EMBER
COAL TO CLEAN ENERGY POLICY

Coal-free Czechia 2030

November 2020

Pocerady power station, Czechia

An energy pathway towards 2030 coal phase-out

Summary for policymakers

In 2019 the Czech government convened a coal commission to recommend an end date for coal, with a decision due by the end of 2020. In this context we have modelled a pathway to a coal-free Czechia by 2030. We use hourly power system modelling to show how coal can be replaced in power and large-scale heat generation. Our objective was to investigate the scale and feasibility of changes necessary to achieve a 2030 coal phase-out. We believe the evidence presented should bring 2030 into serious contention for the Czech coal commission.

Modelling was performed using the Artelys Crystal Supergrid platform. This is an established energy modelling tool, frequently used to plan and evaluate European infrastructure development. The Czech power system was modelled as part of an integrated european electricity network. In the model, all Czech coal capacity was required to close by 2030. The generation of power and heat is replaced by an optimised combination of alternatives, at least cost.

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Main Conclusions

#1

There is a feasible route to phase-out coal from electricity and heating in Czechia by 2030. With ambitious but credible action, a substantial coal to clean transition can be achieved in a decade. The lowest cost route is achieved by a strong focus on wind and solar.

#2

A sizable but realistic expansion of renewable electricity capacity is required. Czechia's power system can incorporate much higher renewable capacity than current ambitions. This pathway adds 3.7GW onshore wind and 7.9GW solar, reaching 4GW and 10GW respectively by 2030, without curtailment of generation. To reach these levels, Czechia must build quickly, but other EU countries with similar potential (or less) are already deploying wind and solar at the rates required.

#3

There is a small need for new dispatchable capacity. This pathway adds between 2.5-3.4GW new gas generation while closing 9.7GW coal by 2030. The lower end of the range is reached by utilising grid-scale battery storage. Fast renewables growth is key to limiting the need for new gas assets - which risk becoming stranded as Europe moves to net zero.

#4

At least two thirds of heat from coal CHP plants could be replaced by large heat pumps and waste heat recovery. These are the most economic replacements for coal heat, and sufficient potential exists in Czechia. Immediate action is needed to diversify and decarbonise heat sources in district heating, as well as reducing demand through efficiency measures.

#5

A 2030 coal phase-out would allow Czechia to achieve new EU climate targets. Modelled emissions from power generation decrease by 85% between 2020 and 2030. We find a 2030 coal phase-out can save an additional 32MtCO_2 on top of plans outlined in the NECP, all else being equal. These additional savings would allow Czechia to reduce total GHG emissions by more than 60% from 1990 levels, meeting 2030 targets proposed by the EU Green Deal.

Key Results

Electricity

- Wind and solar are deployed as the cheapest option, limited only by constraints imposed on potential. We limit deployment to 10GW solar and 4GW onshore wind (see methodology). The model optimisation deploys all of this available capacity, which contributes to production without significant curtailment. The resulting share of renewables in gross final consumption of electricity in 2030 is 38%, compared to 17% forecast in the NECP. The fossil-free share is 79%.

- Grid-scale battery storage reduces the need for new dispatchable thermal capacity. We assess the impact of adding 2GW battery storage (equivalent to 20% of installed solar capacity) to the system in 2030, finding it reduces the deployment of flexible gas capacity by 1GW. Without battery storage, 3.4GW flexible gas is deployed. With battery storage, 2.5GW is deployed. Both scenarios include 760MWe of new gas CHP to partially replace coal CHP heat.

- Czechia becomes a small net importer of electricity in 2030. Net imports total 550TWh, or less than 1% of consumption. New solar and wind capacities are crucial to maintain the balance between imports and exports.

- There is sufficient dispatchable capacity in 2030 to meet peak demand. Even in the absence of any solar or wind generation, Czechia could still generate enough power to cover demand in any hour across all modelled years and weather conditions. After phasing out coal and adding flexible gas (or gas and batteries), the system has at least 13.3GW dispatchable capacity, whereas modelled peak demand reaches 12.6GW.

- A 2030 coal phase-out would allow Czechia to reduce GHG emissions more than 60% compared to 1990. Modelled CO_2 emissions from power generation decrease by 85% between 2020 and 2030. Taking into account electricity and heat production, we estimate a 2030 coal phase-out can deliver approximately 32MtCO_2 additional savings compared to estimates based on the NECP. This would reduce overall GHG emissions by more than 60% compared to 1990, exceeding the proposed 2030 EU climate target of 'at least 55%'.

