Climate Change

C3S Energy Webinar

Unlocking Climate Data for Energy – Case Studies on Seasonal Forecasts and Climate Projections

20 November 2024

Case study 1 - Enhanced Gas demand modeling through seasonal temperatures forecasts

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Summary

- ❑ Overview about Enel and decision making
- ❑ Evaluation of the Seas5 skills
- ❑ Backtest & Performance Analysis of the Gas Model
- ❑ Analysis of the demand scenarios and prices distribution
- ❑ Conclusions

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Enel in pills

World Presence

28 Countries,
Of which 5 core

World's largest player in renewables[2]

87.1 GW
installed capacity[2]

1st network operator[3]

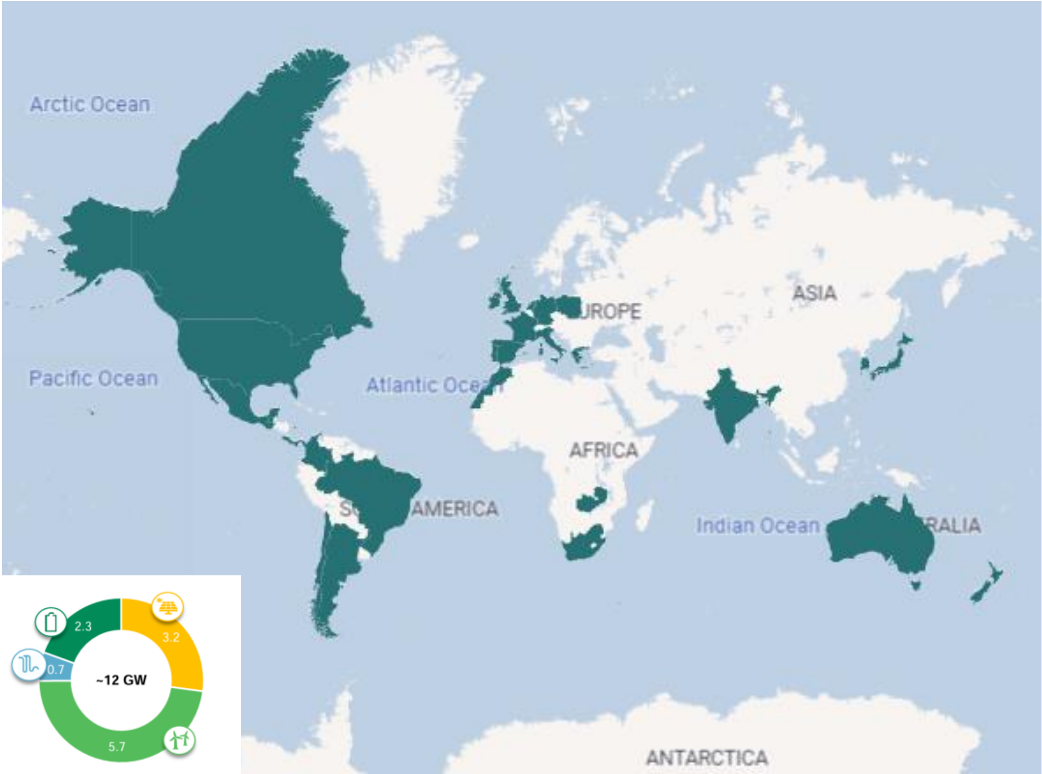
69.2 mn end users[5]

Largest retail customer base worldwide[3, 4]

55.4 mn customers[5]

EBITDA

22€bn



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Weather Risk Management

Margin variability factors

Weather variables...

- Temperature
- Rainfall
- Wind Speed
- Solar radiation

...Impact...

Directly → **Enel RES + Retail volumes**

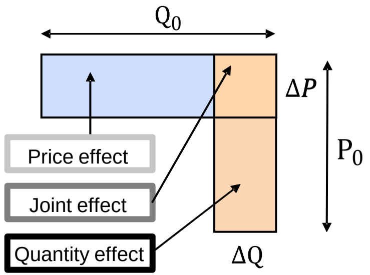
Indirectly → **System thermal gap** → **Power Market prices** → **Enel Conventional Generation volumes**

...Margin Drivers

Volumetric Risk
$P_0 \times \Delta Q$

Joint Risk
$\Delta Q \times \Delta P$

Price Risk
$Q_0 \times \Delta P$



The **margin variability** depends on a price effect, a quantity effect and a price-quantity joint effect

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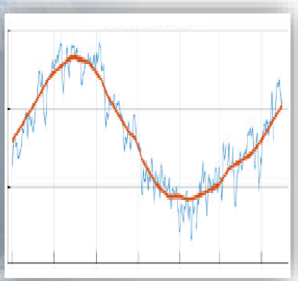
Weather Risk Management

