Disaggregating cost components of the supply function of wind power and welfare effects for different allocation mechanisms

Lukas Weissensteiner, Hans Auer
Institute of Power Systems and Energy Economics, Vienna University of Technology
Energy Economics Group (EEG)
weissensteiner@eeg.tuwien.ac.at

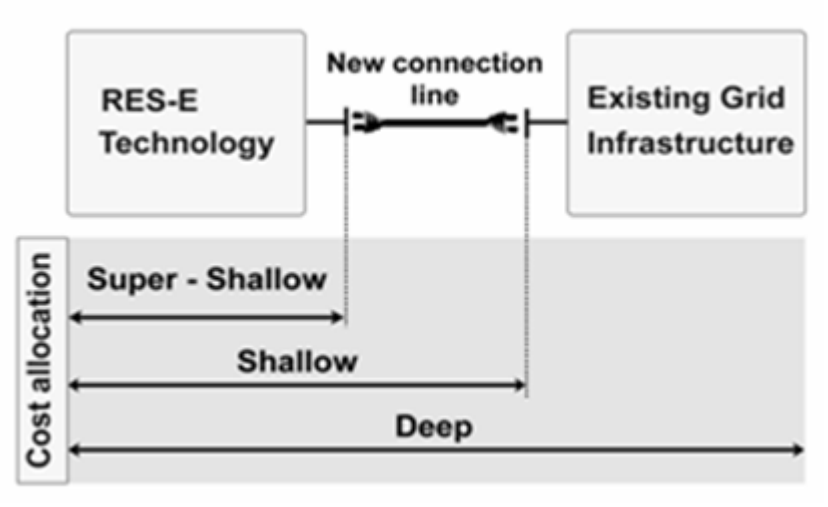
Contents

1. Motivation

Liberalisation of the electricity sector, unbundling and the deployment of renewable energy sources for electricity generation …

… raise the question where to define the boundary of responsibilities between operators of power plants and operators of grids and whom to attribute corresponding connection costs.

… have resulted in the European Union to a broad range of interpretations and to accordingly diverging regulations



super-shallow /
shallow /
deep charging

1. Motivation – Allocation of system integration costs

	Grid connection	Grid reinforcement	Balancing
Austria	Producer	Producer	End user
Belgium	Producer	End user	Producer
Denmark	Producer[1)]	End user	Producer
France	Producer	Producer	End user
Germany	Producer[1)]	End user	End user
Greece	Producer	End user	End user
Ireland	Producer	Producer	End user
Italy	Producer	Producer	Producer
Portugal	Producer	Producer	End user
Spain	Producer	Producer	Producer
United Kingdom	Producer	Producer	Producer
Cyprus	Producer	End user	End user
Czech Republic	Producer	Producer	Producer
Estonia	Producer	End user	Producer
Hungary	End user	End user	Producer
Lithuania	Producer	Producer	End user
Malta	Producer	End user	End user
Poland	Producer	Producer	Producer
Bulgaria	Producer	End user	End user

Source: http://res-legal.eu/en.html (visited January 2009), own investigations
1) Costs for connecting offshore wind are borne by the TSO and passed on to the end user.

1. Motivation

Electricity production from renewable energy sources as (offshore) wind energy …

… is characterised by high specific costs for the connection to distribution and transmission grids.

… is induced by energy policy and is supported via different promotion instruments.

… needs to be organised economically efficient in order to save electricity consumers' money (= transfer costs).

