

Regulating Electricity Networks

- A Norm Model for Electricity Distribution

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Background

- Norwegian electricity sector
 - Competitive supply of (and demand for) power
 - Transmission and distribution are regulated
- Present regulatory scheme
 - Limit on total revenue for each company
 - 5 year regulation period
 - Initial revenue limit based on historical costs
 - Yearly reduction in income limit for inefficient companies
 - Inefficiency is determined using DEA (data envelopment analysis)



Background

- The regulatory scheme is to be revised from 2007
 - Increased use of norms?
 - Role of efficiency analyses?
 - Research Projects
 - Regulator (NVE)
 - Companies/industry (EBL)
- Our project
 - Efficiency requirements and cost pools
 - Correct?
 - Understandable?
 - Network related costs
 - Present model – cost plus?
 - Low reinvestment levels?
 - Challenge in new model – increased revenue level



Normative Revenues – Incentives

- Give correct incentives for operation and investment
- Facilitate the best possible organization of the companies and the industry
 - Revenue = cost of "marginal" company, given the company's "output" (volume and quality)
 - Operating income: depends also on the company's efficiency and costs
- Reinvestments: Efficient VOLL (KILE)
 - Internalize quality cost
 - Price-surrogate in operations and investment decisions
- New investments
 - Investment plans
 - Ex post control and "punishment"



Normative Revenues – Revenue Level

- Competitive rate of return on invested capital
- Possibility (financially) to carry out good investments
- ➔ Dynamic and attractive industry: access both to financial and human capital
- Cost norms
 - To share efficiency gains with customers
 - Must reflect characteristics of delivery area ("geography factor")
- Must accept lasting efficiency differences



Normative Revenues – Time Profile

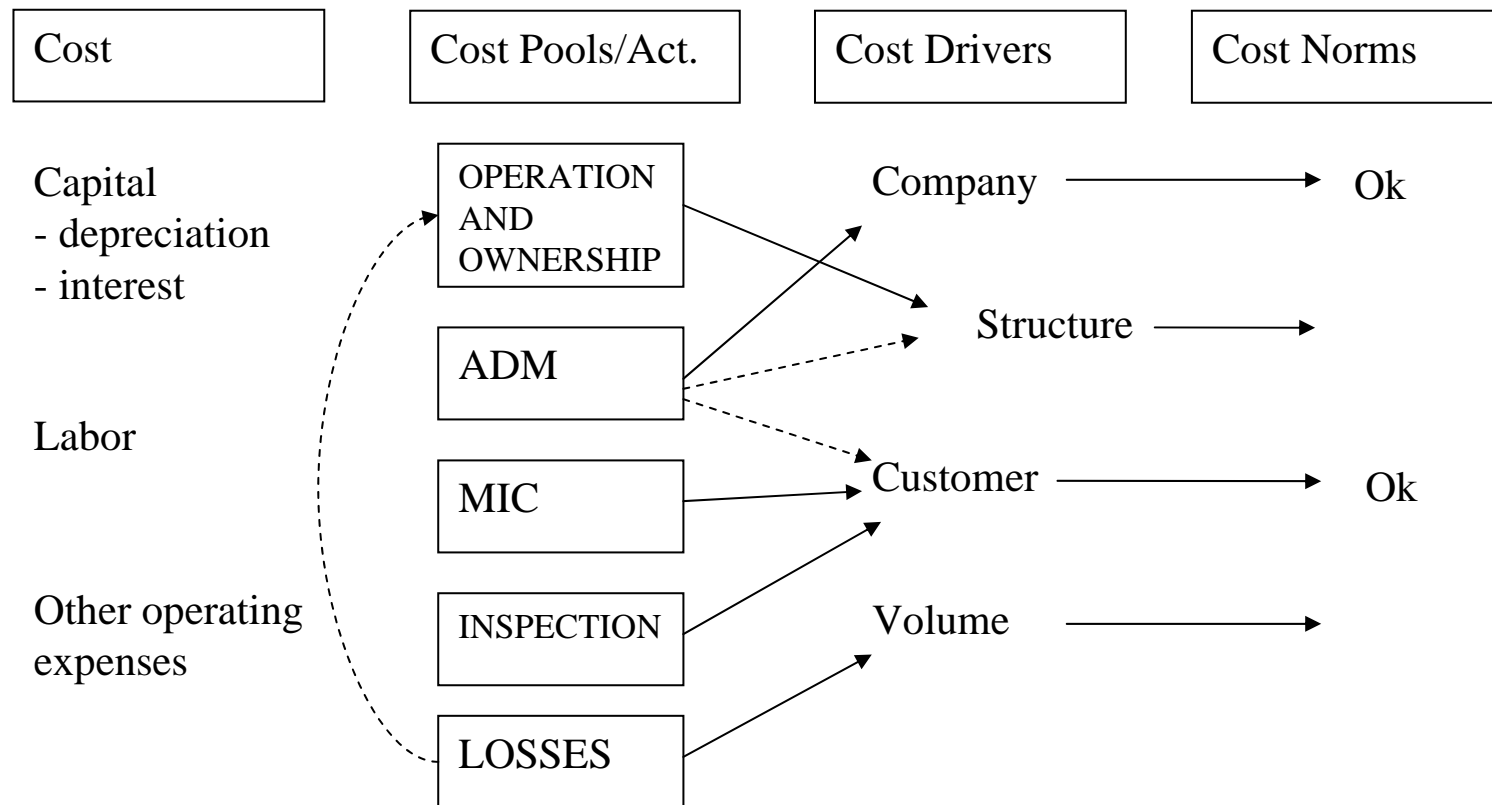
- Productivity independent of age
 - Real annuity based on new replacement values / catalogue values
 - Ref. annuity versus fixed part payment
- Investments, operations and maintenance must be considered together
 - To some extent substitutes
 - Depend on each other over time
 - Difficult to separate accounts
- "Protection" against customers / owners
 - Increased revenues with inflated real annuity
 - Accounting depreciation may give substantial temporary operating incomes
 - Need for "guarantee fund" / NVE-accounts?



