Modeling long-term impacts of regulatory instruments on the German energy sector

Sustainable Energy Supply of the Future

MSE 2011 – 1st Colloquium of the Munich School of Engineering

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Agenda

1. Research overview
   - Scope, research questions and contributions
2. Approach
   - Procedure
   - Scenario description
   - Objective function and constraints
   - Optimization of decision variables
3. Results
   - Investments
   - Portfolio of power capacities
   - Power and heat production per energy source
   - Emission Allowance price and emission costs
   - Power price
4. Conclusion

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1. Research overview

- **Scope:**
  - **Optimization models** for CO_2 emission control, power generation and investment decisions

- **Research questions:**

  Is the Emission Trade System (ETS) an effective regulation instrument for reaching environmental and economic policy goals?

  - What will be the effects (**emission abatement**) and costs (**EA price**) of the ETS?
  - What impact has the ETS on the **future plant portfolio** as well as on the **power and heat generation**?
  - What further effects does the ETS have on the German economy (e.g. **power price**)?

- **Contribution:**
  1. Respect the difference between EAs and taxes in taking the **EA price as endogenous variable**
  2. Integration and comparison of **different environmental policy instruments**
  3. Regulation framework, technical and market **data of the German energy sector**
  4. Consideration of combined heat and power generation plants (**CHP**) and so the **heat market** as well

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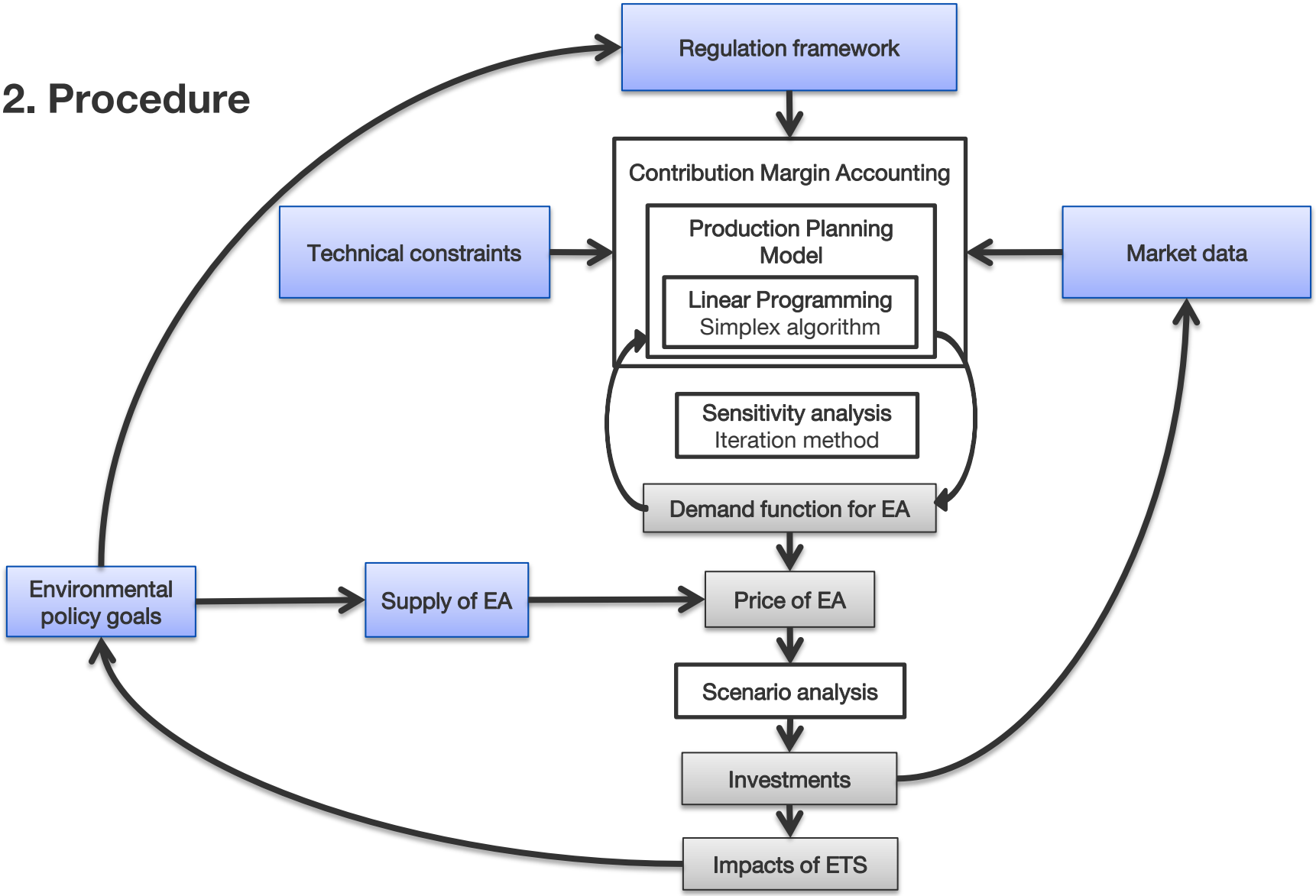
2. Procedure



