Bibata Sagnon and Haikel Khalfallah

A DYNAMIC GAME MODEL FOR LONG-TERM COORDINATION BETWEEN DISTRIBUTION SYSTEM INVESTMENTS AND GENERATION UNDER VOLATILE RENEWABLE INCENTIVES.

Bibata Sagnon : Grenoble Applied Economics Laboratory, GAEL, Energy section
GAEL - CS 40700 - 38058 Grenoble CEDEX 9
bibata.sagnon@univ-grenoble-alpes.fr
Haikel Khalfallah: Grenoble Applied Economics Laboratory, GAEL, Energy section
GAEL - CS 40700 - 38058 Grenoble CEDEX 9
haikel.khalfallah@univ-grenoble-alpes.fr

Overview

France and many European countries have been committed for several years to an ambitious energy transition. And the energy crisis that Europe is currently experiencing is a reminder that getting out of fossil fuels is not just a climate imperative. To achieve the ambitious objectives of this transition, many countries have put in place support schemes for renewable energies to accelerate investment. However, in recent years, many support schemes have been revised or retracted suddenly and unexpectedly (Boomsma and Linnerud, 2015). The massive introduction of renewable and variable sources requires a rethinking of the business model of network operators. With the opening of electricity markets to competition, there is a problem of coordination of investment in the grid and investments of competitive parties. Investment coordination is becoming increasingly relevant in countries that are restructuring their industries towards a greater share of renewable electricity generation. This raises the important question of how these sunk investment decisions should be coordinated in a context of regulatory instability in renewable energy support mechanisms.

Method

We assess the optimal coordination of the grid operator's investment choices under a regulated monopoly and analyze the strategic behavior of renewable generators who face a double constraint : instability of support schemes and grid unavailability. We consider three active actors in the system : the grid operator, the new conventional and the renewable. Through a three-stage strategic game, we develop a benchmark model where the operator is proactive and then confront it with an alternative model where the operator is reactive. We use dynamic stochastic modeling to formalize the choices of the actors as a mathematical program with equilibrium constraints. And the mixed complementarity problem technique is then used to solve the subproblems of the game and find the equilibrium at each step.

Results

We find that renewable investments are conditioned on one side by the stability of price signals related to renewable specific regulatory incentives and by the expected grid availability on the other side. The decision to invest or not in renewable energy depends on the level of its marginal revenue compared to its unit investment cost. This marginal revenue depends strongly on the premium and its rational probability distribution. These two parameters internalize the incentives specific to renewable energy as well as the predictability of their sustainability. We then show that renewable-related network investments are only efficient if the price signals from renewable regulation are sufficient. Finally, we find that the price signal of renewable-specific regulation must offset the gap between the social investment cost of renewable and the opportunity cost of not having renewable, to trigger the necessary investments. Therefore, we find an original result of the study that highlights a threshold level of renewable-specific grid extension at which a reactive operator is more beneficial to welfare than a proactive operator. When network costs are significant, the reactive operator is socially more beneficial. And this result is even more valid when renewable technologies are more mature and/or when network operationalization times are short.

Conclusion

Contrary to much of the literature, we find that a reactive operator is socially beneficial when renewable technologies are fairly mature or when grid costs are significant. In this period of energy crisis, strong regulatory signals related to incentives are needed to encourage new investments in renewable but also in flexibility technologies such as electric vehicles which will be the subject of our next paper.

References

Abrell J., Koscha M. and Rausch S. (2019), « Carbon abatement with renewables : evaluating wind and solar subsidies in Germany and Spain ». J. Public Econ. 169, 172–202.

Adkins R. and Paxson D. (2016), « Subsidies for renewable energy facilities under uncertainty ». Manch. Sch. 84, 222–250.
Azevedo A., Pereira P.J.and Rodrigues A. (2020), « Optimal timing and capacity choice with taxes and subsidies under uncertainty ». Omega. In press.
Bigerna S.,Wen X., Hagspiel V. and Kort P.M. (2019), « Green electricity investments : environmental target and the optimal subsidy ». Eur. J. Oper. Res. 279, 635–644.
Biggar D. R. and Hesamzadeh M. R. (2014), « The Economics of Electricity Markets ». IEEE-Wiley Press, August 2014.
Boomsma T.K. and Linnerud K. (2015), « Market and policy risk under different renewable electricity support schemes ». Eur. J. Oper. Res. 89, 435–448.
Clastres C. and Khalfallah H. (2021), « Dynamic pricing efficiency with strategic retaillers and consumers : An analytical analysis of short-term market interactions ». Energy Economics 98 (2021) 105169.
Després J., Hadjsaid N., Criqui P., et Noirot I. (2015), « Modelling the impacts of variable renewable sources on the power sector: Reconsidering the typology of energy modelling tools ». Energy Policy, vol. 80, pp. 486–495, Feb. 2015.
Eryilmaz D. and Homans F.R. (2016), « How does uncertainty in renewable energy policy affect decisions to invest in wind energy ». Electr. J. 29, 64–71.
Guthrie G. (2020), « Regulation, welfare, and the risk of asset stranding » Q. Rev. Econ. Fin. 78, 273–287.
Hesamzadeh M. R. and Tohidi Y. (2016), « Sequential coordination of transmission expansion planning with strategic generation investments », IEEE 2016.
Hesamzadeh M., Biggar D., Hosseinzadeh N., and Wolfs P. (2011), « Transmission augmentation with mathematical modeling of market power and strategic generation expansion-part I ». Power Systems, IEEE Transactions on, vol. 26, no. 4, pp. 2040–2048, Nov. 2011.
Kang S.B. and Létourneau P. (2016), « Investors' reaction to the government credibility problem - a real option analysis of emission permit policy risk ». Energy Econ. 54, 96–107.
Karneyeva Y. and Wüstenhagen R. (2017), « Solar feed-in tariffs in a post-grid parity world : the role of risk, investor diversity and business models ». Energy Policy 106, 445–456.
Nagy R. L., Hagspiel V. and Kort P. M. (2021), « Green capacity investment under subsidy withdrawal risk ». Energy Economics, 98 , 105259. https://doi.org/10.1016/j. eneco. 2021.105259.
Pozo D., Sauma E., and Contreras J. (2013), « A three-level static MILP model for generation and transmission expansion planning ». Power Systems, IEEE Transactions on, vol. 28, no. 1, pp. 202–210, Feb. 2013.
Rious V., Perez Y. and Glachant J-M. (2011), « Power Transmission Network Investment as an Anticipation Problem ». Review of Network Economics
Sauma E. and Oren S. (2006), « Proactive planning and valuation of transmission investments in restructured electricity markets ». Journal of Regulatory Economics, vol. 30, pp. 358–387, 2006.
The Economist, 2018. On the Solarcoaster - Can the Solar Industry Survive Without Subsidies ? https://www.economist.com/business/2018/06/14/can-the-solar-industry-survive-without-subsidies