outdoor lighting.

## NETWORKED LIGHTING CONTROLS POTENTIAL

Importantly, the scenario shown in Figure 3 only models savings from LED fixtures and lamps, excluding any controls. Networked lighting controls (NLC)<sup>3</sup> offer added savings potential – on average 47% additional savings are possible after LED conversion (DLC 2017). NLC adoption has been limited to date by the expensive and complicated nature of the systems; under-trained contractors; poorly understood benefits; and limited (or poorly designed) utility support. Additionally, NLC adoption is hindered when utility programs focus on the lowest cost incremental saving opportunities such as LED tube retrofits. Unfortunately, if C&I LED products are installed without networked lighting controls, the opportunity to capture much of the savings potential that they offer can become stranded for many years because retrofitting NLC systems onto already installed LED products is both expensive and technically challenging.



**Figure 4: Non-residential (C&I) annual energy savings potential from LED & networked lighting controls, assuming aggressive utility support**

The slow adoption to date of NLC systems has not yet adversely affected total C&I savings potential in a significant way. However, with adoption of indoor LED products accelerating rapidly, we are now at a crossroads for NLCs. As Figure 4 illustrates, if current levels of relatively limited utility promotion of NLCs continue into the future, the additional savings NLCs will provide (shown the solid green area) will

<sup>3</sup> Networked lighting controls combine multiple control strategies, including at least occupancy sensing; daylight harvesting; and high-end trim, with the capability to exchange digital information among luminaires and control devices. Some NLC systems include additional strategies, such as scheduling or personal control, and may offer a user interface.

be very modest throughout the 2020s. However, if utilities aggressively promote and support NLCs, the additional savings possible (shown in the cross-hatched green area) result in total NLC savings of more than twice as much compared to what might be realized under the current path by 2035.<sup>4</sup> Accelerating the adoption of NLCs ensures that more systems are coupled with LED products at the time of installation. Aggressive utility promotion of networked lighting controls will push the peak savings to a higher level in the mid-2020s and will enable C&I utility lighting savings to be maintained at or above 2017 levels until 2030 – twice as long when compared to LED fixtures and lamps alone. This long-term potential offered by NLCs is even more important when considered in the context of net savings. Lighting controls have historically had very low levels of free ridership, so NLCs offer a potentially dependable path for utility savings.

To capitalize on the NLC opportunity, utilities should consider employing strategies that address both breadth and depth. Prescriptive and midstream<sup>5</sup> program designs are simple to understand, make participation easy for customers, and are preferred by supply chain partners. Increasingly, utilities are using these program models to more rapidly reach scale of NLC adoption.<sup>6</sup> These widget-based programs are especially well suited to networked lighting control solutions that are integral to LED lighting fixtures. When establishing prescriptive and midstream NLC rebate levels, utilities should consider shifting resources away from stand-alone LED lighting measures and toward the system solution of LED + NLC. Performance-based or space-based program models are being employed by some utilities to accommodate more complex NLC systems and/or larger scale projects.<sup>7</sup> While these program designs tend to be more complicated and are less likely to reach high volumes, they can maximize the per-project savings of NLCs. And finally, other industry solutions such as lighting as a service hold promise for accelerating NLC adoption.

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<sup>4</sup> NLC savings by 2035 total 34 TWh under the current path and 78 TWh under an aggressive utility promotion scenario.