2. Scenario description

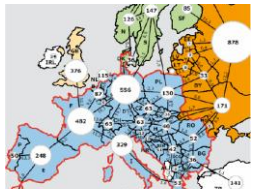
Scenarios	a) Constant primary energy prices	b) Increasing primary energy prices
0 Referent scenario: Without ETS	0a	0b
1 Basis scenario: With ETS	1a	1b
2 Enlargement of grid capacity at the boarders	2a	2b
3 Without phasing out nuclear energy program	3a	3b
4 With market incentive program	4a	4b

Time horizon:

2. Optimization Model

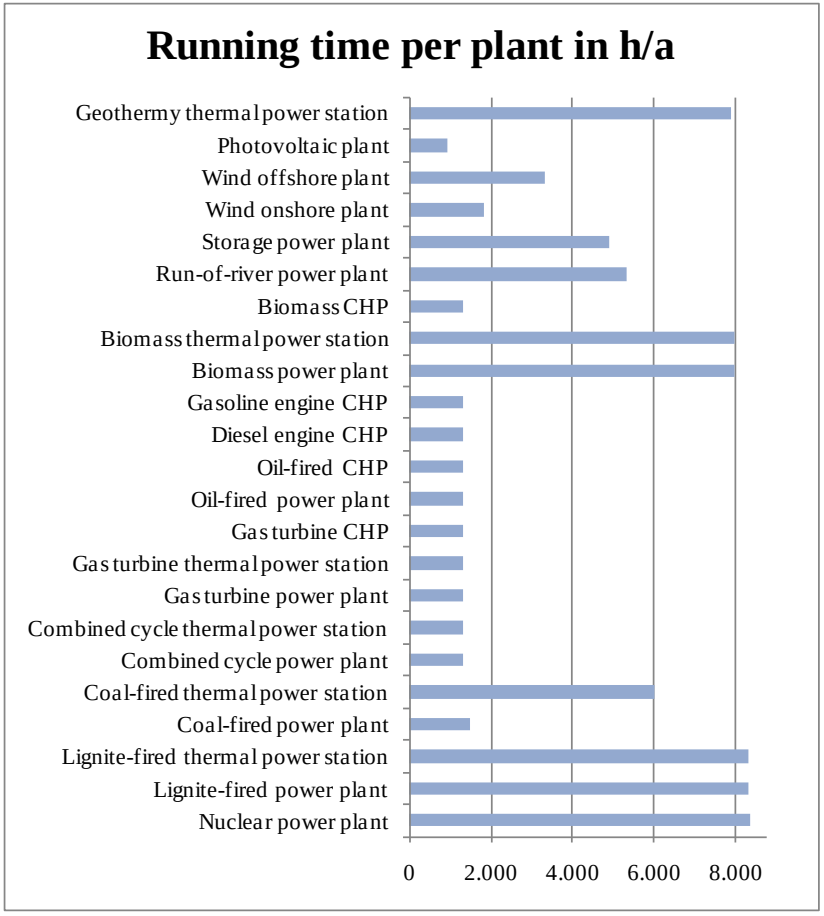
- *Objective function*
  - Profit maximization
  - Max $G = \sum_i G_i + \sum_h G_h + \sum_b G_b$