2. Research question

– **What effects do different approaches of allocation of grid connection costs have on the supply curve for (offshore) wind power?**

and:

– **What effects do these changes impose on respective (social) transfer costs and producer surplus?**

3. Method of approach

- **Comparative analysis of stylised supply curves for electricity production from wind power considering 2 different scenarios for the allocation of grid connection**

  → derivation of supply and demand curves

  → producer surplus in 2 scenarios

  → comparison of transfer costs to consumers

- **Outlook: Real world supply curve for offshore wind power**

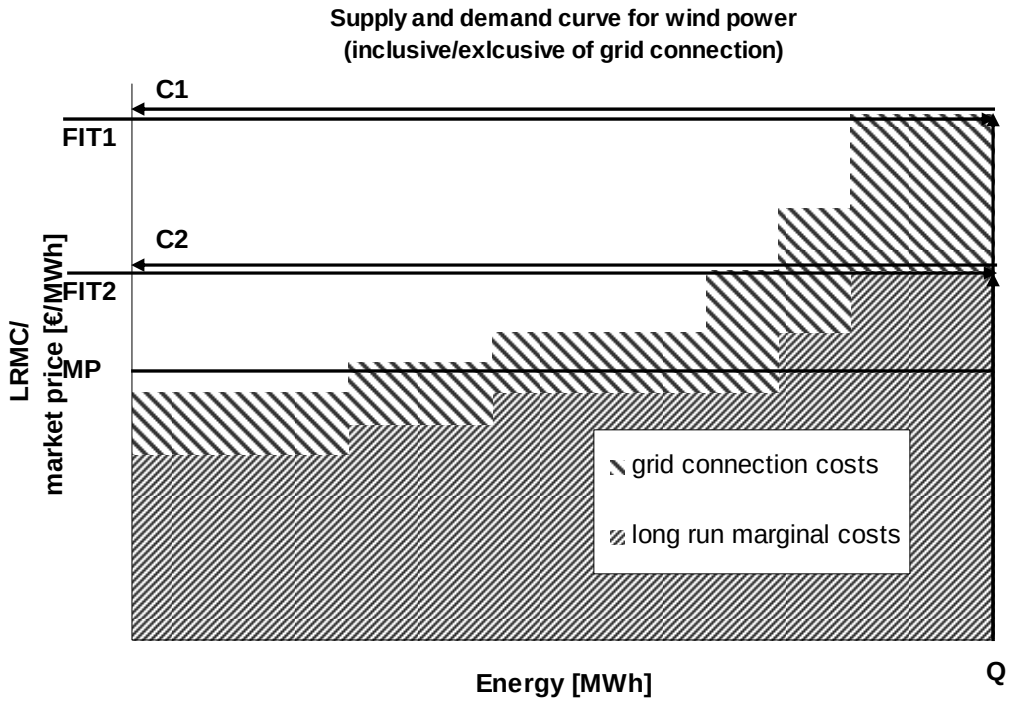
  → Quantification of transfer costs under different cost allocation scenarios on the basis of empirical data

4. Long run marginal cost of electricity production from wind power

- **capital cost**
  - **life time (depreciation time / investment horizon)**
  - **full-load hours**
  - **rate of return**
  - **investment costs**
    - **inclusive of grid connection?**
      grid extension / reinforcement?

- **operational costs**
  - **maintenance, repair**
  - **rental of land insurances**
  - **operation and power sales (including balancing)**

