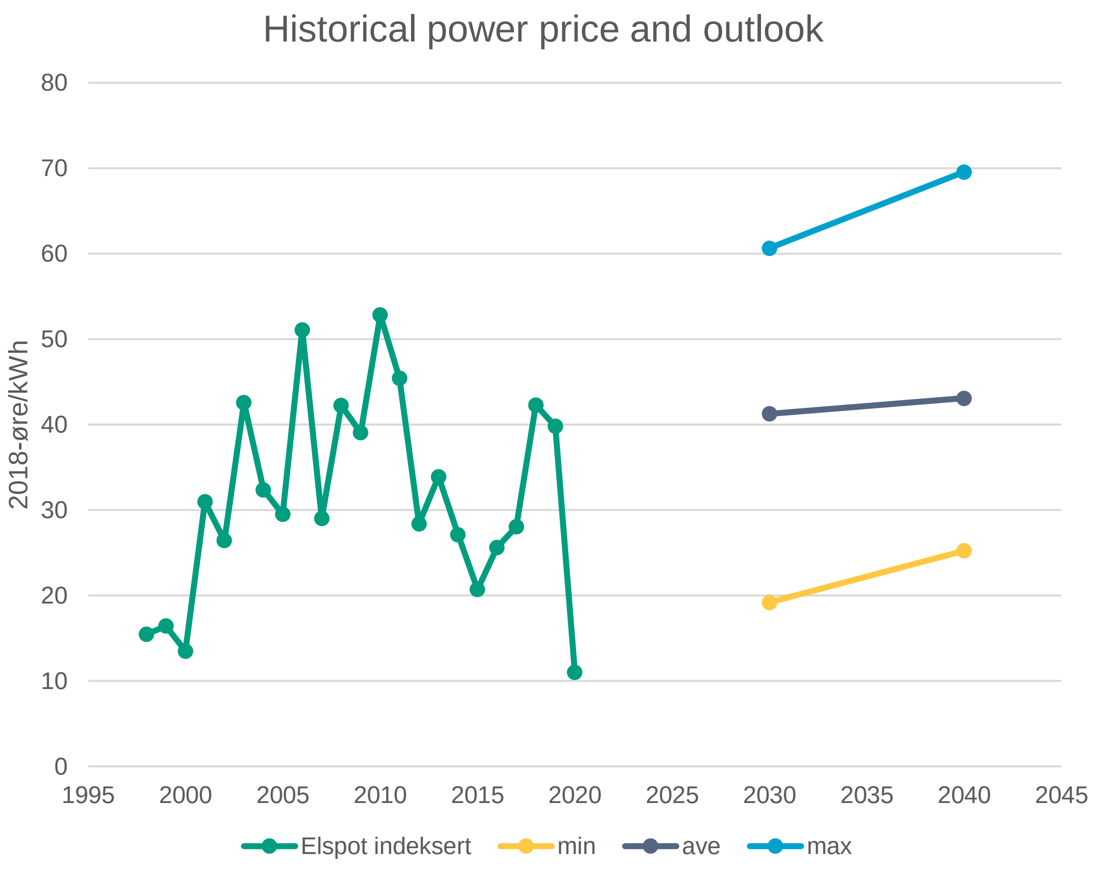
Quantifying uncertainties in the future power market?