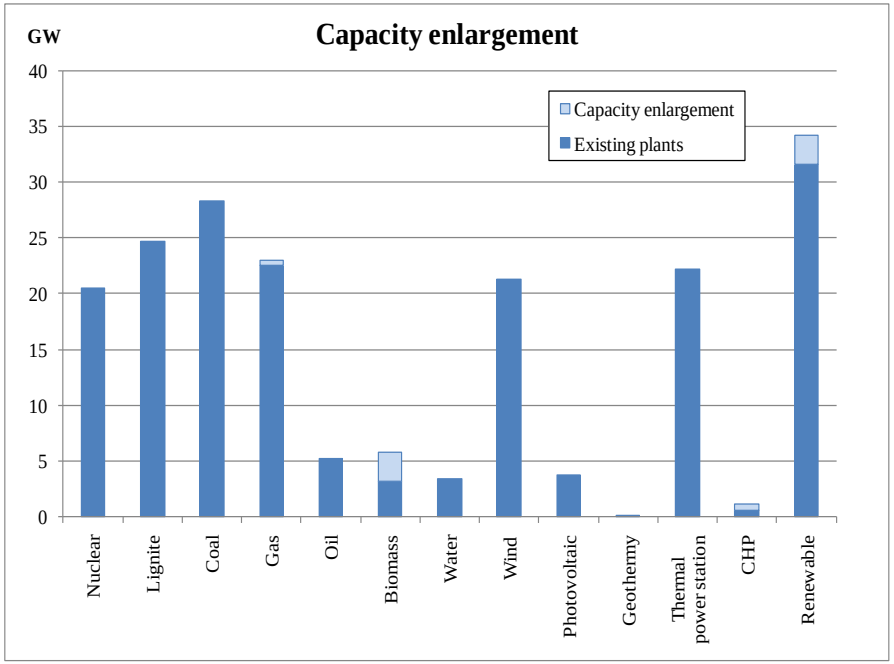




- *Constraints*
  - Power and heat demand
  - Lower and upper bound of running time
  - Availability of plants
  - Plant and grid capacities
  - Maximal grid enlargement
  - Potential of technologies
  - Upper bound for capacity enlargement per technology


