Development of an Integrated Energy Simulation Tool for Buildings and MEP Systems, the BEST(Part 9)

Weather Data for the BEST

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In this report, the weather datasets available in the BEST calculations are summarized. The datasets contain hourly or 1-minute weather data for 842 stations in Japan and over 3700 stations in the world. The datasets consist of daily or weekly design weather data as well as annual weather data selected from many years. As the BEST discriminates EPW data format or simple CSV data, users can input their own weather data for the BEST calculations.

1. Introduction

This report addresses the weather data used in BEST, starting with types of weather data and the manipulation thereof and later introduces the structure and behaviors of programs handling weather data.

2. Sources of weather data used in BEST

Figure 1 shows the weather data and elements that can be used in BEST. BEST handles the following five types of weather date:

* BEST weather data

1) Annual weather data

2) Weather data for design

3) World weather data (BEST-WeaDAC)

* Outsourced weather data

4) EnergyPlus weather data

5) Weather data created by users

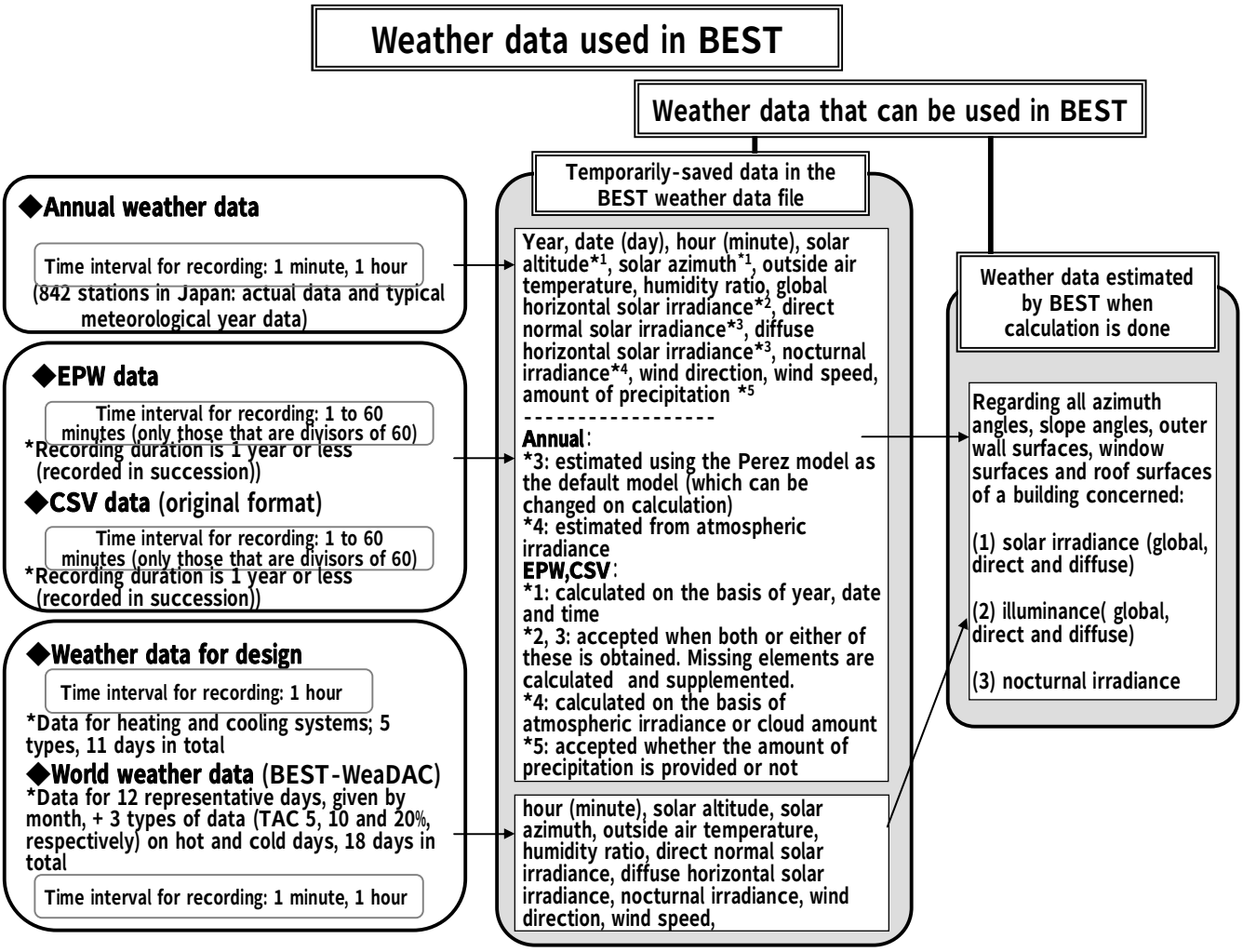


Figure 1 Weather data and elements that can be used in BEST

2.1 Annual weather data

BEST annual weather data is obtained at intervals of 1 minute or 1 hour and is created by reformatting Expanded AMeDAS Weather Data [1)]. Weather elements include air temperature, humidity ratio, global horizontal solar irradiance, diffuse horizontal solar irradiance, direct normal solar irradiance, the solar position, wind direction, wind speed, amount of precipitation, atmospheric irradiance and extraterrestrial solar irradiance. We are planning to provide the hourly data, obtained from 842 stations nationwide during 20 years from 1981 until 2000 and the hourly data for a typical meteorological year. We are also planning to provide one-minute interval data obtained from 56 stations nationwide, most of which are located in prefectural capitals. Once the above-mentioned data becomes available to the public, we are going to add the latest data and improve the database.

2.2 Weather data for design

Weather data for design is used to determine the design of air conditioning systems and is created by reformatting Expanded AMeDAS weather data. This includes the hourly values of weather elements

