

Distributed Generation in Electricity Networks

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Agenda

- Background
 - Norwegian market
 - Regulation model
- Effects of Distributed Generation on the model
 - A typical DG project
 - Effects of the project for individual companies and the industry
 - Sensitivity analysis of the DG coefficient
- Effects of changes in the benchmarking model



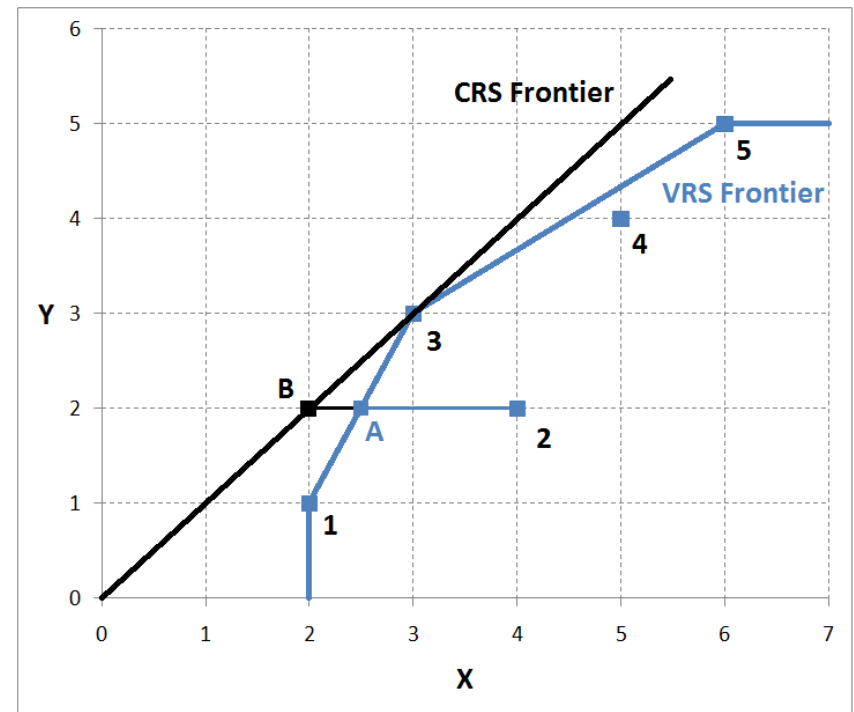
Background

- Norwegian electricity sector
 - Competitive supply and demand for power
 - Regulated transmission and distribution
 - Incentive regulation from 1997
 - Third regulation period from 2007
 - Changes every 5 years
 - NVE is looking at a new modification to start in 2012
- Regulatory model 2010
 - Cost norm based on benchmarking analysis
 - Separate models for distributions and transmission
 - 2-stage model for distribution (DEA & regression)
 - Pure DEA model for transmission
 - *Revenue Cap* = *Cost Norm* x 0.6 + *Cost Base* x 0.4



Benchmarking Model – Stage One

- DEA
 - Input-oriented
 - CRS
 - One input = TotEx
 - Capital costs based on accounting book values
 - 8 outputs
 - Energy delivered, customers except cottages, cottage customers, high voltage lines, network stations, forest, wind, coast
 - Allows for super efficiency