Norm Model – Trade Off

- Perfect normative revenue
 - Optimal dimensioning and development of the grid over time in a given delivery area
- It is not possible to find a perfect system
 - Simpler model that is not 100 % accurate, but good enough so that the advantages of the incentives provided by the norm based revenue more than compensate for the imperfections in the exact determination of the correct revenue level
- Alternative: Minimum rate of return
 - For particularly inefficient or atypical companies

Cost Model





Normative Revenues

Quality	Σ Amount per asset group
Losses	
Customers/ Adm	NOK/customer x customers
OM	Σ Replacement value, new* x real annuity (varying) x “geography factor”
Capital	Replacement value, new* x real annuity

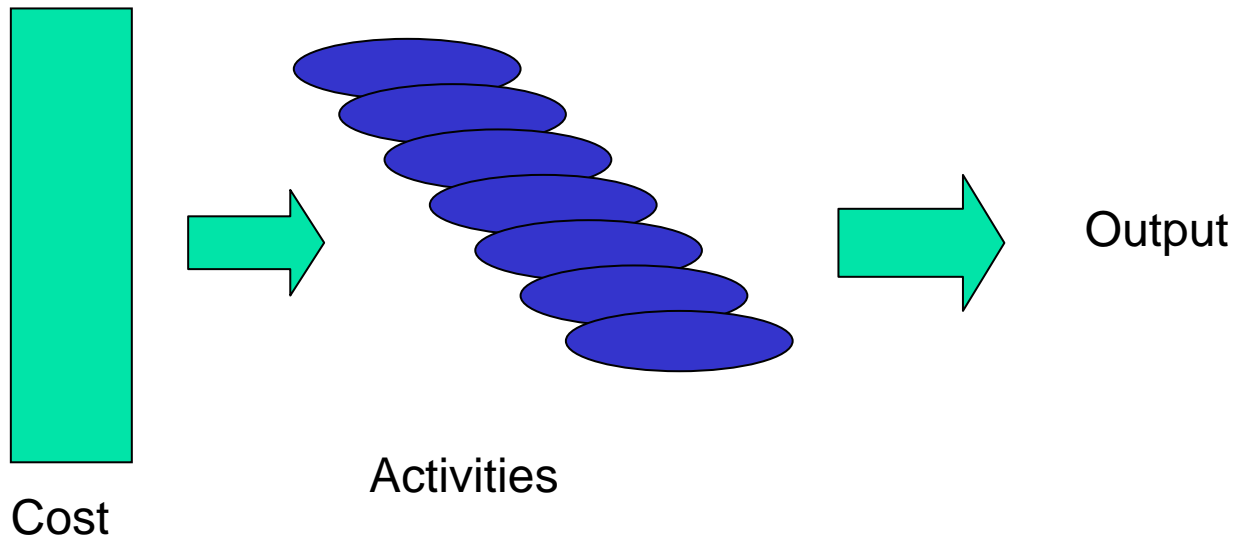
Efficiency Analyses

DEA analyses



Depends on quality of data and same underlying structure

ABC model



Assumptions are "visible"
How to find the structure?



DEA Model Used by NVE

- Data
 - 166 distribution companies for the period 1996-1999
 - Separate analysis for regional transmission activities
- Model
 - Cost efficiency
 - Input-based model
 - VRS



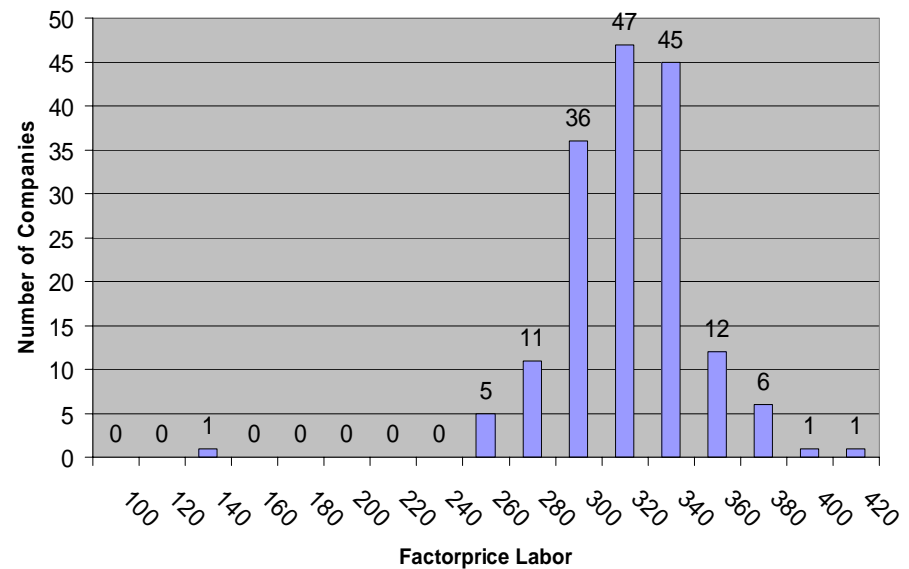
NVE and DEA – Size Effects

Output	Units	Company	No. of customers
Low voltage lines (km)	8 951	BKK Distribusjon AS	147 500
High voltage lines (km)	4 969	Nord-Trøndelag elektrisitetsnett	73 557
Customers	303 312	Viken Energinett AS	303 312
Delivered energy (MWh)	8 370 400	Viken Energinett AS	303 312
Exp. cost of non-delivered energy (1000 NOK)	48 089	Troms Kraft Nett AS	59 376

- Largest with respect to one output implies 100% efficiency
 - "automatically" efficient companies comprise a large share of the customer base (the companies shown above have approx. ¼ of the customers)
- Effect of mergers

Uncertainty in Reported Man-years

- Number of man-years are very uncertain
 - Mix of man-years and employees
 - Mix of company employees and others
 - Low focus on quality of reports
 - Internal deliveries are unclear
 - Different organization
 - Allocation between grid levels are random



Man-years	Factor-price	Cost	Efficiency	Change
94.05	311112	29260084	87.96%	
94.05	250000	23512500	88.59%	0.63%
75.58	311112		91.02%	3.06%



Conclusions – Man-years

- Today's reporting of man-years is strongly misleading and a considerable source of error in the efficiency measurements
- The problem can only partly be resolved by improved reporting as different organization may give distortions in the number of man-years reported
- Model should be replaced by one that measures all inputs in NOK

