Supplementary Information for

Does myopic foresight modeling better capture real-world electricity system transition? Hindcasting in 31 European countries

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1. Supplementary Figures

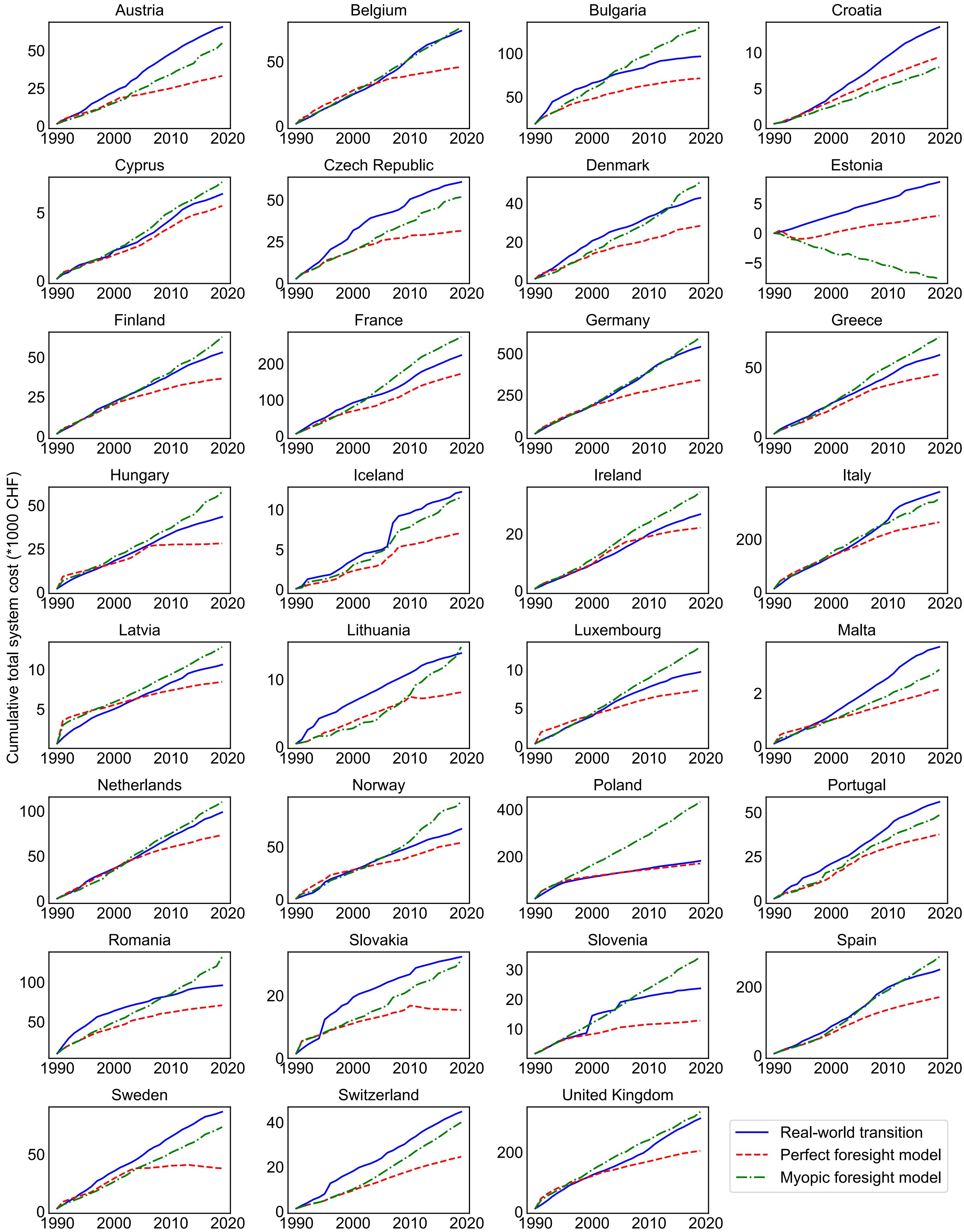

Fig. S1 Cumulative total system costs in 31 European countries from 1990 to 2019 in the real-world transition, perfect foresight model, and myopic foresight model with a 10-year scenario horizon and a five-year decision horizon. Note: In Estonia, the cumulative total system costs in the myopic foresight model are negative and notably lower than those in the perfect foresight model and real-world transition. This disparity is primarily attributed to Estonia's electricity export structure,where nearly 50% of its electricity is exported at price consistently exceeding the fuel costs of different technologies, especially for years from 1990 to 1995. Since 1995 electricity export price has steadily declined after 1995, reaching less than one-third of its initial value by 2019. The myopic foresight model, with its limited scenario horizon, prioritizes higher electricity production to maximize short-term export profits. This leads to increased investment costs in export transmission capacity, which can only be retired after the end of its lifetime. In this case, myopic foresight model prefers to generate and export more electricity as compared to the perfect foresight model. Conversely, the perfect foresight model anticipates the long-term decline in export price, leading to a strategic reduction in electricity generation and exports.

