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The effect of carbon caps and renewable share targets on the European energy system using capacity expansion modeling
(topic presentation)

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Background

- Growing sustainability and CO2-level concerns worldwide due to climate change
- The European Commission has set a climate and energy framework for 2030 and a long term strategy for 2050
  - 2030: 55% reduction in CO2 emissions compared to 1990 and at least 32% share of renewable energy
  - 2050: net-zero greenhouse gas emissions
- Energy system models can be used to analyze energy systems under such constraints to aid policy-making

Objectives

- Finish and expand a capacity expansion model that is already partly implemented in Julia by Oliveira and Tollander de Balsch
- Optimize the system cost under 9 different constraint combinations:
  - Renewables shares: 32% (EU 2030), 80% and 100% (EU 2050)
  - CO2 reduction: 55% (EU 2030), 80% and 95% (EU 2050)
- Study the effect of the constraints on system cost, energy mix and transmission patterns

Scope

- Europe condensed into 11 regions
  - Slight emphasis on the Nordics
- 9 generation technologies, load shedding, transmission and battery storage considered
  - 5 renewables: ons-wind, offs-wind, solar, biomass, hydro
  - 4 non-renewables: nuclear, coal, cc-gas, oc-gas
- Available area and hourly availability taken into account for renewables
- Hydro capacity expansion not considered
  - Environmental regulations
- Transmission from outside Europe not considered

Methods

- A linear optimization capacity expansion model in Julia
  - Objective: minimize total system cost
  - Satisfy demand
  - Carbon cap
  - Minimum renewables share
- Availability and demand data from year 2018 ERA5 datasets using the GlobalEnergyGIS Julia package by Mattsson et al.
- Solve with Gurobi solver

Schedule

- Topic presentation 14.10.
- Thesis ready by January
- Final presentation 19.1.

Literature and references

- Pfenninger, S., Hawkes, A., & Keirstead, J. (2014). Energy systems modeling for twenty-first century energy challenges. Renewable and Sustainable Energy Reviews, 33, 74-86.
- European Commission. (2020). Climate strategies & targets. https://ec.europa.eu/clima/policies/strategies_en
- Oliveira, F., Tollander de Balsch, J. (2020). Energy System Modeling. https://github.com/gamma-opt/EnergySystemModeling.jl
- Mattsson et al. (2020). GlobalEnergyGIS. https://github.com/niclasmattsson/GlobalEnergyGIS
- Gurobi Optimization, LLC. (2020). Gurobi Optimizer Reference Manual. https://www.gurobi.com