House model References HT Heat Pump

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Contents

1 Introduction

This document presents the basic information for calculating a house model based on an RC network. The specific model can be found in the References.

2 R and C values

Thermal circuits with purely resistive components and the expressions used in a heat transfer model are shown in Figure 1.

Equations for different heat transfer modes and their thermal resistances.

Transfer Mode	Rate of Heat Transfer	Thermal Resistance
Conduction	$\dot{Q} = \frac{T_1 - T_2}{\left(\frac{L}{kA}\right)}$	$\frac{L}{kA}$
Convection	$\dot{Q} = \frac{T_{\text{surf}} - T_{\text{envr}}}{\left(\frac{1}{h_{\text{conv}} A_{\text{surf}}}\right)}$	$\frac{1}{h_{\text{conv}} A_{\text{surf}}}$
Radiation	$\dot{Q} = \frac{T_{\text{surf}} - T_{\text{surr}}}{\left(\frac{1}{h_r A_{\text{surf}}}\right)}$	$\frac{1}{h_r A}$, where $h_r = \epsilon\sigma(T_{\text{surf}}^2 + T_{\text{surr}}^2)(T_{\text{surf}} + T_{\text{surr}})$

Figure 1: Heat transfer model[1]

Some typical heat transfer resistances [2]:

- Static layer of air, 40 mm (1.57 in) : R = 0.18 $[m^2K/W]$.
- Inside heat transfer resistance, horizontal current : R = 0.13 $[m^2k/W]$.
- Outside heat transfer resistance, horizontal current : R = 0.04 $[m^2K/W]$.
- Inside heat transfer resistance, heat current from down upwards : R = 0.10 $[m^2K/W]$.
- Outside heat transfer resistance, heat current from above downwards : R = 0.17 $[m^2K/W]$.

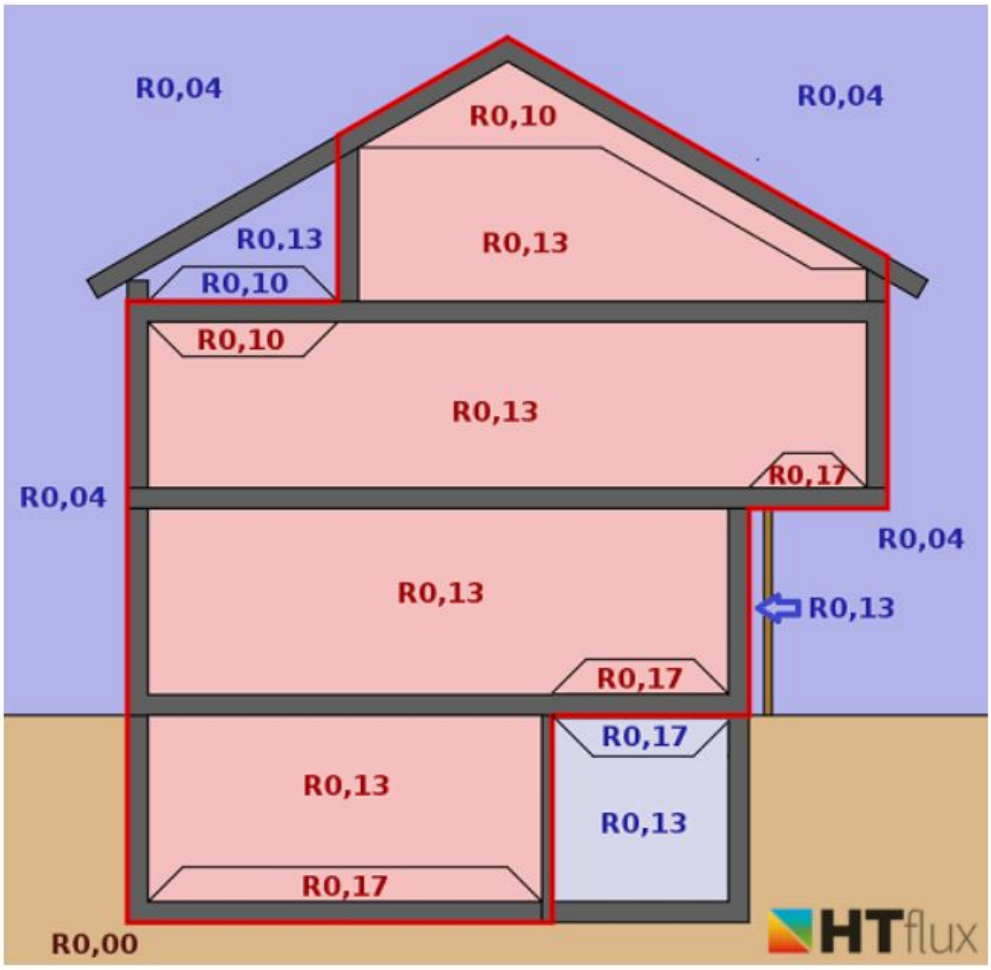

Figure 2: An overview of heat transfer resistance [3]