5a. Supply curve for wind energy

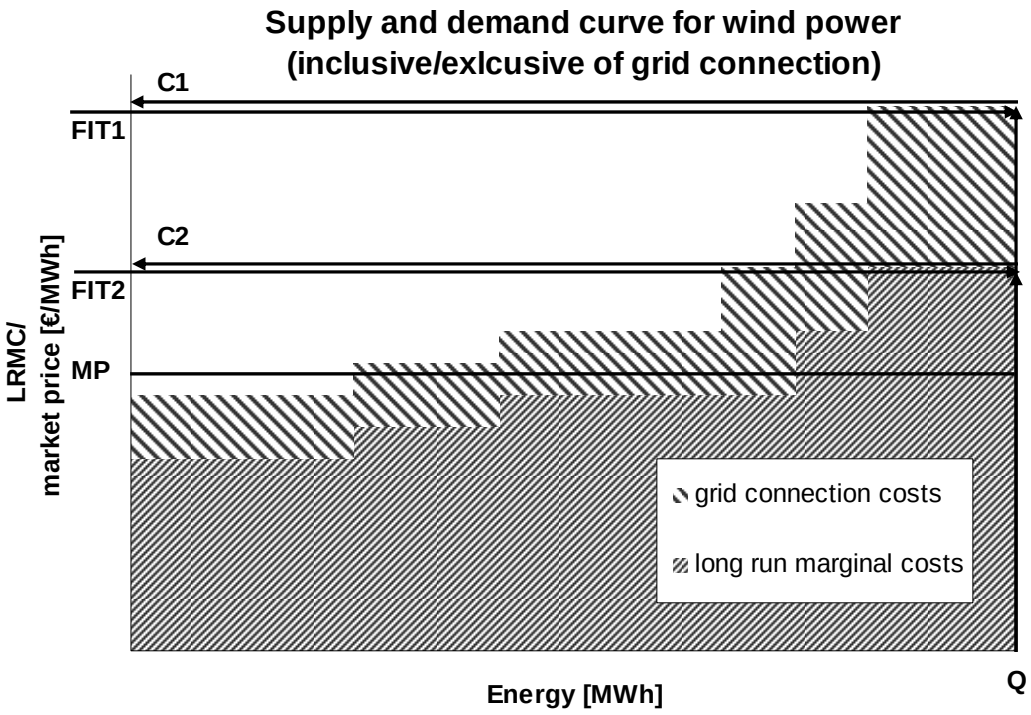


supply curve:

- stylised
- determined by allocation method of grid connection costs
- 2 scenarios
  - → 1. inclusive of grid connection
  - → 2. exclusive of grid connection
- according to long run marginal costs (including specific investment costs)
- high specific grid connection costs:
  - → comparatively low capacity
  - → remote resources

C1, C2 … long run costs of the marginal wind farm deployed, inclusive (1) or exclusive (2) of grid connection costs

