TYPE 686: SYNTHETIC BUILDING LOADS GENERATOR

General Description

This component will generate hourly heating and cooling loads for a synthetic building based on user-defined peak heating and cooling loads and modifying sine-wave functions used to account for seasonal variations, time-of-day variations and weekday/weekend differences. The user may also have the model generate some random noise on both an hourly basis and a daily basis to more realistically model real building loads. This component is an excellent first choice for simulations requiring heating and cooling loads for commercial, industrial, and residential buildings. The model represents a quick method of providing realistic loads without the time-intensive modeling required of a real building.

Nomenclature

Load	[kJ/h]	The heating or cooling load as a function of time.
DesignLoad	[kJ/h]	The design heating or cooling load (Parameters 22 and 23).
X_{day}	[-]	Modifying function for seasonal variations in the loads.
X_{hour}	[-]	Modifying function for hourly variations in the loads
$X_{noise,hour}$	[-]	Modifying function for hourly noise in the calculated loads.
$X_{noise,day}$	[-]	Modifying function for daily noise in the calculated loads.
a_{season}	[-]	Offset for season (Parameter 16 or 18).
b_{season}	[-]	Multiplier for season (Parameter 17 or 19).
TIME	[h]	The current simulation time.
StartOfSeason	[h]	The hour of the year at which the specified season begins (Parameter 4 or 6).
EndOfSeason	[h]	The hour of the year at which the specified season ends (Parameter 5 or 7).
a_{day}	[-]	Offset for daily load variation (Parameter 8 or 10 or 12 or 14).
b_{day}	[-]	Multiplier for daily load variation (Parameter 9 or 11 or 13 or 15).
PeakHour	[h]	The hour of the day at which the peak load occurs (Parameter 2 or 3).

Detailed Description

1. Mathematical Description

The hourly heating and cooling loads for a building are defined in this method as:

$$Load = DesignLoad * X_{day} * X_{hour} * X_{noise,hour} * X_{noise,day} \quad \text{(Eq. 686.1)}$$

2. Seasonal Variations

The model allows the heating and cooling loads to vary throughout the heating and cooling season by use of a modifying SIN wave function. The user must enter the start and stop times of the heating and cooling seasons and offset and multiplier parameters for the SIN function. The formulation of the function depends on whether the season crosses over the first day of the year or whether the season is completely contained within one year. For the case where the season crosses the annual boundary, two

functions are needed; 1 for the time of the year from the start of the year to the end of the season and 1 for the time of the year from the start of the season to the end of the year. There are no heating loads during the non-heating season and no cooling loads during the non-cooling season.

Season contained within a year:

$$X_{day} = a_{season} + b_{season} \sin\left(180\left(\frac{TIME - StartOfSeason}{EndOfSeason - StartOfSeason}\right)\right) \qquad \text{(Eq. 686.2)}$$

Season crosses annual boundary (Time from Start of Year to End of Season) :

$$X_{day} = a_{season} + b_{season} \sin\left(180\left(\frac{TIME - StartOfSeason}{8760 + EndOfSeason - StartOfSeason}\right)\right) \qquad \text{(Eq. 686.3)}$$

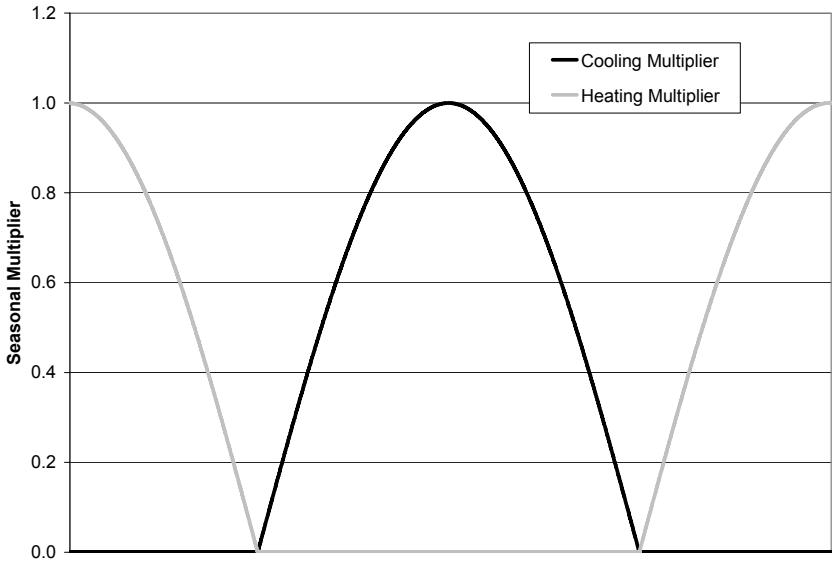
Season crosses annual boundary (Time from Start of Year to End of Season) :

$$X_{day} = a_{season} + b_{season} \sin\left(180\left(\frac{EndOfSeason - TIME}{8760 + EndOfSeason - StartOfSeason}\right)\right) \qquad \text{(Eq. 686.4)}$$

Several examples are shown below to illustrate the use of the seasonal variations for this model. The examples show the variation of the normalized peak daily loads as a function of time for a period of 1 year.

