Documentation for CWEC solar fix
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Problem

When reviewing ESP-r's photovoltaic model, (Thevenard, 2004) found that ESP-r operates on hourly-centered weather data. That is, the amount of solar irradiance at the recorded hour is the instantaneous irradiance at the hour. For example, a solar irradiance value of 400 W/m^2 at 10h00 means that the irradiance is exactly equal to 400 W/m^2 at 10h00. In comparison, In CWEC files, solar radiation is integrated over the previous hour; the value given for 10 o'clock, for example, is the amount of solar radiation received between 9 and 10. Since hour-centered values of solar radiation are not available in the CWEC files, an algorithm has to be devised to correct for the half-hour shift. A flag could indicate that the solar data contained in the weather file is half-hour centered.

Solution

Implemented an optional flag in the .cfg file and a simulation toggle within bps to specify that the solar radiation data in the weather file is half-hour centered. The former was done so that it is possible to specify that the solar radiation data in the weather file is half-hour centered even when bps is run in silent text mode (important for GUIs that run bps). If the flag exists in the .cfg file and is changed via the simulation toggle menu in bps, the value assigned to the flag in the .cfg file is not modified. However, the simulation will run with the appropriate consideration of the flag set in the simulation toggle menu.

In summary, there are two ways to specify that the solar radiation data contained in the weather file is half-hour centered:
1. Via the bps interface (graphic or text mode), by setting the simulation toggle 'Solar radiation data' to half-hour centered;
2. By inserting the line:
*slr_half_hr 1
in the .cfg file. If the *slr_half_hr flag in the .cfg file is set to zero, the solar radiation data contained in the weather file is assumed to be hour-centered (the default).

For any simulations that use CWEC weather files, the solar radiation data should be specified as half-hour centered.

Code changes

Modifications were made to the following ESP-r/HOT3000 files:

esrucom/esystem.F: The subroutine ERSYS, which reads the .cfg file, was modified. Specifically, the solar half hour flag is initialized to the default value of 0 (hour centered) and the value of the solar half hour flag is read if '*slr_half_hr' appears in the .cfg file.

esrubps/simcon.F (and esrubld/simcon.F): The subroutine SIMTOG, which sets the simulation toggles within bps, was modified. Specifically, the 'solar radiation data' item was added to the simulation toggles menu. If the 'solar radiation data' item is selected, users are prompted to enter the value of the solar half hour flag.

esrubld/blibsv.F: The subroutine MZLS2, which writes the simulation control information to res, was modified. Specifically, the solar half hour flag is added as an item that is written to the res library.

esrubld/climi.F: The subroutines MZCLMP and MZCLMPT were modified. These subroutines are called by MZCLMI and prepare climatic information for interpolation. MZCLMPT is called (versus MZCLMP) if there are any temporal definition flags defined. The modifications made to the two subroutines include code to verify the value of the solar half hour flag. If the value is 1 (meaning the solar data in the weather file is half-hour centered), then the diffuse solar and direct solar irradiance at a given hour is the average of the value at the previous hour and the value at the next hour.

esrubld/bmatsv.F (and esrubps/bmatsv.F, esruplt/pmatsv.F): The main controller subroutine for the numberical simulation, MZNUMA, was modified. Specifically, the solar radiation data for the second hour of the future day is stored in COMMON variables. This information is needed for the averaging that is done in MZCLMP or MZCLMPT when the solar radiation half hour flag is equal to 1.

esrures/resdef.F: The subroutine MORESS, which assigns a user-defined result set in res, was modified. Specifically, the solar radiation half hour flag is added to the header information that is displayed when the result set is opened in res.

esrures/moclim.F: The subroutine MOCLIM which sets up the climatic parameters in res, was modified. Specifically, if the value of the solar radiation half hour flag is 1 (meaning the solar data in the weather file is half-hour centered), then the diffuse solar and direct solar irradiance at a given hour is the average of the value at the previous hour and the value at the next hour.

Impact on results

Simulations were performed with two test cases (ccht_basic and ccht_detailed) to determine the impact on the annual heating and cooling loads when the CWEC weather data is specified as half-hour centered. Both test cases use the CWEC weather file for Ottawa, Ontario. Table 1 presents the simulation results.

Specifying that the solar radiation data in the weather file is half-hour centered leads to a considerable impact on the predicted annual heating loads and cooling loads for the two test cases considered. Specifically, there is a decrease in the predicted annual heating load of 1-2% and an increase in the predicted annual cooling load of 3-6%. The solar radiation

data should be treated as half-hour centered (i.e. the solar radiation half hour flag should be set to 1) for all simulations using CWEC weather data.

Table 1. Simulation results for two test cases.

Time step averaging off						
Test case	Hour centered		Half-hour centered		**Percent difference**	
	Annual heating load (kWh)	Annual cooling load (kWh)	Annual heating load (kWh)	Annual cooling load (kWh)	**Annual heating load (%)**	**Annual cooling load (%)**
ccht_basic	15122.51	3963.3	14944.16	4096.26	**-1.2**	**3.4**
ccht_detailed	16257.35	4913.79	15953.61	5210.13	**-1.9**	**6**
Time step averaging on						
Test case	Hour centered		Half-hour centered		**Percent difference**	
	Annual heating load (kWh)	Annual cooling load (kWh)	Annual heating load (kWh)	Annual cooling load (kWh)	**Annual heating load (%)**	**Annual cooling load (%)**
ccht_basic	15122.26	3963.30	14943.92	4096.26	**-1.2**	**3.4**
ccht_detailed	16257.07	4913.79	15953.34	5210.13	**-1.9**	**6**

References

Thevenard, D. (2004), 'Literature Review and Source Code Review of ESP-r's Existing Photovoltaic (PV) Models', Internal Report, CETC-Ottawa, Natural Resources Canada.