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C3S Energy Webinar 3

Electricity/Energy Demand proxy using Energy Degree Days

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Introduction

For countries outside of Europe, or those in Europe for which demand data are not of sufficient quality, the electricity demand data is represented by a proxy, Energy Degree Days (EDD).

EDD is computed for every country, i.e. also those with electricity demand from the statistical model.

EDD is given as the sum of Heating Degree Days (HDD) and Cooling Degree Days (CDD), and are computed according to standard methodologies, as also adopted by the International Energy Agency (IEA)*.

**https://www.iea.org/data-and-statistics/data-tools/weather-for-energy-tracker*

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Global Energy Data – Demand

DATA SOURCE	SPATIAL COVERAGE	TEMPORAL RESOLUTION
ENTSO-E Transparency Platform	Pan-European countries (PECD)	Hourly
EMBER	85 countries	Monthly
Global Energy Outlook	Worldwide	Annual
GECO – European Commission	Worldwide	Annual
IEA (International Energy Agency)	38 OECD countries and 14 non –OECD countries	Annual/monthly
Australian Energy Market Operator (AEMO)	Australia	Half-hourly

(1) https://transparency.entsoe.eu
(2) https://ember-climate.org/data-catalogue/monthly-electricity-data/
(3) https://eneroutlook.enerdata.net
(4) https://joint-research-centre.ec.europa.eu/geco-2021-advancing-towards-climate-neutrality/geco-visualisation_en
(5) https://www.iea.org/data-and-statistics/data-product/electricity-information
(6) https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/market-management-system-mms-data/generation-and-load

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Heating Degree Day (HDD)

HDD is a climate indicator used in the estimation of the needs and demand of energy for heating purposes. There are several operational definitions for HDD. Currently, we define HDD as the monthly sum of the daily difference between a reference temperature (perceived as comfortable) and the daily average of the outside air temperature (at 2 m height, T_{2m}) but only when T_{2m} subceeds a threshold temperature (which defines the “heating days” throughout the year), according to the following definition (all temperatures in °C):

$$if\ T_{2m} \geq T_{threshold}: HDD = 0$$

$$if\ T_{2m} \leq T_{threshold}: HDD = T_{ref} - T_{2m}$$

with reference temperature T_{ref} 18°C and threshold temperature $T_{threshold}$ 15°C according to HDD definition of HHDThold18 (IEA, 2023; Scoccimarro et al., 2023).

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Cooling Degree Day (CDD)

CDD is a climate indicator used in the estimation of the needs and demand of energy for cooling purposes. CDD is here defined as the monthly sum of the daily difference between a reference temperature (perceived as comfortable) and the daily average of the outside air temperature (at 2 m height, T_{2m}) but only when T_{2m} exceeds a threshold temperature (a condition that defines the “cooling days” throughout the year), according to the following definition (all temperatures in °C):

$$if\ T_{2m} \geq T_{threshold}: CDD = T_{2m} - T_{ref}$$

$$if\ T_{2m} \leq T_{threshold}: CDD = 0$$

with reference temperature T_{ref} 21°C and threshold temperature $T_{threshold}$ 24°C according to CDD definition of CDDThold21 (IEA, 2023; Scoccimarro et al., 2023) .

