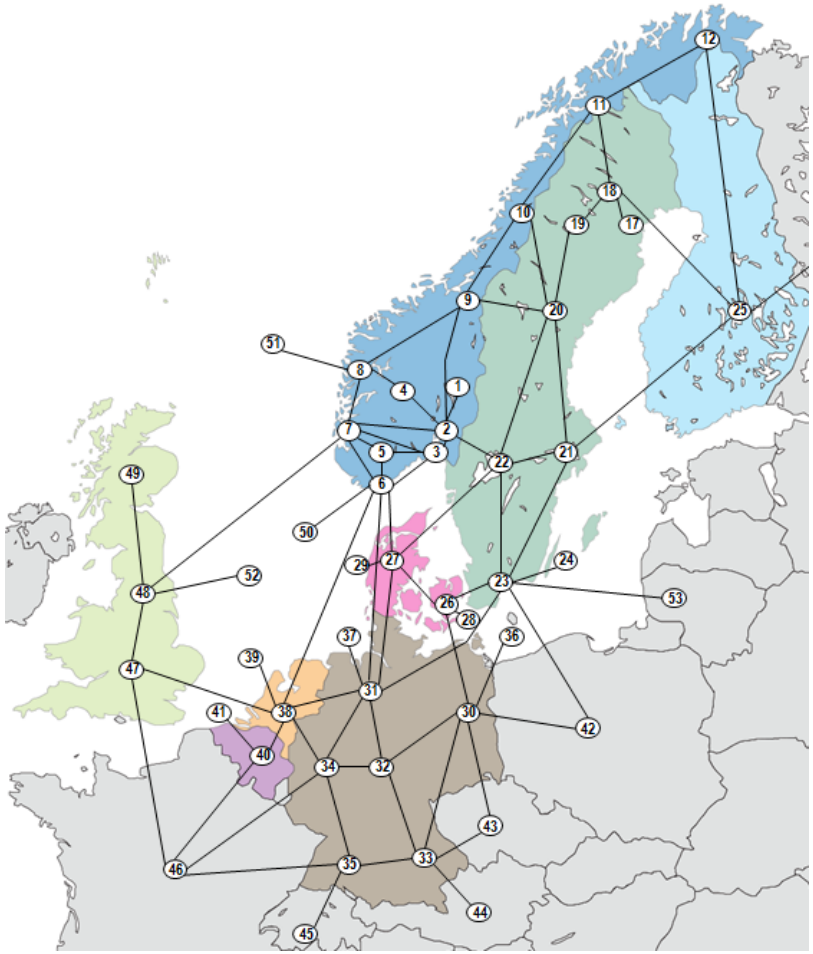
Investment Analyses

- A new functionality for EMPS*

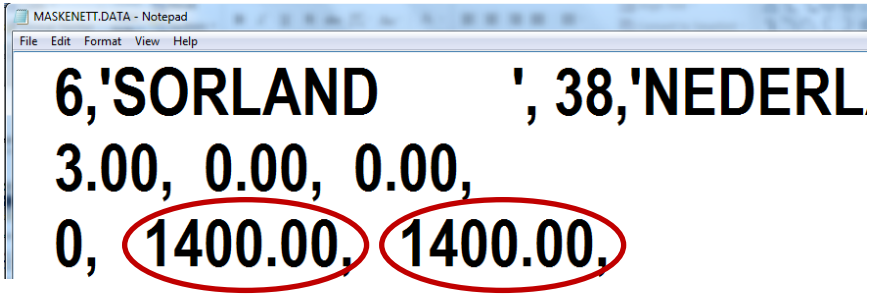


*) no: Samkjøringsmodellen

ove.wolfgang@sintef.no, Brukermøtet 2013, Trondheim 22. – 23. mai 2013.