5b. Demand curve for wind energy

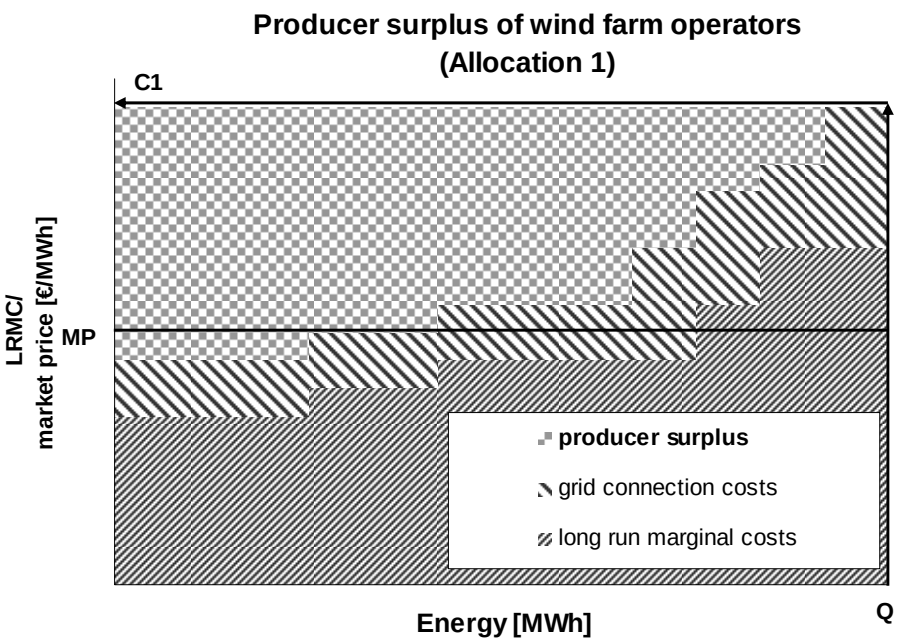


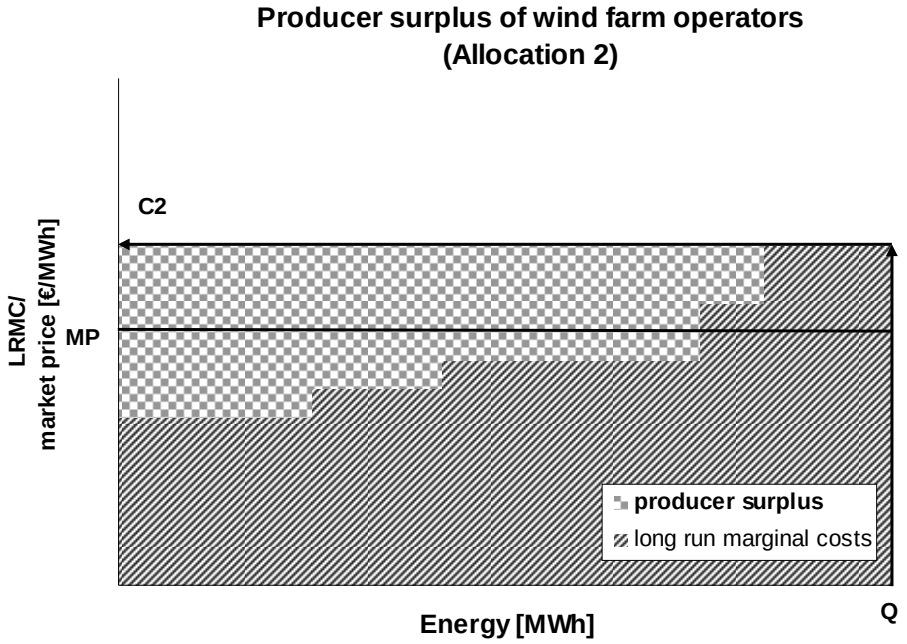
Demand curve:

- intersection of a totally inelastic (Q) and a totally elastic demand (FIT) in one point of the supply curve.
- motivated by renewable energy policy
- defined / designed according to long run marginal costs

FIT1, FIT2 … feed-in tariff sufficient for the deployment of capacity Q
Q1, Q2 … quota (corresponding volume reached with FIT1, FIT2)
MP … market value of wind energy

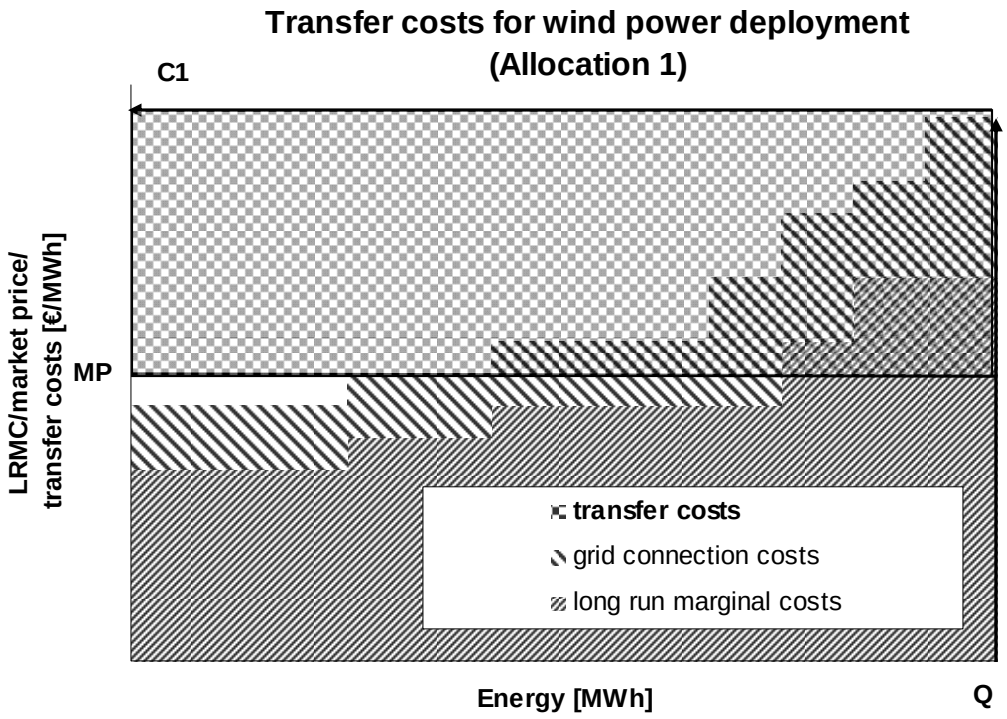
6. Producer surplus of wind power producer





