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# **Benchmarking of electricity distribution companies in ERRA member countries**

Adapted & Presented by Novak Medenica

# Contents

## **Presentation contains:**

- ✓ **The theoretical approaches for different benchmarking techniques which can be applied for distribution companies**
- ✓ **Practical example**
- ✓ **Overview of comparative results from applying different benchmarking techniques**
- ✓ **Conclusions**

# Methodologies for determination of maximum allowed revenue of energy distribution companies

## Two prevailing models of regulation - Cost plus and Incentive regulation

- ✓ **Cost plus - price which enables a return on justified operating costs, depreciation as well as a return on assets employed.**

**The basic goal of this method is to identify and guarantee a certain profit.**

**Justified costs:  $OPEX + Am + \text{Return on Assets}$**

- ✓ **Incentive methods – introduce incentives for operational efficiency improvements in the pricing models.**

**These methods are based on the performance of each individual distribution company. Performances are determined by applying benchmarking techniques.**

# Incentive method

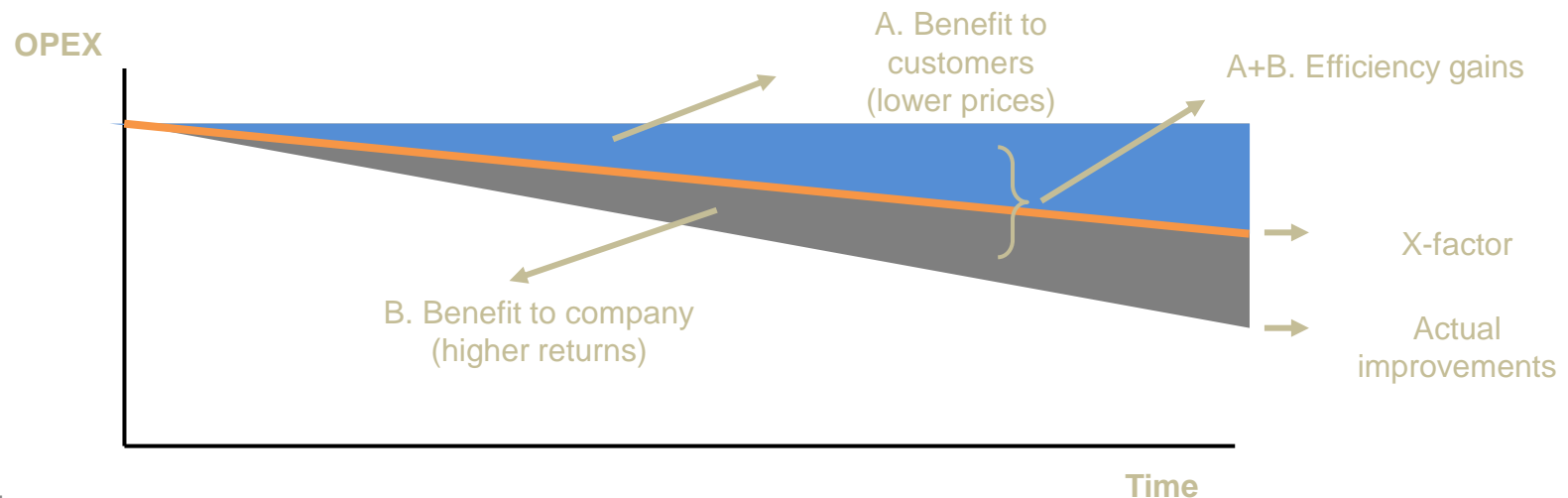
**General formulas which provide incentives to increase efficiency would be:**

$$R_t = R_{t-1} * (1 + \text{CPI} - X) \text{ or}$$

$$P_t = P_{t-1} * (1 + \text{CPI} - X) \text{ or}$$

$$\text{OPEX}_t = \text{OPEX}_{t-1} * (1 + \text{CPI} - X)$$

**By this formula, approved OPEX for the distribution company in year t (Pt) is equal to the OPEX from the previous year (OPEX-1) increased by the planned inflation (CPI) and less the efficiency factor (X).**



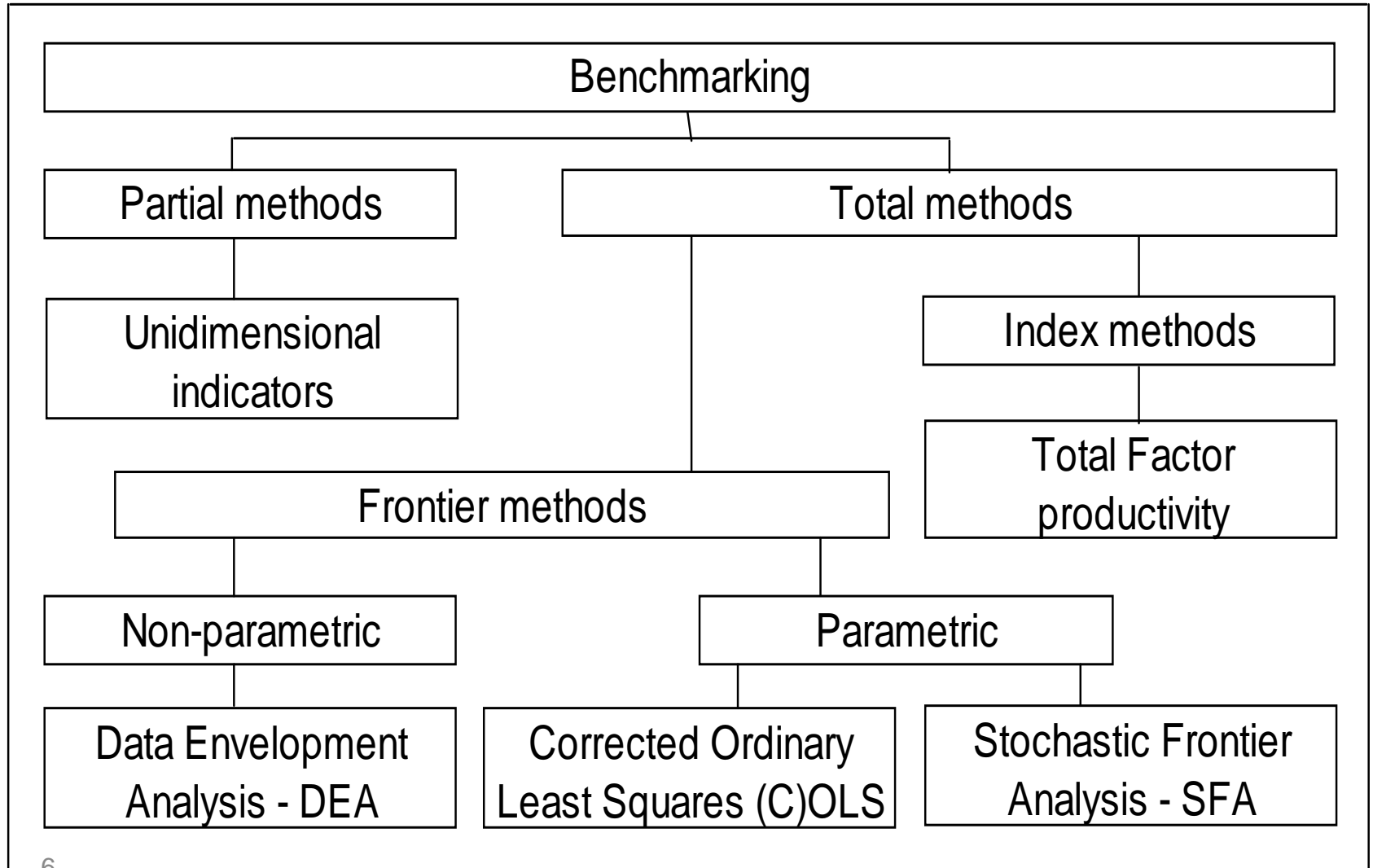
## Definition of benchmarking

**Benchmarking identifies the most efficient companies in the sample and measures the relative performance of less efficient companies against a reference performance.**

