Market RES

Market performance: energy only, capacity remuneration & RES support schemes

Peter Ahcin
SINTEF Energy Research

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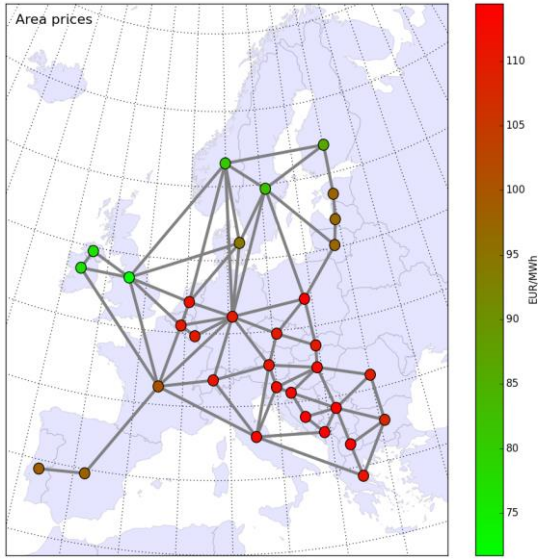
Overview of the tasks and the model

- Analysing different visions from ENTSO-E with CRM and increased RES
  - Vision 3 as reference case and Vision 4 with more RES
  - Implementing in both cases CRM with increased production capacity

- Compare the differences between the cases for e.g.:
  - Prices in the countries
  - Profitability of the technologies
  - Producer vs. consumer surplus
  - RES share and production

- Model in EMPS
  - Each country is one area including different types of power plants, consumption, timeseries for RES…
  - Countries are connected via lines with transfer limits



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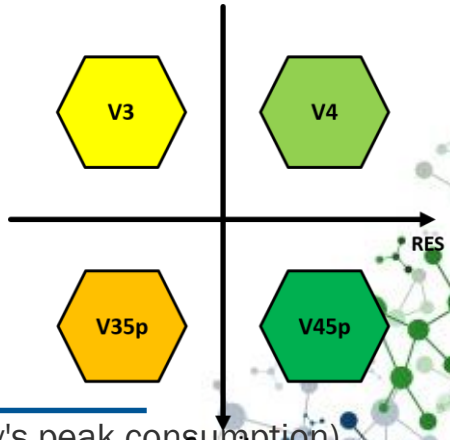
Capacity remuneration mechanism and RES support

- Base-visions are taken from ENTSO-E
  - V3 – "National Green Transition"

    Weak coordination among the countries, minor changes at the energy market, favour old technologies, high CO_2 prices, weaker interconnections
  - V4 – "European Green Revolution"

    Coordinated European energy strategy, highest support for RES, new market designs, coordinated R&D for new technologies, high CO_2 prices

- Four different visions including CRM and RES support
  - V3 Energy only market without any support
  - V35p CRM without RES support
  - V4 Energy only market with RES support
  - V45p CRM and RES support



CRM additional gas power capacity in each country (extra 5% of the country's peak consumption)

RES increased installed RES-capacity by 37% (production share of RES increases from 47% to 57%)

