Smart Energy Systems
INTERNATIONAL CONFERENCE

International Conference On Smart Energy Systems

4th Generation District Heating, Electrification, Electrofuels and Energy Efficiency

The 6th International Conference on Smart Energy Systems took place on 6-7 October 2020 as an online event.

Thank you to everyone who participated in making this a successful event.

The website is currently undergoing updates.

The correlation between variable renewable energy sources and energy demand for heating&cooling

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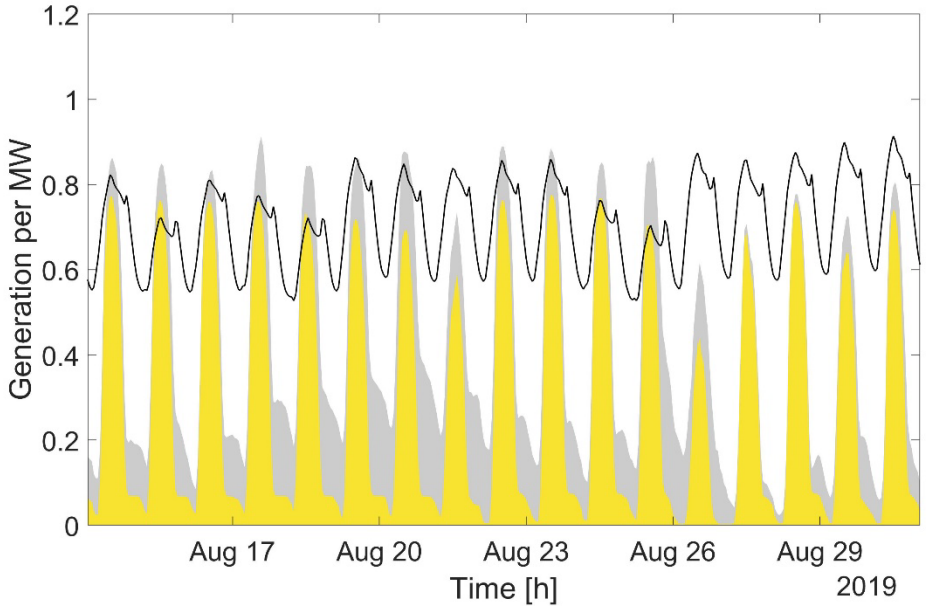
1	Background & Objectives
2	Approach
3	Exemplary Case Study for Austria
4	Conclusions and Outlook

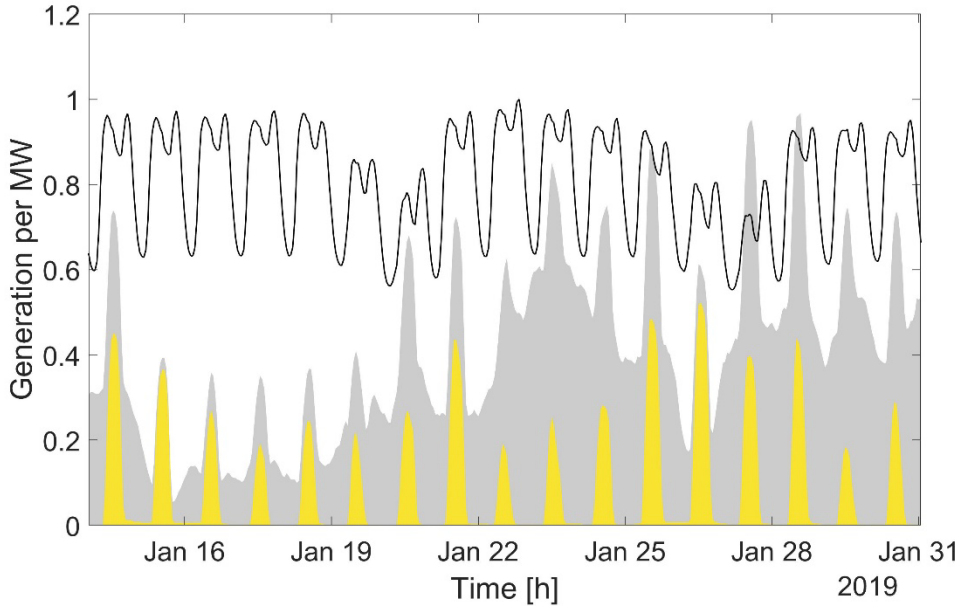
Climate goals promote the integration of VRE, adding new challenges to the energy system

The intermittency of sun and wind - variable renewable energy (VRE) - causes substantial daily and seasonal variability.

Summer



Winter



Power generation per MW installed in Spain 2019

PV Wind

How can this be used as an advantage?

