# Potential Gains from Mergers among Electricity Distribution Companies in Germany


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*6th Conference on Applied Infrastructure Research*

Berlin, October 2007

# *Outline:*

1. **Introduction**
2. **Methodology**
3. **Data and Analysis**
4. **Results**
5. **Conclusions**

# 1. Introduction

- **Ongoing regulatory reforms in the German energy sector**
  - New incentive regulation scheme for DSOs (electricity, gas) from 2009
  - Efficiency of network operations becomes key performance driver
- **Two possibilities to increase efficiency:**
  - Cost reductions
  - Utilization of scale and synergy effects from mergers
- **Questions:**
  - How large are potential merger gains for German DSOs?
  - What are the sources for those gains?

# Related literature

- **Efficiency and productivity analysis**
  - Parametric (SFA) and non-parametric (DEA) benchmarking techniques
  - Extension of DEA to estimate potential merger gains:
    - *Bogetoft and Wang (2005*)
- **Application in energy sector**
  - Benchmarking of German electricity DSOs
    - *Hirschhausen, Cullmann and Kappeler(2006)*
    - *Cullmann and Hess (2007*)
  - Application of *Bogetoft/Wang* framework to estimate potential merger gains
    - *Bagdadioglu, Price and Weyman-Jones (2007*)

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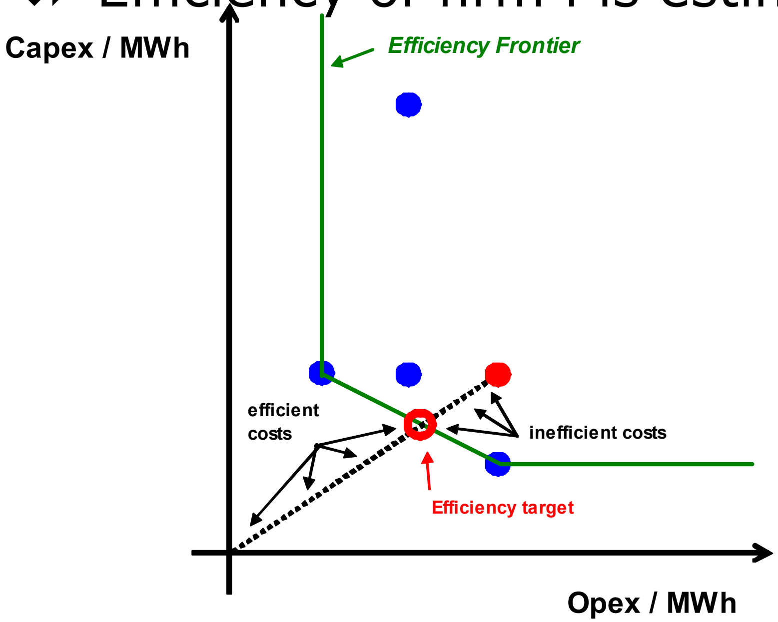
# 2. Methodology

- **Non Parametric approach (DEA)**
- **Technical efficiency of firm i:**
  - How many inputs $x_i$ are necessary to produce a given set of outputs $y_i$ $(x_i\ ;\ y_i \in I)$
  - Efficiency of firm i is estimated relative to control group I




$$
\begin{aligned}
&\min_{\theta,\lambda} \theta \\
&s.t. \\
&-y_i + Y\lambda \geq 0 \\
&\theta x_i - X\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}
$$

# 2. Methodology *(continued)*

## Estimating potential overall merger gains:

*following Bogetoft and Wang (2005)*

- J $\subseteq$ I contains all merging firms: $\sum_{j \in J} x_i^j, \sum_{j \in J} y_i^j$

  (requires *J-additivity* condition!)

