Different regulation schemes and welfare implications: an application to the electricity distribution industry

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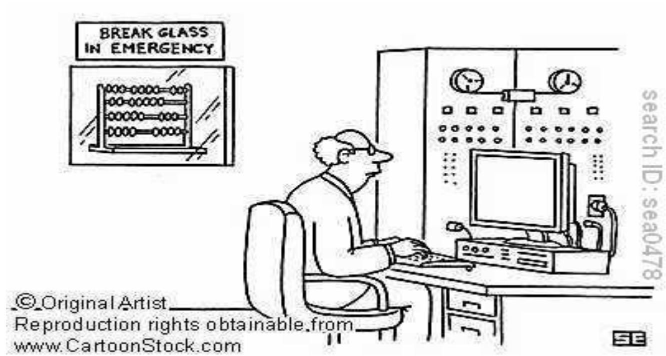
Outline

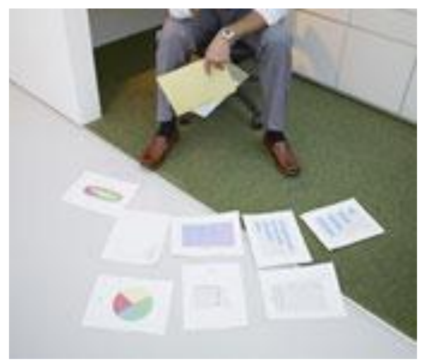
- Motivation
- Efficiency measurement
- Regulation models
- Welfare effects
- Future challenges