Ramsebner, Haas & Linares, SES Aalborg 2020

entsoe (2020)

How can this be used as an advantage?

Heating & cooling demand largely depend on outdoor temperature

We assume that the temperature is substantially influenced by wind speed and solar radiation

Research Questions:

- Is there a significant correlation between wind speed or solar radiation and heating or cooling demand that enables direct use of VRE?
- Is short term storage still required? (thermal, pumped hydro…)
- Would the conversion of power into hydrogen be convenient for heating&cooling ?
    - To decouple demand and supply
    - Considering the applicability of the technology in the specific country

Approach (1/2)

1. We use the following climate data to analyze the correlation between VRE and heating/cooling demand:
   - Solar Radiation [W/m²]
   - Wind speed [m/s]
   - Temperature [T] [°C]
   - Temporal resolution: Hourly and daily average
2. The temperature data defines heating/cooling demand via HDD and CDD*

If $T_{h/d} \leq T_H$ then $[HDD = \sum_i (T_{RoomH} - T^i_{h/d})]$ else [HDD = 0]

If $T_{h/d} \geq 24°C$ then $[CDD = \sum_i T^i_{h/d} - T_{RoomC})]$ else [CDD = 0]

$T^i_{h/d}$ … air temperature of hour/day

Heating demand: T_H = 15°C	Desired Room T: T_{RoomH} = 18°C
Cooling demand : T_C = 24°C	Desired Room T: T_{RoomC} = 21°C

*HDD… Heating degree days, CDD… Cooling degree days

Ramsebner, Haas & Linares, SES Aalborg 2020

eurostat (2020)

Approach (2/2)

3. We analyze the **correlation coefficient *r after Pearson*** for the following scenarios:
   - $\boldsymbol{R_H}$ between HDD & wind speed winter time = 1.October – 30.April
   - $\boldsymbol{R_C}$ between CDD & solar radiation summer time = 1.June – 31.August

$$R = \frac{Cov_{x,y}}{\sigma_x \ \sigma_y} \qquad -1 < r < +1$$

   - As correlation with hourly resolution of climate data (*h* - R_{Hh} / R_{Ch})
   - As correlation with average daily resolution of climate data (*d* - R_{Hd} / R_{Cd})

4. R is interpreted as the following:

< 0.19	Very weak
0. 20-0.39	Weak
0. 40-0.59	Moderate
0. 60-0.79	Strong
0. 80-1.00	Very strong

Evans (1996)