- Estimation of potential overall merger gains relative to control group I:

- Overall merger gains $\theta^J$ consist of technical efficiency gains, scale and synergy effects

$$\min_{\theta^J, \lambda} \theta^J$$

$$s.t.$$

$$-\sum_{j \in J} y_i^j + Y\lambda \geq 0$$

$$\theta^J \sum_{j \in J} x_i^j - X\lambda \geq 0$$

$$\lambda \geq 0$$

# 2. Methodology *(continued)*

## Decomposing potential overall merger gains:

### a) Technical efficiency effect:

- Measures how many inputs can be saved if all firms $j \in J$ are technically efficient:

$$\min_{\theta^{*J},\lambda} \theta^{*J}$$
$$s.t.$$
$$-\sum_{j \in J} y_i^j + Y\lambda \geq 0$$
$$\theta^{*J} \sum_{j \in J} \theta^j x_i^j - X\lambda \geq 0$$
$$\lambda \geq 0$$

- With $T^J = \theta^J / \theta^{*J}$ we get $\theta^J = T^J * \theta^{*J}$

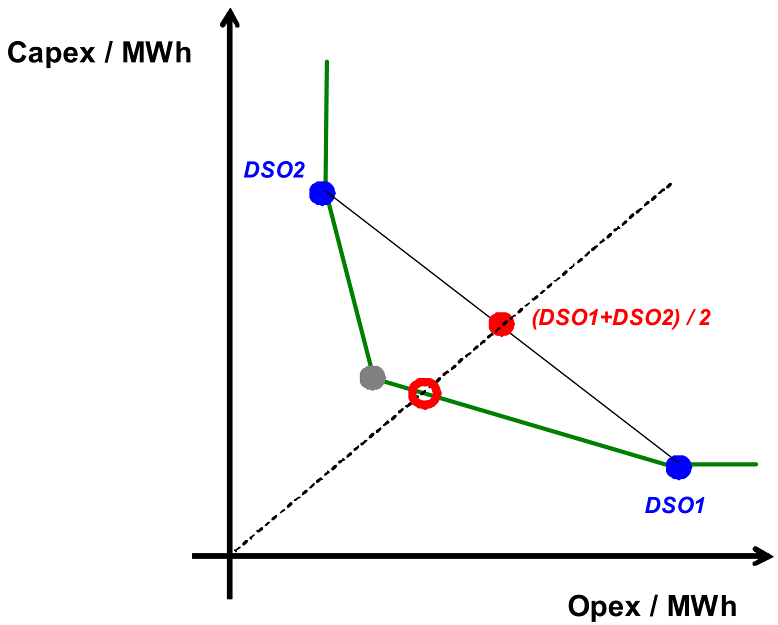
- $\theta^{*J}$ contains scale and synergy effects

# 2. Methodology (continued)

## Decomposing potential overall merger gains:

### b) Synergy effect:

- Measures how much of average inputs can be saved in the production of average outputs




$$\min_{H^J,\lambda} H^J$$

$$s.t.$$

$$-\frac{\sum_{j\in J} y_i^j}{|J|}+Y\lambda \geq 0$$

$$H^J\frac{\sum_{j\in J} \theta^j x_i^j}{|J|}-X\lambda \geq 0$$

$$\lambda \geq 0$$

# 2. Methodology *(continued)*

## Decomposing potential overall merger gains:

### c) Scale effect:

- Measures how many inputs can be saved by operating at full scale rather than average scale

- All merger gains that are not attributed to technical efficiency or synergy effects are due to scale economies

- Hence, $\theta^{*J} = H^J * S^J$ and:

$$\boldsymbol{\theta^J = T^J * H^J * S^J}$$

$$\begin{aligned}
&\min_{S^J,\lambda} S^J \\
&s.t. \\
&-\sum_{j\in J} y_i^j + Y\lambda \geq 0 \\
&S^J\left[H^J \sum_{j\in J} \theta^j x_i^j\right] - X\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}$$

