Illinois Energy Efficiency Stakeholder Advisory Group

2024 SAG Portfolio Planning Process
Energy Efficiency Idea Submittal: DarkSky Chicago

Questions

1. **Submitter Contact Information**
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2. **Description and Rationale:** Describe the proposed EE Idea and rationale for submission. Explain why this idea is needed and what main objectives the implementation of the idea would accomplish. Describe whether this is an idea that could be implemented in an existing EE program, or whether the idea involves establishing a new program. Please indicate whether additional research may be required before implementation.

This proposal is for an Energy Efficiency plan based on the efficient and effective use of outdoor lighting as outlined in the IES/DarkSky 5 Principles of Responsible Outdoor Lighting. Whereas the adoption of SSL technology has provided a potential energy reduction, in practice, our habits of our uses and applications of light at night is reducing – or even in some cases eliminating – those gains.

In 2020, the IES and DarkSky International released the 5 Principles of Responsible Outdoor Lighting. These Principles are common-sense guidance to the use of light at night based on scientific research that address the impact outdoor light has on human health, ecological preservation, safety, quality of life and the excessive use of light at night, thus energy efficiency. The 5 Principles are intended to produce wide-ranging societal benefits through effective lighting practices, yet they also offer an opportunity as positive energy efficiency guidelines. A potential win-win scenario.

In brief, the 5 Principles of Responsible Outdoor Lighting recommend that any light should be:

1. *Useful – it must solve a problem that cannot be addressed without that light.*
2. *Directed – it must illuminate only the intended area or surface.*
3. *Limited – it must only use as much light as required.*
4. *Controlled – it must utilize control technology such as timing, dimming and sensors.*
5. *Warm – it must use the least amount of blue emissions possible.*

Useful
Often the choice to install and use lighting is made without consideration of the utility of that light. This is particularly the case in residential lighting, although it applies in commercial and municipal properties as well. The most efficient lighting is that which is not needed. Guidance and education on the benefits of the reduced use of luminaires could reduce not only energy use but also cost of installation and maintenance.

Directed
The luminous efficacy – and thus efficiency – of a luminaire is directly affected by how well its light is illuminating the intended surface. All other light it emits can be considered a loss of energy. Beyond the inefficiency, poorly directed light can create disability glare and light trespass.

Limited
The use of proper light levels is integral to not only that light's effectiveness but also its efficiency. Illumination in excess of standards is by definition inefficient. Additionally, light levels above standards can create a more unsafe environment. Lighting standards should not be regarded as minimum guidelines but as target guidelines.

Controlled
The tools of modern lighting technology afford multiple options for energy savings. Lighting controls – from integrated to networked – are available at nearly every level of application from residential to the municipal level. The availability of inexpensive motion sensing, light triggered and dimmable lightbulbs and systems for residential use is growing yet adoption of these technologies is lagging. The adoption of network controls for commercial also leaves much use for growth.

Color Temperature
The efficiency of lower color temperature SSL has nearly reached parity with lighting of higher Kelvin. In many applications, modern 2700K lights provide the equivalent CCT as 3000K or even 4000K lights with a small impact on efficiency. At present, warmer color lighting may not, on its own, provide a direct energy savings but do provide a non-energy benefit.

To properly quantify the total EE gain of this proposal, additional research would be preferrable.

Regarding fixtures, there are two sources of reliable information and guidelines for fixtures that comply to these principles. DarkSky International maintains a database of approved lighting with their DarkSky Approved program. In addition, the Design Lights Consortium (DLC) LUNA program provided a database of certified lighting.

See Section 5: Benefits for a more thorough background of the research regarding light use at night.

3. **Illinois Utility Impacted:** Identify which utilities are impacted by the proposed EE Idea:

Check	Illinois Utility Impacted
☒	Ameren Illinois
☒	ComEd
☐	Nicor Gas
☐	Peoples Gas & North Shore Gas
☐	All Illinois Utilities