Traditional approaches

- Capacities (MW)
  - Specified before simulation
  - Transmission, gas-power, …

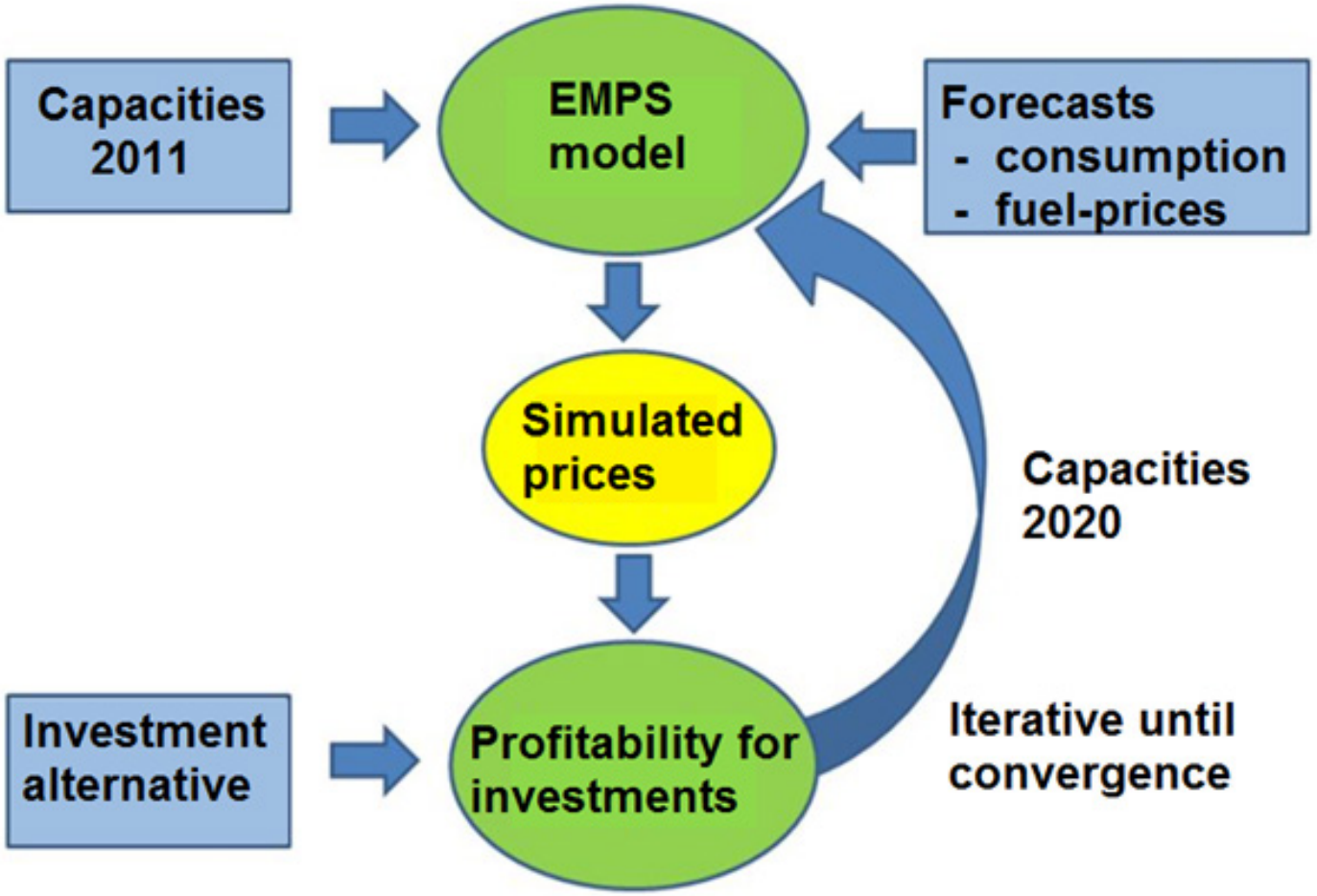


- Investment analysis
  - Run model with/without investment
  - *Δtotal surplus* vs. *investment costs*

- Future-year study (e.g. 2030)
  - Too many combinations (technology/MW/area)
  - External forecast, or user-tuning

New functionality

- profitable investments included step by step



Development

- Script-based system
  - Developed in 2008
  - Applied in several SINTEF-studies (ref last slide)
- On-going project
  - Implement in SAMINN
  - Advantage: Lower start-up costs for new users (users & developer)
  - Energinet.dk, Fingrid, NVE, Vattenfall, and LinkS-project (SINTEF)
- First version is ready for use

Investment options

- Transmission lines
  - MASKENETT.DATA capacities
- Thermal power units
  - Gas, coal, nuclear, …
  - Units on preference function, ENMDAT
- Renewable power
  - Wind, solar, and run-of-river
  - Scaling of energy-series (e.g. V30)

Inputs

- All units are specified in dataset from start
- Extra information
  - Investment objects
  - Initial capacity (MW)
  - Investment costs (€ per MW per year)
  - …
- New input-files
  - TERMISK.XML, VIND.XML, LINJER.XML (opened in Excel)
  - Default-files created if non-existing

Outputs

- Investments
  - Amount (MW)
  - Technology
  - Area

Ex: 2100 MW, gas-power, Belgium

- Standard EMPS output
  - Prices
  - Production
  - Transmission
  - …

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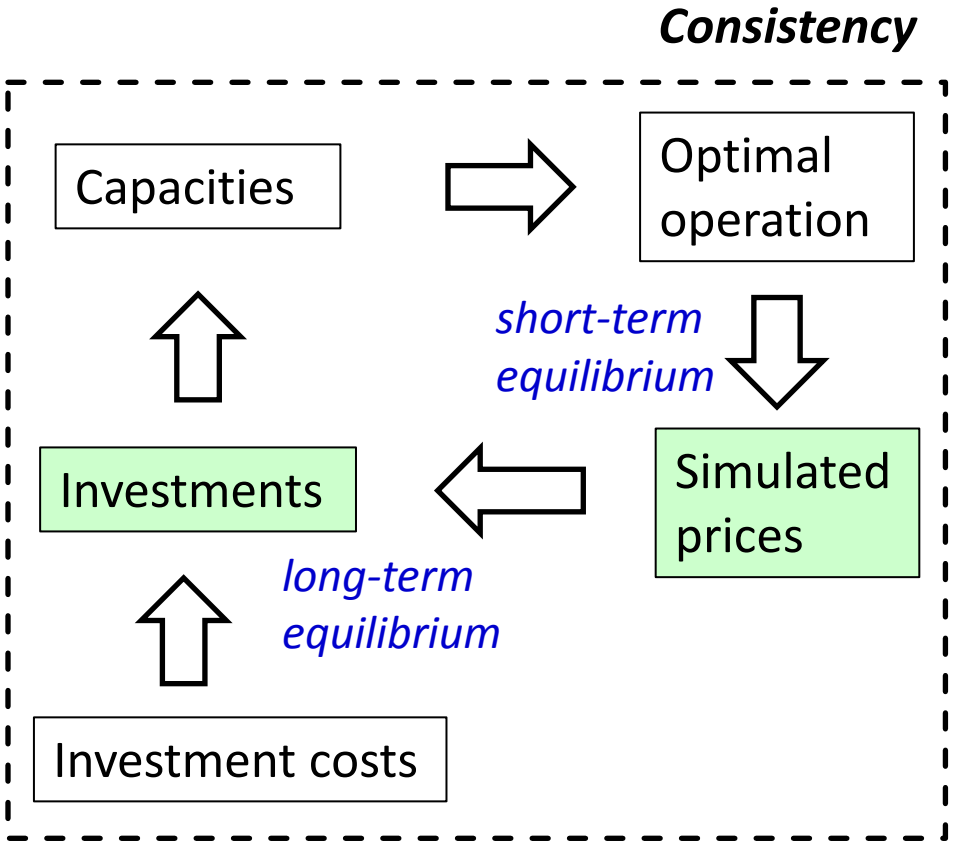