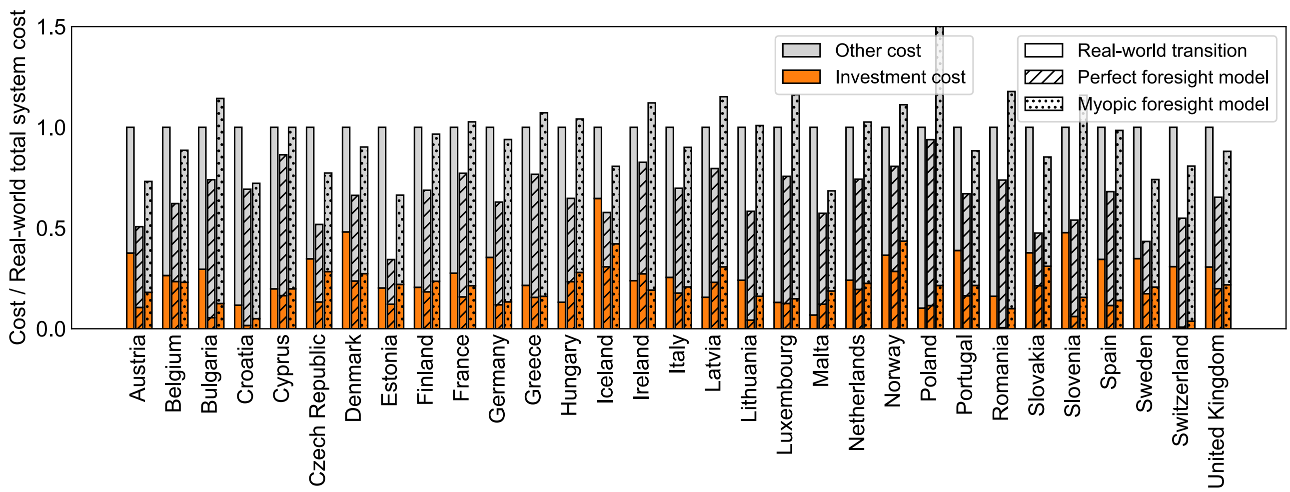

Fig. S2 Comparison of total system cost and investment cost in 31 European countries in the real-world transition, perfect foresight (PF) and myopic foresight (MF) models. The values for the myopic foresight model are the average of 406 total results. By dividing by the total system cost in real-world transition, we standardize the magnitude of cost across countries.