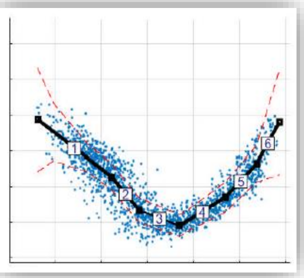
Risk exposure modelling structure

WEATHER DATA



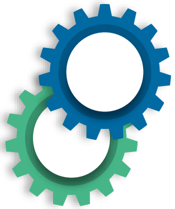
Statistical & meteorological analysis of weather variables

GAS DEMAND



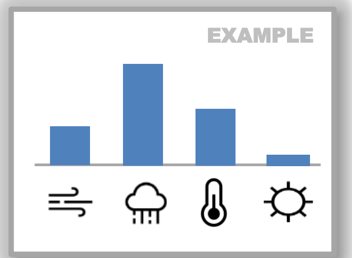
Impact on gas consumption driven by temperatures

FUNDAMENTAL MODEL



Impact on market prices

WEATHER RISK EXPOSURE



Weather driven impact on Enel margin

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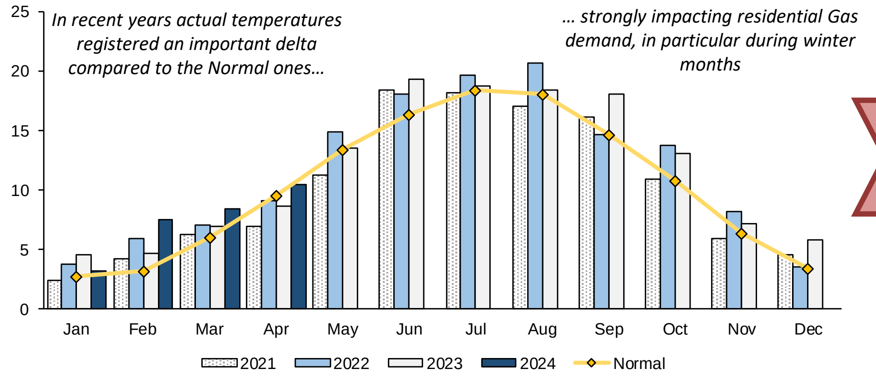
Weather Risk Management

Gas Demand vs Temperature

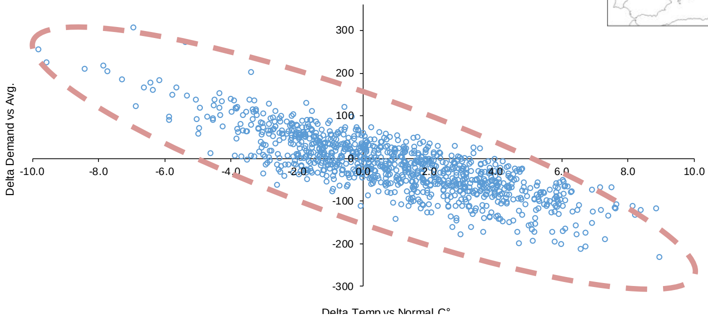
Actual Temperature vs Normal

North West Europe



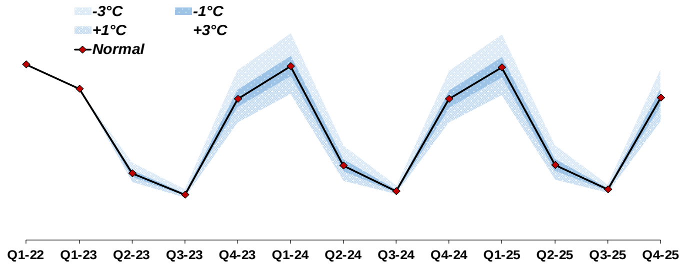
Delta Temperature vs Delta Demand

Residential Gas Demand



Residential Gas Demand in Northwest Europe is strictly related to temperatures*. In particular, there is a stronger effect during winter months rather than summer.*

Impact of ΔT° on demand forecast



- ***Power and Gas Demand*** *are strictly related to* ***temperatures****. Therefore, the deviation from the normal can lead to spike in consumption in both Gas and Power sector.*
- *We decided to focus on the impact of temperature in the* ***Gas demand****, since the gas demand dynamics strongly impact* ***gas prices that have in turn an impact in the power prices.***
- *Therefore, the possibility to have a f****orecast of temperatures*** *for the future instead of normal values can lead to a* ***better forecast of Gas and Power prices.***