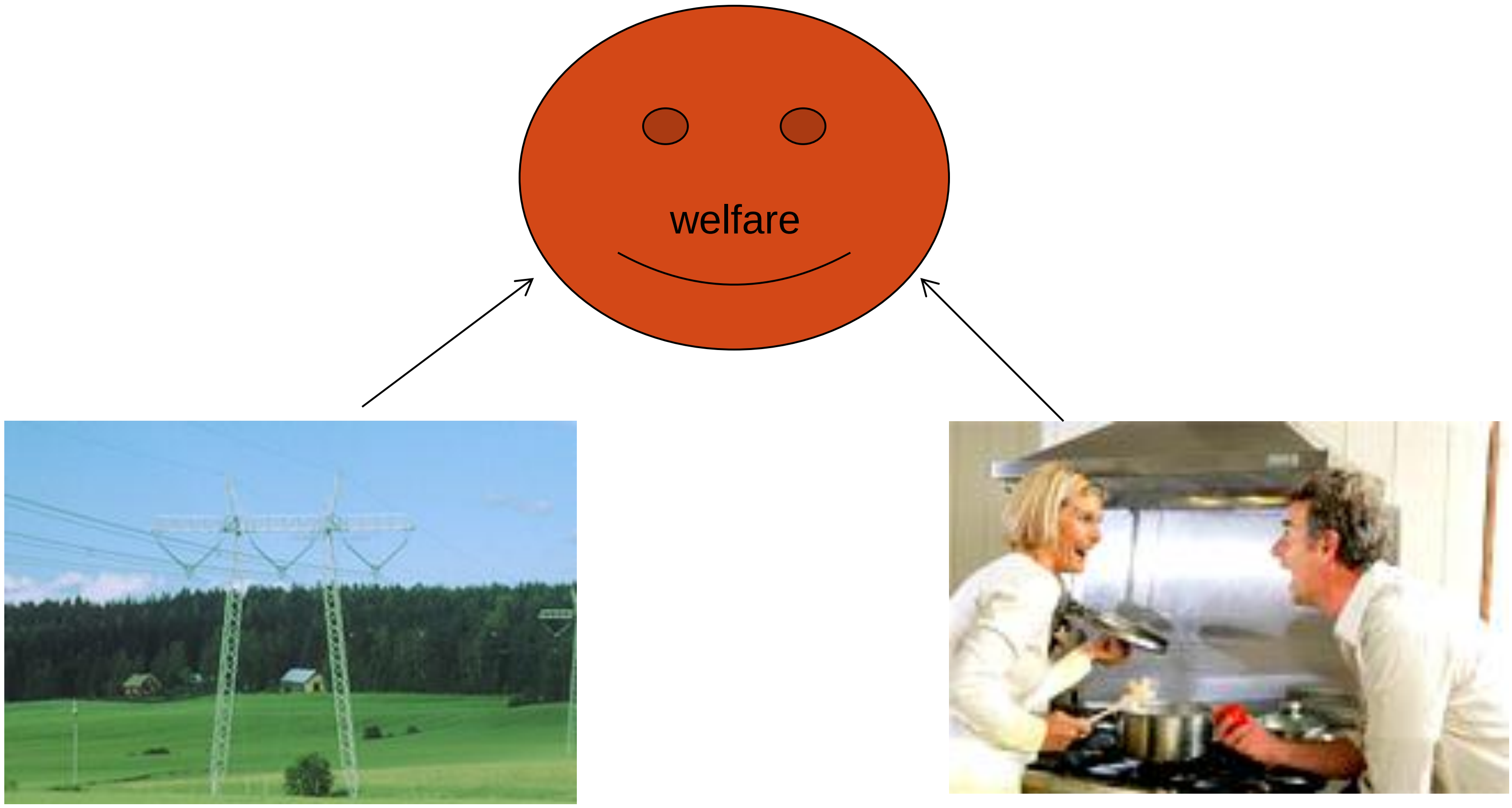
Understanding regulation theories

regulation

Understanding efficiency measuring



Regulated price


welfare

Motivation

- Most regulation schemes need some information of the unit specific efficiency
- SFA, DEA and StoNED are examples of the methods used in measuring cost efficiency
- This paper gives an example how to utilise this firm specific cost information (obtained by SFA) in order to evaluate the effects of different regulation schemes for the consumer and producer surplus.

Literature

- Armstrong, Cowan and Vickers (1994), Armstrong and Sappington (2004)(2007), Joskow (2006), Jamasb and Pollitt (2001),) Laffont and Tirole (1986),(1993), Laffont (1994), Rogerson (2003), Kopsakangas-Savolainen and Svento (2010).
- Farsi, Filippini and Greene (2006) (2005), Greene (2005a, 2005b), Kopsakangas-Savolainen and Svento (2008)(2011)(2012)), Kumbhakar and Lovell (2000), Kuosmanen and Kortelainen (2011), Pitt and Lee (1981), Schmidt and Sickles (1984).

Efficiency measuring: the SFA models

RE Model

$$\ln c_{it} = \alpha + \beta_y \ln y_{it} + \beta_{LF} \ln LF_{it} + \beta_{CU} \ln CU_{it} + \beta_l \ln p_{Lit} + \beta_k \ln p_{Kit} + \beta_t T + v_{it} + u_i$$

REH Model

$$\ln c_{it} = \alpha + \beta_y \ln y_{it} + \beta_{CU} \ln CU_{it} + \beta_l \ln p_{Lit} + \beta_k \ln p_{Kit} + \beta_t T + v_{it} + u_i$$

$$v_{it} = N(0, \sigma_v^2), \quad u_i = N^+\left(\mu_i, \sigma_u^2\right),$$

$$\mu_i = \delta_0 + \delta_1 \ln LF_i,$$

TRE Model

$$\ln c_{it} = (\alpha + w_i) + \beta_y \ln y_{it} + \beta_{LF} \ln LF_{it} + \beta_{CU} \ln CU_{it} + \beta_l \ln p_{Lit} + \beta_k \ln p_{Kit} + \beta_t T + v_{it} + u_{it}$$