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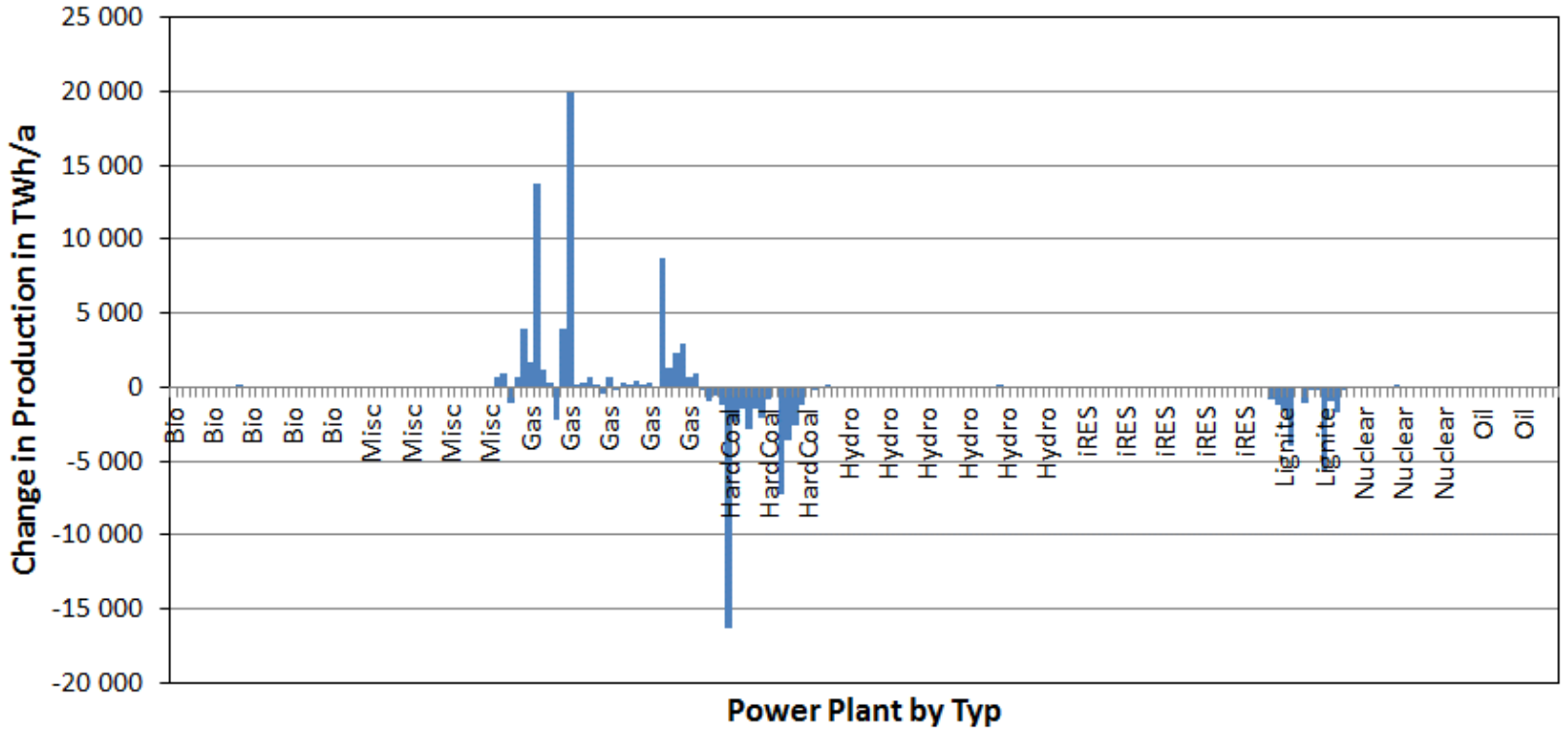
Scenarios considered in the analysis

Scenario name	Cost of capital	CO_2 price	Fuel prices	Wind and solar capacities
2020 scenario (ENTSO-E publications for 2020)	favorable economic and financial conditions	low CO_2 price	low primary energy prices	current RES targets for 2020
2030 Reference scenario (ENTSO-E "Green transition scenario" (TYNDP 2030 Vision 3))	favorable economic and financial conditions	high CO_2 price	low primary energy prices	current RES targets for 2030
2030 High scenario (ENTSO-E "Green revolution scenario" (TYNDP 2030 Vision 4))	favorable economic and financial conditions	high CO_2 price	low primary energy prices	higher share of renewables
2030 Low scenario (ENTSO-E "Slow progress scenario" (TYNDP Vision 1))	less favorable economic and financial conditions	low CO_2 price	high primary energy prices	lower share of renewables

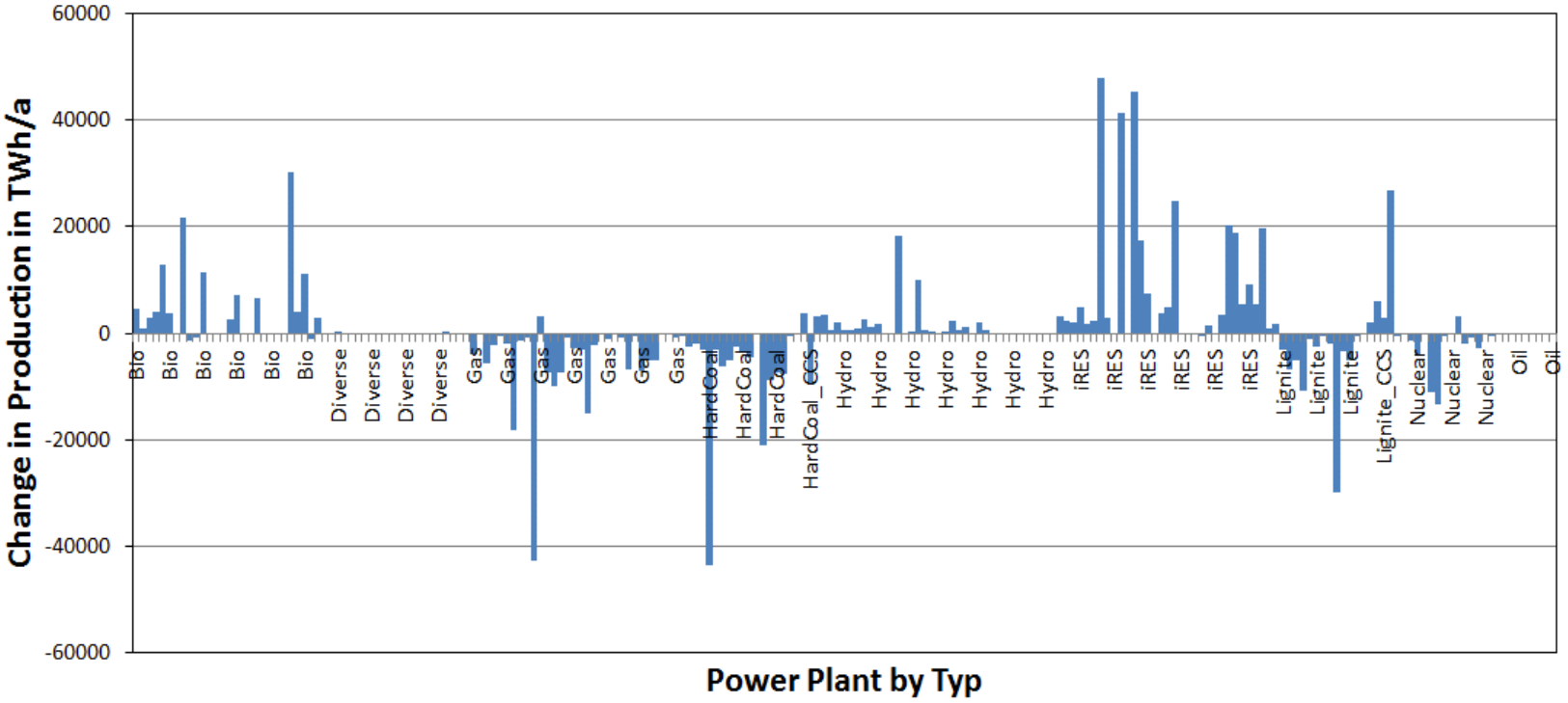
Change in production with CRM (V3 vs V35p)