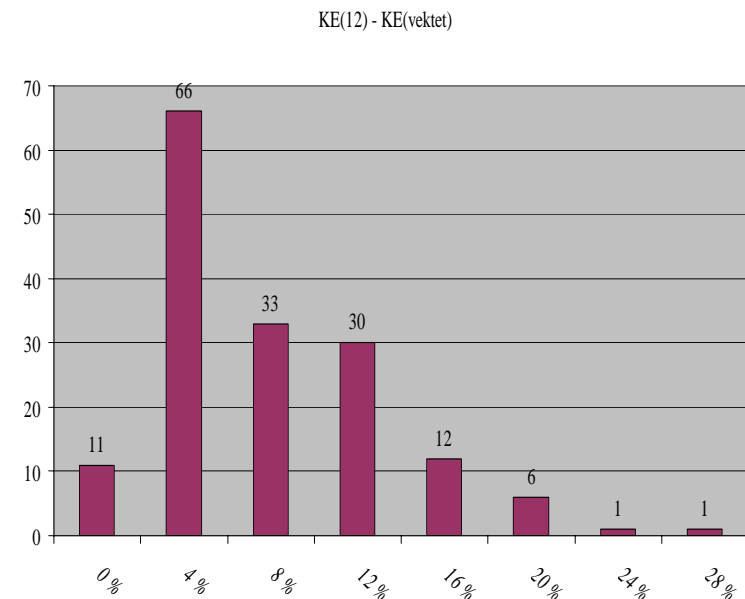


Separable Costs

- Cost groups with different cost drivers are aggregated
 - Do not utilize the data optimally
 - Lose information on where you are efficient and where you are not
 - Will typically reduce the efficiency requirements
 - If different companies are efficient in different activities, the combined efficiency frontier will not show the whole potential
- Two separable activities
 - Network related activities
 - Customer related activities
- In the present DEA-model the two activities are aggregated
 - Overestimate the efficiency

Simulated Effect of Aggregation

- Experiment with two activities
 - Use the same input factors
 - activity 1: three products
 - activity 2: one product
 - Cost is in average approximately 24% of total cost
 - 200 companies / units



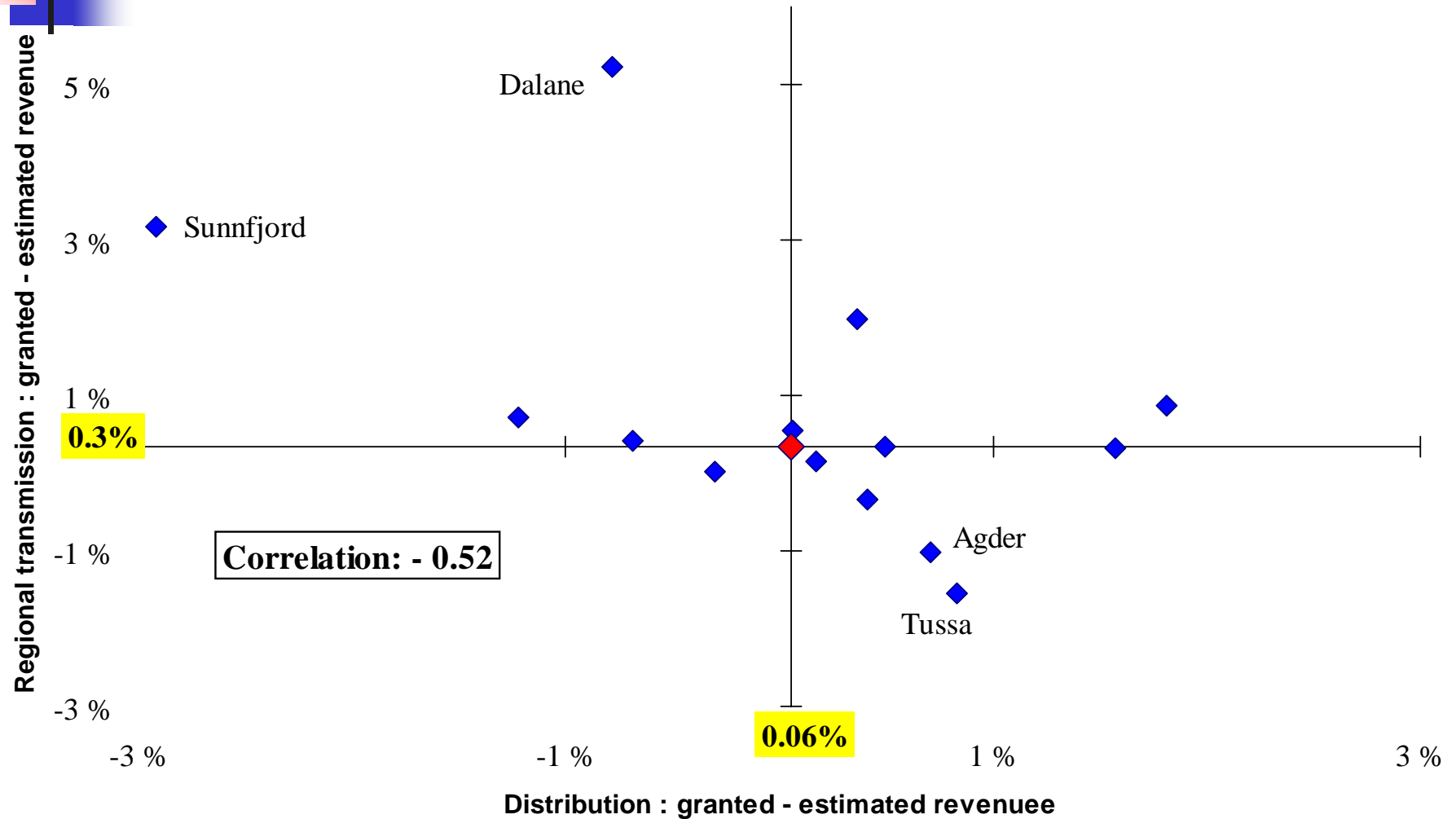
- Average overestimation of efficiency is 6%
- More than 12% for 20 units



Three alternative cost groups

Criteria	Regional transm. / distribution	Customer rel. / Network rel.	Activities
Divisibility	Problematic cost allocations	Possible to separate accounts	Difficult to compare between companies
Measurement errors when comparing units	Large	Some, but possible to reduce	Very large
Controllability	Not considered	Partly	Great possibilities
Information value	Very low	Medium	Potentially high

Cost Allocation Problems





Recommendations

- Model
 - Cost pools that distinguish between network related and other costs
 - Other costs are regulated with respect to the number of customers
- How to determine cost norm
 - Based on studies of 3-4 companies
 - Consider weights for different customers
 - Quality requirements for customer related activities
- Verification / revisions
 - Guidelines for documentation of the separation of accounts must be developed



Network Related Costs

- Present model – cost plus?
- Low reinvestment levels?
- Challenge in new model – increased revenue level

