

03.03\_PH-SUMMER SCHOOL

# PH-CALCULATION – Thermal bridge coefficients with THERM

Composition: Christoph BUXBAUM

Language support: Mark TOLSON

Date: 2008-09-18

This presentation is being used for non-commercial purposes.

## CONTENT OF THIS PRESENTATION:

03.03.01 Description of the software “Therm”

03.03.02 Working with “Therm” for the generation of thermal bridge coefficients

In the PH-calculation software PHPP, no thermal bridge coefficients are included. They can be taken from thermal bridge coefficient libraries or can be calculated by yourself.

This presentation has been prepared by

Christoph BUXBAUM, Arch. DI. Dr.

Carinthia University of Applied Sciences

A-9800, Spittal / Drau, Villacher Str. 1, Tel +43 05 90500 11

E-mail: [c.buxbaum@cuas.at](mailto:c.buxbaum@cuas.at), Web: [www.fh-kaernten.at/bph](http://www.fh-kaernten.at/bph)

## The THERM heat transfer software Description

### **THERM**

Analysis of two-dimensional heat transfer through building products. Includes a graphical user interface that allows users to draw cross sections of fenestration and other building products, which can then be analyzed by an automatic mesh generator and finite-element heat transfer algorithms. Results are displayed graphically.

### **Keywords**

two-D heat transfer, building products, fenestration

### **Validation/Testing**

N/A

### **Expertise Required**

Understanding of heat flows through building products; knowledge of properties of materials useful.

## The THERM heat transfer software

### Description

#### **Users**

Version 5.2 in use by over 1000 users internationally.

#### **Audience**

Building product developers, designers, analysts determining window ratings (NFRC).

#### **Input**

Graphic user interface; user enters cross sections of the building products, can read .DXF files and bitmaps.

#### **Output**

U-factors, isotherms, color-flooded isotherms, heat-flux vector plot, and color-flooded lines of constant flux.

#### **Computer Platform**

Requires Windows 98, Windows NT, Windows 2000, or Windows XP. Pentium or better. At least 64MB of random access memory (RAM), 128 MB of RAM is preferred for optimum operation. Hard disk drive with at least 15 megabytes of available disk space.

Source: [http://apps1.eere.energy.gov/buildings/tools\\_directory/software.cfm/ID=136/pagename=alpha\\_list](http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=136/pagename=alpha_list)

## The THERM heat transfer software

### Description

#### **Programming Language**

C, FORTRAN

#### **Strengths**

State-of-the-art user interface; automatic meshing/re-meshing completely user transparent; advanced radiation and convection models can be incorporated into the finite element analysis algorithms used. The current version is 32-bit, which is faster than previous versions.

#### **Weaknesses**

...

#### **Contact**

Company: Lawrence Berkeley National Laboratory

E-mail: [THERMHelp@lbl.gov](mailto:THERMHelp@lbl.gov)

Website: <http://windows.lbl.gov/software/therm/therm.html>

Freeware

## The THERM heat transfer software Description

THERM is a finite element computer program for the calculation of two dimensional heat fluxes.