- CRM = increasing the gas power capacity in each country
- Gas power will replace hard coal and lignite (also in V4 vs V45p)
  - Figure shows all power plants in the countries sorted by type (iRES = PV & wind)



Change in production with increased RES (V3 vs V4)

- 37% more RES (bio, hydro, iRES [PV & wind]) will substitute all other technologies
- Biggest changes in Spain, Germany, Italy and Poland
- Similar results for V35p vs V45p



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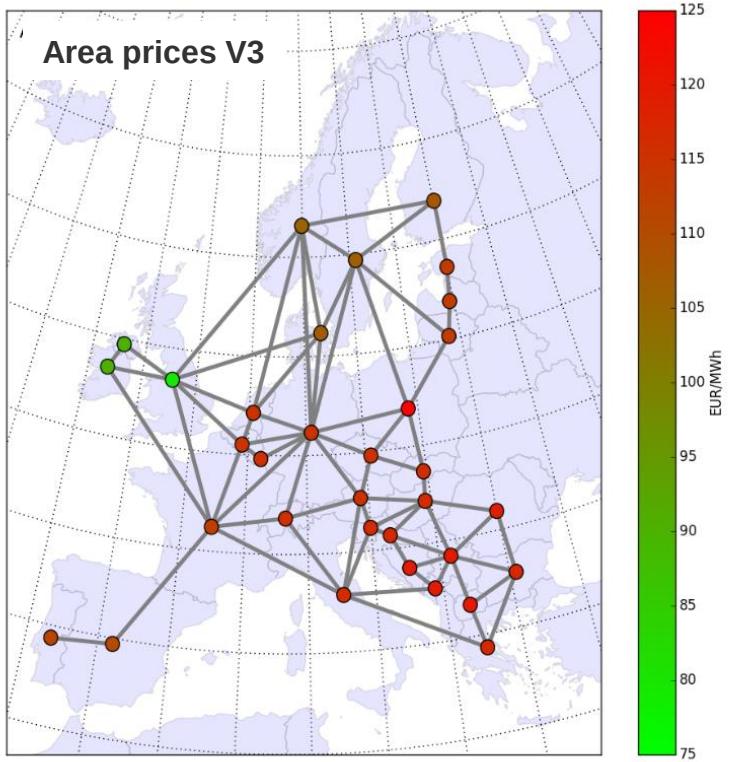
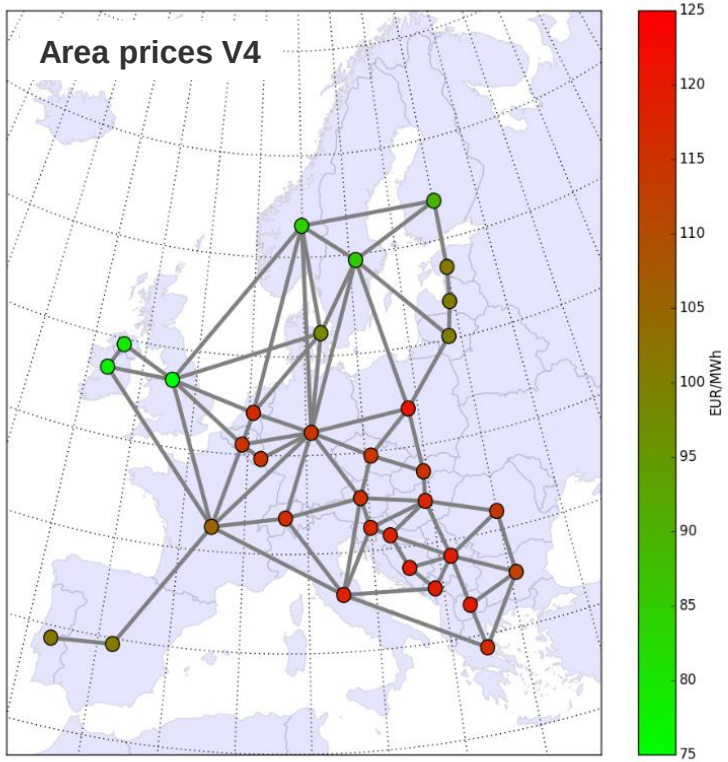
Average area power price