A global sensitivity analysis

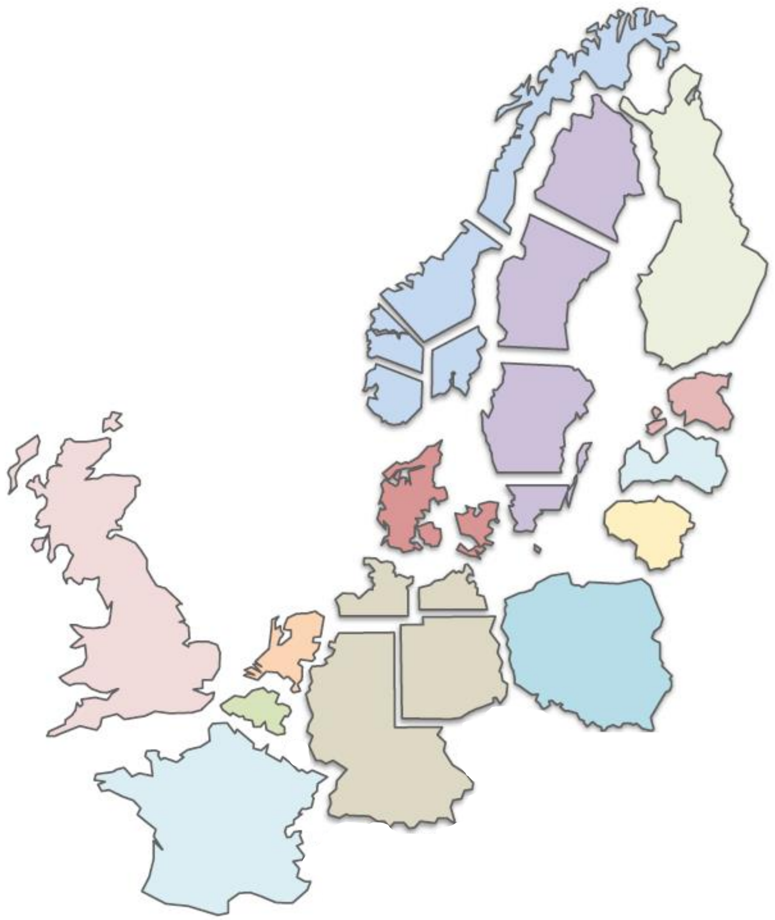
Scope

- Background:
  - There exists a significant uncertainty within the future policy and technology development in the electricity market towards 2040.
  - This study addresses how the different uncertainties impact the model results, for example future power prices.
- How:
  - The study builds on quasi-random Monte Carlo simulations, with use of Morris screening, which in a relative efficient way of finding the input values that maximum the input variance, and hence, maximum the output uncertainty



Model setups:

- Year: 2040, with 288 timestep
- Known investments in transmission line (exogenously defined)
- Endogenously investment in generation capacity
  - Except for capacities that are tested, but specific technology and regional capacities within the country is endogenously defined.
- Norway is the main focus