**Benchmarking is a multi-step process for comparison of distribution companies in the following steps:**

- ✓ **Selection of a sample of appropriate companies**
- ✓ **Determination of input/output data which will be analysed**
- ✓ **Identification of the most efficient companies in the sector (in the sample)**
- ✓ **Determination of the efficiency frontier (reference value)**
- ✓ **Measurement of the relative inefficiency of other companies against the referent value**
- ✓ **Assignment of individual incentive factor  $X$  on MAR (Maximum Allowed Revenue) to the companies**

# Benchmarking techniques



# Partial vs. Total Methods

- **Partial methods identify individual improvement areas at a time**
- **However, they are not able to make any trade-offs between different improvement possibilities at the same time**
- **Total methods can capture this trade-off**
- **... At the expense of higher computational complexity**
- **Total methods can be either index- or frontier-based**
- **Index-based methods are purely computational and do not imply any data elaboration (TFP)**

## Partial methods

### Uni-dimensional indicators:

- ✓ **Distributed energy / employee**
- ✓ **Distributed energy / number of customers**
- ✓ **OPEX / employee**
- ✓ **OPEX / length of lines**

**They appear in annual reports of companies.**

**They are easy to calculate and interpret.**

**A firm that performs well on one measure may do badly on another, while one firm may do reasonably well on all measures, but not be the most efficient on any.**



# Uni-Dimensional Ratios (1)

- Productivity (Managerial) Indicators
  - GWh/Employee
  - OPEX/GWh
  - OPEX/Employee
  - GWh/Line Length
- Financial indicators
  - Debt/Equity Ratio
  - Return on Investment (ROI)
  - Return on Capital Employed (ROCE)
  - All to be found in the accounts...

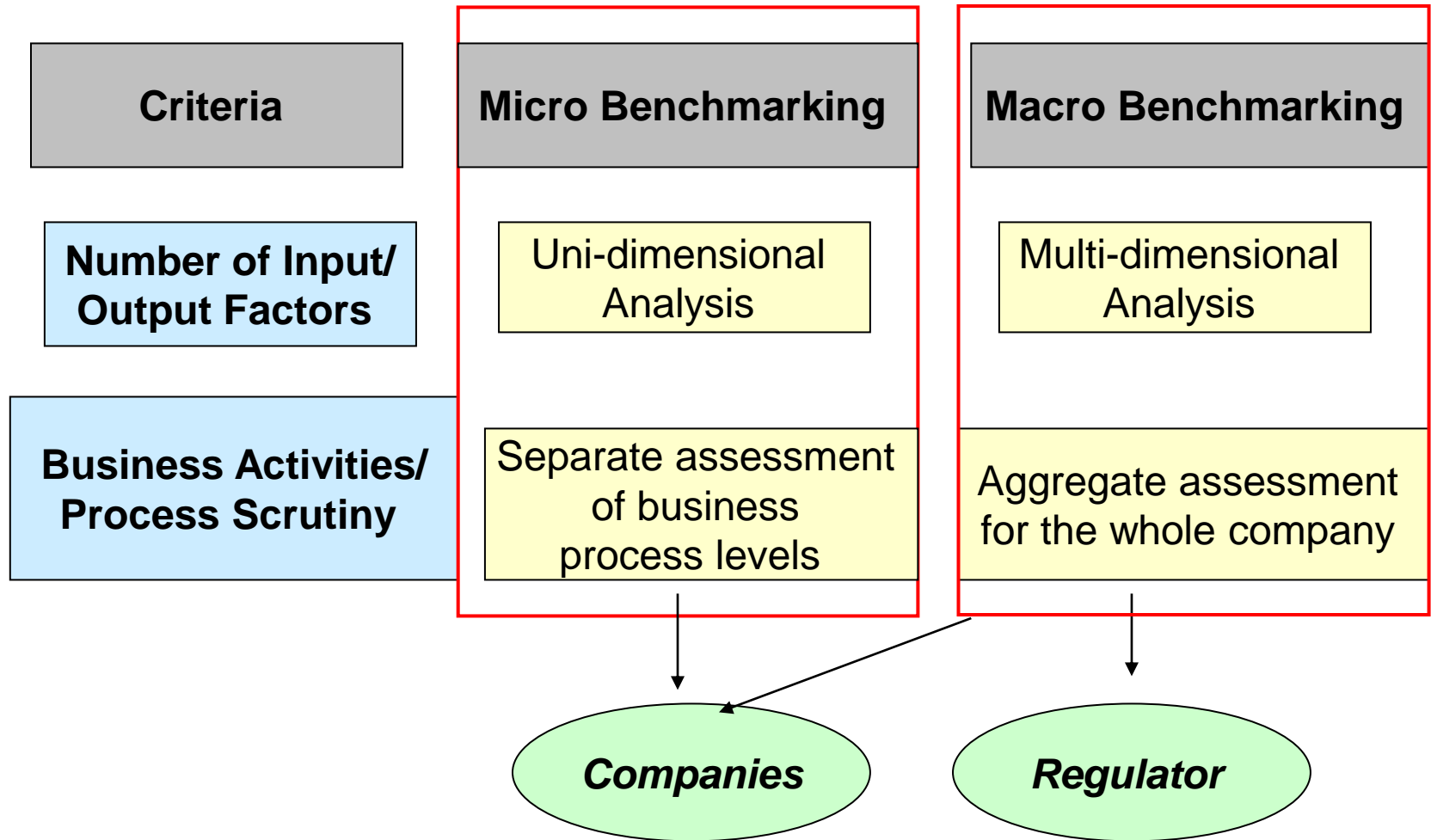
## Example of application of partial benchmarking methods

**There are no unique approach for:**

- ✓ **selecting the observed indicators and**
- ✓ **determining weighting factors for each observed indicator**

| Company       |          |         | A                          | B       |
|---------------|----------|---------|----------------------------|---------|
|               |          |         | Uni-dimensional indicators |         |
|               | O&M/ GWh | Ranking | MVA / GWh                  | Ranking |
| Distributor 1 | 0,50     | 2       | 0,5                        | 2       |
| Distributor 2 | 0,67     | 4       | 0,44                       | 1       |
| Distributor 3 | 0,58     | 3       | 0,75                       | 4       |
| Distributor 4 | 1,5      | 5       | 0,5                        | 2       |
| Distributor 5 | 0,43     | 1       | 1                          | 5       |