TFE Model

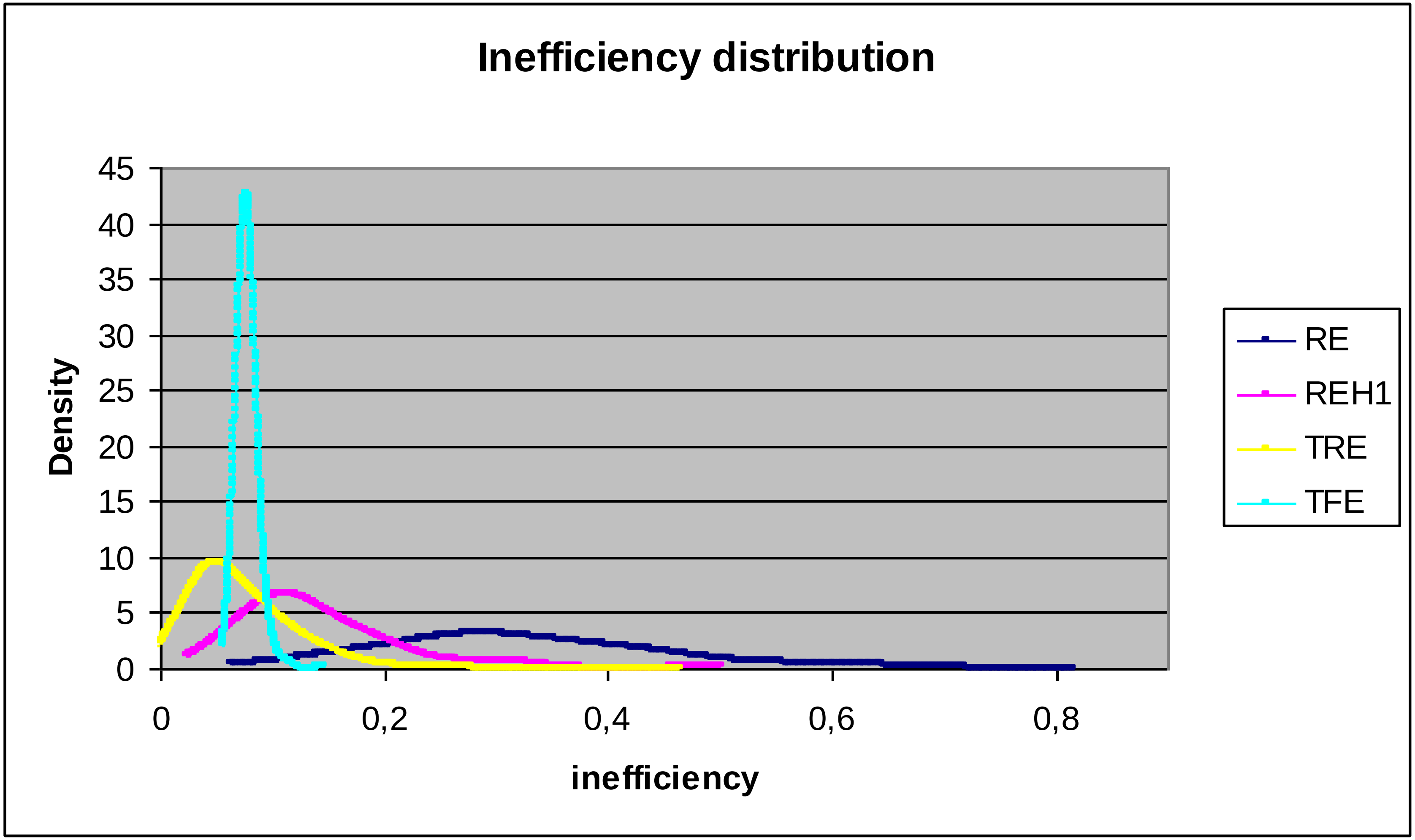
$$\ln c_{it} = \alpha_i + \beta_y \ln y_{it} + \beta_{LF} \ln LF_{it} + \beta_{CU} \ln CU_{it} + \beta_l \ln p_{Lit} + \beta_k \ln p_{Kit} + \beta_t T + v_{it} + u_{it}$$

Table 1 Descriptive statistics

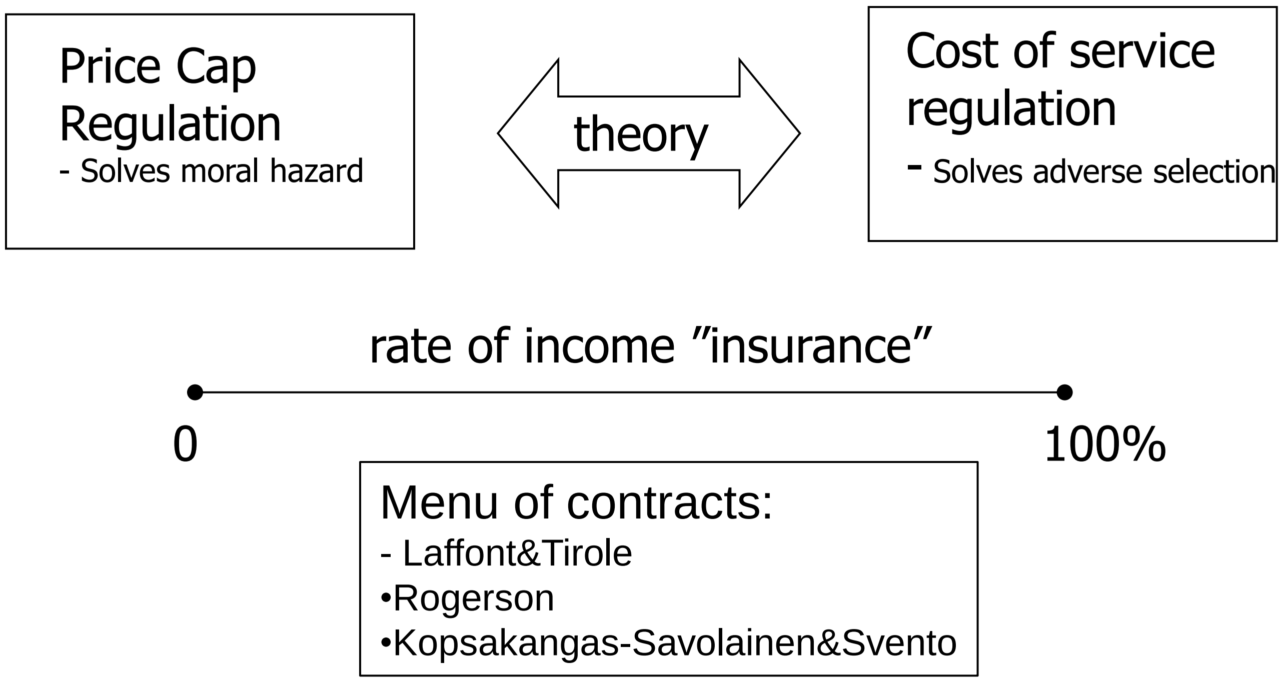
	Mean	Standard Deviation	Minimum	Maximum
Total annual costs (C) per kWh output (cents)	1.74	.40	.77	2.97
Annual output (Y) in GWh	433.47	727.87	11.83	5825.90
Service Area (AS) in network km	2761.05	4075.66	127.00	23478.00
Number of customers (CU)	27494	42784	1109	324197
Annual labour price (P_L) per employee (1000€)	28.39	7.75	8.14	53.00
Capital price (P_K) (1000€)	.103	.058	.020	.353
Price of input power (P_P) per kWh	.36	.14	.09	1.06

