undendlich viele Lösungen...

Paul Nahmmacher

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**Objective**
- minimizing cumulated costs for electricity provision
- optimal investment and dispatch decisions for generation, storage and transmission capacities

**Linear optimization model**
- GAMS / CPLEX Solver

**Technologies**
- generation [nuclear, hard coal (+ccs), lignite (+ccs), natural gas cc/gt, hydro, wind on-/offshore, solar pv/csp, biomass]
- storage [diurnal, seasonal]
- transmission [net transfer capacities between regions]

**Geographical scope & resolution**
- EU28 countries w/o Malta & Cyprus
- plus Norway & Switzerland & Balkan

**Temporal scope & resolution**
- 5 year steps 2010 – 2050
- representative days per year
- perfect foresight

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**Policy equations**
- CO₂ targets / RES targets
- EU or Member State level

**Exogenous parameters**
- electricity demand per region
- nuclear / ccs policies
- investment costs
- fuel costs
- ...

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Paul Nahmmacher
ESED – Energy Strategies Europe and Germany

Based on Haller et al. (2012)
LIMES-EU Long-term investment model of the electricity sector

Paul Nahmmacher
ESED – Energy Strategies Europe and Germany
Multiple optimal solutions for base year

non-convex solution space
Multiple optimal solutions for base year

One optimal solution for the overall European electricity mix

...but different distribution of electricity generation between model regions

convex solution space
Multiple optimal solutions for base year

One optimal solution for the overall European electricity mix

…but different distribution of electricity generation between model regions.

- multiple regions
- same fuel prices, efficiencies, ...
- excess capacity
- emission cap (not price)

<table>
<thead>
<tr>
<th>Demand</th>
<th>Hard Coal / Natural Gas</th>
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<tbody>
<tr>
<td>Region A</td>
<td>8</td>
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<td>Region B</td>
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<tr>
<td>Sum A+B</td>
<td>16</td>
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Multiple optimal solutions for base year

What is the „right“ solution?
Diversified national generation portfolio.

- transmission losses between regions – still multiple (but less) optimal solutions
- fuel prices that depend on consumption – non-linear equation
- more detail in technology representation – computation time
- approximation of historic emissions – only for base year, still multiple (but less) optimal solutions

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<td>5/3</td>
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