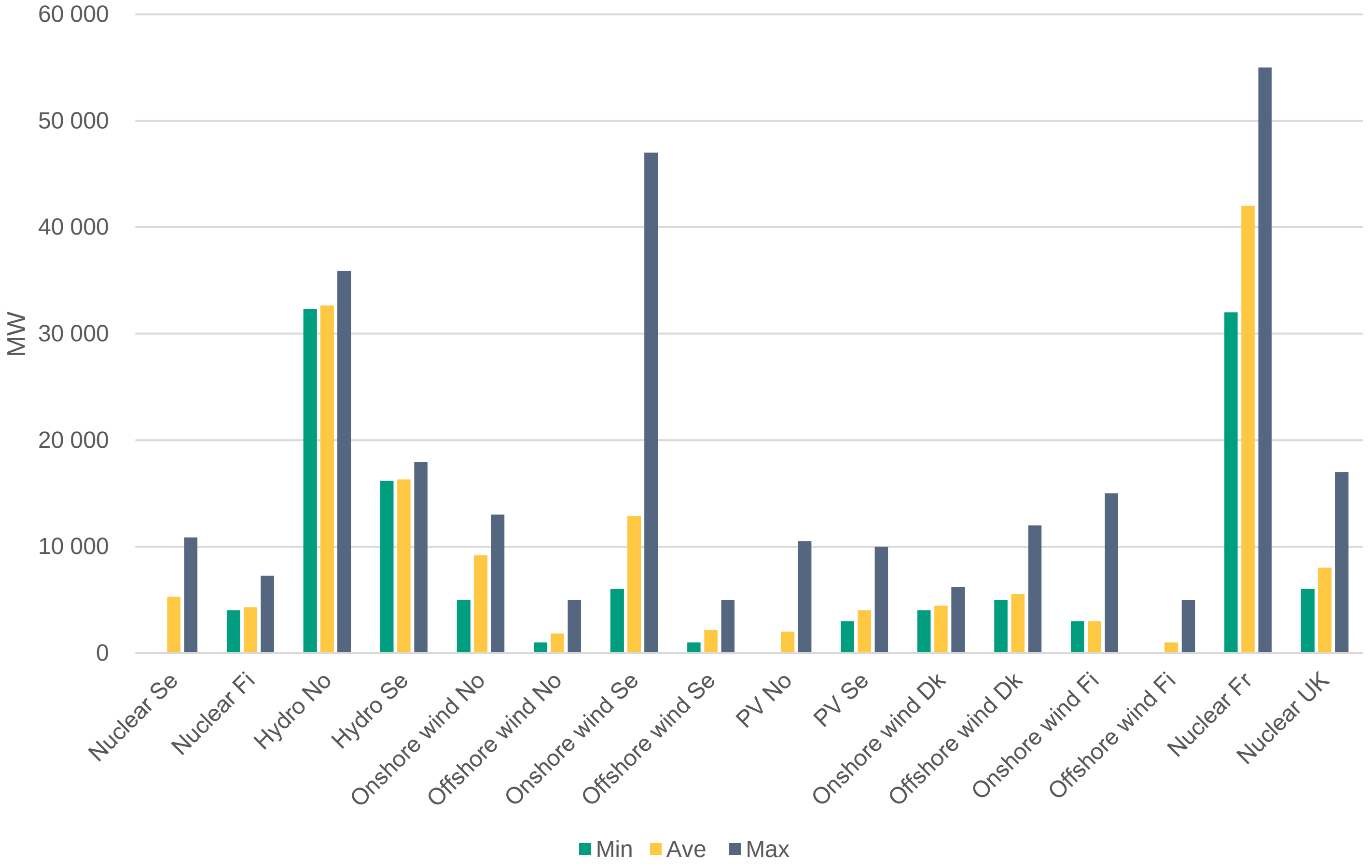
Ea Energianalyse

Parameters and uncertainty assumptions included so far

Q1: Do these assumed uncertainty ranges cover the assumed uncertainty level in 2040?

Q2: Are there important uncertainty factors missing?