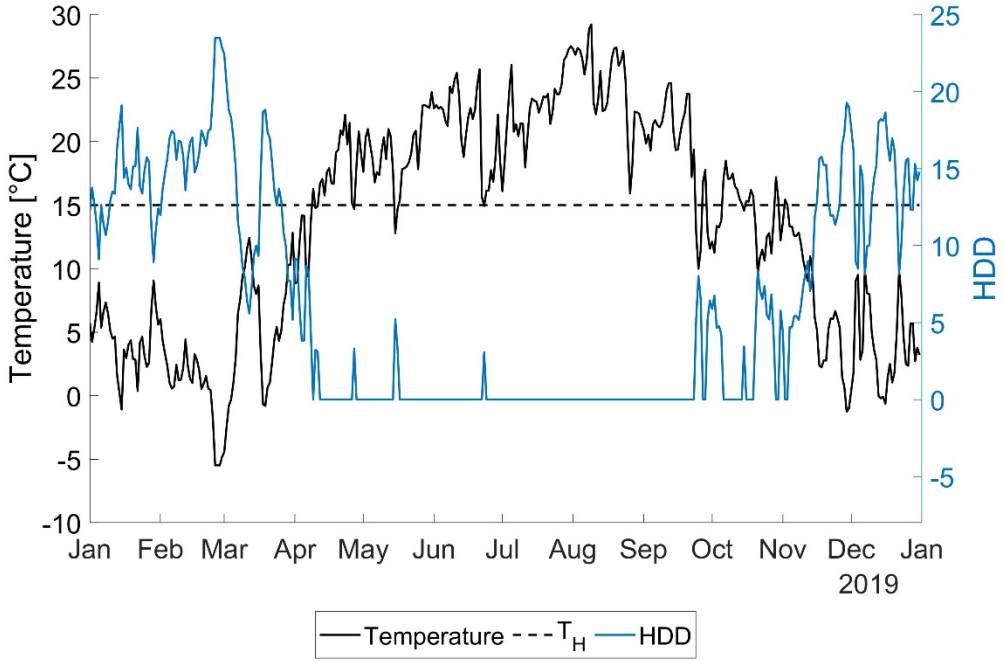
Exemplary case study for Austria/Vienna

- This study uses climate data for Vienna from 2018

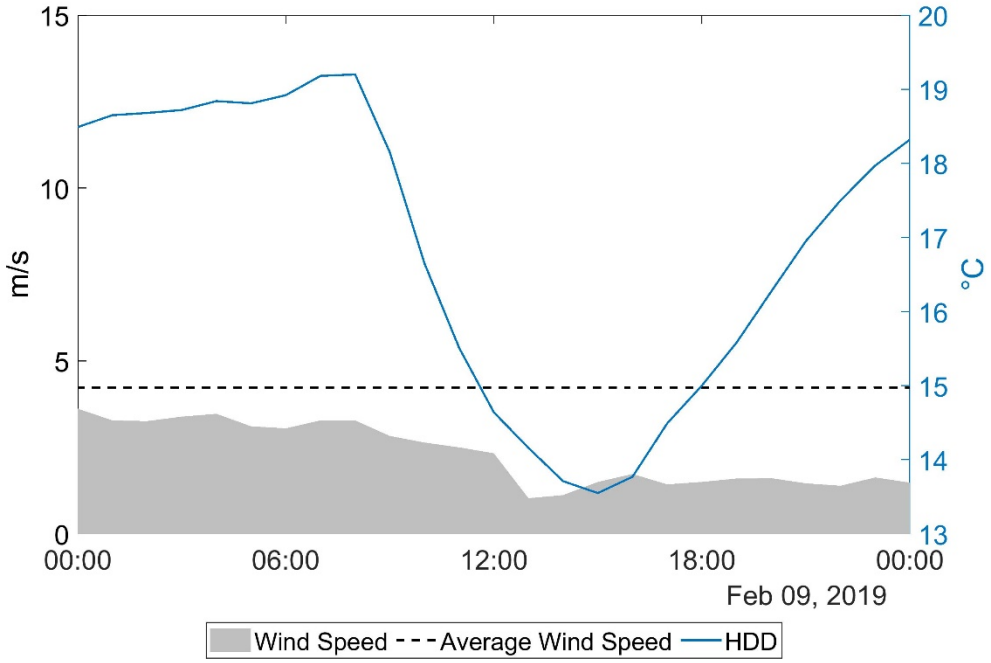
Heat demand (HDD) increases with decreasing temperatures

Example: If T = 12°C then [HDD = $\sum_i(18°C - 12°C)$] HDD = 6°C

Once the Temperature falls below T_H, heating is required



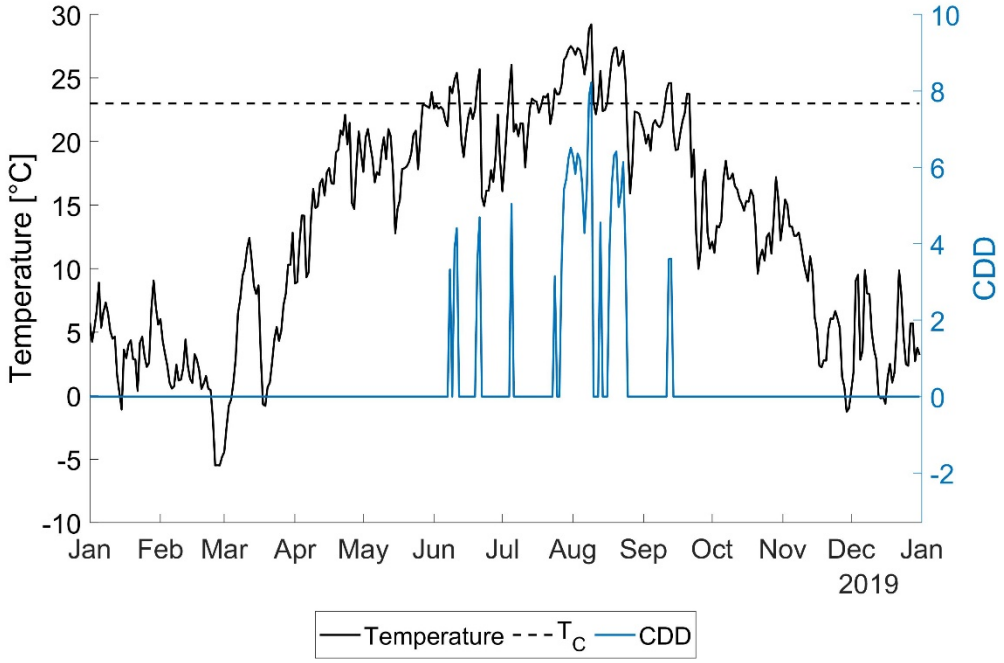
Exemplary day of hourly wind speed & HDD