2. Optimization of decision variables: running time and capacity enlargement





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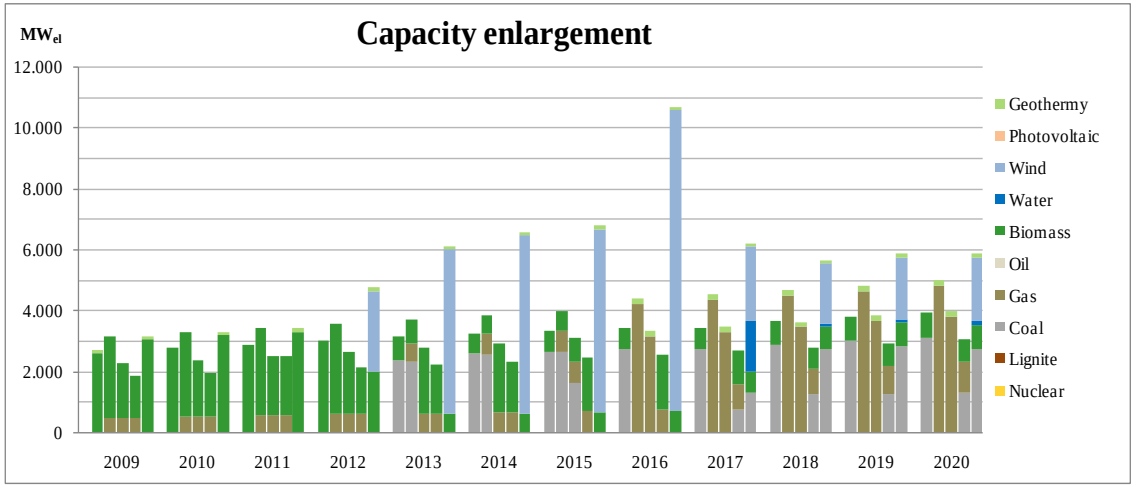
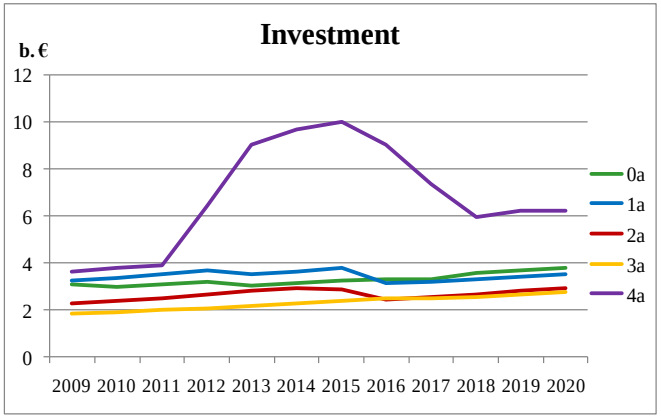
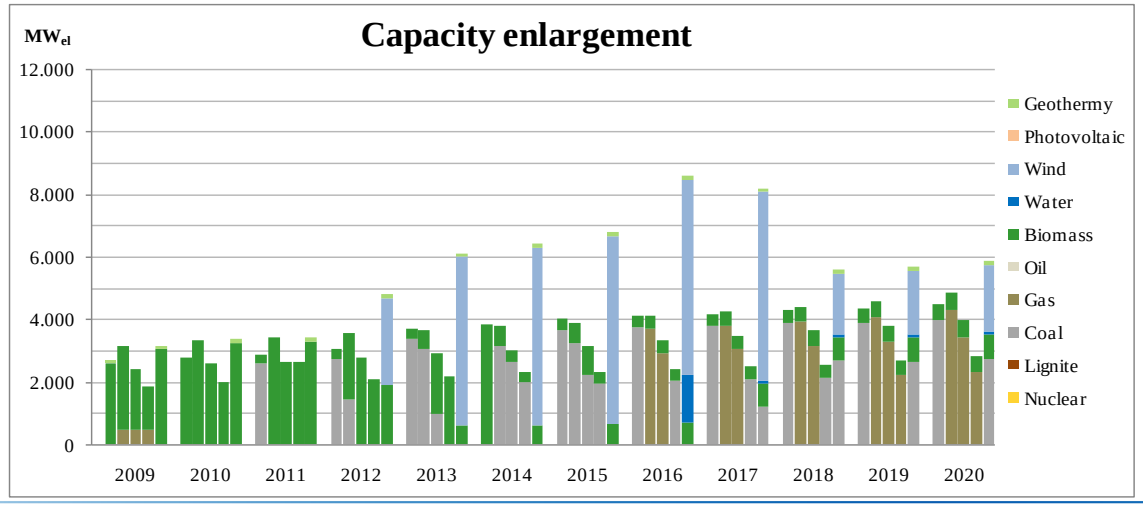
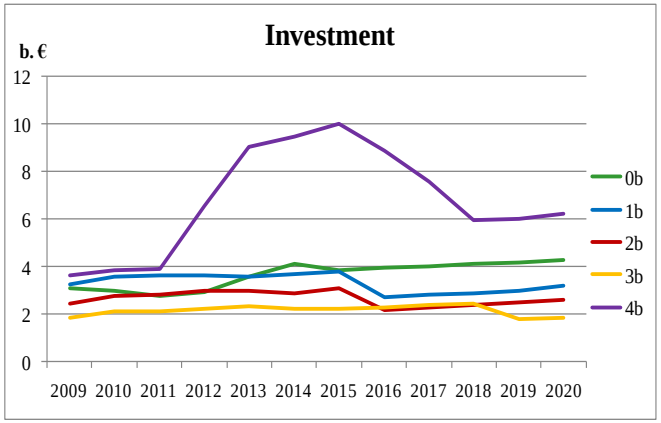
3. Capacity enlargement and investment expenses