Input uncertainty – generation capacity



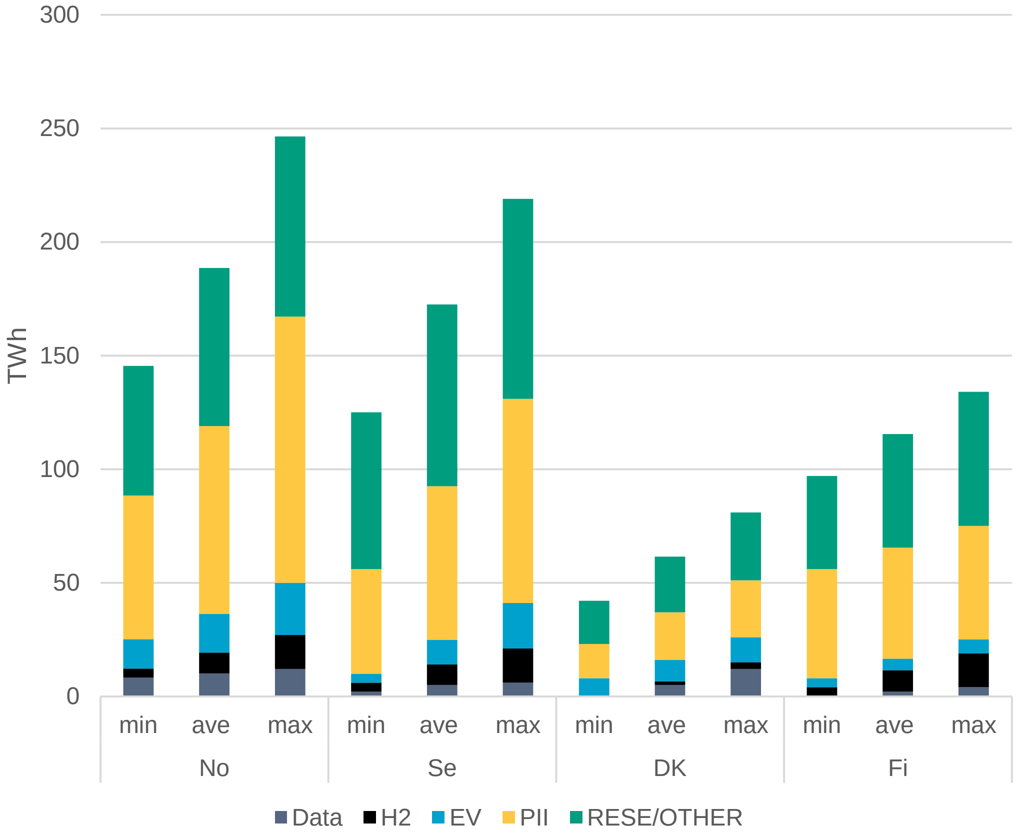
Triangular distribution

Capacity – unit: MW

	Min	Ave	Max
Nuclear Se	0	5 290	10 870
Nuclear Fi	4 000	4 300	7 247
Hydro No	32 310	32 637	35 900
Hydro Se	16 153	16 316	17 947
Onshore wind No	5 000	9 167	13 000
Offshore wind No	1 000	1 833	5 000
Onshore wind Se	6 000	12 857	47 000
Offshore wind Se	1 000	2 143	5 000
PV No	0	2 000	10 500
PV Se	3 000	4 000	10 000
Onshore wind Dk	4 000	4 444	6 200
Offshore wind Dk	5 000	5 556	12 000
Onshore wind Fi	3 000	3 000	15 000
Offshore wind Fi	0	1 000	5 000
Nuclear Fr	32 000	42 000	55 000
Nuclear UK	6 000	8 000	17 000
Carbon price - €/ton	10	57	130

Sources is mainly the outlook study and “Langsiktig kraftmarketsanalyse *2020 – 2040*”

Electricity demand



Triangular distribution
Unit TWh

		Min	Ave	Max
Norway	Residential	57	70	79
	Power intense industry	63	83	117
	Datacenters	8	10	12
	EV	13	17	23
	H2-production	4	9	15
Sweden	Residential	69	80	88
	Power intense industry	46	68	90
	Datacenters	2	5	6
	EV	4	11	20
	H2-production	4	9	15
Denmark	Residential	19	25	30
	Power intense industry	15	21	25
	Datacenters	0	5	12
	EV	8	10	11
	H2-production	0	2	3
Finland	Residential	41	50	59
	Power intense industry	48	49	50
	Datacenters	0	2	4
	EV	4	5	6
	H2-production	4	10	15

Other uncertainties

- Technological and fuel price uncertainties are applied for the entire model
- Technological uncertainties are uniform
- Fuel price uncertainties are normal distributed

