Chair of Public Economics

Centos
Oldenburg Center for Sustainability Economics and Management

Efficient diffusion of renewable energies – A roller-coaster ride

Abstract

Intermittency of renewable energies like wind and solar leads to the following effect: when their supply is high, the price of energy is low, or even zero. Conversely, when prices are high, the supply of renewables is low. This constellations reduces the ability of renewables to earn money, and one might expect that this leads to too little investments in renewable capacities. Our paper shows that this intuition is wrong.

Model and methodology

Consider a market in which electricity can be generated from two technologies. They have capacity costs, β_j, that are constant per unit of capacity, Q_j, and production costs, b_j, that are constant per unit of output, $q_j(\sigma)$. Technology *f* represents fossil technologies – like conventional power plants on the basis of gas or coal – that are fully available for electricity production up to the limit of their installed capacity. Technology *r* is a renewable technology with intermittent supply – like wind turbines, solar PV or solar thermal plants. Intermittency is represented by an availability factor, σ ∈ [*a*,1]. Thus, a higher *a* can be interpreted as a higher reliability of the renewable technology. We assume an uniform distribution of σ, and linear demand, while demand must equal supply, $x = A - \gamma p = \sum q_j(\sigma)$. We consider the following timing: In the first stage, a regulator chooses optimal capacities for renewables and fossils. In the second stage, the regulator chooses optimal production of renewables and fossils for a specific realization of the availability of renewables. By backwards induction, we first examine the second stage, where capacities and the availability are given. Several outcomes can be distinguished, depending on the market diffusion of renewables and their availability. First, stage 1 may have led to only fossil, only renewable or capacities of both types. Second, we will show that in the two diffusion stages with renewables four cases (see Figure 1) may obtain that depend on the realization of the availability factor.

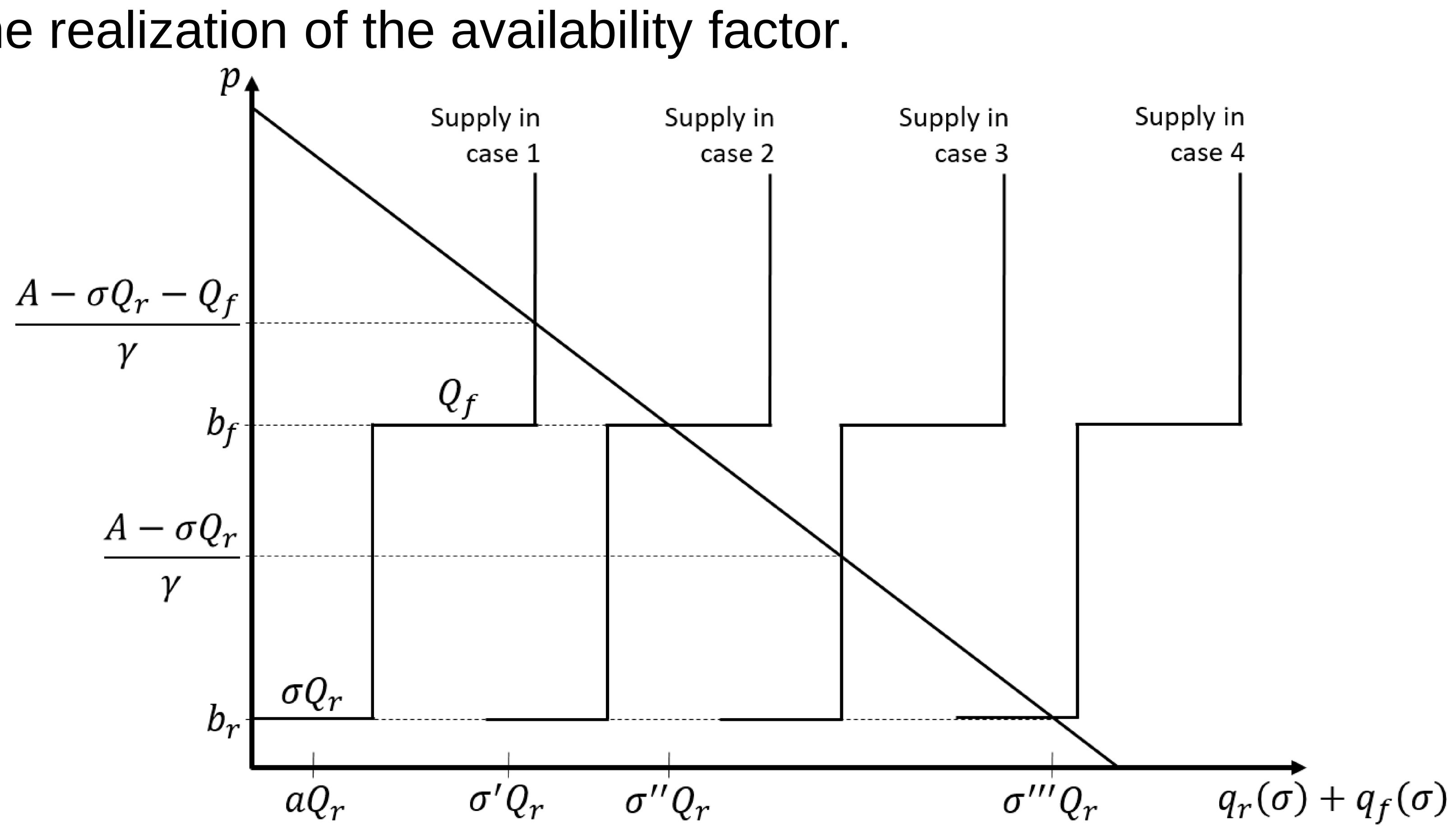

Figure 1: Equilibrium on electricity market

Results

Compared to fossils, renewables are still a “new” technology for which rapidly falling capacity costs are anticipated. As capacity costs of renewables fall, it is efficient to install more renewable and less fossil capacities. The diffusion of renewables starts linear, changes to convex, to concave, and to convex again (see Figure 2). a reduction in the capacity costs initially leads to a high build-up of renewable capacities. However, the build-up rate falls dramatically once the market penetration is such that renewables are able to satisfy the whole demand at times of high availability. Thus, the most difficult stages of the energy transition are still to come. As renewables become more reliable, both their market entry as well as their complete market capture occur already at higher capacity cost. Hence, both costs reductions and technology improvements are suitable to speed up the market diffusion of renewables.