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# 3. Data and Analysis

- **190 German electricity DSOs**
- **Annual data of 2004**
- **6 outputs, 4 inputs:**

| Variable | Unit | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| **Outputs** | | | | | | |
| - Electricity delivered to end users | MWh | 190 | 803,746 | 2,679,366 | 38,357 | 22,832,856 |
| - Number of residential consumers | | 190 | 58,457 | 154,055 | 81 | 1,482,765 |
| - Number of non-residential consumers | | 190 | 6,938 | 21,207 | 40 | 155,904 |
| - Inverse density index, low voltage | $m^2$ / Population | 190 | 353 | 256 | 124 | 2,049 |
| - Inverse density index, medium voltage | $m^2$ / kWh | 190 | 718 | 815 | 0 | 4,831 |
| - Inverse density index, high voltage | $m^2$ / kWh | 190 | 67 | 315 | 0 | 2,381 |
| **Inputs** | | | | | | |
| - Number of workers | | 190 | 116 | 297 | 1 | 2,485 |
| - Grid length* (aerial lines) | km | 190 | 1,001 | 5,817 | 0 | 66,479 |
| - Grid length* (cable) | km | 190 | 1,982 | 7,485 | 114 | 85,015 |
| - Network losses | MWh | 190 | 24,254 | 78,573 | 3 | 767,963 |

* Weighted aggregate over voltage levels.

# 3. Data and Analysis *(continued)*

- **Benchmarking technique: DEA**
- **Merger cases:**
  - Merger between two or three neighboring firms (189 or 188 possible mergers)
  - Formation of 14 large-scale DSOs at the federal state level
- **Technology assumptions:**
  - CRS and NDRS (DRS ruled out for technical reasons)

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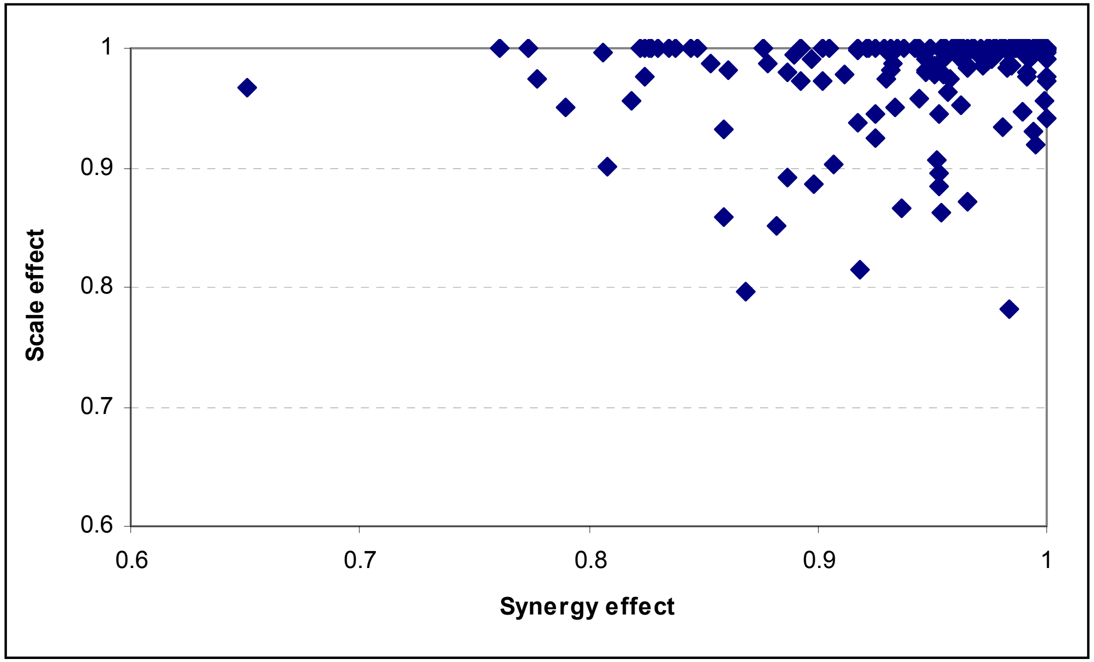
# 4. Results