throughout a day that are necessary to calculate maximum thermal loads. Several types of data for the design of heating and cooling systems are obtained from the same stations as the annual weather data.

2.3 World weather data (BEST-WeaDAC)

World weather data (BEST-WeaDAC) is made on the basis of the concepts of "WEADAC" [2], the software used to create weather data worldwide.

Based on source data such as monthly statistical values for over 3,700 cities worldwide, hourly weather data of a typical day and that of a day with the maximum thermal load in a specific month, are created by WEADAC.

2.4 EnergyPlus weather data

EnergyPlus weather (EPW) data is used in "EnergyPlus," an energy analysis and thermal load simulation program, which has been made available publicly by the U.S. Department of Energy [3].

EPW data is in CSV format, which has been set up to contain as many elements as possible [4]. BEST can read EPW data and use it as weather data for calculation. The use of EPW data, however, is restrained by some requirements such as "the data used must be chronologically successive."

2.5 Weather data created by users

Weather data created by users can be used in BEST. Users need to define a format for the weather data using CSV and weather data made in that format can be imported into BEST.

The previously-mentioned EPW data is also in CSV format and users can create their own data on the basis of EPW data or rearrange it to their satisfaction. However, as many additional or missing items are found in EPW data (see section 3.1), it is pointless to create data appropriate for BEST based on EPW data just because they are needed for calculation.

Therefore, a file containing only the necessary elements in CSV format is defined for the use of user weather data, enabling users to enter their weather data into BEST with ease.

3. Manipulation of weather data

3.1 Import of outsourced weather data

Annual weather data, weather data for design and world weather data (BEST-WeaDAC), all of which are incorporated in BEST, include values for the necessary weather elements appropriate for calculation. In addition, regarding the use of outsourced data such as EPW data and weather data created by users, it is essential to remove extra information and supplement existing data. Imported and supplemented data is temporarily saved in a file inside the computer in the same format as the data incorporated in BEST. This temporarily-saved data, as well as the data incorporated in BEST, are used for calculation.