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Concept

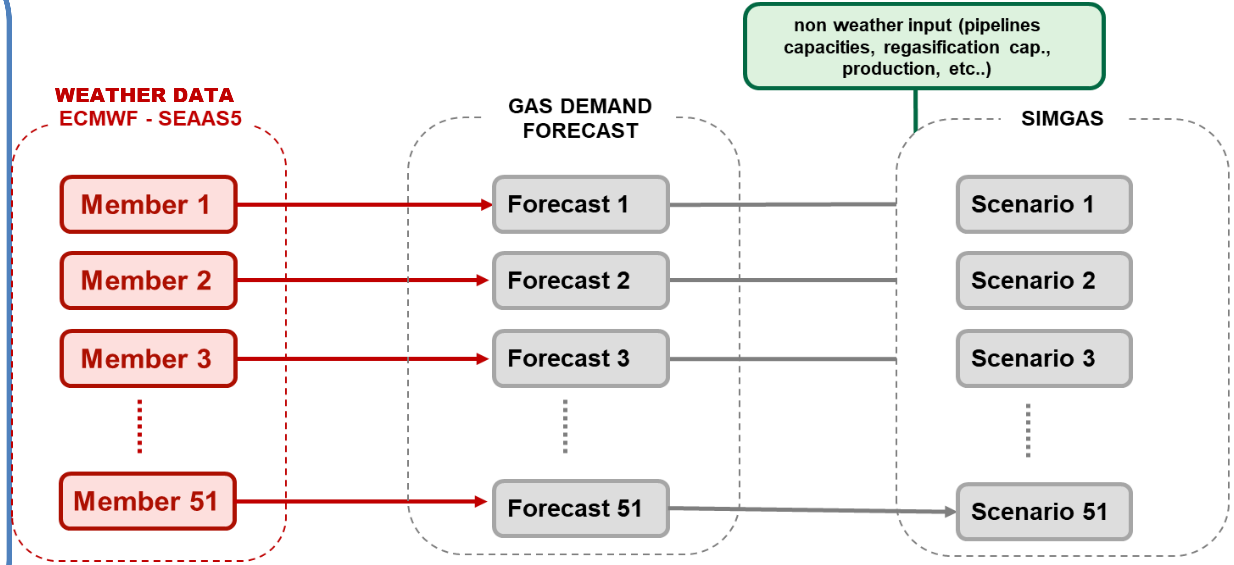
Use of ECMWF Season forecasts SEAS5 to develop a gas demand model

Area of interest:
- Northwest Europe

Parameters:
- Temperature

Forecasts:
- 6-months into the future

Periods:
- 2010-2022 (testing period)
- 2024-onwards (operational)



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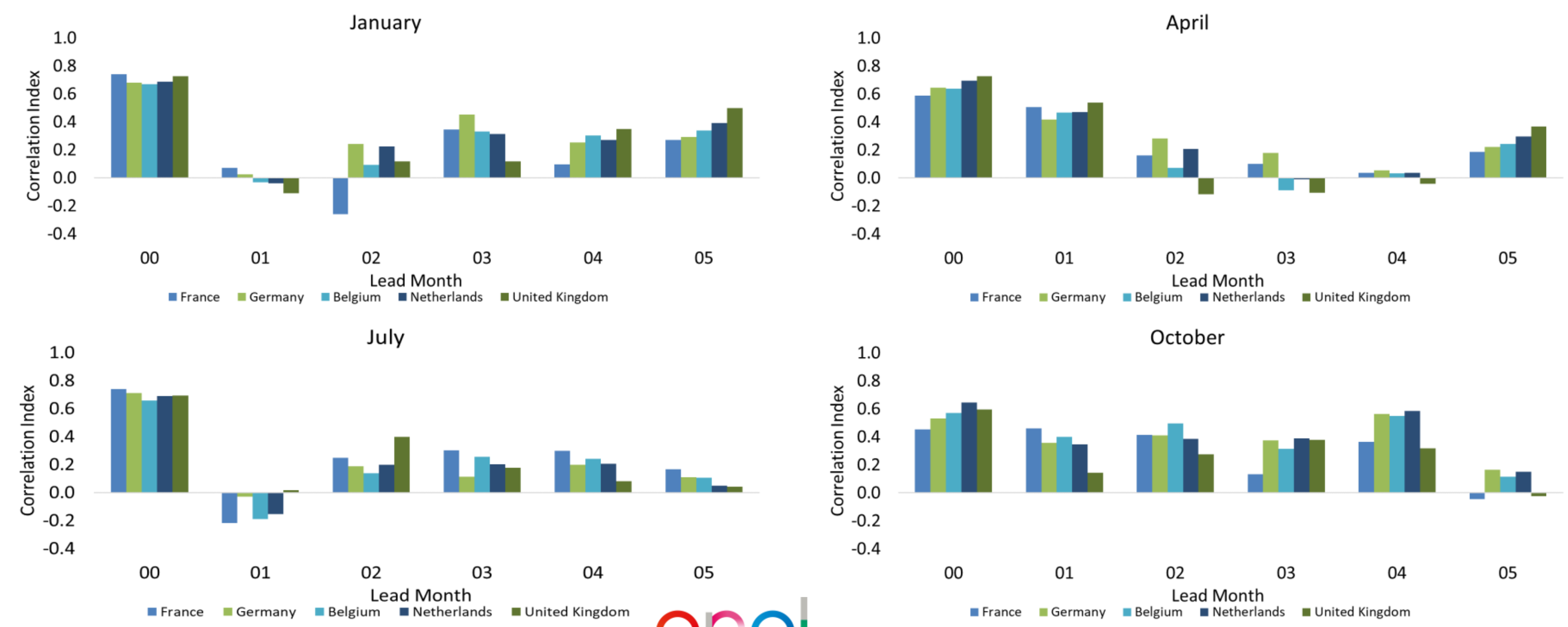
Evaluation of the skills of the temperature forecasts