The R_c values for facades, roof and floor standard until 2020:

Construction	New construction	Renovation
Facades [1]	Rc 4.5 m2K / W	Rc 1.3 m2K / W
Roofs [2]	Rc 6.0 m2K / W	Rc 2.0 m2K / W
Floors [3]	Rc 3.5 m2K / W	Rc 2.5 m2K / W

Figure 3: R_c values[4]

The values that will be used from 2021 onwards are described in [5].

From 2015, the following RC values apply to new construction in the Netherlands:

Location	*RC value (NEN 1068, until 1-1-2021) [m2K / W]*	*Rc value (NTA 8800, from 1-1-2021) [m2K / W]*
floor	**>= 3.5**	**>= 3.7**
facade	**>= 4.5**	**>= 4.7**
roof	**>= 6.0**	**>= 6.3**

Figure 4: R_c values[6]

The values used for different types of houses such as: row house, detached house, apartments, etc. can be found in "Voorbeeldwoningen 2011" [7]. A set of example values for a row house which was built in the period 1975-1991 is shown in Figure 5:

Bouwdelen	Huidig			Besparingspakket			Investeringskosten	
	Opp. (m^2)	Rc-Waarde (m^2 K/W)	U-Waarde (W/m^2K)	Opp. (m^2)	Rc-Waarde (m^2 K/W)	U-Waarde (W/m^2K)	Per m^2	Totaal
Begane grondvloer [3]	51,0	0,52	1,28	51,0	2,53	0,36	€ 20	€ 1.020
Plat dak [3]	-	-	-	-	-	-	-	€ 0
Hellend dak [3]	68,6	1,30	0,64	68,6	2,53	0,36	€ 53	€ 3.640
Achter- en voorgevel								
– Gesloten [3]	40,6	1,30	0,64	40,6	2,53	0,36	€ 21	€ 850
– Enkelglas [3]	3,1		5,20	-		-	€ 139	€ 430
– Dubbelglas [3]	16,2		2,90	-		-	€ 142	€ 2.300
– HR++ glas	-		-	19,3		1,80		
Zijgevel								
– Gesloten	58,4	1,30	0,64	58,4	2,53	0,36	€ 21	€ 1.230
– Enkelglas	-		-	-		-	-	€ 0
– Dubbelglas	1,8		2,90	-		-	€ 142	€ 260
– HR++ glas	-		-	1,8		1,80		

Figure 5: R_c values for row house built in 1975-1991 [7]

3 Envelope house model analogous to a 2R-2C network

The 2R-2C house model structure is implemented as described below:

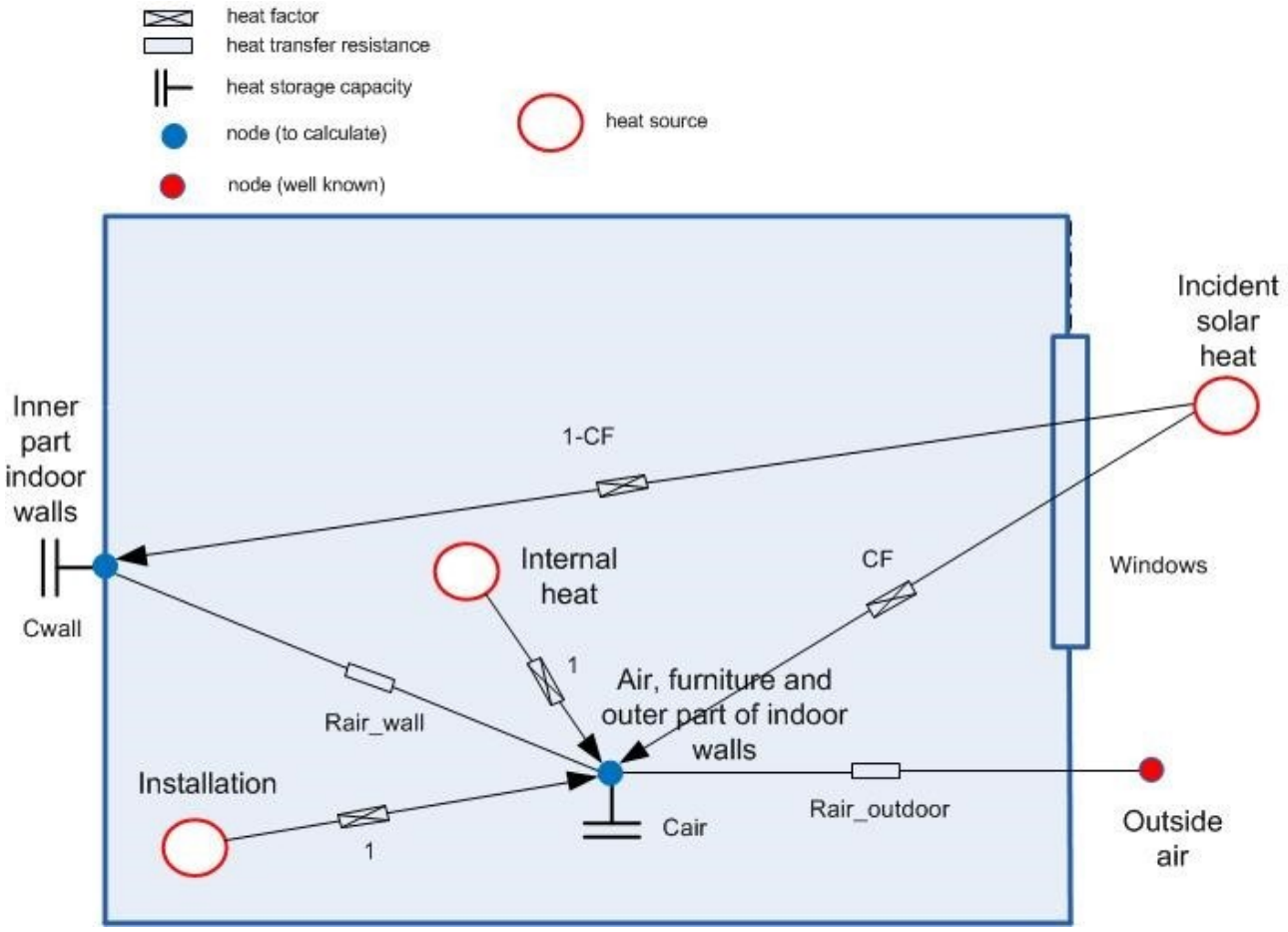

Figure 6: Schematic of envelope model

The equivalent electrical 2R-2C network with components and topology is given in Fig. 7.

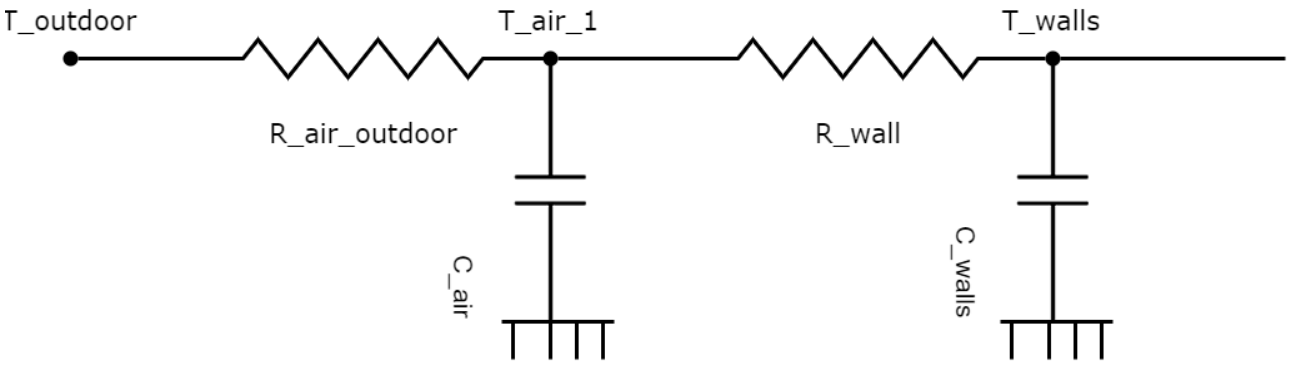

Figure 7: 2R2C house model

The model consists of two capacitances $C_{air,\ indoor}$ and C_{wall} and two resistances R_{wall} and $R_{air,\ outdoor}$. The incident solar energy is divided between C_{wall} and C_{air} through the convection factor CF. It is assumed that both internal heat (lighting, occupancy and electric devices) and supplied heat (installation) initially heat up the indoor air. In Fig. 7, they are fully released at the T_{air} node.

