

# Efficient diffusion of renewable energies – A roller-coaster ride

## Abstract

We use the peak-load pricing model to examine how the intermittency of renewable energies affects their efficient market diffusion. Diffusion starts slowly as capacity costs fall, then accelerates, but slows down substantially once renewable capacities are large enough to satisfy the whole electricity demand at times of high availability. Technology improvements such as better storage capabilities have substantial effects on the speed and the pattern of market penetration. Perfect competition and dynamic pricing lead to efficient choices of renewable and fossil capacities, provided that external costs of fossils are internalized. However, fluctuations of electricity prices rise with the share of renewables. If regulators impose a price cap, this accelerates the market diffusion of renewables.

## Model and methodology

- Electricity market with renewable ( $r$ ) and fossil ( $f$ ) technologies
- Capacity costs,  $\beta_j$ , and production costs,  $b_j$ , per unit of output,  $q_j(\sigma)$ ,  $j = r, f$
- Intermittency of renewables is represented by an availability factor,  $\sigma \in [a, 1]$
- Linear demand,  $x = A - \gamma p(\sigma)$
- Timing:
  - 1<sup>st</sup> stage: regulator/firms chooses capacities,  $Q_j$
  - 2<sup>nd</sup> stage: regulator/firms chooses optimal production,  $q_j(\sigma)$ , for a specific realization of  $\sigma$
- Solution by backwards induction
- If  $Q_r, Q_f > 0$ , four cases may obtain that depend on the realization of  $\sigma$  (see Figure 1)

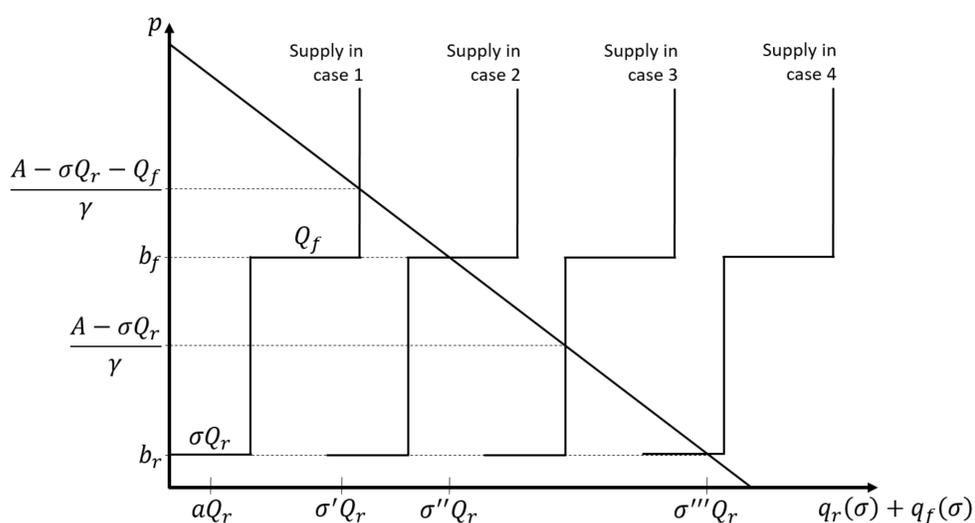


Figure 1: Equilibrium on electricity market

## Results

- Initially, high build-up of renewable capacity
- Build-up rate falls dramatically once renewables are able to satisfy the whole demand at times of high availability
- Most difficult stages of the energy transition are still to come (see Figure 2)

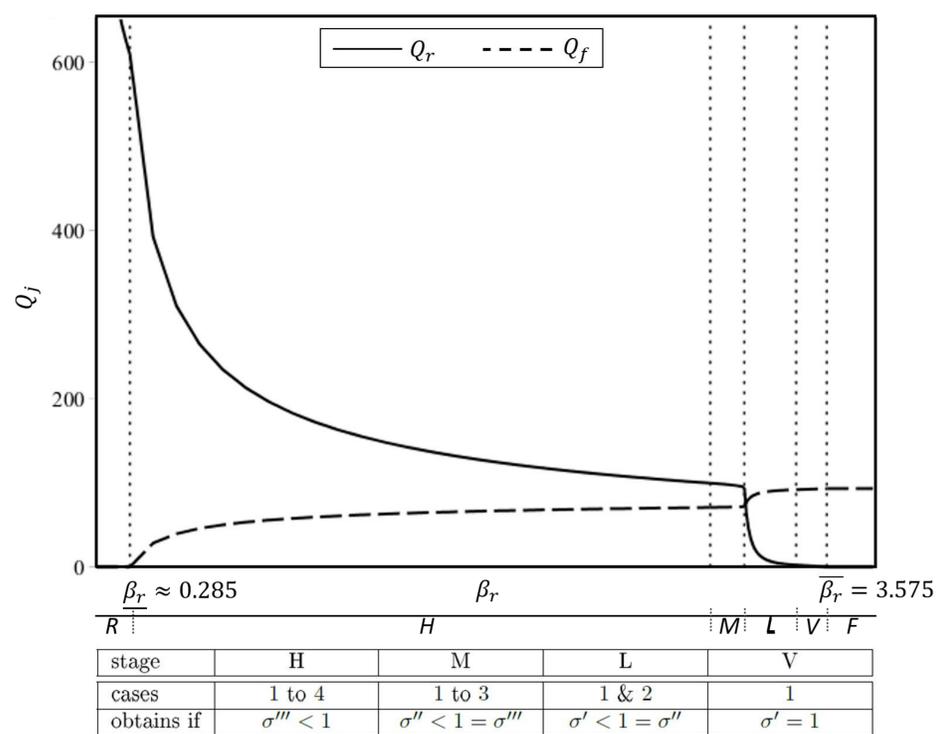


Figure 2: Capacity choices in dependency of  $\beta_r$

- As renewables become more reliable (higher  $a$ ), market entry and complete market capture occur already at higher capacity cost
- Competitive markets lead to efficient capacity and production choices
- Price fluctuations rise with a higher share of renewables
- Price cap leads to a faster market diffusion of renewables
  - Renewable capacities inefficiently high
  - Fossil capacities inefficiently low

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## Research Topics

International environmental agreements, transformation of the electricity system

## Recurring Courses

Microeconomic Theory, Public Economics, Advanced Microeconomics



## References

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