Statistical analysis of the forecast's errors with respect to the control variables

CORRELATION



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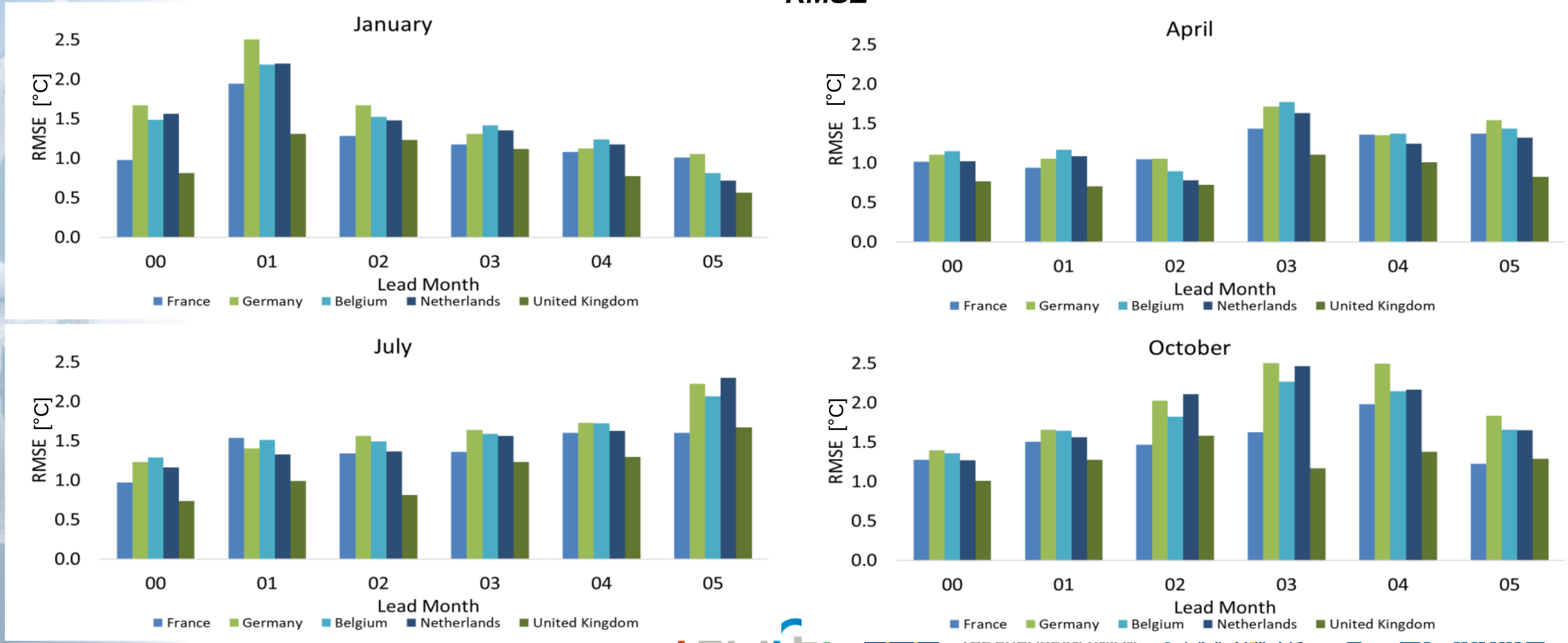
Evaluation of the skills of the temperature forecasts

Statistical analysis of the forecast's errors with respect to the control variables