C1, C2 … long run costs of the marginal wind farm deployed,
inclusive of (1) respectively exclusive of (2) grid connection costs

7. Transfer costs

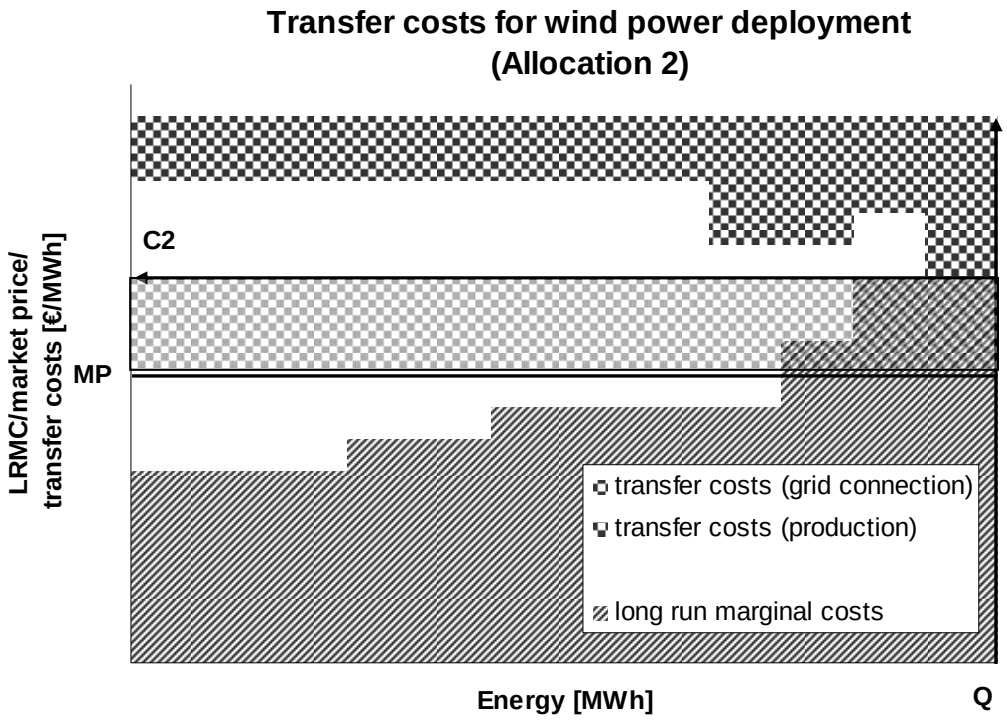


$$TC_1 = (C_1 - MP) \times Q_1$$

transfer costs:

difference between long run costs of marginal wind farm and the market value (related to the volume Q)