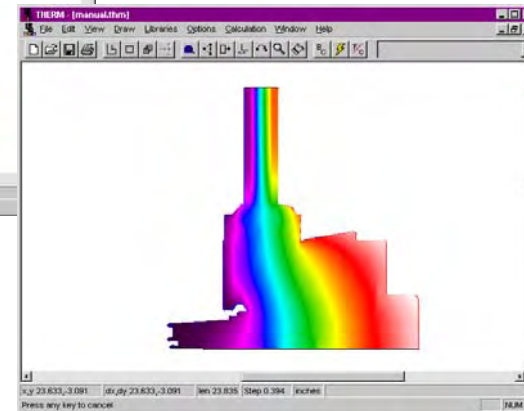
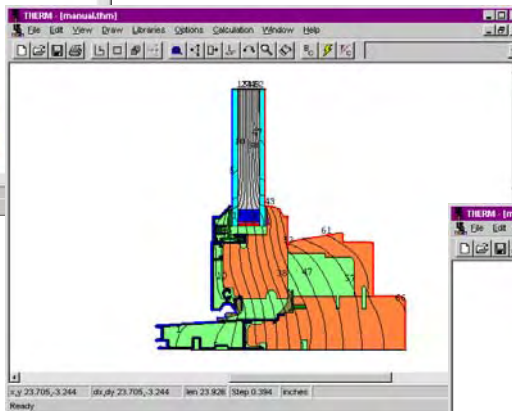
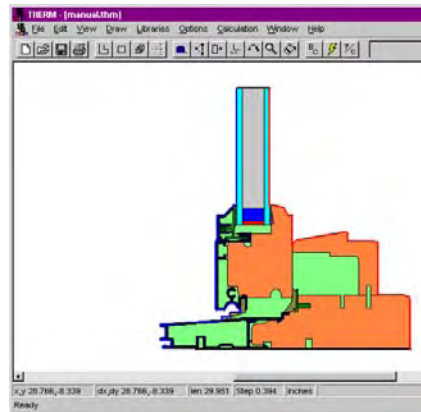
### Features

- Model one and two dimensional heat transfer effects
- Evaluate thermal bridges
- Optimize construction details (joints...)

Download link: <http://windows.lbl.gov/software/therm/therm.html>

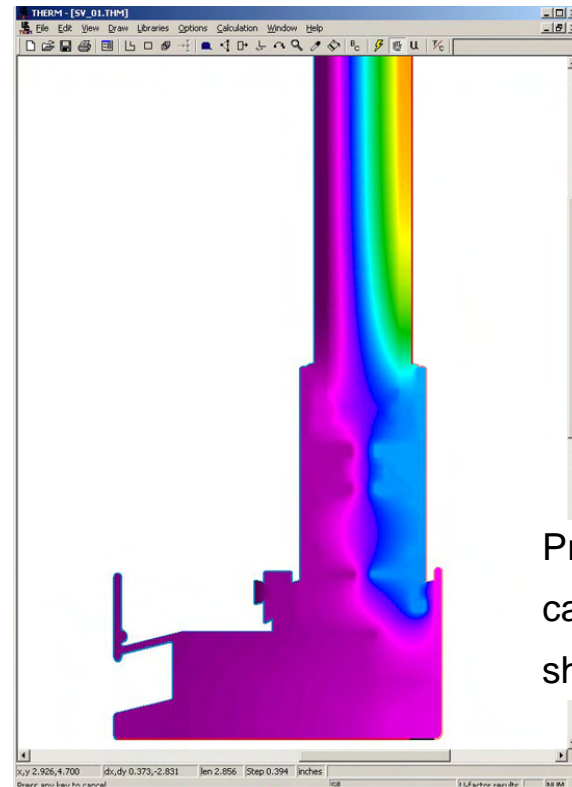
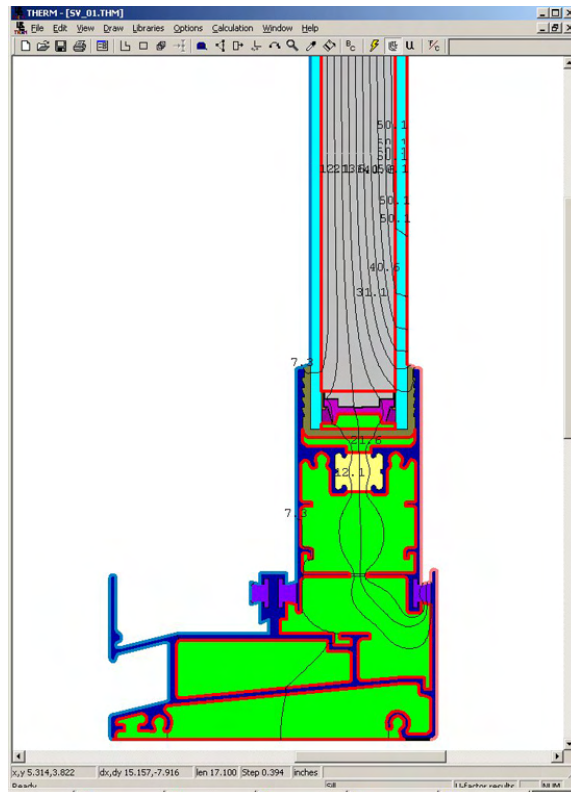
## The THERM heat transfer software Description / Examples

The thermal behaviour is visible with lines  
of isotherms or coloured.