RMSE



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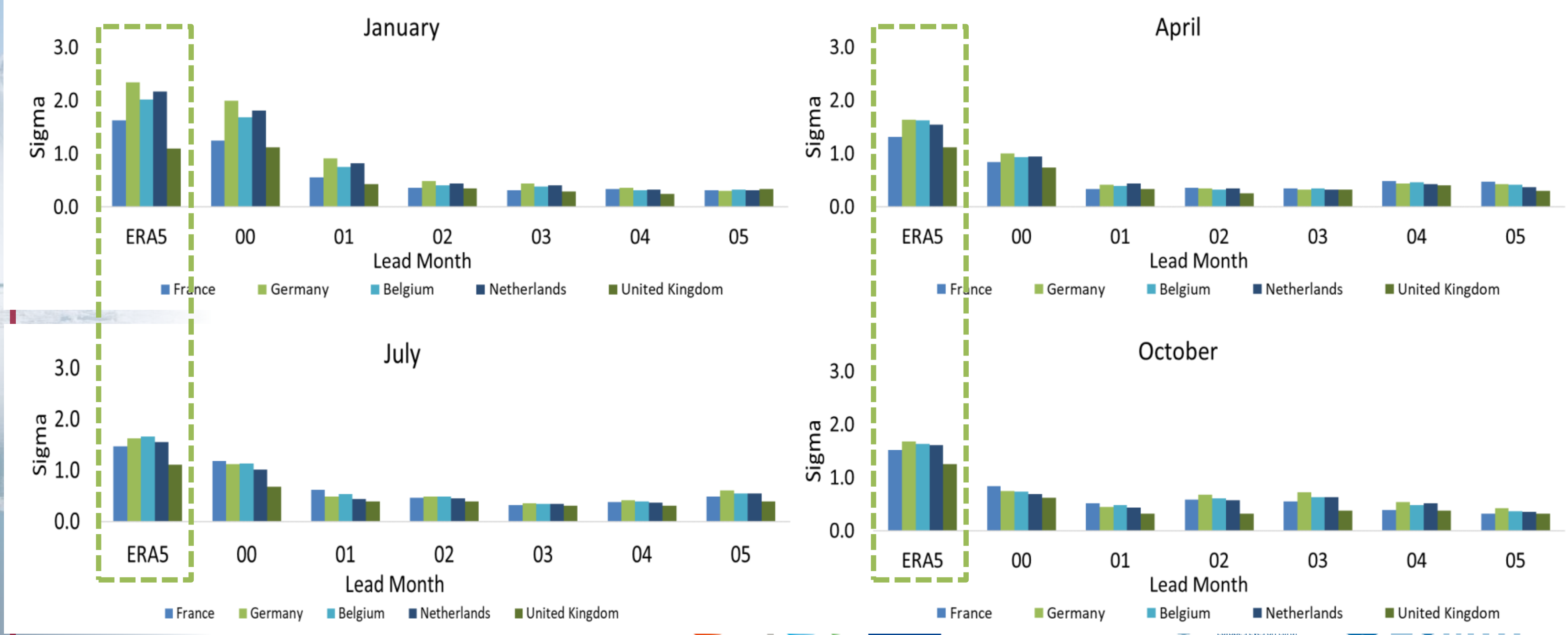
E v a l u a t i o n   o f   t h e   S E A S 5   s k i l l s

Statistical analysis of SEAS5 vs normal values

Do the SEAS5 forecasts represent the real variability of the weather?



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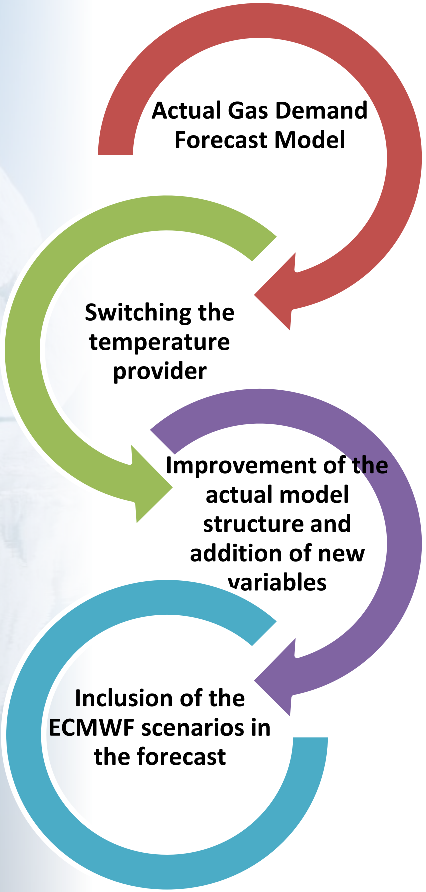
Gas Demand Forecasting Model



- ❑ ***Due to the seasonality of the Gas Demand the considered model is a seasonal ARIMA with external regressors (SARIMA-X).***
- ❑ ***Changing the temperature provider from Volue to ERA5, allowing the utilization of the ECMWF 51 wheatear scenarios.***
- ❑ ***Inclusion of the external variable to reduce the forecasting error (i.e. tightness, net imports, winter temperature) and revision of the model parameters.***
- ❑ ***Possibility to run different demand scenarios based on the 51 weather scenarios provided by the ECMWF.***

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Forecasting Gas Demand in NorthWest Europe

Development and implementation of the new model features with consequent backtest and performance evaluation

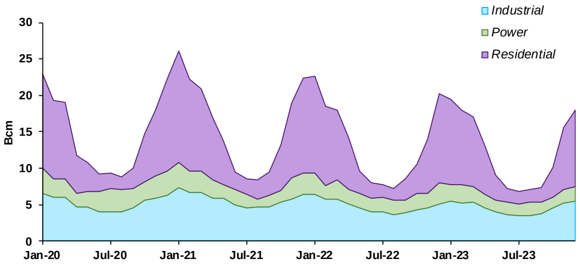
Model

- *Due to the **seasonality of the Gas Demand** the considered model is a **seasonal ARIMA** with **external regressors** (**SARIMA-X**). A seasonal ARIMA model is formed by including additional seasonal terms in the ARIMA model. The equation of the **SARIMA** $(\boldsymbol{p},\boldsymbol{d},\boldsymbol{q})(\boldsymbol{P},\boldsymbol{D},\boldsymbol{Q})_{\boldsymbol{m}}$ model reads:*

Model Equation:

$$(1-\phi_p B)(1-\Phi_P B)(1-B)^d\,(1-B^m)^D y_t = \left(1+\theta_q B^m\right)^d\left(1+\Theta_Q B^m\right)^D\,\varepsilon_t + \gamma_i X_i$$

North West Europe Gas Demand by Sector [Bcm]



External Variables

… we considered different in relation to the different dynamics of the sectorial gas demand…

Residential

- ***Temperature:*** *is the main explicative variable for the residential consumption.*

Power

- ***Tightness****: it is an indicator related to the power sector, computed as:*

$$\boldsymbol{Consumption - Renewables\ Production - Nuclear\ production}$$

It indicates the tension of the power market.