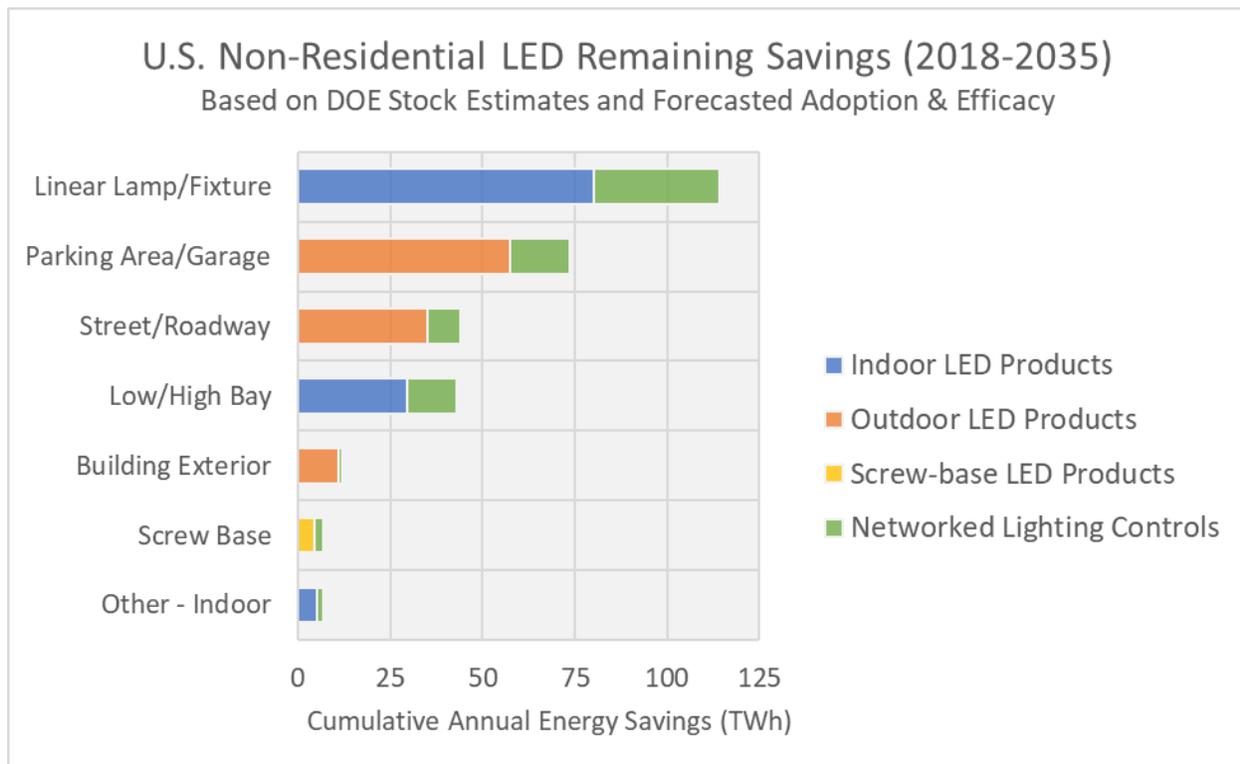
<sup>5</sup> Midstream programs apply rebates instantly at the wholesale point of purchase.

<sup>6</sup> Examples include the [Bonneville Power Association Lighting Calculator v4.0 prescriptive offer](#) for Networked Lighting Controls, [Puget Sound Energy prescriptive bonus incentive](#) for luminaire level lighting controls (LLLC), and the [National Grid MA and RI midstream offer](#) for LED troffers with integral controls.

<sup>7</sup> Examples include [MassSave Performance Lighting](#), which offers rebates based on system capabilities and power savings; and Wisconsin Focus on Energy [Networked Lighting Controls Offering](#), which pays rebates based on building area.

## SAVINGS BY PRODUCT APPLICATION

The most significant C&I savings opportunity exists within the linear LED lamp & fixture category when installed with networked controls as shown in Figure 5.<sup>8</sup> This upgrade opportunity will be ubiquitous among C&I customers, with an estimated 850 million linear fixtures available nationwide for replacement or retrofit (U.S. DOE 2017). The parking area/garage product category offers the second highest remaining potential due to a large installed base coupled with an excellent opportunity for networked controls. Meanwhile screw base LED products, which have been a major source of utility savings for both residential and C&I portfolios over the past ten years, represent a much smaller portion of the remaining savings potential.