| | Overall merger gain $\theta^J$ | Technical efficiency effect $T^J$ | Synergy effect $H^J$ | Scale effect $S^J$ |
|---|---|---|---|---|
| **Average over all analysed mergers:** | | | | |
| 2-DSO mergers (CRS) | 0.72 | 0.76 | 0.94 | 1.00 |
| 3-DSO mergers (CRS) | 0.70 | 0.76 | 0.92 | 1.00 |
| 2-DSO mergers (NDRS) | 0.72 | 0.78 | 0.95 | 0.98 |
| 3-DSO mergers (NDRS) | 0.70 | 0.77 | 0.92 | 0.99 |
| **Minimum over all analysed mergers:** | | | | |
| 2-DSO mergers (CRS) | 0.43 | 0.43 | 0.63 | 1.00 |
| 3-DSO mergers (CRS) | 0.45 | 0.46 | 0.68 | 1.00 |
| 2-DSO mergers (NDRS) | 0.43 | 0.43 | 0.65 | 0.78 |
| 3-DSO mergers (NDRS) | 0.45 | 0.46 | 0.69 | 0.82 |

- **Average merger gains allow for 30% cost reduction, but:**
  - **Technical efficiency effect is most significant (24% cost reduction)**
  - **Synergy effect allows for cost reduction of 6-8%**
  - **Scale effects allow for cost reduction of only 1-2%**
  - **Significantly higher effects (>30% cost reduction) on case-by-case basis**

# 4. Results *(continued)*

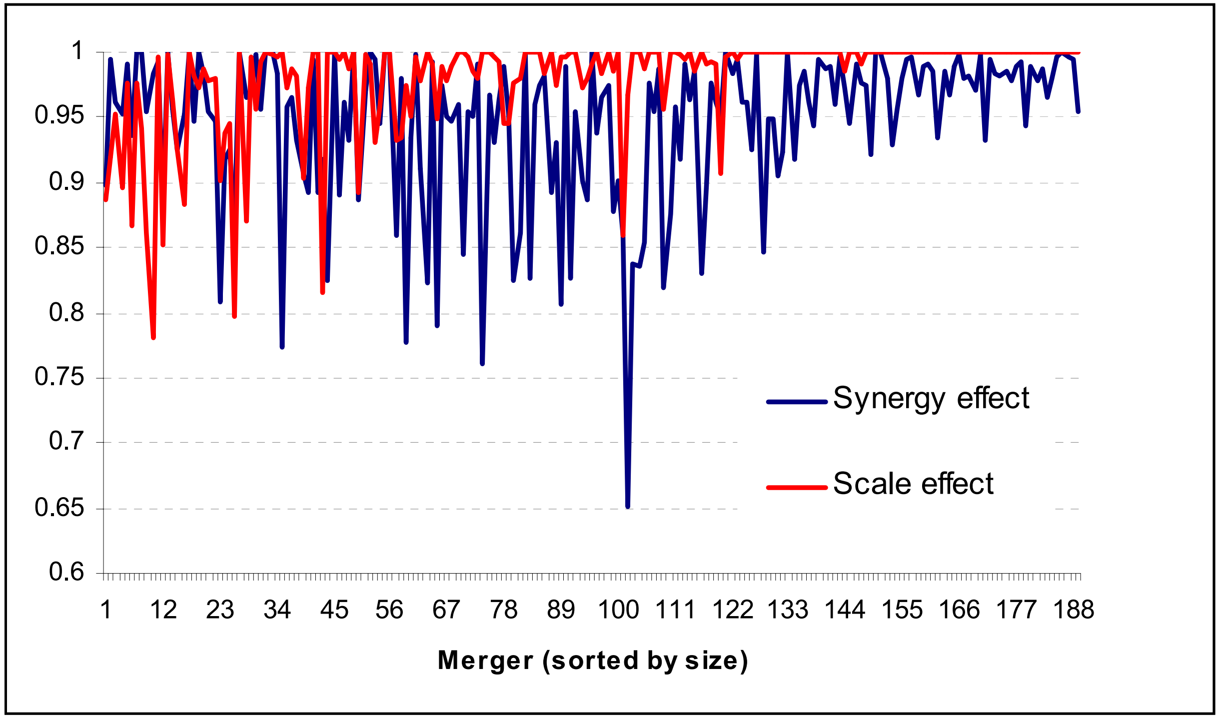
## Scale and Synergy effects (2-DSO mergers, NDRS)