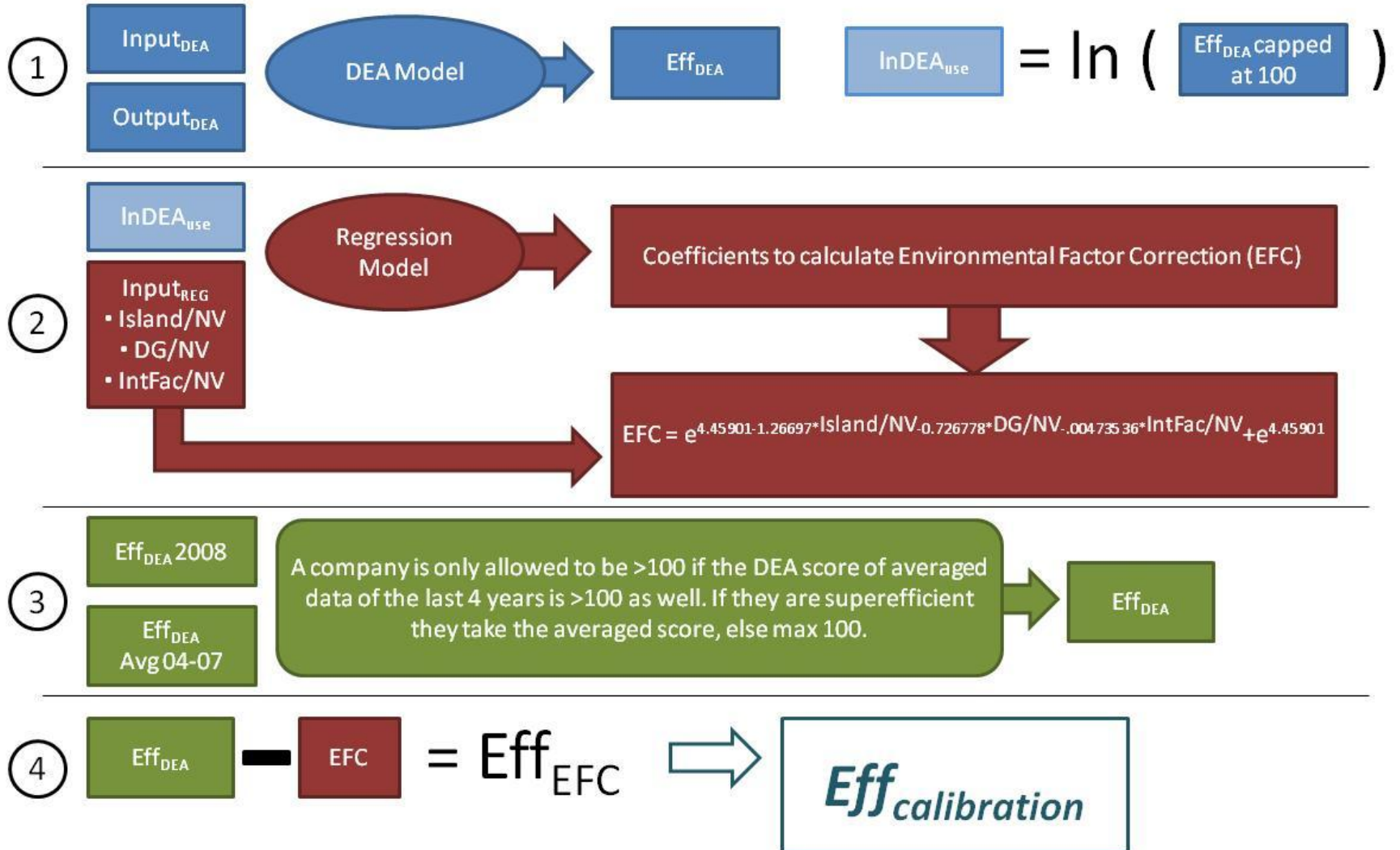
Benchmarking Model – Stage Two

- Environmental Factor Correction
 - Coefficients calculated via a model using panel data
 - $\ln(\text{DEA}_{\text{res}}) = \alpha + \beta Z + u = \text{DEA}_{\text{res}} = e^{(\alpha + \beta Z + u)}$
 - $\text{EFC} = e^{(\alpha + \beta Z + u)} - e^{(\alpha)}$
 - $\text{DEA}_{\text{EFC}} = \text{DEA}_{\text{res}} - \text{EFC}$

After 2nd stage

- Efficiency results are normalized
 - Cost weighted average efficiency = 100 %
- Resulting efficiency score is used to calculate a norm cost for each company
 - *Revenue Cap = Cost Norm x 0.6 + Cost Base x 0.4*