TERMISK.XML

- default values

	A	B	C	D	E	F	G	H	I	J	K
1	area	name	nu	name3	init	start	max	step	cost	unit	trig
2	40	BELGIA	10	GAS	2326	0		1000		EUR	30
3	40	BELGIA	11	GT_GAS	476	0		1000		EUR	30
4	40	BELGIA	12	DH_GAS_KO	779	0		1000		EUR	30
5	40	BELGIA	13	NUCLEAR	4217	0		1000		EUR	30
6	40	BELGIA	14	BIO NEW	2470	0		1000		EUR	30
7	40	BELGIA	15	GAS NEW	1337	0		1000		EUR	30
8	40	BELGIA	16	GAS GT NEW	5350	0		1000		EUR	30
9	40	BELGIA	50	DH_GAS_BP	559	0		1000		EUR	30

VIND.XML

- default values

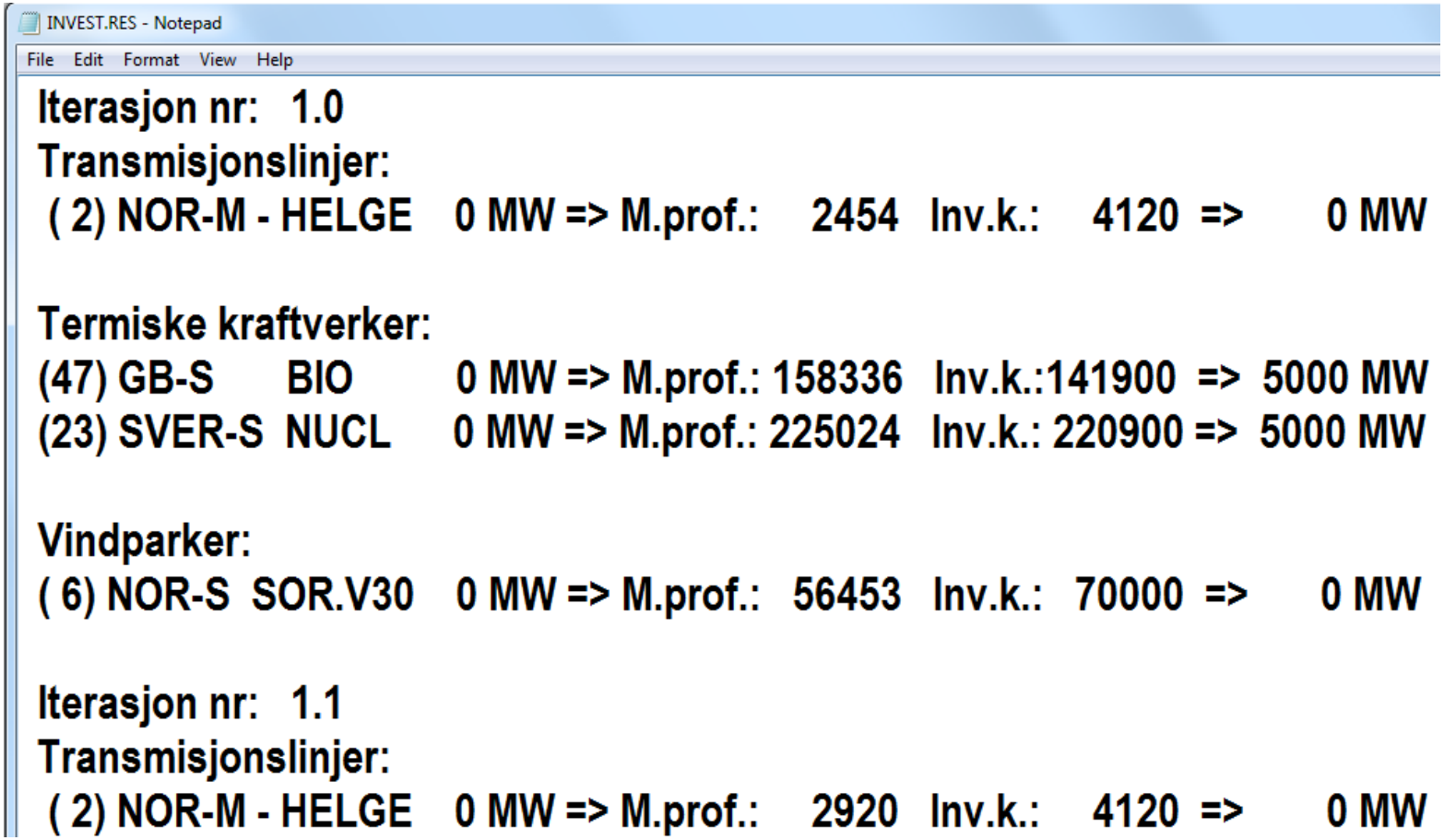
A	B	C	D	E	F	G	H	I	J	K
area	name	name3	init	scale	start	max	step	cost	uni	trig
6	NOR-SORLAND	NOR-SORLAND.V30	1000	1000	0		1000		EUR	30
7	NOR-VESTSYD	NOR-VESTSYD.V30	1000	1000	0		1000		EUR	30
8	NOR-VESTMIDT	NOR-VESTMIDT.V30	1000	1000	0		1000		EUR	30
9	NOR-MIDT	NOR-MIDT.V30	1000	1000	0		1000		EUR	30
10	NOR-HELGE	NOR-HELGE.V30	1000	1000	0		1000		EUR	30
11	NOR-TROMS	NOR-TROMS.V30	1000	1000	0		1000		EUR	30
12	NOR-FINNMARK	NOR-FINNMARK.V30	1000	1000	0		1000		EUR	30
17	SVER-ON1	SVER-ON1.V30	1000	1000	0		1000		EUR	30