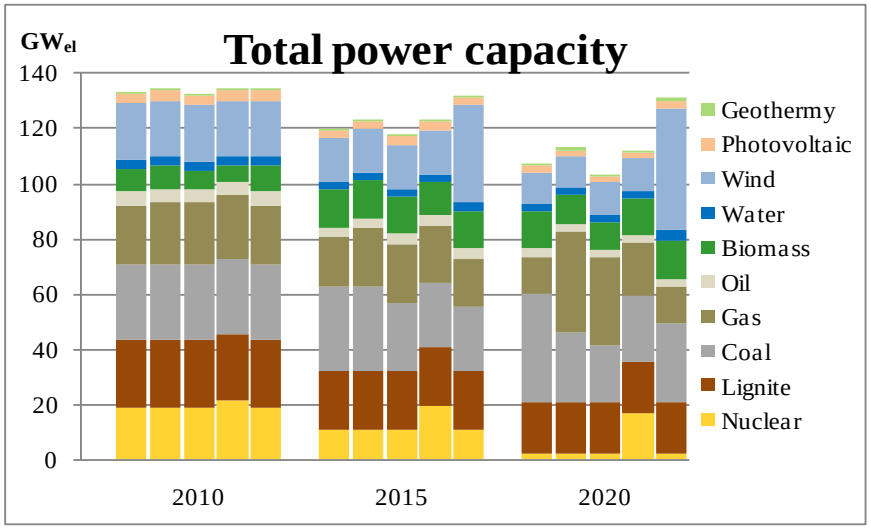


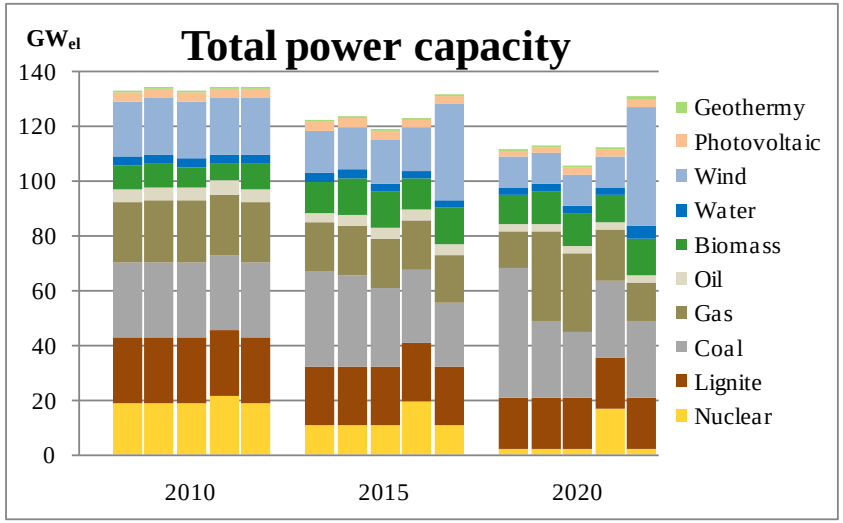


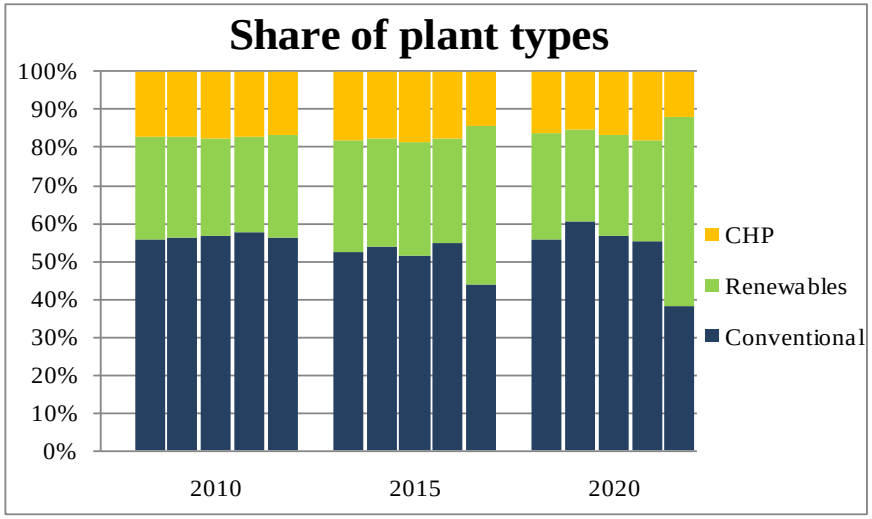


