HAMBASE

Part II Input and Output

Heat Air and Moisture model for Building And Systems Evaluation

Martin de Wit

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1 General structure of Hambase

![Diagram of Hambase structure]

Fig. 1-1 m-files of Hambase
In figure 1.1 the m-files of Hambase of given:

- **Input.** This is the standard input of Hambase with data for the building, the HVAC-installation, the building use and the exterior climate-file and calculation period (Chapter 2)

- **Inputextra.** With this input default values can be changed and advanced options can be used (Chapter 3). Hambase can run without Inputextra. With the function inextradaylf the daylightfactor on a horizontal cross-section of a shoebox shaped room is calculated and drawn and with the function inextraairflwi the properties of an airflow window that can be used in Hambase are calculated.

The input is stored completely in a structured array BAS (type BAS in the command window and you will see the input files). If you will keep the input save input and inputextra with an unique name.

- **Bastrans.** With this m-file the input BAS is checked on missing or wrong data and warning and error messages are given. Moreover the files are transformed (e.g. arrays are renumbered to make them smaller) and stored in 5 different structured arrays: Meteo (meteodata for the calculation period), Building (data regarding the building), Elan (data regarding the thermal and hygric electric network model), Control (all controls), Profiles (the use of the building) (Chapter 4).

In matpropf material properties of many materials are stored. If the one needed is not in there the properties of the material can be added. In Bastransbuilding and btwallsrc the transfer function coefficients and components of the electric network are calculated. In Bastransshadowfac the shadowed fraction of a window for sunshine coming from each small element of the discretized sky is calculated. Drawings of the environment and obstructed sky elements can be made with brshaddraw. This is helpful to check whether the input is correct. In Bastransshadow the shadow factors are combined with the dependance of glazing transmittance on the incident angle of the radiation.

In Bastranswhc and btwhcrespfac the transfer function coefficients for wall heating(e.g. floor heating) are calculated.
- **Hambasex.** The output is calculated with Hambasex using Hambasexinit and Hambasexupdate, hbuprad (solar radiation calculation) and Hambasexwhc (for wall heating). The zone equations are solved with an hourly timestep.

- **Hamoutput.** In this m-file the files Output, Control and Elan are used to make plots.

- **Hambasesimulink** If Simulink is used the clear all command and the removal of the figures at the beginning of the input cannot be used. The zone equations are solved by Simulink so Hambasex is not needed. Instead the S-function Hambasesimulink is needed (see figure 1.1). Wall heating is not yet an option in the Simulink calculation so only Hambasexinit, Hambasexupdate and hbuprad are needed.

The number of zones is not limited but grouping of rooms with about the same indoor climate into one zone can save time without losing much of the accuracy.

If different variants are used of the same building the calculation can be done with only one input file. There are two ways:

- Making a loop around this input so: for k=1:n ...input with one or more variable(s) that depend on k...end. n=number of variants.

The second way is considering all variants as one building that has no interzonal walls between the variants. This is probably quicker and has the advantage that plots can be made with the results of the variants.
Fig 1-2 Input variables
2 The standard input

2.1 The calculation period and meteo data.

2.1.1 Period

Default the available climate data of De Bilt of the years 1971 till now are used. A more or less average year runs from 1 May 1974 till 30 April 1975.
A cold Dutch winter (242 days) started 1 September 1978. A hot Dutch summer (123 days) started 1 May 1976 9 hot days started at 1 July 1976 and 9 cold days started at 30 Dec. 1978.

BAS.Period = [yr, month, day, ndays]

yr = start year, month = start month, day = start day, ndays = number of days simulated
So if the calculation starts 1 Jan 1971 and ndays=10,000 then more than 27 years are simulated. For other locations than De Bilt see below.

2.1.2 Meteo data and station

For other locations than De Bilt yr = -1. A meteofile ('Meteofile'.dat) of hourly weather data is needed and some data of the location. BAS.station = [latitude, longitude (east is negative), time zone (east is negative), albedo of the site].
The file 'Meteofile'.dat must start at 1 January 0h. and should have at maximum 365 days. A longer period than 365 days can be simulated but then the year is repeated. In leap years the last day is used twice.
'Meteofile'(1:365*24, 1:8) = [year, Diffuse solar radiation [W/m²], 10*exterior air temperature, Direct solar radiation (plane normal to the direction) [W/m²], cloud cover(1...8), 100*relative humidity outside, 10*wind velocity; wind direction (degrees north)]. Hourly meteofiles of an average year can be generated with the program: METEONORM

Table 1 Albedo

<table>
<thead>
<tr>
<th>Site</th>
<th>albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry soil</td>
<td>0.25 – 0.30</td>
</tr>
<tr>
<td>wet soil</td>
<td>0.10 – 0.12</td>
</tr>
<tr>
<td>grass (long)</td>
<td>0.18 – 0.20</td>
</tr>
<tr>
<td>grass (dry)</td>
<td>0.19</td>
</tr>
<tr>
<td>Snow</td>
<td>0.20 – 0.98*</td>
</tr>
<tr>
<td>asphalt</td>
<td>0.10</td>
</tr>
<tr>
<td>Concrete</td>
<td>0.33</td>
</tr>
<tr>
<td>Grey stone</td>
<td>0.20</td>
</tr>
<tr>
<td>Red stone</td>
<td>0.44</td>
</tr>
</tbody>
</table>

* 0.98 for fresh snow and 0.2 for old, dirty snow.

If no infiltration calculation is made wind velocity and direction are not needed. If data of longwave atmospheric radiation are available they can be inserted. 'Meteofile'(1:365*24, 9): Blackbody radiation with air temperature minus the radiation from the atmosphere on a horizontal surface (W/m²) (\(\sigma T^4_{a} - L_{atmos}\)). This is a positive value and small for clouded skies. 'Meteofile'(1:365*24, 10): Blackbody radiation with air temperature minus the radiation from horizontal surface of the ground (W/m²) (\(\sigma T^4_{a} - L_{ground}\)). If these values are not known they are estimated: column 9 is with the cloud cover and air temperature and column 10 is assumed to be zero. This is calculated in Bastrans below atmos==0. This is not accurate and measured data are preferred.

Example
BAS.Period = [-1, 1, 1, 370];
The default station coordinates of De Bilt-The Netherlands (BAS.station = [52.1, -5, 1, -1, 0, 2]) can be changed in Inputextra.m e.g. to avoid the limitation of 365 days (see above). In that case the meteofile must have a similar name as the meteo mat-files of De Bilt. These names start with mt followed by the year, e.g. mt1995.mat. The format is: [Diffuse solar radiation [W/m²], 10*exterior air temperature, Direct solar radiation (plane normal to the direction)[W/m²], 10*wind velocity; wind direction (degrees north], 100*relative humidity outside, column7, column8 ,cloud cover(1...8)].

2.1.3 Daylight savings time

If BAS.DSTime = 1 the EU daylight-savings time is taken into account. It starts on the last Sunday of March and ends on the last Sunday of October (the total duration is 30 or 31 weeks). Without a daylight-savings period BAS.DSTime = 0. If the daylight-savings period is different from the EU the starting and ending day must be given:

BAS.DSTime(1, :) = [year, starting month, day, ending month, day];
BAS.DSTime(2, :) = [year+1, starting month, day, ending month, day]; etc.

2.2 The building

2.2.1 Zone-numbers & volumes

A zone consists of one room or several adjacent rooms with about the same temperature and relative humidity and the same climate control e.g. a dwelling might have three zones: the ground floor (living room etc), the first floor
(sleeping) and the attic (not heated). There is no limit in number of zones that can be simulated. All zones get a zone number (zoneNo).

Example: 3 zones: BAS.Vol{1} = …; BAS.Vol{2} = …; BAS.Vol{3} = …; If alone zone with number 2 (zone2): define only BAS.Vol{2}. The air mass in the zone is 1.2*volume. If the density is very different from 1.2 kg/m³ e.g. at a high altitude location, the volume should be corrected to get the correct air mass (lower density is corrected by a lower volume).

BAS.Vol{zoneNo} = volume \([m^3]\);

### 2.2.2 Construction components

The construction components defined here are the different walls, doors, floors and roofs, but not the glazing systems in the envelope. The construction component usually consists of different layers. The order of the input of the properties of these layers is standard from indoors to outdoors. The material properties of the component layer are inserted by a material ID-number. By typing 'help matpropf' a list of materials appears with a material ID-number.

Example:

```
help matpropf
```

```
matID Material     Lambda Rho C Eps Mu Ksi bv.10^7source
……     …………………………………………………………………………..
422    mineral wool    0.04 60 850 0.9 1.3 1 0 annex41
423    Fiberglass quilt 0.04  12  840 0.9 1.3 2.6 annex41
```

The function `matpropf(d,matID)` with \(d=\) layer thickness returns a vector matprop. matprop = \([\text{thickness, heat conductivity, density, heat capacity, emissivity, diffusion resistance factor, vapour capacity} \times 10^7\) or \([d, \lambda, \rho, C, \epsilon, \mu, \kappa, \text{bv.} \times 10^7\). In case of an air cavity (matID = 2 or 3 or 4) the heat conductivity is calculated with \(\lambda = \text{thickness}/R_{cav}\).