- An estimated €11bn of capital investment in the power sector is required to achieve this pathway.[i] This amounts to just 0.45% of Czech GDP per year for the next ten years. These costs should be considered against the avoided carbon and health costs of coal. These investments would deliver an estimated 45,000 direct FTE (Full Time Employment), of which 95% are generated by wind and solar[ii]. Evidence that a coal phase-out focussed on renewables will deliver most for the wider economy.

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i This estimate excludes investments in the electricity network, which is out of scope. Previous research has suggested that, with existing development plans, the Czech network could handle far higher renewables penetration than current levels (Energynautics, 2018).

ii Using estimates of the employment intensity of energy investments by Vivid Economics based on Garrett-Peltier (2017). Capital investments in the power system in this pathway create an estimated 45,000 direct FTE and 39,000 indirect FTE.

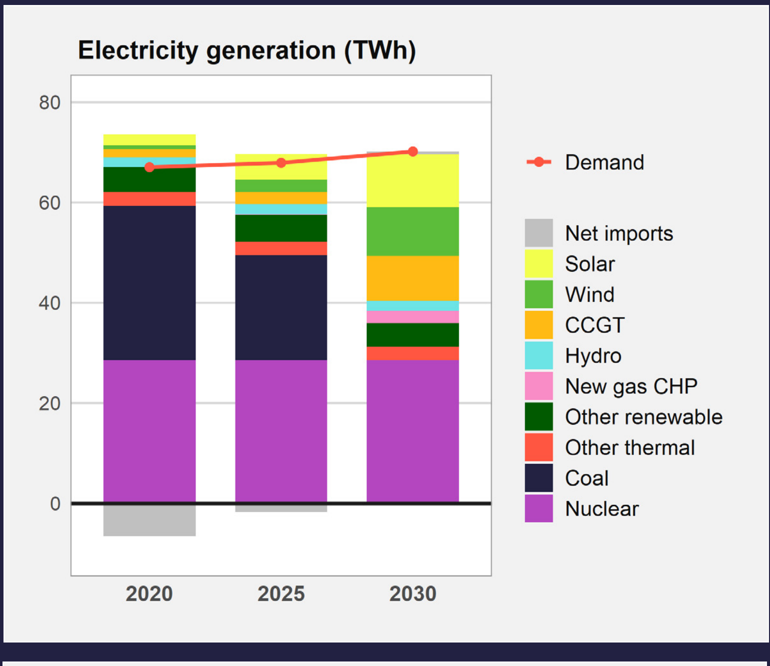

Figure 1: Annual power generation in the modelled pathway to a 2030 coal phase-out (scenario without battery storage). Electricity demand follows NECP estimates, increasing gradually from 2020 to 2030. Additional demand is added in 2030 due to the modelled impact of large heat pumps replacing coal CHP heat.

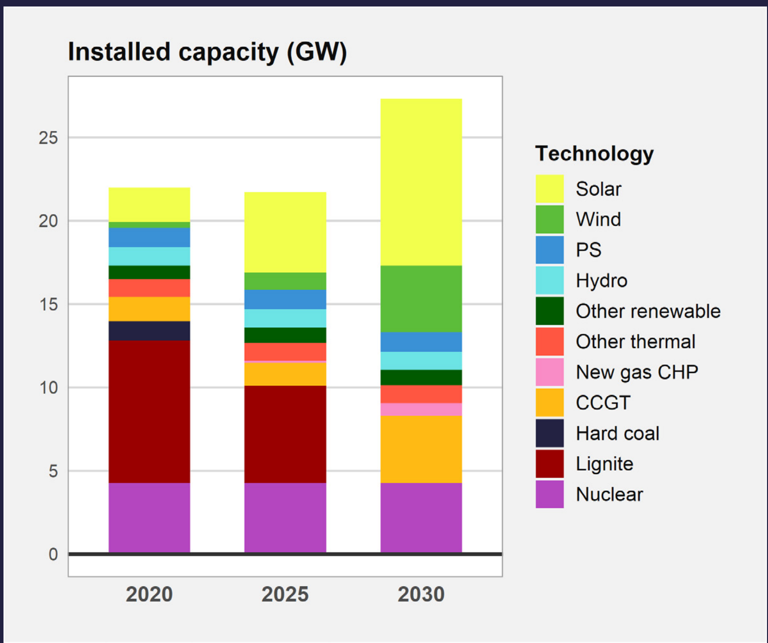

Figure 2: Installed capacity in the modelled 2030 coal phase-out pathway (scenario without battery storage).