# Micro Versus Macro Perspective

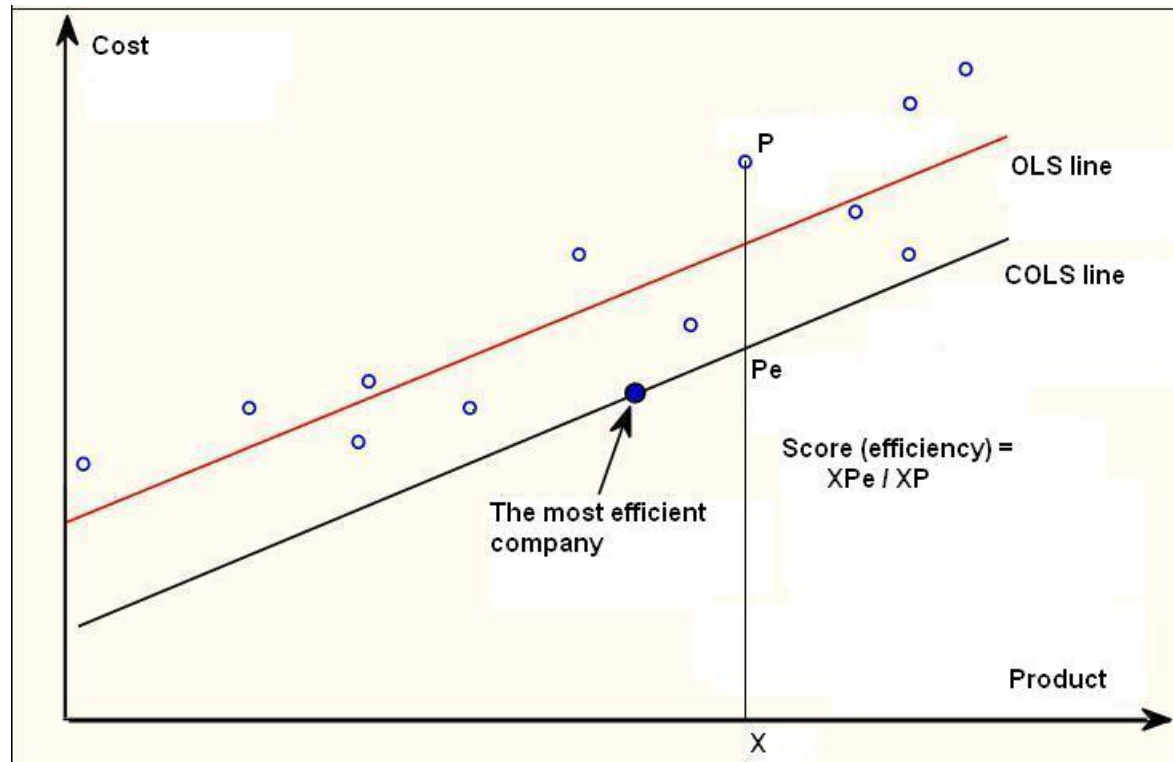


# Ordinary least squares (OLS) and corrected ordinary least squares (COLS)

## Statistical method of regression analysis

Reference line shows the average cost for each input unit of product

Corrected reference line is determined for the company that has the best ratio of costs per unit of electricity distributed



## Data envelopment analysis (DEA)

**DEA is a non parametric method based on linear programming technique**

**Maximization of operational efficiency of company**

- ✓ **Technical efficiency reflects the ability of a company to achieve maximum production output from a given combination of inputs (labor, capital) and**
- ✓ **Allocative efficiency reflects the ability of company to use inputs (labor, capital) in optimal proportions taking into account their relative prices.**

## Data envelopment analysis (DEA)

This method provides the possibility of using a large number of input / output data

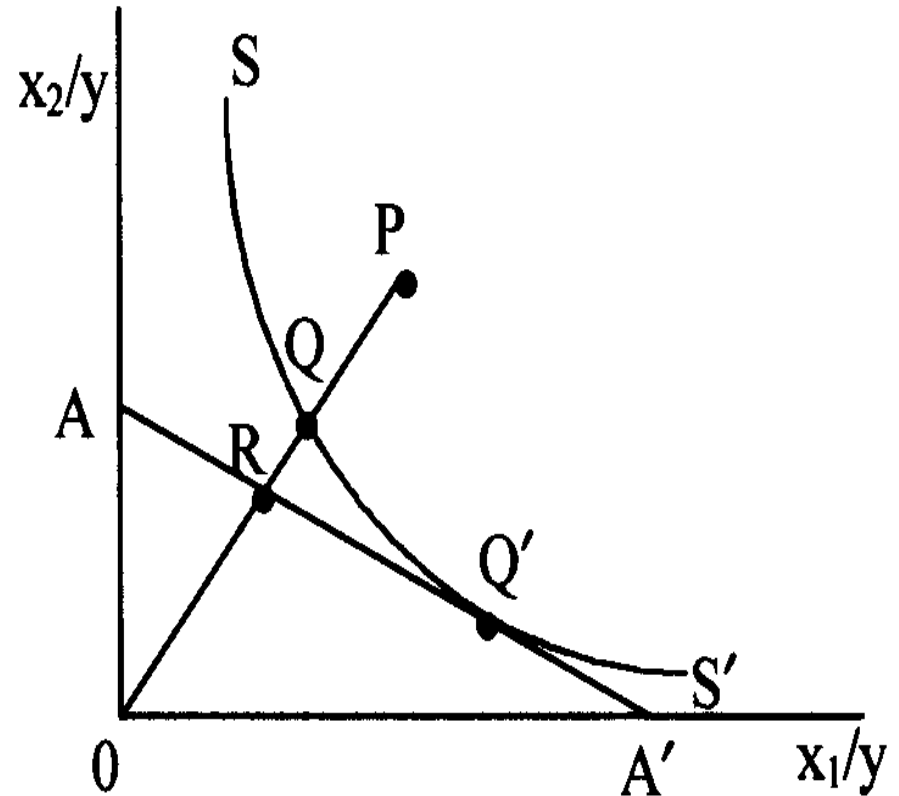
**Input orientated model** uses two inputs to produce a single output

**Output orientated model** uses two outputs and one input

$$TE_i = OQ/OP$$

$$AE_i = OR/OQ$$

$$OE_i = TE_i * AE_i = OR/OP$$



# Application of benchmarking

**When applying benchmarking, it is necessary to take into account:**

**Size and structure of the observed sample**

**The sample should be as large as possible**

**It is desirable that the sample consists of companies that operate in the same region, which are approximately the same size, operate in a similar legal and economic environment**

**Which type of data is used for comparison**

**Operating costs and technical data**

**Quality of data**

**Published data from official financial reports**

**Choice of methods**

**To apply at least two different approaches**

## Example – methods

### Three benchmarking methods have been applied:

- ✓ **Partial indicators** - combined indicator was calculated by applying the weighted average (weights of 50%) to uni-dimensional indicators: distributed energy / operating costs and the number of users / operating costs.
- ✓ **COLS** - value of operating costs was used as the dependent variable, and the weighted average data on the distributed energy and number of users as the independent variable, with selected weighted factors of 50%.
- ✓ **DEA** - operating costs were used as input data, and data on the distributed energy and number of users were used as output data.