A higher level of tightness indicates a higher reliance on thermal production (i.e. Gas&Coal).

Industrial

- ***Temperature***
- ***Industrial Production Index***

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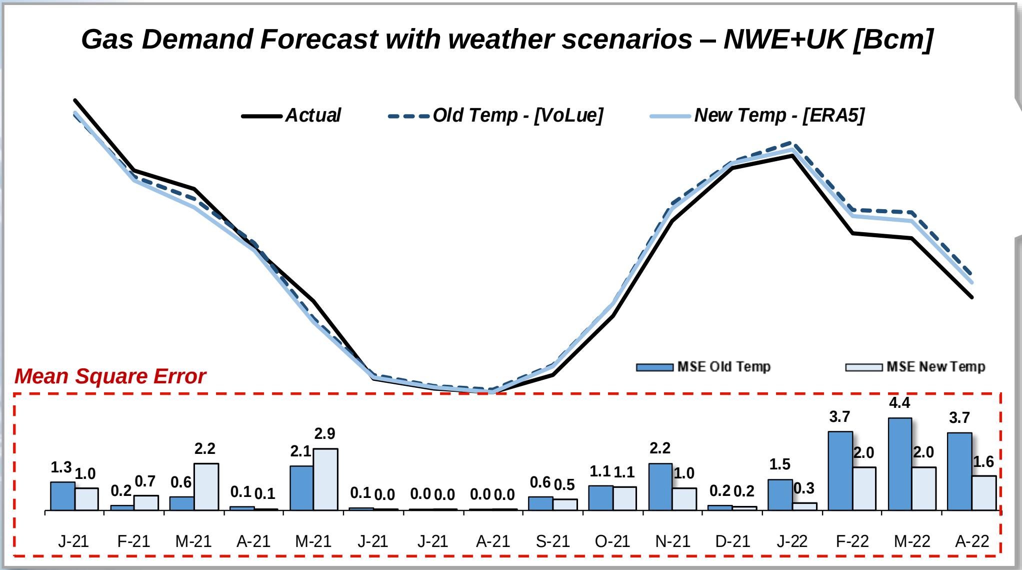
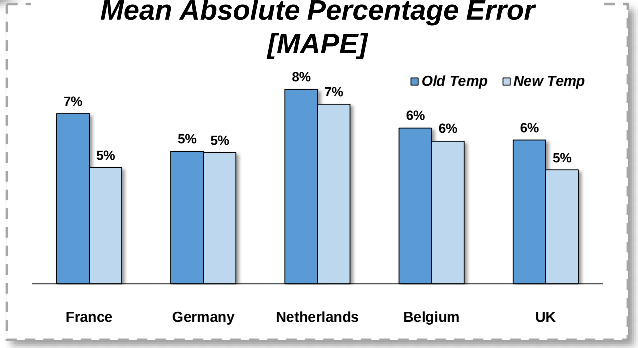
Backtest Analysis Gas Model

Backtest and performance evaluation of the new model features



- *The new model developed in order to **forecast the Monthly Gas demand** for different European countries is a **SARIMA-X** model where **temperature** is the most significative regressor among other variables (industrial production, thermal gap..)*



- ***The switching from the temperature of Volue* to the ones of ERA5 leads to a reduction of the Forecasting error…***
- ***… both in terms of Mean Square Error (MSE) that in terms of Mean Absolute Percentage Error (MAPE) that decreased in all country considered except for Germany that remained stable.***

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**Volue is a data provider for Power market which provides, in addition to data specifically related to the European Power Markets (i.e. Consumption, Renewable and Thermal generation, flows etc.) also data related to historical temperatures.*