Flow Chart – Efficiency calculation



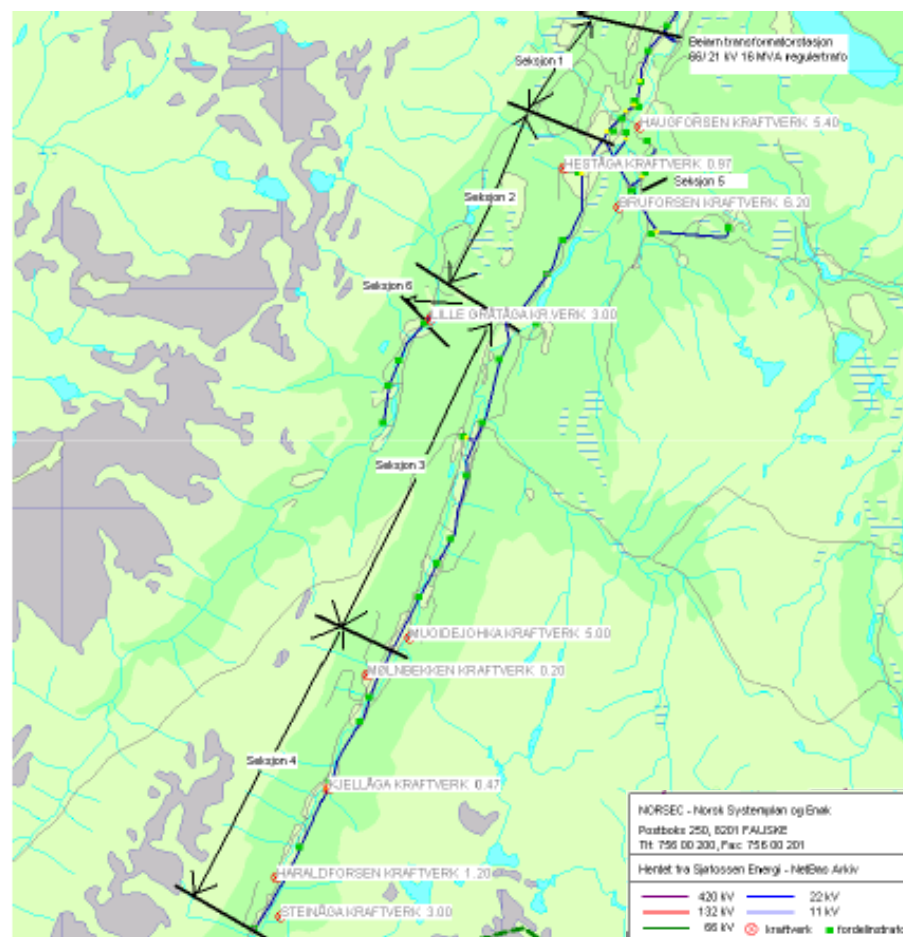


Research Questions

- How does the project affect the revenue cap of a company?
- Does the regulation model of 2010 compensate companies for investments into DG projects?

A typical DG project in Norway

- Extension/reinforcement of the grid to eight small hydropower plants (grid access) totalling 26.67 km
- Increased generation capacity: +25 MW
- Today's value of future reinvestments:
 - 13 MNOK (with DG)
 - 4 MNOK (without DG)