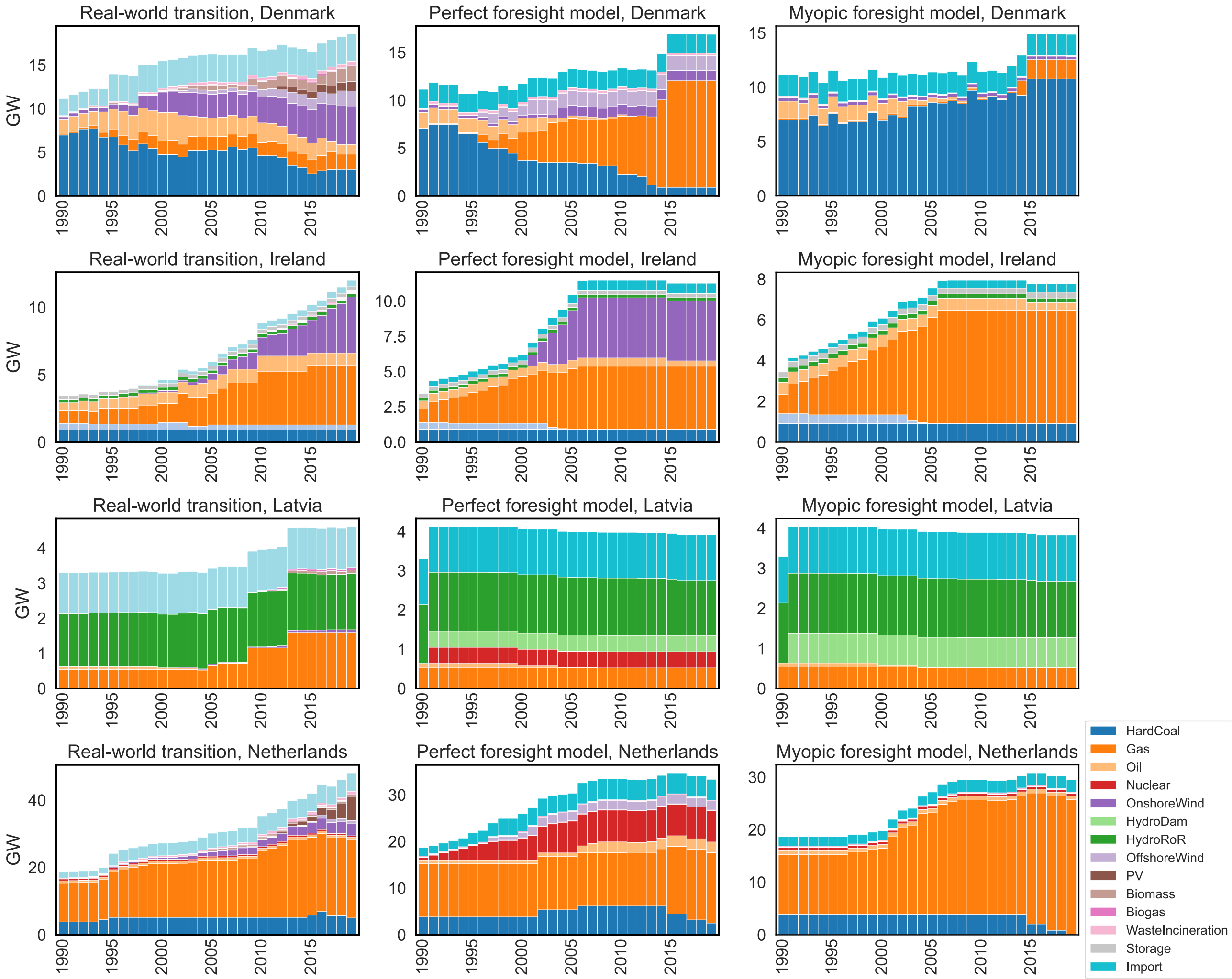

Fig. S3 Comparison of installed capacity in real-world transition, perfect foresight model, and myopic foresight model with five-year scenario horizon and three-year decision horizon for selected countries.

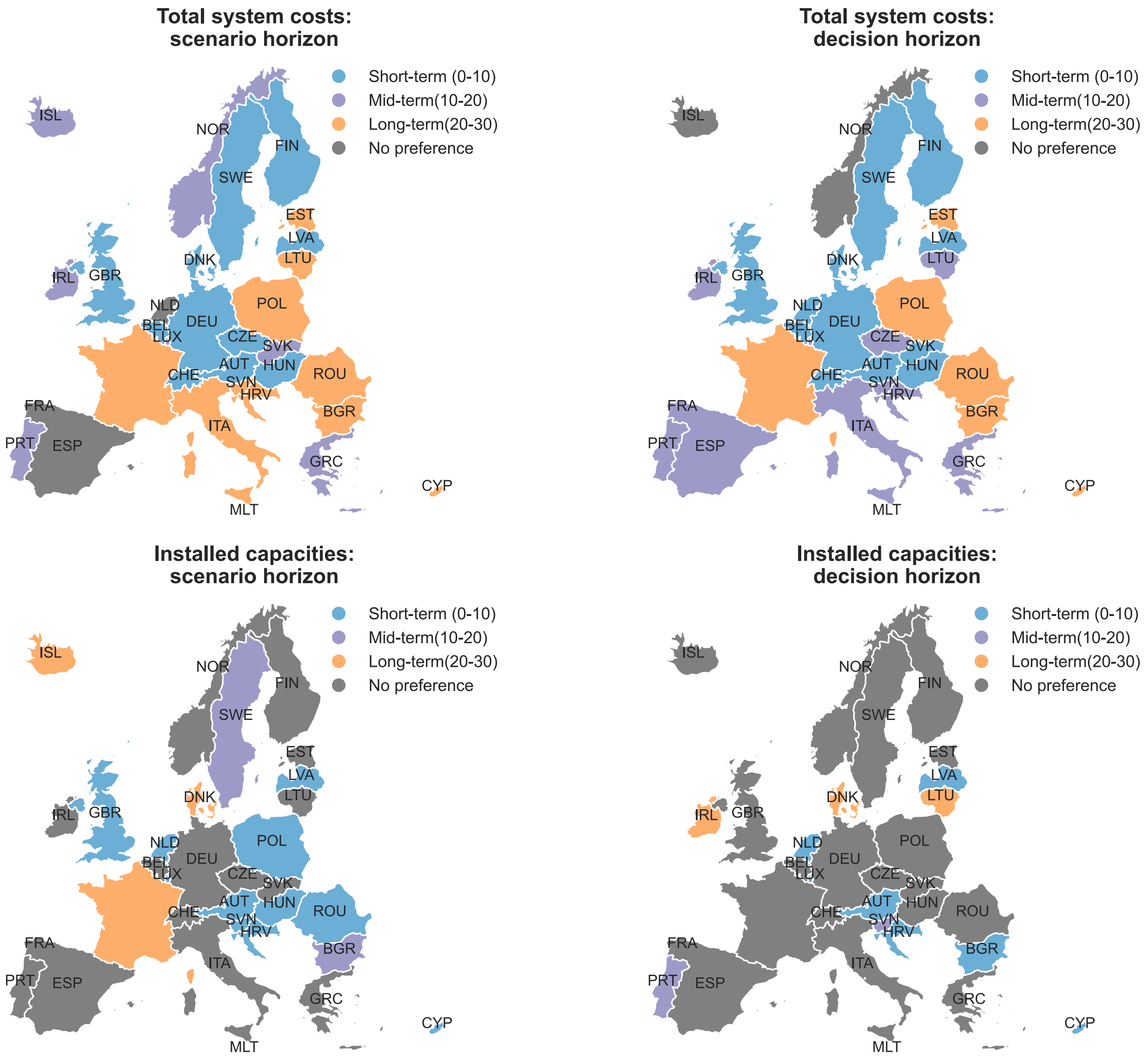

Fig. S4 Recommendation of decision and scenario horizons for projecting total system costs and installed capacities across 31 European countries in the myopic foresight model. The 30-year time horizon is divided into three distinct periods: short-term (0–10 years), mid-term (10–20 years), and long-term (20–30 years). For each country, the accuracy is evaluated by comparing the symmetric Mean Absolute Percentage Error (sMAPE) across these intervals. If a statistically significant difference is observed, the time period with the lowest sMAPE is recommended. Countries where no significant difference is found are marked in gray, indicating no clear preference for a specific horizon, suggesting that the choice of horizon does not have a significant impact on the accuracy of the myopic model for that country.