Uniform distributed

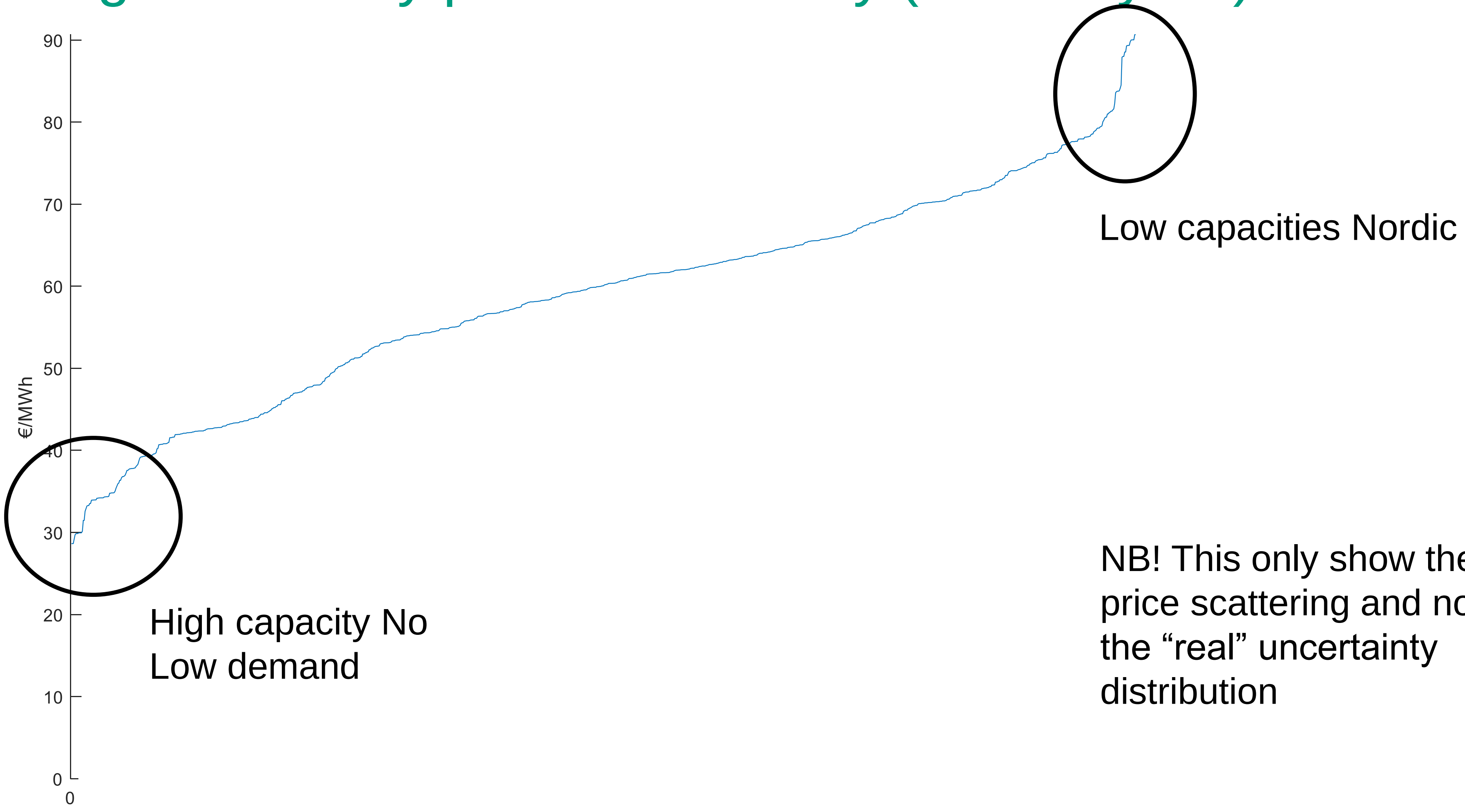
		Lower bound	Upper bound
Investment costs	MUNIWASTE	-27 %	37 %
	WindOn	-17 %	75 %
	WindOff	-20 %	10 %
	SolarCol	-13 %	14 %
	SolarPV	-36 %	22 %
	NATGAS	-33 %	63 %
	PellCHP	-24 %	46 %
	PellHeatOnly	-17 %	46 %
	ChipsCHP	-23 %	43 %
	ChipsHeatOnly	-29 %	92 %
	HeatPump	-22 %	38 %
	NATGASHeatOnly	-30 %	400 %
	BiogassCHP	-6 %	41 %
Operation and management costs	MUNIWASTE	-27 %	29 %
	WindOn	-20 %	20 %
	WindOff	-20 %	10 %
	SolarCol	-13 %	0 %
	SolarPV	-26 %	29 %
	NATGAS	-25 %	75 %
	PellCHP	-32 %	31 %
	PellHeatOnly	-22 %	33 %
	ChipsCHP	-39 %	31 %
	ChipsHeatOnly	-79 %	150 %
	HeatPump	-25 %	40 %
	NATGASHeatOnly	-41 %	120 %
	BiogassCHP	-33 %	100 %
Conversion effectivity	MUNIWASTE	-20 %	14 %
	NATGAS	-20 %	5 %
	PellCHP	-8 %	41 %
	PellHeatOnly	-12 %	1 %
	ChipsCHP	-10 %	43 %
	ChipsHeatOnly	-12 %	14 %
	HeatPump	-23 %	1 %
	NATGASHeatOnly	-10 %	2 %
	BiogassCHP	-11 %	2 %

		Mean [€/GJ]	std
Fuel price	Coal	2.74	32 %
	NatGas	7.81	26 %
	FuelOil	11.82	106 %
	WoodChips	10.14	9 %
	WoodPellets	12.44	11 %