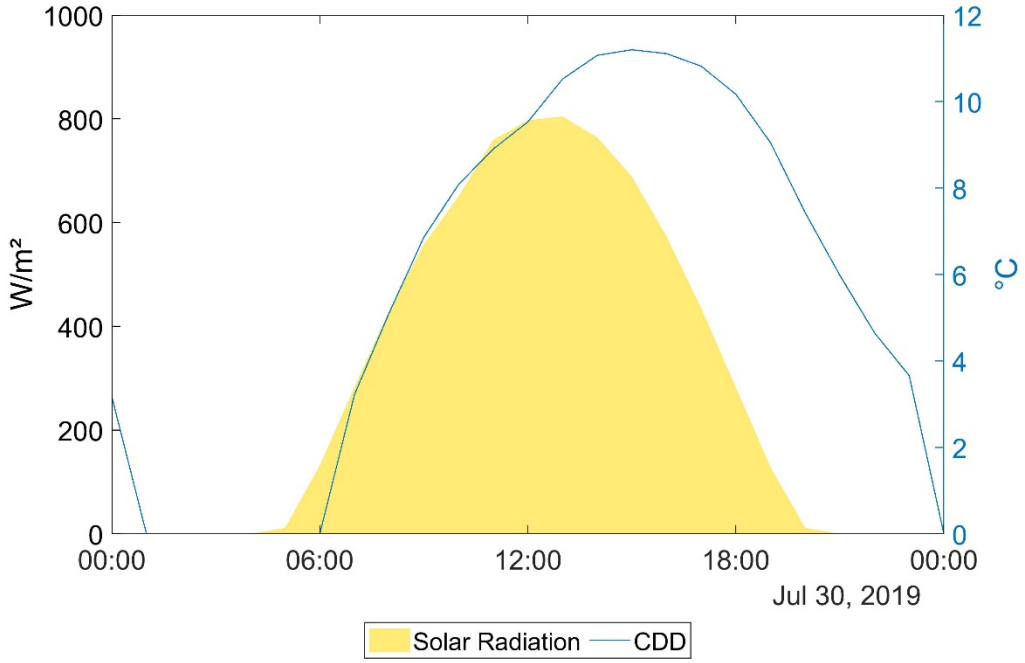
Cooling demand (CDD) increase with increasing temperatures

Example: If T = 28°C then [CDD = $\sum_i(28°C - 21°C)$] CDD = 7°C

Once the Temperature exceeds T_C, cooling is required



Exemplary day of hourly Solar Radiation & CDD



Results

Hourly and daily correlation between…

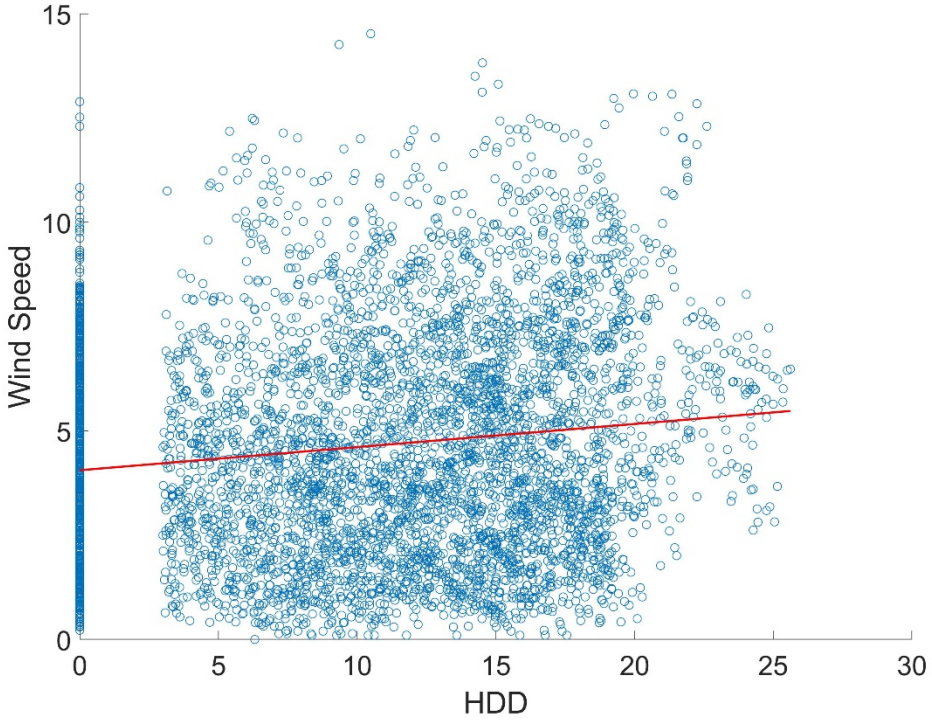
1. … HDD & Wind Speed for the winter months
2. … CDD & Solar Radiation for the summer months