LINJER.XML
- default values

from	name	to	name2	init	start	max	step	cost	unit	trig
2	NOR-OSTLAND	4	NOR-HALLING	3300	0		1000		EUR	30
2	NOR-OSTLAND	5	NOR-TELEMARK	800	0		1000		EUR	30
2	NOR-OSTLAND	7	NOR-VESTSYD	900	0		1000		EUR	30
2	NOR-OSTLAND	9	NOR-MIDT	600	0		1000		EUR	30
2	NOR-OSTLAND	22	SVER-MVEST	3400	0		1000		EUR	30
3	NOR-SOROST	5	NOR-TELEMARK	1800	0		1000		EUR	30
3	NOR-SOROST	7	NOR-VESTSYD	1000	0		1000		EUR	30
4	NOR-HALLING	8	NOR-VESTMIDT	1800	0		1000		EUR	30
5	NOR-TELEMARK	6	NOR-SORLAND	800	0		1000		EUR	30

INVEST.RES

Example; file shortened

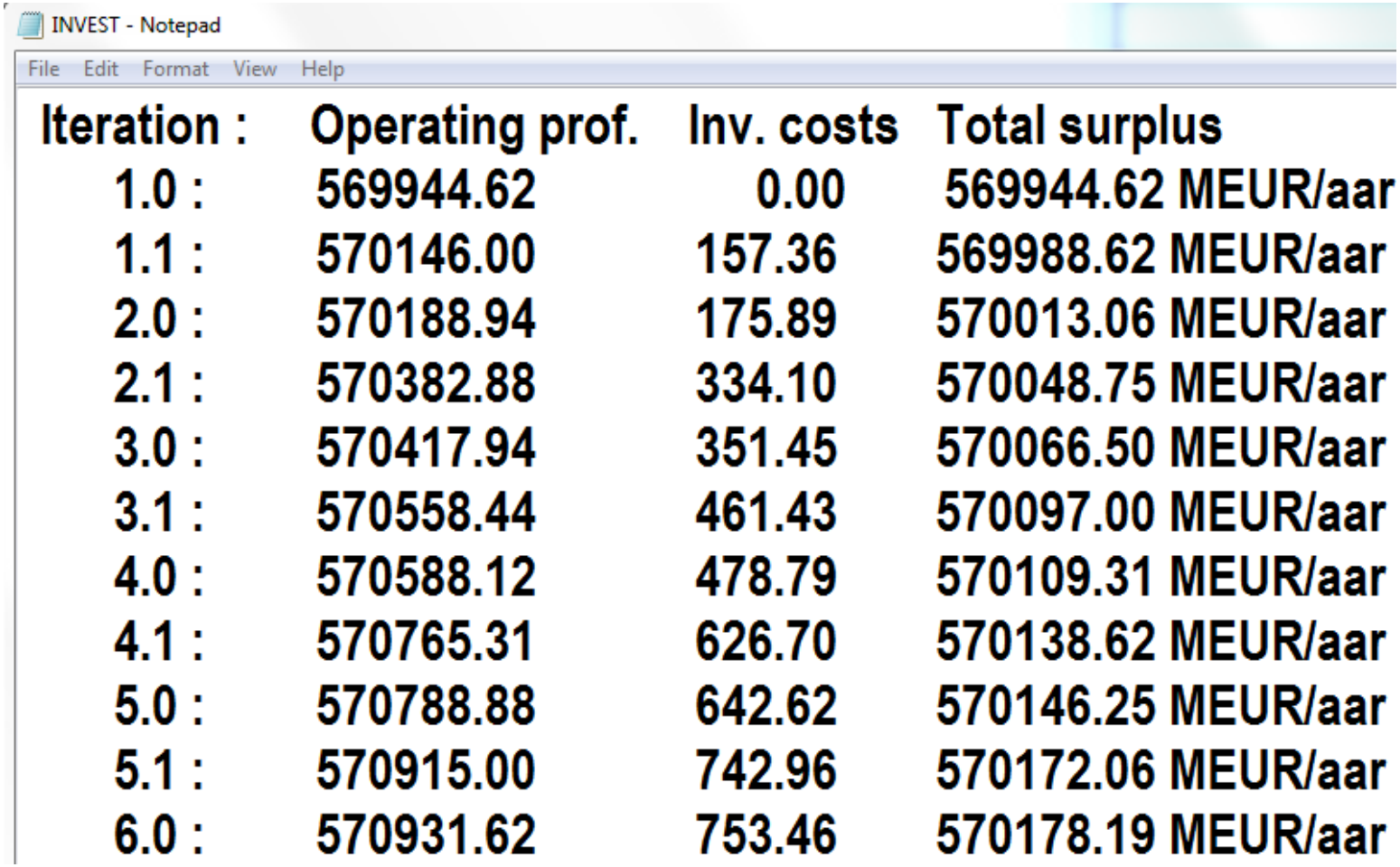

INVEST.RES - Notepad

File Edit Format View Help

```
Iterasjon nr:  1.0
Transmisjonslinjer:
 ( 2) NOR-M - HELGE   0 MW => M.prof.:    2454  Inv.k.:    4120  =>      0 MW

Termiske kraftverker:
(47) GB-S      BIO      0 MW => M.prof.: 158336  Inv.k.:141900  =>  5000 MW