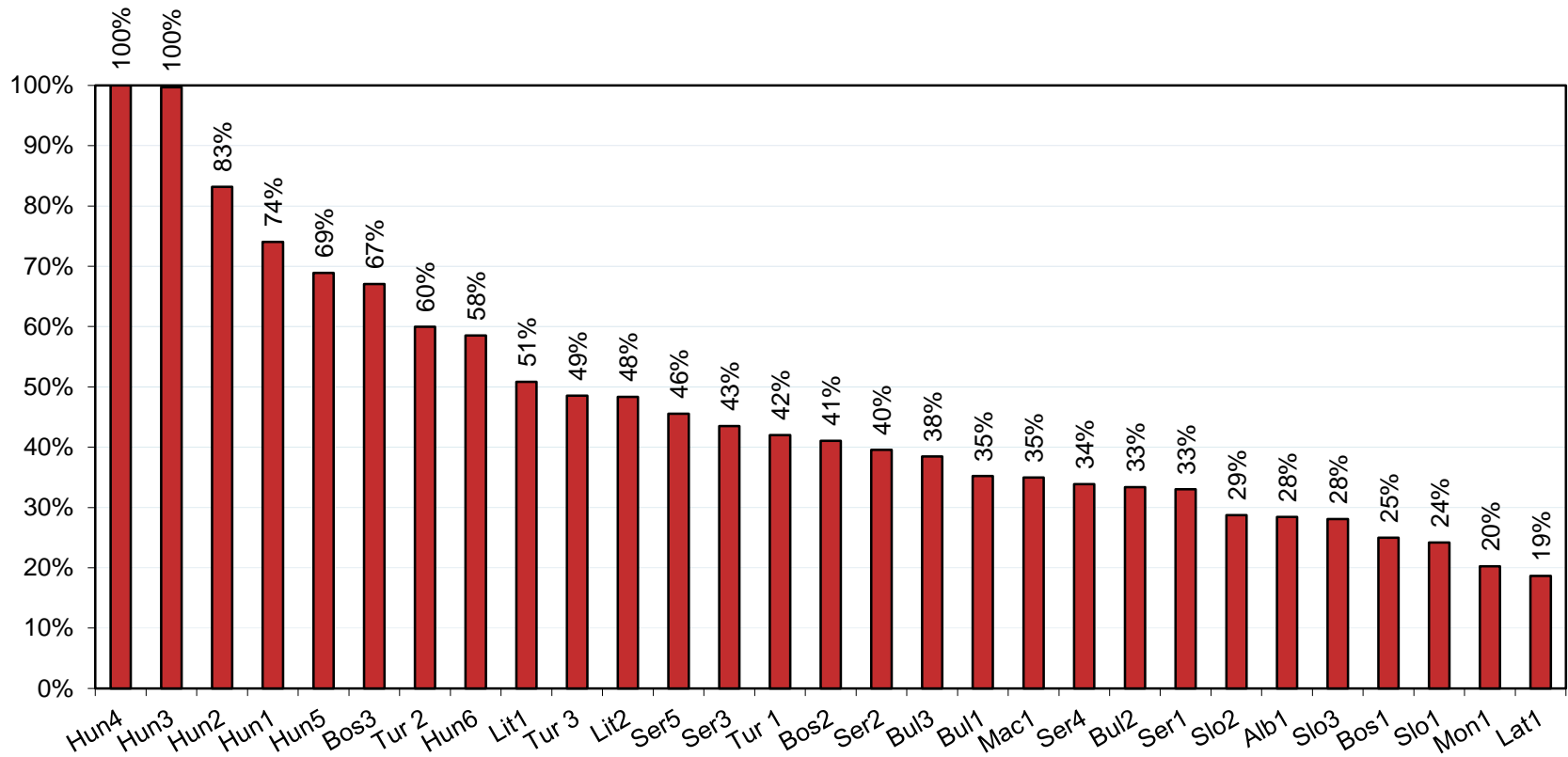
# Example - Data

| DATA VALIDATION - ADJUSTED DATA (Data for 2009) |             |               |                     |                        |                      |                            |                                     |                                     |           |                      |                     |
|---|-------------|---------------|---------------------|------------------------|----------------------|----------------------------|-------------------------------------|-------------------------------------|-----------|----------------------|---------------------|
| Ordinal number                                  | Country     | Country Codes | Ownership Status x) | Method of Regulationy) | Served Area (sq. km) | Total length of Lines (km) | Total Electricity Distributed (MWh) | Total number of consumers connected | Employees | O&M Costs (000 US\$) | O&M Costs (000 PPS) |
| 1   | Albania     | Alb1          | 1                   | 0                      | 28.000               | 42.768                     | 6.223.000                           | 990.831                             | 6.700     | 179.132              | 219.244             |
| 2   | Serbia 1    | Ser1          | 1                   | 0                      | 25.211               | 58.737                     | 6.255.954                           | 885.438                             | 2.653     | 127.063              | 189.866             |
| 3   | Serbia 2    | Ser2          | 1                   | 0                      | 21.500               | 25.261                     | 7.583.166                           | 911.633                             | 2.191     | 128.507              | 192.023             |
| 4   | Serbia 3    | Ser3          | 1                   | 0                      | 2.838                | 16.138                     | 6.747.211                           | 797.658                             | 1.522     | 103.950              | 155.329             |
| 5   | Serbia 4    | Ser4          | 1                   | 0                      | 22.029               | 33.059                     | 3.989.499                           | 595.376                             | 1.680     | 78.918               | 117.924             |
| 6   | Serbia 5    | Ser5          | 1                   | 0                      | 6.120                | 14.647                     | 2.582.647                           | 278.288                             | 686       | 37.994               | 56.772              |
| 5   | Lithuania 1 | Lit1          | 0&1                 | 1                      | 30.378               | 57.326                     | 3.766.010                           | 721.504                             | 1.353     | 74.284               | 74.200              |
| 6   | Lithuania 2 | Lit2          | 0                   | 1                      | 34.700               | 63.510                     | 3.998.162                           | 792.518                             | 1.772     | 82.945               | 82.851              |
| 7   | Latvia      | Lat1          | 1                   | 0                      | 63.943               | 103.850                    | 6.142.599                           | 1.096.585                           | 2.656     | 351.869              | 329.777             |
| 8   | Macedonia   | Mac1          | 0                   | 1                      | 25.000               | 23.226                     | 5.282.084                           | 664.390                             | 3.059     | 101.637              | 151.291             |
| 9   | Bulgaria 1  | Bul1          | 0&1                 | 1                      | 40.000               | 54.758                     | 8.789.369                           | 2.040.635                           | 2.693     | 211.829              | 250.098             |
| 10  | Bulgaria 2  | Bul2          | 0&1                 | 1                      | 29.617               | 41.804                     | 5.281.446                           | 1.200.700                           | 1.496     | 134.259              | 158.514             |
| 11  | Bulgaria 3  | Bul3          | 0&1                 | 1                      | 42.745               | 55.375                     | 7.886.138                           | 1.616.220                           | 2.975     | 173.461              | 205.279             |
| 12  | Hungary 1   | Hun1          | 0                   | 1                      | 18.235               | 31.749                     | 3.971.291                           | 992.202                             | 128       | 61.813               | 53.696              |
| 13  | Hungary 2   | Hun2          | 0                   | 1                      | 4.134                | 23.124                     | 9.597.655                           | 1.757.733                           | 226       | 133.048              | 115.578             |
| 14  | Hungary 3   | Hun3          | 0                   | 1                      | 15.509               | 22.237                     | 4.982.282                           | 1.018.282                           | 125       | 57.602               | 50.039              |
| 15  | Hungary 4   | Hun4          | 0                   | 1                      | 18.472               | 25.376                     | 3.976.189                           | 1.016.685                           | 453       | 45.837               | 39.818              |
| 16  | Hungary 5   | Hun5          | 0                   | 1                      | 18.223               | 30.741                     | 6.661.164                           | 1.344.486                           | 506       | 111.420              | 96.789              |
| 17  | Hungary 6   | Hun6          | 0                   | 1                      | 18.728               | 25.555                     | 3.957.522                           | 1.072.244                           | 390       | 77.991               | 67.750              |
| 18  | Slovakia 1  | Slo1          | 0&1                 | 1                      | 15.746               | 20.611                     | 3.755.307                           | 609.554                             | 88        | 230.521              | 155.436             |
| 19  | Slovakia 2  | Slo2          | 0                   | 1                      | 14.928               | 35.986                     | 8.022.142                           | 1.055.934                           | 83        | 414.388              | 279.414             |
| 20  | Slovakia 3  | Slo3          | 0                   | 1                      | 17.978               | 32.701                     | 5.458.205                           | 711.749                             | 176       | 288.669              | 194.644             |
| 21  | Turkey 1    | Tur 1         | 0                   | 1                      | 77.393               | 62.114                     | 6.094.727                           | 1.582.666                           | 2.601     | 162.978              | 145.317             |
| 22  | Turkey 2    | Tur 2         | 0                   | 1                      | 60.382               | 95.271                     | 11.547.028                          | 3.190.095                           | 4.195     | 216.304              | 192.864             |
| 23  | Turkey 3    | Tur 3         | 0                   | 1                      | 39.782               | 75.437                     | 4.437.161                           | 1.521.183                           | 2.129     | 102.698              | 91.570              |
| 24  | Bosnia 1    | Bos1          | 0&1                 | 0                      | 3.697                | 10.553                     | 562.152                             | 102.107                             | 557       | 20.596               | 22.541              |
| 25  | Bosnia 2    | Bos2          | 0&1                 | 0                      | 16.754               | 33.435                     | 3.822.559                           | 695.833                             | 2.414     | 85.166               | 93.211              |
| 26  | Bosnia 3    | Bos3          | 0&1                 | 0                      | 9.356                | 11.618                     | 1.852.489                           | 185.196                             | 1.130     | 25.284               | 27.673              |
| 27  | Montenegro  | Mon1          | 1                   | 0                      | 13.812               | 18.964                     | 1.924.600                           | 351.719                             | 1.559     | 85.616               | 95.139              |