BAS.Con\{conID\} = [Ri, d1, matID,..., dn, matID, Re, ab, eps];
\[ d_1 \ldots d_n = \text{material layer thickness [m]}, \]
\[ \text{matID} = \text{material ID-number}, \]
\[ R_i = \text{internal surface heat transfer resistance} \]
\[ R_e = \text{surface heat transfer resistance at the opposite site} \]
\[ a_b = \text{external solar radiation absorption coefficient} \]
\[ \varepsilon = \text{external longwave emissivity [-]} \]

E.g. \( R_i = 0.13 \text{ [Km }^2/\text{W}] ); \( R_e = 0.04 \text{ [Km }^2/\text{W}] \); light colour: \( a_b = 0.4 \); dark colour: \( a_b = 0.9 \); \( \varepsilon = 0.9 \).

The U-value of a door without translucent parts and including the frame is about 3.4 W/m\(^2\)K. A door with insulation is about 2 W/m\(^2\)K.

### 2.2.3 Glazing system data

The solar gain factor of glazing depends on the incident angle of the solar radiation. The properties below are independent of this angle but if one wants to account for the incident angle this can be done (see inputextra, glazingtransmittance). In that case the solar gain factor at normal incidence should be inserted here. Each different glazing system gets an ID-number: glaID = 1, 2,..

\[ \text{BAS.Glas}\{\text{glaID}\} = \{U_{\text{glas}}, CFr, ZTA, ZTAw, CFrw, U_{\text{glasw}}\}; \]
\[ U_{\text{glas}} = \text{U-value without sun blinds [W/m}^2\text{K]}, \]
\[ CFr = \text{convection factor without sun blinds [-]}, \]
\[ ZTA = \text{Solar gain factor [-] without sun blinds}, \]
\[ ZTAw = \text{Solar gain factor [-] with sun blinds}, \]
\[ CFrw = \text{convection factor with sun blinds [-]}, \]
\[ U_{\text{glasw}} = \text{U-value with sun blinds [W/m}^2\text{K]}. \]

Examples

Single glazing with interior sun blinds (light transmission 0.88/0.14)
\[ \text{BAS.Glas}\{1\} = [6.5-5.7, 0.01, 0.83, 0.48-0.42, 0.48-0.35, 6.2-5.7]; \]
Single glazing with exterior sun blinds (light transmission 0.88/0.10)
BAS.Glas\{2\} = [6.5-5.7, 0.01, 0.83, 0.16-0.19, 0.07-0.12, 5.3-4.9];
Double glazing with interior blinds (light transmission 0.74/0.12-0.30)
BAS.Glas\{3\} = [3.4, 0.04, 0.70, 0.49, 0.54, 3.3];
Double glazing with exterior blinds (light transmission 0.74/0.08-0.17)
BAS.Glas\{4\} = [3.4, 0.04, 0.70, 0.14, 0.07, 2.9];
HR glazing with interior blinds (light transmission 0.74/0.12-0.30)
BAS.Glas\{5\} = [1.8, 0.05, 0.66, 0.42, 0.19, 1.5];
HR glazing with exterior blinds
BAS.Glas\{6\} = [1.8, 0.05, 0.66, 0.16-0.18, 0.09-0.13, 1.6-1.5];
HR glazing with interior blinds (2)
BAS.Glas\{7\} = [1.4, 0.03, 0.65, 0.30, 0.40, 1.4];
Saint-Roch skn 165
BAS.Glas\{8\} = [1.309, 0.047, 0.308, 0.072, 0.116, 1.253];
The window frame can be included i.e. instead of glazing surface the window surface with frame is needed and a modified U-value. A wooden or plastic frame has a U-value of 2.4W/m²K, a metal one with a thermal break about 3.8W/m²K and without the break about 7W/m²K.

2.2.4 Orientations

For each surface of the building envelope (exterior walls) the tilt and the orientation (azimuth) with respect to the south has to be known. Each different orientation gets a different orientation-number: orNo.

BAS.Or\{orNo\} = [tilt, azimuth];
Tilt:  vertical = 90, horizontal = 0;
Azimuth: east = -90, west = 90, south = 0, north = 180.
If in Inputextra shadow for a horizontal window is defined the azimuth of the horizontal window here is the orientation for which in the shadow definition the azimuth equals zero.
2.2.5  Building components (introduction)

A building is an assembly of different construction components and windows. The input is about the type, size and place in the building of these different components (for convenience called walls and windows). The walls are divided into 4 walltypes:
I Constructions separating a zone from the exterior climate: External walls (walltype=-1):
II Constructions separating a zone from an environment with a constant temperature e.g. the ground: Constant temperature walls (walltype=0):
III Constructions separating a zone from an environment with the same conditions: Adiabatic external walls (walltype=-2):
IV Constructions between and in zones: Internal walls (walltype=1):
For external walls and constant temperature walls the heat loss by thermal bridges can be accounted for if the steady state heat loss in Watt per 1K temperature difference across these bridges is known. These values can be obtained by thermal bridge software or approximate methods. Use '0' if not known.
Windows are only possible in external walls. If not, they have to be treated as an opaque construction (e.g. a door)

2.2.6  External walls

For each wall number exNo = 1, 2,...
BAS.wallex{exNo} = [zoneNo, surf, conID, orNo, bridge];
zoneNo= select zonenumber from zones section,
surf = total surface [m²] the windows surface area is included,
conID = select construction ID-number from constructions section,
orNo = select orientation number from orientations section,
bridge = the heat loss in W/K of the thermal bridges (0 if not known)
2.2.7 Windows in external walls

Each external wall can have one or more windows. The surface area is the area of the transparent part. If the surface is curved the effective area for solar radiation transmittance is needed. The U-value must be increased in such a way that the heat loss per 1K temperature difference equals the one for the curved glazing, e.g. a glazed dome in a flat roof has an orientation with tilt = 0, surface area $\pi r^2$ and U-value $U_{\text{glazing}} \times 2 \times \pi r^2 / \pi r^2$.

If a wall has 100% glazing use an external wall that is slightly larger than the window area. Each window gets a number $\text{winNo} = 1, 2, \ldots$

```
BAS.window{ winNo } = [exNo, surf, glaID, shaNo];
exNo  = select external wall number from external walls section,
surf   = surface area of the glazing [m²],
glaID = select glass ID-number from glazing section
shaNo = select number of shadow from shadow section. This section is located in the m-file Inputextra, no shadow: shaNo = 0.
```

2.2.8 Constant temperature walls

Each constant temperature wall gets a number: $i0No = 1, 2, \ldots$

```
BAS.walli0{i0No} = [zoneNo, surf, conID, temp, bridge];
zoneNo = select zone number from zones section,
surf = total surface area [m²]
conID  = select construction ID-number from construction section,
temp  = constant temperature [°C], e.g. ground = '10',
bridge = the heat loss in W/K of the thermal bridges (0 if unknown).
```

2.2.9 Adiabatic external walls

Each adiabatic wall gets a number: $iaNo = 1, 2, \ldots$

```
BAS.wallia{iaNo} = [zoneNo, surf, conID];
```
zoneNo = select zone number from zones section,
surf = total surface area in m$^2$,
conID = select construction ID-number from constructions section

2.2.10 Internal walls

All different internal walls get a different number: inNo. If there are 3 different walls (or floors) between zone1 and zone2 the input is BAS.wallin{1} = [1, 2,...] through BAS.wallin{3} = [1, 2,...]. If the 4th construction is completely in zone2 the input is consequently: BAS.wallin{4} = [2, 2,... ]
The first layer (R_i) of the construction component is in the zone that is defined in the first column. If instead BAS.wallin{3} = [2, 1,...] is used the construction is reversed and R_i is in zone2. The surface area is the surface area of one side of the wall, also for walls that are completely in the same zone.

BAS.wallin{inNo} = [zone1, zone2, surf, conID];
zone1 = select zone number from zones section
zone2 = select zone number from zones section
surf = total surface area [m$^2$]
conID = select construction number from constructions section.

2.3 Profiles for casual gains, ventilation and controls

2.3.1 Profiles types

Profiles are related to the use of a zone: office, living room, school etc. Each day of a week can have a different profile e.g. weekends are different. Below the profiles are defined and given an ID-number; proID.
For each day up to 24 different periods can be defined with different data. period1: start time = hrnr1 and end time = hrnr2; period2: start time = hrnr2 and end time = hrnr3; last period: the hours that are left on the same day. For example
[1, 8, 18] means period1: 1h till 8h, period2: 8h till 18h, period 3: 24h (=0h) till 1h and 18h till 24h. (3 periods are often used). The inserted hours are the clock time. The profile allows for free cooling i.e. above a certain threshold Tfc the ventilation air change rate per hour (ach) is increased from minimum to a maximum value (vvmin to vvmax: e.g. vvmax = 3*vvmin). So if vvmin = vvmax there is no free cooling.

The temperature Tfc is also used for the control of sun blinds: if the solar irradiance on the window is higher than Ers and the indoor temperature higher than Tfc the blinds will be used. This means that if there is no free cooling the temperature Tfc is still necessary for the control of sun blinds.