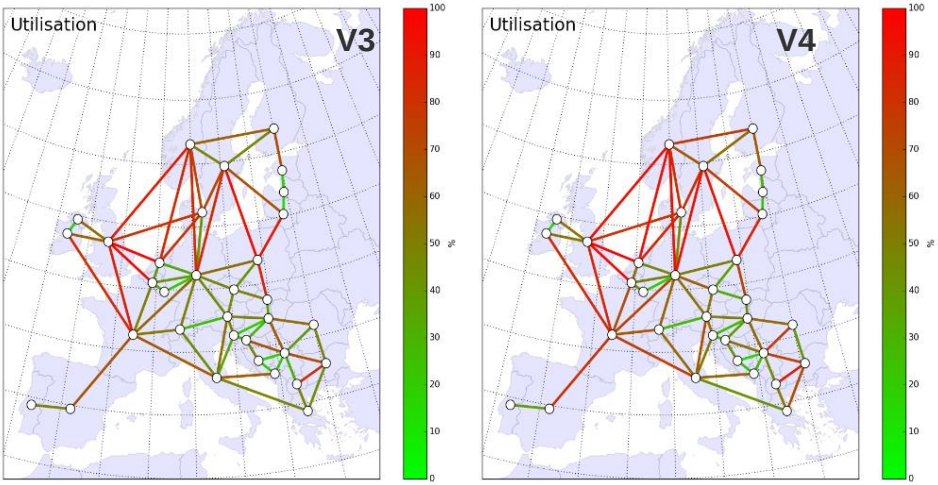
- The average power price over all timesteps lies between 75€/MWh (Great Britain) and 125€/MWh (Poland)
- The overall weighted average power price (price x production) decreases from V3 (111€/MWh) to V45p (102€/MWh)
- With an increased share of renewables prices in the Nordic area fall by 16%.

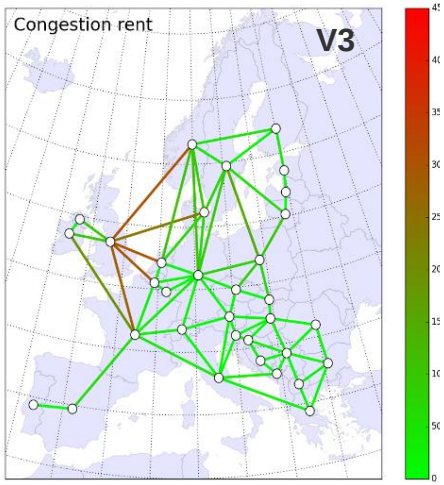


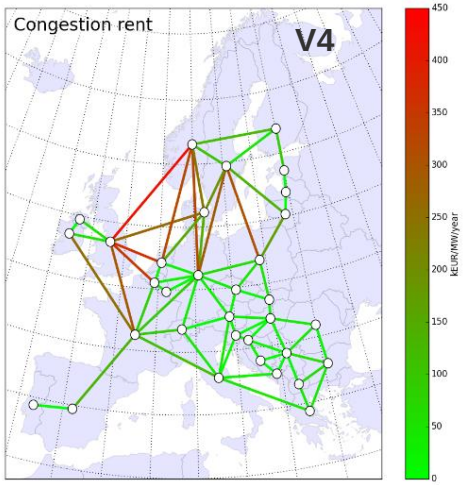


Utilization and congestion rent of the transmission system

- High utilization of the transmission system due to exchanged energy
- High congestion rent on subsea cables connecting Great Britain & the Nordic Area to Continental Europe due to price differences and limited transmission capacity
- Even with high utilization, the transmission capacity within Continental Europe is enough to avoid large congestion
- Increasing congestion frequency with increasing RES capacity