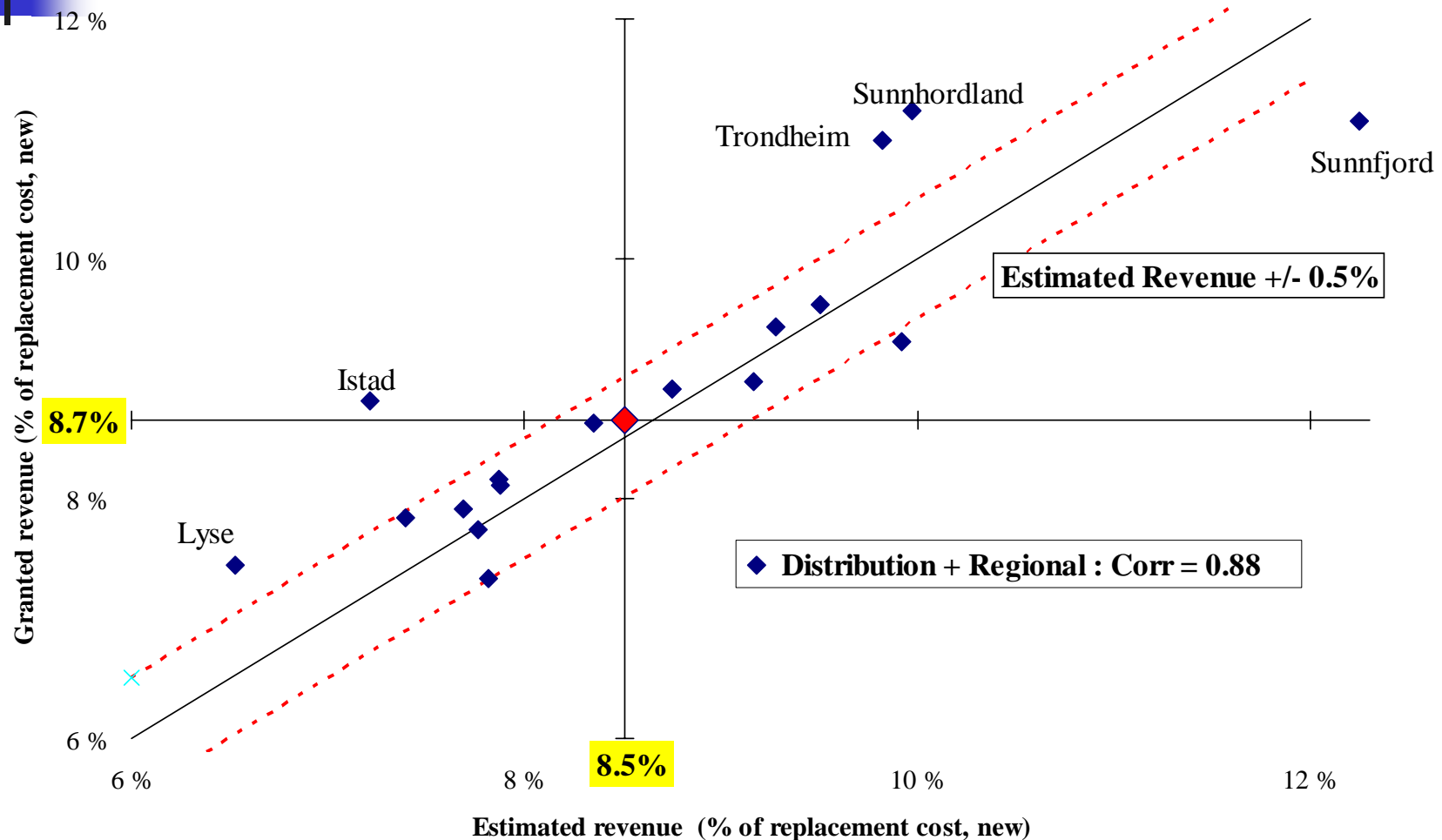
Cost of Capital, 2002

	MNOK	% of Catalogue Value	% of Est. Revenue
Power loss	808	0,9 %	11 %
Customer related	1 210	1,4 %	16 %
Opex+ Maintenance	2 157	2,4 %	28 %
Deprecation	1 502	1,7 %	20 %
Rate of return	1 924	2,2 %	25 %
Estimated revenue	7 601	8,5 %	100 %
Granted revenue	7 732	8,7 %	
Catalogue Value	89 355		
Book Value	22 686	25 %	

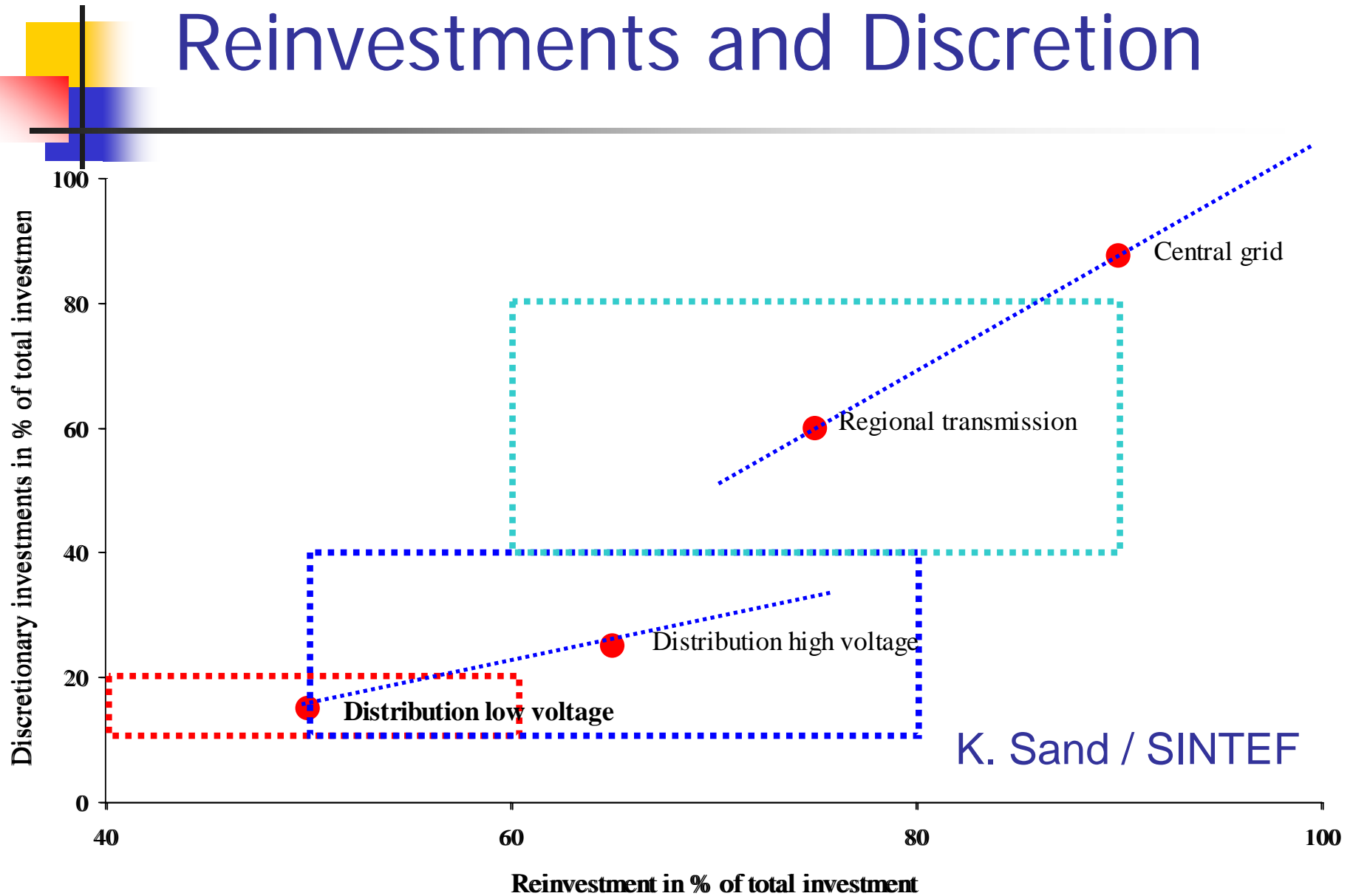
- ◆ **Accounting Cost** = Depr. + CoC · Book Value
- ◆ % av Catalogue Value = (Depr/CV) + CoC·(Book/CV)
= 1.7% + 6.6% · 0.25 = **3.3%**
- ◆ **Economic Cost** = Inflated Real Annuity · Norm CV
- ◆ % av Catalogue Value = (1 + i) · Real Annuity
= 1.015 · 5.8% = **5.9%**