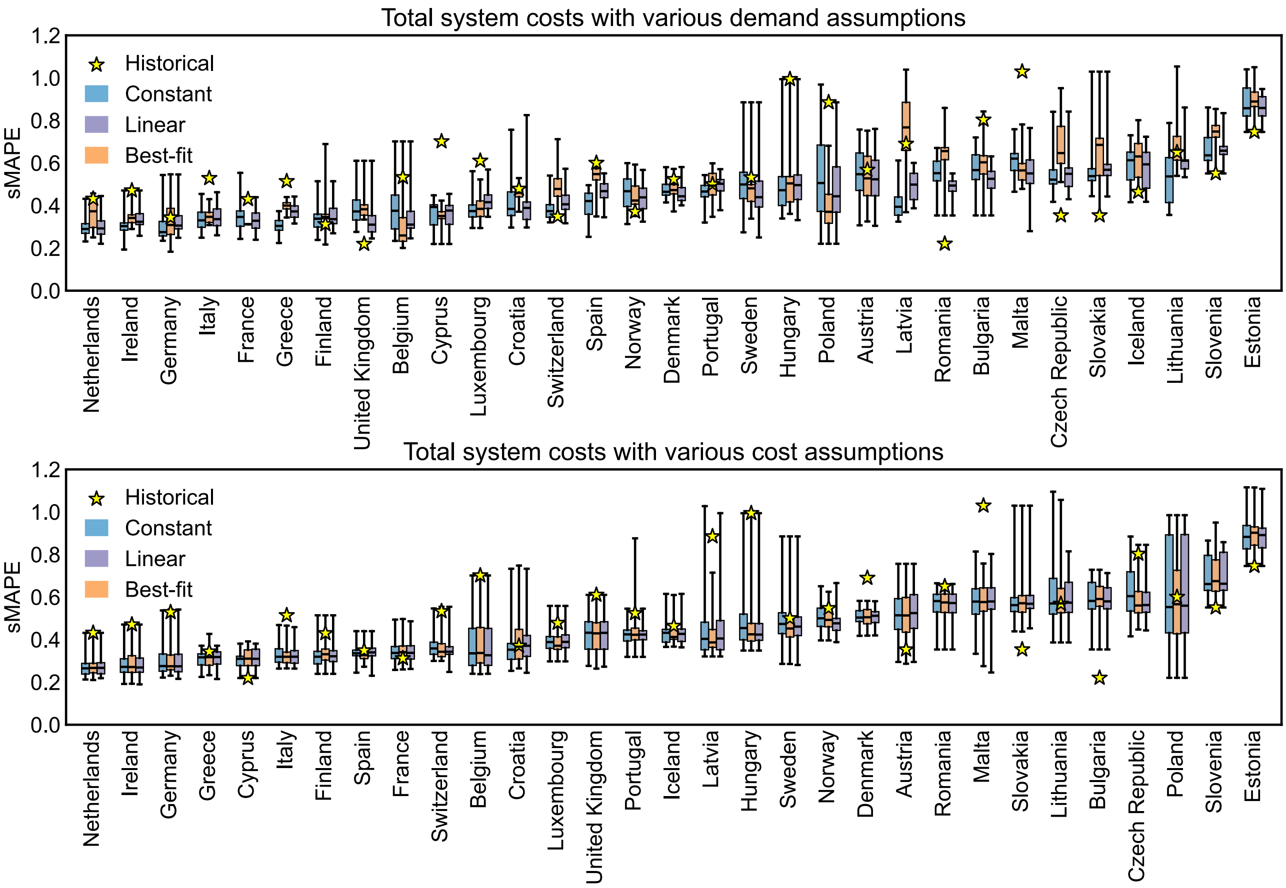

Fig. S5 Accuracy comparison in total system costs for 31 European countries from 1990 to 2019 in myopic foresight models with electricity demand and technology costs assumptions, and perfect foresight models with historical data. Boxplots depicting the range, upper and lower quantiles, and medians of sMAPE values across 100 myopic foresight scenarios; the star representing sMAPE value of the single perfect foresight scenario. The sMAPE, bounded within the range of [0, 2], indicates that lower value corresponds to higher accuracy, reflecting a closer alignment with real-world situations.

