Effects of fuel switching on electricity consumption and greenhouse gas emissions after the Russia-Ukraine War

ENERDAY
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Motivation

IN FOCUS | 6-8 min read

Will Russia-Ukraine war disrupt Europe's energy transition?

While short-term transition plans may be in jeopardy the continent is taking steps to accelerate renewable energy production over the medium-term.

06-30-2022

Motivation

- Russia's invasion of Ukraine has made oil and gas prices soar. The War has impacted the global supply chain, fueling dramatic cost increases and accelerating inflation.
- It has impacted the speed and direction of the energy transition.
- The unexpected disruption has pushed some EU countries to reduce the consumption of water and electricity.

Motivation

- Since the war's inception, the European Union (EU) and its members have been implementing measures that may cause imminent slow down or even reversal in progress toward energy transition.
- For example, Germany's Economy Minister Rober Habeck announced that Germany will increase the usage of coal to compensate for a cut in Russian gas (Meredith, 2022).

Objective

- We examine the short-term effects of the energy crisis caused by the Russia-Ukraine War on Europe's energy transition toward carbon neutrality.
- As a case study, we forecast electricity generation from nuclear, coal, natural gas, hydro, and renewables in Germany and Italy with and without the effects of war.
- We compare short-term forecasts of electricity generation from the five energy sources and resulting impacts on carbon emissions with and without the war effect in these two countries separately.

Method

- First, we employ a time series model (i.e., ARIMA model) to construct the model best fit for forecasting electricity generation of each of the five energy sources for Germany and Italy independently.

Method

- Second, we forecast electricity generation from each energy source for 2022-2027 based on the seasonal ARIMA model using historical data of 2017-2021 without the effect of the war in 2022 and compare with corresponding forecasts for 2023-2027 based on the seasonal ARIMA model using historical data of 2017-2021 with the effect of the war in 2022 in each country.

Method

- Third, the predicted electricity generation in 2022-2027 without the war in 2022 and the predicted electricity supply in 2023-2027 with the war in 2022 are converted to carbon dioxide (CO2) emissions based on CO2 conversion factors.

Data

- Data are from ENTSO-e (actual generation per production type: 15 mins).
- For Germany, “With shock” is the forecasted results by using the whole sample (96 months from January 2015 to December 2022). On the other hand, “Counterfactual” is the forecasted results by using the part of the sample (86 months); the Russian invasion period (10 months from March 2022 to December 2022) excluded.
- For Italy, With shock” is the forecasted results by using the whole sample (84 months from January 2016 to December 2022). On the other hand, “Counterfactual” is the forecasted results by using the part of the sample (74 months); the Russian invasion period (10 months from March 2022 to December 2022) excluded.

