Supporting Power System Modelers in Choosing Appropriate Meteorological Data

Group 5 - Presentation

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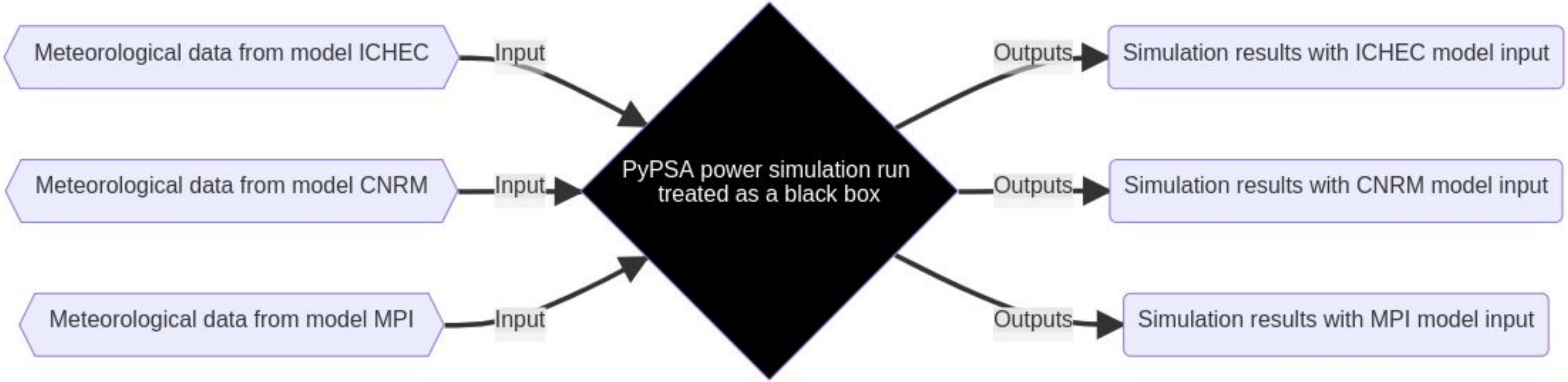
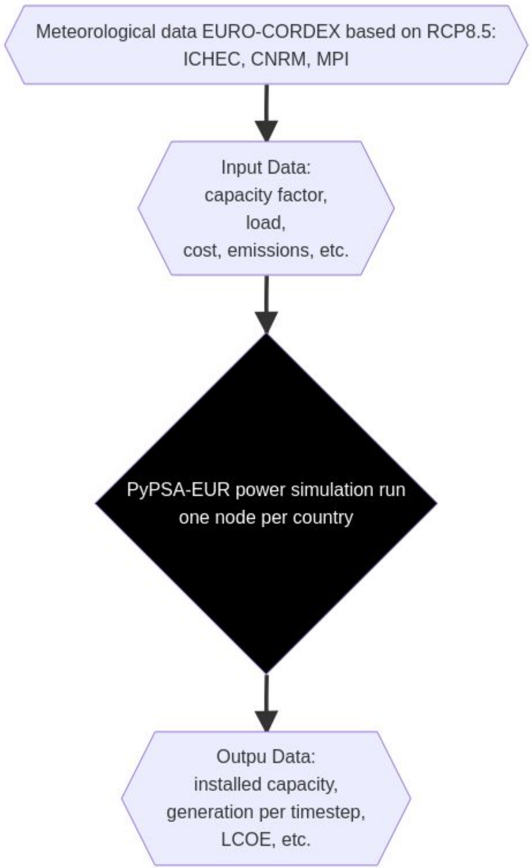
Project Idea / Goals



- Find statistical features in inputs and outputs
- Input: 3 data sets from EURO CORDEX project based on RCP8.5 climate data
- Output: Power system simulations

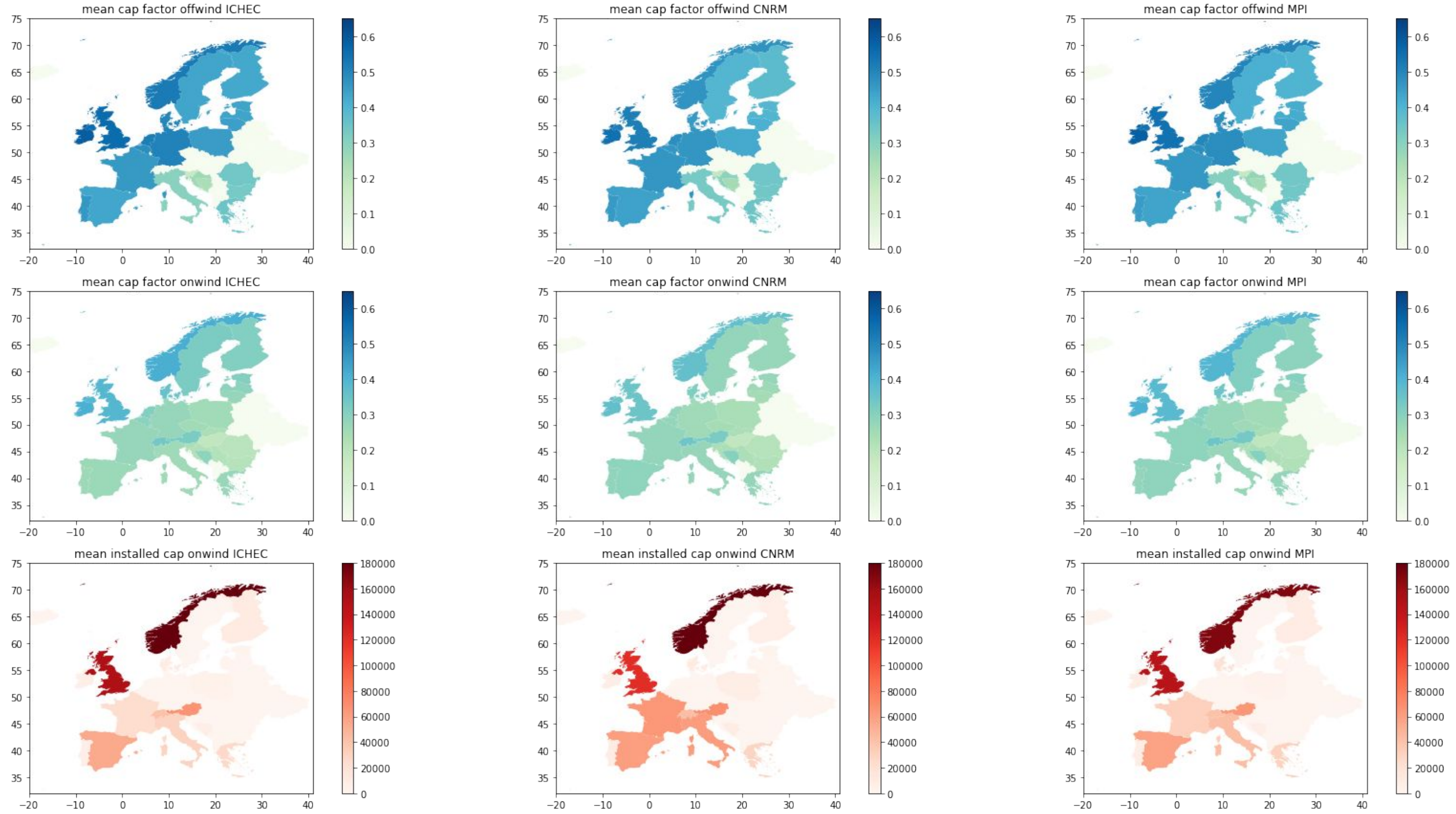
Project Idea / Goals

- Power system simulation using various meteorological data sets[1] [2]
- Gain insights of features connecting meteorological input data with output of power simulation
- Important parameters:
  - capacity factor: availability of nominal generation power (input)
  - installed capacity: deployment of generators (output)
  - dispatch of generators (output)
  - levelized cost of electricity (output)
- Datasets:
  - 3 climate models
  - Time horizon 1970-2101, split in periods of 6-8 years



