Is a mix of wind and gas a feasible alternative to coal in Poland?

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We build a bottom-up energy system model for Poland and focus on how coal can be partially replaced with intermittent renewable energy: wind and pv. We find that additional costs due to intermittency are negligible up to approximately a 30% share of RES, and for a 60% share costs rise by less than 10%. Given the time it will take to even reach a 30% share, we see no techno-economic barriers to an expansion of renewable electricity generation.

OVERVIEW

Under the 3x20 EU climate and energy package, Poland is obliged to:

- Increase energy efficiency by 20%.
- Reduce CO2 emissions by 20% with respect to 1990 levels.
- Increase the share of electricity generated by renewable energy sources (RES) to 15%.

Beyond 2020 there is no specific target for RES share, however, since the Polish electricity generating sector is dominated by coal, meeting more stringent CO2 emission targets will require a transition towards RES at the expense of coal and lignite. We explore the possibilities of moving towards RES taking into account the problem of intermittency and look at potential increase in cost of electricity, structure of the energy mix and energy security.

MODEL AND SIMULATIONS

We use a bottom-up energy system model using the Calliope framework (www.callio.pe). The framework allows for modelling the energy system with high spatial and temporal resolution, thereby accounting for intermittency of energy sources and fluctuations in energy demand. The current model uses a single location, we use an hourly time period and consider all currently available technologies. A single simulation consists of finding a least-cost energy mix for an entire year (8760 time periods), given constraints, and data on energy demand and energy supply. The model is to be updated along these dimensions:

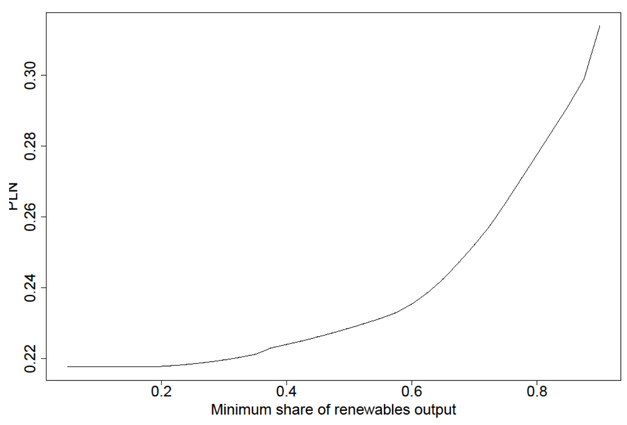
- Develop spatial aspect of model, energy demand for multiple regions, interconnections, import, export, exact locations of power plants.
- Run simulations for supply data for wind and pv for multiple years.
- Include benefits from cogeneration for coal and lignite.

In our simulation experiment we solve for an optimal energy mix for a required minimum share of energy produced from RES for a range of 0%-90%.

RESULTS AND DISCUSSION

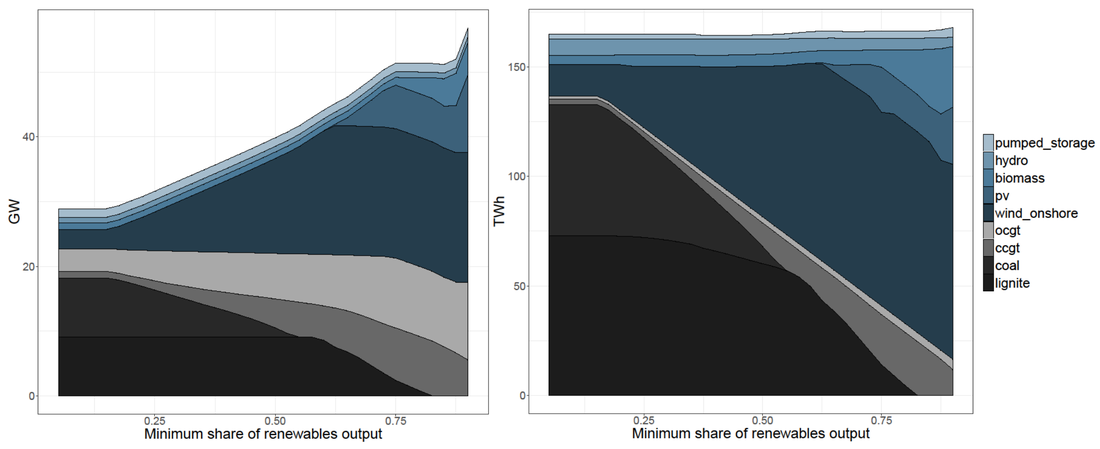
Our first finding is that increasing the share of RES in the mix in the low (up to 30%) to mid (up to 60%) range results in a rather small increase (0,9% and 8,1% respectively) in the LCOE relative to the unconstrained simulation. However, beyond this point the overall costs starts increasing rapidly, with a mix consisting of 90% RES costing 45% more.

Figure 1. LCOE in PLN per kWh for different minimum required shares of RES output.



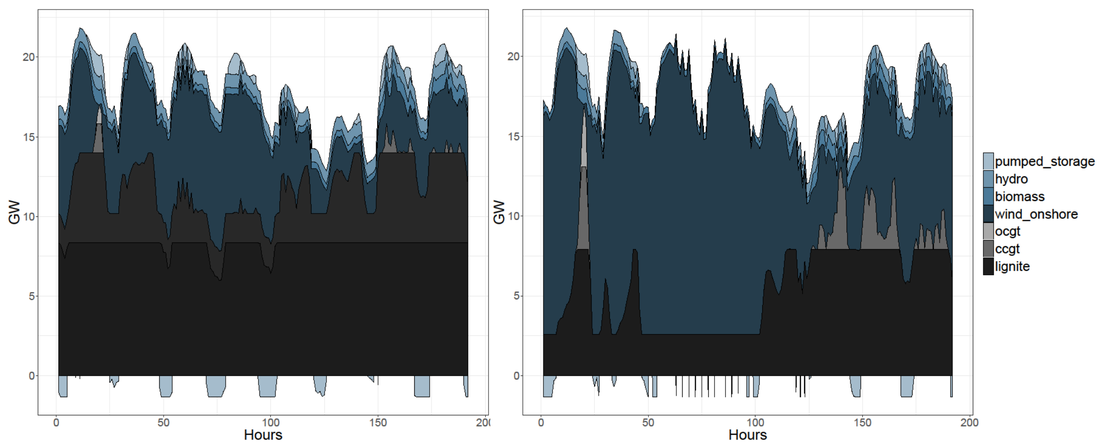
Increasing the required amount of RES results in a replacement of coal with a mix of wind backed up by gas power. Since this mix is slightly more expensive than coal, LCOE increases slightly. The second effect which increases the price in the mid range is an increase in the LCOE generated from lignite due to the increased fluctuations in energy production from this source.

Figure 2. Installed capacity (left panel) and energy production structure (right panel) for different minimum required share of renewable energy output.



Pushing for a RES share of more than 60% would require the introduction of photo-voltaics into the system (cost 0.34 PLN/kWh), followed by increasing the amount of biomass (cost 0.46 PLN/kWh). Despite a large amount of gas power needed to offset variations in intermittent sources, the amount of gas required would not exceed 15% of today's use.

Figure 3. Electricity production structure for the week of 7-14 July 2015 for 30% (left panel) and 60% (right panel) minimum required share of renewable energy output.



CONCLUDING REMARKS

- We find that a mix of wind and gas is a feasible and cost effective alternative to coal
- Model does not inform about optimal dynamics of transition
- Work in progress – analysis and model to be expanded along several dimensions

SELECTED REFERENCES

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