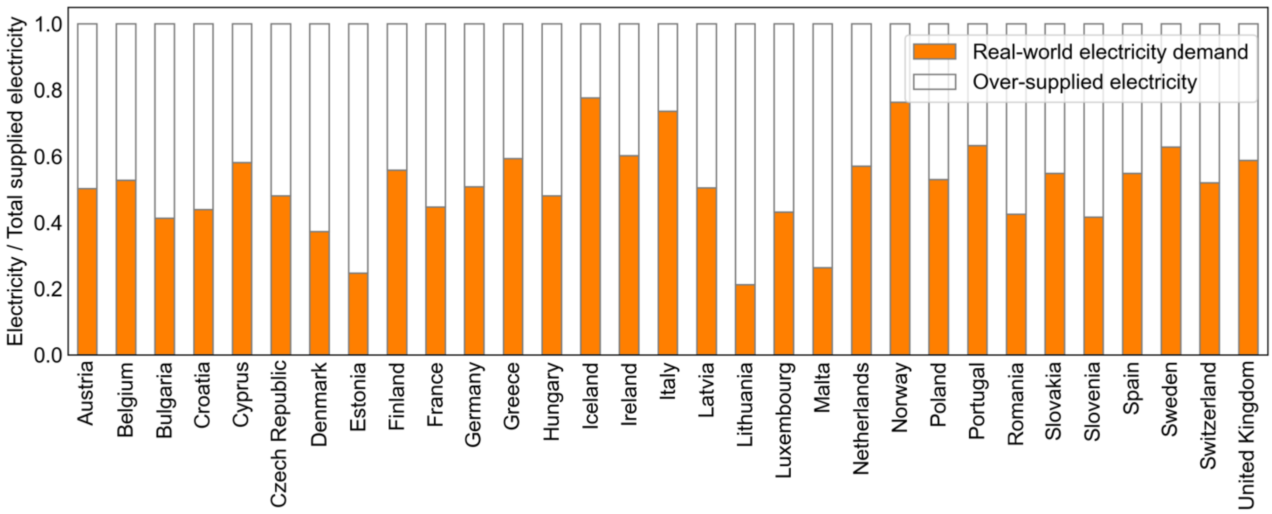

Fig. S6 Comparison of maximum annual electricity generation from existing installed capacity in 1990 and electricity demand in 1990 in real-world transitions in 31 European countries.