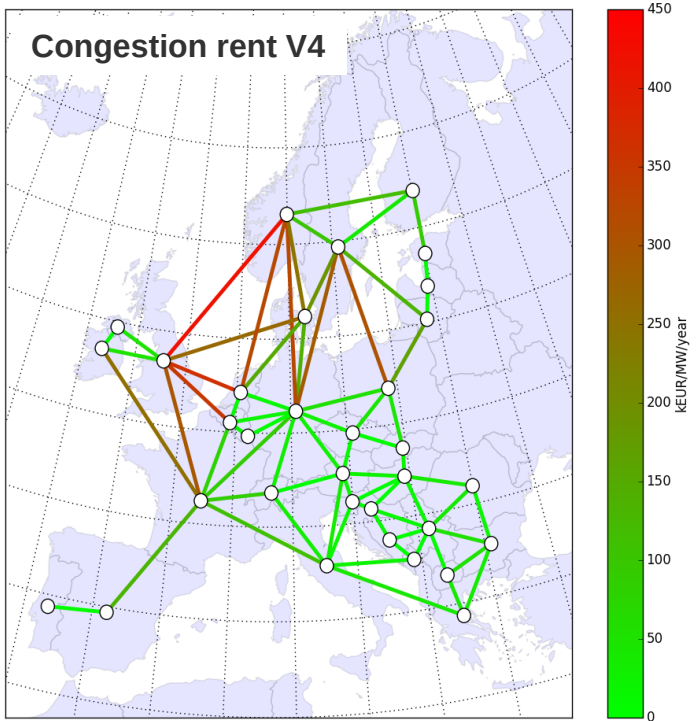




Need for more transmission capacity

- Norway, Sweden and the UK will produce together over 37% of all hydro power and over 27% of wind power in the ENTSO-E system in 2030.
- Given the insufficient transmission capacity and the abundance of this renewable low marginal cost electricity, prices in the these three countries will be relatively low compared to the rest of Europe.
- Congestion on the lines connecting Norway, Sweden and the UK to continental Europe will get more acute as renewables shares rise further after 2030.

- Additional transmission capacity could:
  - Reduce the amount of spilled energy.
  - Allow renewables to replace thermal generation on the continent.
  - Reward existing capacity and incentivize further development of these cheaper and clean sources.



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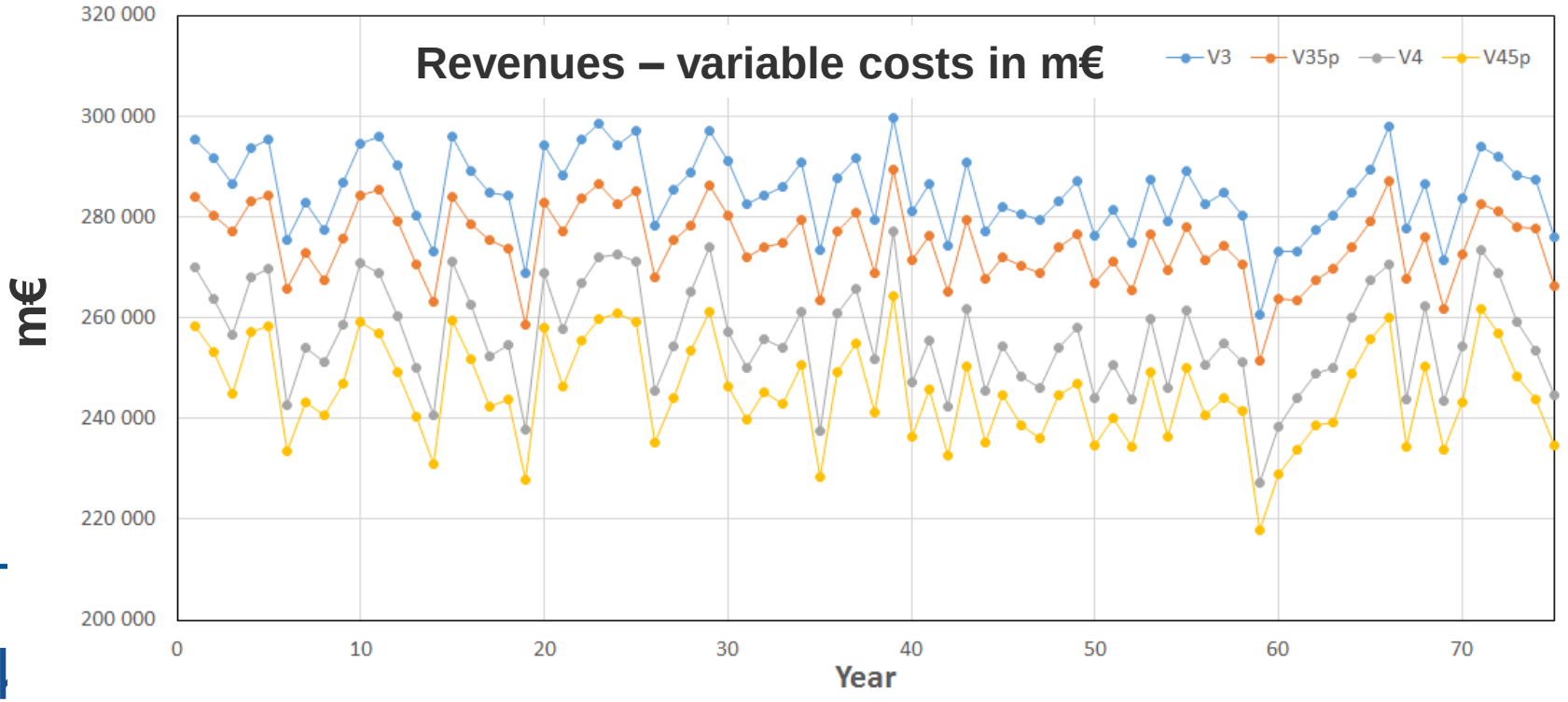
Revenue variability