Present Model – Cost + ?

- ◆ 17 companies / replacement value, new 83 billion NOK / distribution + regional transmission



Reinvestments and Discretion





Key Figures for 2002

Company	Pct of replacement cost, new			
	Book value	Depreciation	Reinvest	New invest
DISTRIBUTION	25 %	1,7 %	0,6 %	1,2 %
REGIONAL	26 %	1,7 %	0,5 %	0,7 %
DIST + REGION	25 %	1,7 %	0,5 %	1,0 %
min	17 %	1,2 %	0 %	0 %
max	38 %	2,3 %	1,5 %	3,6 %

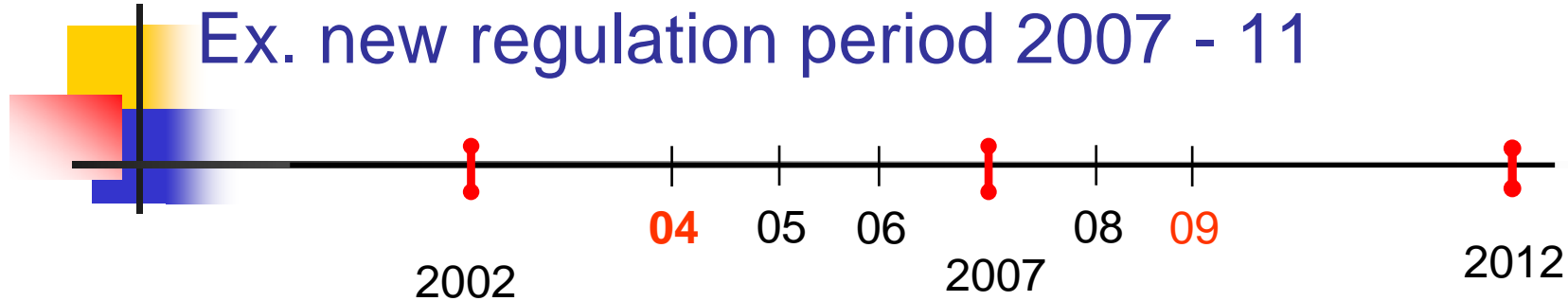
MODEL¹:

Old	28 %	1,8 %	2,2 %	1,4
Medium	33 %	2,2 %	1,1 %	0,5

¹ 40 yrs life, 1% real growth, inflasjon adjusted until 1990; 30 yrs straight line depre

Updating of NVE-Revenue

Ex. new regulation period 2007 - 11



- ◆ Revenue due to cost of capital

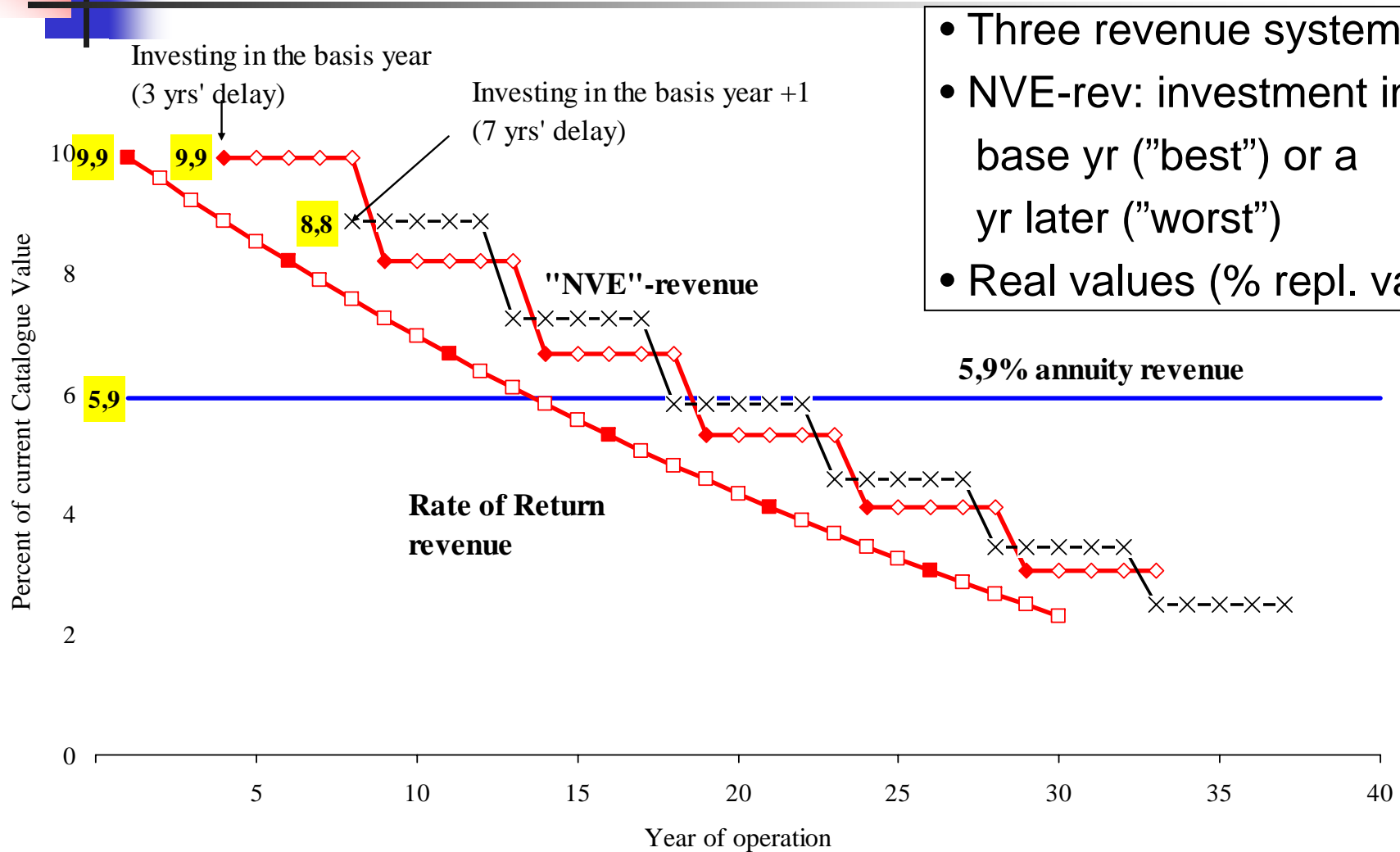
$$KK_t = [AVS_{04} + R_t \cdot Bok_{04}] \cdot \frac{KPI_t}{KPI_{04}} \cdot (1 - \mathbf{eff}_{04})^{t-06}$$