Notes: x) 0 - Private, 1 - State owned; y) 0 - Cost based, 1 - Incentive  
 Weighted factor: 50% MWh/Opex(000 PPS) and 50% Customers/Opex(000 PPS)

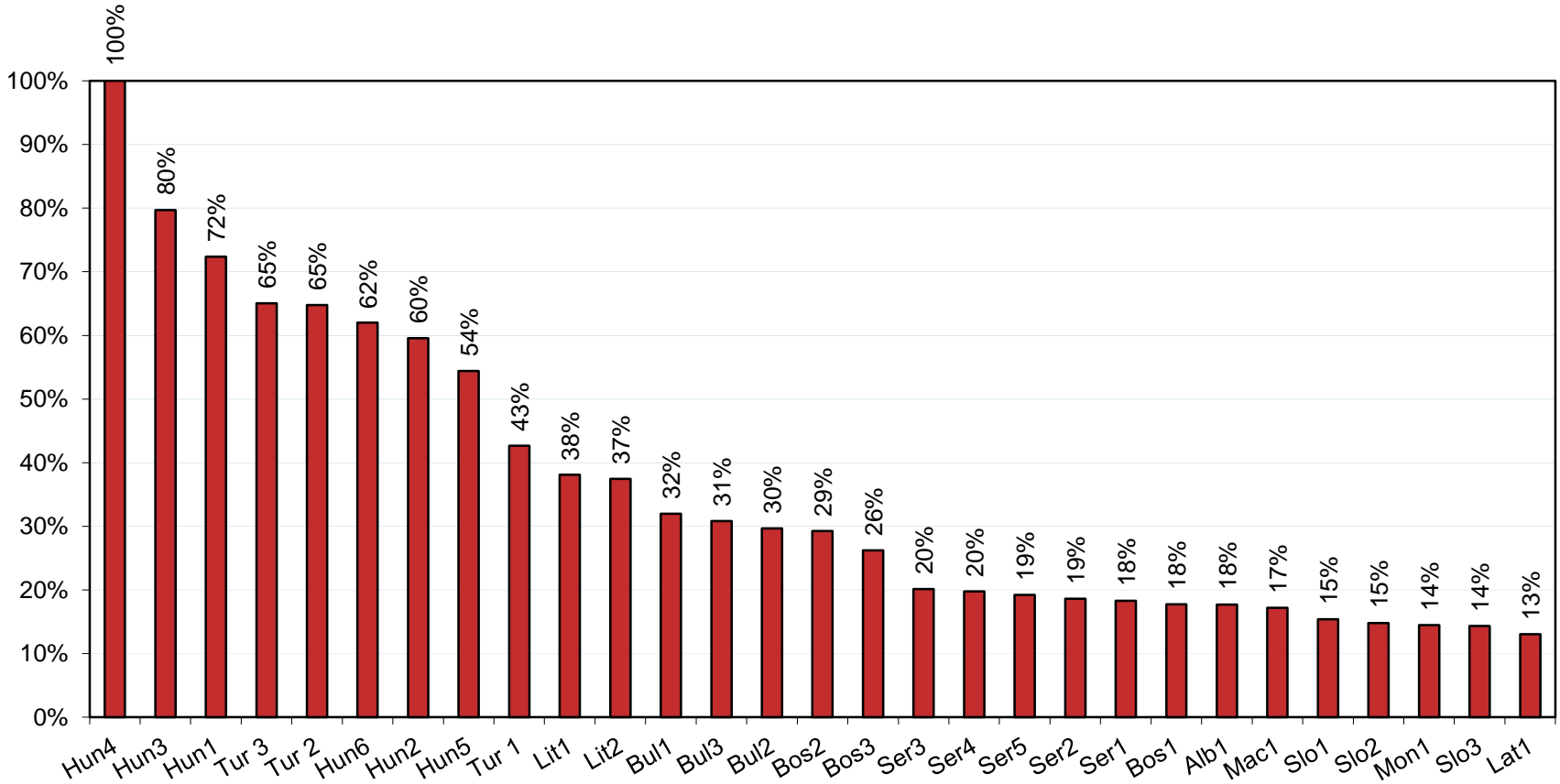
# Example – Unidimensional indicators 1

MWh/OPEX(000 PPS)