- An increase in either flexible capacity or intermittent RES generation will result in lower prices and revenues.
- As the share of renewables increases the variance of yearly revenues increases over a lower base raising investor risk.



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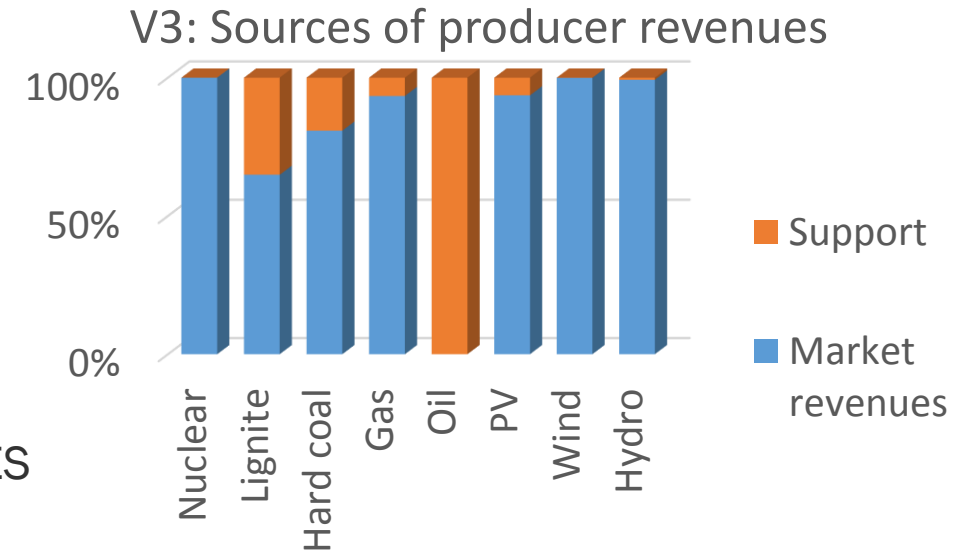
Producer/consumer surplus and social welfare

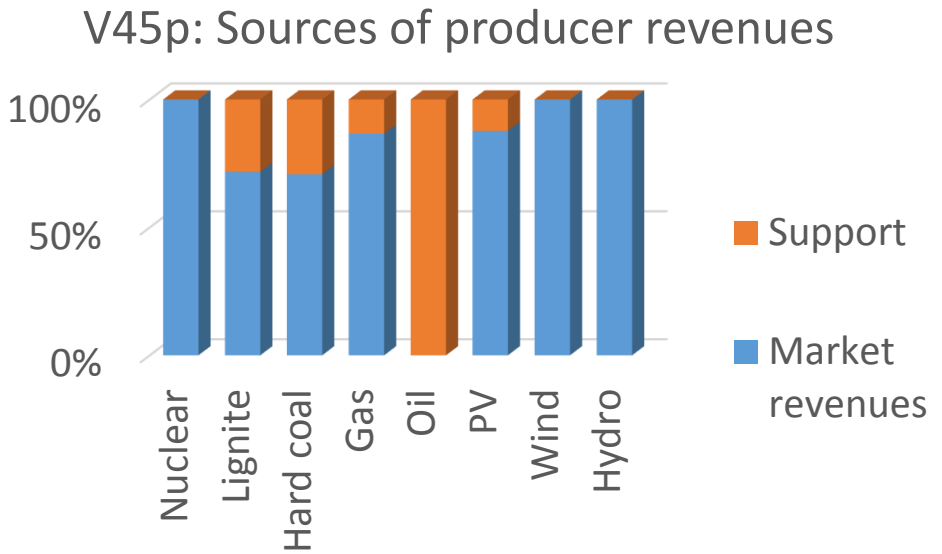
- Producer surplus is reduced with more CRM but increased with more RES. However, the investments in RES are greater than the surplus, so in the end all results are a loss for the producers.
- Consumers profit from CRM and RES and so does the social welfare.