Ers is the same for all zones. A number often encountered for manual control Ers = 300W/m². If the control is automatic it is somewhat lower: Ers= 250W/m²

BAS.Ers{proID} = irradiance level for sun blinds [W/m2]
BAS.dayper{proID} = [hrnr1, hrnr2, hrnr3], the starting time of a new period
BAS.vvmin{proID} = [. . . ], the ach [1/hr] for each period
BAS.vvmax{proID} = [. . . ], the maximum ach [1/hr] in case of free cooling
BAS.Tfc{proID} = [. . . ], threshold [°C] for free cooling for each period
BAS.Tsetmin{proID} = [. . . ], setpoint [°C] switch for heating, (in case of no heating choose -100)
BAS.Tsetmax{proID} = [. . . ], setpoint [°C] switch for cooling, (in case of no cooling choose 100)
BAS.Qint{proID} = [. . . ], casual heat gains [W]
BAS.Gint{proID} = [. . . ], water vapour sources [kg/s]
BAS.RVmin{proID} = [. . . ], setpoint relative humidity [%] switch humidification, (in case of no humidification choose -1)
BAS.RVmax{proID} = [. . . ], setpoint relative humidity [%] switch dehumidification, (in case of no dehumidification choose 101)

Casual heat gains W/m² floor
office: 4.865   school: 3.95   hospital: 13.80
factory: 5.75   general room (not dwelling): 2.00   warehouse: 2.50
railway station: 9.10  pub/restaurant: 7.00  meeting room: 3.60
hotel: 11.30  prison: 14.30  sports: 3.75

Casual gains in dwellings:
Living: 7.00-17.00h: 25W,  17.00-23.00h: 100W
Kitchen: 7.00-17.00h: 250W, 17.00-19.00h: 600W, 19.00-23.00h: 250W

clo value persons (1clo=0.155Km²/W):
male summer: 0.5/0.6clo , normal (business suit): 1clo
female: 0.3/0.4 , normal (dress): 0.7

<table>
<thead>
<tr>
<th>clothing</th>
<th>0.4 clo</th>
<th>0.6 clo</th>
<th>0.8 clo</th>
<th>1clo</th>
</tr>
</thead>
<tbody>
<tr>
<td>seated, at rest (M=85W/m²)</td>
<td>90 W</td>
<td>80 W</td>
<td>75 W</td>
<td>70 W</td>
</tr>
<tr>
<td>seated (M=130W/m²):</td>
<td>100 W</td>
<td>90 W</td>
<td>85 W</td>
<td>80 W</td>
</tr>
<tr>
<td>standing (M=160W/m²):</td>
<td>110 W</td>
<td>100 W</td>
<td>95 W</td>
<td>90 W</td>
</tr>
<tr>
<td>seated light work (M=210W/m²)</td>
<td>115 W</td>
<td>105 W</td>
<td>100 W</td>
<td>95 W</td>
</tr>
<tr>
<td>standing light work (M=300W/m²)</td>
<td>150 W</td>
<td>140 W</td>
<td>130 W</td>
<td>120 W</td>
</tr>
</tbody>
</table>

moisture production G=0.4e-6*(M-phi) kg/s, phi=sensible heat, M=metabolism
children <2y, awake: 30gr/h, asleep: 10gr/h,
children 10 to13, awake: 45gr/h, asleep: 15gr/h
seated, at rest: 50 gr/h asleep: 30 gr/h
light activity: 30-60 gr/h
seated, very light work: 70gr/h
seated, moderately active or standing, light work, walking: 90gr/h
walking, standing: 110 gr/h
medium work: 120-200 gr/h
seated, light work: 200 gr/h
moderate dancing: 240gr/h
walking briskly with loads: 270 gr/h
hard work: 200-300 gr/h
light exercises: 380 gr/h
heavy work with lifting: 420 gr/h
athletics: 470 gr/h
bath: about 700gr/h, 15min 60gr
shower: about 2600 gr/h, 15 min 660 gr
breakfast preparation (4 p): 160 to 270gr ,dishes 100
lunch preparation (4 p): 250to 320gr ,dishes 70 gr
dinner preparation (4 p): 550to 720gr ,dishes 310gr
cooking and working: 600-1500 gr/h
non-vented cloth drier: 2130 to 2900 gr

Table 4 Typical moisture production (gr/h) for a family of 2 persons (4320gr/day) and one of 4 persons(13680 gr/day)

<table>
<thead>
<tr>
<th>time</th>
<th>1-5</th>
<th>6-7</th>
<th>8-9</th>
<th>10</th>
<th>11-12</th>
<th>13-14</th>
<th>15-17</th>
<th>18</th>
<th>19-20</th>
<th>21-24</th>
</tr>
</thead>
<tbody>
<tr>
<td>2pers</td>
<td>120</td>
<td>720</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>120</td>
<td>840</td>
<td>120</td>
</tr>
<tr>
<td>4pers</td>
<td>240</td>
<td>1440</td>
<td>240</td>
<td>960</td>
<td>1440</td>
<td>720</td>
<td>240</td>
<td>240</td>
<td>960</td>
<td>240</td>
</tr>
</tbody>
</table>

2.3.2 The profiles of the building

Each day of a week can have a different profile (profile ID-number: proID.) e.g. weekends are ID-number: proID.) e.g. weekends can be different.

BAS.weekfun{zoneNo} = [pnrmon, pnrTue, pnrWed, pnrThu, pnrFri, pnrSat, pnrSun]

For each zone zone = 1….etc. select the proID-numbers for each day of the week: pnrmon = proID of Monday, pnrTue = proID of Tuesday, pnrWed, Thursday: pnrThu, Friday: pnrFri, Saturday: pnrSat, Sunday: pnrSun
2.4 Heating, cooling, humidification, dehumidification

2.4.1 Heating and cooling plant

If the maximum heating capacity (W) is known then that value can be used. If it is unknown the value '-1' means an infinite capacity. The value '-2' can be used for a reasonable estimate of the maximum heating capacity. For cooling the capacity is always needed. If there is no cooling cooling capacity=0. Cooling capacity and dehumidification are negative! For each zone:

\[ \text{BAS.Plant\{zoneNo\} = [heating capacity [W], cooling capacity [W],... humidification capacity [kg/s], dehumidification capacity [kg/s]]} \]

2.4.2 Convection factors

The simulation program treats radiant heat and convective heat differently. For each zone:

\[ \text{BAS.convfac\{zoneNo\} = [CFh CFset CFint]} \]

CFh = Convection factor of the heating system: air heating CFh = 1, radiators CFh = 0.8 floor heating CFh = 0.5, cooling usually CFh = 1

CFset = Factor that determines whether the temperature control is on the air temperature (CFset = 1), or comfort-temperature (CFset = 0.6), \( \text{Tset = CFset*Ta+(1-CFset)*Tr} \)

CFint = is the convection factor of the casual gains (usually CFint = 0.5)

2.4.3 Heat recovery

In order to apply heat recovery from ventilation air a balanced ventilation system is needed. Only a simple system is modelled:
a) the amount of air from a zone passing the heat recovery unit is equal to the amount supplied to that zone.
b) In case of heating the unit is only used when the air temperature of a zone (in
case of more zones the highest temperature) connected to a unit is higher than the outdoor temperature and lower than the temperature $T_{wws}$ (e.g. $T_{wws} = 22^\circ C$). For cooling the air temperature (in case of more zones the lowest temperature) must be lower than the outdoor temperature and higher than the temperature $T_{wwc}$. So between $T_{wws}$ and $T_{wwc}$ the unit is by-passed.

c) the heat recovery unit has a constant temperature efficiency.

In a building or combination of buildings (e.g. terraced housing) more units are possible. The units are numbered $HRUNo$. If there is just one unit $T_{wws}$ and $T_{wwc}$ are the same for all zones. The product of the efficiency and the fraction of $v_{vmin}$ of each room that is going to the heatexchanger is 'etaww'. ($etaww < 1$)

BAS.heatexch\{zoneNo\}=[etaww, $T_{wws}$, $T_{wwc}$, $HRUNo$];
3 Inputextra

3.1 Default values

3.1.1 pre-conditioning days

The number of pre-conditioning days (nin): number of extra days calculated before starting the calculation period. For heavy constructions this value should be larger.

BAS.nin=3;

3.1.2 heating system efficiency

The heating system efficiency (e.g. 72)

BAS.etainst=100;

3.1.3 density of air

The density of air (kg/m3)

BAS.rho=1.2;

3.1.4 Subdivision of an hour

No subdivision: Bas.interhour=1, Each halfhour: Bas.interhour=2. This is not yet correct (febr 2011) and so use only Bas.interhour=1
3.1.5 **Iterations per time step**

If zones are strongly linked by convection or heat transmittance (e.g. doors) iterations are necessary. If an air-to-air heat recovery unit is used that mixes air from different zones there is also a strong coupling.

\[ \text{BAS.maxuur} = \text{[iterations for thermal coupling, hygric coupling]} \]

If there are air flows between zones \( \text{BAS.maxuur} = [5,5] \); if a heat recovery unit is used without moisture recovery \( \text{BAS.maxuur} = [5,1] \); if coupling is only by heat conduction between zones \( \text{BAS.maxuur} = [2,1] \);

\[ \text{BAS.maxuur} = [5,5] \]

3.1.6 **Meteo station coordinates and meteo files**

Default station is De Bilt-The Netherlands with the files mt1971, mt1972, etc.

\[ \text{BAS.stationdef} = \text{[latitude, longitude (east is negative), time zone (east is negative), albedo of the site]} \]

De Bilt-The Netherlands: \( \text{BAS.station} = [52.1, -5.1, -1, 0.2] \);

\[ \text{Meteofile(:,2:8)=mtyear(:,[1 2 3 9 6 4 5])}; \] [Diffuse solar radiation \([\text{W/m}^2]\), 10*exterior air temperature\([\text{°C}] \), Direct solar radiation (plane normal to the direction)\([\text{W/m}^2] \), cloud cover(1...8), relative humidity outside \([\%]\), 10*wind velocity\([\text{m/s}] \); wind direction (degrees north)], \( \text{Meteofile(:,1)=year} \)
3.1.7 Thermal comfort

The operative temperature and the PPD and PMV according to ISO 7730 can be estimated for each zone if the relative velocity is given together with some data about the clothing and activity. The operative temperature is calculated as a weighted mean of air (Ta) and mean radiant temperature (Tr): 

\[ T_{\text{operative}} = C_F^{\text{oper}} \times T_a + (1 - C_F^{\text{oper}}) \times T_r \]

The value of \( C_F^{\text{oper}} \) depends on the (unknown) air velocity \( v \):
- \( v < 0.2 \text{m/s} \): \( C_F^{\text{oper}} = 0.5 \)
- \( 0.2 < v < 0.6 \text{m/s} \): \( C_F^{\text{oper}} = 0.6 \)
- \( 0.6 < v < 1 \text{m/s} \): \( C_F^{\text{oper}} = 0.7 \)

The data for each zone that are needed for the PPD and PMV:
- Relative velocity \( v \) (between 0 and 1 m/s)
- The Metabolic rate MET (between 46 and 232 W/m²) (1 met = 58.2 W/m²)
- The effective mechanical power W (W/m²)
- The clothing insulation \( I_{cl} \) (0 = nude, 0.155 m²K/W typical business suit max 0.310)

The format is:

\[ \text{BAS.Fanger\{zoneNo\}} = [C_F^{\text{oper}}, v, \text{MET}, W, I_{cl}] \]

With MET < 0, PPD and PMV will not be calculated.