Table 3 Statistics of inefficiency scores

	RE	REH	TRE	TFE
Minimum	.972-01	.419-01	.117-01	.575-01
Maximum	.782	.481	.450	.142
Mean	.327	.141	.737-01	.775-01
Std.Dev. of $E[u_i \mid \varepsilon_i]$	.130	.738-01	.470-01	.948-02
σ(v)	.068	.067	.032	.165
σ(u)	.353	.150	.096	.101


Inefficiency distribution
Density
45
40
35
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
inefficiency
RE
REH1
TRE
TFE

Regulation models



The rule for regulated price

- Consider a regulatory process in which the firm's allowed price *P* is determined based on a component of efficient costs of the highest type, C*, and on a component that is based on the firm's realized costs *C*. Then the allowed price is determined according to following equation:

$$P_{i,t} = aC^{*}_{t-1} + (1-a)C_{i,t-1}$$

where *a* is the sharing parameter that defines the responsiveness of the firm's allowed price to the realized costs, t refers to time and i to the firm in question.

Profit maximizing strategies

$$P_{i,t} = aC^{*}_{t-1} + (1-a)C_{i,t-1}$$

- Price cap regulation:
  - In the case of price cap regulation $a = 1$,

  →profit maximizing strategy for each firm is to produce at efficient costs.
- Cost of service regulation:
  - In the case of cost of service regulation $a = 0$,

  →firms produce at zero profits.

- Simple menu of contract:
  - The firm can choose between either price cap or cost of service regulation.
  - The regulator chooses the so called ”cut-off type” such that the cost of the regulator is minimized if it should cover the procurement costs.
  - The “cut-off type” is the highest type willing to accept the price cap contract.
  - Now each firm more or as efficient as the cut-off type firm maximizes it profits by choosing price cap contract (parameter *a* equal to 1) and the best strategy for rest of the firms is to choose cost of service regulation (parameter *a* equal to zero).

- Menu of contracts (our model): $0 < a < 1$.
- The game behind the contracts of menu in our application is as follows:
  - The regulator announces the regulation rule i.e. the rules according to which the value of parameter *a* is determined and then the firm decides what efficiency level to choose.
  - The value of parameter *a* for each firm *i* is now based on our SFA results scaled followingly

$$a_i = 1 - \frac{eff^{\,i} - eff^{\,\max}}{eff^{\,\min} - eff^{\,\max}}$$

  - for the most efficient firm the value of $a = 1$ and for the most inefficient firm $a = 0$.
  - For firms between the most efficient and most inefficient firms the value of parameter *a* is bigger the more efficient the firms is.

$\longrightarrow$ Profit maximizing strategy for each firm is to produce at efficient costs.