	Producer surplus in M€	Consumer surplus in M€	Total welfare in M€
V3	79 446	10 378 075	10 457 521
V35p	63 373	10 394 360	10 457 733
V4	54 414	10 706 343	10 760 757
V45p	36 067	10 724 715	10 760 782

Cost of CRM and RES support

- The increase in both CRM and RES support cost is quite modest.
- Oil engines are never used. Would probably be taken out of operation.
- Even under V45 with a 57% share of RES and increased thermal capacity renewables seem to require little direct support.





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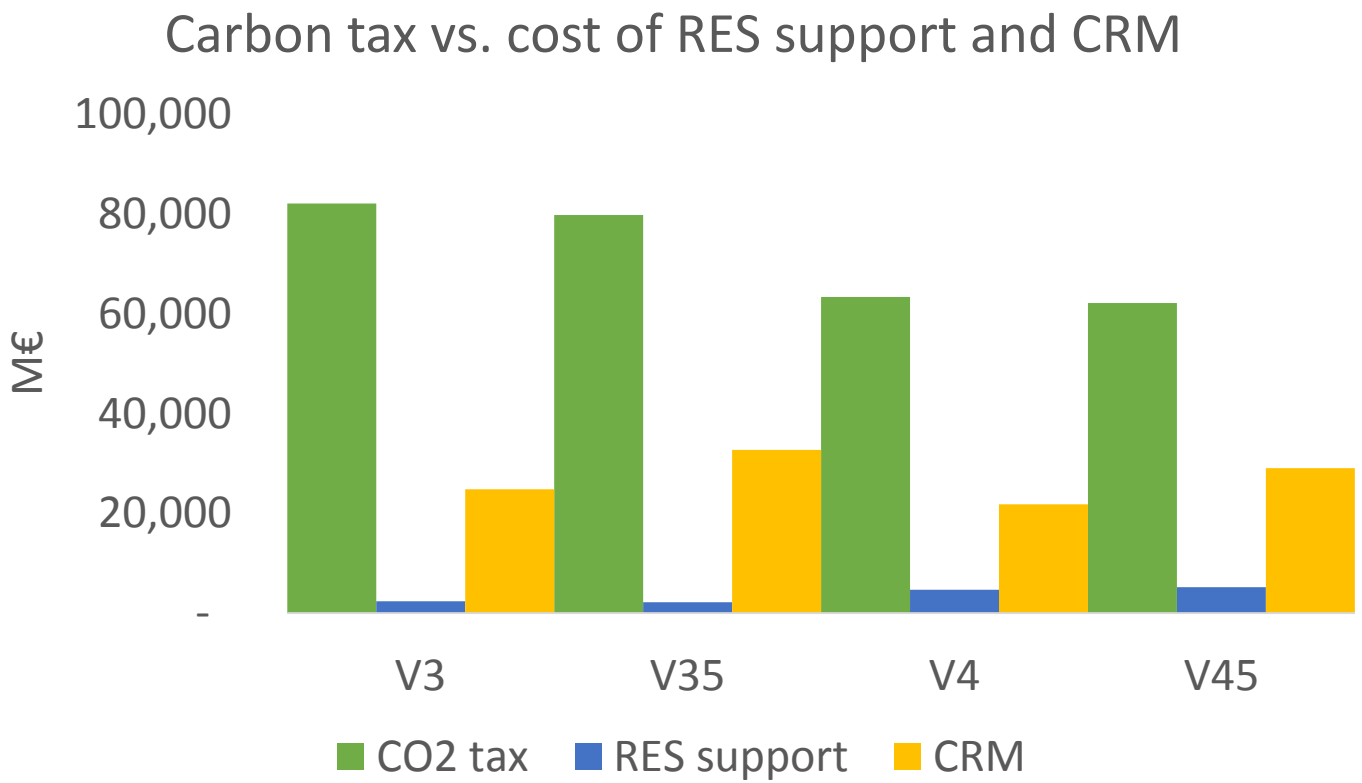
Cost of CRM and RES support

- Over all scenarios the carbon tax collected exceeds by a large margin the combined cost of CRM and RES support mechanisms



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Cost of CRM and RES support

- By taxing fossil fuel generation and raising prices, the carbon tax transfers income from consumers and thermal generators to RES generators.
- The total collected carbon tax exceeds the required funding for CRM and RES support. Where does the rest go?
- If it is redistributed back to the consumer the carbon tax is not simply an additional cost.

	V3	V35p	V4	V45p
Average power price in €/MWh	110.88	107.18	105.74	101.53

Conclusions

- **Apart from the direct cost CRM has an indirect cost in the form of losses for intermittent sources and higher RES support and vice versa;** In addition to their individual cost, there also is a non-negligible extra cost due to the interplay of these mechanisms.