Additionally, in the absence of market restrictions - such as price ceilings - markets will lead to efficient capacity and production choices. As the share of renewables increases, the equilibrium price depends increasingly on their availability. Regulators may perceive the resulting price fluctuations as politically unacceptable and respond with a price cap. A price cap does not influence the start of the market diffusion of renewables. However, it leads to a faster market diffusion of renewables. Specifically, the level of capacity costs at which renewables completely replace fossils in the competitive solution, is larger the stricter the price cap.

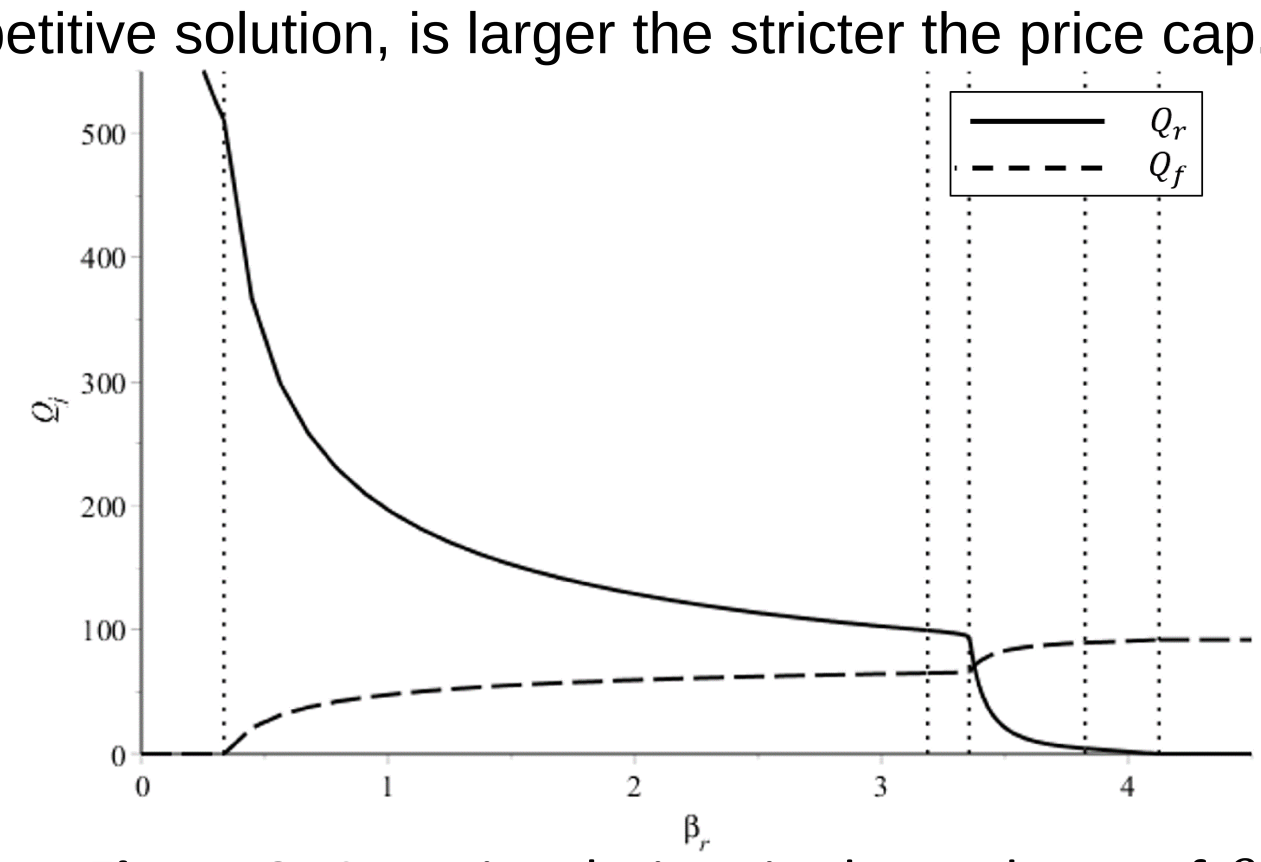

Figure 2: Capacity choices in dependency of β_r

Prof. Dr. Carsten Helm

Mathias Mier, Marius Paschen, Anna Deckert, Catharina Schramm

Research Topics

International Environmental Agreements, Transformation of the Energy System

Recurring Courses

Microeconomic Theory, Public Economics, Advanced Microeconomics

References

Ambec & Crampes (2012): “Electricity provision with intermittent sources of energy”, *Resource and Energy Economics* 34, 319-336.
Borenstein (2012): “The Private and Public Economics of Renewable Electricity Generation”, *Journal of Economic Perspectives* 26(1), 67-92.
Crew, Fernando & Kleindorfer (1995): “The Theory of Peak-Load Pricing: A Survey”, *Journal of Regulatory Economics* 8, 215-24.
Joskow (2011): “Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies”, *AER PP* 101(3), 238-241.