Source: <http://windows.lbl.gov/software/therm/images/therm2-1.gif>

# The THERM heat transfer software Description / Examples



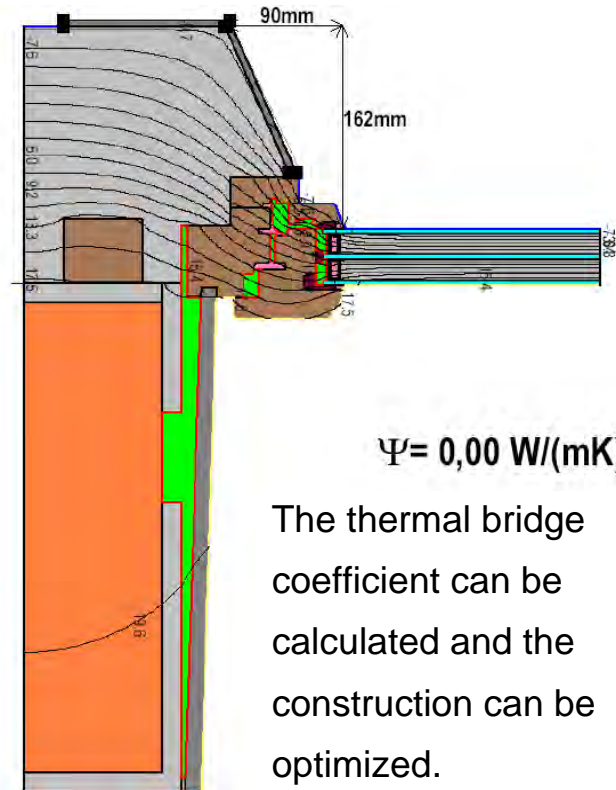
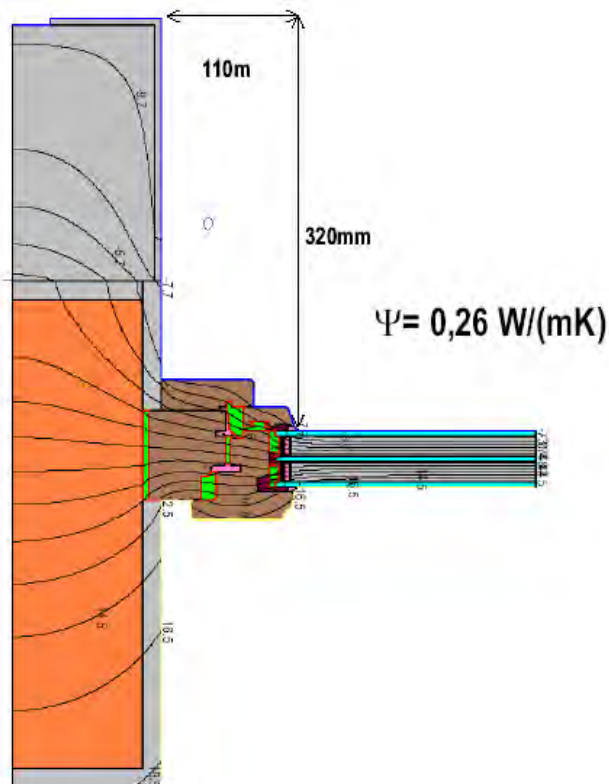
Problems  
can be  
shown

Source: [http://apps1.eere.energy.gov/buildings/tools\\_directory/screenshots.cfm/ID=136/pagename\\_submenu=/pagename\\_menu=/pagename=alpha\\_list](http://apps1.eere.energy.gov/buildings/tools_directory/screenshots.cfm/ID=136/pagename_submenu=/pagename_menu=/pagename=alpha_list)