Welfare effects

- We combine the cost information obtained by our SFA estimations to the four theoretical regulation models
- We calculate the changes in welfare compared to the benchmark which is Cost of Service Regulation

Welfare Results

- The change in consumer surplus can be written as the line integral:

$$\Delta CS_i = \int_{P_{Ci}}^{P_{Ni}} D^{-1}(Q_i)dQ_i$$

- The corresponding change in producer's surplus is:

$$\Delta PS_i = \left(P_{Ni}Q_{Ni} - C(Q_{Ni})\right) - \left(P_{Ci}Q_{Ci} - C(Q_{Ci})\right),$$

- Therefore, the change of total surplus is

$$\sum_{i=1}^{76}\left(\Delta CS_i + \Delta PS_i\right) = \sum_{i=1}^{76}\left[\int_{P_C}^{P_N} D^{-1}(Q_i)dQ_i + \left[\left(P_{Ni}Q_{Ni} - C(Q_{Ni})\right) - \left(P_{Ci}Q_{Ci} - C(Q_{Ci})\right)\right]\right],$$

Welfare changes, million€

SFA Model	Price cap ΔTS	ΔPS	ΔCS	Menu of Contracts ΔTS	ΔPS	ΔCS	Simple menu of Contracts ΔTS	ΔPS	ΔCS
RE	**177,8 (33,1%)**	240,9	-63,1	**194,4 (36,2%)**	150,0	44,4	**144,43 (26,9%)**	70,6	73,9
REH	**49,6 (9,2%)**	234,2	-184,5	**61,5 (11,5%)**	184,1	-122,6	**25,9 (4,8%)**	10,4	15,6
TRE	**5,6 (1,1%)**	239,7	-234,1	**25,8 (4,8%)**	163,6	-137,8	**6,4 (1,2%)**	4,5	1,9
TFE	**8,3 (1,5%)**	235,5	-227,2	**14,7 (2,7%)**	207,4	-192,7	**3,6 (0,7%)**	1,4	2,2

Conclusions on regulation schemes and welfare effects

- Changing the regulation scheme from cost of service to whatever other regulation regime presented above results welfare improvement.
- However, there is clear difference how different regulation schemes divide welfare to producers and consumers.
- The only regulation scheme which improves both producer and consumer welfare regardless of the model used in efficiency estimations is the simple menu of contracts. However, the overall welfare improvement is smaller than resulting from the price cap regulation or menu of contracts regulation
- The underlying benchmarking results (which method/model specification to use) have an important role.

Future challenges?

Di uted market

SMART MANAGEMENT?

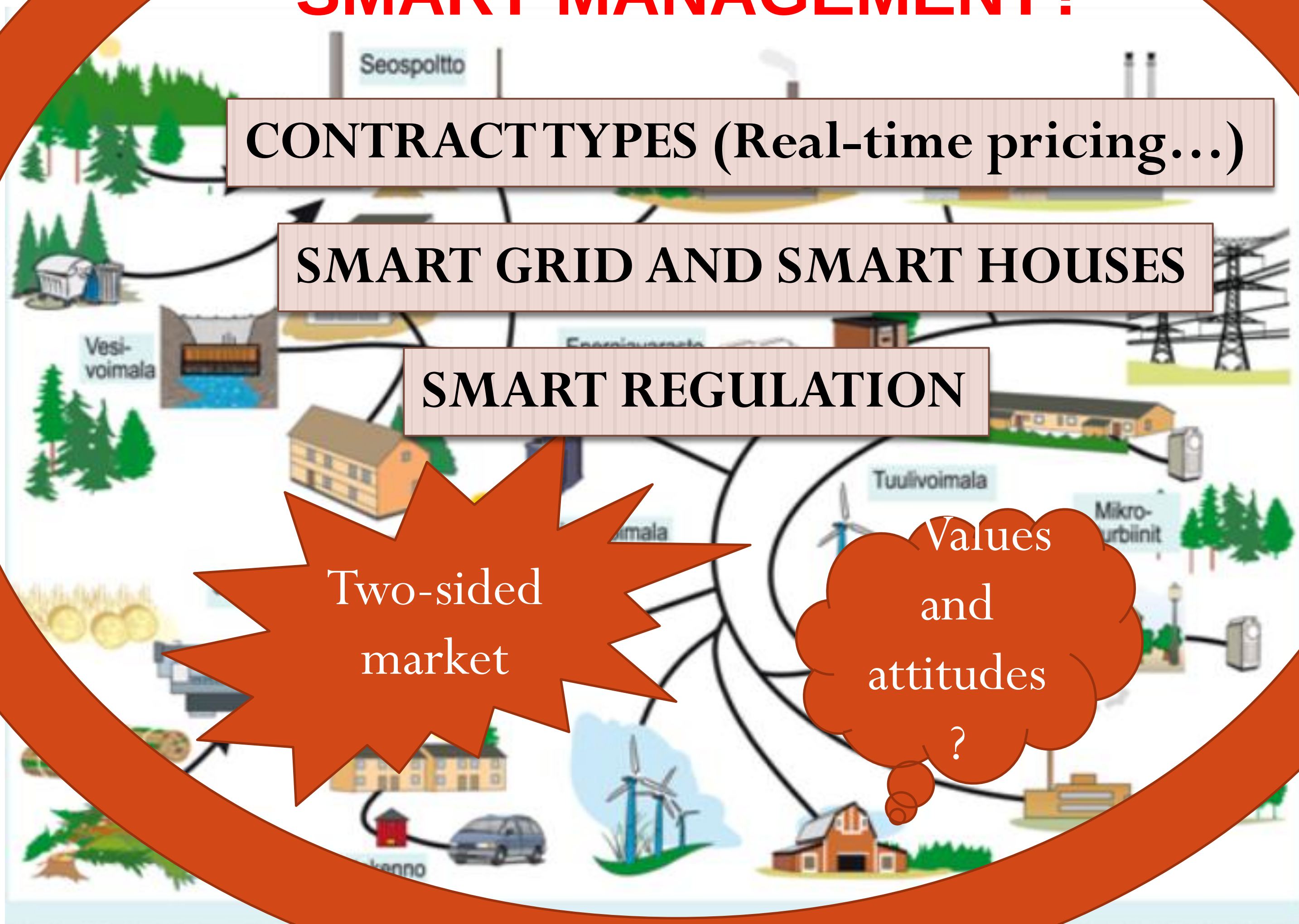
CONTRACT TYPES (Real-time pricing…)