4 2 Zones house model 7R-4C network

The 7R4C structure implemented is shown in Figure 8.

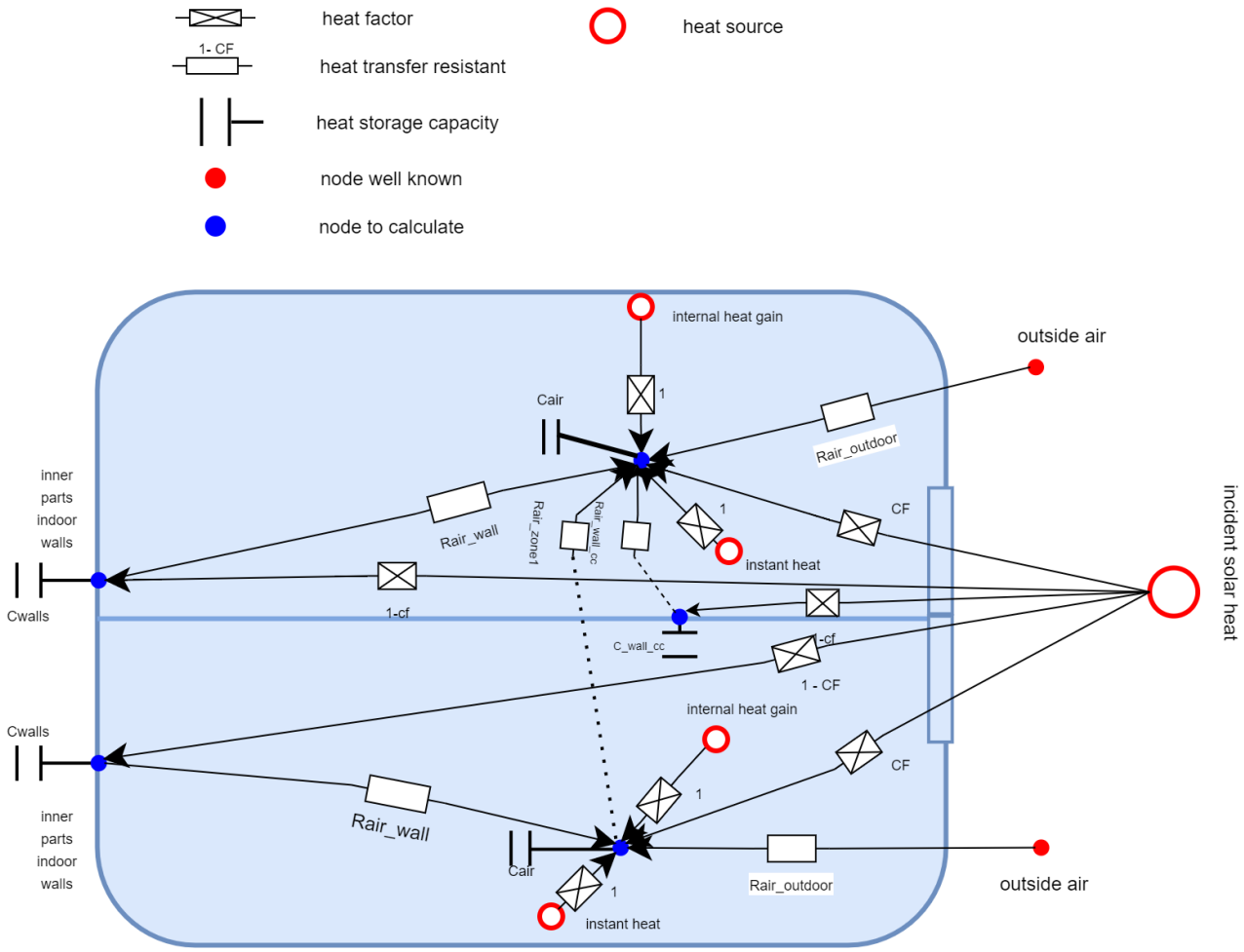

Figure 8: Schematic of 2 zones house model

The equivalent electrical 7R-4C network with components and topology is given in Fig. 9.