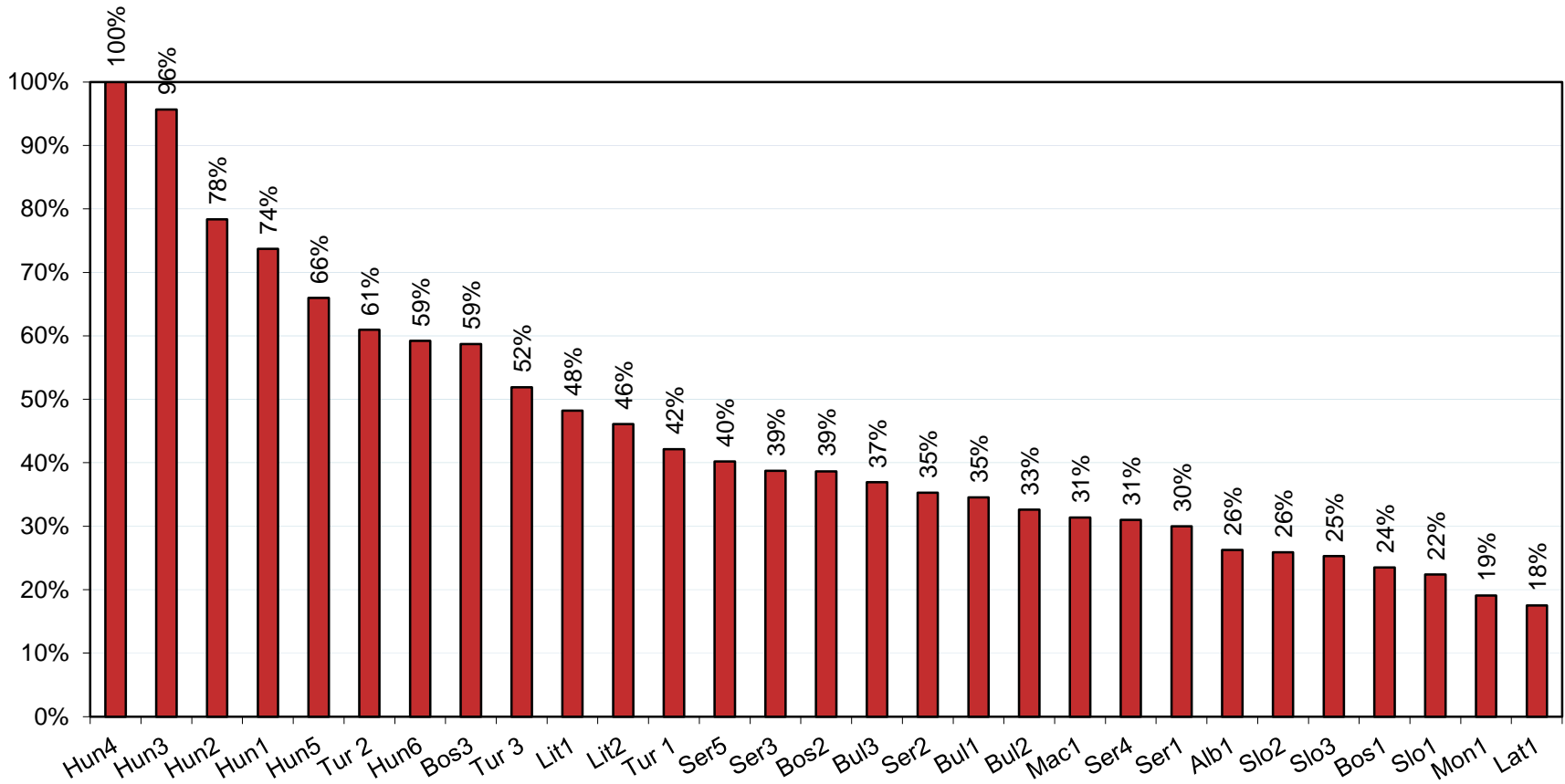
# Example – Unidimensional indicators 2

Customers/OPEX (000 PPS)