- **Three clusters:**
  1. Mergers with no efficiency gains (upper right side)
  2. Mergers with large synergy and low scale effects
  3. Mergers with significant synergy and scale effects

# 4. Results *(continued)*

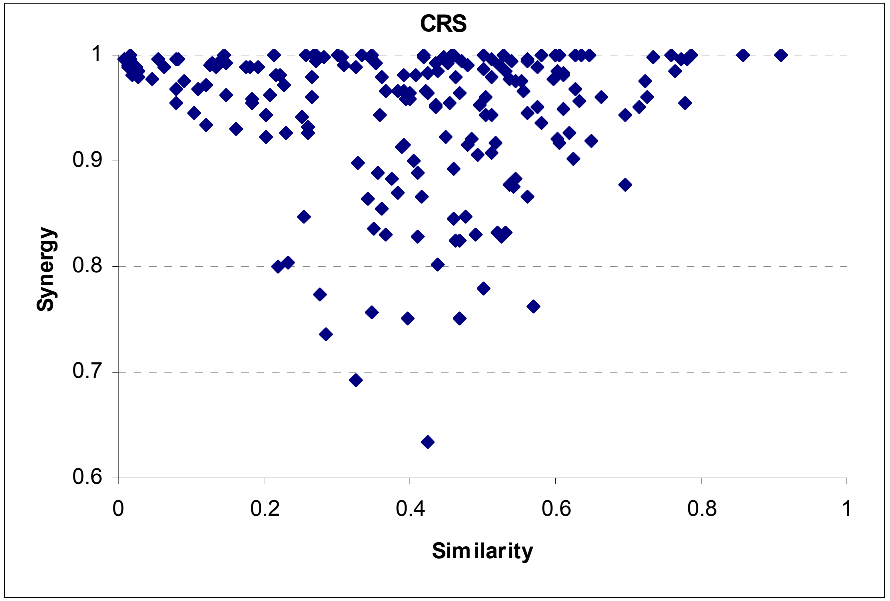
**The impact of post-merger size (2 DSOs, NDRS):**

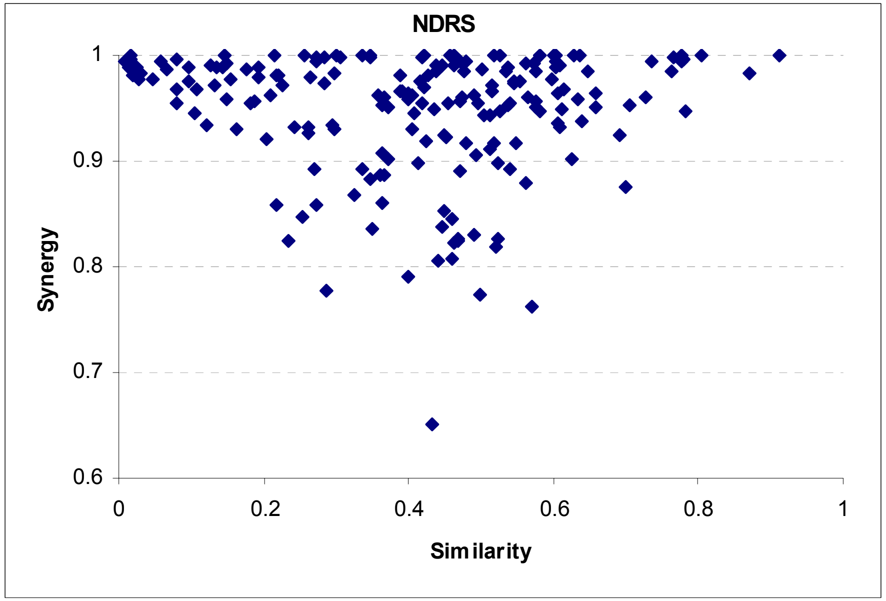



- **Diverse results if merged unit is small or medium**
- **Scale and synergy effects tend to be small if merged unit is large**
- **Scale effect goes to zero if merged unit is large**