(23) SVER-S  NUCL       0 MW => M.prof.: 225024  Inv.k.: 220900 =>  5000 MW

Vindparker:
( 6) NOR-S  SOR.V30     0 MW => M.prof.:  56453  Inv.k.:  70000  =>     0 MW

Iterasjon nr:  1.1
Transmisjonslinjer:
 ( 2) NOR-M - HELGE   0 MW => M.prof.:    2920  Inv.k.:    4120  =>      0 MW
```

INVEST.SURPLUS

Example


INVEST - Notepad

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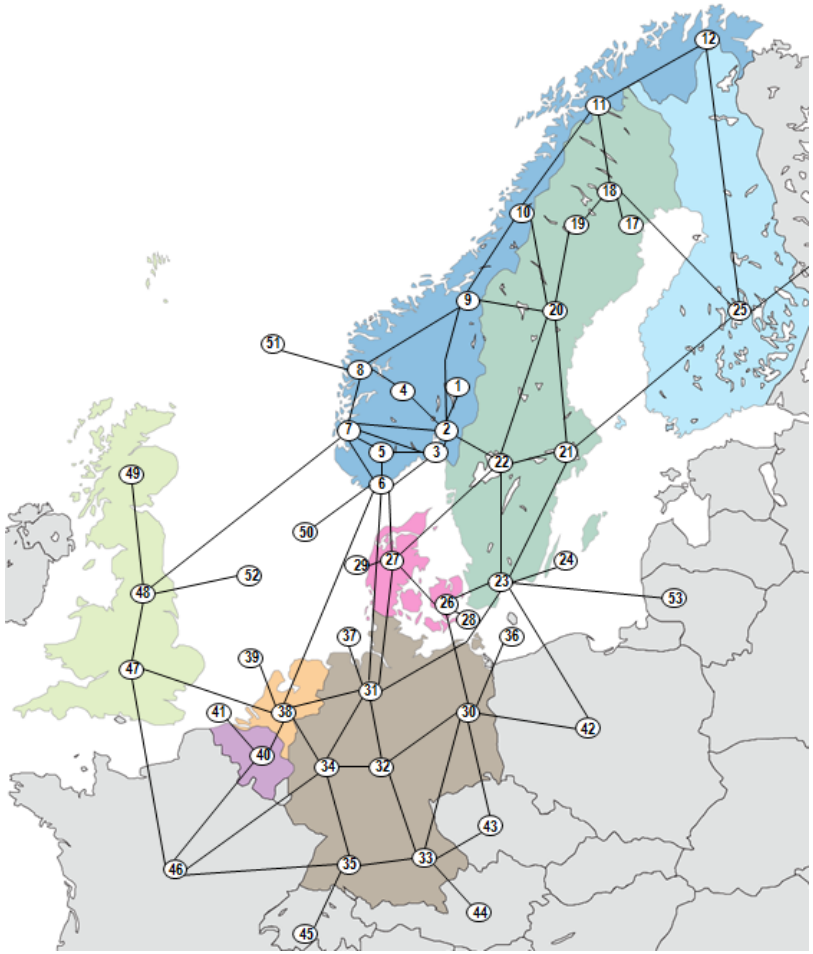
Iteration :	Operating prof.	Inv. costs	Total surplus
1.0 :	569944.62	0.00	569944.62 MEUR/aar
1.1 :	570146.00	157.36	569988.62 MEUR/aar
2.0 :	570188.94	175.89	570013.06 MEUR/aar
2.1 :	570382.88	334.10	570048.75 MEUR/aar
3.0 :	570417.94	351.45	570066.50 MEUR/aar
3.1 :	570558.44	461.43	570097.00 MEUR/aar
4.0 :	570588.12	478.79	570109.31 MEUR/aar
4.1 :	570765.31	626.70	570138.62 MEUR/aar
5.0 :	570788.88	642.62	570146.25 MEUR/aar
5.1 :	570915.00	742.96	570172.06 MEUR/aar
6.0 :	570931.62	753.46	570178.19 MEUR/aar

