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diyepw: A Python package for Do-It-Yourself EnergyPlus weather file generation

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Software

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Summary

`diyepw` allows for quick and easy generation of a set of EnergyPlus weather (EPW) files for a given location over a given historical period. The user can obtain weather files using an open-source, automated workflow by simply specifying the location of interest using the World Meteorological Organization weather station ID number (*Integrated Surface Database Station History*, 2021), and specifying a year or set of years for which to generate EPW files. Building energy modelers can use these auto-generated weather files in building performance simulations to represent the actual observed weather conditions in the location(s) of interest, based on observed weather data obtained from the National Oceanic and Atmospheric Administration's Integrated Surface Database (*Integrated Surface Database (ISD)*, 2021; Smith et al., 2011). Because observed weather data are not available for every meteorological variable specified in the EPW format (*EnergyPlus Weather File (EPW) Data Dictionary*, 2015), `diyepw` starts with a widely-used set of typical meteorological year (TMY) EPW files (*Weather Data*, n.d.), using them as the template to generate new EPW files by substituting in the observed values of selected meteorological variables that are known to affect building energy performance (see Using DIYEPW to generate AMY EPW files for details). Its output is an weather file or group of weather files that conform to the EPW format so they can be used with any building performance simulation software employing EnergyPlus (U.S. Department of Energy's (DOE) Building Technologies Office (BTO), 2020) as its simulation engine.

`diyepw` is available here as a Python package (*Diyepw*, 2021), and as a set of scripts in a separate repository (*Diyepw-Scripts*, 2021). It can be called directly as a package to incorporate EPW file generation into a custom script, or used as a command-line tool, and is customizable according to the modeler's needs. A step-by-step example tutorial is provided as a quick start option here: Tutorial.

Statement of need

Building energy modeling (BEM) practitioners and researchers have few options for obtaining EnergyPlus weather files that contain historical weather observations. Modelers often use EPW files that are based on typical meteorological year (TMY) data, which do not represent any given historical year and are usually only available for airport weather station locations. The Integrated Multisector Multiscale Modeling (IM3) project (*Integrated Multisector Multiscale Modeling*, 2021) needed a way to use observed weather data to drive simulations of model buildings using EnergyPlus for specific years in the past. Previous IM3 research (Burleyson et al., 2018) showed that for regional-scale BEM, where many buildings are aggregated, a model

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that is forced with weather files taken from stations throughout the region will have lower bias in predicting the aggregate load than a model forced with only a few weather files that don't capture the heterogeneity in the region. Some commercial providers will offer weather files for given year(s) and location(s), but they may charge for each weather file and the source data and code used to process it will not be transparent to the user. Some modelers have created their own weather files by obtaining weather data and manipulating it to meet the EPW format, but it is a labor-intensive process and no open-source, automated software package existed to produce EPW files from publicly available weather observations until `diyepw`. This software will benefit the BEM community by allowing for easy use of reliable, quality-checked, publicly available weather data in their EnergyPlus simulations to represent actual historical years in specific location(s).

Relationship to other resources in this research area

`diyepw` was inspired by the Local Actual Meteorological Year File (LAF) application (Bianchi & Smith, 2019). `diyepw` addresses some of its key limitations:

- LAF's workflow requires downloading and clicking and is not fully automated.
- LAF is no longer developed or maintained.
- LAF relies on an API for downloading observed weather data that has limitations on the amount of data that can be downloaded without a paid account.
- LAF is not directly extensible to other sources of weather data, such as the NOAA ISD Lite format used here.

The EnergyPlus website lists additional resources for obtaining EPW files for building energy modeling (*Weather Data for Simulation*, n.d.). Few data providers can produce weather files for specific locations over a given historical period, and when they do provide such EPW files, the raw data representing the weather observations may not be available to the user. Thus the processing of that data to produce the EPWs is not fully transparent and reproducible. The user may be required to pay for these files and would not have the option to adjust the standards for data quality–for determining which values are acceptable for a given meteorological variable, or for limiting the amount of data that is interpolated or otherwise imputed by the software generating the EPW files.

Dependencies

`diyepw` relies on functionality from the following Python packages: `NumPy` (NumPy contributors, 2021), `pandas` (pandas contributors, 2021), and `xarray` (xarray contributors, 2021).

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References

Bianchi, C., & Smith, A. D. (2019). Localized actual meteorological year file creator (LAF): A tool for using locally observed weather data in building energy simulations. *SoftwareX*, *10*, 100299. https://doi.org/10.1016/j.softx.2019.100299

Burleyson, C. D., Voisin, N., Taylor, Z. T., Xie, Y., & Kraucunas, I. (2018). Simulated building energy demand biases resulting from the use of representative weather stations. *Appl. Energy*, *209*, 516–528. https://doi.org/10.1016/j.apenergy.2017.08.244

Diyepw. (2021). Pacific Northwest National Laboratory; Github. https://github.com/IMMM-SFA/diyepw

Diyepw-scripts. (2021). Pacific Northwest National Laboratory; Github. https://github.com/IMMM-SFA/diyepw-scripts

EnergyPlus weather file (EPW) data dictionary. (2015). https://bigladdersoftware.com/epx/docs/8-3/auxiliary-programs/energyplus-weather-file-epw-data-dictionary.html; {Big Ladder Software LLC}. https://bigladdersoftware.com/epx/docs/8-3/auxiliary-programs/energyplus-weather-file-epw-data-dictionary.html

Integrated multisector multiscale modeling. (2021). https://im3.pnnl.gov/. https://im3.pnnl.gov/

Integrated surface database (ISD). (2021). https://www.ncdc.noaa.gov/isd; National Oceanic; Atmospheric Administration. https://www.ncdc.noaa.gov/isd

Integrated surface database station history. (2021). https://www1.ncdc.noaa.gov/pub/data/noaa/isd-history.txt. https://www1.ncdc.noaa.gov/pub/data/noaa/isd-history.txt

NumPy contributors. (2021). *NumPy: The fundamental package for scientific computing with python* [Manual]. Numpy.

pandas contributors. (2021). *pandas: Flexible and powerful data analysis / manipulation library for python* [Manual]. PyData.

Smith, A., Lott, N., & Vose, R. (2011). The integrated surface database: Recent developments and partnerships. *Bull. Am. Meteorol. Soc.*, *92*(6), 704–708. https://doi.org/10.1175/2011BAMS3015.1

U.S. Department of Energy's (DOE) Building Technologies Office (BTO). (2020). *EnergyPlus*. https://energyplus.net/. https://energyplus.net/

Weather data. (n.d.). https://energyplus.net/weather. https://energyplus.net/weather

Weather data for simulation. (n.d.). https://energyplus.net/weather/simulation. https://energyplus.net/weather/simulation

xarray contributors. (2021). *xarray: N-d labeled arrays and datasets in python* [Manual]. The Climate Corporation.