- **Need for more transmission capacity connecting Northern Europe and UK to continent;** With increased generation from RES-E, much more generation curtailment (of RES) occurs, indicating a not-efficient integration of RES in the system. As the utilisation factors of the transmission corridors (especially in Northern Europe) indicate, transmission expansions will be necessary in addition to a pure RES support scheme.

- **Increasing RES or CRM will lead to lower power prices, resulting in lower and more variable profits for producers.** This in turn will raise the WACC.

- **The carbon tax seems to be necessary to keep prices high enough for RES to compete with conventional sources.** It taxes some industries but effectively costs less than it appears – at least that it appeared to us.

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Coordinated by SINTEF

Info: Market4RES@sintef.no
Results and news: www.market4RES.eu

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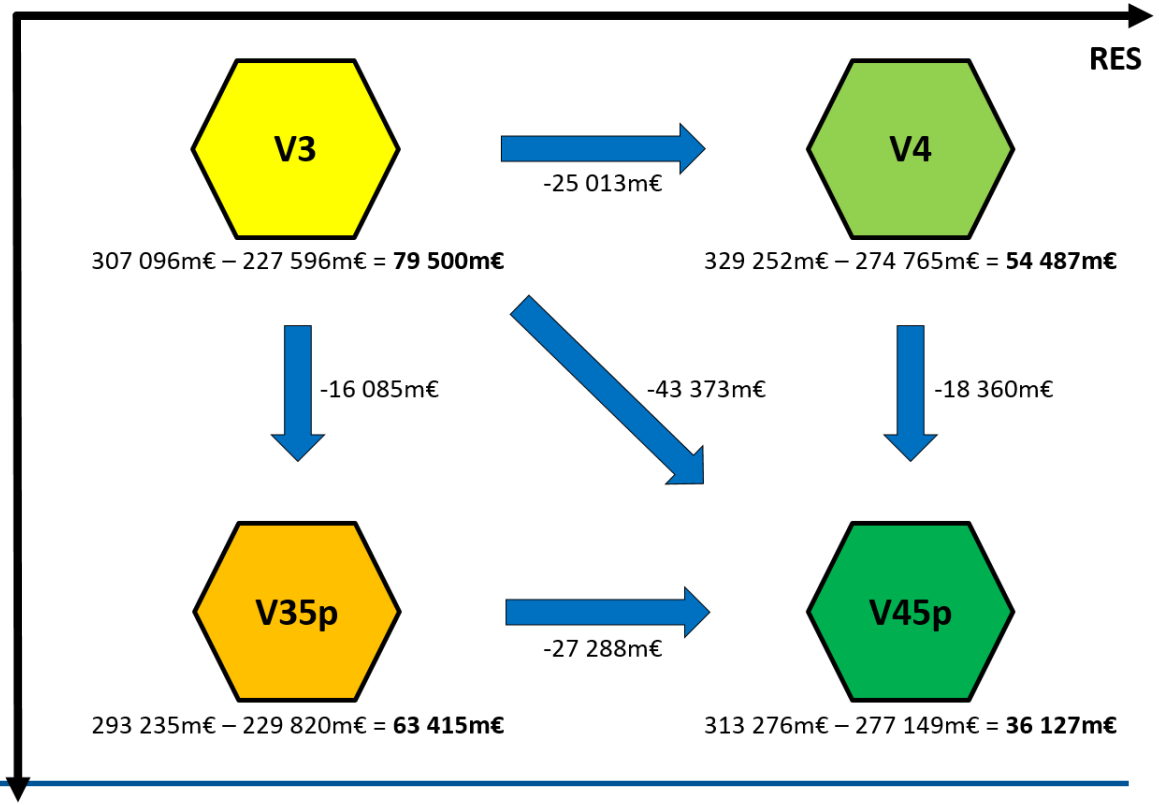
Cost of CRM and RES support for producers

- The figure shows the long-term profit (producer surplus – investment costs in m€) for the 4 visions and the changes between them.



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		Producer Surplus in m€	Consumer Surplus in m€	Social Welfare in m€	Investments in m€/a
Results	V3	307 096	10 378 075	10 691 904	227 650
	V35p	293 235	10 394 360	10 693 647	229 862
	V4	329 252	10 706 343	11 047 630	274 838
	V45p	313 276	10 724 715	11 049 100	277 209
Change absolute	V3 vs V35p	-13 861	16 285	1 743	2 212
	V3 vs V4	22 156	328 268	355 726	47 188
	V3 vs V45p	6 180	346 640	357 196	49 559
	V4 vs V45p	-15 976	18 372	1 470	2 371
Change in percent	V3 vs V35p	-4,5 %	0,2 %	0,0 %	1,0 %
	V3 vs V4	7,2 %	3,2 %	3,3 %	20,7 %
	V3 vs V45p	2,0 %	3,3 %	3,3 %	21,8 %
	V4 vs V45p	-4,9 %	0,2 %	0,0 %	0,9 %

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