Example study

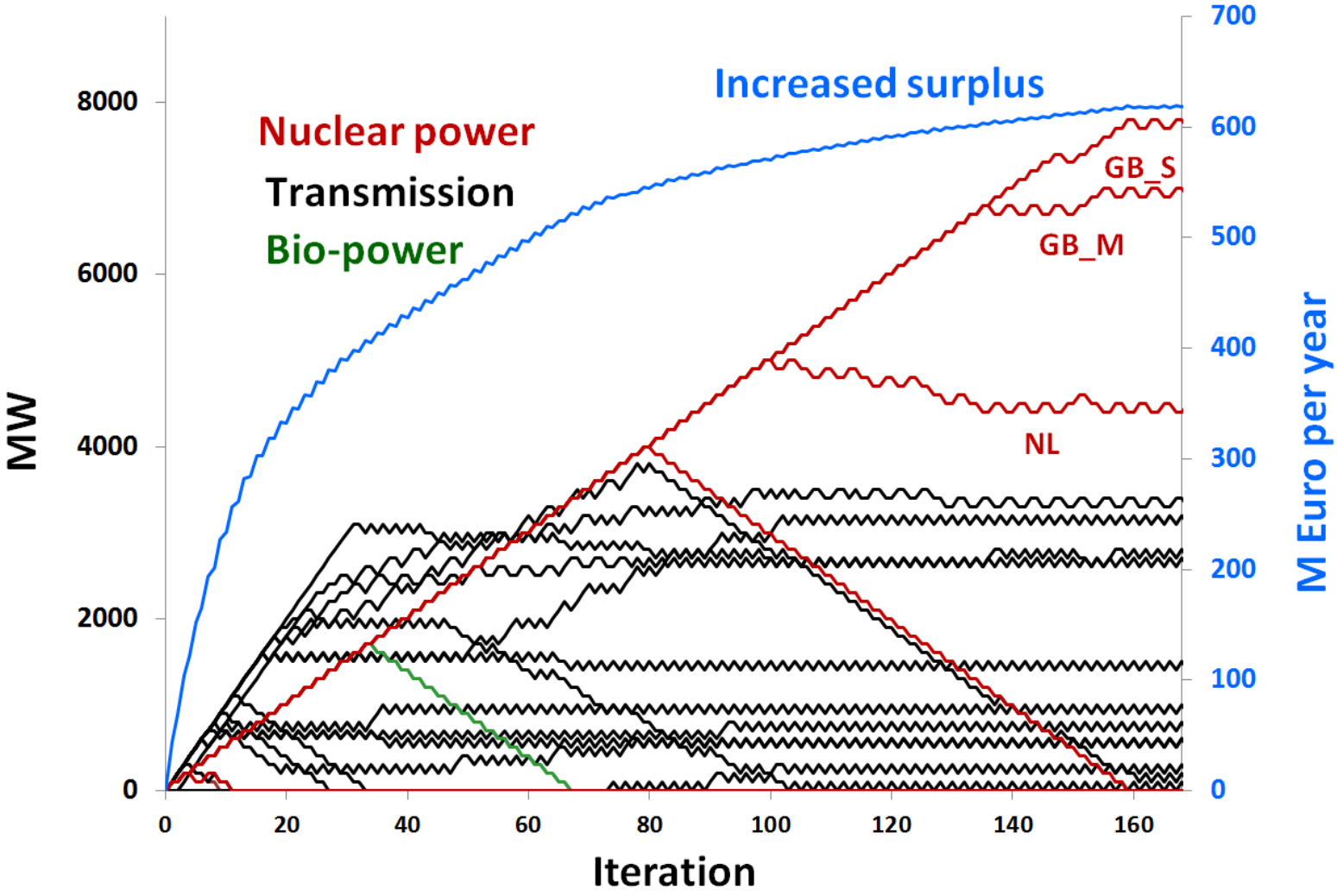
- Data-set
  - "Role of North Sea", KMB *)
  - North Europe, 2020
  - 20/20/20, ENTSO-E, Primes, …
- Investments
  - Transmission lines
  - Thermal power (gas, coal, nuclear, …)