- ◆ Revenue due to OM (operation and maintenance)

$$DV_t = \overline{DV}_{02-04} \cdot \frac{KPI_t}{KPI_{04}} \cdot (1 - \mathbf{eff}_{04})^{t-06}$$

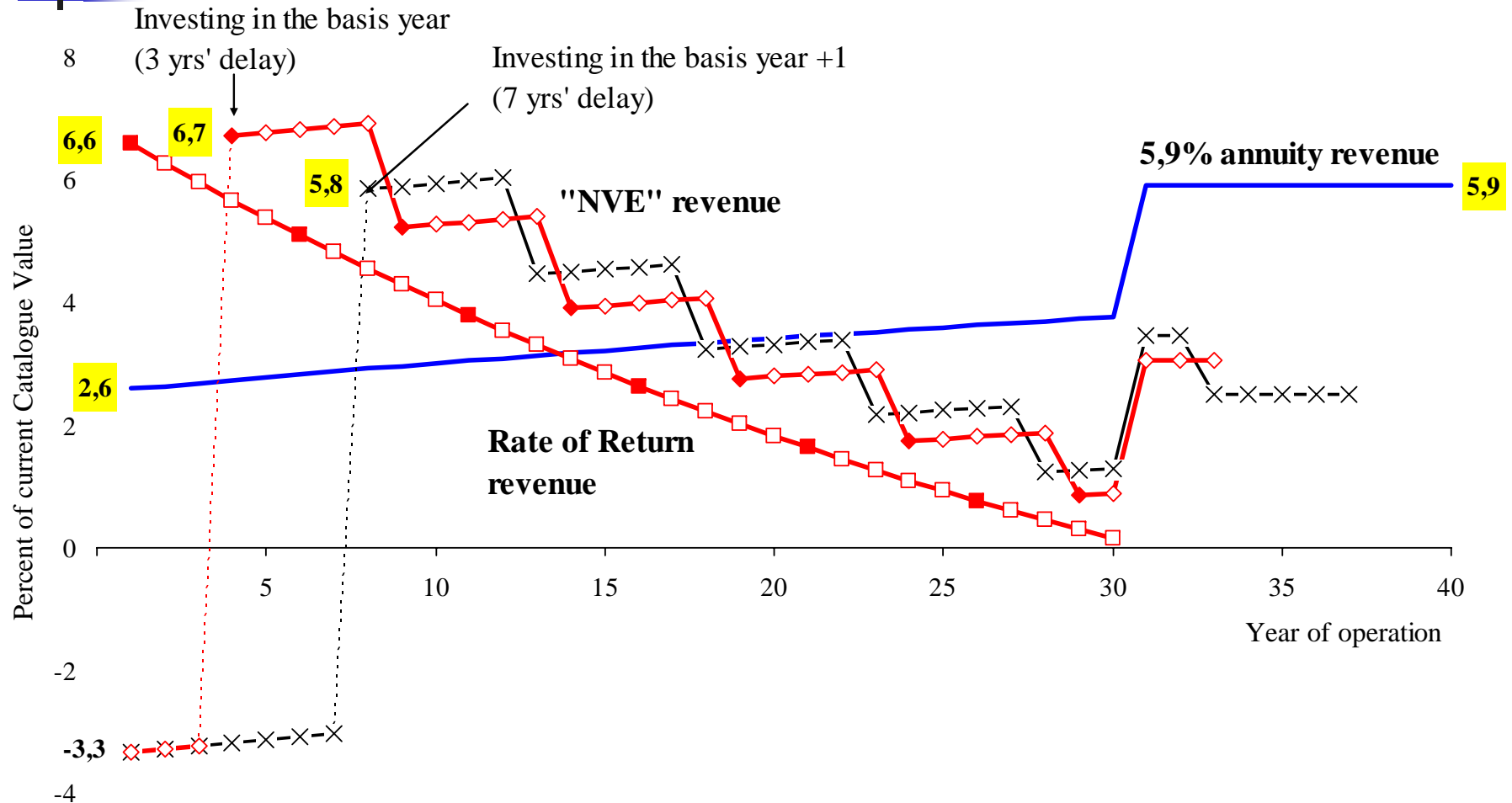
- ◆ Efficiency requirements are disregarded in the following

Revenue Due to Cost of Capital (real value / 30 yrs depreciation)



- Three revenue systems
- NVE-rev: investment in base yr ("best") or a yr later ("worst")
- Real values (% repl. val.)

Accounting Profit (real value / 30 yrs depreciation)



Investment – NPV and IRR

(without adjustment for new investments)

Revenue basis	Delay ¹	Capital cost ²		Cap.cost + 2% OM-cost ³	
		PV	IRR	PV	IRR
Catalogue Value		100	6,6 %	100	6,6 %
Rate of Return		100	6,6 %	100	6,6 %
"NVE" / yr of investment					
- basis yr	3 yr	94	6,0 %	84	5,3 %
- basis yr +1	7 yr	68	4,1 %	57	3,7 %
- basis yr +1 / 10 yr	12 yr	46	3,0 %	31	2,5 %

¹ Years from investment to the first year of incr. Revenue

² NVE revenue: Inflated Capital cost for the basis year.