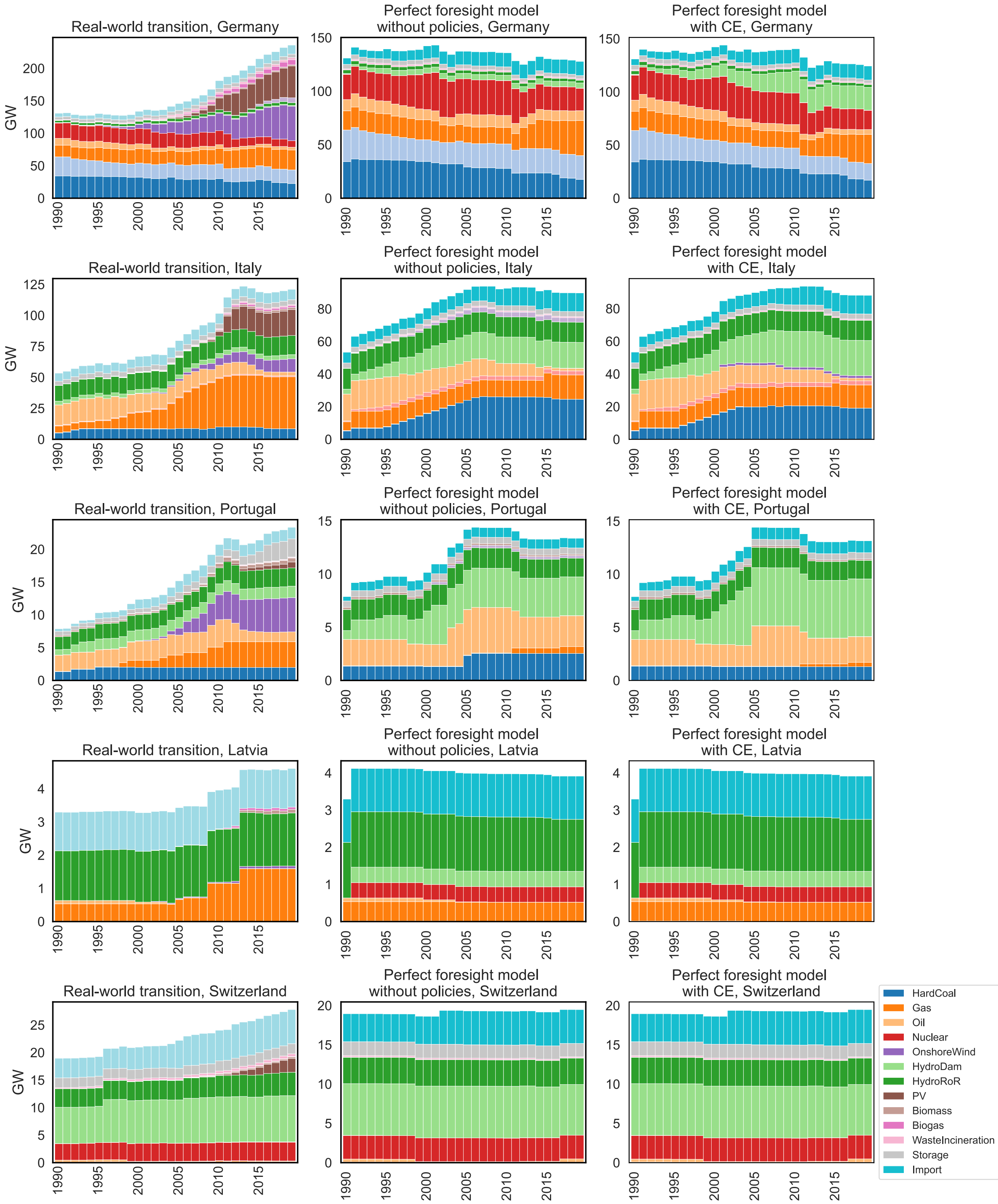

Fig. S7 Comparison of annual installed capacity in real-world transition, perfect foresight model without policies, and perfect foresight model with CO_2 emission targets (CE) for selected countries.

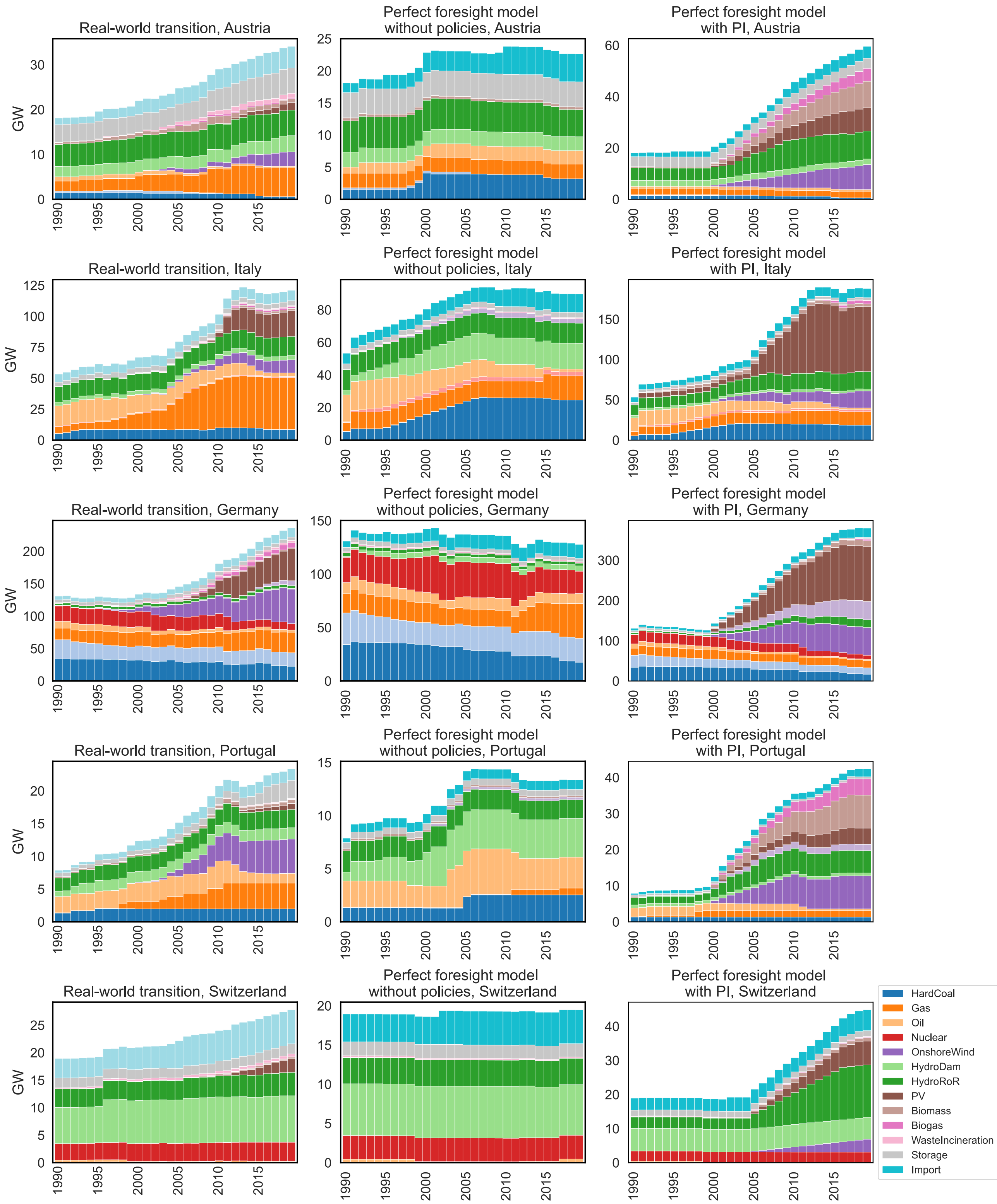

Fig. S8 Comparison of annual installed capacity in real-world transition, perfect foresight model without policies, and perfect foresight model with three policy instruments that reduce technology costs for selected countries.

