# AixWeather: A Weather Data Generation Tool for Building Energy System Simulations. Pull, Transform, Export.

Martin Rätz [1], **Fabian Wüllhorst** [1], **Rita Streblow** [1], **and Dirk Müller** [1]

1 Institute for Energy Efficient Buildings and Indoor Climate, E.ON Energy Research Center, RWTH Aachen University, Germany

Summary

AixWeather is a tool for generating weather data for building energy system simulations. It can be used to retrieve, format, enrich, and ultimately export weather data in various file formats. It addresses the challenges researchers and industry players face in obtaining accurate and formatted weather data by providing a streamlined process.

Key features of AixWeather:

Data retrieval: AixWeather can directly retrieve data from the German weather provider DWD and supports historical, recent, and forecasted weather data retrieval. It also supports uploading test reference years (TRY) from the DWD and .epw files from EnergyPlus. A custom weather data upload is also supported, but depending on the import structure, the user needs to adjust the transformation code.

Data conversion: AixWeather converts this raw weather data from various sources into a defined core format and, from there, into the desired export format.

Data accuracy: AixWeather ensures data accuracy by taking into account critical factors that are often overlooked in custom solutions, which are specifically the consideration of time zones, the time reference of the measurement, unit conversions, correct handling of incomplete data series and, where possible, the avoidance of interpolation-related smoothing.

Data enrichment: AixWeather uses physical relationships to calculate missing weather variables from the available weather- and metadata.

Flexibility: AixWeather offers a modular structure that simplifies the addition of new import and output formats, and the maintenance of existing formats.

Modelica ReaderTMY3 compatibility: A particular feature of AixWeather is its support for generating weather data compatible with the Modelica ReaderTMY3 format. This covers a so far unsatisfied need.

Statement of need

Building energy simulations, crucial for research in building energy systems, often rely on specific weather data formats. Creating such weather data can be a labor-intensive and error-prone task. AixWeather addresses these challenges by offering a comprehensive solution for pulling, transforming, enriching, and exporting weather data from various sources and formats.

Some tools focus on generating typical meteorological year (TMY) data, like the PVGIS (Huld et al., 2018) from the European Commission, which provides TMY exports in .csv, .json, and .epw formats. EnergyPlus (Crawley et al., 2001), a widely used building energy simulation tool, also provides a weather data converter to cover the needs of its users, again only supporting the .epw format. There is a lack of tools supporting conversions to the ReaderTMY3 format. The ReaderTMY3 is a Modelica model of the well-established open-source library Buildings (Wetter et al., 2014). Other libraries, such as the open-source library AixLib (Maier et al., 2023), import this model to handle weather data. Often users of these libraries, who do not have a TMY3 file at hand, get stuck or spend a lot of time to convert their weather data into the required format. Solving this problem was the initial motivation to develop AixWeather. Moreover, there are only limited tools for importing real, historical or forecast, weather data and converting it to building energy simulation formats. The same is true for the Test Reference Years (TRY) of the German Weather Service (DWD). AixWeather also addresses these needs, making it a valuable tool, not only for researchers who work with the ReaderTMY3 format.

Accessibility

AixWeather can be accessed through the GitHub repository itself (https://github.com/RWTH-EBC/AixWeather), e.g., to be incorporated in simulation automation workflows. For manual weather data generation, we recommend our locally hosted web application at https://aixweather.eonerc.rwth-aachen.de, which omits the need to set up an environment. The web application's source code is open source and hosted in a separate repository at https://github.com/RWTH-EBC/AixWeather-WebApp.

