Discount and hurdle rates: the dark horses of capacity expansion planning

Integrated modelling and role of renewables in future energy networks

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Overview

Discount and hurdle rates are part of the input data in each state-of-the-art capacity expansion model, but these parameters do not receive adequate attention to the impact they have on model outputs. A few studies (García-Gusano et al., 2016; Hermelink & de Jager, 2015) highlight this issue and point out the need for further research.

In this paper, our contribution is twofold. First, we analyze the impact of technology-specific hurdle rates in a state-of-the-art bottom-up optimization model for the European electricity market. Second, we quantify the impacts caused by the choice of social discount rates on the key model outputs.

Methods

The methodology takes stock of the numerous bottom-up investment optimization models developed for electricity markets (Georgiou, 2016; Nguyen, 2008; Riepin et al., 2021; Weijde & Hobbs, 2012). These models minimize the investment and operating costs of satisfying electricity demand under the set of relevant interspatial and intertemporal constraints, which always involve discounting operations. These are conducted as computation of annuities, which is a standard practice. The model we use classically optimizes ‘greenfield’ investments in conventional and renewable power generation capacities, while accounting system constraints and three projected energy futures based on (ENTSO-E & ENTSOG, 2018). Less classically, we perform an analysis of how a wide range of social discount rates and hurdle rates (both risk-based technology-specific and uniform), as well as combinations of these factors affect the key model outputs, namely the investment mix, total system cost and CO_2 emission intensity.

Results and conclusions

We show that a range of plausible risk-based assumptions on hurdle rates lead to a broad range of technology pathways. In particular, lower hurdle rates favor the investment in renewable sources, hence leading to a system with lower carbon emissions intensity. Regarding the second objective, we highlight that technologies such as nuclear and lignite benefit from high social discount rates, while gas fired technologies experience the reciprocal effect. Overall, increasing the social discount rate from 3% to 15% lowers the carbon emission intensity up to 72% and reduces the total system cost by half. The impacts caused by the choice of the discount and hurdle rates are illustratively compared with those caused by the choice of other uncertain input parameters, such as electricity demand, fuel and CO_2 prices.

Taken together, we organize our discussion around the particularly important assumptions made for every electricity market model: discount and hurdle rates. Our findings indicate that careful consideration of these factors and understanding how they affect model outputs is of paramount importance for modelling exercises that aim for long-term policy planning. Our illustrative modelling example and conclusions are relevant for both energy modelers and policy makers with an interest in European energy markets.

Bibliography

[1] ENTSO-E, & ENTSOG. (2018). TYNDP 2018: Scenario Report. *European Network of Transmission System Operator*, 30. https://tyndp.entsoe.eu/tyndp2018/scenario-report/

[2] García-Gusano, D., Espegren, K., Lind, A., & Kirkengen, M. (2016). The role of the discount rates in energy systems optimisation models. *Renewable and Sustainable Energy Reviews*, vol. *59*, pp.

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56–72. https://doi.org/10.1016/j.rser.2015.12.359

[3] Georgiou, P. N. (2016). A bottom-up optimization model for the long-term energy planning of the Greek power supply sector integrating mainland and insular electric systems. *Computers and Operations Research*, vol. *66*, pp. 292–312. https://doi.org/10.1016/j.cor.2015.02.015

[4] Hermelink, A., & de Jager, D. (2015). Evaluating our future - The crucial role of discount rates in. *The European Council for an Energy Efficient Economy (Eceee) & Ecofys*. https://doi.org/10.13140/RG.2.2.20152.65285

[5] Nguyen, K. Q. (2008). Internalizing externalities into capacity expansion planning: The case of electricity in Vietnam. *Energy*, vol. *33*(5), pp. 740–746. https://doi.org/10.1016/j.energy.2008.01.014

[6] Riepin, I., Möbius, T., & Müsgens, F. (2021). Modelling uncertainty in coupled electricity and gas systems - Is it worth the effort? *Applied Energy*, vol. *285*. https://doi.org/10.1016/j.apenergy.2020.116363

[7] Weijde, A. H. Van Der, & Hobbs, B. F. (2012). The economics of planning electricity transmission to accommodate renewables : Using two-stage optimisation to evaluate fl exibility and the cost of disregarding uncertainty. *Energy Economics*, vol. *34*(6), pp. 2089–2101. https://doi.org/10.1016/j.eneco.2012.02.015