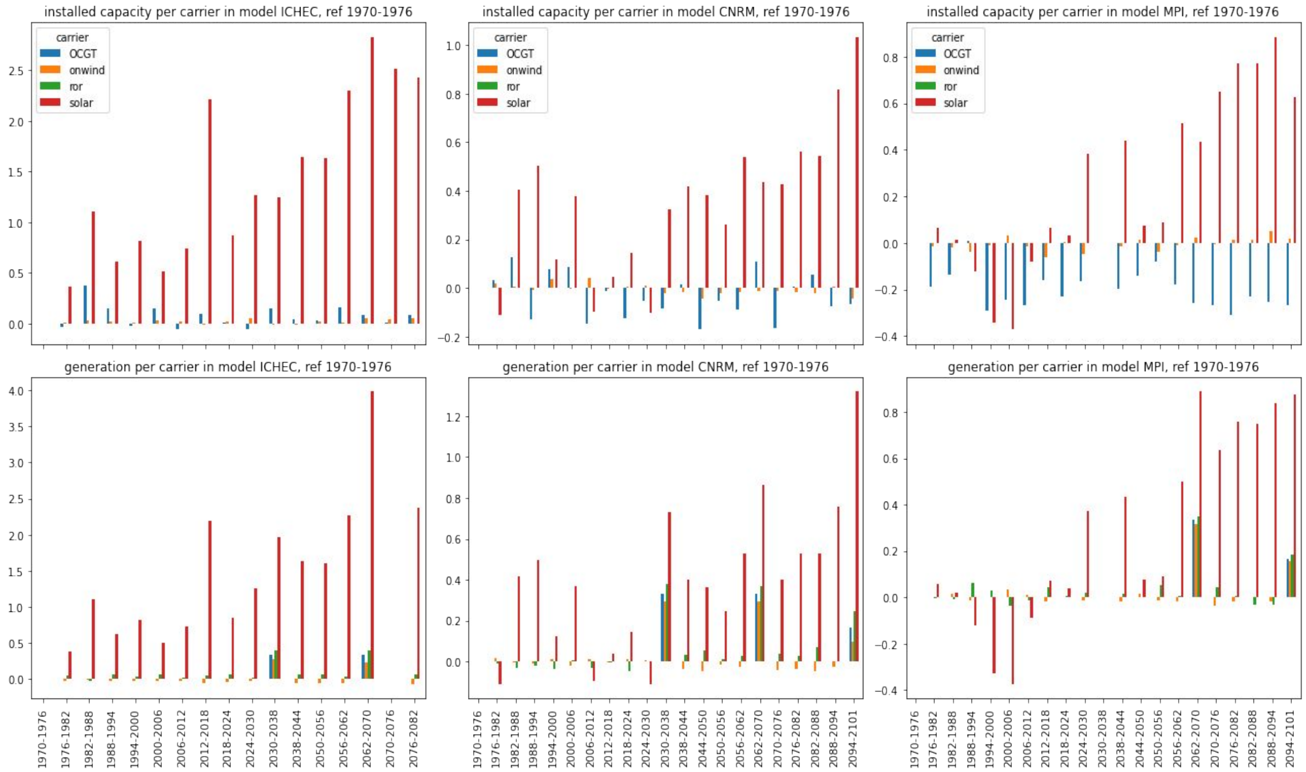
1. Schlott et al. 2018, The impact of climate change on a cost-optimal highly renewable European electricity network
2. Hörsch et al 2018, PyPSA-Eur: An Open Optimisation Model of the European Transmission System

Difference in models



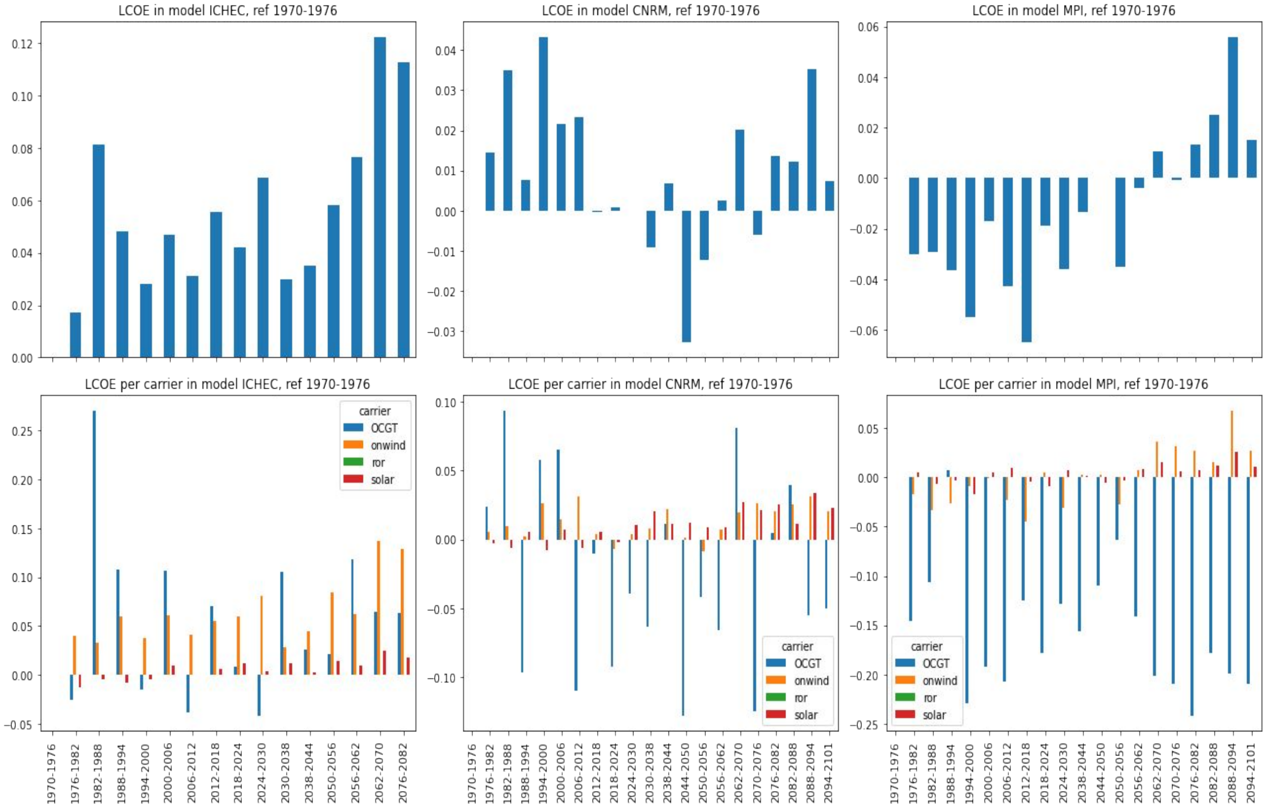
Difference in models

- Nominal installed capacity and generation of each technology
- norm difference with respect to first period (1970-1976)