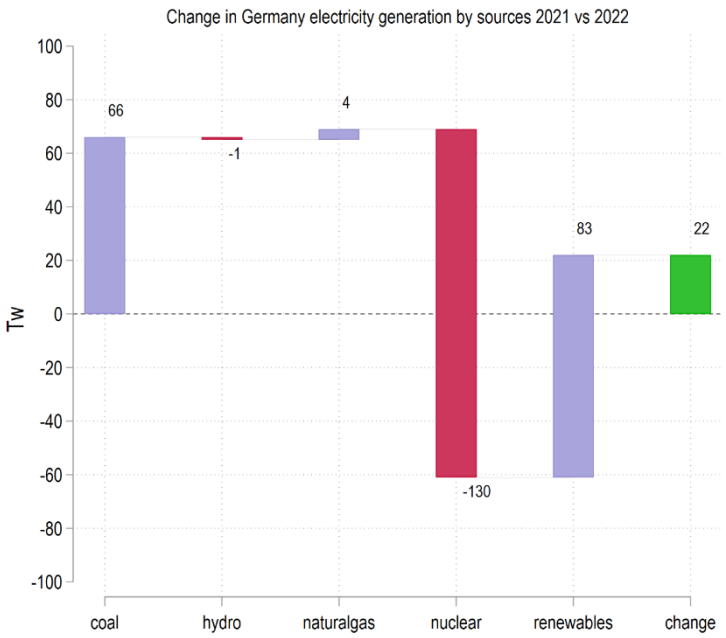
Data

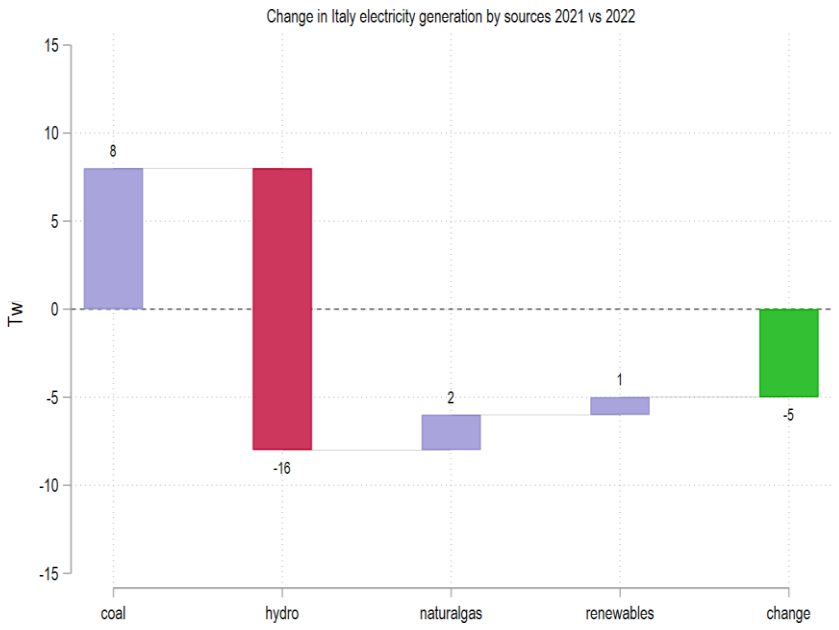
- In Germany's CO2 emission calculation, we use Fuel Emission Factor (Nicolae et al., 2022). However, we aggregate hard coal and brown coal into one coal by employing a weighted average based on our observations, in which the calculation is 0.66*1.7 (hard coal) + 0.34*16 (brown coal).
- In Italy's CO2 emission calculation, we rely on the same source. Italy uses only hard coal.

Fuel Emission factor	[g CO2eq/MJfuel]
Nuclear	1.4
Hard coal	16
Brown coal	1.4
Natural gas	12.8

toc2 = Heating value (MJ) * Fuel emission factor (g CO2eq/MJ) * 44/(12*1000000)