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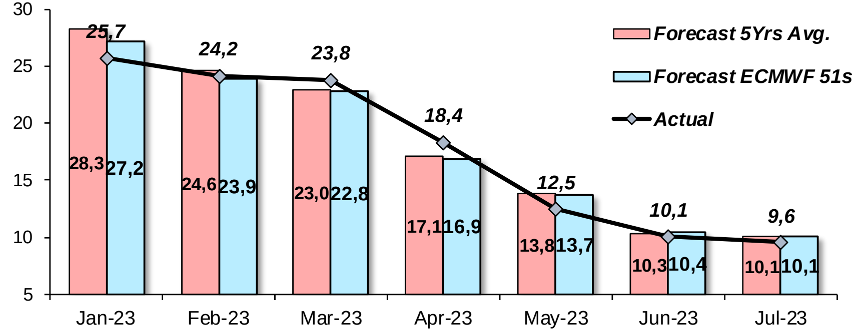
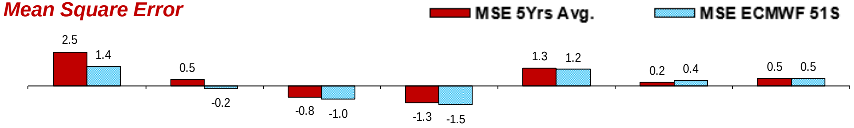
Backtest & Performance Analysis of the Gas Model

Comparison of the forecast performance using the 5Yrs Avg. temperatures vs median of the ECMWF-SEAS5 weather scenarios

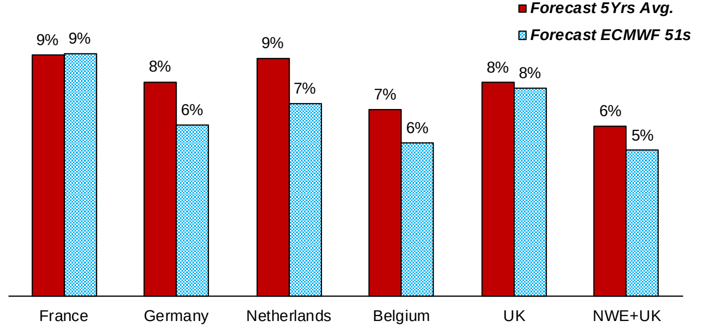
Gas Demand Forecast with weather scenarios – NWE+UK [Bcm]



Mean Square Error



Mean Absolute Percentage Error [MAPE]



Reduction of the error in Q1 thanks to the weather scenarios

Error	5Y Avg.	ECMWF 51s
Jan-23	10%	6%
Feb-23	4%	1%
Mar-23	6%	4%
Apr-23	6%	8%
May-23	11%	10%
Jun-23	2%	4%
Jul-23	5%	5%
MAPE	**6.3%**	**5.4%**
Bcm	**3.2**	**0.8**

- *The possibility to use the run of the SEAS5, **considering the median of the different scenarios**, led to a reduction of the forecasting error compared to the use of the simple 5Yrs Avg. temperatures…*
- *… in particular, the error reduction is more significant in winter periods, in which the gas demand is more reactive to temperatures.*

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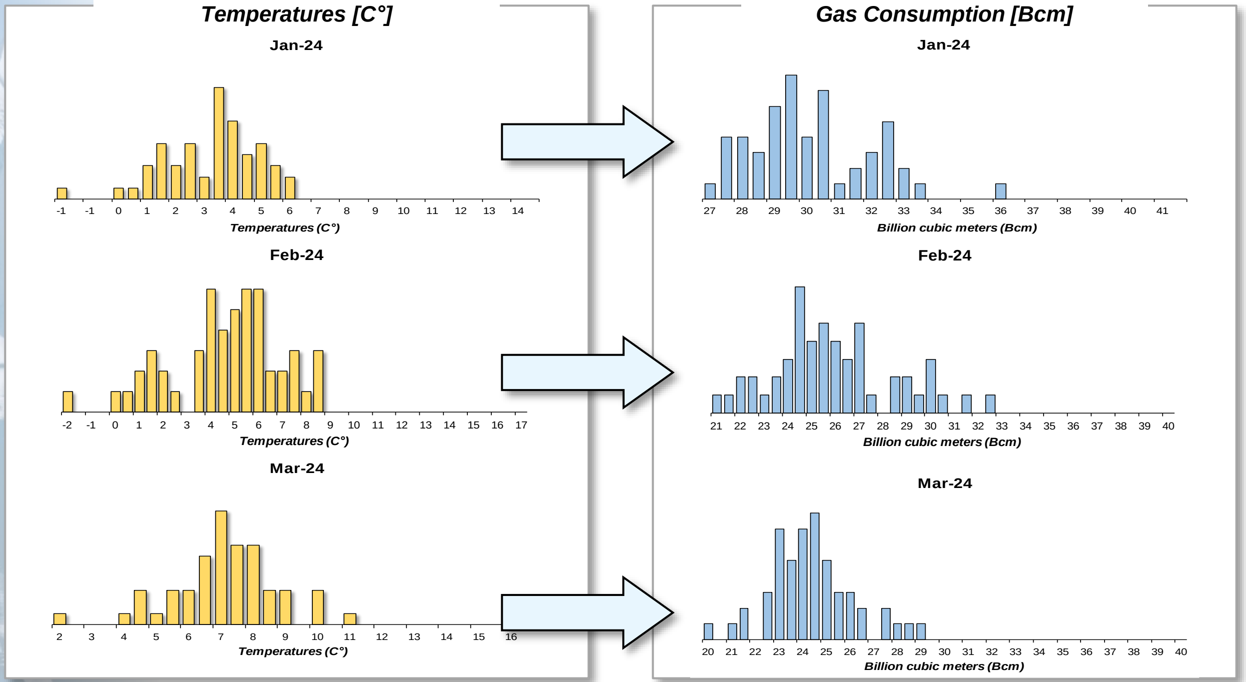
Analysis of the demand scenarios distribution arising from the SEAS5 members