Structure of AixWeather

Figure 1 shows the current data flow and structure of AixWeather. First, the data is imported as raw as possible, to enable inspection of the raw data. The imported data is then converted into a core format, including all transformations like data enrichment, unit conversions, time zone and measurement time handling. The core format is a defined format that allows for generalized conversion to the different export formats. The pass-through handling avoids avoidable interpolation-related smoothing by storing the original unsmoothed time series and, if the shift sequence allows, overwriting the smoothed time series in the output file.
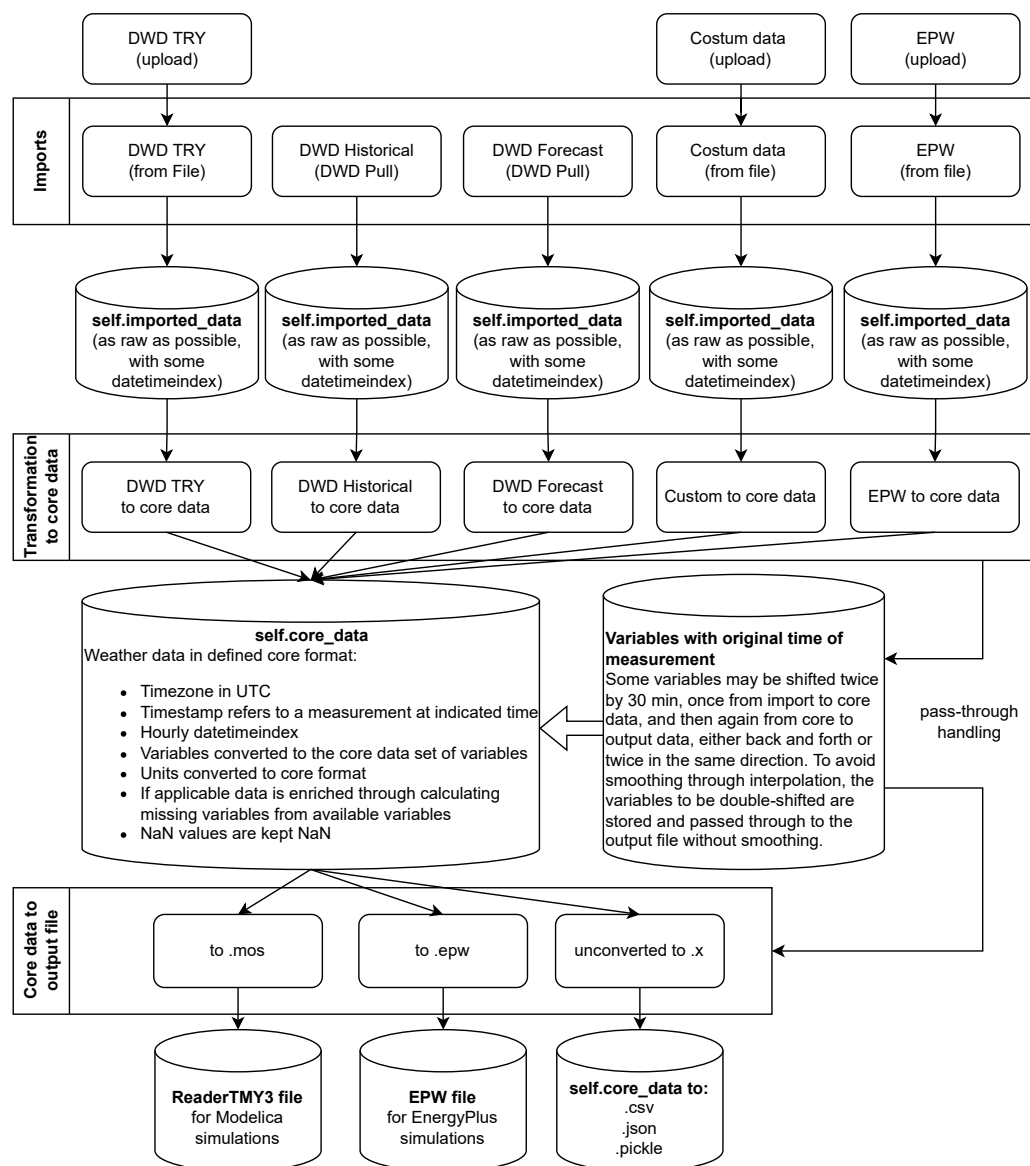
Figure 1: Data flow and structure of AixWeather.

Comparison with Similar Tools

While several weather data tools exist, AixWeather offers distinct capabilities compared to similar software.

For instance, Elements (*Elements, 2016*), developed by Big Ladder Software, is a free open-source tool focused on editing and creating custom weather files. While Elements excels at weather file manipulation through its spreadsheet-like interface and visualization capabilities, AixWeather differentiates itself through automated data retrieval and processing pipelines that reduce both the expertise and time required to generate weather data. Elements' strengths lie in manual data editing. In contrast, AixWeather focuses on automated workflows, direct integration with data sources like DWD, and specialized support for the Modelica ReaderTMY3 format.

The EnergyPlus Weather Converter (*Crawley et al., 2001*) is a widely used tool that focuses

specifically on creating and converting weather files for EnergyPlus simulations. While it excels at EPW file handling, AixWeather offers multi-source data retrieval and multi-format export capabilities.

Meteonorm (AG, 2023), a commercial tool, provides sophisticated weather data generation and processing capabilities. While it offers extensive global coverage and detailed data analysis, AixWeather provides a free, open-source alternative with specific strengths in German weather data integration and the Modelica ReaderTMY3 compatibility.

AixWeather's unique contribution lies in its automated workflows, direct integration with German weather services, specialized support for the Modelica ReaderTMY3 format, and web-based accessibility.

Acknowledgements

References

AG, M. (2023). *Meteonorm: Global climate data for solar applications and building design*. Meteotest AG. https://meteonorm.com/

Crawley, D. B., Lawrie, L. K., Winkelmann, F. C., Buhl, W. F., Huang, Y. J., Pedersen, C. O., Strand, R. K., Liesen, R. J., Fisher, D. E., Witte, M. J., & Glazer, J. (2001). EnergyPlus: Creating a new-generation building energy simulation program. *Energy and Buildings*, *33*(4), 319–331. https://doi.org/10.1016/S0378-7788(00)00114-6

Elements: Weather file tool. (2016). Big Ladder Software; Big Ladder Software. https://bigladdersoftware.com/projects/elements/

Huld, T., Paietta, E., Zangheri, P., & Pinedo Pascua, I. (2018). Assembling typical meteorological year data sets for building energy performance using reanalysis and satellite-based data. *Atmosphere*, *9*(2). https://doi.org/10.3390/atmos9020053

Maier, L., Jansen, D., Wüllhorst, F., Kremer, M., Kümpel, A., Blacha, T., & Müller, D. (2023). AixLib: An open-source modelica library for compound building energy systems from component to district level with automated quality management. *Journal of Building Performance Simulation*, *0*(0), 1–24. https://doi.org/10.1080/19401493.2023.2250521

Wetter, M., Zuo, W., Nouidui, T. S., & Pang, X. (2014). Modelica Buildings library. *Journal of Building Performance Simulation*, *7*(4), 253–270. https://doi.org/10.1080/19401493.2013.765506