For \( k = \text{zone1} \)

\[ \text{BAS.Fanger}\{k\} = [0.6, 0.2, -81, 0, 0.2] \]

end

\[ \text{BAS.Fanger}\{1\} = [0.6, 0.2, -81, 0, 0.2] \]
\[ \text{BAS.Fanger}\{2\} = [0.6, 0.2, -81, 0, 0.2] \]
\[ \text{BAS.Fanger}\{3\} = [0.6, 0.2, -81, 0, 0.2] \]

3.1.8 Surface coefficients of vapour transfer

The surface coefficients of vapour transfer are default derived from the surface coefficients for heat transfer with the Lewis relation \( Z_v = 1000/(1/R - 5*\varepsilon/0.9) \).

For the constructions with a surface coefficient very different from the default value the cellfunction BAS.Zvi\{conID\} or BAS.Zve\{conID\} has to be changed. \( Z_{vi}(\text{conID}) \) is at the side of \( R_i \) of construction with conID and \( Z_{ve}(\text{conID}) \) at the
side of $R_e$. Changing these values might be necessary if $Z_v$ is known and very
different from the default ones.

BAS.Zvi{conID} = new value
BAS.Zve{conID} = new value

Example

\[
\begin{align*}
&kCon = \text{find(cellfun('isempty',BAS.Con)==0);} \\
&\text{for } i=kCon, \\
&\quad \text{BAS.Zvi} \{i\} = 300; \quad \% (m^2/kg) \\
&\quad \text{BAS.Zve} \{i\} = 300; \\
&\text{end} \\
&\text{clear kCon}
\end{align*}
\]

3.1.9 Surface resistances of glazing systems

For the impact of longwave atmospheric radiation the emissivity and the surface
resistance at the exterior surface of a glazing system must be known. Moreover
for the estimation of the fraction of solar radiation that entered the zone but is
reflected back through the windows the interior surface coefficient must be
known. As HAMBASE doesn't use detailed geometrical input this estimate is not
accurate and in case of very much glazing a correction on the SGA ($Z_T$) to
account for this effect is recommended.

The default values are

BAS.Glas\{i\}(5)>0.2 interior solar blinds
BAS.Glas\{i\}(7)=1;
BAS.Glas\{i\}(5)<0.2 exterior solar blinds
BAS.Glas\{i\}(7)=2; convection factor with blinds
BAS.Glas\{i\}(8)=0.13; Ri surface resistance of the glazing without blinds
BAS.Glas\{i\}(9)=0.04; Re
BAS.Glas\{i\}(10)=0.13; Riw surface resistance of the glazing with blinds
BAS.Glas\{i\}(11)=0.04; Rew
BAS.Glas\{i\}(12)=0.84; eps emissivity at the outside surface.
3.1.10  **Condensation on glazing**

By condensation on glazing moisture is removed from the air in the zone. Default this is not taken into account. Then the surface coefficient for vapour transfer at the glazing is betaglas=0. If this is not zero, e.g. betaglas=2.7*0.622*1e-8 kg/Pa/m² then this condensation is calculated and removed. Only one value for the whole building can be given.

BAS.betaglas=2.7*0.622*1e-8;

3.1.11  **Difference mean radiant and air temperature**

The difference between the air and mean radiant temperature equals the convective heat flow to the envelope of a zone divided by the product of envelope surface and surface coefficient for convective heat transfer hcv. So the difference is very sensitive for hcv in a bad-insulated envelope (large heat flow). Default this coefficient is BAS.hcvlink=2.7 W/m²K. If there is a good reason to change this value it can be done here.

```for k=zone1
    BAS.hcvlink{k}=2.7;
End```

3.1.12  **Output of radiation on specified planes**

In the output file hourly values for solar radiation (Output.Enr) and longwave radiation (Output.Lnr) on different surfaces are given. The format for the input is BAS.radout=[orNo, ShaNo, glaID; ....] where with orNo the orientation (see input) is known, shaNo refers to the shadow number (see below) and glaID refers to glazing transmittance (see below, dependence of the glazing transmittance on incident angle). Each row of BAS.radout refers to a different plane. Without nputextra Output.Enr and Output.Lnr is the radiation on a horizontal plane.

BAS.radout=0*[1 1 0;4 4 1];
3.1.13 Number of sky elements for shadow calculation

For the calculation of the shadow factor and/or the influence of incident angle on the transmittance of glazing, the sky dome is divided in \( m \times n \) elements. The elevation angle (0-90) is divided in \( n \) steps and the azimuth (-180+180) in \( m \) steps. \( \text{BAS.skyelem} = [n,m] \);

\( \text{BAS.skyelem} = [30,120] \);

3.2 Extra Options

If an option is not used or default values are used \( \text{BAS.option} = 0 \)
The data needed for an option are given in section 3.3

3.2.1 Incident angle dependence of glazing

For each glazing type (glaID) the dependence of glazing transmittance on incident angle of direct solar radiation can be accounted for. If this is not taken into account for all glazing types \( \text{BAS.glazingtrans} = 0 \) else \( \text{BAS.glazingtrans} = 1 \)

\( \text{BAS.glazingtrans} = 0 \);

3.2.2 Shadow data

For each vertical window the shadow by exterior obstacles of direct solar radiation can be accounted for. No shadow \( \text{BAS.shadow} = 0 \) else \( \text{BAS.shadow} = 1 \)

\( \text{BAS.shadow} = 0 \);

3.2.3 Daylight factor calculation

For a simple geometry of a room (shoebox) the CIE overcast sky daylight factor can be calculated with a split flux method. For each window the input of \( \text{BAS.shadow} \) is needed i.e. the window geometry, the data for exterior obstacles,
the angle dependence of the light transmission through the glazing etc. If this calculation is wished BAS.daylight=1 else 0

```java
BAS.daylight=1;
if BAS.daylight==1
    BAS.shadow=1;
end
```

### 3.2.4 Furniture.

Real rooms are furnished. Furniture is important for moisture storage. Moreover furniture intercepts solar radiation and releases a fraction of it directly to the indoor air. No furniture: BAS.furnish=0 and with BAS.furnish=1 data can be inserted (see below)

```java
BAS.furnish=0;
```

### 3.2.5 Interzonal airflows

If airflows between zones are known(e.g. by a mechanical ventilation system) the values can be inserted below and BAS.Interzonal=1. If there are no known values BAS.Interzonal=0. Often it is better to combine zones that are strongly linked by airflows.

```java
BAS.Interzonal=0;
```

### 3.2.6 Air infiltration

If airflows to zones and between zones are calculated BAS.infiltration=1 and data for cracks etc. have to be inserted below. If infiltration is not calculated BAS.infiltration=0