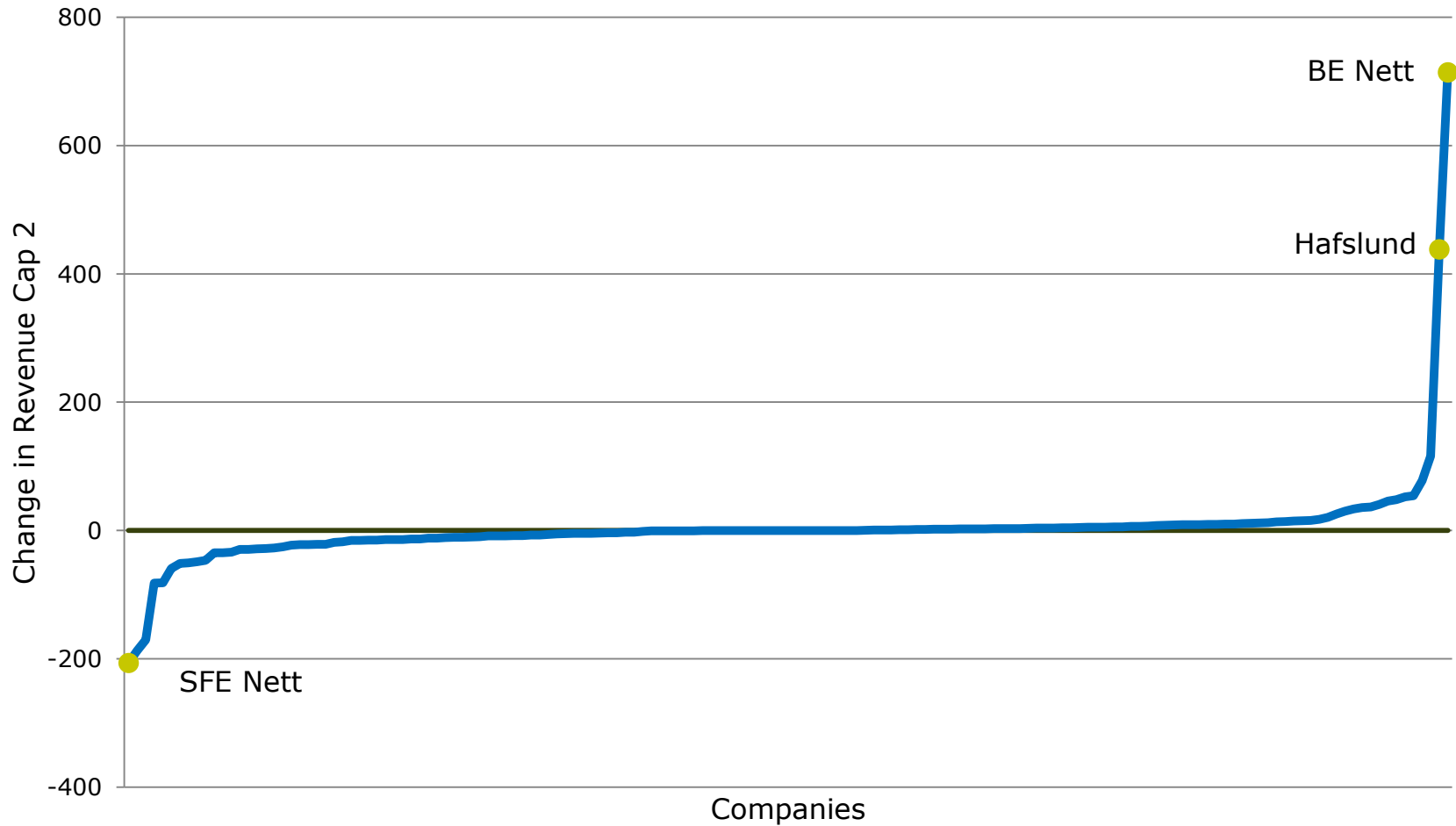
Effects of the project

Adding project to BE Nett AS		Adding project to Lyse Nett AS		Adding project to Dalane Energi IKS	
Company	Δ RC2	Company	Δ RC2	Company	Δ RC2
SFE Nett AS	-207	SFE Nett AS	-55	SFE Nett AS	-107
Tussa Nett AS	-187	Tussa Nett AS	-44	Tussa Nett AS	-93
Sunnfjord Energi AS	-171	Sunnfjord Energi AS	-37	Sunnfjord Energi AS	-85
Stranda Energiverk AS	-82	BKK Nett AS	-20	Agder Energi Nett AS	-68
x	x	x	x	x	x
x	x	x	x	x	x
Fortum Distribution AS	78	Trondheim Energiverk Nett AS	8	Trondheim Energiverk Nett AS	21
Skagerak Nett AS	116	Fortum Distribution AS	14	Fortum Distribution AS	33
Hafslund Nett AS	438	Hafslund Nett AS	53	Hafslund Nett AS	135
BE Nett AS	714	Lyse Nett AS	785	Dalane Energi IKS	881
Average	3	Average	3	Average	3

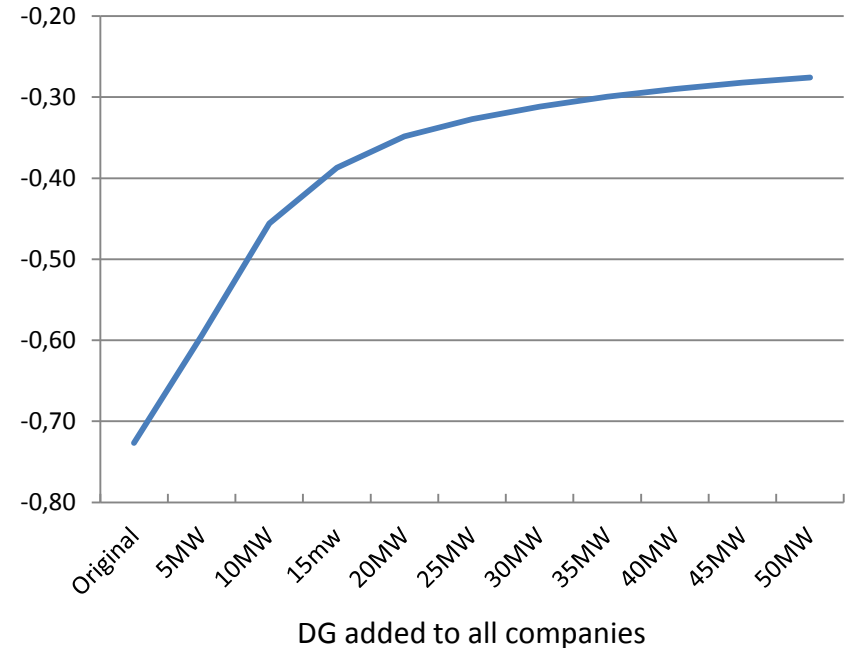
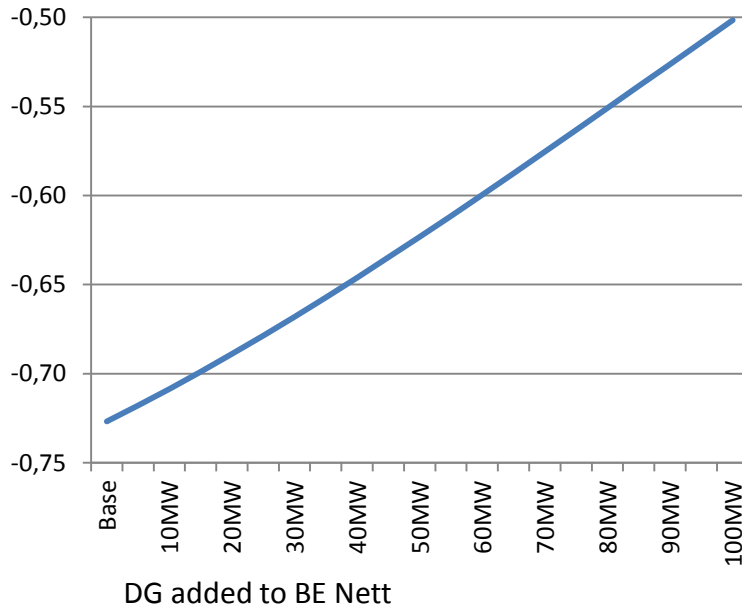
- The project is very profitable for the companies we add it to
- The project has an effect on other grid companies in the industry
 - Average effect is zero because of calibration
- Some companies loose a lot
 - Large shares of distributed generation
 - Size matters
- Companies with no or little DG don't suffer or win