Normal distributed

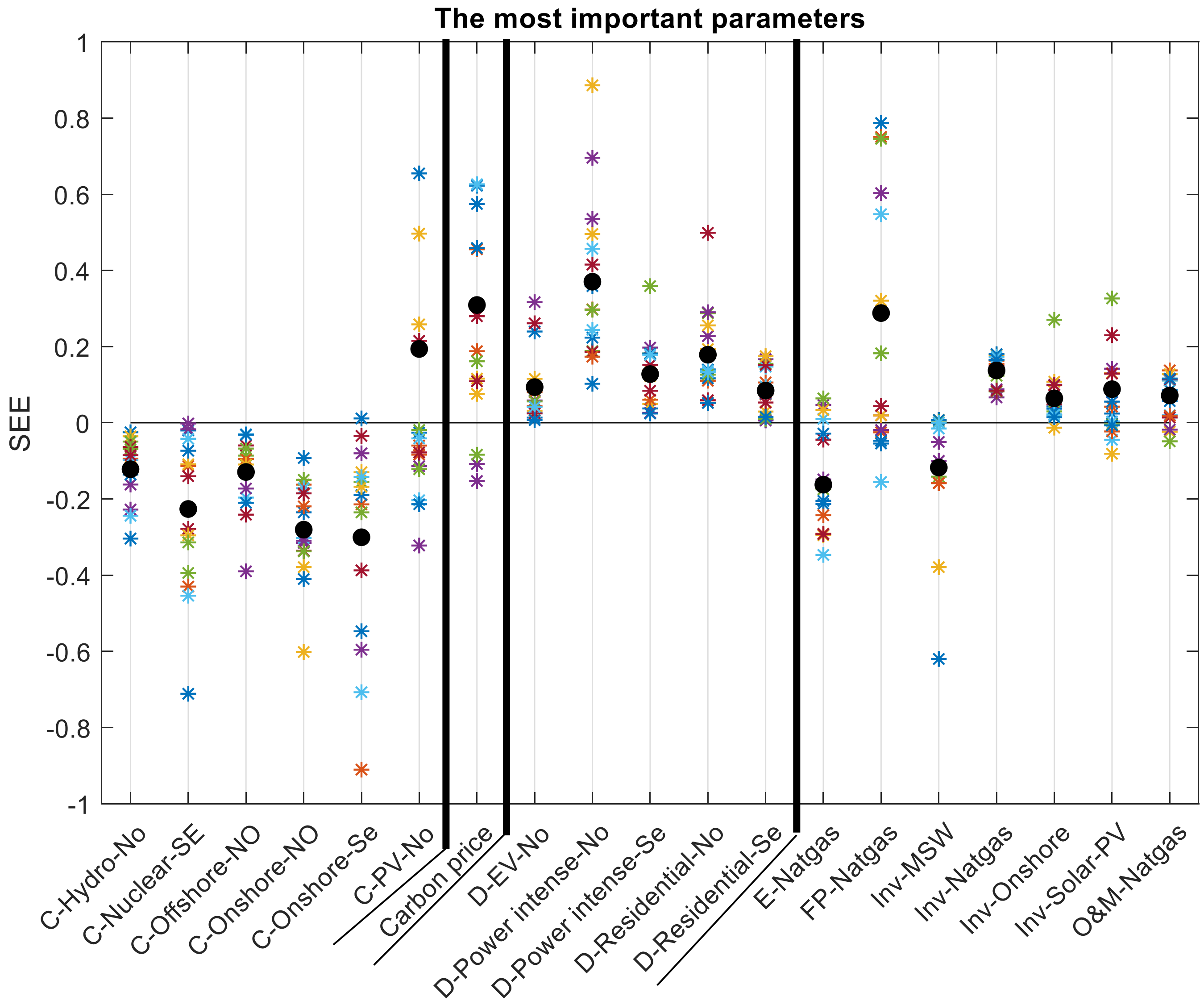
Preliminary results

Preliminary result:
Annual average electricity prices in Norway (normal year)



NB! This only show the price scattering and not the “real” uncertainty distribution

Variance



INTERPRETATIONS

High absolute mean (black bullet point)
⇒ High influence on the electricity prices

High scattering
⇒ Importance is dependent on other parameters (correlations)