Case 1: Typical Heating and Cooling Seasons where Heating Ends on April 1st (and Cooling Begins) and Cooling Ends on October 1st (and Heating Begins). This situation may represent a residential or light commercial building.

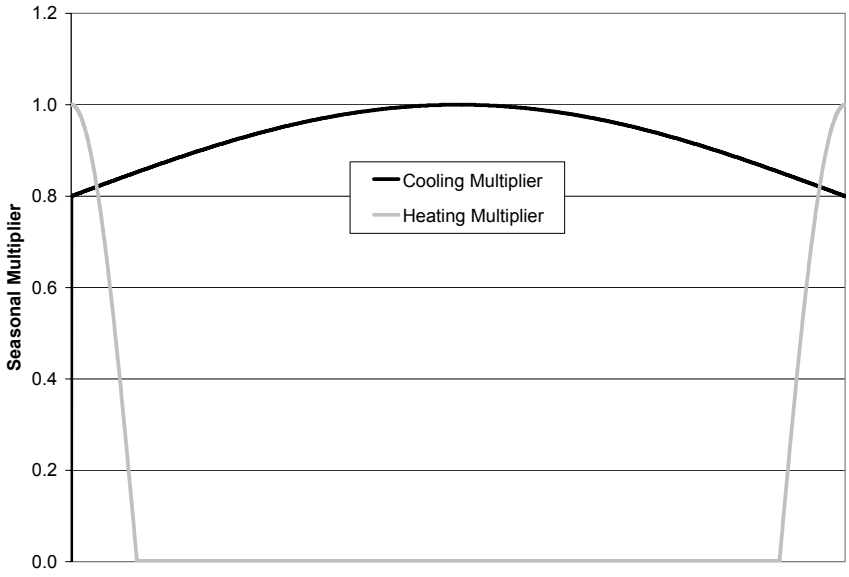
Parameter 4 = 2160
Parameter 5 = 6552
Parameter 6 = 6552
Parameter 7 = 2160
Parameter 16 = 0.0
Parameter 17 = 1.0
Parameter 18 = 0.0
Parameter 19 = 1.0



Notice how the peak loads will vary with time throughout the year with these parameters; peaking during the middle of the season and dropping off to zero at the crossover times.

Case 2: Typical Heating Season (April 1st to October 1st) but a year-long cooling season that varies very little with the time of year. This situation may represent an industrial plant with high internal heat loads.

Parameter 4 = 0
Parameter 5 = 8760
Parameter 6 = 8016
Parameter 7 = 744
Parameter 16 = 0.8
Parameter 17 = 0.2
Parameter 18 = 0.0
Parameter 19 = 1.0



3. Hourly Variations

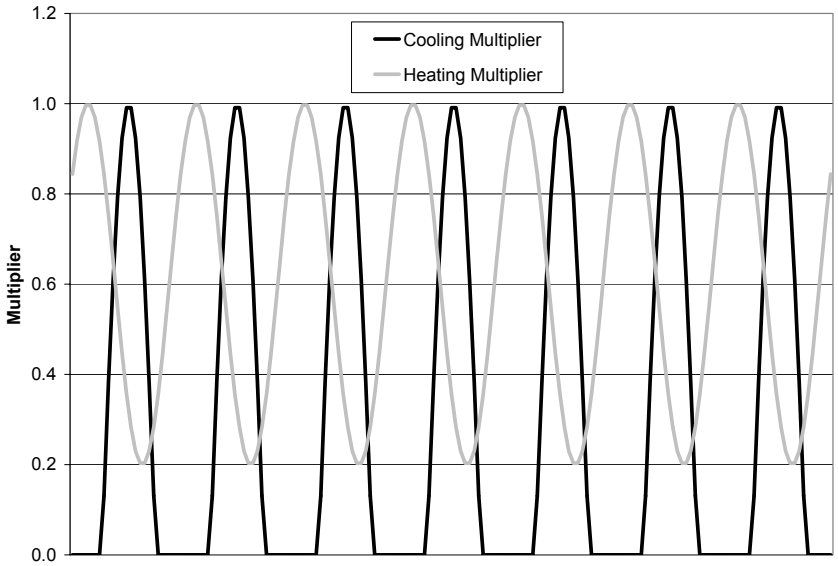
The model allows the heating and cooling loads to vary throughout the day by use of a modifying SIN wave function. The user must enter the times of the peak daily heating and cooling loads and offset and multiplier parameters for the SIN function for both weekday and weekend operation.