```java
BAS.infiltration=0;
```
3.2.7 Concentration of a gas in the indoor air

The concentration of a gas X in the indoor air can be calculated if it is not absorbed and if it is ideally mixed in the indoor air. For this calculation

BAS.ConcenX=1 else BAS.ConcenX=0
BAS.ConcenX=0;

3.2.8 Evaporating of water

The source for vapour can also be water with a certain surface area evaporating into a zone. If this vapour production is calculated BAS.Evap=1 else BAS.Evap=0
BAS.Evap=0;

3.2.9 Temperature stratification

In badly insulated buildings with air heating en little ventilation there can be much more heat loss by temperature stratification. A very rough estimate of this effect can be made. If one wants to investigate possible effects BAS.Tempstrat=1 else BAS.Tempstrat=0;
BAS.Tempstrat=0;

3.2.10 Heating system with a time constant

If the heating system is a first order process with a time constant BAS.heatingtimeconstant=1 else BAS.heatingtimeconstant=0. A time constant implies that the maximum heat of the plant cannot be delivered instantly and that sometimes heat is delivered that is not demanded. This feature cannot be applied if wallheating==1 (see below) or Simulink is used
BAS.heatingtimeconstant=0;
3.2.11  Limited room temperature change per timestep

To avoid rapid changes of indoor temperature a maximum increase of temperature for each zone can be given. If the feature is used BAS.heatingtemperatediff=1 else BAS.heatingtemperatediff=0. This feature cannot be applied if Simulink is used.

BAS.heatingtemperatediff=0;

3.2.12  Hygrostatic control

The relative humidity indoors can be controlled by (de)humidification (the usual solution), but also by changing the temperature (hygrostatic control): BAS.hygrostatcontrol=1. This cannot be applied if Simulink is used.

If no hygrostatic control: BAS.hygrostatcontrol=0;

3.2.13  Wall/floor heating or cooling system

A wall/floor heating or cooling system can be modelled. If this is used BAS.surfheating=1 else BAS.surfheating=0. If BAS.surfheating==1 then BAS.heatingtimeconstant=0; Only if the wallheating is not controlled by the indoor temperature (the base case, see below) it will work in Simulink.

BAS.surfheating=0;

3.2.14  Response factors check

Figures to check correct calculation of wall responses. BAS.respcheck=1: In the figures 21 etc the results of the 2nd order wall model vs the response factors wall model are compared and in the figures >30 the check of the 'exact' wall model vs the 2nd order wall model. (period=dper*24h) BAS.respcheck=-1: check of room 2nd order model vs. the exact room model, figure 21 etc heat, figure >30 etc moisture.
If surfheating==1 and BAS.respcheck==2 the results obtained with the response factors of the constructions with surfheating are compared in plots with the exact ones.

Response factors needed for wallheating/cooling

\[
\text{respfac} = [R_i, R_e, R_vw_s, \text{respfacqup}, \text{respfacTin}, \text{respfaqdown}]
\]

responsefactors:

\[
\begin{align*}
quint &= \text{respfacq}(1)qin + \text{respfacq}(2)qin^* + \text{respfacq}(4)qin^{**} + \text{respfacq}(3)qin^* + \\
&Tin = \text{respfacT}(1)qin + \text{respfacT}(2)qin^* + \text{respfacT}(4)qin^{**} + \text{respfacT}(3)Tin^* + \\
&\text{respfacT}(5)Tin^{**} \quad (*\text{timestep back})
\end{align*}
\]

BAS.respcheck=0 no check
BAS.respcheck=0;

3.2.15 Airflow windows

With this input the glazing properties can be calculated but also simple airflow windows and second skin facades. Sun blinds are situated in the ventilated cavity.

BAS.airflowwindow=0;

if hambasesimulink==1
    BAS.heatingtimeconstant=0;
    BAS.heatingtemperaturerediff=0;
    BAS.hygrostatcontrol=0;
    BAS.surfheating=0;
end
3.3 Data input

3.3.1 Incident angle dependence of glazing

The dependence of the transmittance of glazing on the incident angle is given in BAS.glazingtransmittance{glaID} = [incident angle1, incident angle2, ..., transmittivity1, transmittivity2, ...]. glaID refers to the glazing type of the input (glaID).

The first incident angle1 is 0 and the last one is 90 degrees. If the Solar gain factor at the input refers to normal incidence radiation

\[
\text{BAS.glazingtransmittance(glaID(:,1) = (0;1). For 90 degrees the transmittivity is always 0 so BAS.glazingtransmittance(glaID(:,last')=(90;0))}
\]

if BAS.glazingtrans == 1

‘Example input’

\[
\text{BAS.glazingtransmittance{1} = [0 10 20 30 50 60 80 85 90;...}
\]

\[
1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0];
\]

\[
\text{BAS.glazingtransmittance{2}=[0 20 30 40 50 60 70 80 90;...}
\]

\[
1 787/789 784/789 775/789 754/789 700/789 563/789 302/789 0];
\]

end

3.3.2 Shadow and incident angle dependence

Each different combination of window and shadow gets a number shaNo. In the file with this shaNo the data about shadow and incident angle dependence are stored. This shaNo is used in file BAS.window{winNo}. With exception of typeno=4 and 5 the FORMAT is:

\[
\text{BAS.shad{shaNo} = [typeNo, size1, size2, size3, x, y, z, extra;}
\]

\[
\ldots,\ldots,\ldots,\ldots,\ldots,\ldots;
\]

\[
\text{typeNo, size1, size2, size3, x, y, z, extra;}
\]

\[
\text{typeNo, size1, size2, size3, x, y, z, extra;}
\]

\[
x, y, z \text{ are Cartesian coordinates where } z \text{ is vertical and } x \text{ is horizontal and in the direction of the window orientation (for a horizontal window the orientation is}
\]
given in the input) and y is horizontal and parallel to the window pane. Left
(negative azimuth angle) and right are defined by facing the window from outside.
size1, size2, size3 are always positive numbers.
In the first column of the file a typeNo is given:

tipoNo=1: data referring to the window geometry. This row is not necessary if
there are only far away obstructions (tipoNo 4/5)
BAS.shad{shaNo}(1,:)=[1,depth, width, length, x, y, z, 0];
depth = distance glazing to exterior surface, width = the size in the y-direction
and length = the remaining size of the window pane. [x,y,z] = the coordinates of
the lowest window corner (of the glazing) at the left side.

tipoNo=2: Blocks in front of the window. For two sides of the block the x-
coordinate is constant, for two sides the y-coordinate and for two sides the z-
coordinate. Format for n-1blocks:
BAS.shad{shaNo}(2:n,:)= [2, width, length, height, x, y, z, transmittivity];
width = size in x-direction, length = size in y-direction, height = in z-direction.
[x,y,z] coordinates of the block corner with the smallest x, y and z coordinate
(note that e.g. -1<-5), transmittivity = solar transmission factor (0= opaque)

tipoNo=3: Cylinders and spheres. The axis of the cylinder must be vertical. A tree
is a cylinder and a sphere. Format for m-n cylinders and/or spheres:
BAS.shad{shaNo}(n+1:m,:)= [3, radius sphere, radius cylinder, height cylinder, x,
y, z, transmittivity];
e.g. tree: radius sphere= radius crown, radius cylinder = radius trunk (e.g.
1/20*radius crown), height cylinder = height to center of crown. [x,y,z]:
coordinates of the bottom of cylinder (trunk). transmittivity = solar transmission
factor of sphere (crown, 0=opaque). In winter (120<iday< 304) this is higher than
in summer. e.g. winter transmittivity =0.8, summer transmittivity =0.35

tipoNo=4 Shadow caused by very far away obstructions in front of the window
BAS.shad{shaNo}(m+1:m+2,:)=\([4, \text{ elevation angles of the horizon for azimuth angles (degree)}]=[-90,-60,-30,+0,+30,+60] \)

typeno=5 Shadow caused by very far away obstructions at the back of the window
% BAS.shad{shaNo}(m+2:m+3,:)=\([5, \text{ elevation angles of the horizon for azimuth angles (degree)}]=[90,120,150,180,-150,-120,-90] \)

For vertical windows only typeno=4 is relevant.
Note that the values for -90 and 90 degrees appear twice!

In order to check if the input is correct a drawing of the obstacle geometry with number shaNo (e.g. shaNo = 1) can be made (see fig 3-2). Moreover a polar plot of the obstructed sky is made.
No check: shadcheck=0 else shadcheck=1. This drawing is made with the function: \texttt{bastransshadow/btshaddraw(BAS.shad,shaNo)};

\texttt{Fig. 3-1. Drawing of shadowing geometry}
Fig. 3-2 Drawings for checking the shadowing input
3.3.3 Daylightfactor

The daylight factor can be estimated to get some idea about the distribution of the daylight in a room and whether or not artificial light is needed;

daylightfactor > 10% too much daylight, use blinds
daylightfactor > 5% and < 10%. Not much artificial light is needed
daylightfactor > 2% and < 5%. daylight is ok but artificial light is needed
daylightfactor < 2% dark room and much artificial light is needed

The daylight factor is calculated with the function `dayfac = inextradaylf (BAS.shad, DLcal)`: DLcal is a structured array with the room and window data

- DLcal.room = [mainorientation, depth(x), width(y), height(z)(from inside), workplanelevel, rhofloor, rhoceiling, fig]
- DLcal.windows = [orientation, shortest distance to right wall(y) seen from inside, shortest distance to floor (reference,z), shaNo, LT, fig].

![Fig. 3-3 Position of the window and working plane](image)
For a horizontal window: \( DLcal.windows=[5,\text{shortest distance to right wall(y)seen from the inside, shortest distance to wall with mainorientation seen from inside,shaNo,LT,fig}] \). There is no shadow taken into account for a horizontal window but as window dimensions and incident angle dependence must be known a BAS.shad for a horizontal window must be made.

The output for the dayfac CIE daylightfactor (%) on the working plane can be found in dayfac(\( ::,3 \)), the corresponding meshgrid of the plane in dayfac(\( ::,1 \)) and dayfac(\( ::,2 \))

With \( \text{fig}=1 \) a plot is made. \( \text{fig}=0 \) no plot.

Example plot

