Learning curves and diffusion dynamics of energy-efficient public lighting in Germany

Themenbereich 2: Energieerzeugung/-infrastruktur und Netze

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Motivation and Key Question

The question posed in this study is to what extent learning processes regarding light control and light distribution curves have already led and will lead to faster and more cost-efficient planning processes regarding energy-efficient lighting over time in the case of German municipalities. A goal of the German federal government is to reach climate neutrality until the year 2045, which can only be reached by massively increasing the electricity production from renewables and decreasing electricity demand in energy-intensive sectors. In Germany, artificial lighting accounts for 13% of total electricity supply in 2019. In that year, around 30% of all street lights in Germany were equipped with highly energy-efficient LED lamps, and according to the modeled diffusion process in this study LED saturation is likely to be reached between 2035 and 2040 depending on the actual market potential for LED in street lights.

Methodical Approach

The diffusion of innovation model of Bass (1969) was applied to model the diffusion of LED technology for public street lighting in Germany. In doing so, the rate of growth of the proportion of adopting individuals or, in our case, cities and municipalities can be determined, making it possible to predict the future development of the diffusion process. The occurrence of the typical sigmoid diffusion curve is explained by the premise that adoption of new technology or processes is limited by the diffusion of information about the innovation, which can be considered as an epidemic process (Geroski, 1999).

Results and Conclusions

All simulations indicate high coefficients of correlation for all considered market potentials of 95%, 90%, and 80%. The 95% market potential, reflecting a number of possible LEDs in the German street lighting system of 8,550,000, shows a slightly higher correlation with the known number of LED lamps of 2009, 2014, and 2019. We therefore assume the simulated 95% market potential to be closer to the real market potential than the other simulated potentials. In addition, the results indicate a peak of around 420,000 to 460,000 LED implementations in streetlights between 2021 and 2024. However, simulating the development of LED installations in street lighting is possible only to a limited extent. If the actual number of installed LEDs would be available for more years than just for 2009, 2014, and 2019, the simulations are likely to indicate a more accurate image of the potential diffusion process. Evaluating the economic impact of government subsidies on the likeliness of street lighting operators to modernize with LED, we can detect a general consistency between the calculated net present values (NPV) and the payback periods of the considered ventures. For almost all cases where payback periods are within the 25-year timeframe, the NPV calculations indicate positive values after a 25-year period of operation. When considering 2% inflation to 25% subsidizing rate, these being close to the years of the projects’ execution, all except for one project investigated indicate positive NPV.

Figure 1: Bass diffusion model applied to cumulative LED adoption for public lighting (95%, 90%, and 80% market potential)

References

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