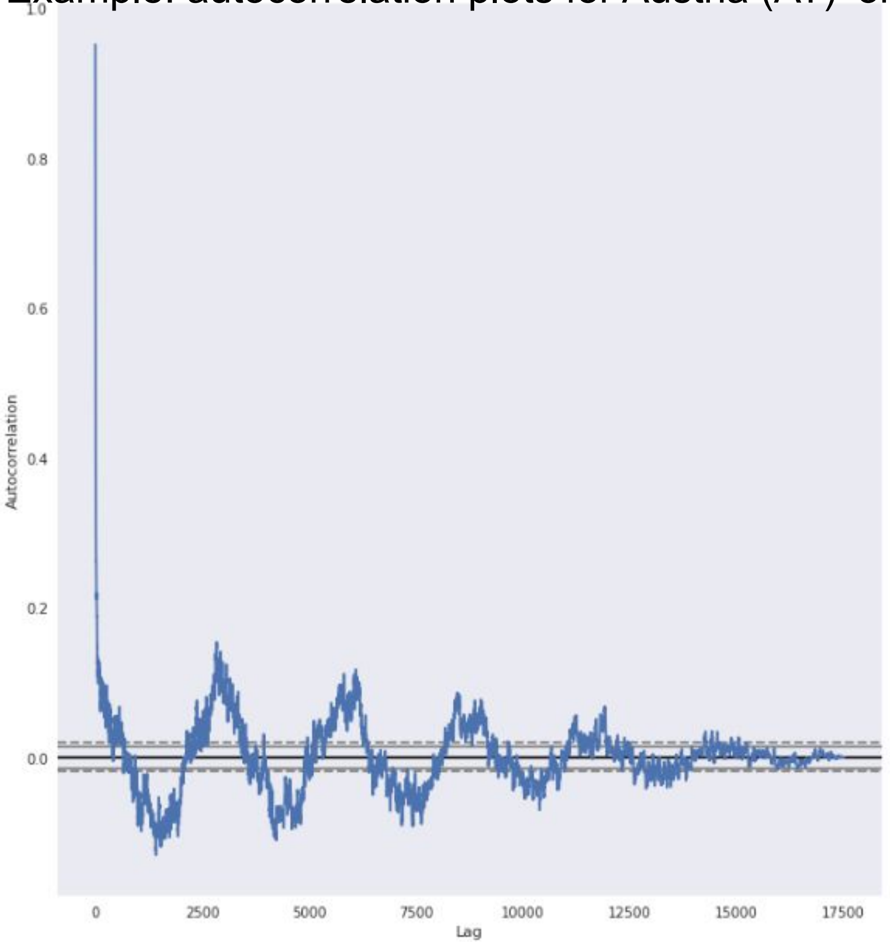
Difference in models

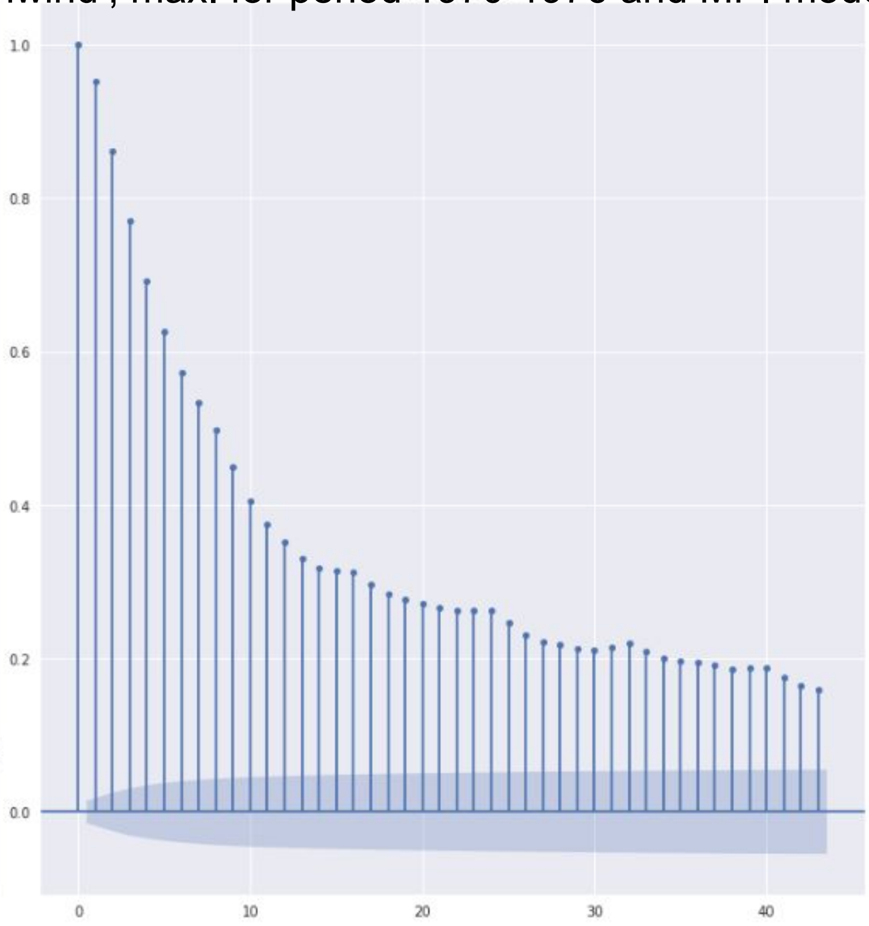
- Levelized Cost of Electricity of whole system and each technology
- norm difference with respect to first period (1970-1976)



Autocorrelation of input capacity factors: example

Example: autocorrelation plots for Austria (AT) 'onwind', max. for period 1970-1976 and MPI model