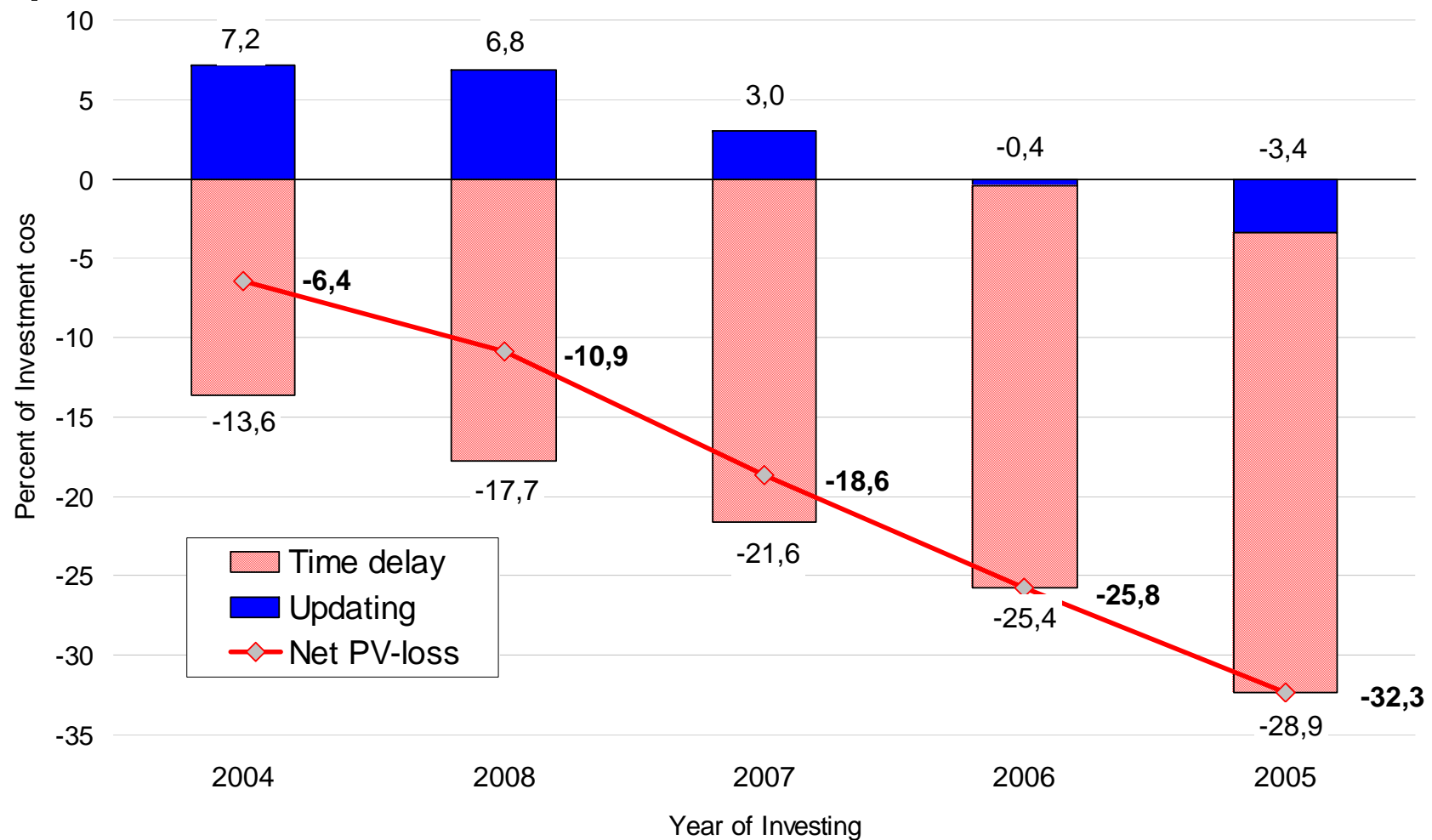
³ NVE revenue: Inflated, avg OM-cost for four up to the basis year

⁴ Extended 10 yrs' regulation period, ref Sandbakken (2003)..

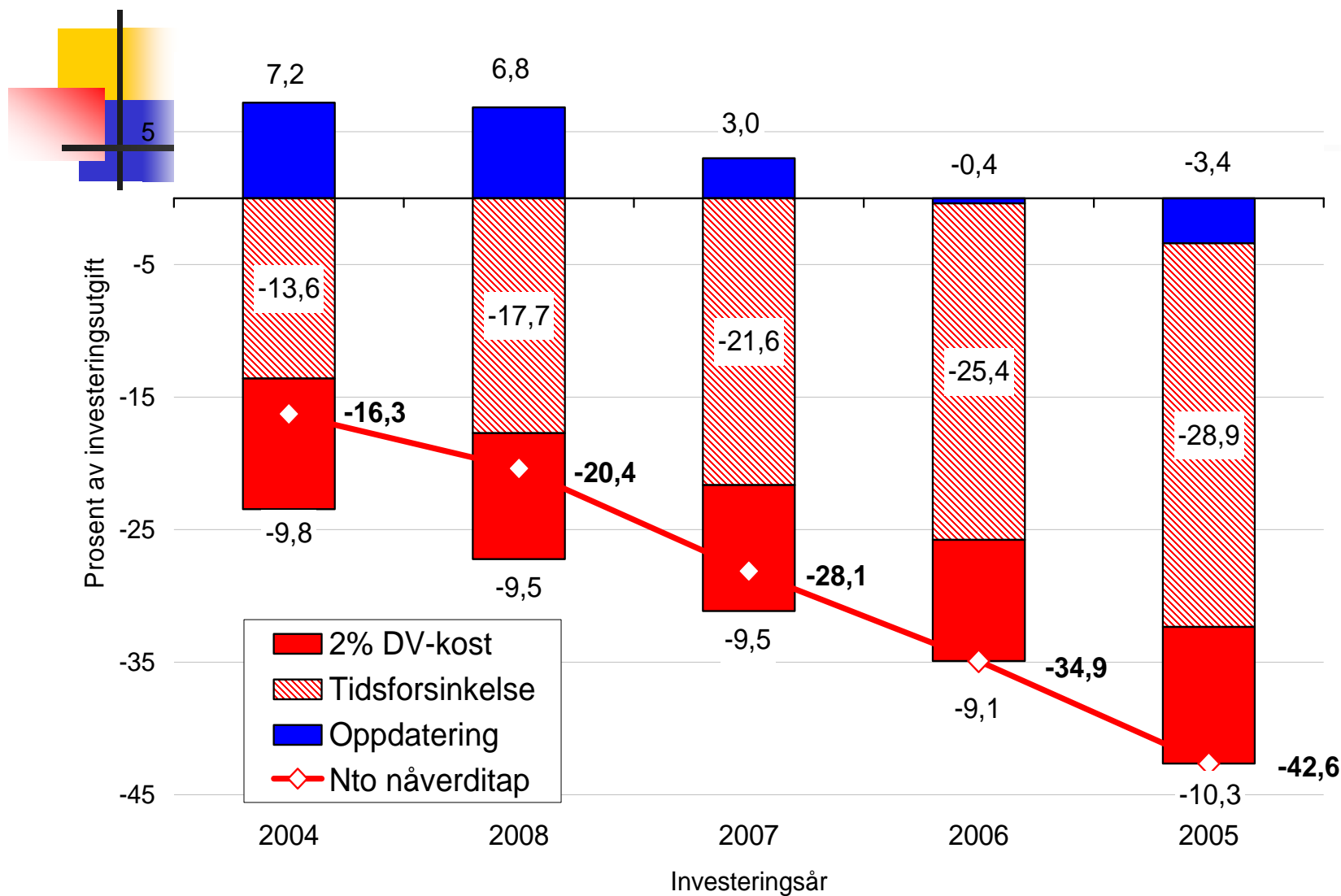
- ◆ NVE-revenue (5 yrs): NPV-loss is 16% or 6% of investment expense ("best") with and without OM-cost respectively, and 43% and 32% ("worst")
- ◆ Extended regulation period (10 yrs): NPV-loss is in worst case 69% or 54% of the investment expense