	2020		2025		2030	
Fuel	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**
Coal	9,690	30,758	5,820	20,975	0	0
Nuclear	4,290	28,581	4,290	28,582	4,290	28,552
Gas CCGT & new CHP	1,364	1,554	1,508	2,490	4,786	11,331
Solar	2,061	2,172	4,811	5,070	10,000	10,538
Wind	339	828	1,039	2,539	4,000	9,776
Hydro & pumped storage	2,266	2,028	2,274	2,031	2,282	2,052
Other*	1,895	7,701	1,976	8,028	1,966	7,441
Net imports	- 6,531		- 1,746		547	
Net production	73,623		69,714		70,175	
Demand	67,059		67,930		70,175	

Table 1: Electricity generation and installed capacity in the modelled 2030 coal phase-out pathway. Numbers here correspond to the pathway without grid-scale battery storage. In an equivalent scenario with 2GW (2-hour) batteries added in 2030, gas capacity and generation reduces to 3838MW and 9931GWh respectively, and net imports increase to 1982GWh.

*category includes other renewables (biogas, biomass, geothermal) and other thermal (mostly gas fired power stations burning industrial gasses and fossil gas). Historical capacity factors are assumed to persist for these technologies.

Key Results

Heat

- Coal CHP heat production can be replaced by a combination of options by 2030. Our modelling approach replaces coal CHP heat with: further efficiency gains in buildings (11%), waste heat recovery (24%), industrial heat pumps (33%), and gas CHP + boilers (32%).

- Significant potential for waste heat recovery exists in Czechia. This proven, low-cost option requires urgent consideration and a route to market. Previous estimates of available excess high-temperature heat (>100C) range from 22PJ (today) to 35PJ (2050).[i] We model a 11PJ contribution in 2030.

i Based on data from the Hotmaps EU and Heat Roadmap Europe projects.

- Large heat pumps are a highly efficient replacement for coal CHP heat production. This technology is deployed by the model in favour of gas or biomass CHP units on a cost basis. The model deploys 500MWth large heat pumps by 2030, and would expand further were it not for constraints imposed (see methodology). Despite replacing a third of coal CHP heat, they add only 1.2TWh (1.7%) to annual electricity consumption, and a maximum of 0.15GW to electricity demand. Furthermore, our modelling does not account for the important role heat pumps can play as a source of demand-side flexibility. While this model shows they are feasible on an energy and cost basis, we do not consider local factors such as grid constraints and availability of appropriate ambient heat sources. These should be investigated urgently.