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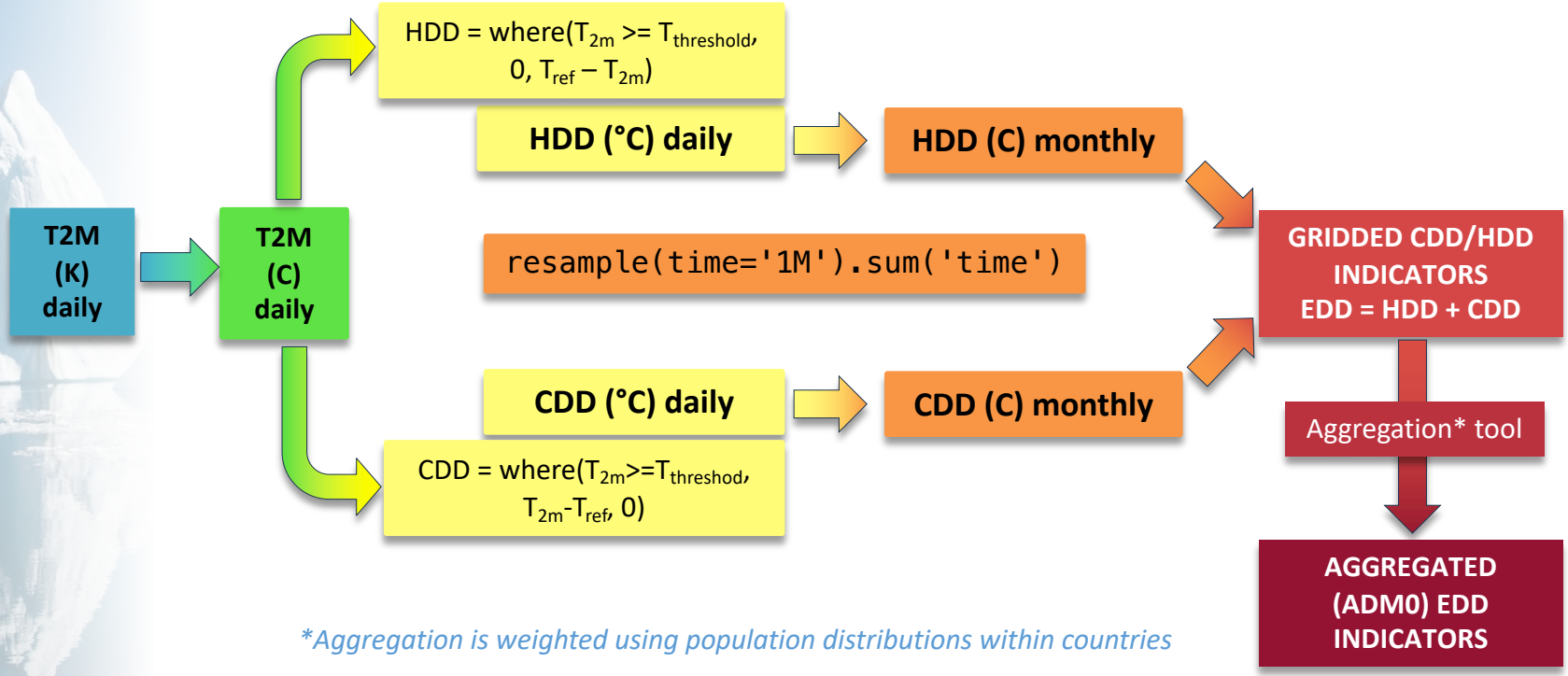
Computation flow



**Aggregation is weighted using population distributions within countries*

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Validation procedure

To validate the methodology, the resulting gridded HDD/CDD have been compared to the dataset published by IEA*. The comparison involved the climatology calculated over the reference period 2000-2019 according to the following:

$$climatology_m = \frac{\sum_{y=1}^{N} x_m^y}{N}$$

Where m is the month for which the climatology is calculated, y indicates the year of the selected reference period (2000, 2001...etc until 2019), N is the numbers of years considered, i.e., 20, while x_m^y is the monthly mean of HDD/CDD for the month *m* and the year *y* considered.