\[ \text{pcolor(x,y,df),colormap('gray'), shading interp, colorbar,axis image, title('mean daylightfactor=',num2str(mean(df(:)),3),"')} \]
3.3.4 Furniture

Moisture is stored by furnishings dependent on the change in relative humidity. Especially in zones with a lot of paper of textiles this can easily outweigh the moisture storage of the building. A value of '1' means that about the same amount is stored as in the air that fills the volume of the zone. The heat storage of furnishings is less important but by absorbing solar radiation and releasing that directly to the indoor air more solar energy is released in a convective way. Recommended values are: 1 for storage and 0.1-0.2 for the convective fraction.

The convective fraction without furnishings: 0.05

For each zone:
BAS.furnishings{zoneNo}=[fbv  CFfbi];

fbv = Moisture storage factor
CFfbi = The convection factor for the solar radiation due to furnishings.

3.3.5 Interzonal airflow

Known interzonal known airflows (e.g. by mechanical ventilation system) are given by a profile that is not a zone profile (as the profiles given before) but a building profile because for each value two zones are involved and the periods of different zones don't need to be equal. From the interzonal airflows an hourly file is made so the experienced user can change the values each hour and a maximum flexibility is guaranteed.

The linking of zones by mechanical ventilation can cause numerical problems if the value is high (many iterations are needed). As the indoor climate in two very strongly coupled zones is almost equal it is often better to combine the zones. The profiles for the interzonal airflows are given by:

BAS.Linkv{k}=[zoneNoj,zoneNoi,value(dm3/s);zoneNo1,zoneNok,value(dm3/s); etc];

k is the profile number, in the first two columns the two zones involved are given: first column the zone the flow enters and the second column the zone
where the flow is coming from. In the third column the value for the flow rate (dm$^3$/s)(are always positive) is given. If between 2 zones the ventilation is zero there no need to enter a value.

Each day of the week a different interzonal airflow profile can be used. The profiles are given by a weekfun for interzonal airflows.

\[
\text{BAS.weekfunlink}\{v\} = [\text{upnrmon, upnrtue, upnrwed, upnrthu, upnrfri, upnrsat, upnrsun}]
\]

3.3.6 Mass balance of a room

Default the ventilation in the profile is considered as supply air flow of the zone. So the net air flow to other zones cannot exceed the ventilation in the profile. If this is violated an error message will appear. If there is infiltration this doesn't need to be an error. (see below)

3.3.7 Air infiltration

Air leakages (cracks and openings) are characterized with two coefficients Cd and N: volume flow=$\text{Cd} \cdot (\text{pressure drop})^N$ (dm$^3$/s).

Each different leakage has an ID (lekID). Sometimes Cd is known per m$^2$ surface area of the opening (CdA) and has to be multiplied here with this area (Cd=\text{A} \cdot \text{CdA}). Also a value per m length of a crack (CdL, Cd=\text{L} \cdot \text{CdL}) is possible:

\[
\text{BAS.Lek}\{\text{lekID}\} = [\text{Cd, N}]; \text{Cd} (\text{dm}^3/\text{s}) = \text{flow coefficient and N = flow exponent}
\]

The pressure on the building envelope caused by wind is calculated with a wind pressure coefficient Cp: wind pressure=0.5*1.2*Cp*v$\text{wind}^2$

The wind pressure coefficients must be known for different wind angles. The wind angle is the difference between the wind direction and the azimuth of the orientation of the surface with the crack.
The direction of the wind coming from the north is zero, east is 90, south 180 and west is 270. The orientation of surfaces is defined differently: north is 180 and south is 0 (also clockwise).

So the wind angle = winddirection +/- 180-orientation. (Note that a different definition of wind angle might be used in AIVC tables)

All openings of a building to the exterior must have the same number of Cp-values. E.g. if length(Cp) = 4: Cp(1:4) = [Cp(windangle=0), Cp(90), Cp(180), Cp(270), (clockwise, 360 is not used==0)

The reference velocity for which pressure coefficients are defined differs from the meteorological velocity vwind (at height=10m and roughness length=0.03m), so a correction is necessary cp=Cp*fwind^2.

The wind amplification factor (fwind) is defined as the ratio of the wind velocity at the reference height and the meteorological velocity. There are several ways to estimate this factor, e.g. the estimation with the meso wind velocity (KNMI),

v_meso= velocity at the height 60m. At the meteostation v_meso=1.31*vwind, in town v_meso= f_meso*1.31*vwind.

So fwind=1.31*f_meso*log(href/z0)/log(60/z0) e.g local z0 in the city:z0=1, f_meso for the location in the town = 0.74 reference height = 8.4m

fwind=1.31*0.74*log(8.4)/4.09;

Cp-values

The first 27 are taken from a publication of the IEA’s Air Infiltration and Ventilation Centre (Air Infiltration Calculation Techniques - An Applications Guide, Liddament M.W. 1996, A guide to energy efficient ventilation, AIVC, pp240 Table A2.1, A2.2,A2.3,A2.4,A2.5,A2.6).

These sets can be used (with care) for low-rise buildings (up to 3 storeys).

The 8 compass directions are expressed relative to the external surface normal vector. The first coefficient therefore corresponds to wind impinging normally on the surface, with the following values corresponding to 45°, 90°, 135°, 180°, 225°, 270° and 315° progressing clockwise in plane from above. A coefficient set can therefore be used for more than one surface, if appropriate, since it is independent of absolute surface orientation.
<table>
<thead>
<tr>
<th>Length to Width Ratio</th>
<th>Shielding Condition</th>
<th>Reference Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>Exposed</td>
<td>Building height</td>
</tr>
<tr>
<td>1:1</td>
<td>Surrounded by obstructions equivalent to half the height of the building</td>
<td>Building height</td>
</tr>
<tr>
<td>1:1</td>
<td>Surrounded by obstructions equivalent to the height of the building</td>
<td>Building height</td>
</tr>
<tr>
<td>2:1</td>
<td>Exposed</td>
<td>Building height</td>
</tr>
<tr>
<td>2:1</td>
<td>Surrounded by obstructions equivalent to half the height of the building, wind speed reference level</td>
<td>Building height</td>
</tr>
<tr>
<td>2:1</td>
<td>Surrounded by obstructions equivalent to the height of the building</td>
<td>Building height</td>
</tr>
</tbody>
</table>

\[
cp = (f_{\text{wind}}^2) \times \begin{bmatrix}
0.7, 0.35, -0.5, -0.4, -0.2, -0.4, -0.5, 0.35; & \% 1, 1:1, exposed wall \\
-0.8, -0.7, -0.6, -0.5, -0.4, -0.5, -0.6, -0.7; & \% 2, 1:1, exposed roof <10\text{deg}
\end{bmatrix}
\]

<table>
<thead>
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<td>Building height</td>
</tr>
<tr>
<td>2:1</td>
<td>Exposed</td>
<td>Building height</td>
</tr>
<tr>
<td>2:1</td>
<td>Surrounded by obstructions equivalent to half the height of the building, wind speed reference level</td>
<td>Building height</td>
</tr>
<tr>
<td>2:1</td>
<td>Surrounded by obstructions equivalent to the height of the building</td>
<td>Building height</td>
</tr>
</tbody>
</table>

\[
cp = (f_{\text{wind}}^2) \times \begin{bmatrix}
0.7, 0.35, -0.5, -0.4, -0.2, -0.4, -0.5, 0.35; & \% 1, 1:1, exposed wall \\
-0.8, -0.7, -0.6, -0.5, -0.4, -0.5, -0.6, -0.7; & \% 2, 1:1, exposed roof <10\text{deg}
\end{bmatrix}
\]
Openings between zones are defined by BAS.Lekin and openings between a zone and outdoors are defined by BAS.Lekex. Each opening gets a number: linNo, lexNo

BAS.Lekex{lexNo} = [zoneNo, orientation, distance, lekID, cp];

orientation = orientation of the envelope part with the opening
distance = the distance from opening to a reference plane (e.g. the top of the roof).
If the reference plane is below the position of the opening the distance is negative!

BAS.Lekin{linNo} = [zone1, zone2, distance, lekID];
distance = the distance to a reference plane.

BAS.Lekin{1}=[1,2,2,4,8];
BAS.Lekin{2}=[1,2,4,4,8];
BAS.Lekin{3}=[1,3,2,4,8];
BAS.Lekin{4}=[1,3,4,4,8];
In this case both the mechanical supply and exhaust must be known. To make it easy the supply and exhaust are assumed to be proportional with \( v_{\text{vmin}} \) with the same constants for all periods.

\[
\text{BAS.mechvfac\{zoneNo\}} = [\text{ksupply kexhaust}];
\]

\([\text{ksupply, kexhaust}] = \) proportionality factors for supply and exhaust. \( k_{\text{supply}} = 1 \): the supply has the values of \( v_{\text{vmin}} \), \( k_{\text{exhaust}} = 1 \): the exhaust has the values of \( v_{\text{vmin}} \), \( k_{\text{supply}} = 1 \& k_{\text{exhaust}} = 1 \): supply and exhaust are balanced. Different values for all hours and zones are possible but this has to be inserted in the hourly profiles files.

Note that if the mechanical system is perfectly balanced one leakage in a zone will not have any influence as from the mass balance it follows that the flow through the leakage must be zero.

\[\text{Fig. 3-5 Results of infiltration calculations for IEA41 CEX common exercise}\]
3.3.8 Concentration of a gas in the indoor air

Input of the production of a gas i (BAS.Xprod{\textit{i}}) for each zone is done in the same way as moisture production. So it is a part of a profile. If the unit of production is X/sec then the concentration is in X/m3. For each profile ID the values have to be known for the same periods as the other profile properties. An hourly file is made that can be modified. It is assumed that there is no absorption of X and that the concentration without the source (zero level) is constant. The calculated concentration is the increase compared with the zero level.

3.3.9 Evaporation of water