$$X_{hour} = a_{day} + b_{day} \sin\left(-180\frac{TIME}{12} + \frac{180(PeakHour - 18)}{12}\right) \qquad \text{(Eq. 686.5)}$$

Several examples are shown below to illustrate the use of the hourly variations for this model. The examples show the variation of the daily loads as a function of time for a period of 1 week.

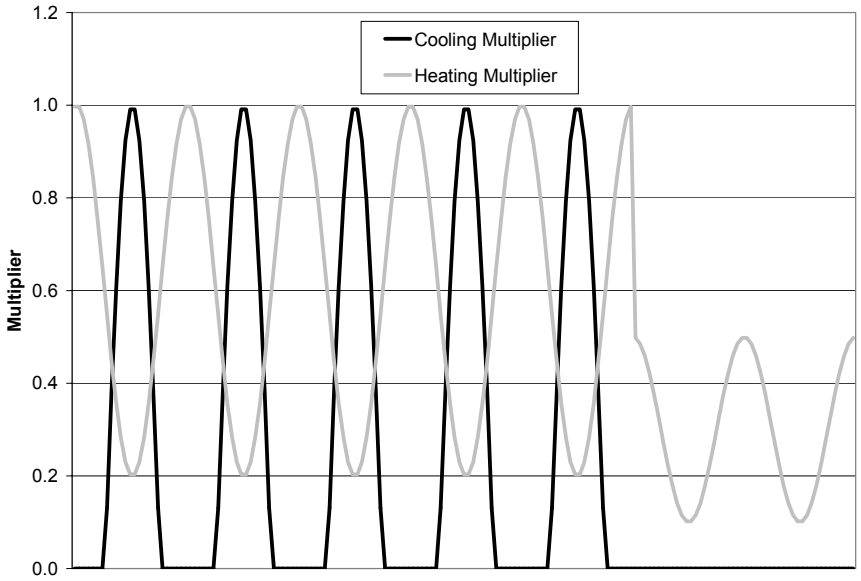
Case 3: Residential building where heating is enabled and on for the entire day (peak at 3 am) and where cooling occurs primarily during day-time hours with a peak at noon. Weekdays are similar to weekends.

Parameter 2 = 12.0
Parameter 3 = 3.0
Parameter 8 = 0.0
Parameter 9 = 1.0
Parameter 10 = 0.0
Parameter 11 = 1.0
Parameter 12 = 0.6
Parameter 13 = 0.4
Parameter 14 = 0.6
Parameter 15 = 0.4



Case 4: Commercial building where weekday heating is enabled and on for the entire day (peak at midnight) and where weekday cooling occurs primarily during day-time hours with a peak at noon. On weekends, there is no cooling and the heating setpoints are reduced; resulting in lower heating loads.

Parameter 2 = 12.0
Parameter 3 = 0.0
Parameter 8 = 0.0
Parameter 9 = 1.0
Parameter 10 = 0.0
Parameter 11 = 0.0
Parameter 12 = 0.6
Parameter 13 = 0.4
Parameter 14 = 0.3
Parameter 15 = 0.2



4. Hourly Noise

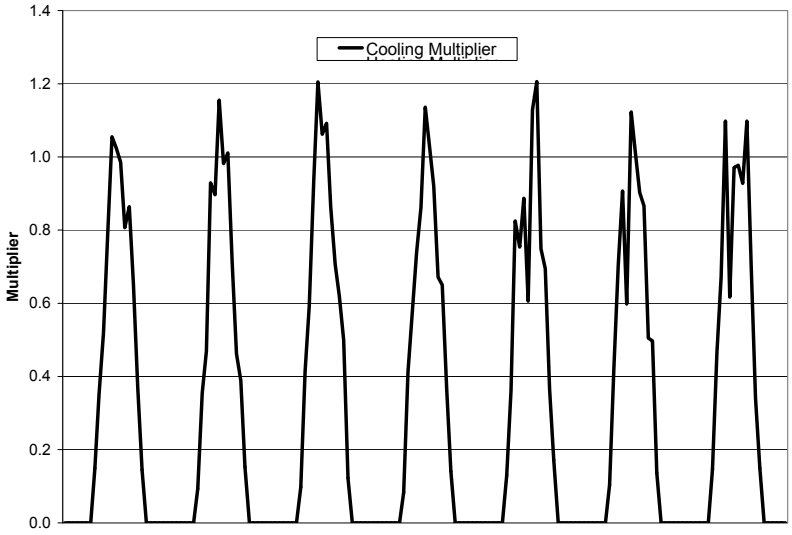
The model allows the user to add "noise" to the calculated hourly heating and cooling loads; thereby making the calculated loads look more like those observed in real building. The "noise" is drawn from a random number generator with a normal statistical distribution. The hourly "noise" can mimic the load changes seen in real buildings due to occupancy or internal heat and moisture generation changes.