Evaluation of the demand scenarios arising from the utilization of the SEAS5 51 members



- *The distribution of the 51scenario for each month allow us to select different scenarios based on percentile assumptions…*
- *…In particular, it can be noticed how the scenarios distribution presents some extreme values, with values on the tail, that are very helpful in performing stress test analysis for the Gas market System…*
- *…important to notice that the distribution of the Gas demand arising from the adoption of the weather scenarios, is asymmetric, since colder temperatures, compared to the normal, lead to a higher gas consumption and vice versa*

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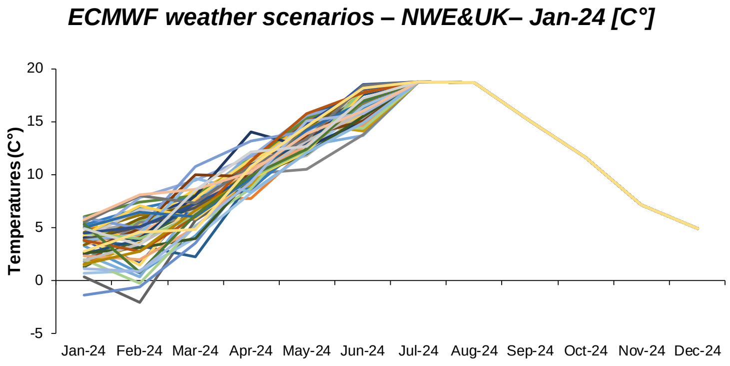
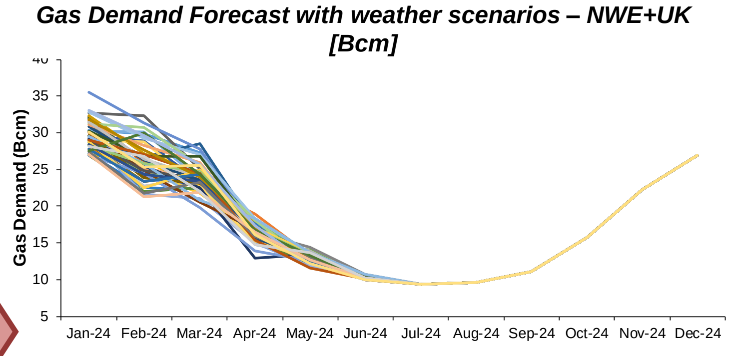
Evaluation of the demand scenarios arising from the utilization of the SEAS5 51 members



C°	Mean	Median	Max	Min	Std
Jan-24	3.4	3.8	6.0	-1.4	1.6
Feb-24	4.1	4.4	8.1	-2.1	2.3
Mar-24	6.8	6.8	10.8	2.2	1.7
Apr-24	10.3	10.1	14.0	7.7	1.3
May-24	13.6	13.5	15.7	10.5	1.2
Jun-24	16.5	16.7	18.5	13.7	1.2



Bcm	Mean	Median	Max	Min	Std
Jan-24	29.7	29.3	35.5	26.9	1.9
Feb-24	25.9	25.4	32.4	21.2	2.6
Mar-24	23.8	23.7	28.5	19.8	1.8
Apr-24	16.5	16.7	18.9	12.9	1.2
May-24	12.9	12.8	14.4	11.6	0.6
Jun-24	10.3	10.2	10.7	10.0	0.2

The 51 weather scenarios are used to generate as many scenarios as possible of gas demand, giving us the possibility to run analysis considering different scenarios of gas demand evolution.

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Post Processing and code optimization

Interactive dashboard to analyze and run the different scenarios forecast

- ***The interactive dashboard allow us to run and evaluate the different weather scenarios in order to forecast the European gas demand evolution***

- *The dashboard will be used to run and evaluate the different gas demand scenarios based on the different weather assumptions. ..*

- *… display and evaluate the ECMWF weather scenarios that will be used in the different simulations*

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Conclusions and next steps

- Use of ECMWF Season forecasts SEAS5 to develop a gas demand model.
- SEAS5 shows good correlation indexes for the lead 0, from the lead 1 the correlation is lower.
- SEAS5 seems to perform better in Spring and Fall, while performance is worse in Winter and Summer.
- The variability of the forecasts decreases significantly after the lead 2 and become roughly 1/3 of the ERA5's one.
- The use of the ECMWF 51 Scenarios data lead to a significant **reduction of the error** in forecasting the European Gas demand compared to the use of normal or average temperatures.
- Furthermore, the possibility to run different simulations based on the ECMWF scenarios, allow us to perform **sensitivity analysis** evaluating the impact of **extreme scenarios on the European Gas Market system.**

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Thank you

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