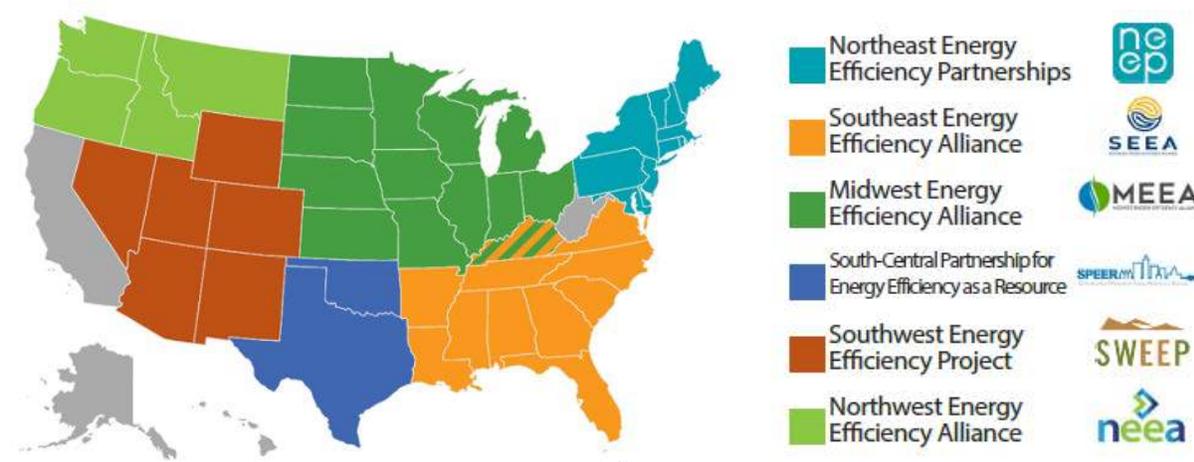


**Figure 5: U.S. non-residential (C&I) lighting savings potential by product type**

<sup>8</sup> Assumes the aggressive utility support scenario

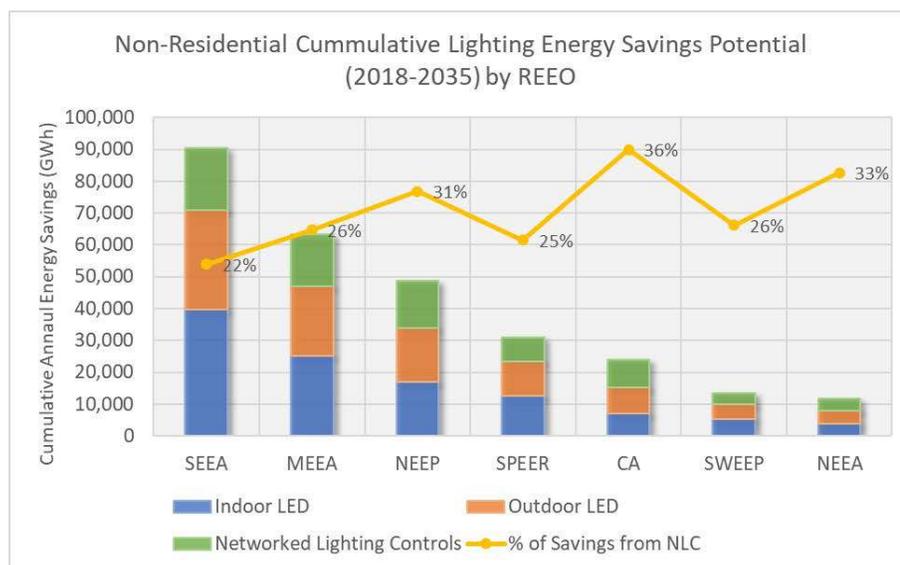
## REGIONAL ANALYSIS

Adoption of efficient lighting has not occurred uniformly throughout the United States. Aggressive energy policies in some states have resulted in a more efficient inventory of installed lighting and have achieved greater levels of LED adoption. As a result, the remaining savings potential for C&I lighting will not be distributed evenly among states. A regional analysis was completed to better understand these differences. States were grouped according to their association with Regional Energy Efficiency Organizations, or “REEOs”, as shown in Figure 6.



**Figure 6: U.S. map of regional energy efficiency organizations (courtesy of Building Codes Assistance Project)**

Relative to other regions, SEEA contains the most number of commercial and industrial businesses and has accomplished the least in terms of lighting energy efficiency. As such, SEEA holds the highest remaining potential for C&I lighting savings – nearly 50% more compared to the next closest region – as shown in Figure 7. In contrast, NEEA has the lowest remaining potential due to a smaller territory and more mature utility programs. Within each region, the contribution of savings from indoor and outdoor LED is roughly equal. However, the quantity of indoor products will far exceed outdoor products by a margin of nearly 6-to-1.