The THERM heat transfer software  
Description / Examples

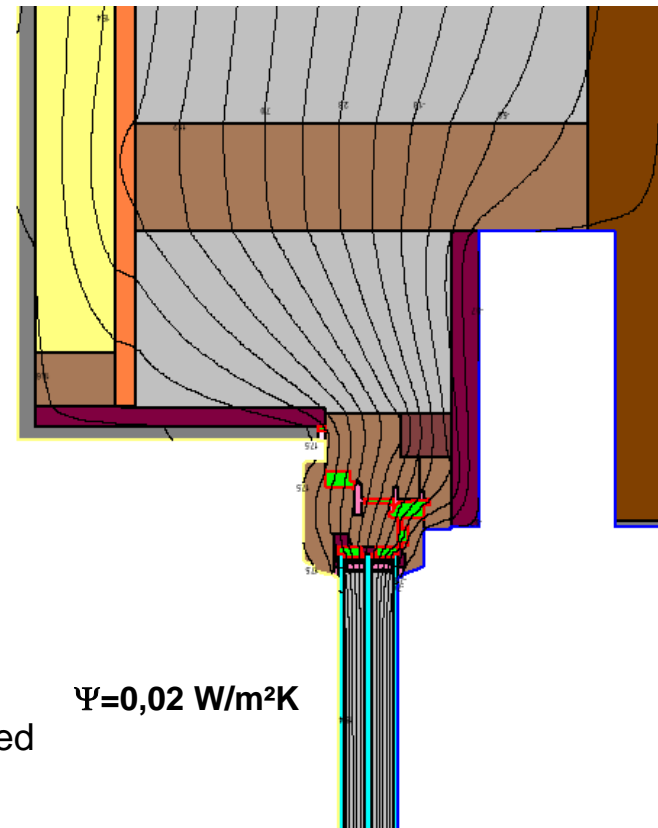
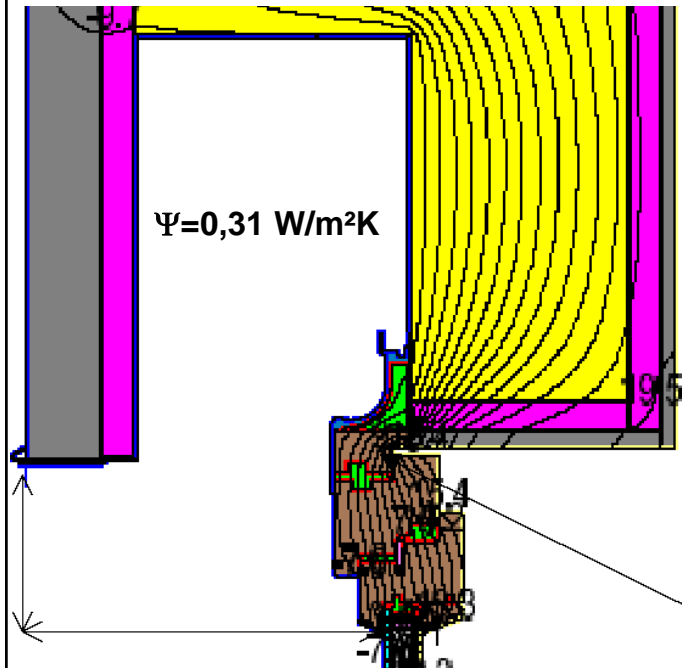
**Renovation: most important for passive house windows**



Source:

## The THERM heat transfer software Description / Examples

## Shadowing systems

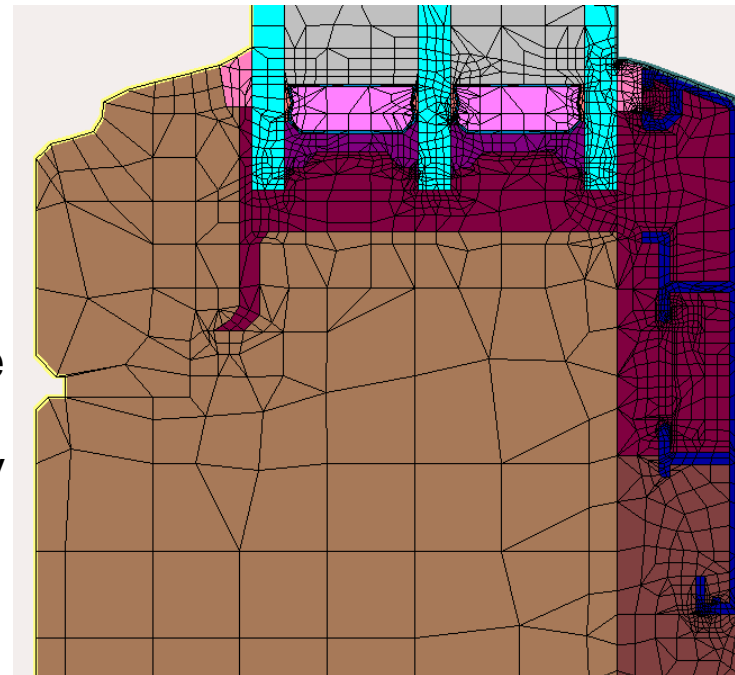


The thermal bridge coefficient can be calculated  
and the construction can be optimized.

Source:

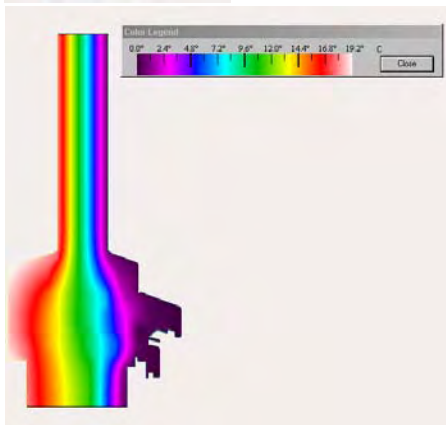
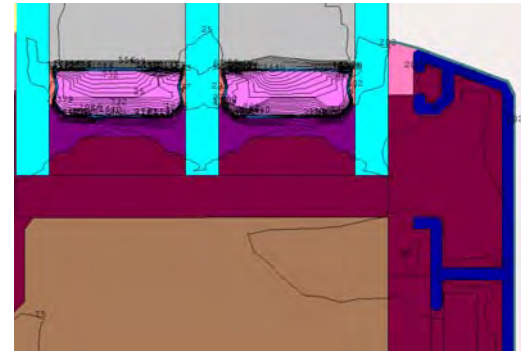
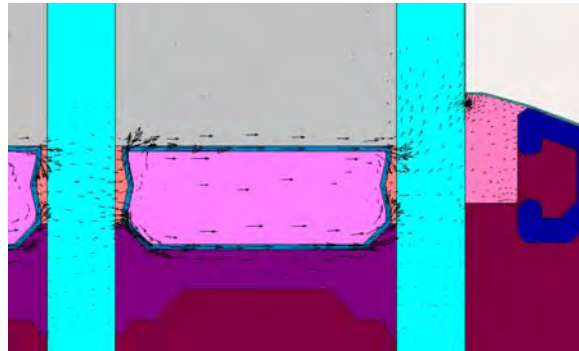
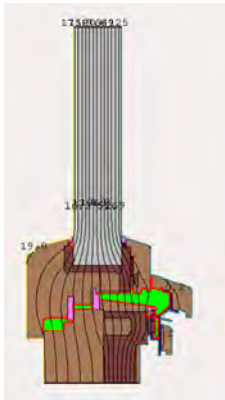
## The THERM heat transfer software Description - Finite Element Method

- We make a calculation model for a structural element consisting out of small elements and we know their thermal quality exactly or nearly exactly.
- If you lay a net over the structural element, calculate all junctions, you can conclude the thermal quality of the whole element out of the grid.