(1) Import of EPW data

As EPW data is contained in a data file for use in EnergyPlus, it has unnecessary elements or it is missing items that are necessary for calculation by BEST. The missing elements in EPW data are humidity ratio, nocturnal irradiance and the amount of precipitation. Of these three, humidity ratio and nocturnal irradiance can be supplemented by estimation using other elements (such as air temperature, relative humidity and atmospheric irradiance). These two elements are calculated and are saved when data is imported. Precipitation amounts are basically treated as "no precipitation."

However, because this makes it impossible to perform the calculation using the precipitation amount, BEST is able to process data in which the values for the precipitation amount are added after the time values provided in the data. Therefore, while always being considered as null data in EPW, data for precipitation amount is processed when the edited and expanded EPW data is imported.

(2) Import of weather data created by users

Weather data created by users is made by users independently and therefore, to prevent errors and to keep from adding to the workload, it is better if fewer elements are to be entered. User weather data does not require the entering of any calculable elements, such as the solar position and the direct component and diffuse component of solar irradiance. However, some of these elements can be entered by users, canceling the automatic calculation by BEST. This is necessary, for example, when solar irradiance (specifically, direct solar irradiance and diffuse solar irradiance) are estimated without carrying out conversion of global to direct (diffuse) irradiance.

3.2 Creation of weather data at any given time interval

As the time intervals for the data used for calculation by BEST are not constant, weather data must be prepared according to the time intervals necessary for a specific calculation. In BEST, therefore, one-minute interval weather data can be used to estimate weather data at intervals that are divisors of 60 (in minutes).

The values of elements estimated at a particular time are the integrated values or averages of data obtained before and after that time.

3.3 Handling solar irradiance

With regard to solar irradiance, the weather data incorporated in BEST includes global solar irradiance, direct solar irradiance and diffuse solar irradiance. The latter two are calculated on the basis of global solar irradiance. Even when outsourced weather data is used, direct solar irradiance and diffuse solar irradiance are estimated from global solar irradiance and are saved, unless a user cancels the automatic calculation.

The Perez model [5] is set as the standard model for the calculation of the conversion of global to direct (diffuse) irradiance. There are also other models available: the Erbs model [6], the Nagata model [7], the Udagawa model [8] and the Watanabe model [9]. If necessary, it is possible to estimate the values by selecting a model other than the standard one when calculation for a specific building is done.
Each building has various tilted surfaces, depending on the shape of the building. Therefore, tilted surface solar irradiance is always estimated when they are used. The model used to calculate tilted surface solar irradiance can also be selected from the Perez model and Isotropic models.

4. Programs handling weather data

This section provides the flow of the behavior of the programs, in addition to user operation, up to the stage at which BEST reads weather data for calculation. Figure 2 shows the relationship among the classes handling weather data. As the figure indicates, inside the weather data folder are weather files and inside the weather-data operating folder is temporarily-saved weather data.
Phase 1 represents the stage in which users select weather data and BEST saves it temporarily; phase 2 denotes the stage in which BEST actually reads the content of the saved weather data.

Phase 1: up to the stage in which BEST saves weather data temporarily

In the case of the use of the weather data incorporated in BEST
1) User inputs the latitude and longitude of an area concerned.
2) Using the "site searching class," BEST searches weather monitoring stations near the given area and the types (and years) of weather data available there. It displays a list of the results to the user.
3) User selects suitable sites and data types (and years) from the list.
4) Using the "file-name searching class," BEST searches actual files of the selected weather data and imports them using the "weather-data saving class." It then creates weather data at necessary time intervals and saves it temporarily.

In the case of the use of outsourced weather data
1) User prepares a weather data file and provides it to BEST.
2) Using the "format converting class," BEST supplements elements of the given data and reformats it. It then saves it temporarily for calculation.

Phase 2: up to the stage in which BEST reads data when calculation is done

Common
1) The Necessary weather data of any given time is read from the temporarily-saved weather data using the "weather-data file reading class." Necessary calculation is also done with regard to solar radiation

("solar irradiance and illuminance data processing class").

BEST is coping with differences in the format of a weather data source in phase 1. Thus, in phase 2, it is capable of handling all weather data according to the procedures mentioned above.