As example the figure in the next slide show the results for HDD, for selected months (January, April, July, and October). As The differences between the HDD and CDD from IEA and those computed in this service are generally very low, which demonstrates that the procedure implemented, and the results obtained are equivalent to the IEA results. *http://weatherforenergydata.iea.org

Validation procedure

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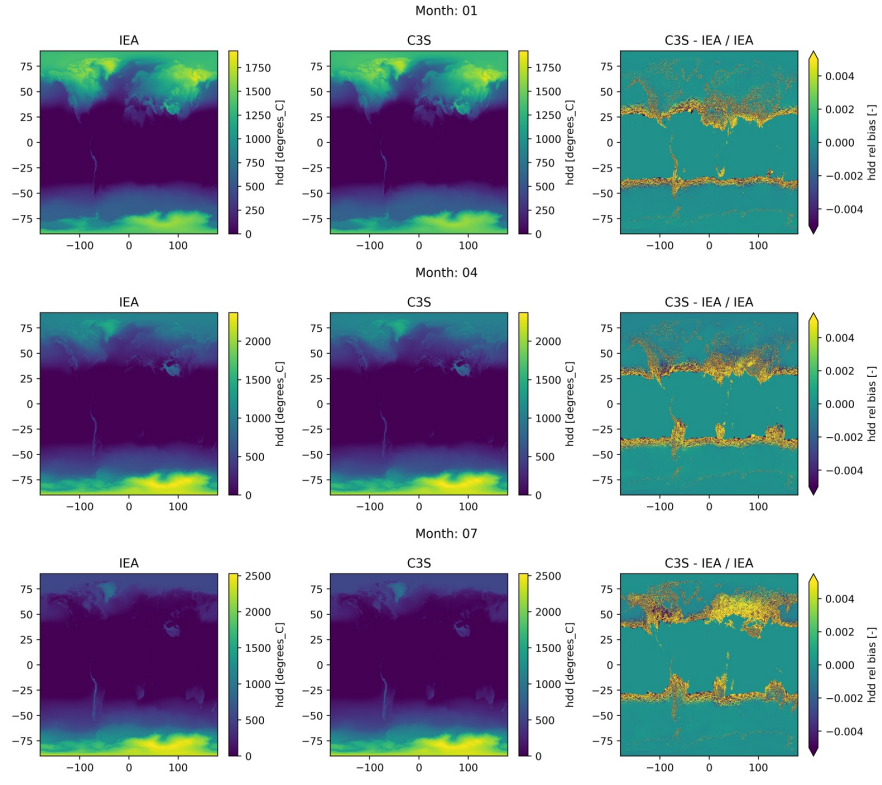

*HDD validation for selected months in 2015: January (top left), April (middle left), July (bottom left), October (top right), for IEA (left), **C3S Energy Lot 1** (middle), and their difference (right).*

Analogous differences were found for CDD.

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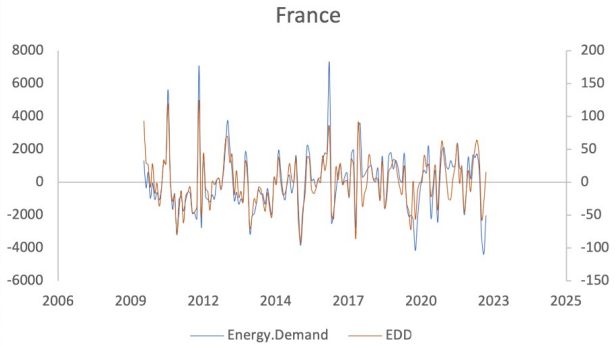
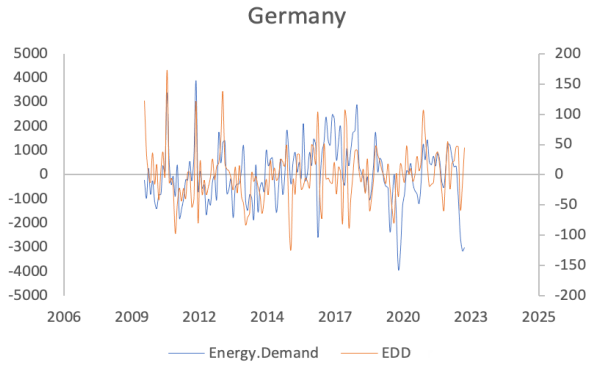
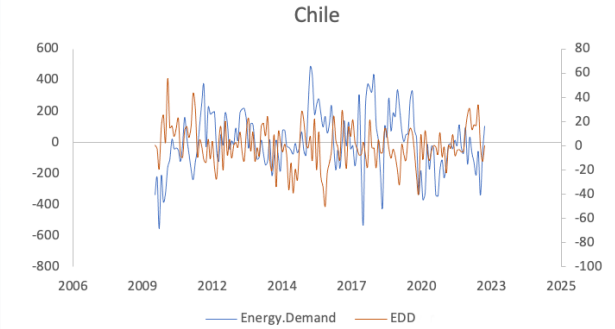
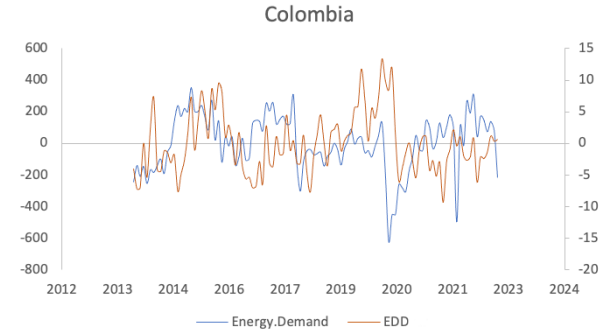
Results