Source:

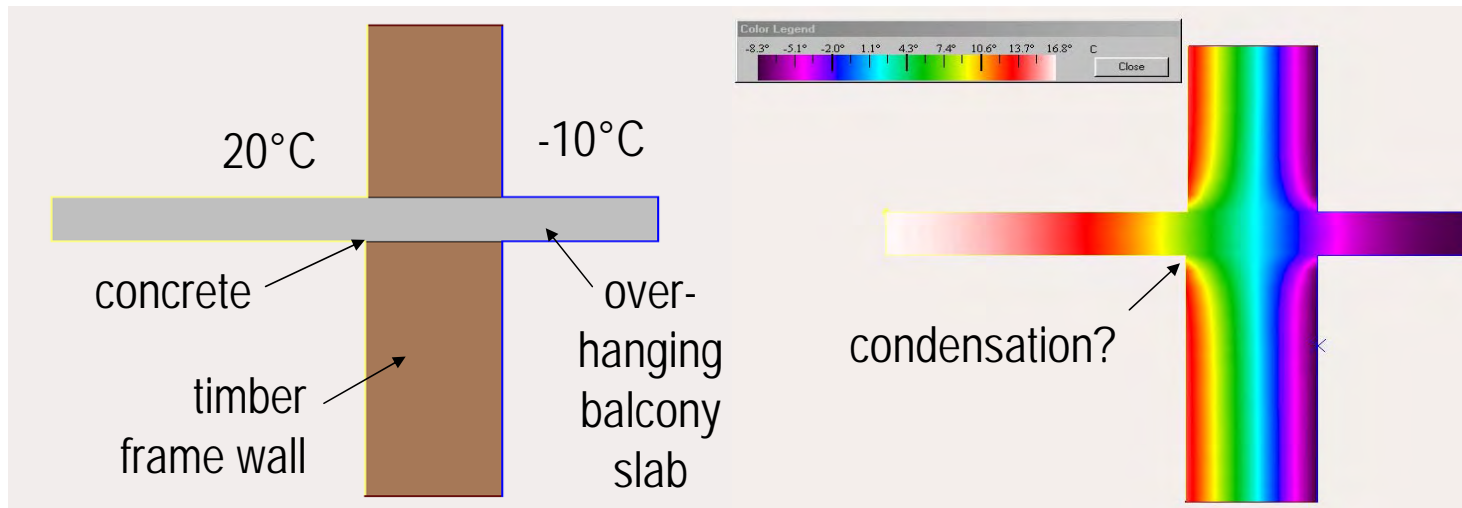
# The THERM heat transfer software Description - Finite Element Method



Source:

# The THERM heat transfer software Description - Finite Element Method

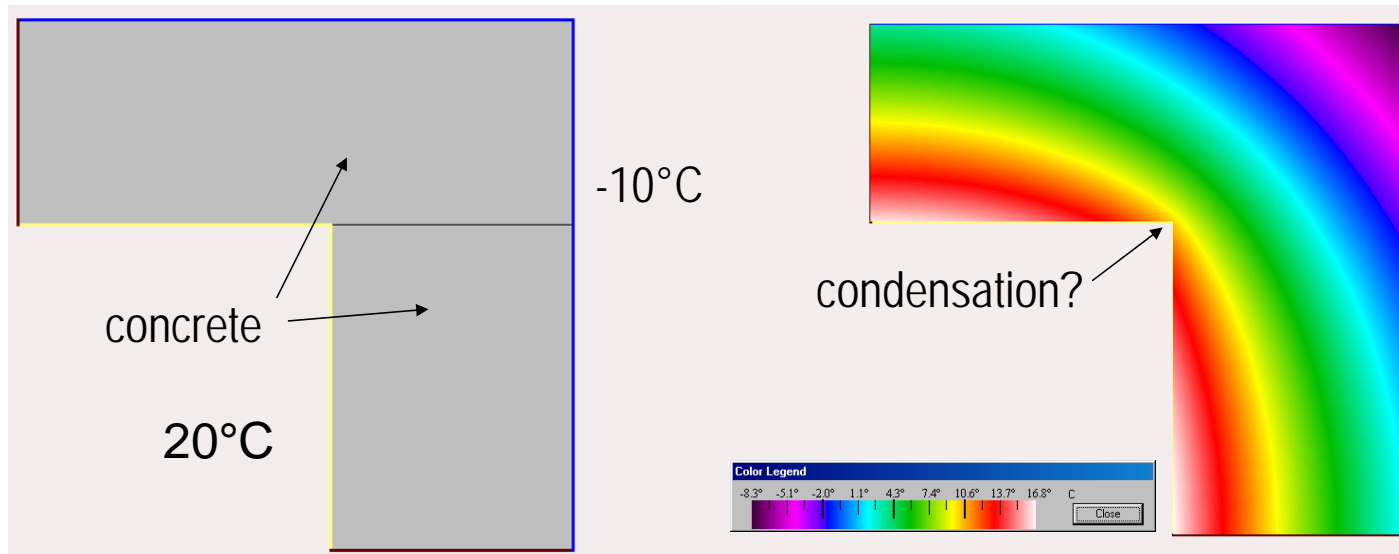
## Example: thermal bridge - constructive