The surface area (BAS.watersurface) and the added water volume for each time-step are needed. The default surface coefficient for mass transfer (evaporation) is 2*0.62e-8 kg/m²sPa. If the coefficient is higher than this value at walls the water surface area can be taken larger, e.g. if there are waves one should do this. The watermass (BAS.watermass) is the mass/sec added to the existing value. If too much is added it cannot evaporate quick enough and the room will flood.

3.3.10 Temperature stratification

An estimate of this effect is given by the formula: $T_a(z) - T_a(z=1.7) = 0.25(z-1.7)h_{cv}(T_a - T_r)$ for $z > 1.7m$. This formula just shows that the stratification depends strongly on the mean heat flow density to the enclosure of a zone. 0,25 is very much ; we prefer 0.1. Note that with air heating in badly insulated envelopes this effect is maximal. As this is surely not the only reason and there can also be much mixing by air systems it is just an estimate and should be handled with care. The reality can be very different and this estimate can be completely wrong. The calculated temperatures $T_x$ and $T_a$ can be very high. The comforttemperature is corrected (the mean stratification effect, $\Delta T_{strat}$, is subtracted from the mean temperature in the zone).
For zones with a height less than 2m no estimate can be made and Facstrat=0. To account for this effect according to the formula above use Facstrat=(H-1.7)^2/H/20. Tmean-Ta(1.7)=Facstrat*hcv(Ta-Tr)

for k=zone1
    BAS.Facstrat{k}=0;
end

3.3.11 Heating system with a time constant

If the time constant is tau hours and the calculation step is 1 hour the maximum heating power for a zone is: \( Q_{\text{max}} = Q_{\text{pmax}}(\text{zoneNo}) - \tau*(1- \exp(-1/\tau))*Q_{\text{pmax}}(\text{zoneNo}-Q_{\text{stook}}') \). \( Q_{\text{stook}}' = \) the heating power of the previous time step. The time constant tau is stored the array BAS.taucontrol{zoneNo}. The default value is BAS.taucontrol{zoneNo}=0

3.3.12 Heating with a maximum temperature increase per hour

For each zone a maximum temperature change by the heating plant can be given. \( \text{delTstook}(\text{zoneNo})= \) maximum temperature change. If a hygrostatic control is used (see below) this option is bypassed. The values are stored in the array: Control.delTstook{zoneNo}. The default value is BAS.delTstook{zoneNo}=100

3.3.13 Hygrostatic control

The relative humidity indoors can be controlled by (de)humidification (the usual solution), but also by changing the temperature (hygrostatic control) i.e. the temperature is increased in order to decrease the relative humidity. Of course there is a limit to this increase: Tsetmaxhygrostat. For increasing the humidity the temperature can be decreased. Also here is a limit: Tsetminhygrostat.

In the program cooling is disabled when hygrosatic control is used (the combination is not logical). Also (de)humidification is disabled. It might be
necessary not to use free cooling because the ventilation might be contra-effective for the humidity control.

For each zone with the data needed are:
BAS.hygrostat{zoneNo} = [Tsetminhygrostat, Tsetmaxhygrostat]. If there is no hygrostatic control in a zone (default): BAS.hygrostat{zoneNo} = [-100,100]

3.3.14 Wall/floor heating or cooling

The input for wall/floor heating or cooling is stored in BAS.Flheat.
If in a zone more than one construction components (wall, floor or ceiling) (or parts of it) are used for heating or cooling these components will have the same inlet temperature. This temperature is controlled by the wall that requires the lowest (heating) or highest (cooling) inlet temperature.
If the component is situated between two zones (wallin) the control of the heating is in the zone that is found in the first column of wallin. If there are several zones with wall heating Flheat.property will be a row vector. The fluid in the system can be either water or air.
Flheat.br(1) = distance between the tubes in the construction.
Flheat.Rvw-s(1) = one dimensional heat resistance (m²K/W) between the surface of the wall at the side of the temperature control and the parallel surface through the centre of the tubes.
Flheat.oppervlakte(1) = surface area of the system. This can be less than the area of the wall.
Flheat.Tmax(1) = maximum inlet temperature of the system e.g. 50°C, for cooling the minimum temperature.
Flheat.Rflow(1) = 1/(massflow x heat capacity).
One way to estimate this is from design conditions: very rough (Tmax - Tout)/Fiflhmax (Tout = outlet temperature, Fiflhmax = max heating power e.g. surface area x 100 W). For a better determination of Fiflhmax the thermal resistance between the whole tube register and the surface has to be calculated: R11 (K/W). Then Fiflhmax = (Tmax+Tout-2*Ti)/(R11*2), Ti is the design temperature of the zone. If electric heating is used Rflow=0;
If the massflow is taken too low the heat/cold) is lost already near the entrance and a warning will appear: Flow is too low.

Flheat.hc(1) = surface coefficient of convective heat transfer in the controlled zone when the system is on (design condition) e.g. 8 W/m²K

Flheat.wandtyp(1) = ..; Here a number for the construction component has to be inserted: -1:wallex, 0:walli0, -2:wallia, >=1:wallin. Note that if the heating/cooling is in wallin and if one of the zones is not defined, there is no wallin and also no heating.

Flheat.hc2(1) = surface coefficient of convective heat transfer in the not controlled zone (wandtype>=1) when the system is on (design condition).

Flheat.wandr(1) = wall No (exNo, i0No, iaNo or inNo)

Flheat.qmax(1) = maximum heat flow density at the surface for a steady state situation.: e.g. \(13*(T_{surface} - T_{set}) \text{W/m}^2 = 100\text{W/m}^2\). If there is cooling the value is negative. This value is the maximum (minimum) the plant can supply.

Flheat.Tsurf(1) = maximum surface temperature in case of heating and minimum in case of cooling relevant for the zone of the floorheating control. This is always a positive value unless the floorheating is a base system; then a minus sign is inserted before this value. This value is used to make a Profiles.Tsurf file with values for each hour of the calculation period. The system can be switched from base to the main system (changing the sign) at wish for each hour. Moreover if Tmax is high and Tsurf is low in a heating situation the supplied heat will depend on this Tsurf. If Tmax is low and Tsurf is high the supplied heat depends on Tmax (constant inlet temperature). If there are more heating/cooling walls in a zone they must be in the same mode i.e. all cooling or all heating and all base or all not.

Comfortable and maximum surface temperatures:

All R-values are for one m² except: Rflow

The input is checked and changed into data for the simulation in Bastranswhc
3.3.15 Airflow windows

Window No (winNo see input) that is considered as an airflow window: Airflwin.No=winNo

The properties of an airflow window are calculated with \( \text{Airflwin.glas} = \text{inextraairflwi}(R, \rho, \tau, sp, hc1, hc2, hr, VA, flowin, flowout, rhozw, tauzw, hczw) \)

The results are stored in BAS.Airflwin and used automatically in Hambase.

Data of system without ventilation and sun blinds:
\( R= [R_e, R_{layer1}, R_{cavity1}, R_{layer2}, R_{cavity2}, \ldots, R_i] \) from outdoors to indoors (so: length=2*layers+1, number of layers=number of cavities+1)
\( \rho \) = reflectance of each layer from outdoors to indoors without sun blinds
\( \tau \) = transmittance of each layer from outdoors to indoors

Data of cavity with ventilation and without sun blinds:
\( sp=\)number of cavity with the ventilation(1:most exterior cavity and highest number :most interior cavity
\( hc1= \) surface coefficient of convective heat transfer at the outdoor side of the cavity
\( hc2= \) surface coefficient of convective heat transfer at the indoor side of the cavity
\( hr= \) surface coefficient of radiative heat transfer between both sides of the cavity
\( VA(1:2)= [\text{cavity ventilation in } \text{dm}^3/\text{sec per } \text{m}^2 \text{ window without sunblinds, with sunblinds}]. \) No ventilation: \( VA=0 \)
\( \text{flowin}(1:2)= [\text{fraction of airflow in the cavity originated from indoors without sunblinds, with sunblinds}, (1-\text{flowin}): \) from outdoors
\( \text{flowout}(1:2)= \text{fraction of airflow leaving the cavity to indoors without sunblinds, with sunblinds}, (1-\text{flowout}): \) to outdoors
flow from indoor to indoor: \( \text{flowin}=(1,1), \text{flowout}=(1,1) \)
flow from outdoor to indoor: \( \text{flowin}=(0,0), \text{flowout}=(1,1) \)
flow from indoor to outdoor: \( \text{flowin}=(1,1), \text{flowout}=(0,0) \)
flow from outdoor to outdoor: \( \text{flowin}=(0,0), \text{flowout}=(0,0) \)
No mechanical ventilation: \( \text{flowin}=\text{flowout}=(1,1) \) or \( \text{flowin}=\text{flowout}=(0,0) \)
\( \rho_{zw} \) = reflectance of the sun blinds
\( \tau_{zw} \) = transmittance of the sun blinds
\( hc_{zw} \) = total convective surface coefficient of the sun blinds to the cavity air

**Output:**

Airflwin.glas=[Uglas,CFr,ZTA,ZTAw,CFrw,Uglasw,Lvairflow,Lvairfloww,0]

\( U_{glas} \) = (apparent) U-value of the system.
Window surface temperature is high for \( flowin=1 \) and low for \( flowin=0 \)
In case of no mechanical ventilation (\( flowin=flowout=1 \) or \( flowin=flowout=0 \))
the U-value will increase as part of the system is shortcircuited. The first case is
the traditional airflow window (comfort) and the second one is a second skin
system (low ZTA and natural ventilation is possible)
The extra ventilation of the system is hidden in \( U_{glas} \): \( flowin<flowout: 1.2 \times VA \times flowin \times (1-flowout) \), \( flowin>flowout: 1.2 \times VA \times flowout \times (1-flowin) \)