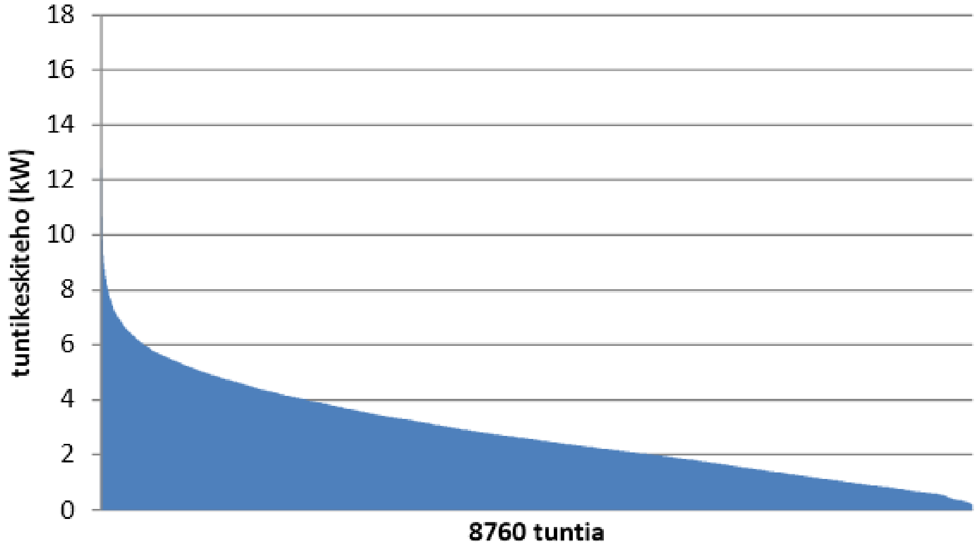
SMART GRID AND SMART HOUSES

SMART REGULATION

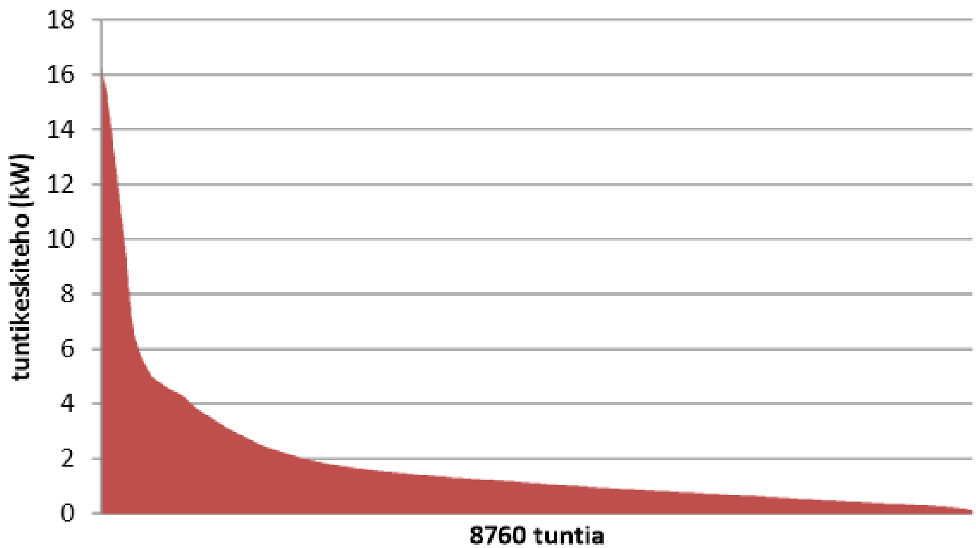
Two-sided market

Values and attitudes ?



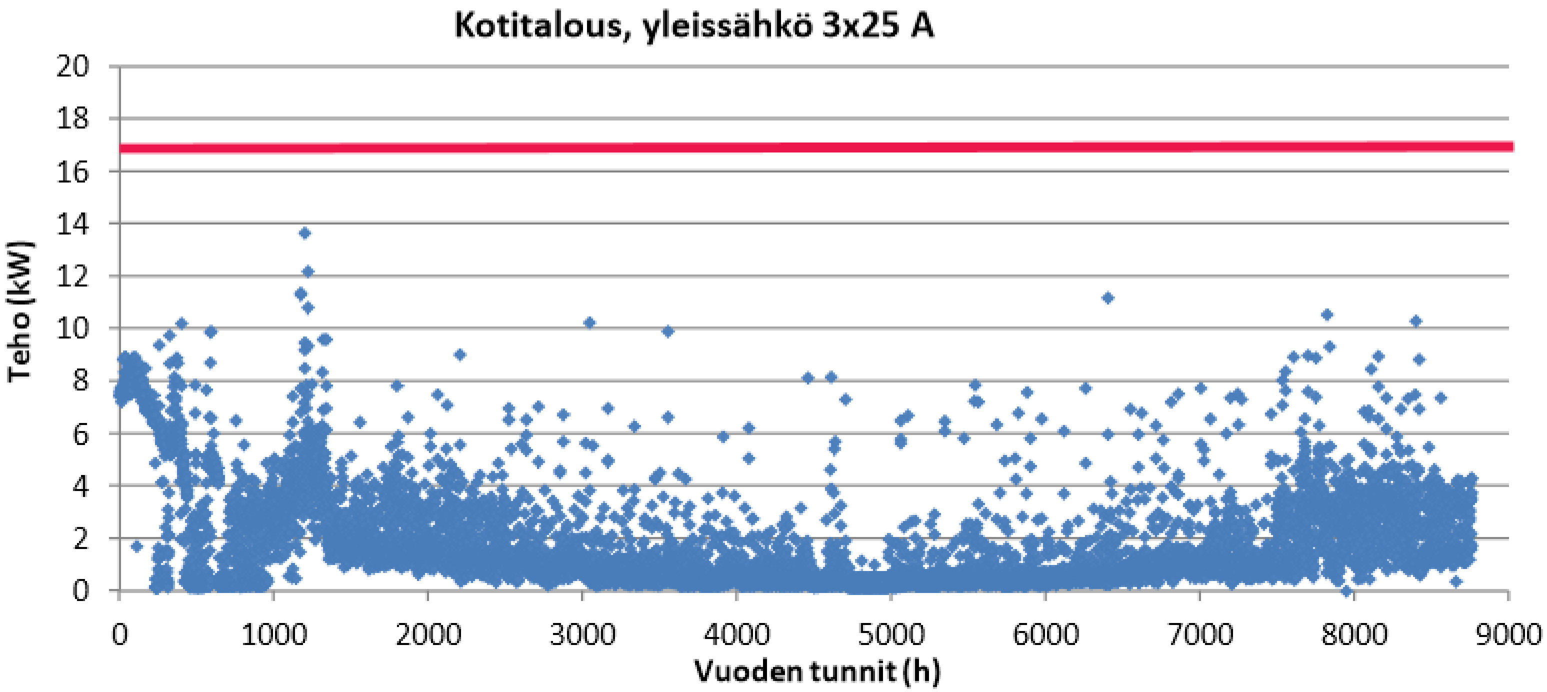


Kuva 3.3 Asiakkaan A sähkönkäytön pysyvyyskäyrä; asiakkaan vuosienergia 24,9 MWh ja huipputeho 12,4 KW.



Kuva 3.4 Asiakkaan B sähkönkäytön pysyvyyskäyrä; asiakkaan vuosienergia 16,1 MWh ja huipputeho 16,7 KW.