Source:

# The THERM heat transfer software Description - Finite Element Method

## Example: thermal bridge - geometric



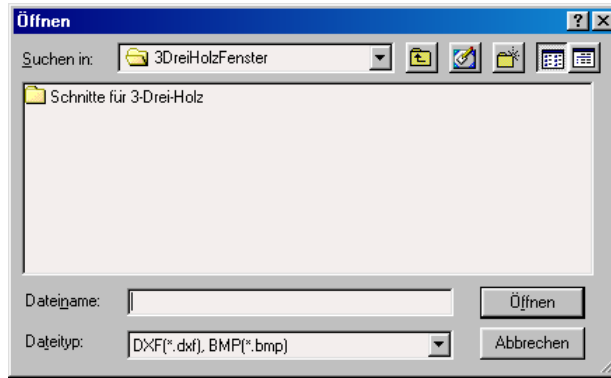
Source:

## Working with THERM

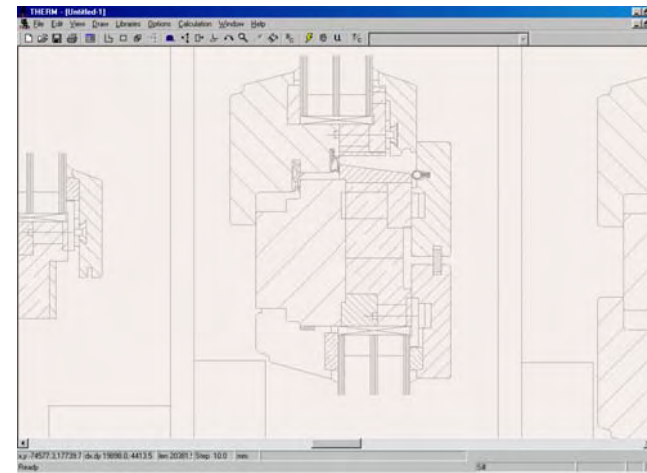
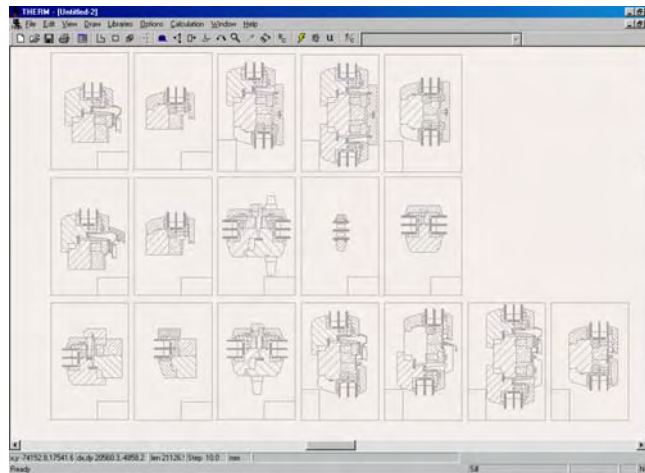
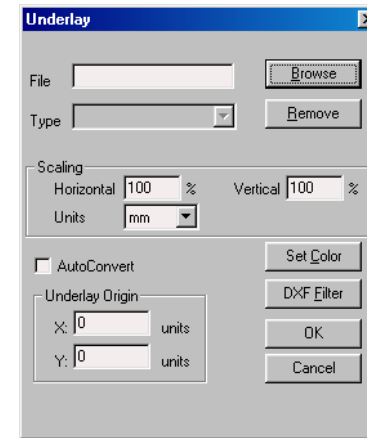
# Generation of thermal bridge coefficients with “Therm”