Technology	Model without policies	Model with CO2 emission targets (CE)	Models with renewable generation targets (RG)	Models with three policy instruments (PI)	Models with CE and RG	Models with CE and PI	Model with RG and PI	Models with CE, RG, and PI	Model without policies	Model with CO2 emission targets (CE)	Models with renewable generation targets (RG)	Models with three policy instruments (PI)	Models with CE and RG	Models with CE and PI	Model with RG and PI	Models with CE, RG, and PI
Hard coal	0.42	0.29	0.43	0.33	0.43	0.27	0.34	0.34	0.35	0.29	0.37	0.34	0.32	0.26	0.32	0.32
Brown coal	0.26	0.23	0.23	0.14	0.23	0.14	0.14	0.14	0.20	0.19	0.19	0.18	0.15	0.14	0.15	0.14
Gas	0.60	0.68	0.67	0.64	0.67	0.66	0.63	0.63	0.61	0.67	0.64	0.66	0.63	0.66	0.64	0.64
Oil	0.44	0.35	0.34	0.33	0.34	0.33	0.33	0.33	0.45	0.36	0.37	0.38	0.40	0.40	0.40	0.40
Nuclear	0.39	0.38	0.38	0.35	0.38	0.36	0.35	0.35	0.30	0.36	0.34	0.34	0.33	0.35	0.33	0.33
Solar PV	1.07	1.07	1.07	1.18	1.07	1.18	1.17	1.17	1.07	1.07	1.07	0.99	1.07	0.98	0.98	0.98
Onshore wind	1.29	1.35	1.27	1.13	1.27	1.13	1.11	1.11	1.39	1.39	1.34	1.13	1.31	1.13	1.11	1.11
Offshore wind	0.27	0.57	0.66	0.73	0.66	0.79	0.75	0.75	0.26	0.43	0.38	0.47	0.24	0.41	0.35	0.35
Biomass	1.02	1.03	1.01	1.20	1.01	1.20	1.22	1.22	1.02	1.03	0.97	0.99	0.96	0.99	0.96	0.96
Biogas	1.25	1.26	1.24	1.24	1.24	1.26	1.24	1.24	1.26	1.26	1.22	1.21	1.21	1.22	1.19	1.20
Waste incineration	0.94	0.92	0.94	0.89	0.94	0.89	0.90	0.90	0.83	0.90	0.83	0.82	0.80	0.91	0.80	0.80
Hydro dam	0.39	0.78	0.84	0.22	0.84	0.22	0.29	0.29	0.43	0.71	0.75	0.66	0.71	0.69	0.69	0.69
Hydro run-of-river	0.28	0.29	0.29	0.56	0.29	0.56	0.56	0.56	0.28	0.28	0.28	0.39	0.28	0.35	0.35	0.35
Storage	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.31	0.32	0.32
Import/Export	0.25	0.28	0.27	0.24	0.27	0.24	0.24	0.24	0.26	0.29	0.27	0.26	0.27	0.26	0.26	0.26
	Perfect foresight model								Myopic foresight model							

Fig. S9 Comparison of hindcasting performance for all the 31 European countries of various model version with and without historical policies. The shown values are means over all 31 countries and one hindcasting iteration for perfect foresight model and 100 hindcasting iterations for myopic foresight models. The sMAPE of installed capacities is calculated as an aggregated value over the whole time horizon (1990 – 2019) and all 31 countries. The sMAPE values are bounded within the range of [0, 2] here, indicates that lower value corresponds to higher accuracy, reflecting a closer alignment with real-world situations. Three policy instruments (PI) include subsidies, tradable green certificates, and feed in tariffs.