Comparison of Energy Demand and EDD for selected Countries









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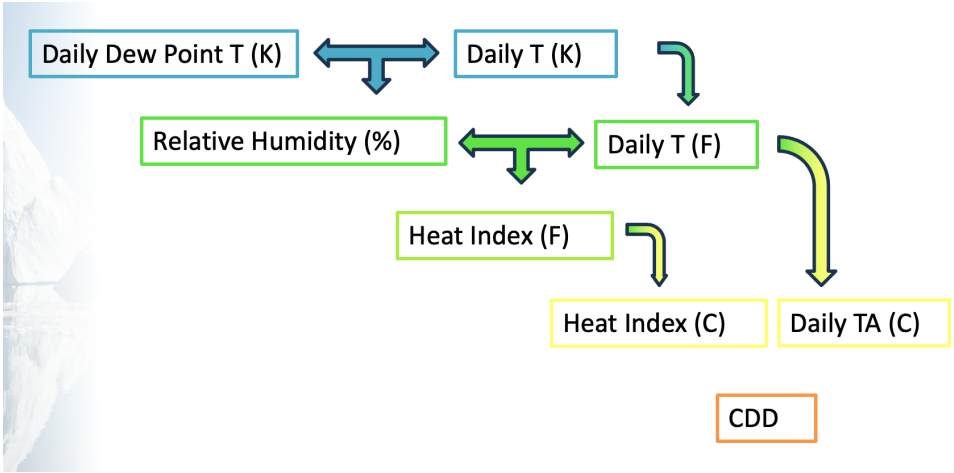
Conclusion and future outlook

Future developments will include a more elaborate estimation of CDD based on the **heat index** (currently the CDD estimation is based on air temperature alone). The heat index was developed by NOAA in 1978 and combines the effects of air temperature and relative humidity into a single parameter that provides a measure of the perceived temperature. Higher values of Heat Index (HI) corresponds to hot perceived environmental conditions:

$$\mathrm{HI}(F) = C_0 + C_1 * T + C_2 * RH + C_3 * RH * T \mp C_4 * T^2 + C_5 * RH^2 + C_6 * T^2 * RH + C_7 * T * RH^2 + C_8 * T^2 * RH^2$$

where T is the air temperature (°F), RH is the relative humidity (%), and the coefficient C_1 to C_8 are constant parameter. If T < 80 °F or RH < 40% the Heat Index is equal to the air temperature.

For datasets that do not provide relative humidity, conversions have to be made. In the case of ERA5, the 2m dewpoint temperature will be used.



Thank you for your attention

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