*) Scenario A1, but without external trade

Results

per iteration, 100 MW steps

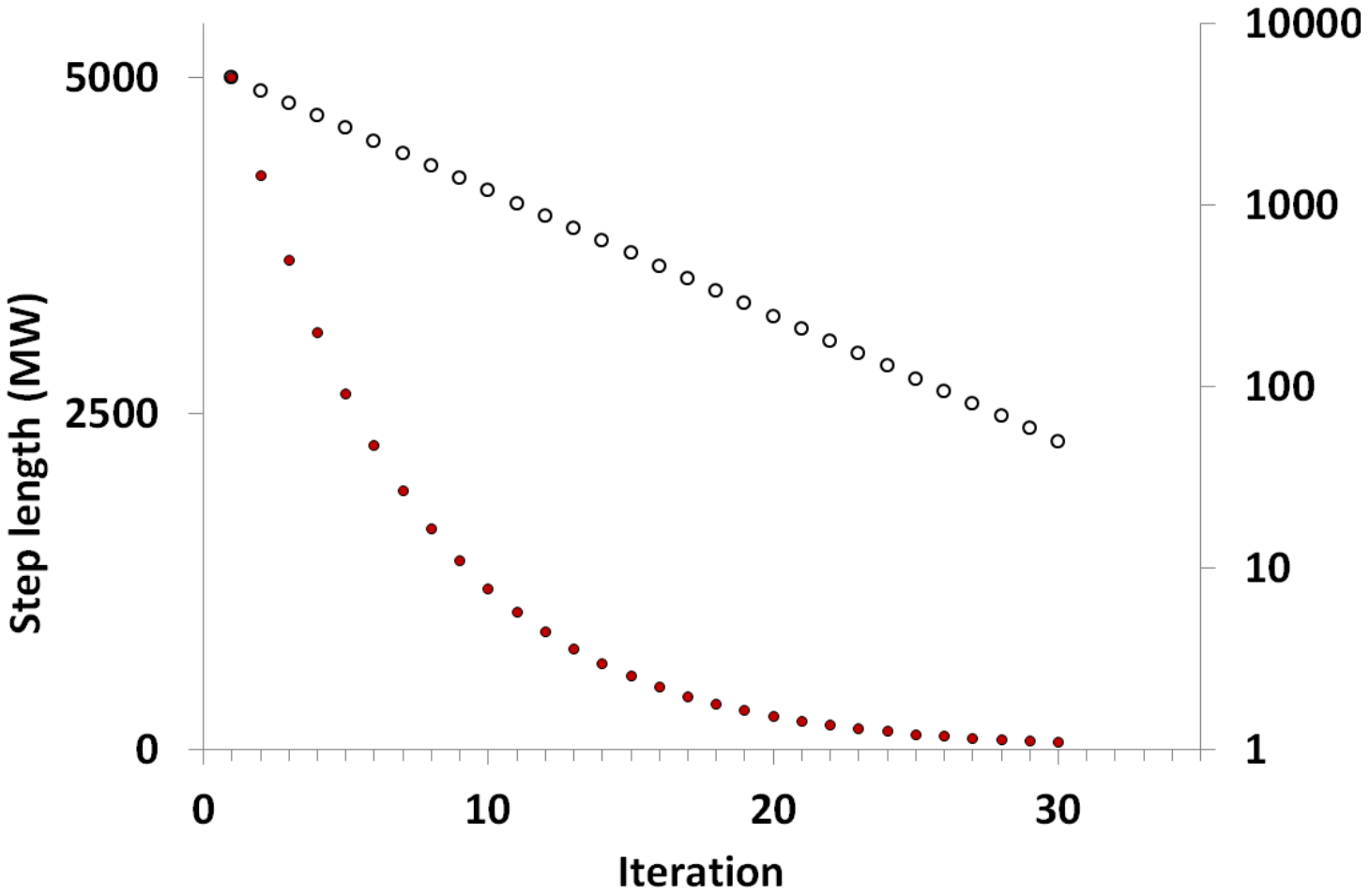


Search for solution

- Price-based optimization per investment
  - Will in principle lead to system-optimization
  - Cf. previous slide
  - But could there be several local optima?
- One simple test: compare two search paths
  - Alt 1: 100 MW steps
  - Alt 2: Default profile