**Figure 7: U.S. non-residential (C&I) lighting savings potential by REEO**

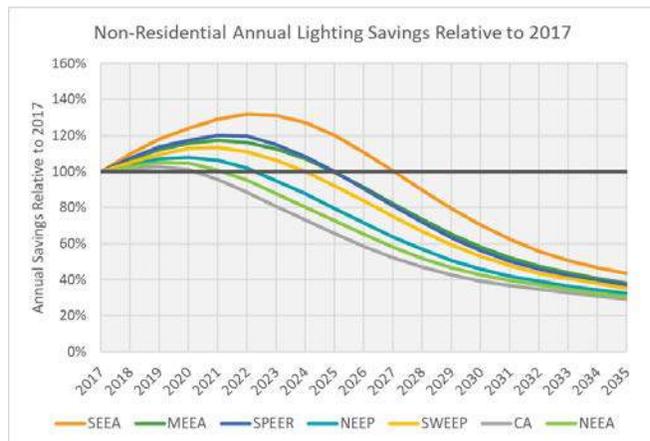
The regional analysis also provides important insights related to networked lighting controls. First, the impact of networked lighting controls varies from one region to the next due to differences in the timing of LED adoption and the efficiency of baseline technologies. While the SEEA region has the highest total savings potential, NLCs represent the lowest share of remaining savings (22%).

Comparatively, networked lighting controls represent roughly one-third of the remaining C&I lighting savings potential within the NEEP, CA, and NEEA regions. Second, as with the national analysis, NLCs have the potential to sustain C&I lighting portfolio savings for a much longer timeframe in every region, as shown in Figure 8. This effect is especially impactful for regions that have been historically more aggressive in promoting energy efficient lighting, as shown in Table 1.

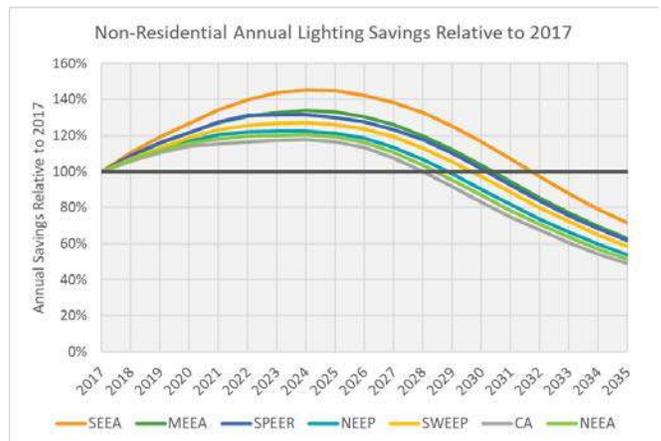
Region	Without NLC	With NLC
CA	2020	2028
NEEA	2021	2029
NEEP	2022	2029