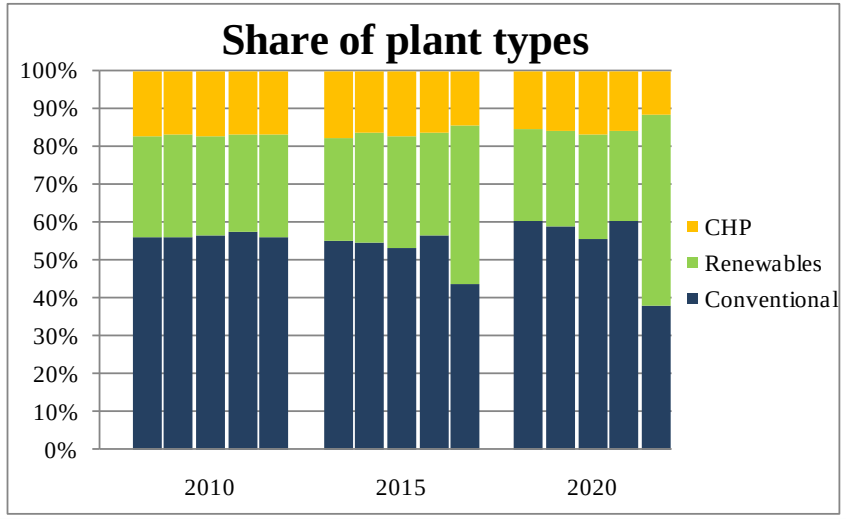


3. Portfolio of power capacities and share of Renewables & CHP

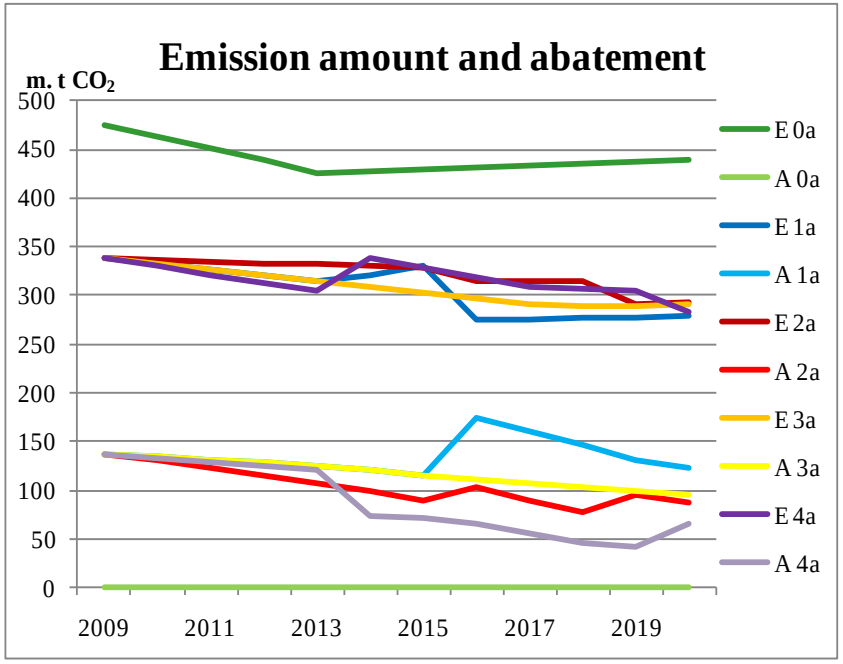