If \( flowin \neq flowout \) part of the heat loss is recuperated and the apparent U-value
is low. A problem is that the window is part of the ventilation system and the
ventilation input in Profiles must be higher than \( (\text{window surface area}) \times VA \) and
no heat exchanger can be used on the air through the cavity!
ZTA = solar gain factor: low for \( flowout=0 \) and high for \( flowout=1 \)
\( L_{vairflow} \) = exhaust ventilation: \( L_{vairflow}=1.2 \times VA \times (flowin-flowout) \times [W/m^2K] \), if
negative it is inlet. If it is too high an error message appears.

The data are stored in BAS.Airflwin:

Airflwin.glas=airflowwindowf(R,\( \rho \),\( \tau \),sp,hc1,hc2,hr,VA,flowin,flowout,\( \rho_{zw} \),
\( \tau_{zw} \),hczw);
glasAirfl=BAS.window{Airflwin.No}(3);
Airflwin.glas(10:14)=BAS.Glas{glasAirfl}(8:12);
BAS.Airflwin=Airflwin;
4 Input check and interface, Bastrans.m

The input above is stored in the structured array BAS. By typing BAS in the command window, the input can be checked and changed.
After Inputextra a function is called for that changes the input BAS into an input the simulation program Hambasex needs:

\[ \text{[Control,Profiles,Meteo,Building,Elan]} = \text{Bastrans (BAS)}; \]

The main simulation function is

\[ \text{Output} = \text{Hambasex(Control, Profiles,Meteo,Building,Elan)}; \]

In Bastrans is checked whether input data are missing or wrong. If a warning is given it might be correct e.g. 'There is a zone without glazing' but it can also be forgotten. With an error the execution is stopped, e.g. because a material number is used for which no data are available in matpropf.
There are errors which might occur without an error warning. Very thick constructions might lead to wrong response factors. Changing the thickness a little bit might be sufficient for a correct result. Also convergence of the infiltration calculation can be a problem if the openings are very large. So check the mass balance when results are strange. If there is but one zone and the openings are on the same height and have the same wind pressure coefficient the pressure difference is zero and also this might lead to a problem.
In order to shorten the files only the data needed for the calculations are selected from the input BAS array with exception of orientations, shadowing and glazing data.
In the output of Bastrans only the zones for which a volume is defined can be found. The used zones also get a new number. The old number is stored in the array: Building.zone(1, 2, etc) = (zone1, zone2,..).
In Meteo only the hours needed for the simulation are stored.

The file Meteo.kli contains the hourly values of the weather data for the whole calculation period.

Meteo.kli(:, 1:7) = [Diffuse solar radiation [W/m²], 10*air temperature outside[°C], Direct solar radiation (plane normal to the direction)[W/m²], cloud cover(1...8), relative humidity outside[%], 10*wind velocity [m/s]; wind direction(degrees north)].

Meteo.LAT = latitude;
Meteo.SMLON = difference local longitude and Local Standard time Meridian;
Meteo.gref = albedo of environment;
Meteo.idag1 = number of days preceding the calculation date till Sunday 1jan 1968, 0h;
Meteo.date = [year, month, day, weekday (1==Monday), hour (when daylight-savings time starts hour = 24 and is followed by hour = 2 and when it ends hour = 1 is followed again by hour = 1]
Meteo.aantaldagen = number of days calculated;
Meteo.nin= number of extra days calculated before starting the calculation period.

If the climate file of the Bilt is mt1970(:, :) then:
Meteo.kli = mt1970(:, [1, 2, 3, 9, 6, 4, 5])

Material properties are obtained with the function: \texttt{matprop = matpropf(l, matID)};
\texttt{l} = thickness (meter), \texttt{matID} = number of the material
\texttt{matprop} = [thickness, heat conductivity, density, heat capacity, emissivity, diffusion resistance factor, vapour capacity, vapour effusivity*10^7]
or \texttt{[l, lambda, rho, C, eps, mu, ksi, bv.10^7]}.
In case of an air cavity (matID = 2 or 3 or 4) the apparent thermal conductivity is calculated with \texttt{lambda = thickness/Rcav}.

If \texttt{l} and \texttt{matID} are vectors the function returns a matrix. Each row of the matrix corresponds with a layer.
Example

\[ l = [0.1, 0.5, 0.4]; \]
\[ \text{matID} = [205, 301, 501]; \]
\[ \text{matprop} = \text{matpropf}(l, \text{matID}) \]
\[ \text{matprop} = \begin{array}{ccccccccc}
1.0e+003 * \\
0.0001 & 0.0006 & 1.3000 & 0.8400 & 0.0009 & 0.0075 & 0.0020 & 0.0015 \\
0.0005 & 0.0001 & 0.5000 & 0.8400 & 0.0009 & 0.0050 & 0.0300 & 0.0072 \\
0.0004 & 0.0002 & 0.8000 & 1.8800 & 0.0009 & 0.0300 & 0.0400 & 0.0034
\end{array} \]

The file in matpropf can be extended with materials that are not yet in the file.

The file Profiles contains the hourly values of the profiles for each zone with a new zone number of the whole calculation period. The names are about the same as in BAS except that 'u' is added.

Useful files:
Profiles.periode\(\text{(zone, hour)}\): contains the period column number for each hour and zone, e.g. with 3 periods numbers 1, 2, 3..
Profiles.weekfun\(\text{(zone, hour)}\): contains the proID for each hour and zone
Profiles can be changed for each hour of the calculation period. An example how to do that is given below:

If the value of Tset has to be changed in zone 2°C to the value 19°C on 11 Dec from 12 till 17hour. (See below for the contents of Meteo.date and Profiles). Insert the lines:

\[ k\text{zone} = \text{find}(\text{Building.zone}==2); \]
\[ k = \text{find}(\text{Meteo.date(:, 2)==12&Meteo.date(:, 3)==11 & (Meteo.date(:, 5) > 12 & Meteo.date(:, 5)<= 17))}; \]
\[ \text{Profiles.Tsetu}(k, k\text{zone}) = 19; \]

Mechanical induced airflow between zones can be entered in Inputextra and is stored in Building.Linkvu. It can be changed or inserted also here.
The leakage data are stored in the files:
Control.infiltration = infiltration; (no infiltration :0, else 1)
Elan.Lekin and Elan.Lekex;
5 Output

5.1 General remarks

In the output all calculated hourly properties are present. See below.

The graphic features of Matlab allow the user in an easy way to make the plots he wants or to make movies for presentation. In figure 5-1 the plots made by a `Hamoutput.m` are shown.
5.2 Standard output

5.2.1 Profiles

Periode, Ersu, rvminu, rvmaxu, Tsetu, Tsetmaxu, Qintu, Gintu, Tvsu, Lvminu, Lvmaxu, watermassu, watersurfaceu, Xprodu, weekfun, Tsurf, linkvu and qmvu

5.2.2 Output

The output contains data for:
- Output.Toperative= 'operative' indoor temperature;
- Output.Tcontrol= temperature that is controlled (combination of Ta and Tr)
- Output.Tx = resultant temperature (apparent temperature for transmission heat loss);
- Output.RHa = indoor relative humidity;
- Output.Ta = indoor air temperature (1.6m);
- Output.Tmean = mean indoor air temperature if stratification;
- Output.Tr = mean radiant temperature;
- Output.Qplant = hourly energy use in Wh, positive 'heating', negative 'cooling' ; to heating/cooling device [W]
- Output.Qplant2 = hourly energy use in Wh, positive 'heating', negative 'cooling' ; from heating/cooling device to room [W]
- Output.Gplant = hourly energy use for latent cooling Wh;
- Output.Trans = hourly transmission heat loss in Wh;
- Output.Vent = hourly ventilation heat loss in Wh;
- Output.Zon = hourly solar energy released indoors in Wh;
- Output.Qint = casual gains [W];
- Output.Gint = vapour production [kg/s];
- Output.figain = hourly total heat gains: solar+casual Wh;
- Output.Twall = mean wall interior surface temperature (glazings excluded);
- Output.RHwall = mean relative humidity at the wall surface;
- Output.Twindowi = mean interior surface temperature of each glazing;
Output.RHwindowi = relative humidity of windows: interior surface,
Output(condenswindowi = condensate on interior side of the window (is removed from zone) [kg/s]
Output.Transglas = hourly conduction heat loss by glazing [Wh];
Output.Latentheat
Output.Lnr and Output.Enr: atmospheric radiation and solar radiation [W/m²]
on surface with orientation orNo, shadow shaNo and glazingtransmittance glaID defined in BAS.radout = [orNo,shaNo,glaID];
Output.PPD= estimated percentage of dissatisfied
Output.PMV=estimated predicted mean vote
Output.fzonab= absorbed solar by opaque external surfaces

5.3 Output extra options

if....

infiltration==1
Output.pwind = wind pressure [Pa]
Output.pstacke = stack pressure outside (==0 at reference plane) [Pa]
Output.pstacci = interior pressure at openings [Pa]
Output.delpex=pressure difference across openings in exterior constructions) (is positive if room pressure>external pressure) [Pa]
Output.delpij=pressure difference across openings in internal constructions) [Pa]
Output.proom= normalized room pressure [Pa]
Output.Qki0= air flow through openings in internal constructions (out is positive) [dm³/s]
Output.Qke0= air flow through openings in external constructions [dm³/s]
Ranking of delpex, delpij, Qke and Qki e.g. delpij and Qki:
  h=Control.Lekin(:,1:2);
  zone=Building.zone;
  hh=[zone(h(:,1));zone(h(:,2))]'
Output.Link= [dm$^3$/s]
Output. Qventin= [dm$^3$/s]

Control.ConcenX==1
Output.Xprod= 
Output.ConXin= 

Control.Evap==1
Output.delwater= storage water
Output.Gevap= evaporated

Control.surfheating==1
Output.Tflh= Inlet temp

Output.Qflh=base heating
Output.Tsurf= surface temperature of heated (cooled) floor;
Output.RHsurf= surface relative humidity of heated (cooled) floor;

Control.hygrostatcontrol==1
Output.Tsetmin= min set temperature
Output.Tsetmax= max set temperature
Output.RHsetmin= min set relative humidity
Output.RHsetmax= max set relative humidity