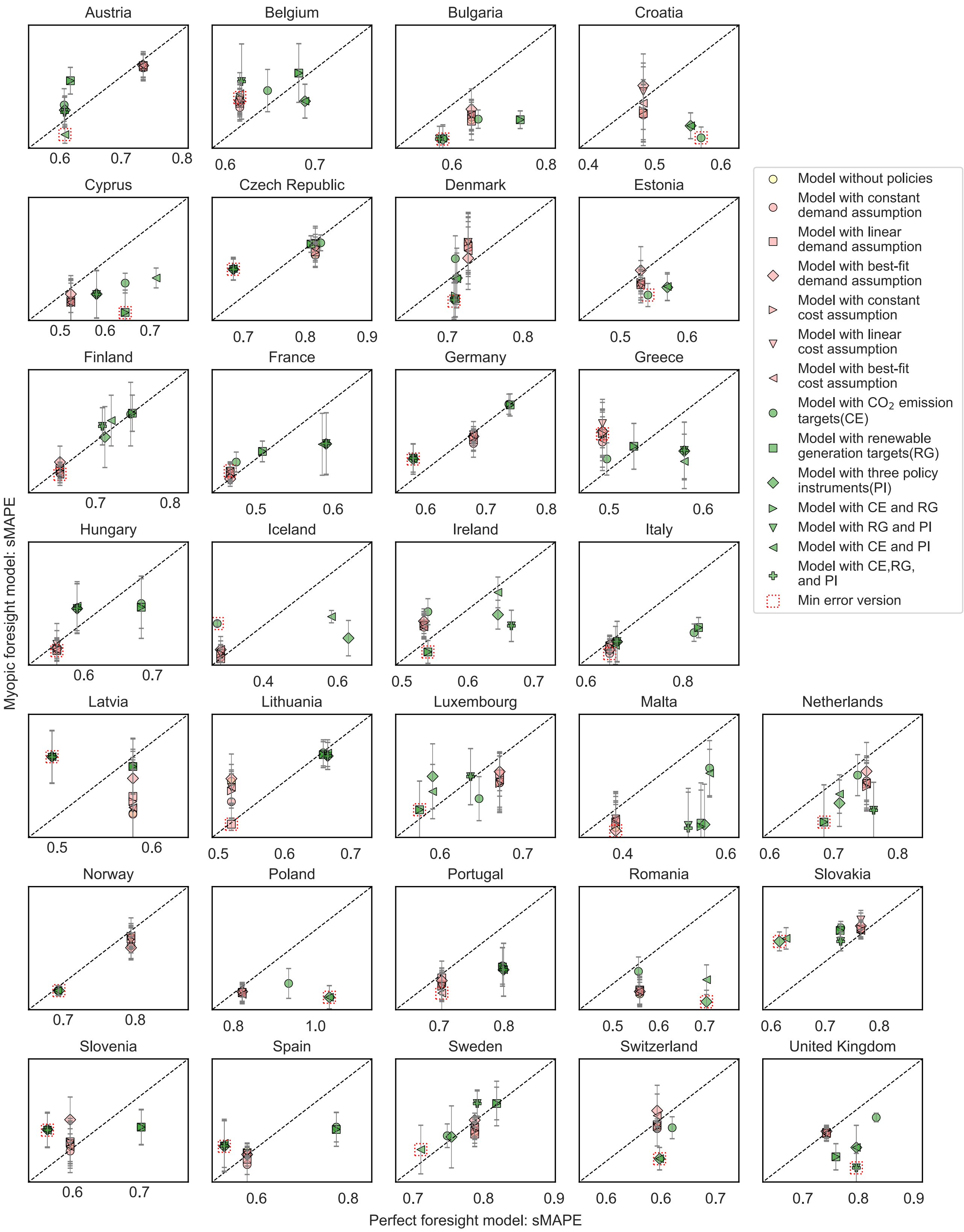

Fig. S10 Comparison of Symmetric Mean Absolute Errors (sMAPE) across all perfect and myopic foresight model versions. It presents an accuracy comparison across model without policies, model with six demand and costs assumptions, and models with seven policy combinations in estimating annual installed capacity for 31 European countries. The three policy instruments considered include subsidies on investment costs, tradable green certificates, and feed-in tariffs.

2. Supplementary tables

Table S1. Techno-economic minimum capacity factors of different technology from 1990 to 2019. The presented values were adapted within the technical limits from the dataset provided by Jaxa-Rozen et al[1].

Country	Hard coal	Brown coal	Gas	Nuclear
Austria	0.45	0.45	0.18	0.63
Belgium	0.45	-	0.18	0.63
Bulgaria	0.36	0.36	0.18	0.36
Croatia	0.45	0.45	0.27	0.63
Cyprus	0.45	-	0.18	0.63
Czech Republic	0.36	0.36	0.18	0.63
Denmark	0.27	-	0.27	0.63
Estonia	0.45	0.36	0.18	0.63
Finland	0.45	0.45	0.18	0.63
France	0.45	0.45	0.18	0.45
Germany	0.27	0.45	0.18	0.45
Greece	0.45	0.45	0.18	0.63
Hungary	0.45	0.45	0.18	0.63
Iceland	0.45	-	-	0.63
Ireland	0.45	0.45	0.18	0.63
Italy	0.45	0.45	0.27	0.63
Latvia	0.45	0.45	0.18	0.63
Lithuania	0.45	-	0.18	0.63
Luxembourg	0.45	-	0.18	0.63
Malta	0.45	-	0.18	0.63
Netherlands	0.36	-	0.27	0.63
Norway	0.45	-	0.18	0.63
Poland	0.36	0.45	0.18	0.63
Portugal	0.45	-	0.18	0.63
Romania	0.27	0.36	0.18	0.63
Slovakia	0.45	0.45	0.18	0.63
Slovenia	0.45	0.45	0.18	0.54
Spain	0.45	0.45	0.18	0.63
Sweden	0.45	0.45	0.18	0.54
Switzerland	0.45	-	0.18	0.63
United Kingdom	0.36	-	0.27	0.59

Table S2. European Union's CO_2 emission targets from 1990 to 2050. "Level" refers to the upper limit of net greenhouse gas emissions in the target year relative to the level in 1990. The CO_2 emission target is extrapolated from the released year to the target year. Considering that CO_2 emissions will not decrease linearly in reality, we give a margin of ±20% for all years except for the target year.

Year	**1990**	**1997**	**2007**	**2014**	**2019**	**2020**
Level	1.00	0.92	0.80	0.60	0.45	0.00
Target year	2010	2012	2020	2030	2030	2050

Supplementary references

1. Jaxa-Rozen, M., Wen, X. & Trutnevyte, E. Historic data of the national electricity system transitions in Europe in 1990–2019 for retrospective evaluation of models. *Data Brief* **43**, (2022).