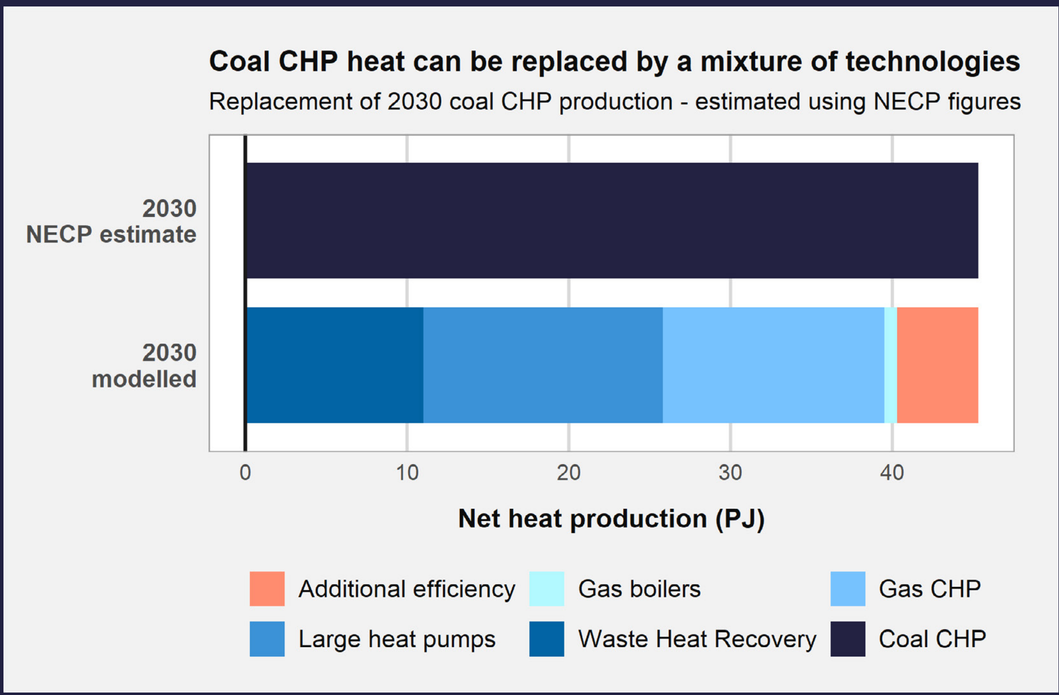

Figure 3: Projected coal CHP heat in 2030 is replaced by a combination of technologies. Large heat pumps are the optimal replacement where possible, due to their high efficiencies.

Methodology overview

This analysis uses an hourly power system model with least-cost optimisation to simulate electricity and coal CHP heat production in the years 2020, 2025, and 2030. Hourly electricity demand was estimated using real climatic data from three representative years.

In the model, Czecha is integrated into the wider European power network, the evolution is which follows ENTSO-E's Ten Year Network Development Plan (TYNDP).[i]

Key assumptions: in our modelled pathway, the NECP is taken as a baseline for electricity and heat demand, as well as some non-coal production capacity. The following modifications are made:

Power capacity: Czech coal capacity (both electricity-only and CHP) was required to fall by 40% by 2025 and 100% by 2030. Technologies with limited scope for development before 2030 were set according to the NECP, i.e., no new nuclear, and only small changes in hydropower (and pumped storage), bioenergy, waste incineration, and interconnection. This meant coal was largely replaced by an optimised combination of solar, wind, and flexible gas generation. We produced an additional scenario to explore the impacts of adding battery storage (equivalent to 20% of solar capacity).[ii]

RES limits: we impose upper limits on wind and solar deployment, in an attempt to remain within economic and territorial constraints. Broadly, we assume maximum deployment rates in agreement with expert estimates over the 2020-25 period, but allow acceleration in the second half of the decade. Onshore wind capacity was limited to 1GW by 2025 and 4GW by 2030. The necessary additions over the next 5 years (760MW) are a significant scale-up for Czechia, but other EU countries with similar resource potential are achieving more. According to Eurostat, between 2013-2018 Austria added 1458MW, Belgium 1003MW, and Denmark 872MW. Solar capacity was limited to 4.8GW by 2025 and 10GW by 2030. Between 2009-2011 Czechia added 1.5GW, exceeding the rate required between 2020-2030 to reach the upper limits set.

Heat demand: we use national statistics and projections in the Czech NECP to estimate the shortfall in heat supply as a consequence of phasing-out coal CHP plants, in both the district heating system and dedicated units for own-consumption. In addition to this, we incorporated estimates of additional savings that could be achieved by more ambitious building renovation.[iii] These estimates combine to reduce the heat demand in scope for the model by approximately one third, from 60PJ to 40PJ between 2020 and 2030. Current non-coal heat production was assumed to evolve according to the NECP, and was not modelled.

Heat production: before optimising the replacement of coal CHP heat, we gathered estimates for the potential of waste heat recovery. Subsequently we subtracted 11PJ of heat demand, assuming a baseload production profile. The remaining supply is optimised by the model, which selects between large heat pumps, gas/biomass CHP, and gas/biomass heat-only boilers. Due to uncertainties about the end-user requirements of own-consumers, we required the model to source at least 15PJ from thermal combustion.

More results from this study, along with further analysis and a complete list of references will be published at **www.ember-climate.org/research/coal-free-cz-2030**

i The rest of Europe was based on an existing model - produced by Artelys - of the "Sustainable Transition" scenario from TYNDP 2018 (based on open ENTSO-E data).

ii This matches assumptions in scenarios produced by the Czech system operator (CEPS).

iii Following the 'progressive' scenario presented by CTU-UCEEB / Chances for Buildings, (Lupíšek, Trubačík & Holub, 2020)