The calculated "noise" is added to the heating and cooling loads with opposite effect; a value of "noise" that increases the cooling load will decrease the heating load in the same proportion.

An example is shown below to illustrate the use of the hourly noise multiplier.

Case 5: Cooling loads identical to those calculated and shown in Case 3, but with a 20% standard deviation on an hourly basis; same parameters as Case 3 except

Parameter 21 = 0.2



Notice that by adding noise to our loads, the peak daily multiplier has risen from 1.0 to greater than 1.2 for this week.

5. Daily Noise

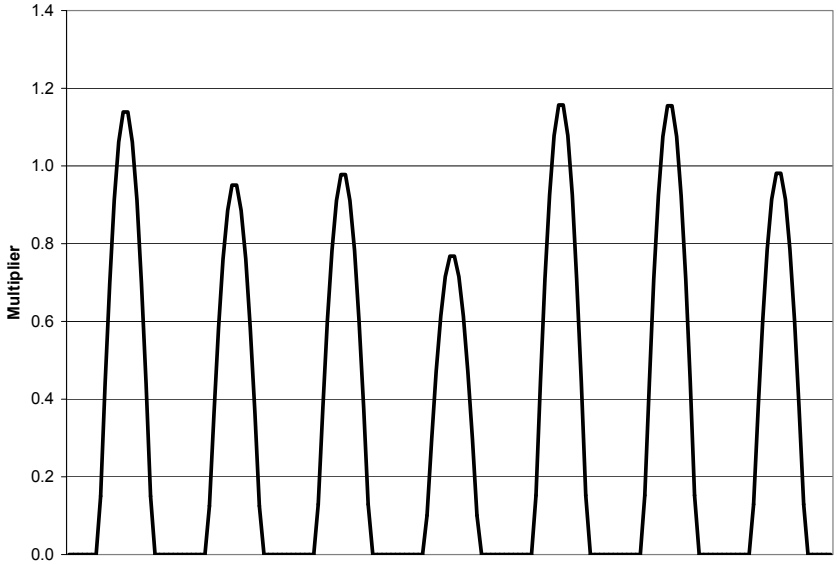
The model allows the user to add "noise" to the calculated daily heating and cooling loads; thereby making the calculated loads look more like those observed in real building. The "noise" is drawn from a random number generator with a normal statistical distribution. The daily "noise" can mimic the load changes seen in real buildings due to changes in the ambient conditions on a daily basis.

The calculated "noise" is added to the heating and cooling loads with opposite effect; a value of "noise" that increases the cooling load will decrease the heating load in the same proportion.

An example is shown below to illustrate the use of the hourly noise multiplier.

Case 6: Cooling loads identical to those calculated and shown in Case 3, but with a 20% standard deviation on an daily basis; same parameters as Case 3 except

Parameter 20 = 0.2



Notice that by adding noise to our loads, the peak daily multiplier has risen from 1.0 to greater than 1.2 for this week.

Important Note:

While the model asks for a design heating and cooling load for this synthetic building, the actual peak heating and cooling load may be higher than that specified. Hourly and daily noise can cause the peak condition to be exceeded as well as the choice of offset and multiplier parameters for the seasonal and daily variations of the load. For most applications of this model, the offset plus multiplier terms for a particular period should equal 1.0. This will guarantee that in the absence of noise, the calculated peak conditions will match those specified. For example, the offset and multiplier parameters for the weekday heating load could be 0.6 and 0.4 respectively. In this case, the peak weekday heating load would be the specified parameter value while the minimum heating load would be 20% of the specified design load (if the seasonal effects are also set for a peak condition of 1.0).

Example

Type686 is used in an example that can be found in:
" ..\trnsys16\TESS Models\Studio Projects\Loads and Structures Library\Synthetic Building.tpf"