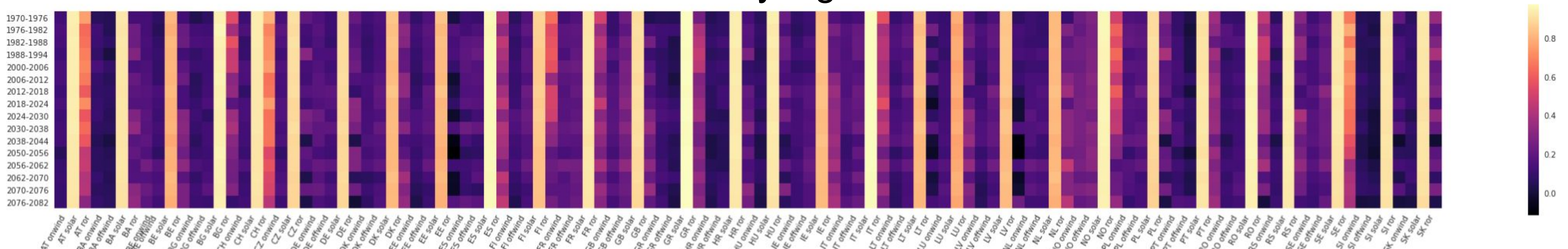


Autocorrelation of input capacity factors: with different lags

Daily lag

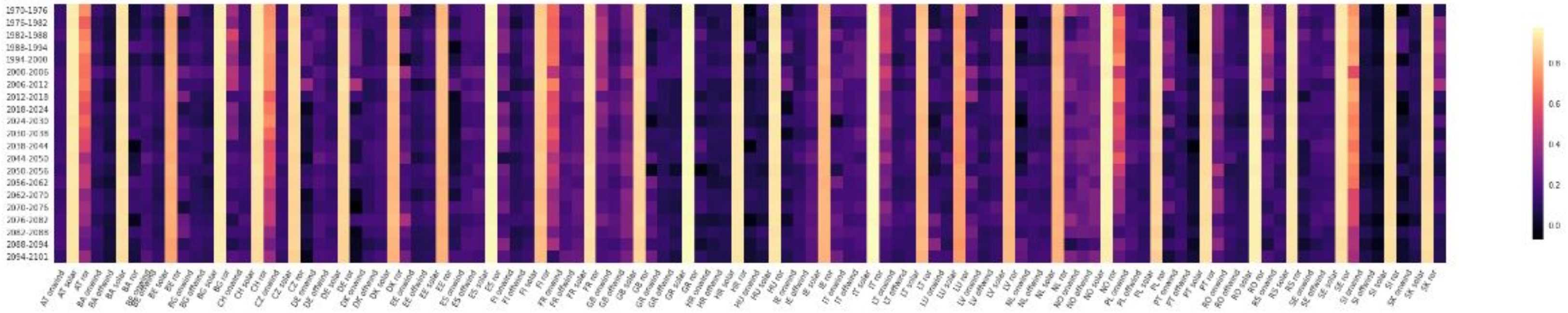
Weekly lag

Yearly lag

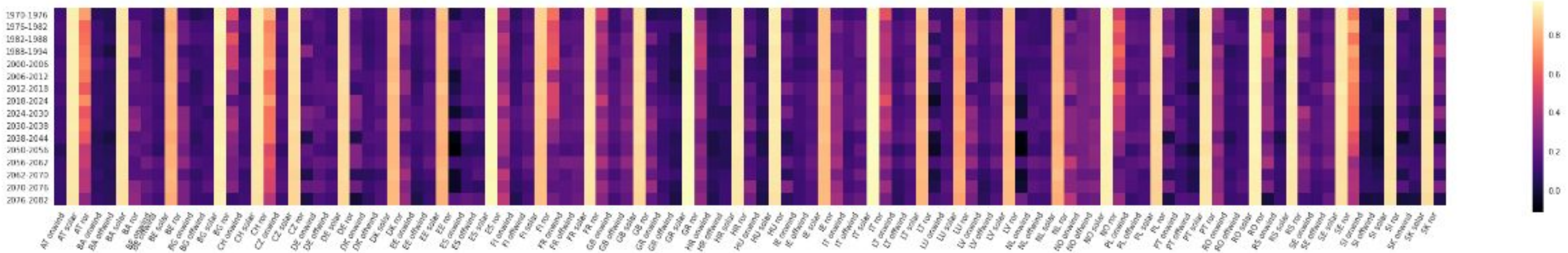