Effects of the project on the industry



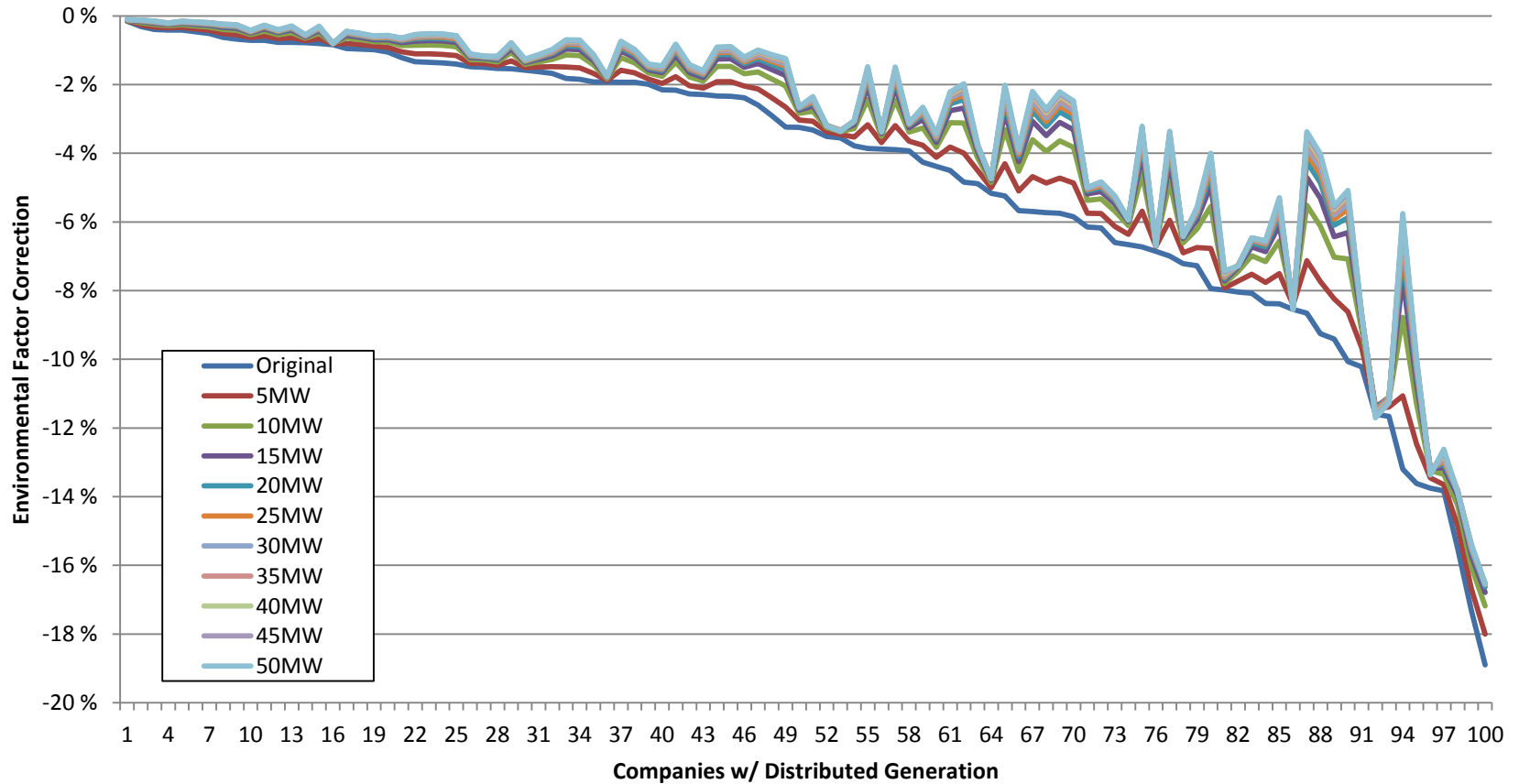
Sensitivity analysis - DG coefficient



- The DG Coefficient drops rapidly more DG is added – i.e. companies will be paid less per share of DG
 - Incentive to invest early?
- The drop in coefficient reduces the effect of the EFC for companies with DG