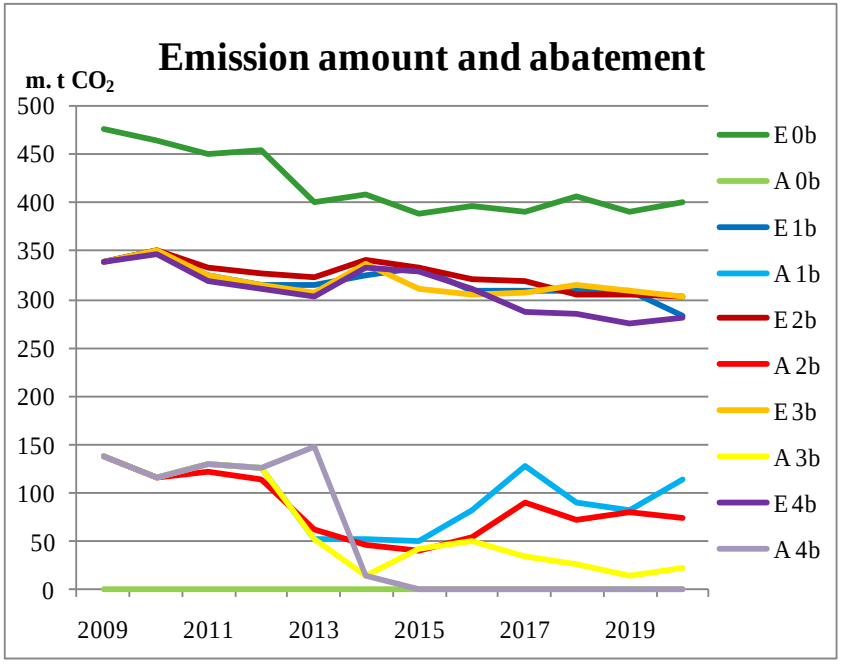




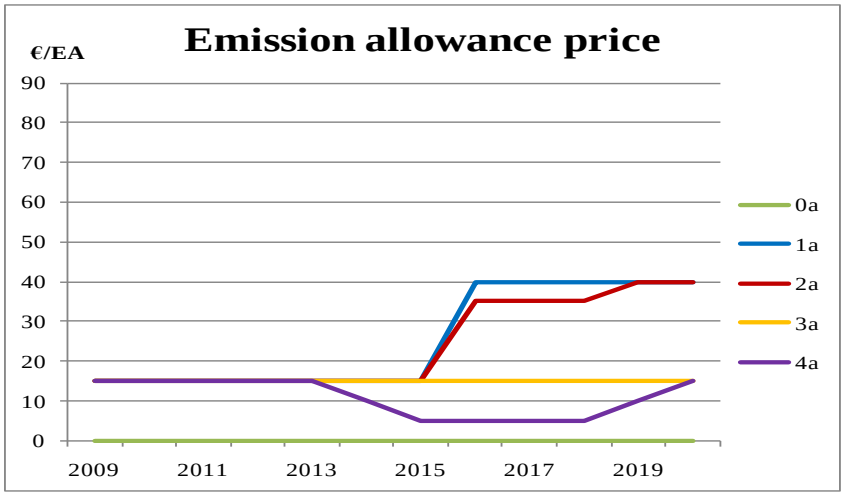


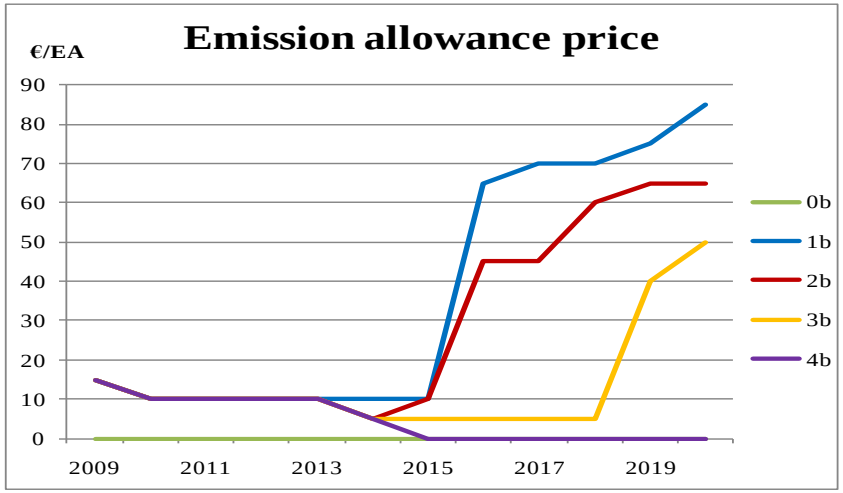
3. Emission amount and emission abatement