Yearly lag, all models

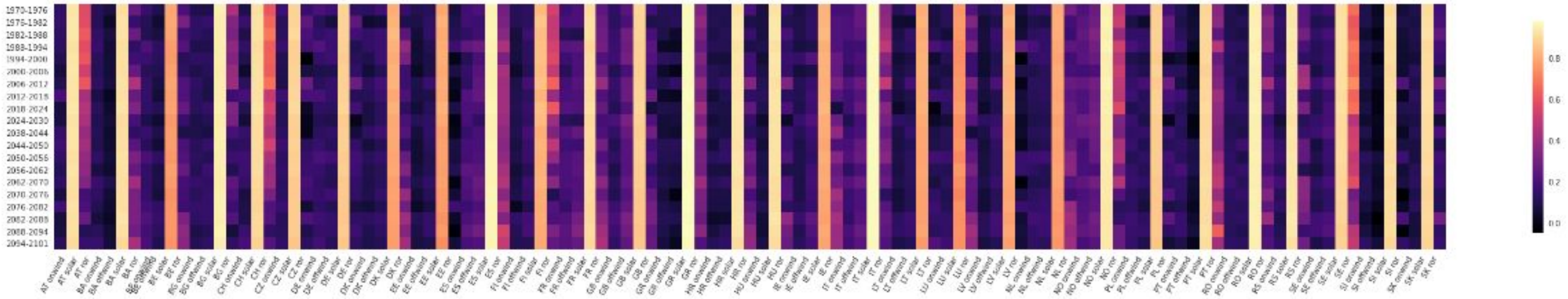
Model: CNRM



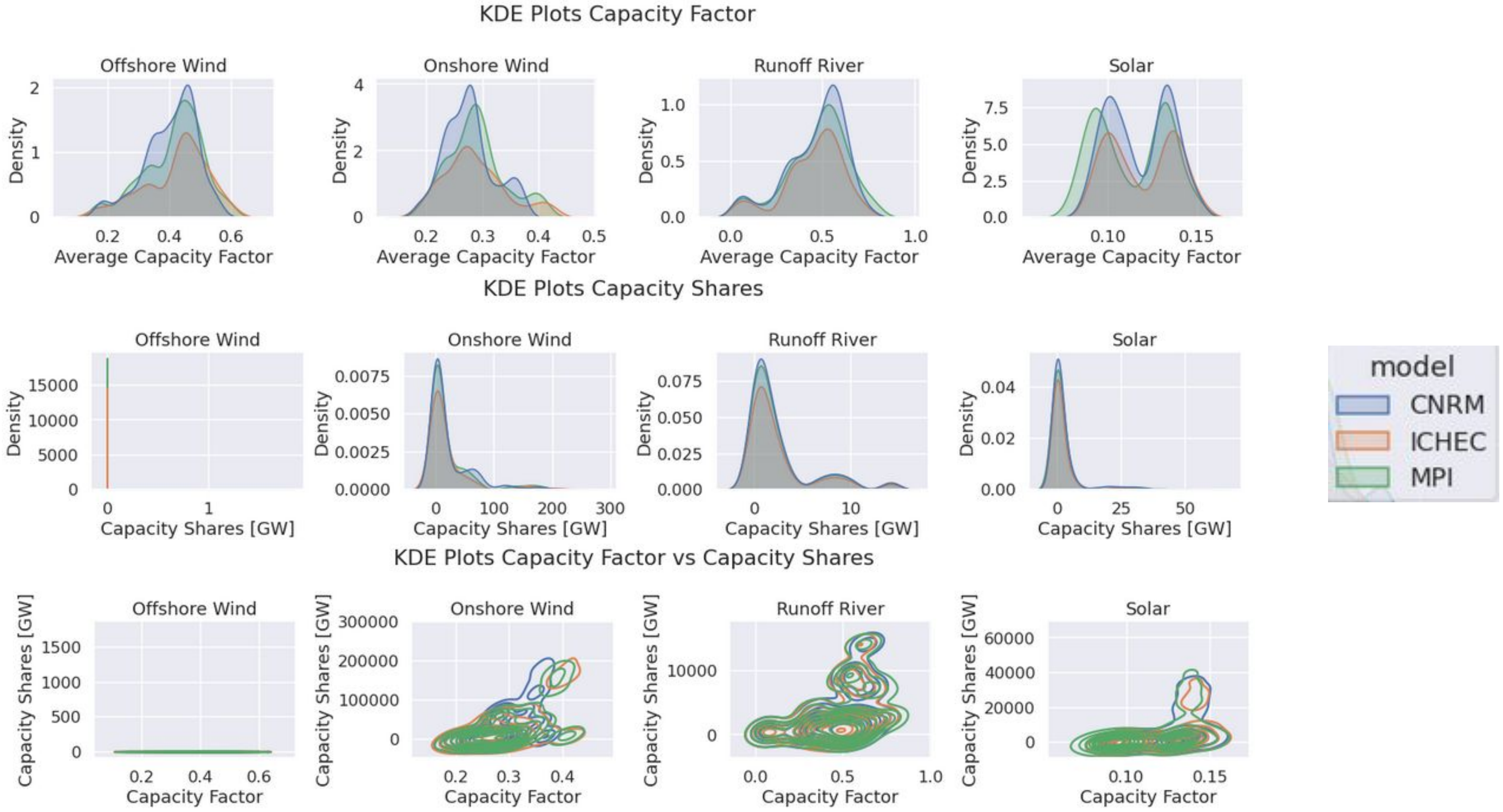
Model: ICHEC



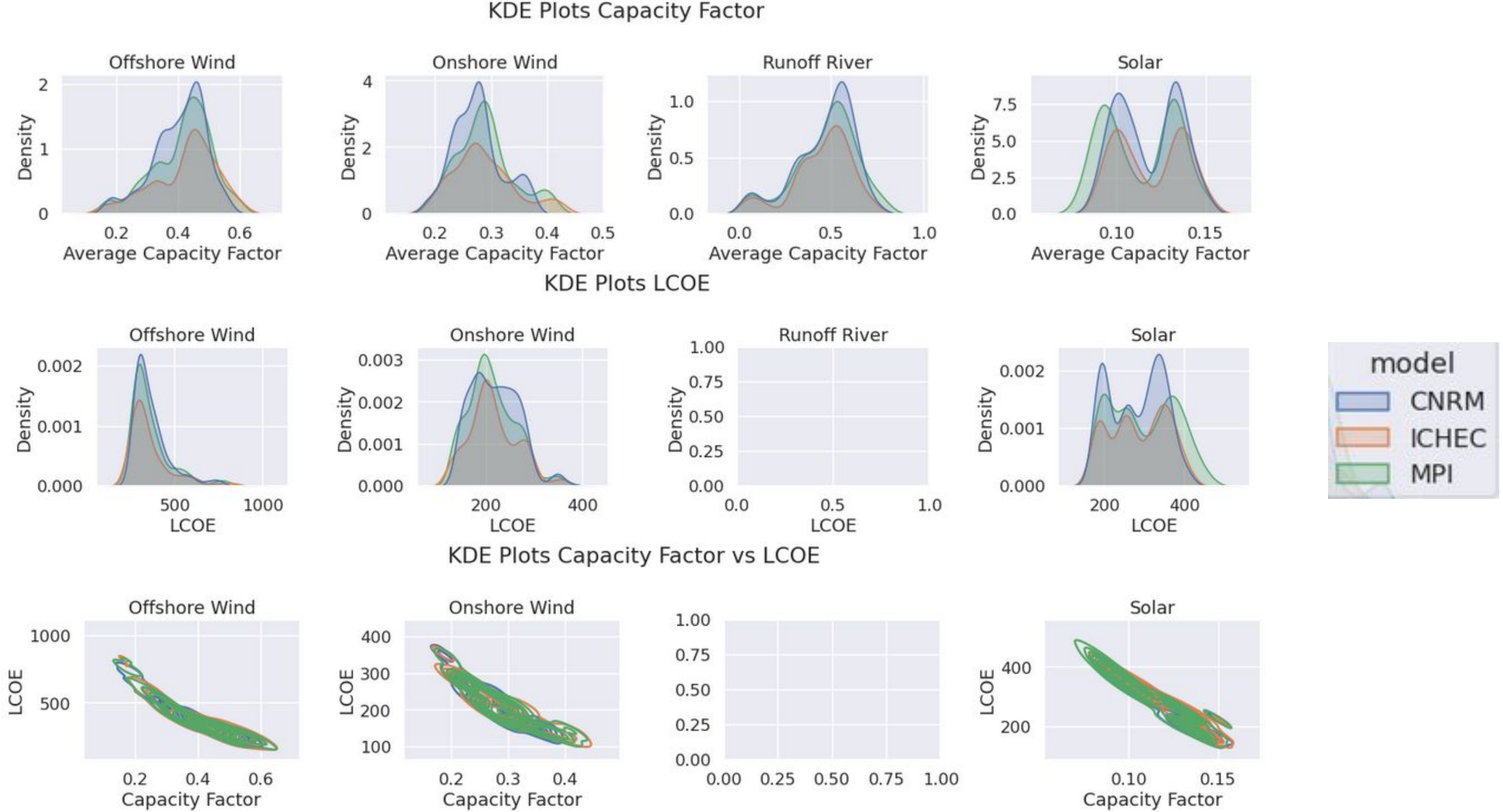
Model: MPI



Kernel Density Estimation Optimized Capacity