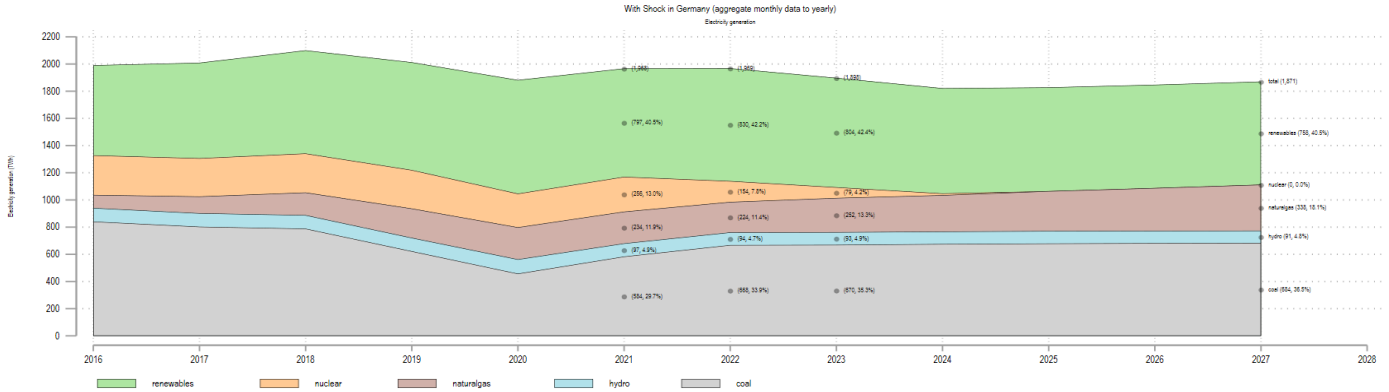
Preliminary analysis



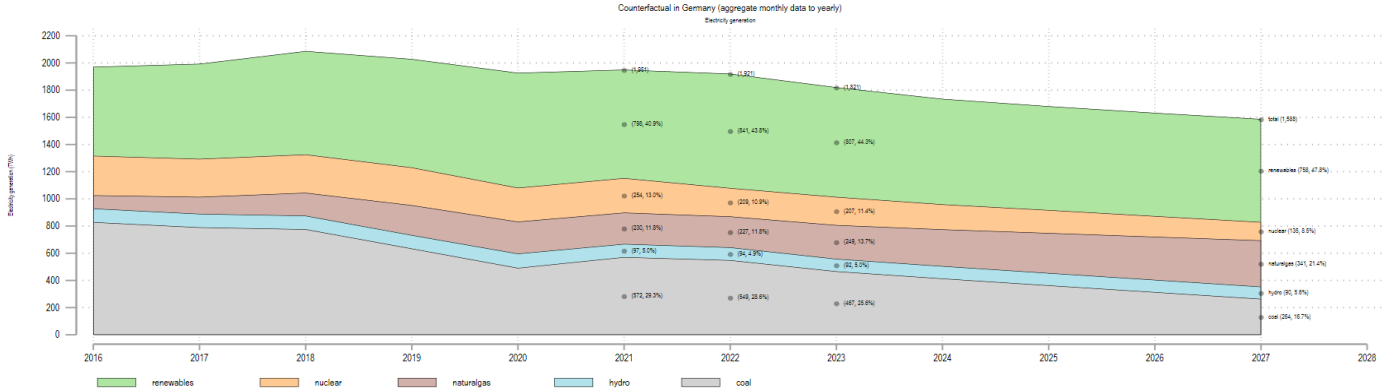


- **Renewables contain biomass, solar, geothermal, wind offshore, and wind onshore.**

Preliminary findings on electricity generation (Germany)



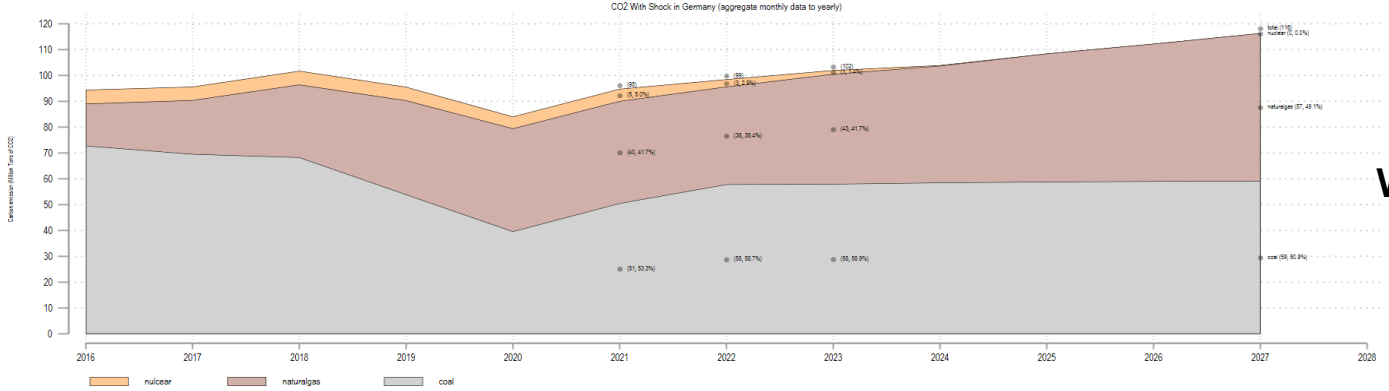
With shock



Without shock

Data source: ENTSOE Transparency Platform.