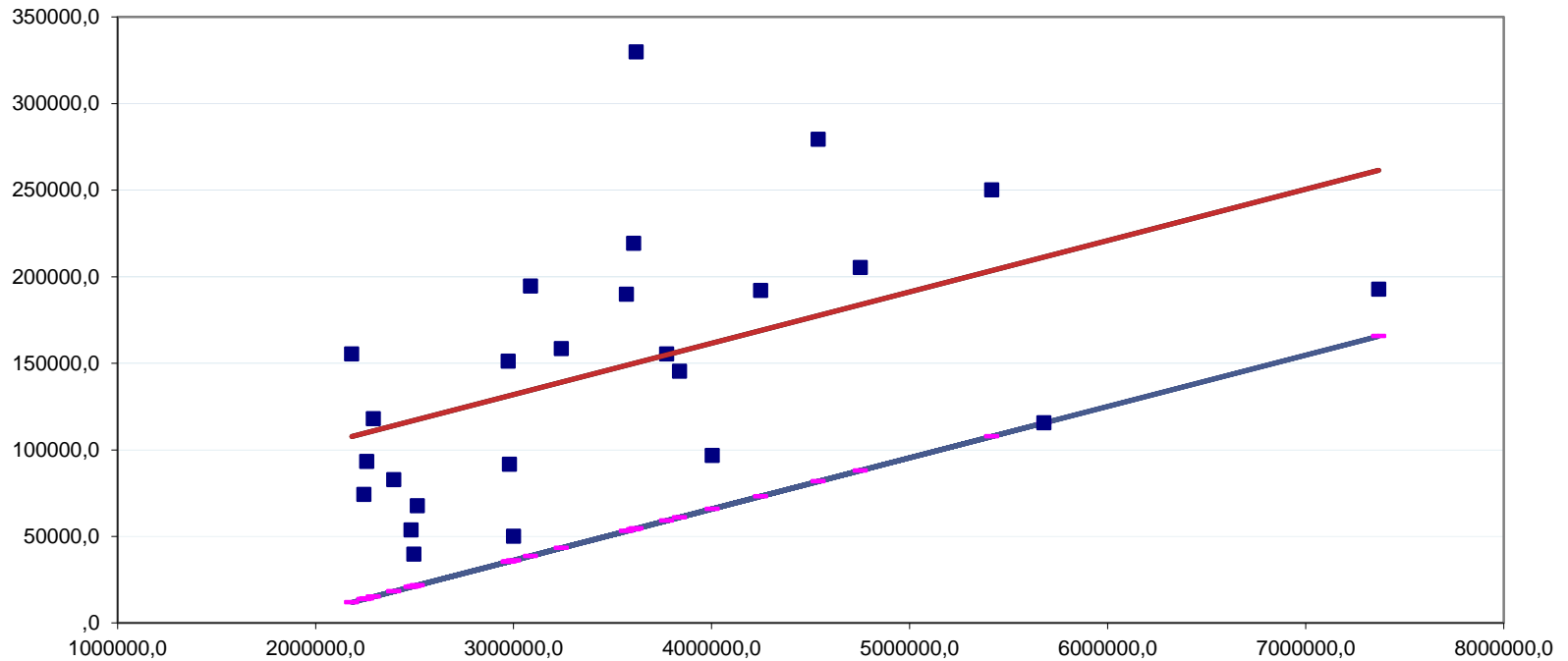
# Example – Unidimensional indicators 3

Total Weighted Rank

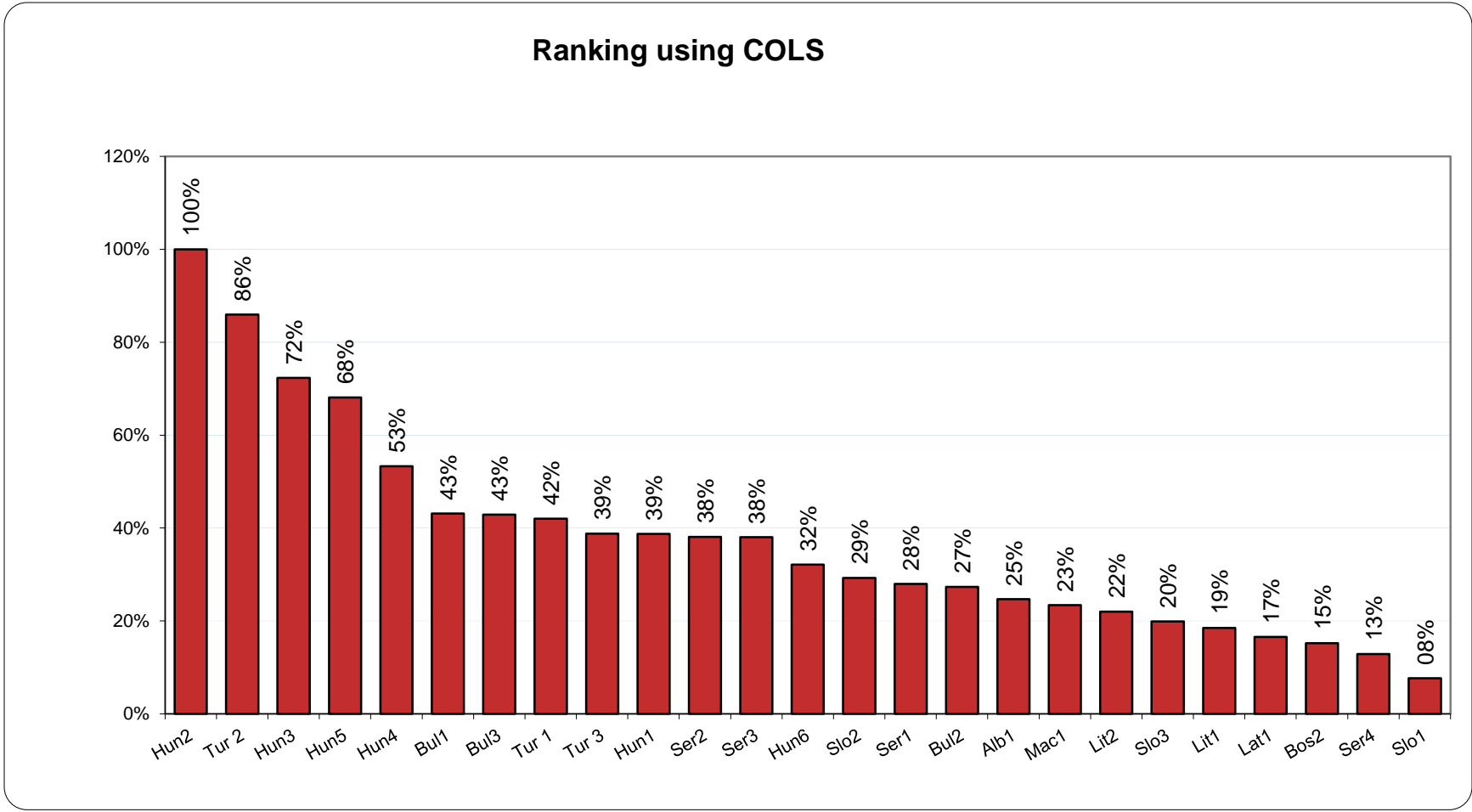


# Example – OLS & COLS regression lines

OLS & COLS

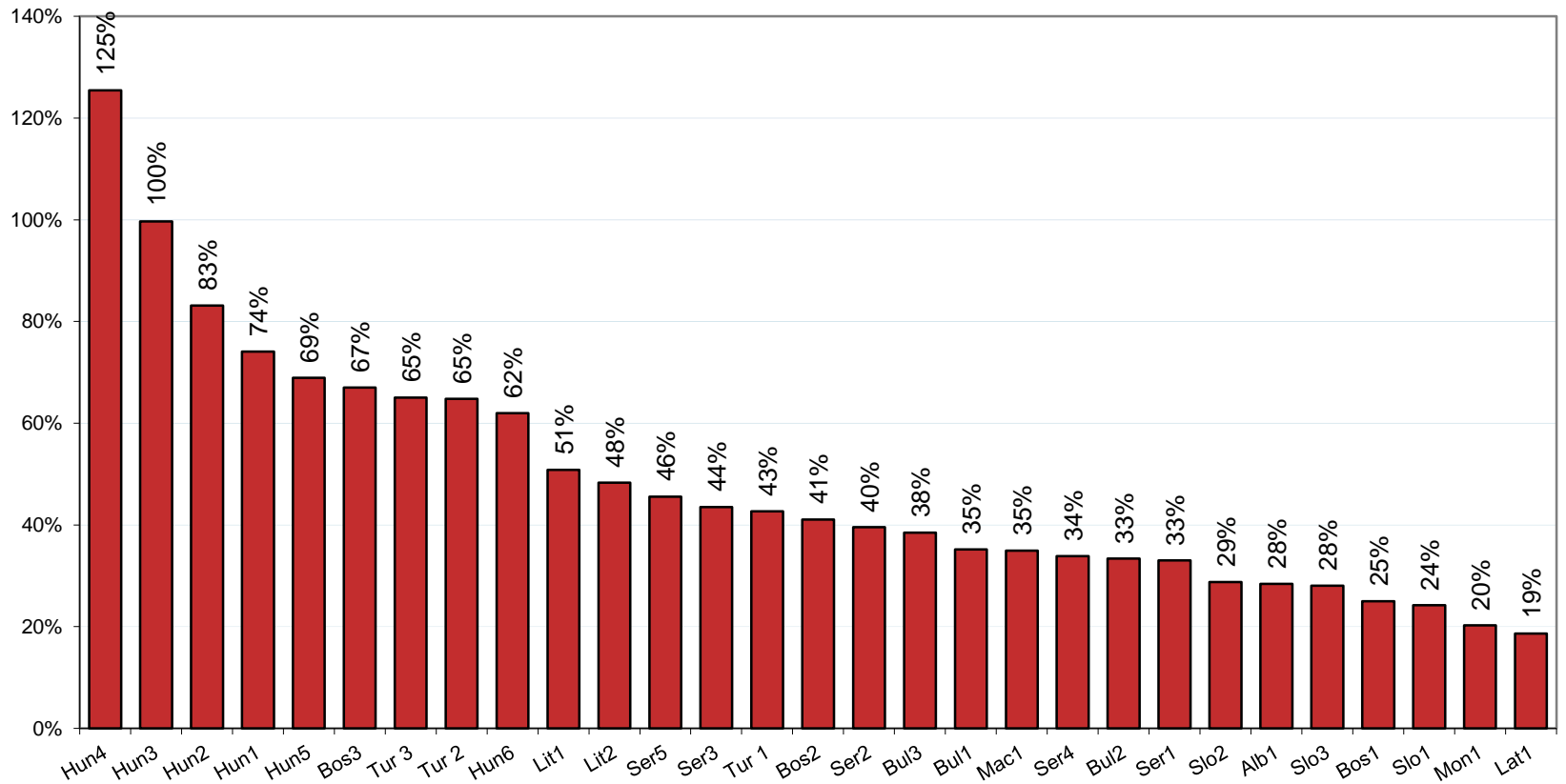


# Example – Ranking using COLS



# Example – Ranking using DEA

## Ranking using DEA



## Example – Ranking using all methods

| Uni-dimensional <sub>x)</sub> |         | COLS  |         | DEA   |         |
|-------------------------------|---------|-------|---------|-------|---------|
| Rank                          | Score   | Rank  | Score   | Rank  | Score   |
| Hun4                          | 100,00% | Hun2  | 100,00% | Hun4  | 125,47% |
| Hun3                          | 95,63%  | Tur 2 | 85,93%  | Hun3  | 99,71%  |
| Hun2                          | 78,35%  | Hun3  | 72,29%  | Hun2  | 83,16%  |
| Hun1                          | 73,72%  | Hun5  | 68,09%  | Hun1  | 74,06%  |
| Hun5                          | 65,96%  | Hun4  | 53,32%  | Hun5  | 68,92%  |
| Tur 2                         | 60,94%  | Bul1  | 43,10%  | Bos3  | 67,04%  |
| Hun6                          | 59,21%  | Bul3  | 42,92%  | Tur 3 | 65,06%  |
| Bos3                          | 58,72%  | Tur 1 | 42,00%  | Tur 2 | 64,78%  |
| Tur 3                         | 51,89%  | Tur 3 | 38,82%  | Hun6  | 61,98%  |
| Lit1                          | 48,23%  | Hun1  | 38,73%  | Lit1  | 50,83%  |
| Lit2                          | 46,11%  | Ser2  | 38,10%  | Lit2  | 48,33%  |
| Tur 1                         | 42,13%  | Ser3  | 38,03%  | Ser5  | 45,56%  |
| Ser5                          | 40,19%  | Hun6  | 32,15%  | Ser3  | 43,50%  |
| Ser3                          | 38,74%  | Slo2  | 29,28%  | Tur 1 | 42,65%  |
| Bos2                          | 38,66%  | Ser1  | 27,96%  | Bos2  | 41,07%  |
| Bul3                          | 36,92%  | Bul2  | 27,33%  | Ser2  | 39,55%  |
| Ser2                          | 35,28%  | Alb1  | 24,71%  | Bul3  | 38,47%  |
| Bul1                          | 34,53%  | Mac1  | 23,38%  | Bul1  | 35,19%  |
| Bul2                          | 32,61%  | Lit2  | 22,01%  | Mac1  | 34,96%  |
| Mac1                          | 31,35%  | Slo3  | 19,88%  | Ser4  | 33,88%  |
| Ser4                          | 31,01%  | Lit1  | 18,52%  | Bul2  | 33,37%  |
| Ser1                          | 30,00%  | Lat1  | 16,54%  | Ser1  | 33,00%  |
| Alb1                          | 26,24%  | Bos2  | 15,23%  | Slo2  | 28,75%  |
| Slo2                          | 25,91%  | Ser4  | 12,87%  | Alb1  | 28,42%  |
| Slo3                          | 25,28%  | Slo1  | 7,67%   | Slo3  | 28,08%  |