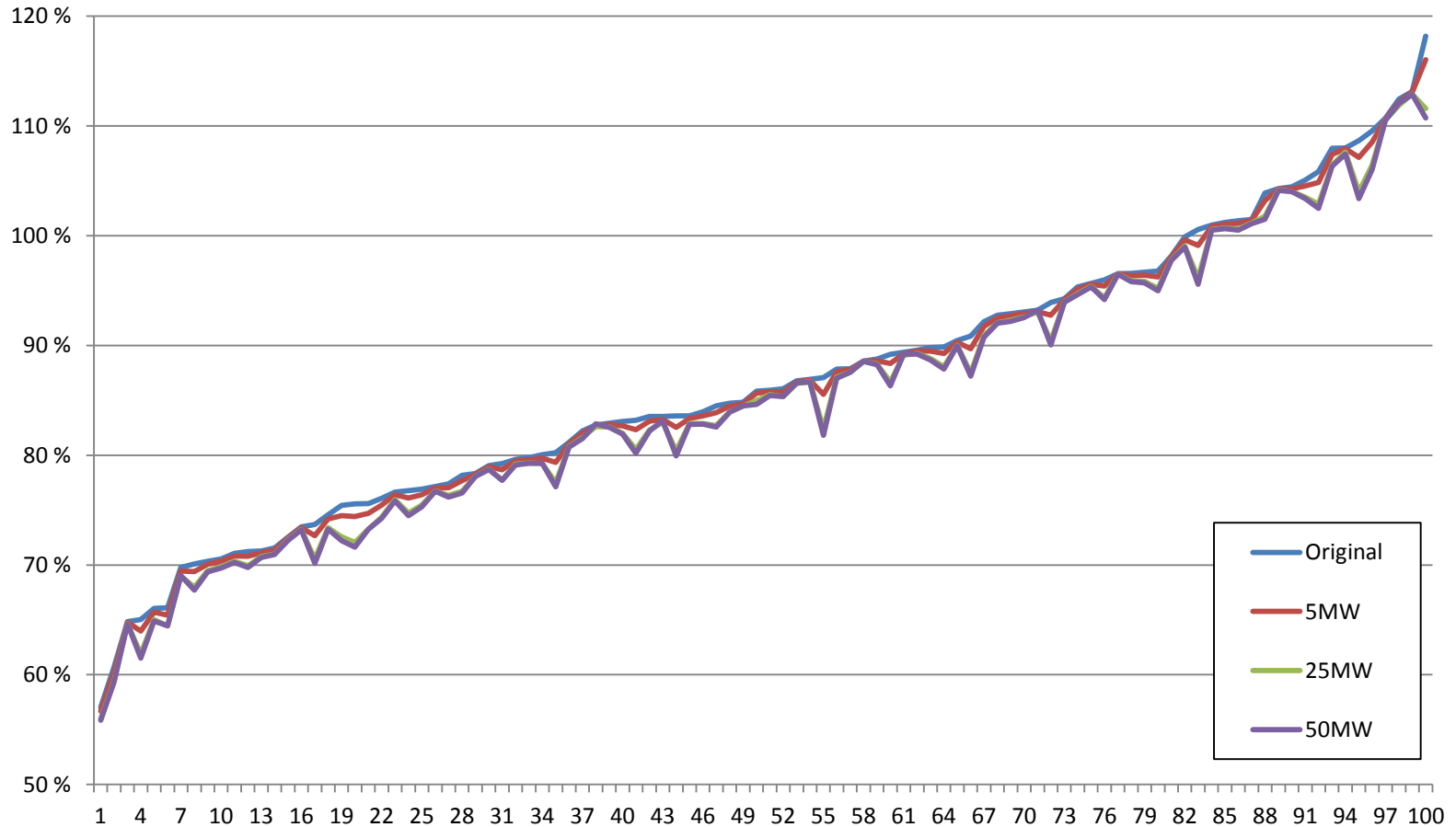


Sensitivity analysis – EFC for DG companies





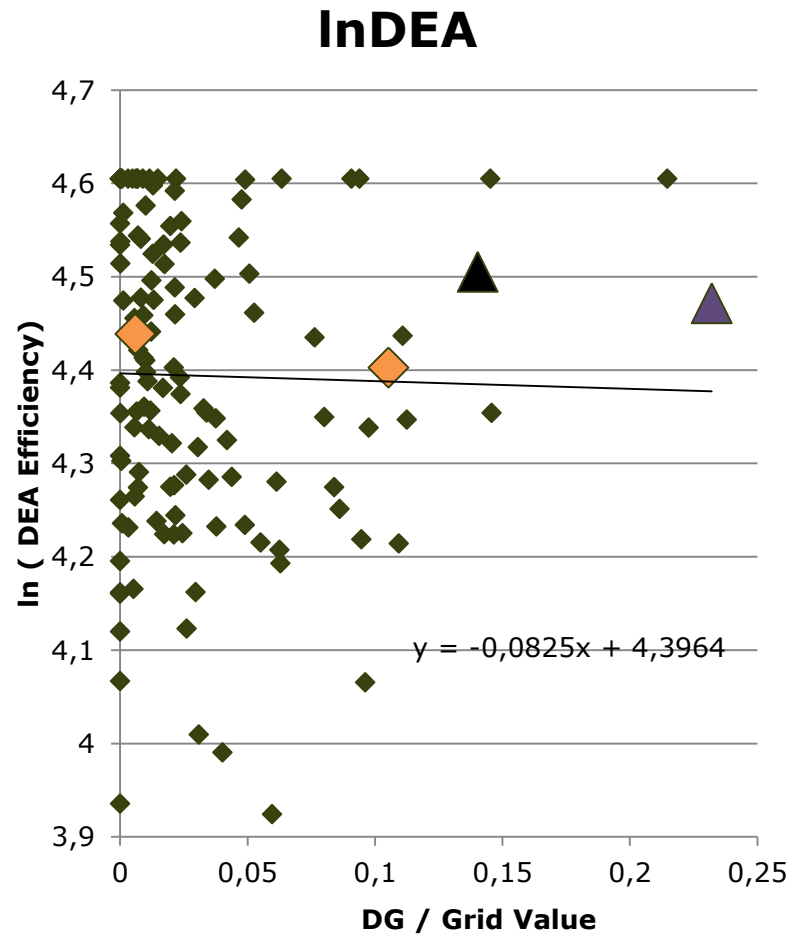
Sensitivity analysis – Total efficiency





Changing Coefficients

- Adding 25 MW with a 3% efficiency loss

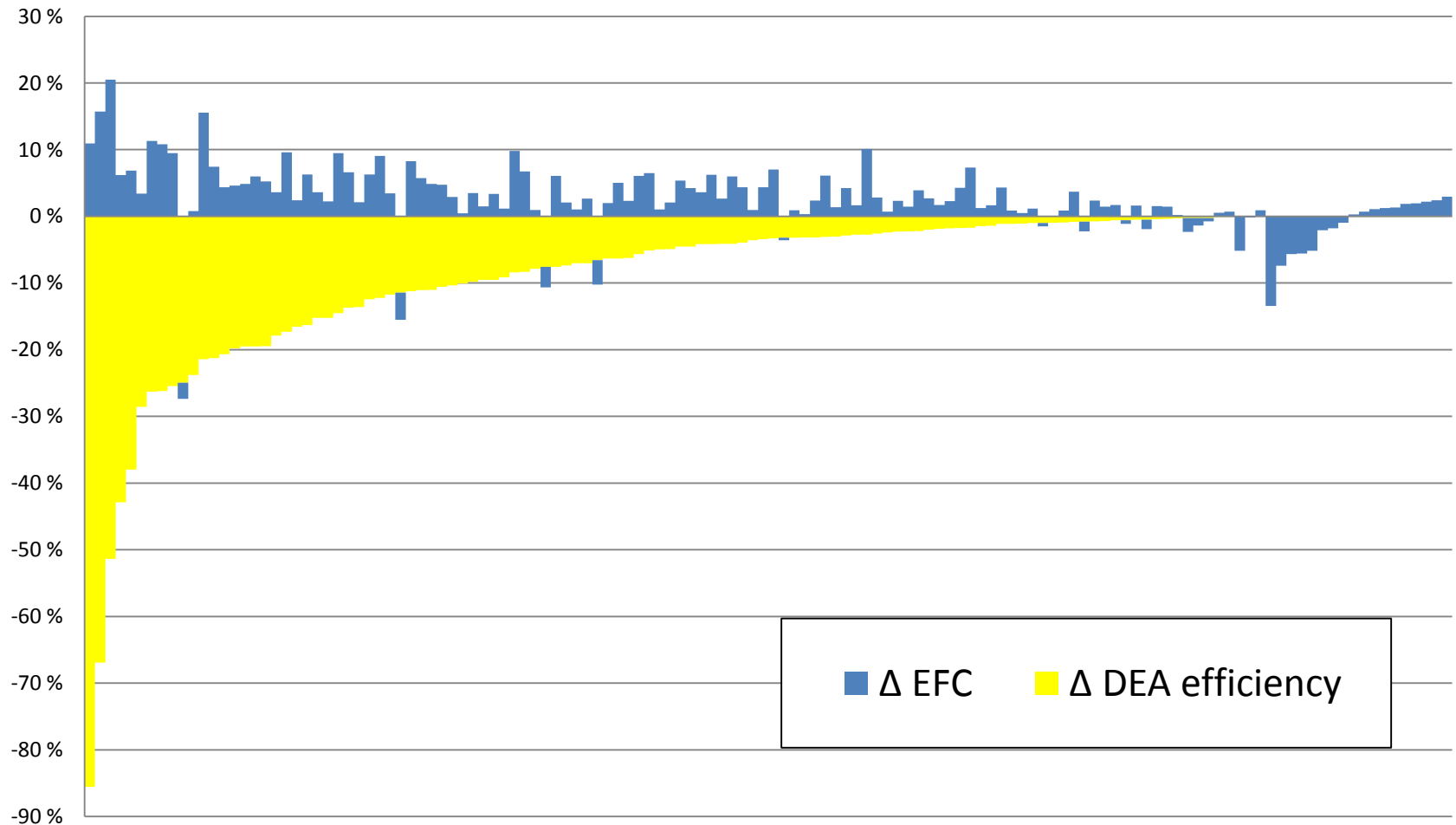


Possible model change from 2012

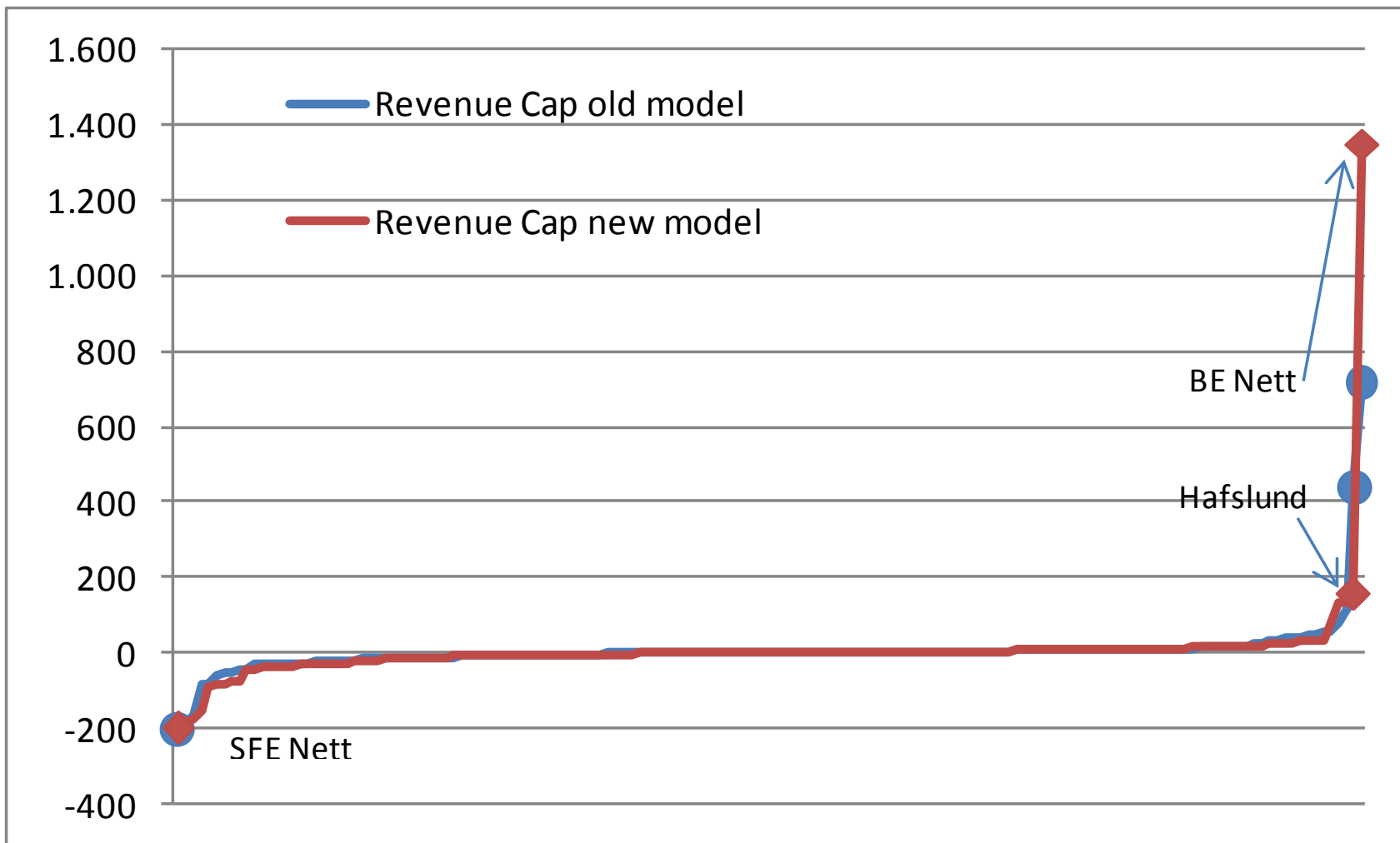
- New model moves environmental variables into the second stage:
- First stage
 - DEA with 1 input (costs) and 5 outputs (Energy Delivered, Customers with and without cabins, Network stations and High Voltage Lines)
- Second stage
 - Regression with 1 dependent (DEA efficiency) and 6 independent variables (Islands, DG, Interfaces, Forest, Snow and Wind)



Total Effect of the Model Change



Change in Revenue Cap for Project in New Model



Conclusions

- Increasing the amount of DG increases the revenue cap significantly for the company adding the DG capacity
 - Other companies are affected
- DG actions of one company affect the industry as a whole
 - Companies receive less and less compensation per unit of DG as the industry adds DG capacity
 - Early investment in DG may be beneficial
- The new model compensates companies even more for adding DG capacity



Questions?

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