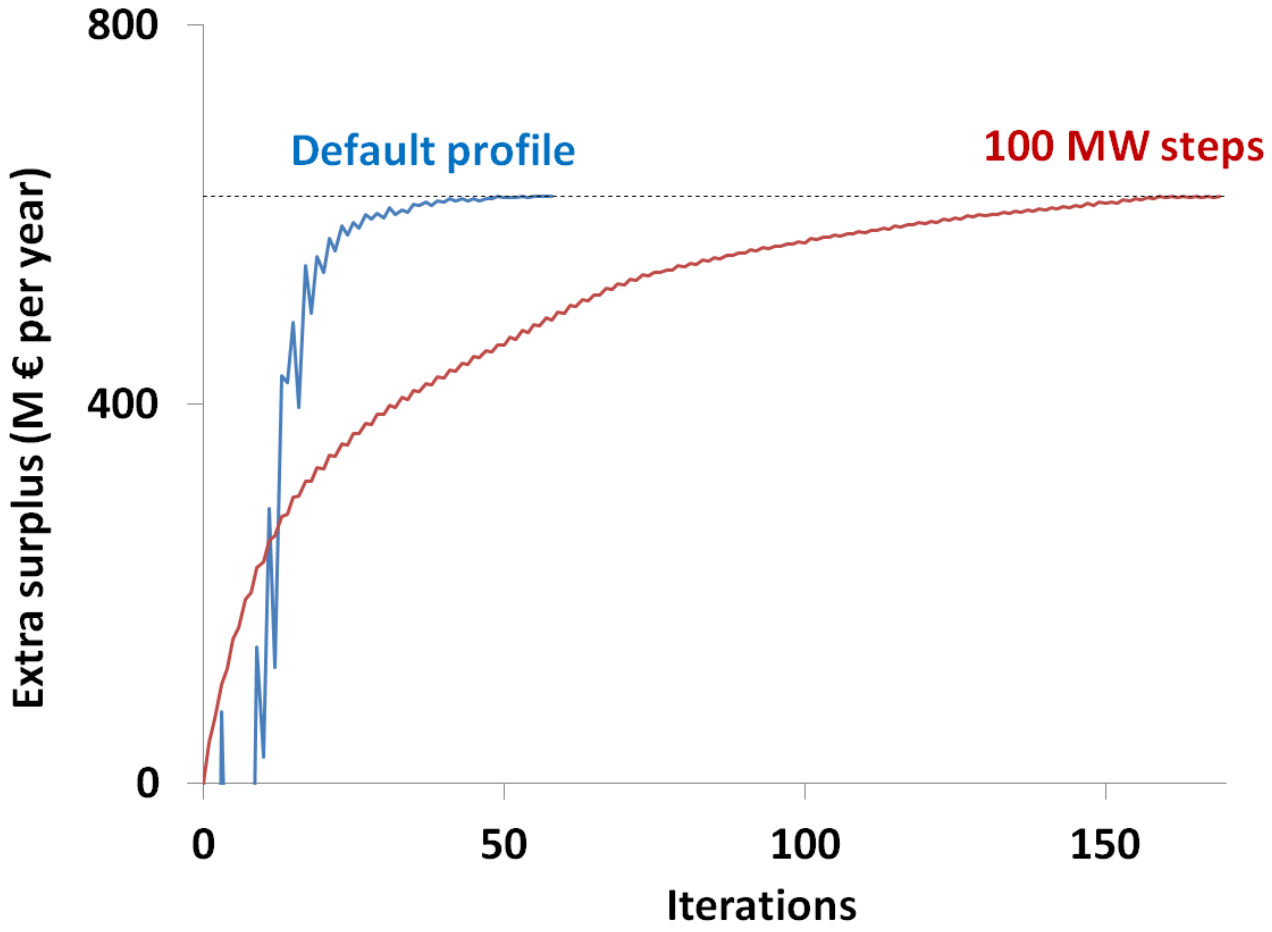
Default profile

reduce by same % in each new iteration



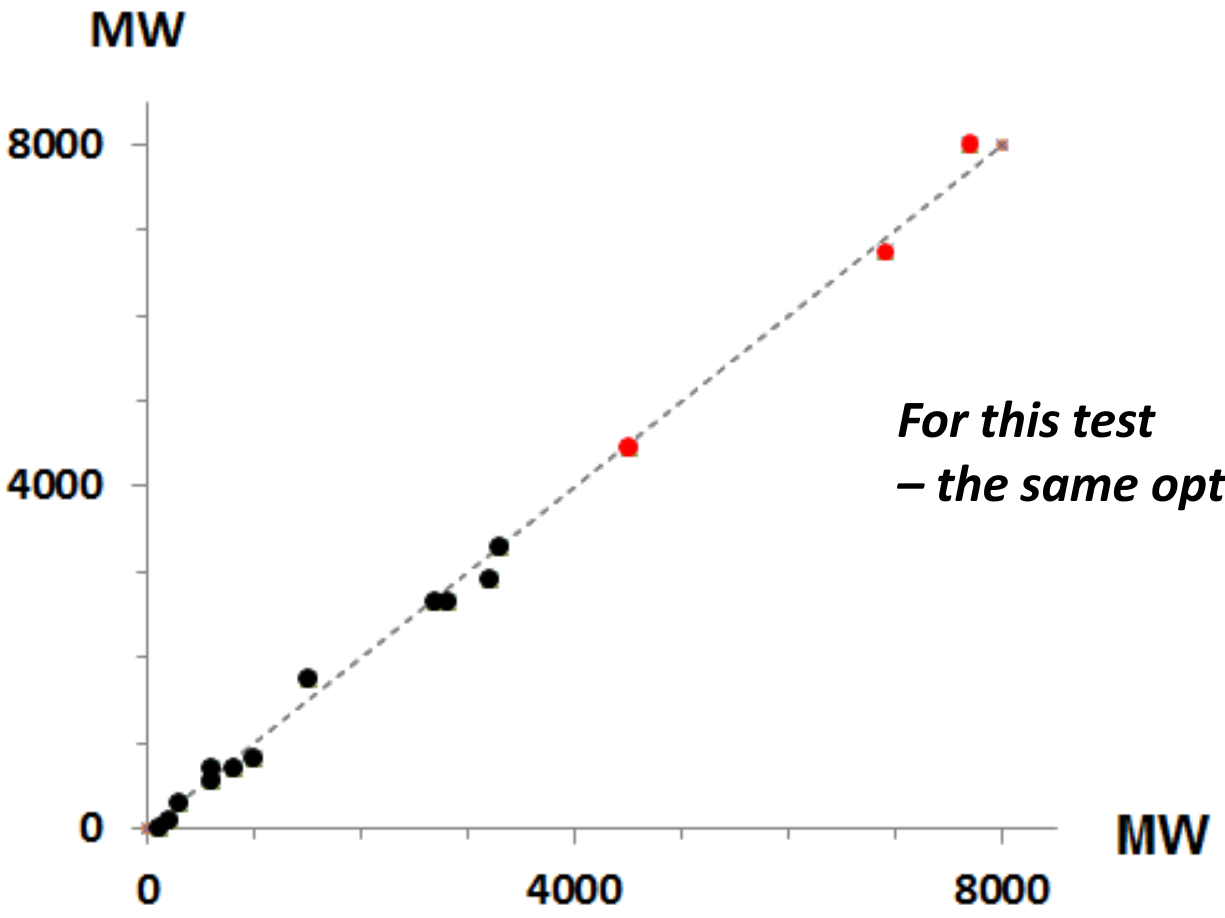
Results for economic surplus

100 MW steps vs. default profile



Results for investments

100 MW steps vs. default profile



For this test
– the same optimum

Possibilities for future development

- Model-determined capacity-retirement
- Several steps (step-by-step or rational expectations)
- Uncertainty, e.g. in fuel & CO2-prices
- Detailed power flow
- Interactions with other markets
  - Capacity market
  - Renewable subsidy

SINTEF publications

Transmission capacity expansion studies

Graabak, Wolfgang, Bakken (2013), "Profitable increases in cross border transmission capacities in a European power system with large shares of renewables", PowerTech 2013 (accepted).

Jaehnert, Farahmand, Völler, Wolfgang, Huertas-Hernando (2012), "Assessment of a methodology for transmission expansion planning around the North Sea", 11th International Workshop on Transmission Networks for Offshore Wind Power Plants, November 2012, Lisbon, Portugal.

Jaehnert, Wolfgang, "Transmission expansion planning in Northern Europe in 2030 - Methodology and analyses Energy Policy, forthcoming.

Völler, Huertas-Hernando, Wolfgang (2012), "Onshore and Offshore Transmission Expansion in the European Grid for Large Scale Wind Integration in the North Sea", Proceedings of the 2012 CIGRE session 44, 26 - 31 August 2012, PARIS