The correlation between wind and HDD is higher with daily average climate data

0.13

The hourly correlation (R_{Hh}) is

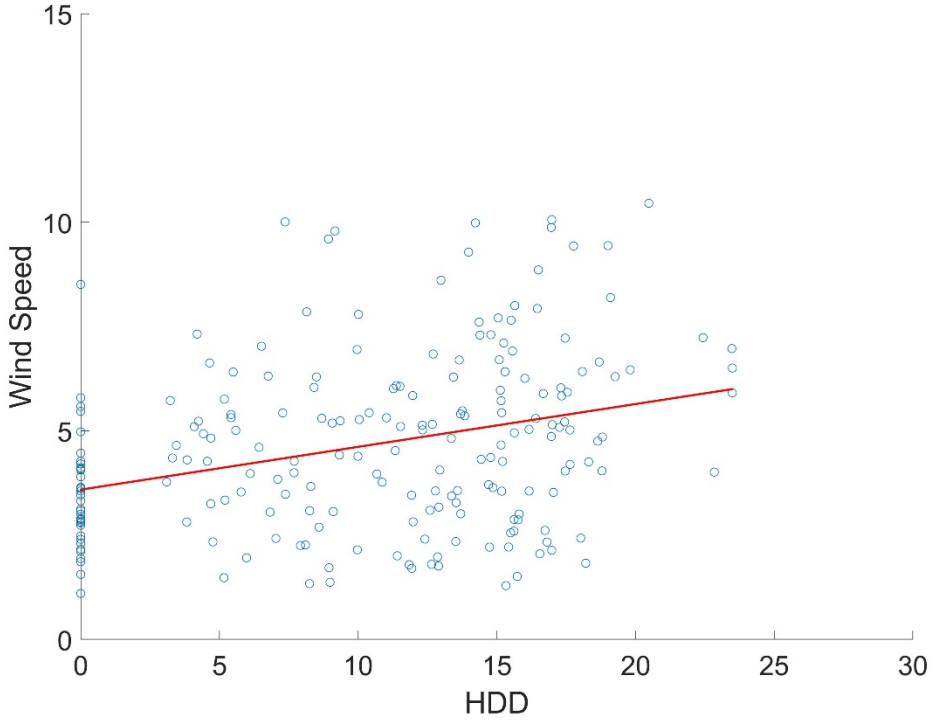
‚Very weak‘



0.32

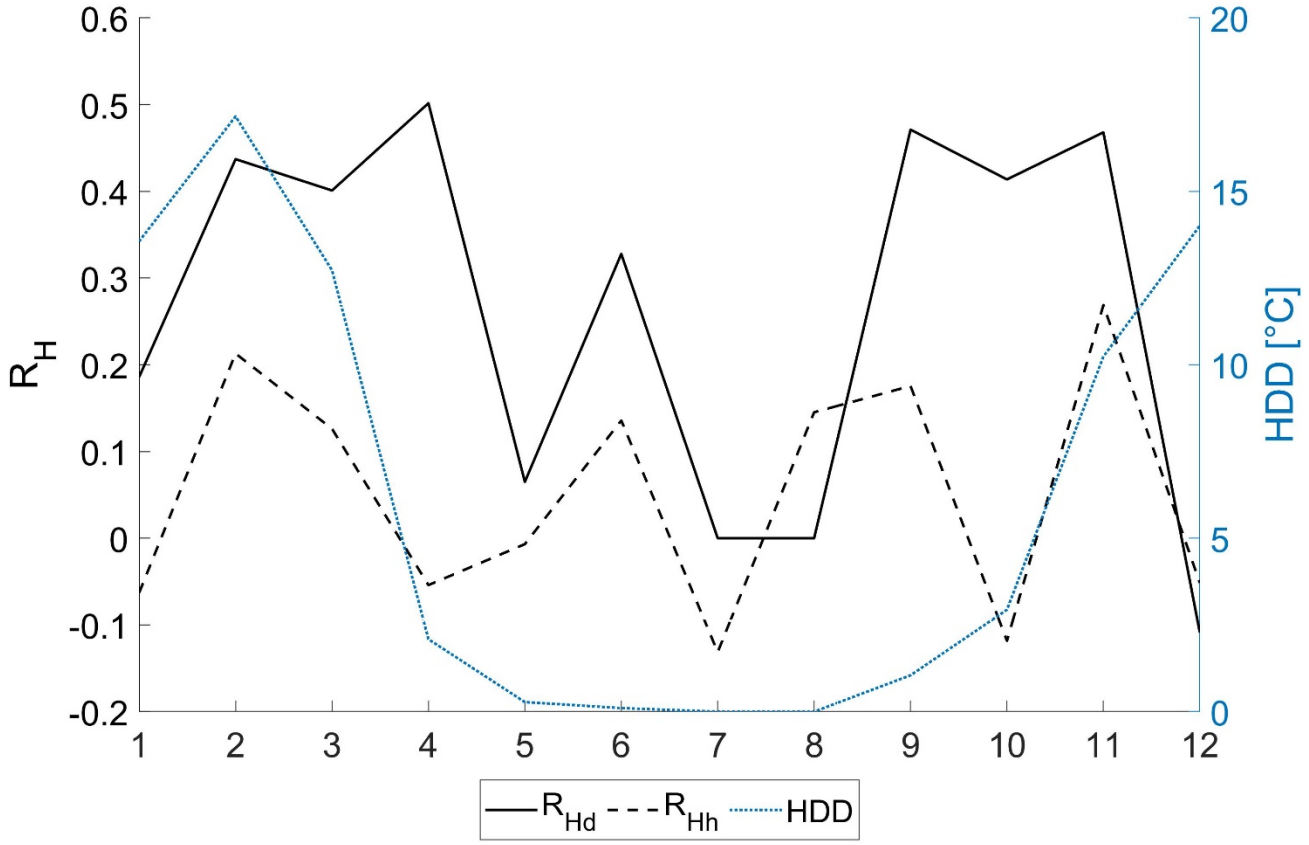
The daily correlation (R_{Hd}) is

‚Weak‘



Characteristics of heating degree days & wind speed applying hourly and daily resolution