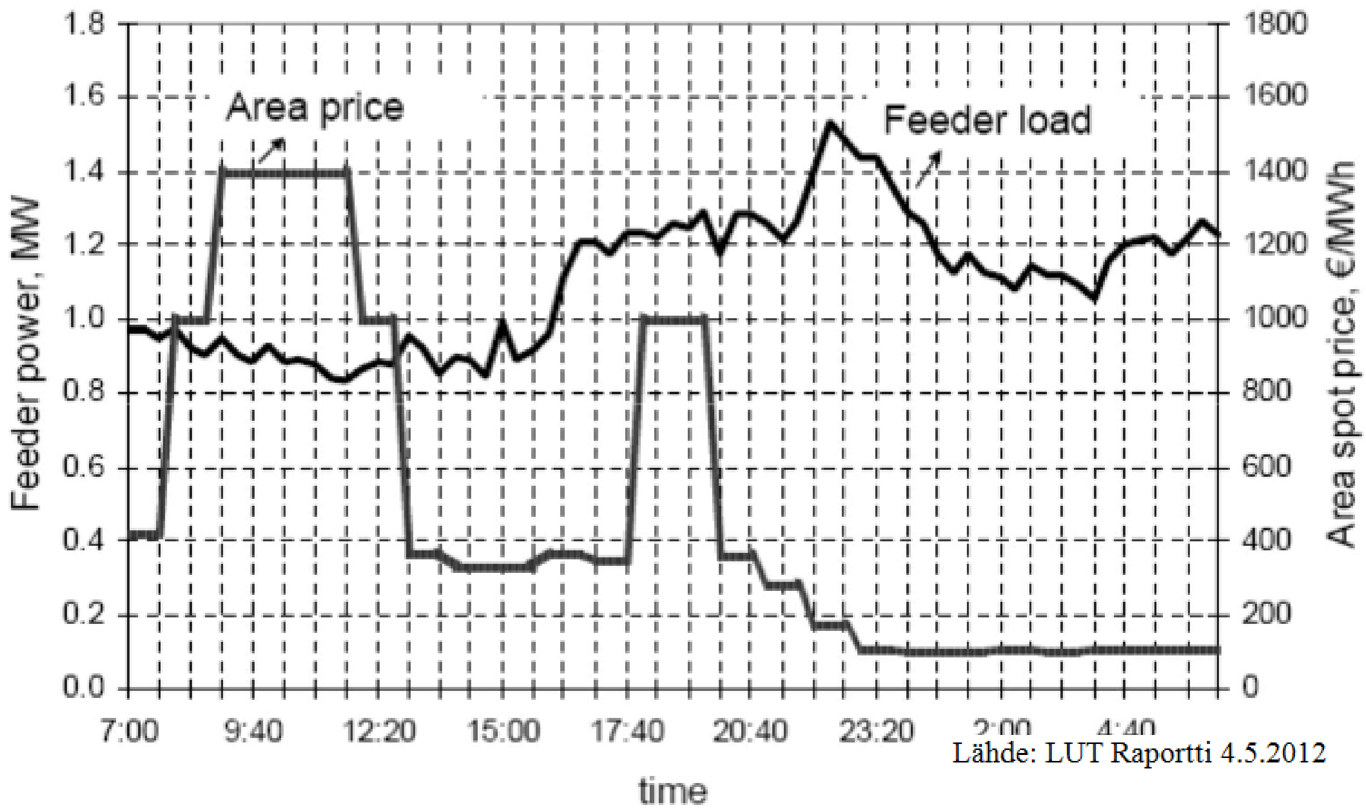
Lähde: LUT Raportti 4.5.2012



Kuva 5.1. Erään kotitalousasiakkaan vuoden 2011 AMR-mitattu tuntidata. Hänen pääsulakkeensa on 3x25 A ja hänellä on yleissähkötariffi. Asiakas on kotitalouskuluttaja ja hänen suurin tuntiteho on ollut n. 14 kW. Asiakas pystyisi vapaasti käyttämään pääsulakkeiden rajoittaman 17 kW:n kaistan (merkitty punaisella) nykyisellä perusmaksulla.

Lähde: LUT Raportti 4.5.2012

Keskijännitejohtolähdön kokonaisteho sekä Suomen aluehinta Spot-markkinoilla yhden päivän (22.2.2010) aikana.



Lähde: LUT Raportti 4.5.2012

Solution?

- Dynamic distribution price
- Whole system becomes dynamic

To optimize benefits of various pricing structures and new smart technology new type of regulation is needed

KIITOS!