7. Transfer costs



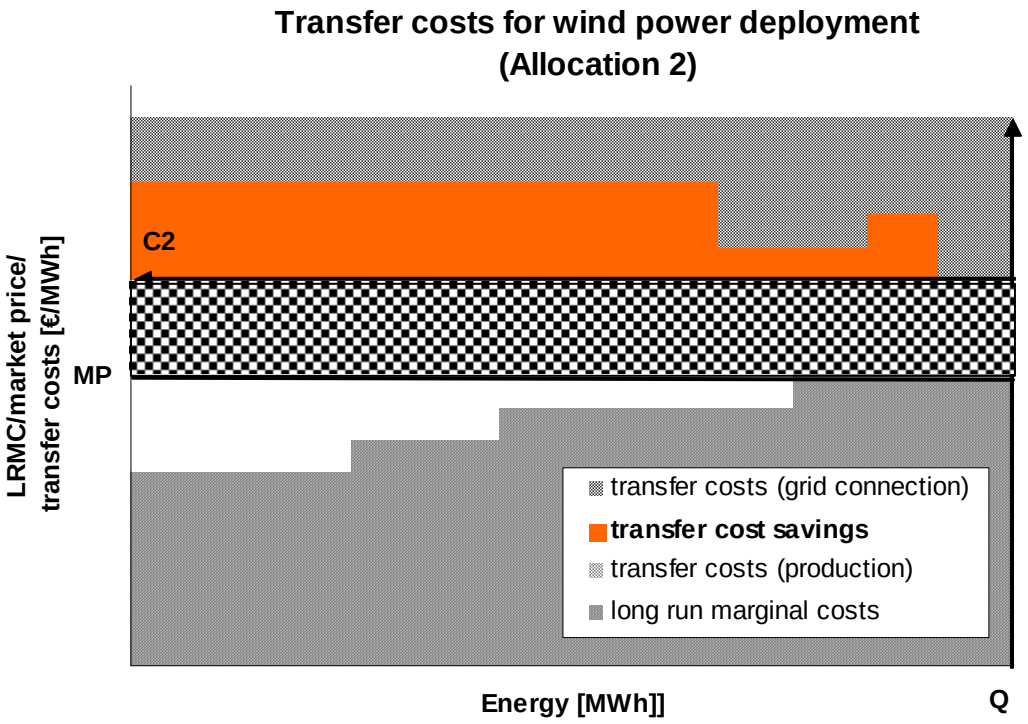
$$TC_2 = (C_2 - MP) * Q_2 + \sum_{i=1}^{n} (q_i * GC_{i,reg})$$

transfer costs:

difference between long run costs of marginal wind farm and the market value (related to the volume Q)
+
aggregated connection costs of regulated grid operators

$GC_{i,reg}$ … regulated connection costs of a wind farm to be borne by grid operators
Q2 … quota (equivalent to the volume deployed via FIT1 / FIT2)
MP … market value of wind energy
q_i … capacity of a single wind farm

7. Transfer cost savings



Reduction of support costs due to:

- a decrease of producer surplus, which is underestimated in the depiction for following reasons:

  → different rates of return
  → subadditive costs of wind connection (at least for offshore)

TCS … Transfer Cost Savings

$$TCS = (C_1 - C_2) * Q_{1,2} - \sum_{i=1}^{n} \left(q_i * GC_{i,reg} \right)$$

8. Criticism

- **Transfer costs are depending on the slope of the supply curve and accordingly the level of producer surplus**

  Revere conclusion in the case of opposing trends of LRMC of production and connection

  Onshore → ?

  Offshore → ✓ → Connection costs determinant (empirical verification necessary)

- **Producer surplus is part of welfare**

  Producer surplus results (to a large extent) from an artificial market and subsidisation

  from a dynamic viewpoint overall deployment will increase (positive effect on producer surplus again)

9. Results and conclusions

Qualitative assessment of stylised supply and demand curves reveals the following:

– **Allocation of grid connection costs influences the level of producer rent and therefore transfer costs to consumers.**

Attribution of these costs to grid operators appears indicated, in case

– **long run marginal costs of electricity production are to a large extent determined by grid connection costs.**
– **grid connection costs are being remunerated to grid operators on the basis of efficiency criteria.**
– **granted rents to grid operators are less than the returns of find farm operators.**
– **overall savings can be realised through a coordinated planning of connection lines. („subadditive cost structure").**
– **priority deployment areas are designated for economically favourable potentials.**

Thank you for your attention

… please contact me for further questions …

Lukas Weissensteiner
Energy Economics Group
Tel.: +43 1 58801 37368
Fax: +43 1 58801 37397
Email: weissensteiner@eeg.tuwien.ac.at

Web: www.eeg.tuwien.ac.at