R_H is much higher with average daily climate data, which implies the need for hourly to daily storage for a most direct, local use of wind power for heating



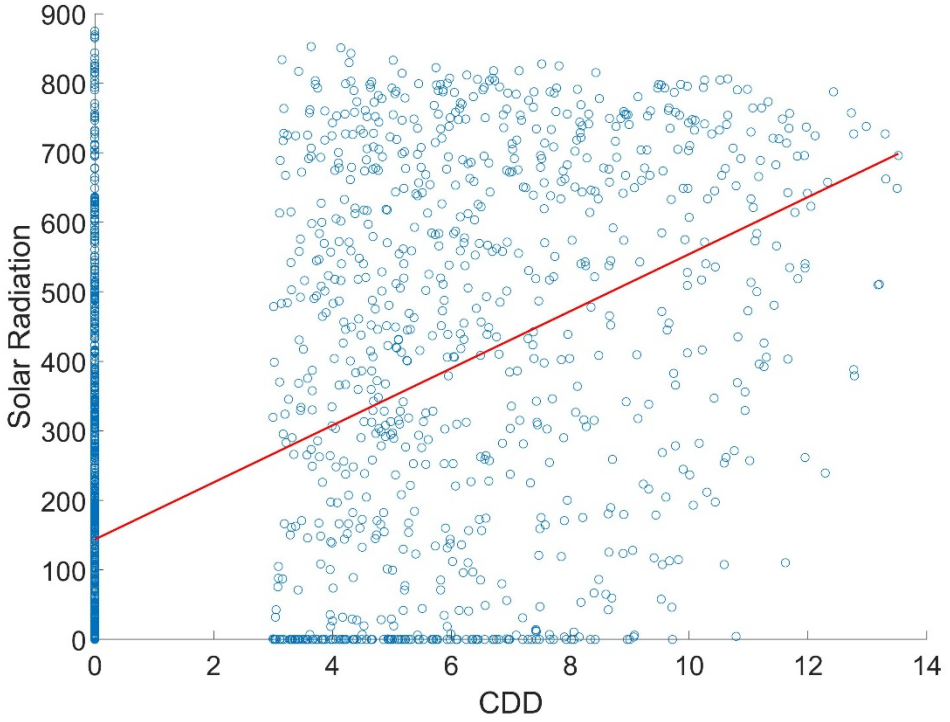
Monthly average of hourly and daily correlation

The correlation between solar radiation and CDD is quite significant throughout the day