**Table 1: Year in which savings drop below 2017 levels**

**C&I ANNUAL LIGHTING SAVINGS WITHOUT NLC**



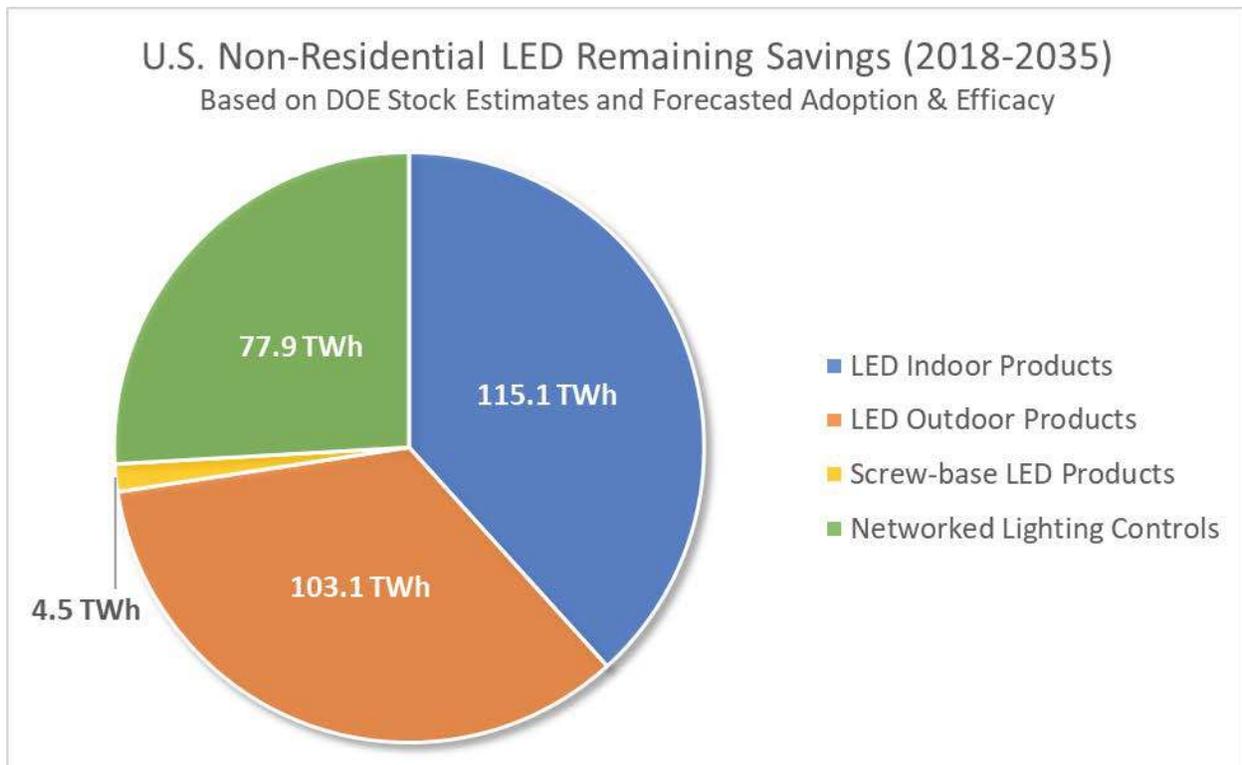
**C&I ANNUAL LIGHTING SAVINGS WITH NLC**



**Figure 8: U.S. non-residential (C&I) savings potential by REEO, without NLC (left) and with NLC (right)**

## CONCLUSION

C&I utility programs have the potential to capture significant lighting savings – and associated carbon reductions – for many years to come with ongoing support of LED and NLCs. Regardless of state or region, a path exists to maintain C&I lighting portfolios at or above current levels until at least 2028. Utility programs must aggressively pursue these opportunities using a multitude of strategies and service delivery models. The promotion and adoption of networked lighting controls is critical to ensure that utilities and customers capture the full benefit of LED systems being installed today. ♦



**Figure 9: U.S. non-residential (C&I) lighting remaining savings potential**

## ANALYSIS RESOURCES & ASSUMPTIONS

Component	Resources	Assumptions
LED Savings Forecast	<ul style="list-style-type: none"> <li>• 2015 U.S. Lighting Market Characterization (U.S. DOE 2017)</li> <li>• Energy Savings Forecast of Solid-State Lighting (U.S. DOE 2016)</li> </ul>	<ul style="list-style-type: none"> <li>• The most recent DOE LED adoption forecast is based on the 2010 U.S. Lighting Market Characterization. Adjustments were made to the adoption forecast to account for the findings contained in the 2015 U.S. Lighting Market Characterization.</li> <li>• Energy savings potential was calculated based on the DOE LED adoption forecast, estimated quantity and performance of incumbent technologies, and anticipated improvements in LED efficacy.</li> </ul>
Networked Lighting Controls Savings Forecast	<ul style="list-style-type: none"> <li>• Energy Savings Forecast of Solid-State Lighting (U.S. DOE 2016)</li> <li>• Energy Savings from Networked Lighting Control Systems (DLC 2017)</li> </ul>	<ul style="list-style-type: none"> <li>• The DOE “current path” forecast for the adoption of networked lighting controls (referred to as connected lighting) was revised to accelerate adoption by 6 years and compress the adoption timeframe by 3 years, reflecting higher levels of utility support.</li> <li>• Whereas the DOE assumed a range of savings for connected lighting (34-71%) depending on building type, this analysis used an average value of 47% based on the Energy Solutions DLC report.</li> </ul>
Savings Potential by REEO	<ul style="list-style-type: none"> <li>• Energy Savings Forecast of Solid-State Lighting (U.S. DOE 2016)</li> <li>• ACEEE 2017 State Scorecard (ACEEE 2017)</li> <li>• Commercial Buildings Energy Consumption Survey (CBECS) (EIA 2012)</li> <li>• State electric sales (EIA 2017)</li> </ul>	<ul style="list-style-type: none"> <li>• Using ACEEE scores for utility programs and building energy efficiency policies, states were ranked into quintiles. Based on these rankings, states were adjusted on the LED adoption curve by +/- 2 years, incumbent technology efficiency levels were revised, and states were repositioned on the NLC adoption curve by +/- 2 years. Leading states were assumed to have more efficient baseline technologies, greater levels of LED adoption, and more aggressive policies toward NLC adoption. Lagging states were assumed to have the opposite.</li> <li>• Savings potential was scaled to the state level using C&amp;I floorspace estimates from CBECS 2012 and grouped by REEO.</li> </ul>

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