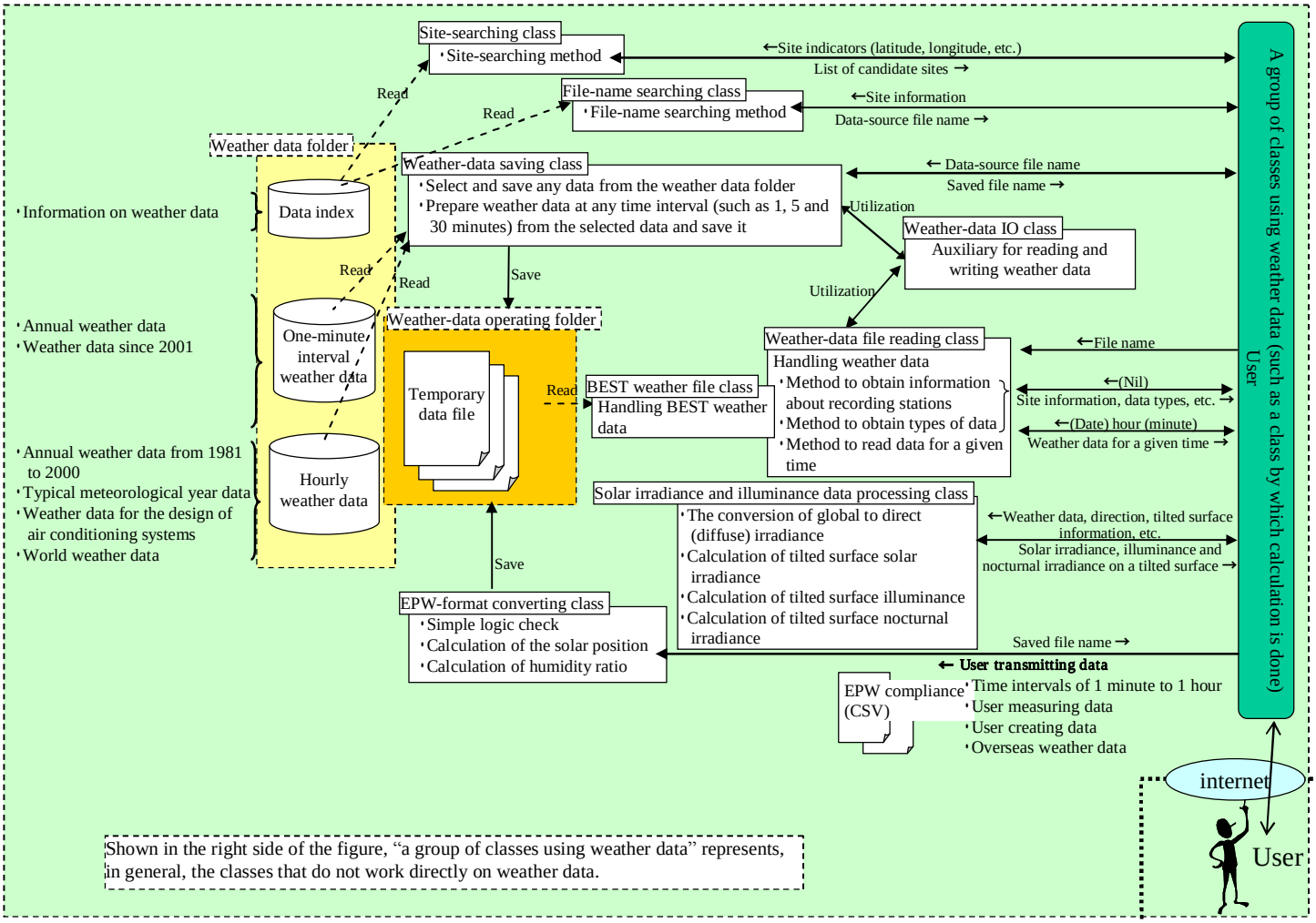


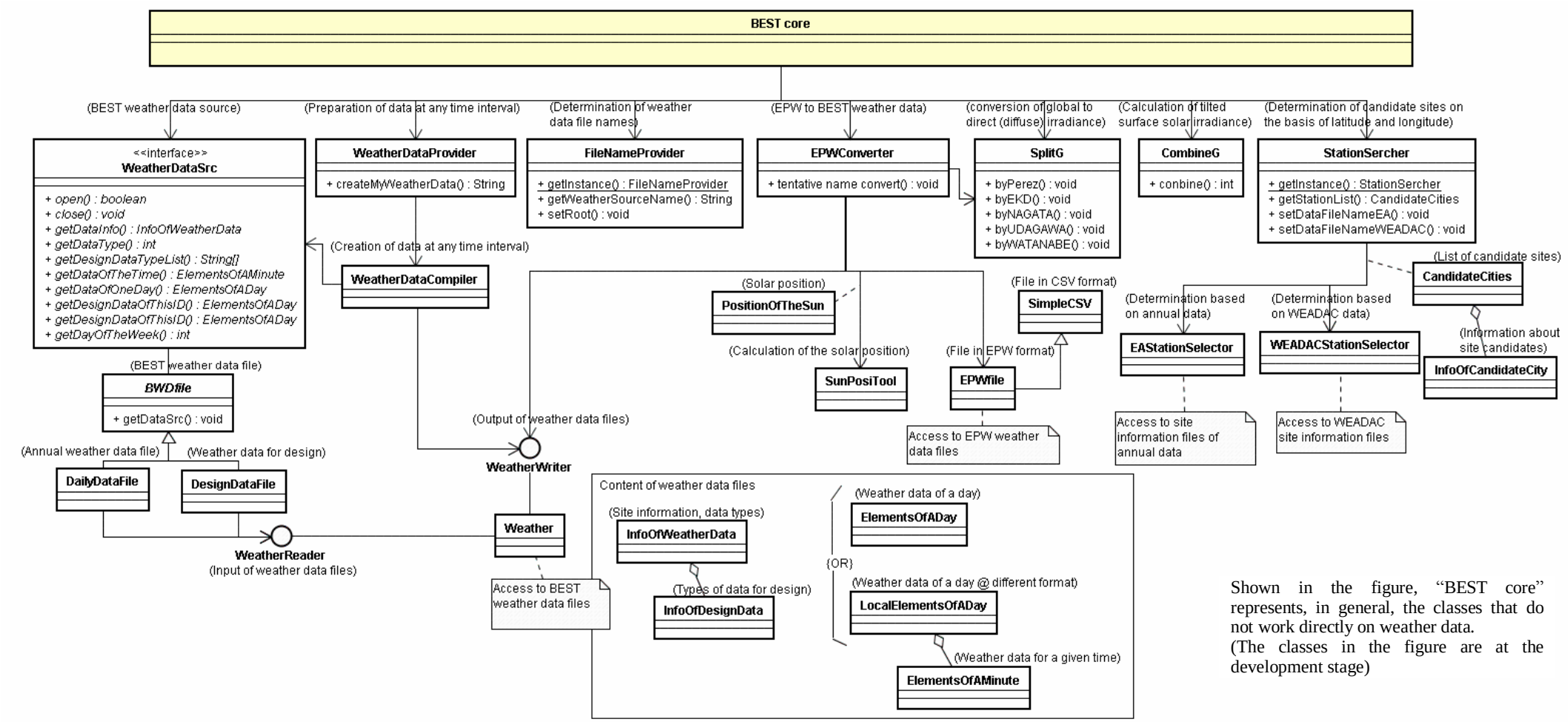
Figure2 An outline of the relationships among classes handling weather data

5. Class diagram

Figure 3 presents a diagram of the classes at the development stage, which was drawn up based on figure 2. These classes are defined more specifically than in figure 2.

6. Summary

In developing BEST, we have also created programs handling the BEST weather data as well as other weather data. BEST makes it possible to calculate energy-consumption estimation using a large amount of weather data.



Shown in the figure, "BEST core" represents, in general, the classes that do not work directly on weather data.
(The classes in the figure are at the development stage)

Figure3 An image of a class diagram

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