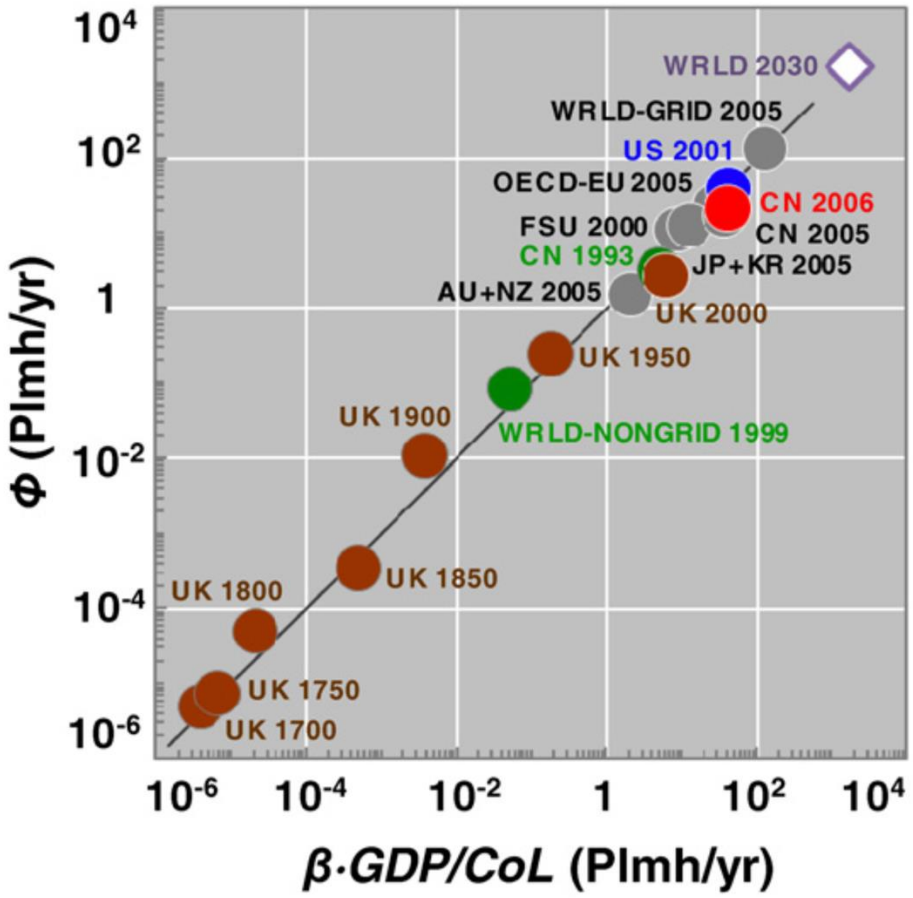
4. **Energy Efficiency Sector:** Identify which sector(s) the proposed EE Idea applies to:

Check	Energy Efficiency Sector
☒	Residential Customers – Single Family (non-income qualified/income eligible)
☒	Residential Customers – Multifamily (non-income qualified/income eligible)
☒	Residential Customers – Single Family Income Qualified/Income Eligible
☒	Residential Customers – Multifamily Income Qualified/Income Eligible
☒	Small Business Customers (commercial & industrial sector)
☒	Medium/Large Business Customers (commercial & industrial sector)
☒	Research & development, emerging technologies, or market transformation
☐	Other (market development initiatives, Trade Ally support, reporting, etc.)

5. **Background:** Describe where the EE Idea originated from, including whether this idea has been successfully implemented in other jurisdiction(s). Provide specific background information that will help utilities and SAG participants understand the proposed idea.

The EE benefit from the transition to SSL from incandescent and HID technologies has been an important element in energy efficiency gains in regards to lighting yet LED technology contains an inherent and an observed risk. The Rebound Effect (also known as Jevons paradox) describes a phenomenon where the gain in efficiency afforded by a new technology leads to an ***increase*** *in its use instead of a reduction due to the lower cost of operation and lower market price from the scale of production.*

A 2010 study reviewed the cost and luminous output of lighting - throughout the past 3 centuries covering 6 continents, 5 types of fuel (tallow, whale oil, gas, petroleum, electricity), 1.4 orders of magnitude in per capita gross domestic product, 4.3 orders of magnitude in cost of light, and 5.4 orders of magnitude in per-capita consumption of light - and found that artificial lighting consumes a remarkably consistent 0.72% of world gross domestic product using an estimated 6.5% of world primary energy (Tsao 2010a). Projecting this trend forward assuming the near-full adoption of LED lighting and its luminous efficacy by 2030, they predict an increase in total lumen use greater than a magnitude above the 2010 level (Tsao 2010b).



Consumption of light (Φ) plotted against the Gross Domestic Product of a nation divided by the Cost of Light (β·GDP/CoL) both in units of petalumen-hours per year. The constant β=0.0072 or 0.72% fits the trend since 1700.

Since the publication of this work, a recent study has partially validated this prediction as the growth in the brightness of the night sky has grown at a rate of 9.6% per year (Kyba 2023). Nighttime satellite observations collected since 2012 have also confirmed a growth in the total emissions of light at night even though the instrument collecting the data is not sensitive to blue light which would infer an even greater increase in reality (Miguel 2021).