| Bos1                          | 23,50%  |       |         | Bos1  | 24,97%  |
| Slo1                          | 22,39%  |       |         | Slo1  | 24,19%  |
| Mon1                          | 19,08%  |       |         | Mon1  | 20,26%  |
| Lat1                          | 17,51%  |       |         | Lat1  | 18,65%  |

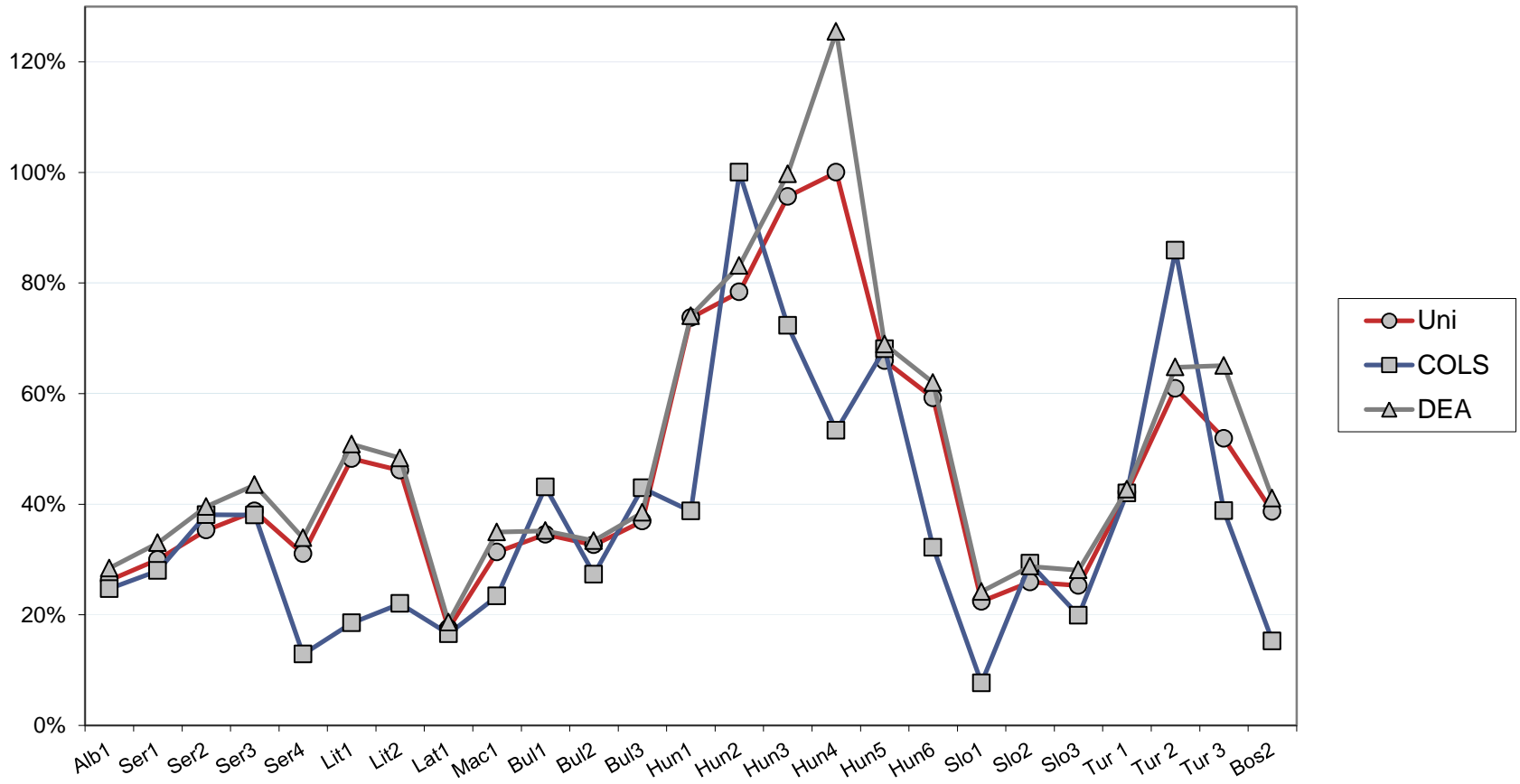
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Note: x) Weighted factor: 50% MWh/Opex and 50% Customers/Opex



# Example – Ranking using all methods

## Ranking using all methods



## Conclusions

- ✓ **The results obtained from distribution companies' efficiency benchmarking can be of great importance for both the Regulator and the distribution companies.**
- ✓ **Basis for assignation of individual incentive X - factors to the distribution companies in ERRA member countries**
- ✓ **Indicators to point out companies' performance inefficiencies.**
- ✓ **Implementation of incentive regulation methods enhance the operational efficiency of companies, resulting in lower prices for distribution service users, as well as in more opportunities for the companies to earn profit by efficiency improvements.**
- ✓ **All 3 methods used - results have shown a relatively high degree of correlation.**

# International Experience/Summary

- **Benchmarking is a mainly empirical issue**
- **There are no right answers to efficiency analysis - Efficiency is relative, so there is a 'sample problem'**
- **Methodologies are not easy to rank in terms of relevance/appropriateness**
- **Regulators tend to learn from each other's experience**

# Conclusions

- **Benchmarking is a fundamental instrument for efficiency assessment and for the establishment of productivity improvement targets – however, it must start from rigorous premises**
- **Regulators use total (macro) frontier methods to benchmark efficiency of network companies, mainly in efficiency terms as opposed to price levels**
- **From a company's perspective, efficiency assessment may require a higher degree of separation of business activities/processes**
- **Regulators in EU economies actively use or consider the use of benchmarking for regulatory purposes. In Central-Eastern Europe, are close to.**

# Benchmarking & Quality

- **Isolated efficiency measurements based on economic quantities usually do not include quality**
  - COLS, SFA, DEA, etc.
- **How to benchmark efficiency and quality simultaneously? Problematic**
- **Technical model specification (e.g. Tech DEA)**
  - Minutes not-lost as output
  - Minutes-lost as input
- **Costs model specification (e.g. Cost DEA)**
  - Outage costs as input