Preliminary findings on carbon emissions (Germany)



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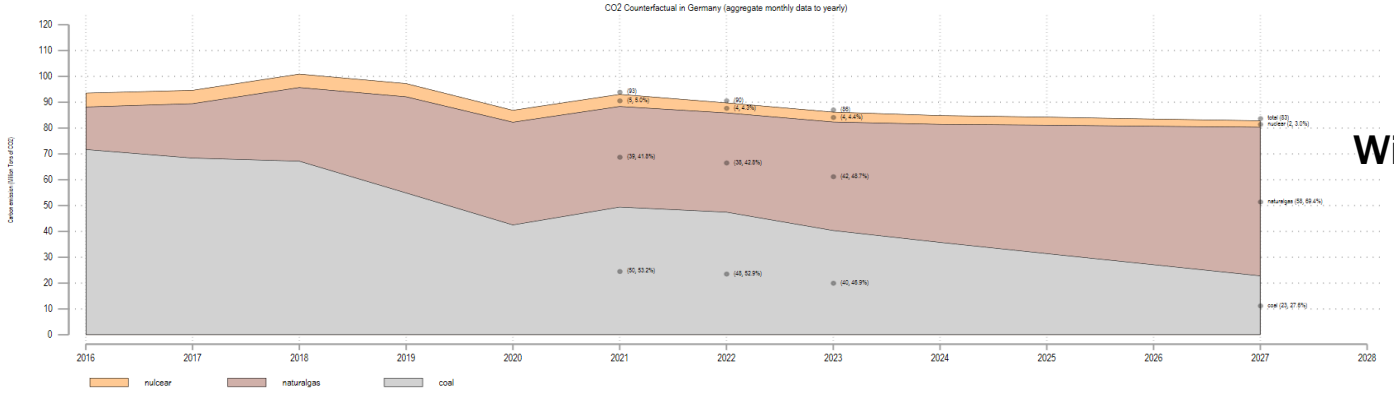

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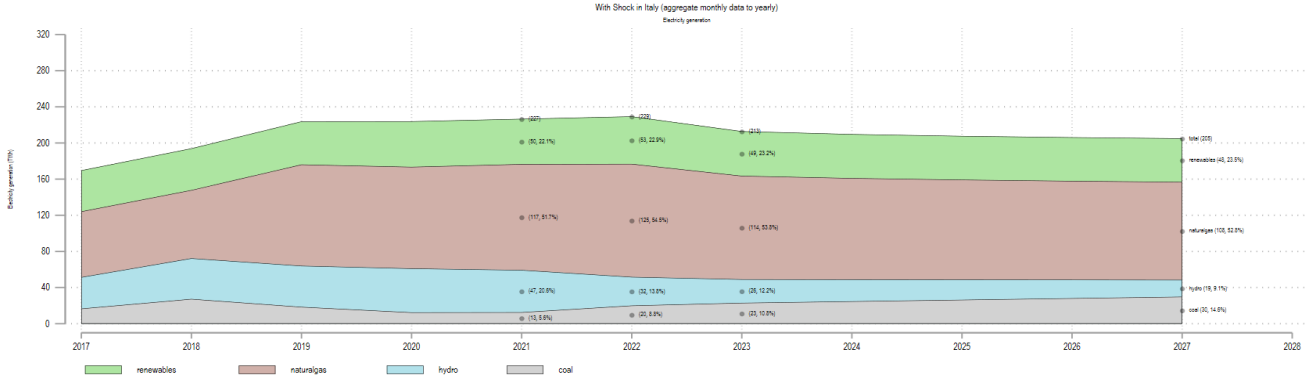
Data sources: ENTSOE Transparency Platform