Kernel Density Estimation LCOE



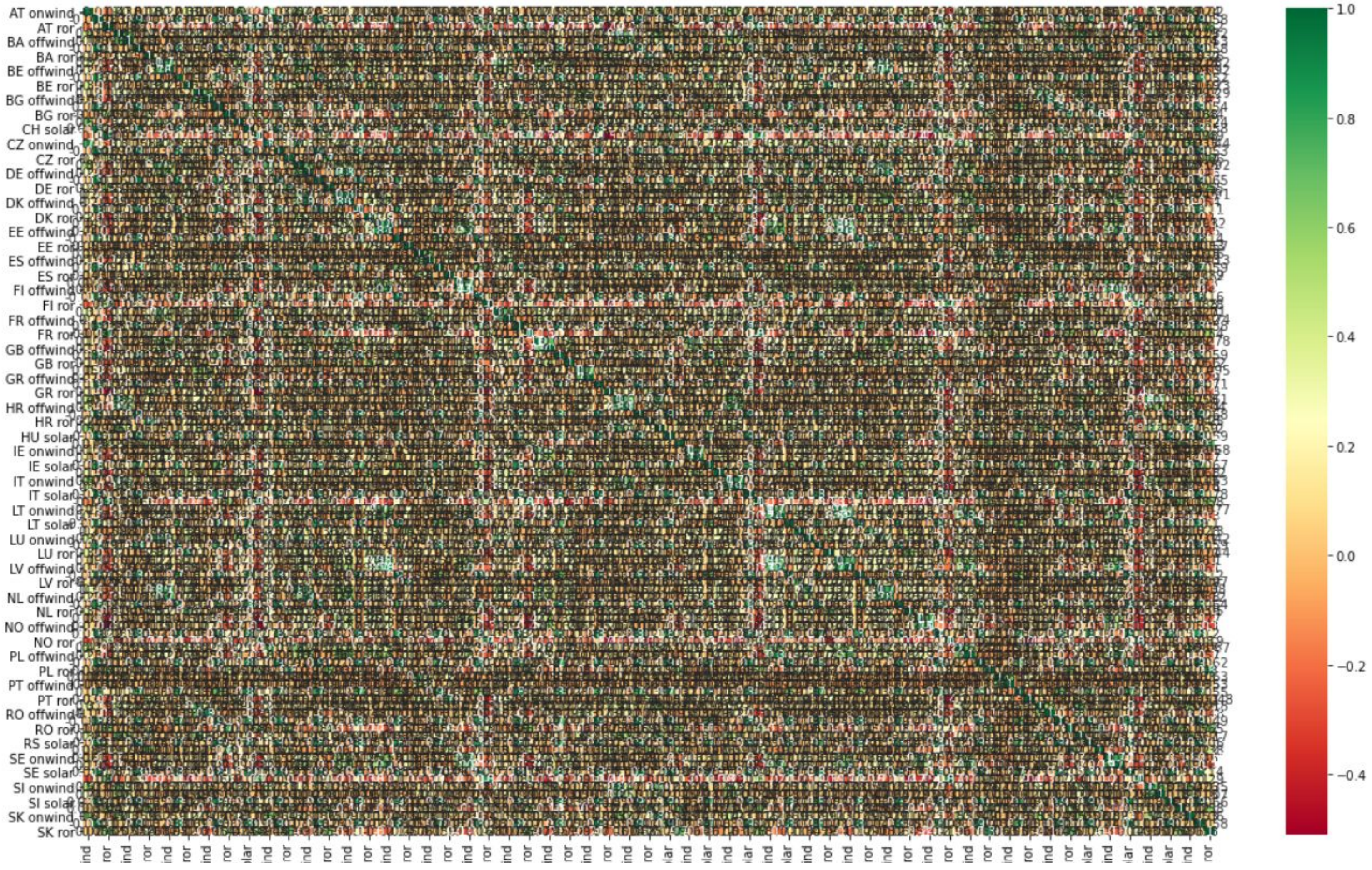
Correlation matrices

Jupyter notebook:

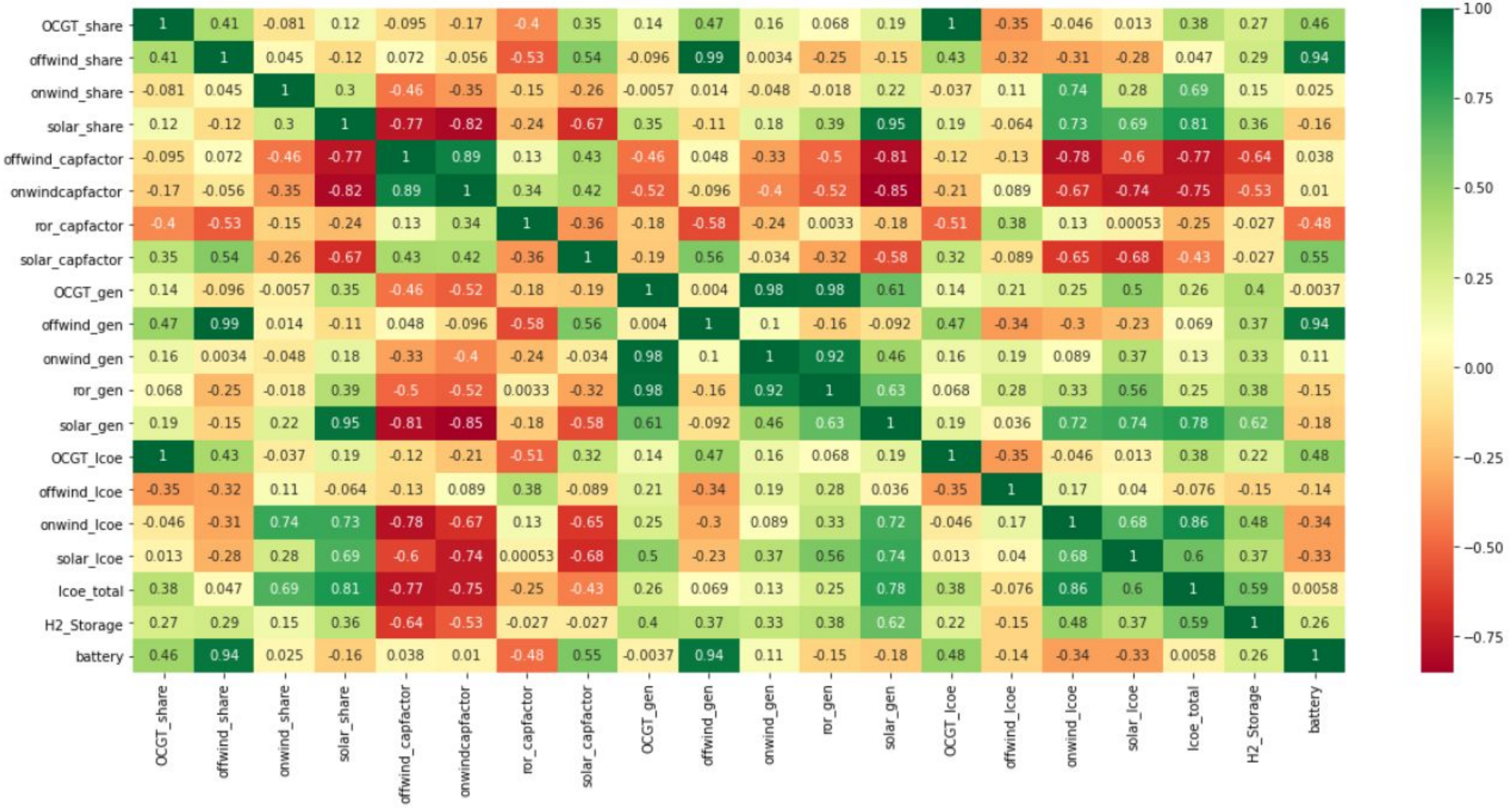
https://github.com/2021-Energy-Climate-Hackathon/group_5.git correlation_matrix.ipynb