NPV-loss

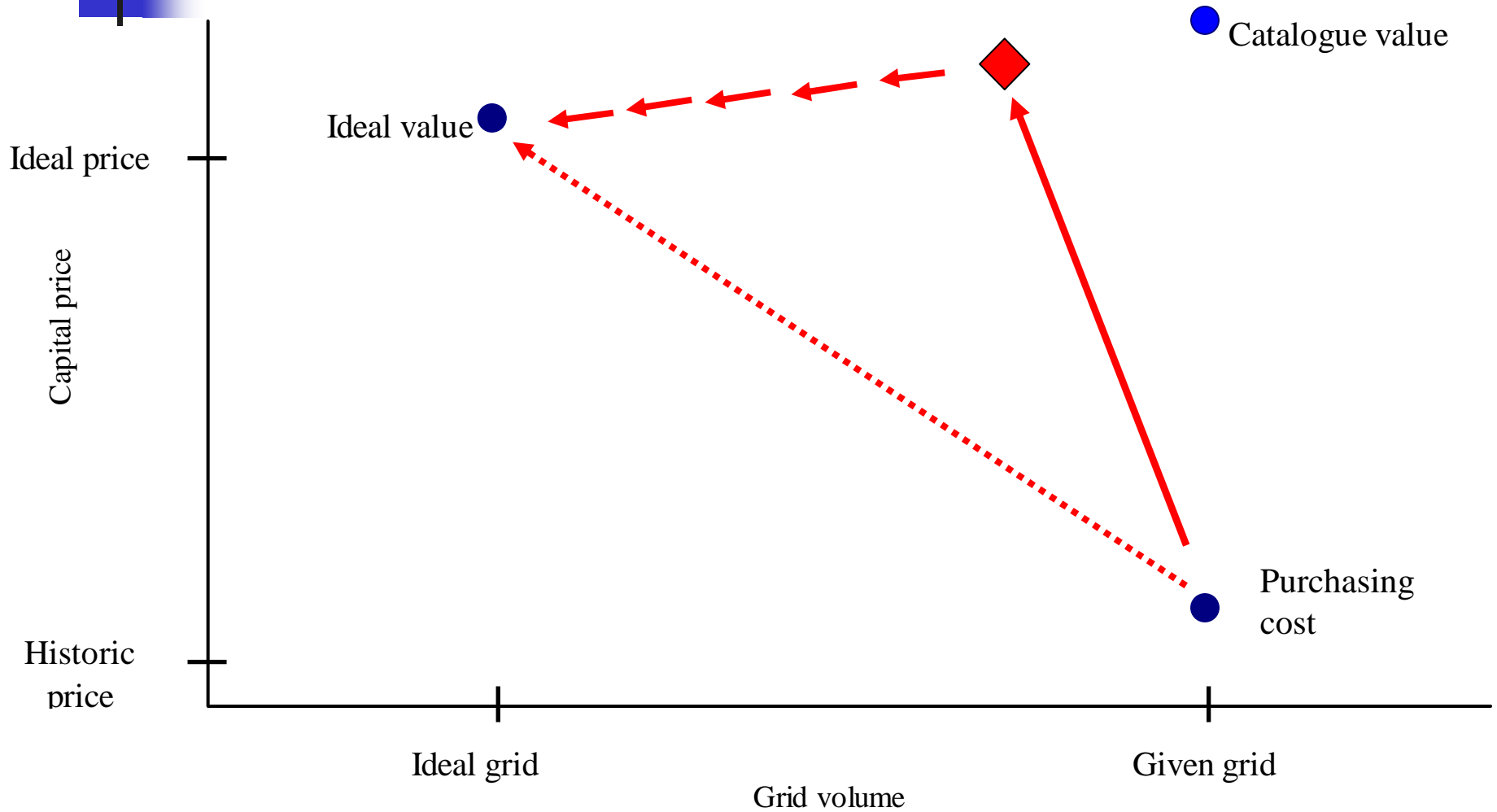
- Delay: loss of interest in revenue cap
- Updating: gain on inflation-adjustment
loss on writing down book value



Rentetap + oppdateringsgev/-tap + DV-tap



Cost Norms – Capital Values





Reducing the Revenue Increase

- ◆ 3,3% of replacement value in present system versus 5,9% in new system

Annuity revenue	5,9 %	
- Normed catalogue value ¹	-1,2 %	-20% av 5.9%
- Normed (OM + Customers) ²	-0,8 %	-20% av 3.8%
Normed Annuity Capital Cost	4,0 %	
Present Capital Cost	3,8 %	
(New - Old) model grid ³	1,3 %	+ (New 4.9% - Old 3.6%)
After increased reinvestments	5,1 %	

- ◆ 5 – 10 years transition period



Conclusions Norm Model

- ◆ Incentives
 - investments; alternative energy providers
 - organization
- ◆ Consistent norms
 - Cost of capital, OM, losses and KILE
 - Including both distribution and regional transmission
 - New requirements and general efficiency requirements are easily incorporated
- ◆ Understandable and predictable
- ◆ Focus on business perspective