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Review article

A review of learning rates for electricity supply technologies

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HIGHLIGHTS

- We review models explaining the cost of 11 electricity supply technologies.
- The most prevalent model is a log-linear equation characterized by a learning rate.
- Reported learning rates for each technology vary considerably across studies.
- More detailed models are limited by data requirements and verification.
- Policy-relevant influences of learning curve uncertainties require systematic study.

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ABSTRACT

A variety of mathematical models have been proposed to characterize and quantify the dependency of electricity supply technology costs on various drivers of technological change. The most prevalent model form, called a learning curve, or experience curve, is a log-linear equation relating the unit cost of a technology to its cumulative installed capacity or electricity generated. This one-factor model is also the most common method used to represent endogenous technical change in large-scale energy-economic models that inform energy planning and policy analysis. A characteristic parameter is the "learning rate," defined as the fractional reduction in cost for each doubling of cumulative production or capacity. In this paper, a literature review of the learning rates reported for 11 power generation technologies employing an array of fossil fuels, nuclear, and renewable energy sources is presented. The review also includes multi-factor models proposed for some energy technologies, especially two-factor models relating cost to cumulative expenditures for research and development (R&D) as well as the cumulative installed capacity or electricity production of a technology. For all technologies studied, we found substantial variability (as much as an order of magnitude) in reported learning rates across different studies. Such variability is not readily explained by systematic differences in the time intervals, geographic regions, choice of independent variable, or other parameters of each study. This uncertainty in learning rates, together with other limitations of current learning curve formulations, suggests the need for much more careful and systematic examination of the influence of how different factors and assumptions affect policy-relevant outcomes related to the future choice and cost of electricity supply and other energy technologies.

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