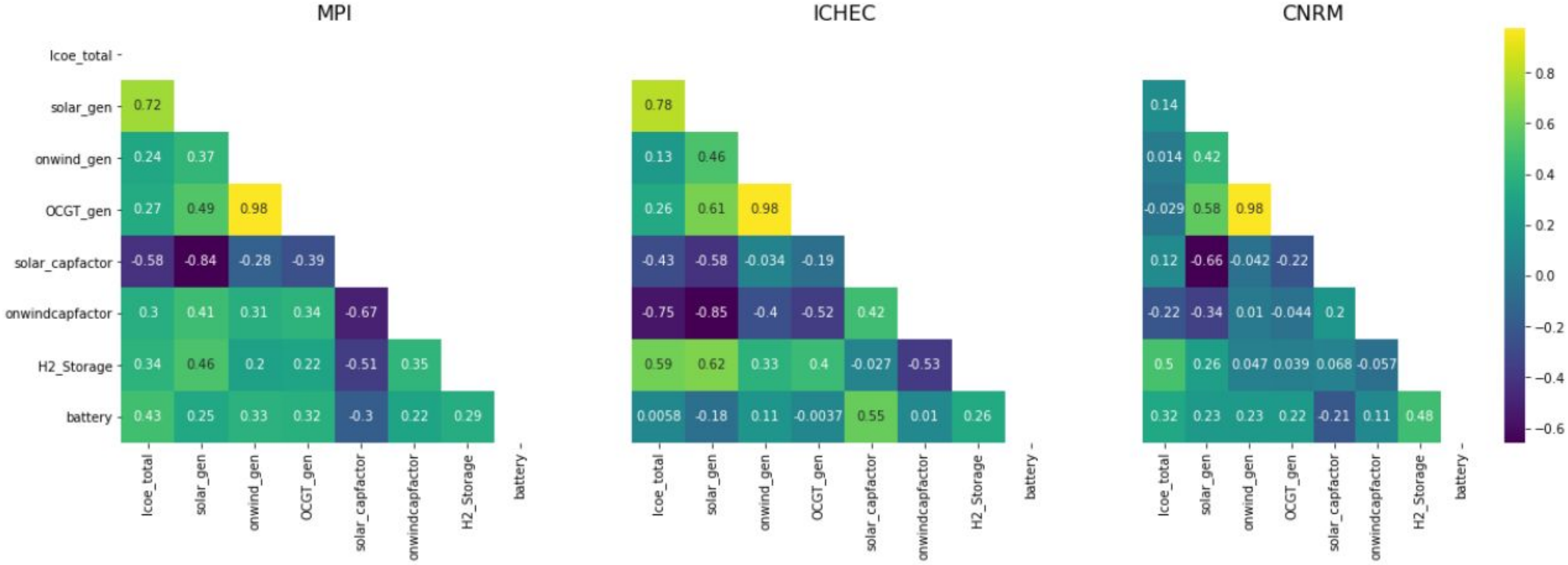
$$\mathrm{Korr}(X,Y) = \frac{\mathrm{Cov}(X,Y)}{\sqrt{\mathrm{Var}(X)}\sqrt{\mathrm{Var}(Y)}} = \frac{\sigma_{X,Y}}{\sigma_X \sigma_Y} =: \rho_{X,Y}$$

```
correlation_matrix = our_data_as_df.corr(method='pearson')
```

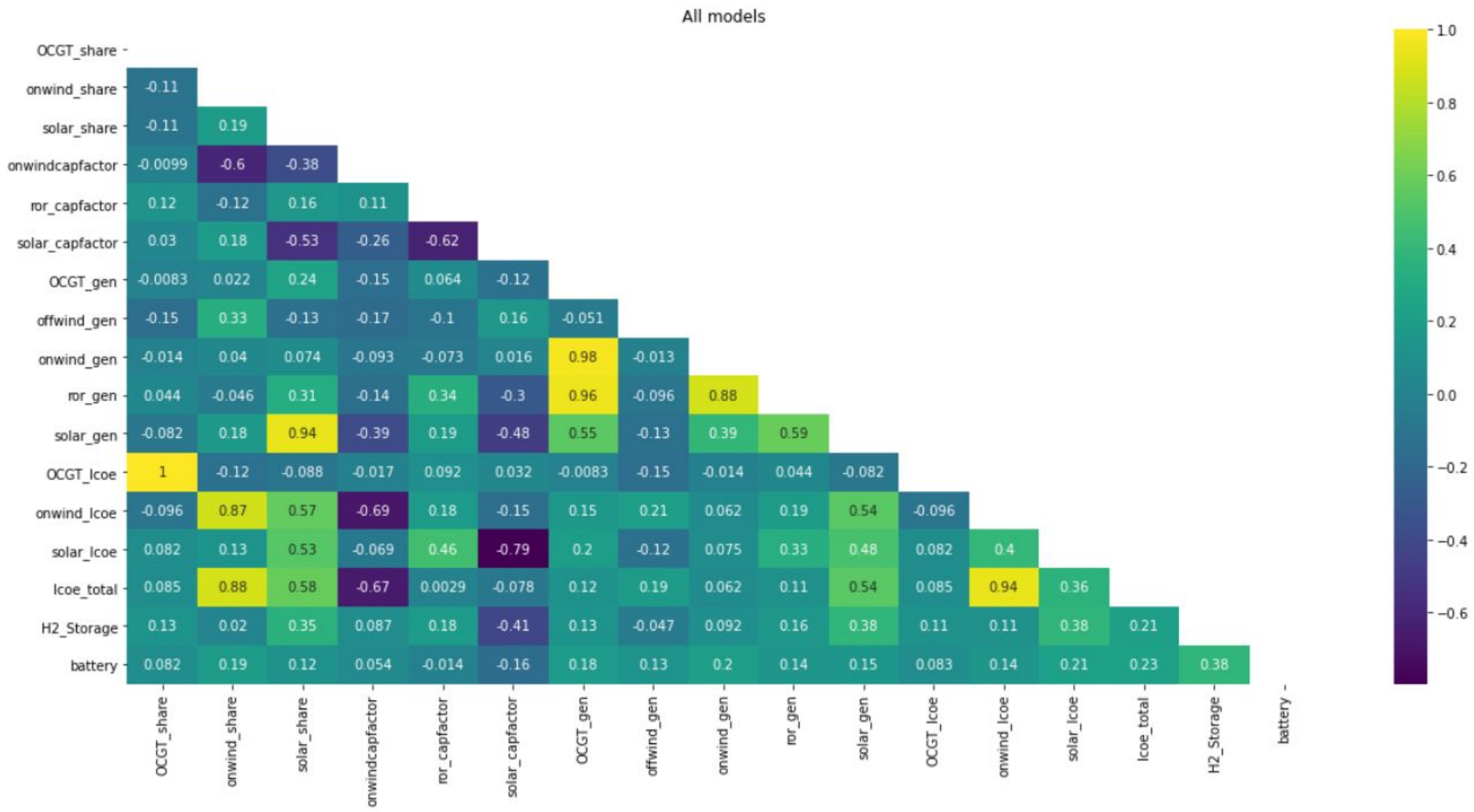


AT onwind
AT ror
BA offwind
BA ror
BE offwind
BE ror
BG offwind
BG ror
CH solar
CZ onwind
CZ ror
DE offwind
DE ror
DK offwind
DK ror
EE offwind
EE ror
ES offwind
ES ror
FI offwind
FI ror
FR offwind
FR ror
GB offwind
GB ror
GR offwind
GR ror
HR offwind
HR ror
HU solar
IE onwind
IE solar
IT onwind
IT solar
LT onwind
LT solar
LU onwind
LU ror
LV offwind
LV ror
NL offwind
NL ror
NO offwind
NO ror
PL offwind
PL ror
PT offwind
PT ror
RO offwind
RO ror
RS solar
SE onwind
SE solar
SI onwind
SI solar
SK onwind
SK ror
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4