# 4. Results *(continued)*

## Synergy effects and pre-merger similarity (size of inputs), 2-DSO mergers:




- **Synergy effect is low if pre-merger units are very similar or very different**
- **Largest synergy effects if one DSO is about half as big as the other (but: not sufficient condition)**

# 4. Results *(continued)*

**Synergy effects and pre-merger similarity (output structure), 2-DSO mergers (NDRS):**

| Service Area | Customer Structure: *Homogeneous* | *Medium* | *Heterogeneous* |
|---|---|---|---|
| *Homogeneous* | *7 obs.* **0.98** | *20 obs.* **0.95** | *12 obs.* **0.94** |
| *Medium* | *26 obs.* **0.96** | *59 obs.* **0.94** | *18 obs.* **0.95** |
| *Heterogeneous* | *12 obs.* **0.96** | *24 obs.* **0.94** | *11 obs.* **0.91** |

- **The more heterogeneous the merging parties the larger the potential synergy effect**

# 4. Results *(continued)*

## Average synergy effects of mergers of two, three or all DSOs within a Federal State (NDRS):

| No. | Bundesland | No. of DSOs *(a)* | CRS, mergers of... ...2 DSOs (b) | ...3 DSOs (c) | ...all DSOs (d) | NDRS, mergers of... ...2 DSOs (e) | ...3 DSOs (f) | ...all DSOs (g) |
|---|---|---|---|---|---|---|---|---|
| 1 | Baden-Württemberg | 20 | 0.94 | 0.92 | **0.83** | 0.94 | 0.92 | **0.83** |
| 2 | Bayern | 39 | 0.92 | 0.90 | **0.81** | 0.93 | 0.91 | **0.81** |
| 3 | Bremen | 1 | **0.74** | 0.77 | 1.00 | **0.82** | 0.82 | 1.00 |
| 4 | Hessen | 12 | 0.94 | **0.93** | 0.94 | 0.94 | 0.93 | **0.93** |
| 5 | Mecklenburg-Vorpommern | 2 | 0.95 | **0.86** | 0.94 | 0.95 | **0.86** | 0.94 |
| 6 | Niedersachsen | 22 | 0.92 | 0.89 | **0.85** | 0.93 | 0.89 | **0.84** |
| 7 | Nordrhein-Westfalen | 28 | 0.94 | **0.92** | 0.93 | 0.94 | **0.92** | 0.93 |
| 8 | Rheinland-Pfalz | 10 | 0.95 | 0.94 | **0.80** | 0.95 | 0.94 | **0.80** |
| 9 | Saarland | 4 | 0.99 | 0.97 | **0.94** | 0.98 | 0.97 | **0.93** |
| 10 | Sachsen-Anhalt | 9 | 0.97 | **0.94** | 0.98 | 0.96 | **0.94** | 0.97 |
| 11 | Schleswig-Holstein | 7 | 0.92 | 0.88 | **0.79** | 0.92 | 0.88 | **0.78** |
| 12 | Thüringen | 9 | 0.94 | 0.93 | **0.89** | 0.94 | 0.94 | **0.88** |
| 13 | Sachsen | 20 | 0.98 | 0.96 | **0.93** | 0.97 | 0.96 | **0.92** |
| 14 | Brandenburg | 7 | 0.97 | **0.95** | 0.97 | 0.97 | **0.95** | 0.96 |
| | **count** (largest efficiency gains) | | **1** | **5** | **8** | **1** | **4** | **9** |

- **Average synergy effects are always larger if three or more DSOs are merged**
- **In most cases, average synergy effects are the largest if all DSOs are merged to a single unit**

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# 5. Conclusions

- **On average, there are significant potential merger gains, however mostly due to technical efficiency effects (which do not strictly require mergers)**
- **Among the typical merger gains, average potential synergy effects by far exceed scale effects**
- **On a case-by-case basis, all three effects can be significantly larger, but synergy effects still tend to be more important than scale effects**
- **Heterogeneity of input and output structure appears to be a main determinant of potential merger gains**
- **Complex mergers (>2 parties) tend to induce larger synergy effects**