Preliminary findings on electricity generation (Italy)



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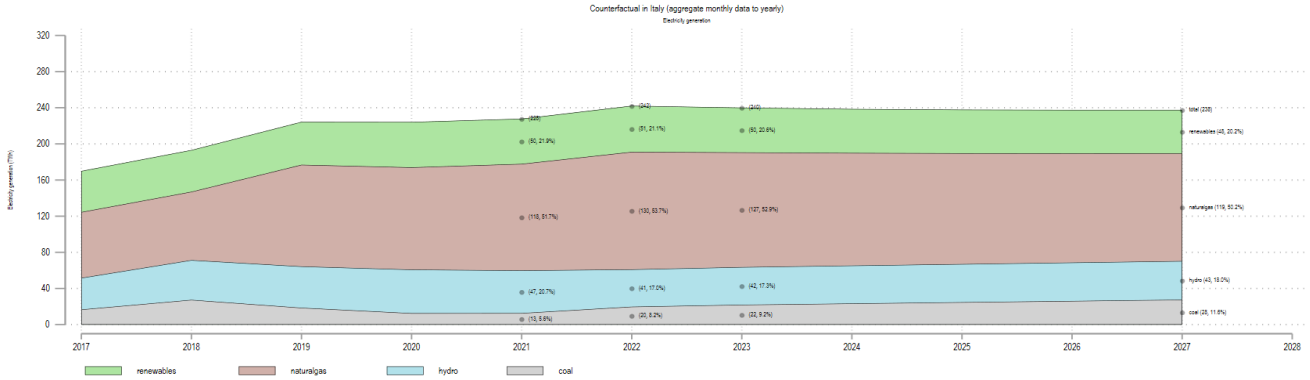

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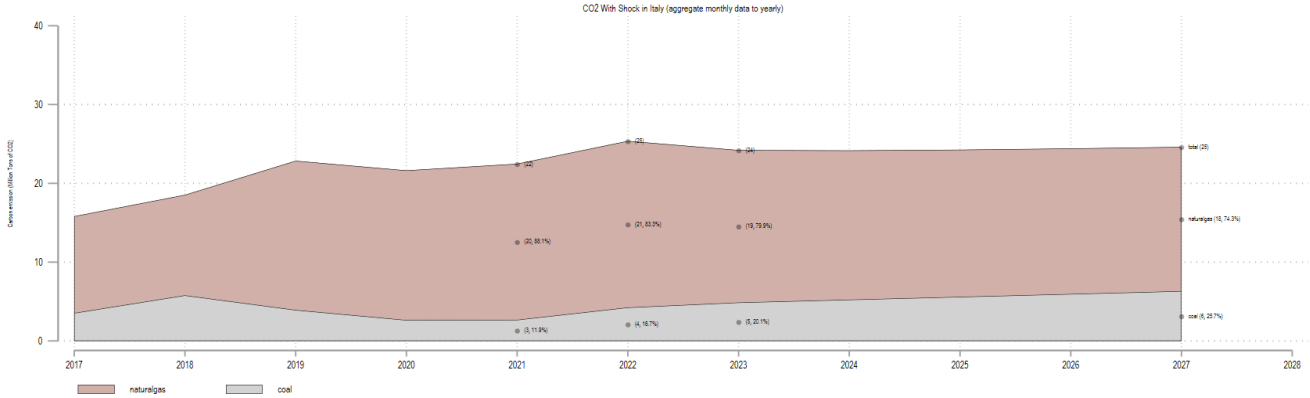
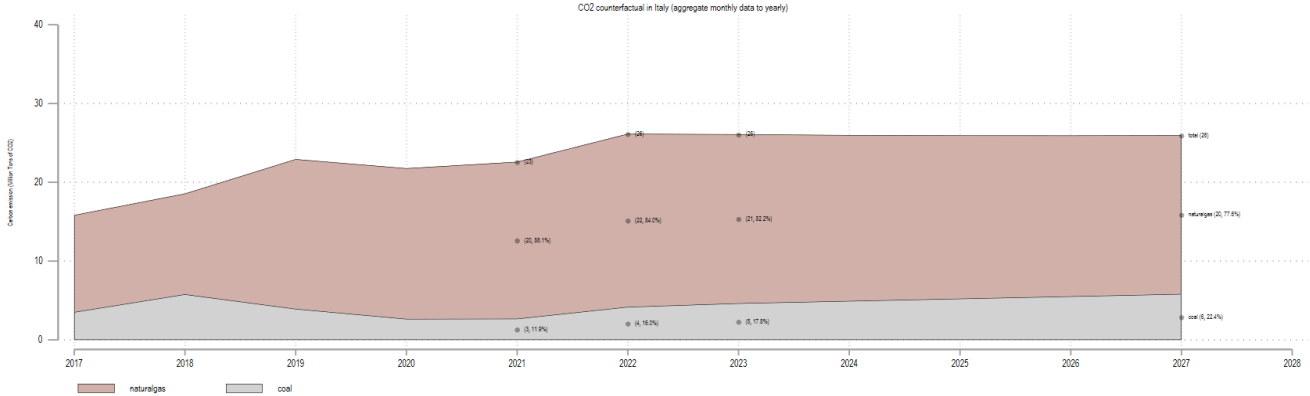
Data sources: ENTSOE Transparency Platform