OCGT_share 1 0.41 -0.081 0.12 -0.095 -0.17 -0.4 0.35 0.14 0.47 0.16 0.068 0.19 1 -0.35 -0.046 0.013 0.38 0.27 0.46
offwind_share 0.41 1 0.045 -0.12 0.072 -0.056 -0.53 0.54 -0.096 0.99 0.0034 -0.25 -0.15 0.43 -0.32 -0.31 -0.28 0.047 0.29 0.94
onwind_share -0.081 0.045 1 0.3 -0.46 -0.35 -0.15 -0.26 -0.0057 0.014 -0.048 -0.018 0.22 -0.037 0.11 0.74 0.28 0.69 0.15 0.025
solar_share 0.12 -0.12 0.3 1 -0.77 -0.82 -0.24 -0.67 0.35 -0.11 0.18 0.39 0.95 0.19 -0.064 0.73 0.69 0.81 0.36 -0.16
offwind_capfactor -0.095 0.072 -0.46 -0.77 1 0.89 0.13 0.43 -0.46 0.048 -0.33 -0.5 -0.81 -0.12 -0.13 -0.78 -0.6 -0.77 -0.64 0.038
onwindcapfactor -0.17 -0.056 -0.35 -0.82 0.89 1 0.34 0.42 -0.52 -0.096 -0.4 -0.52 -0.85 -0.21 0.089 -0.67 -0.74 -0.75 -0.53 0.01
ror_capfactor -0.4 -0.53 -0.15 -0.24 0.13 0.34 1 -0.36 -0.18 -0.58 -0.24 0.0033 -0.18 -0.51 0.38 0.13 0.00053 -0.25 -0.027 -0.48
solar_capfactor 0.35 0.54 -0.26 -0.67 0.43 0.42 -0.36 1 -0.19 0.56 -0.034 -0.32 -0.58 0.32 -0.089 -0.65 -0.68 -0.43 -0.027 0.55
OCGT_gen 0.14 -0.096 -0.0057 0.35 -0.46 -0.52 -0.18 -0.19 1 0.004 0.98 0.98 0.61 0.14 0.21 0.25 0.5 0.26 0.4 -0.0037
offwind_gen 0.47 0.99 0.014 -0.11 0.048 -0.096 -0.58 0.56 0.004 1 0.1 -0.16 -0.092 0.47 -0.34 -0.3 -0.23 0.069 0.37 0.94
onwind_gen 0.16 0.0034 -0.048 0.18 -0.33 -0.4 -0.24 -0.034 0.98 0.1 1 0.92 0.46 0.16 0.19 0.089 0.37 0.13 0.33 0.11
ror_gen 0.068 -0.25 -0.018 0.39 -0.5 -0.52 0.0033 -0.32 0.98 -0.16 0.92 1 0.63 0.068 0.28 0.33 0.56 0.25 0.38 -0.15
solar_gen 0.19 -0.15 0.22 0.95 -0.81 -0.85 -0.18 -0.58 0.61 -0.092 0.46 0.63 1 0.19 0.036 0.72 0.74 0.78 0.62 -0.18
OCGT_lcoe 1 0.43 -0.037 0.19 -0.12 -0.21 -0.51 0.32 0.14 0.47 0.16 0.068 0.19 1 -0.35 -0.046 0.013 0.38 0.22 0.48
offwind_lcoe -0.35 -0.32 0.11 -0.064 -0.13 0.089 0.38 -0.089 0.21 -0.34 0.19 0.28 0.036 -0.35 1 0.17 0.04 -0.076 -0.15 -0.14
onwind_lcoe -0.046 -0.31 0.74 0.73 -0.78 -0.67 0.13 -0.65 0.25 -0.3 0.089 0.33 0.72 -0.046 0.17 1 0.68 0.86 0.48 -0.34
solar_lcoe 0.013 -0.28 0.28 0.69 -0.6 -0.74 0.00053 -0.68 0.5 -0.23 0.37 0.56 0.74 0.013 0.04 0.68 1 0.6 0.37 -0.33
lcoe_total 0.38 0.047 0.69 0.81 -0.77 -0.75 -0.25 -0.43 0.26 0.069 0.13 0.25 0.78 0.38 -0.076 0.86 0.6 1 0.59 0.0058
H2_Storage 0.27 0.29 0.15 0.36 -0.64 -0.53 -0.027 -0.027 0.4 0.37 0.33 0.38 0.62 0.22 -0.15 0.48 0.37 0.59 1 0.26
battery 0.46 0.94 0.025 -0.16 0.038 0.01 -0.48 0.55 -0.0037 0.94 0.11 -0.15 -0.18 0.48 -0.14 -0.34 -0.33 0.0058 0.26 1
OCGT_share offwind_share onwind_share solar_share offwind_capfactor onwindcapfactor ror_capfactor solar_capfactor OCGT_gen offwind_gen onwind_gen ror_gen solar_gen OCGT_lcoe offwind_lcoe onwind_lcoe solar_lcoe lcoe_total H2_Storage battery
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75



Negative correlation of onshore wind capacity factor and solar capacity factor of -0.67 for the MPI Model


All models
OCGT_share
onwind_share -0.11
solar_share -0.11 0.19
onwindcapfactor -0.0099 -0.6 -0.38
ror_capfactor 0.12 -0.12 0.16 0.11
solar_capfactor 0.03 0.18 -0.53 -0.26 -0.62
OCGT_gen -0.0083 0.022 0.24 -0.15 0.064 -0.12
offwind_gen -0.15 0.33 -0.13 -0.17 -0.1 0.16 -0.051
onwind_gen -0.014 0.04 0.074 -0.093 -0.073 0.016 0.98 -0.013
ror_gen 0.044 -0.046 0.31 -0.14 0.34 -0.3 0.96 -0.096 0.88
solar_gen -0.082 0.18 0.94 -0.39 0.19 -0.48 0.55 -0.13 0.39 0.59
OCGT_lcoe 1 -0.12 -0.088 -0.017 0.092 0.032 -0.0083 -0.15 -0.014 0.044 -0.082
onwind_lcoe -0.096 0.87 0.57 -0.69 0.18 -0.15 0.15 0.21 0.062 0.19 0.54 -0.096
solar_lcoe 0.082 0.13 0.53 -0.069 0.46 -0.79 0.2 -0.12 0.075 0.33 0.48 0.082 0.4
lcoe_total 0.085 0.88 0.58 -0.67 0.0029 -0.078 0.12 0.19 0.062 0.11 0.54 0.085 0.94 0.36
H2_Storage 0.13 0.02 0.35 0.087 0.18 -0.41 0.13 -0.047 0.092 0.16 0.38 0.11 0.11 0.38 0.21
battery 0.082 0.19 0.12 0.054 -0.014 -0.16 0.18 0.13 0.2 0.14 0.15 0.083 0.14 0.21 0.23 0.38
OCGT_share onwind_share solar_share onwindcapfactor ror_capfactor solar_capfactor OCGT_gen offwind_gen onwind_gen ror_gen solar_gen OCGT_lcoe onwind_lcoe solar_lcoe lcoe_total H2_Storage battery
1.0 0.8 0.6 0.4 0.2 0.0 −0.2 −0.4 −0.6

Feature Maps

Condition: LCOE for onshore wind power in Denmark is below median (Output)

Feature/ Generator	GB onwind	DK offwind	DK onwind	EE onwind	NL onwind	IE onwind	BE onwind	LV onwind
avg. Cap. Factor	+ (89)	+ (89)	+ (89)	+ (89)	+ (86)	+ (86)	+ (82)	+ (82)

Feature/ Generator	ES ror	EE solar	FI solar	PL solar	LU ror	BE ror	IE ror	GB ror
min. Cap. Factor	- (82)	- (79)	- (79)	- (75)	- (75)	- (71)	- (71)	- (68)

+/- = above/below average, probabilities given in brackets

Outlook

- Extend analysis with further input data features (cold spell/heat waves)
- Refine by adding further quantiles
- Increase robustness by increasing the sample size (input-output data pairs), could be a community effort…

Thank You!
Questions?