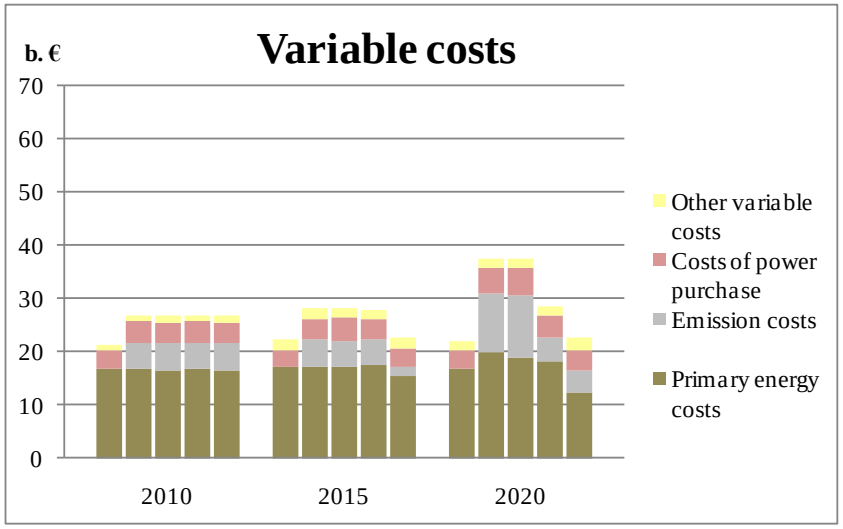


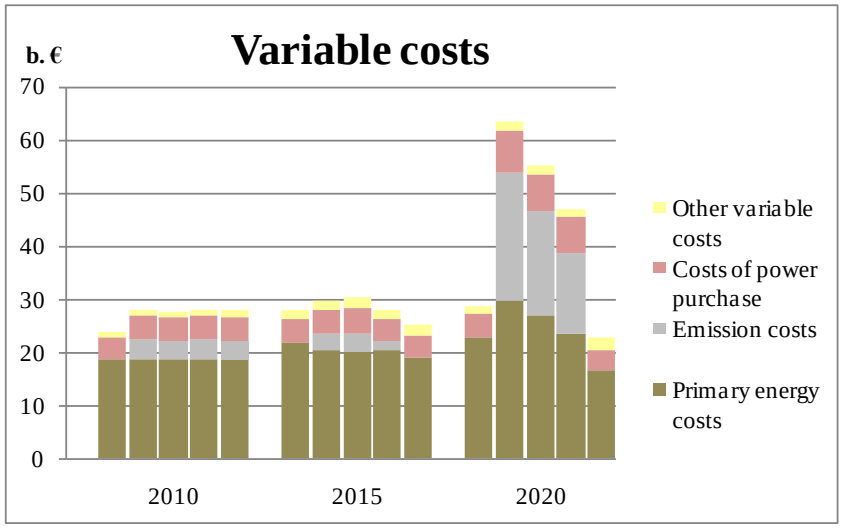


3. Emission allowance price and emission costs

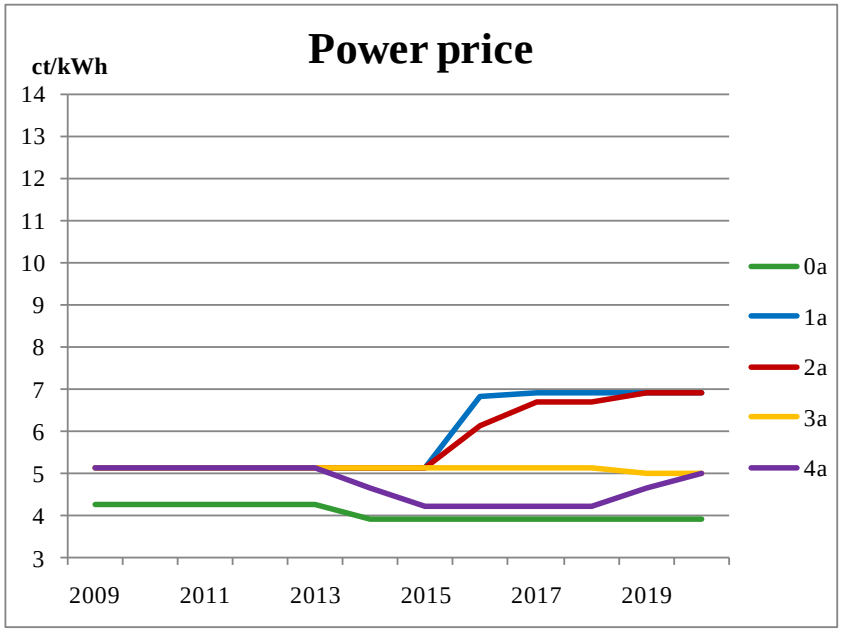


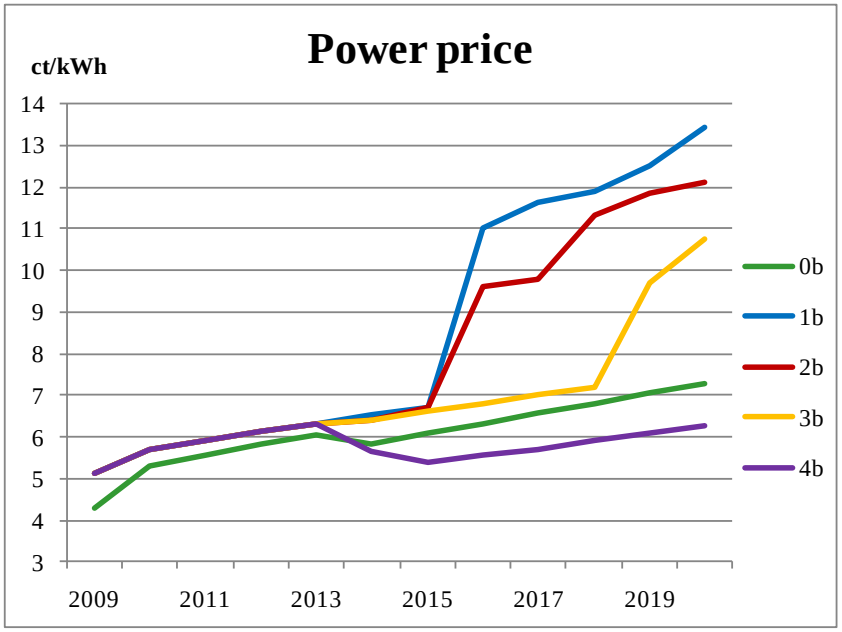






3. Power price





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4. Conclusion

- ETS has **strong impacts on production decisions**
- But influence of **low interest rates is more effective in long-term decisions** like plant investments (scenario 4)
- **Lowest changes in scenario 3** without phasing out nuclear energy program **followed by 0** without ETS
- ETS can **drive up the power prices**, because **emission costs will not be low**

- ETS is **expedient for emission control**, but **not for reaching the EU and national goals** of 22% respectively 30% Renewables in the energy mix
- **Ecological effectiveness** of the ETS is **better than its economic efficiency**

Thank you for your attention.

Please feel free to ask questions.

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