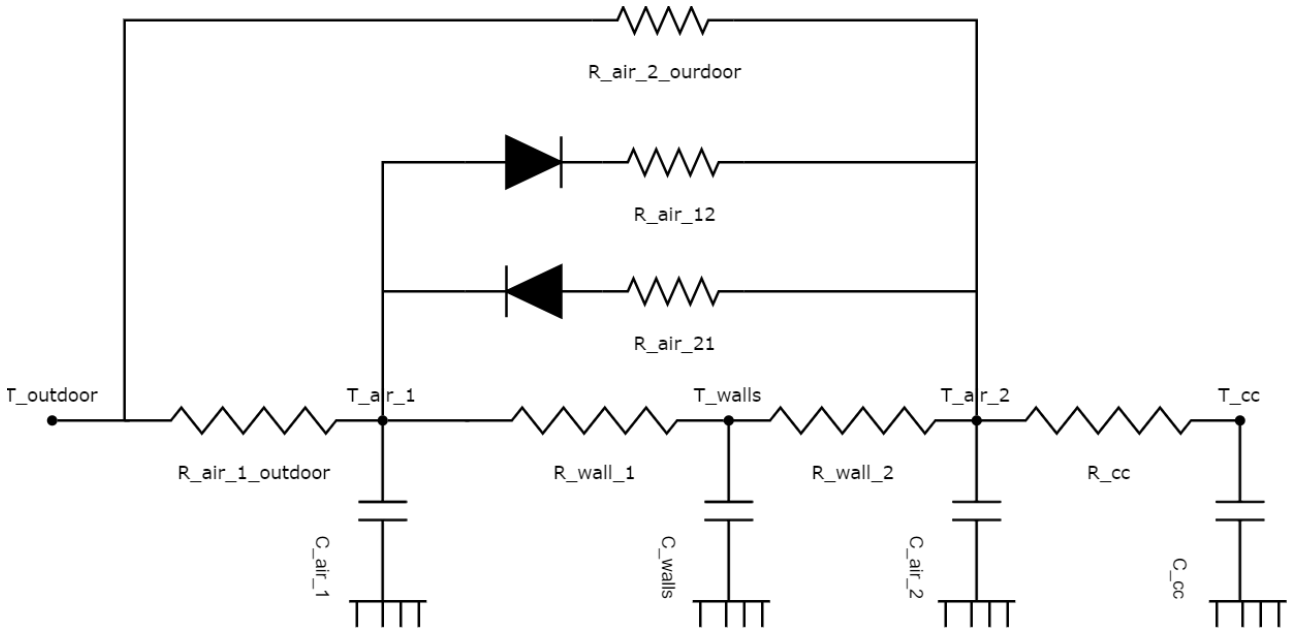

Figure 9: R-C circuits of 2 zones house model

with:

- `T_outdoor` : outdoor temperature $[°C]$
- `T_air_1` : zone 1 air temperature $[°C]$
- `T_walls` : wall temperature $[°C]$
- `T_air_2` : zone 2 air temperature $[°C]$
- `T_cc` : temperature of the concrete layer between zone 1 and zone 2 $[°C]$
- `R_air_1_outdoor` : outdoor resistance valus.
- `R_wall_1` : walls resistance value.
- `R_wall_2` : walls resistance value.
- `R_cc` : concrete resistance value.
- `R_air_12` : resistance value of air flow from zone 1 to zone 2.
- `R_air_21` : resistance value of air flow from zone 2 to zone 1.

5 NEN and ISO

The list of NEN and ISO standards used in the calculation:

- NTA 8800
- NEN 1068
- ISO 6946
- ISO 10077-2
- NEN 7120

References

[1] Wikipedia. *Lumped-element model*. URL: https://en.wikipedia.org/wiki/Lumped-element_model.

[2] Engineering Toolbox. *Overall Heat Transfer Coefficient*. URL: https://www.engineeringtoolbox.com/overall-heat-transfer-coefficient-d_434.html.

[3] *Overall Heat Transfer Coefficient*. URL: https://www.htflux.com/en/documentation/boundary-conditions/surface-resistance-heat-transfer-coefficient.

[4] *Bouwbesluit over isolatie en de Rc-waarde*. URL: https://www.isolatiemateriaal.nl/kenniscentrum/het-bouwbesluit-over-isolatie-en-rc-waarde.

[5] ISSO. *EnergieVademecum Energy-conscious design of new-build homes*. URL: https://v-1isso-1nl-1y6tawt2z0091.stcproxy.han.nl/q/9d67bdb7.

[6] J. De Vree. *R-waarde*. URL: https://www.joostdevree.nl/shtmls/r-waarde.shtml.

[7] RVO. *Voorbeeldwoningen 2011*. URL: https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/woningbouw/particuliere-woningen/voorbeeldwoningen.