The awareness and concern of light pollution is growing. Poor lighting – which is often by definition wasted lighting – is being recognized more often as an environmental and quality of life issue. Light trespass complaints are becoming more frequent particularly since the widespread adoption of inexpensive LEDs. Additionally, research has shown that underserved and minority communities are disproportionately impacted by excessive artificial light at night. An equitable application and adoption of the 5 Principles would often benefit underserved communities to a greater degree than other communities.

Case Studies and Research

This proposal is a practical application of outdoor lighting practices as defined by the 2020 IES/DarkSky 5 Principals of Responsible Outdoor Lighting. Although many of the quantified examples of successful implementation of these concepts have been with municipal streetlight inventories (as described in the first two examples below) the concepts are absolutely applicable to commercial and residential lighting as well. In fact, estimates on the contribution of street lighting to light pollution fall within the range of 13-20% meaning a vast majority of wasted light emissions are from all other sources.

In 2018 Tucson, Arizona completed an LED retrofit of their city's streetlight inventory. Beyond the energy efficiency gained by converting from HPS to LEDs, the more effective application of the fully shielded lights allowed a reduction of lumen output by 63% and by taking advantage of a networked controlled dimming schedule their total annual energy use was reduced by 72%.
https://darksky.org/app/uploads/2019/11/Nights-over-Tucson-PRINT.pdf

As an anecdotal example, in 2019 the cities of Tucson, AZ; Oceanside, CA and West Richland, WA participated in a study with the assistance of the Pacific Northwest National Lab where each city dimmed their LED streetlight inventory on predetermined nights. The experiment used nighttime satellite observations to help quantify the contribution of streetlighting to their city's total light emissions. Each municipality dimmed their lighting inventory down to 30% after midnight during the experiment. After receiving virtually no public complaints or negative comments regarding the light levels, the city of Oceanside simply adopted this dimming schedule which saved their city significant energy.

In 2010, the University of California Davis developed the Smart Lighting Initiative to improve energy efficiency on their campus. Using a combination of LED fixtures with appropriate levels, adaptive networked luminaires and improved applications they achieved an 86% reduction in energy use reducing their annual total by over 1,200 MWh across their 5,300-acre campus.
https://cltc.ucdavis.edu/sites/g/files/dgvnsk12206/files/media/documents/final_case-study-uc-davis-scaled-deployment-networked-ext-07-2014.pdf

The application of this proposal is not intended to be limited to municipal lighting. A recent study of light emissions from Indianapolis, Indiana and the surrounding area finds that commercial properties emitted a disproportionally high amount of light pollution by area and residential lighting is the largest single source of light emissions. If this program was applied to commercial and residential lighting, significant energy savings can be achieved.
https://www.researchgate.net/publication/372764828_Quantifying_Nighttime_Light_Emission_by_Land_Use_from_the_Stratosphere (available on request)

6. **References:** If any additional information will be useful to Illinois utilities and SAG participants in reviewing the EE Idea, please provide a description and links or attachment(s) to the source of information.

*Tsao, J. Y. & Waide, P. The world's appetite for light: Empirical data and trends spanning three centuries and six continents. LEUKOS **6**, 259–281 (2010).*
https://www.tandfonline.com/doi/abs/10.1582/LEUKOS.2010.06.04001

*Tsao, J. Y., Saunders, H. D., Creighton, J. R., Coltrin, M. E. & Simmons, J. A. Solid-state lighting: an energy-economics perspective. J Phys D Appl Phys **43**, 354001 (2010).*
https://iopscience.iop.org/article/10.1088/0022-3727/43/35/354001

*Kyba, C. C. M., Altıntaş, Y. Ö., Walker, C. E. & Newhouse, M. Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022. Science **379**, 265–268 (2023).*
https://www.science.org/doi/10.1126/science.abq7781

*Miguel, A. S. de, Bennie, J., Rosenfeld, E., Dzurjak, S. & Gaston, K. J. First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution. Remote Sens-basel **13**, 3311 (2021).*
https://www.mdpi.com/2072-4292/13/16/3311

7. **<u>Optional</u> Additional Information:**

The estimates for budget, participation and savings are all to be determined through further study.

a. **Estimated Budget:** Provide the total estimated budget for each program year (2026 – 2029).

b. **Estimated Participation:** Provide participation totals for each program year (i.e. number of measures installed, number of customer participants, etc.)

c. **Estimated Savings:** Provide estimated savings for each program year (i.e. total numbers of therms for gas EE programs; total number of kWh for electric EE programs).

8. **Presenting to SAG:** EE Idea submittals will be presented to SAG in April. The SAG Facilitator is reviewing whether to schedule one of the April SAG meetings in-person. Are you interested in presenting this proposed EE Idea in-person?

Check	Are you interested in presenting to SAG in-person?
☒	Yes
☐	No