0.52

The hourly correlation (R_{Ch}) is

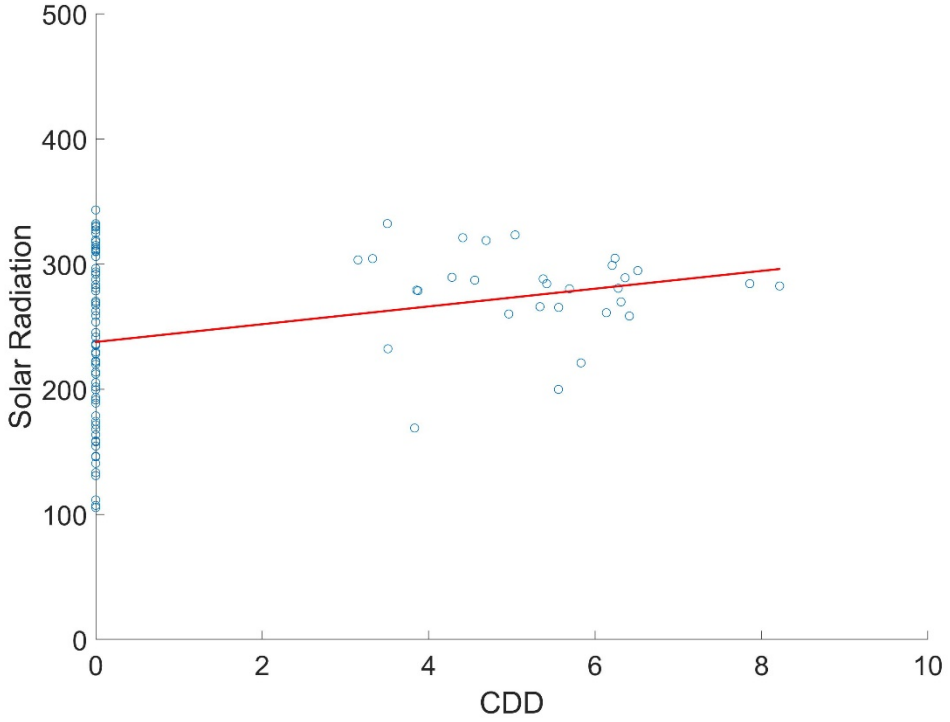
‚Moderate‘



0.32

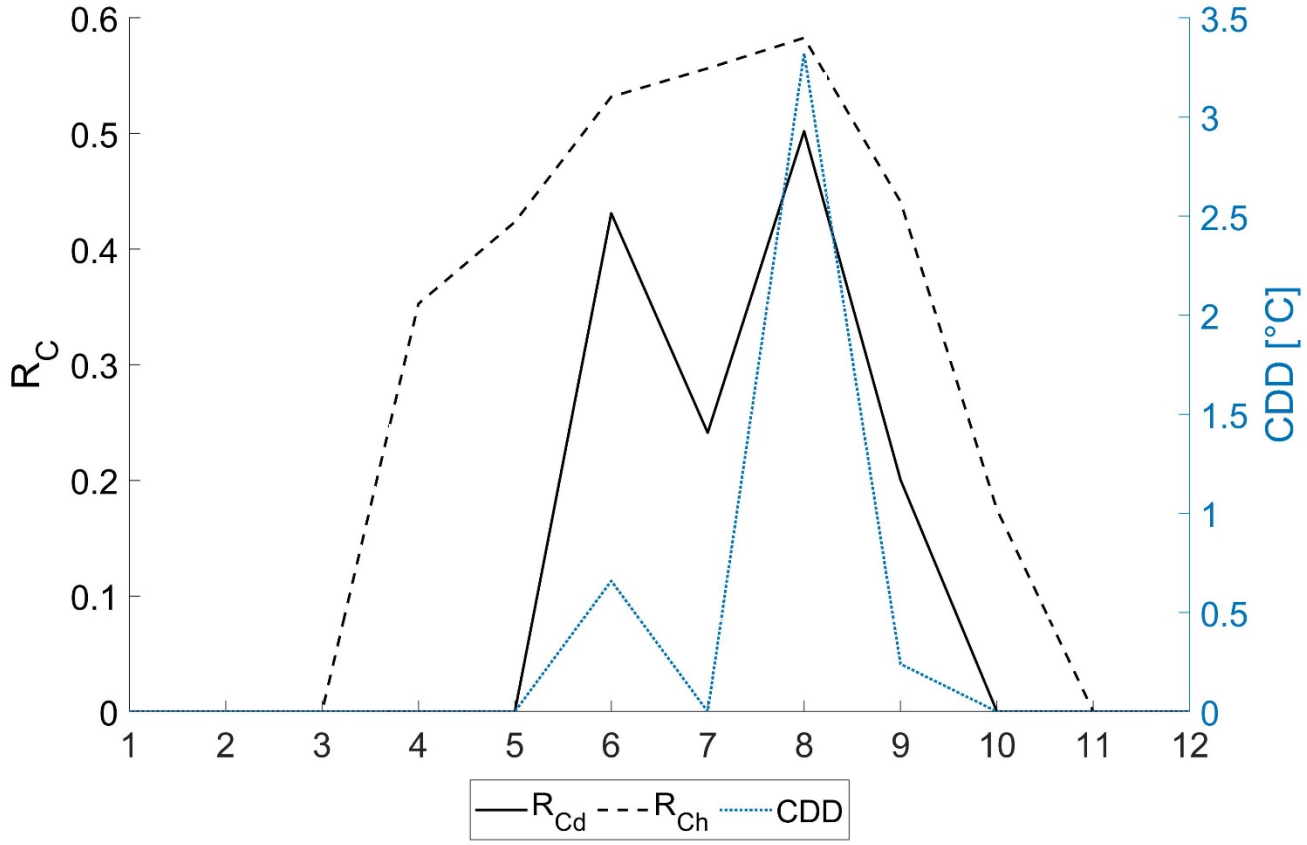
The daily correlation (R_{Cd}) is

‚Weak‘



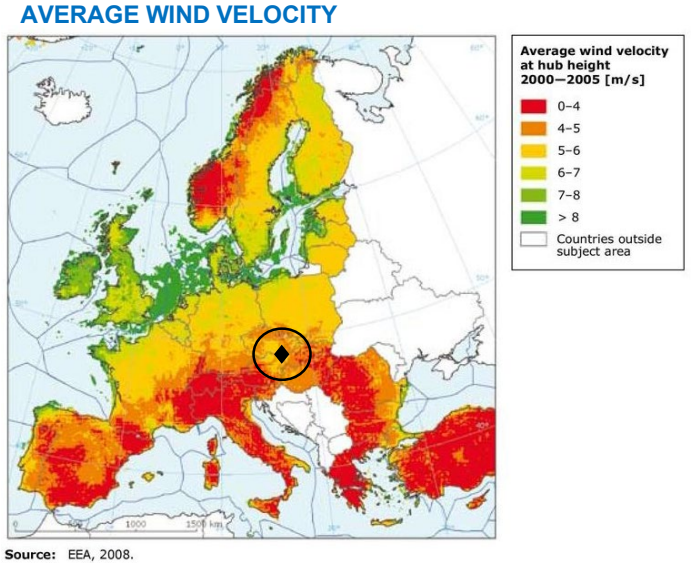
Characteristics of cooling degree days & solar radiation applying hourly and daily resolution

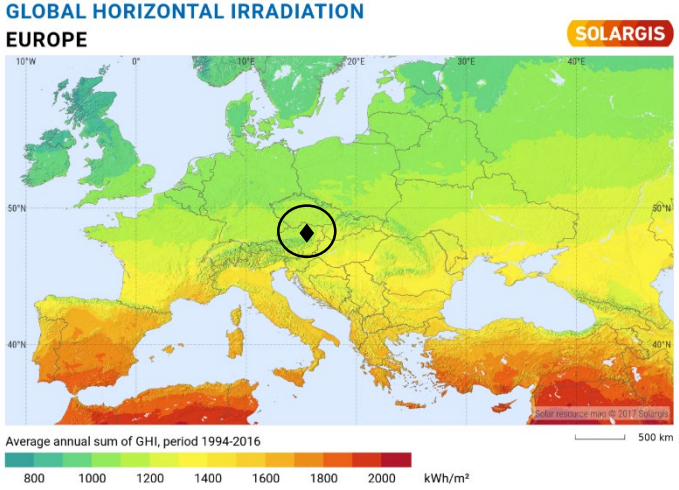
R_C is more substantial with hourly climate data, which implies a very direct, short-term correlation and potential of PV power use for cooling



Monthly average of hourly and daily correlation

Case study findings





Vienna – as a central European city - has neither extreme availability of wind nor solar radiation

The correlation is not very strong in either scenario (Wind/HDD or Solar Radiation/CDD)

Wind speed and heating demand require a wider time frame to improve correlation.

This implies the need for hourly to daily storage.

Solar radiation and cooling demand correlate more obviously on hourly basis.

This implies potential for very direct, short-term use of PV power for cooling.

Ramsebner, Haas & Linares, SES Aalborg 2020

Solargis (2020)
EEA (2008)

Conclusions & outlook

Conclusions

Importance of temporal resolution for correlation results

A lack of correlation and the seasonal variability may suggest the conversion of VRE into hydrogen

We expect stronger results for countries with higher dominance of wind or sun availability

Future Research

Analysis of different climate zones (AT, DK, ES)

Considering spatial variation within countries

The impact of climate change on the development of HDD and CDD.

Derive policy implications

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