Preliminary findings on carbon emissions (Italy)



With shock



Without shock

Data sources: ENTSOE Transparency Platform

Discussion

- In Germany, gas-fired power plants used to generate electricity prior to the Russia-Ukraine War have been replaced by a return to coal-fired power plant operations, causing an increase in carbon emissions.
- This finding suggests that the country is likely to face a greater burden to achieve climate neutrality by 2050.

Preliminary findings

- Italy continues to rely heavily on gas-fired power plants, suggesting the effect of war on the country's original course of energy transition is not as pronounced as that of Germany.
- The findings offer valuable information for potentially shifting strategies to achieve climate neutrality by 2050 through mainstreaming energy transition in Europe.

Appendix

Germany and Italy's energy source aggregation

Germany

Variable	<-	Raw data variable
Electricity source		
renewables	<-	Biomass
coal	<-	Fossil Brown coal/Lignite
fossil1 (naturalg gas)	<-	Fossil Coal-derived gas
fossil1 (naturalg gas)	<-	Fossil Gas
coal	<-	Fossil Hard coal
fossil1	<-	Fossil Oil
	<-	Fossil Oil shale
	<-	Fossil Peat
renewables	<-	Geothermal
hydro	<-	Hydro Pumped Storage
	<-	Hydro Pumped Storage
hydro	<-	Hydro Run-of-river and poundage
hydro	<-	Hydro Water Reservoir
	<-	Marine
nuclear	<-	Nuclear
	<-	Other
		Other renewable
renewables	<-	Solar
	<-	Waste
renewables	<-	Wind Offshore
renewables	<-	Wind Onshore

Italy

Variable	<-	Raw data variable
Electricity source		
renewables	<-	Biomass
coal	<-	Fossil Brown coal/Lignite
fossil1 (natural gas)	<-	Fossil Coal-derived gas
fossil1 (naturalg gas)	<-	Fossil Gas
coal	<-	Fossil Hard coal
fossil1	<-	Fossil Oil
	<-	Fossil Oil shale
	<-	Fossil Peat
renewables	<-	Geothermal
hydro	<-	Hydro Pumped Storage
	<-	Hydro Pumped Storage
hydro	<-	Hydro Run-of-river and poundage
hydro	<-	Hydro Water Reservoir
	<-	Marine
nuclear	<-	Nuclear
	<-	Other
renewables	<-	Solar
	<-	Waste
renewables	<-	Wind Offshore
renewables	<-	Wind Onshore