Negative numbers
⇒ Higher input gives lower electricity price in Norway

Positive number
⇒ Higher input gives higher electricity price in Norway

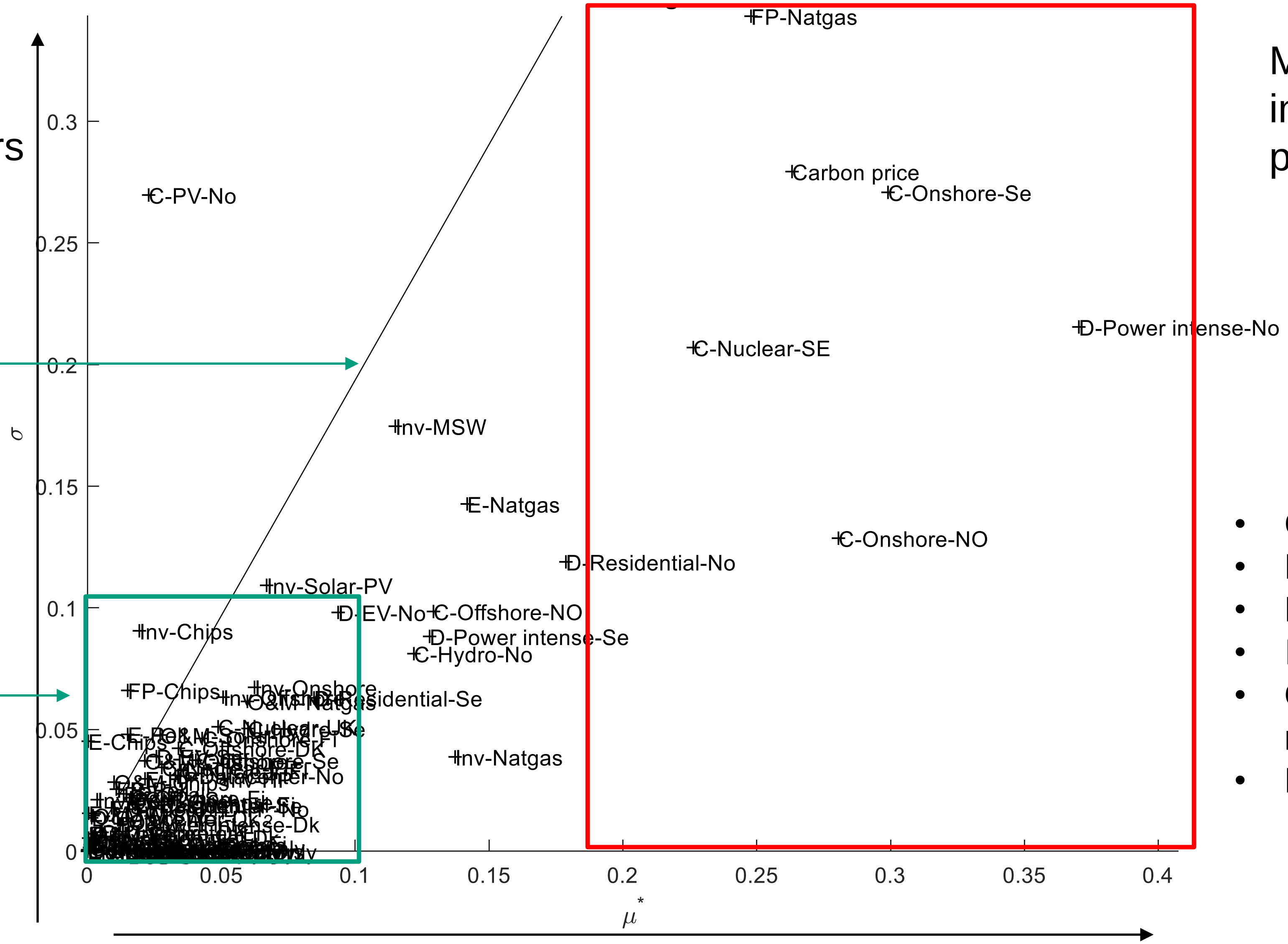
ABBREVIATIONS
C – Capacity constraint,
E – Effectivity
FP – Fuel price,
Inv – Investment cost
O&M – Operation and mangement costs
D – electricty demand

Connection between the parameters

Higher interference with other parameters

2*SEM
=> Parameters to the left has non-significant contribution

Close to no influence



Higher importance

Most important/influence parameters

- C – Capacity constraint
- E – Effectivity
- FP – Fuel price
- Inv – Investment cost
- O&M – Operation and mangement costs
- D – electricty demand

Next steps and discussion points

- Next step:
  - Include a more formal uncertainty analysis of the 10-15 most important factors with use of Monte Carlo simulations.

- Discussion:
  - Do these assumed uncertainty ranges cover the assumed uncertainty level in 2040?
  - Are there important uncertainty factors missing?
  - Other comments