Source:

# Working with THERM Inputs to THERM



Take a  
DXF file as  
underlay

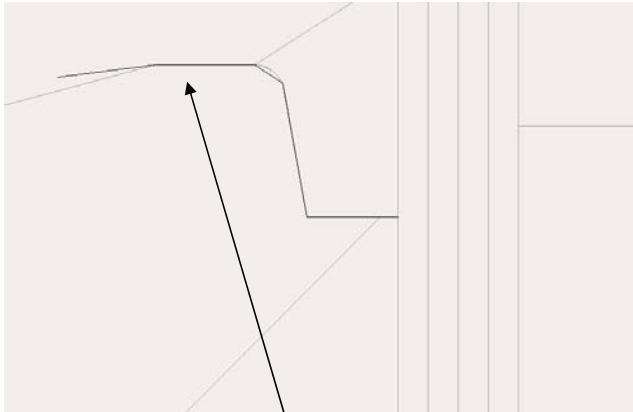


Source:

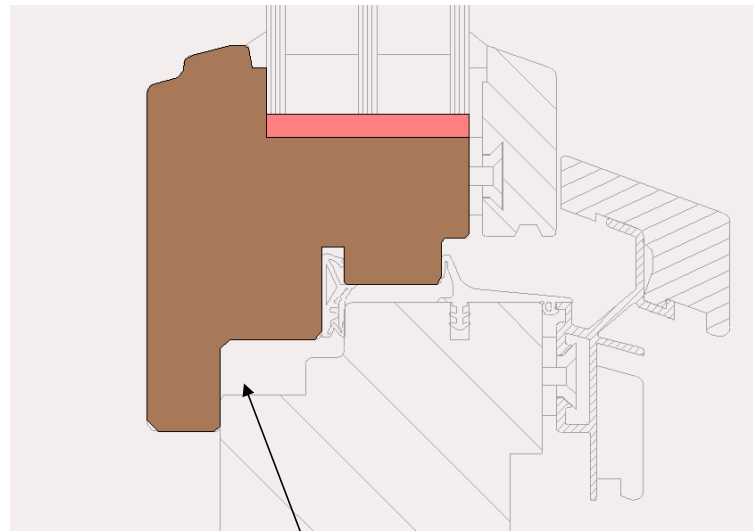


## Working with THERM Inputs to THERM

### Start with drawing a contour



Redraw the contour



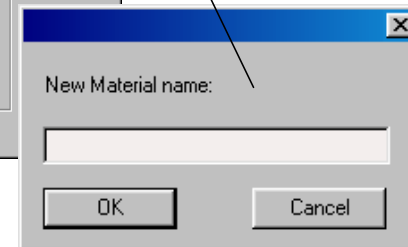
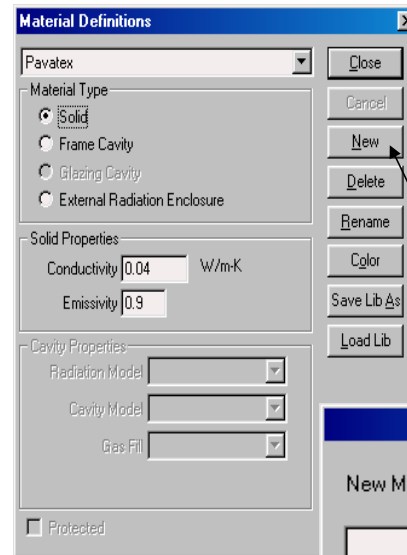
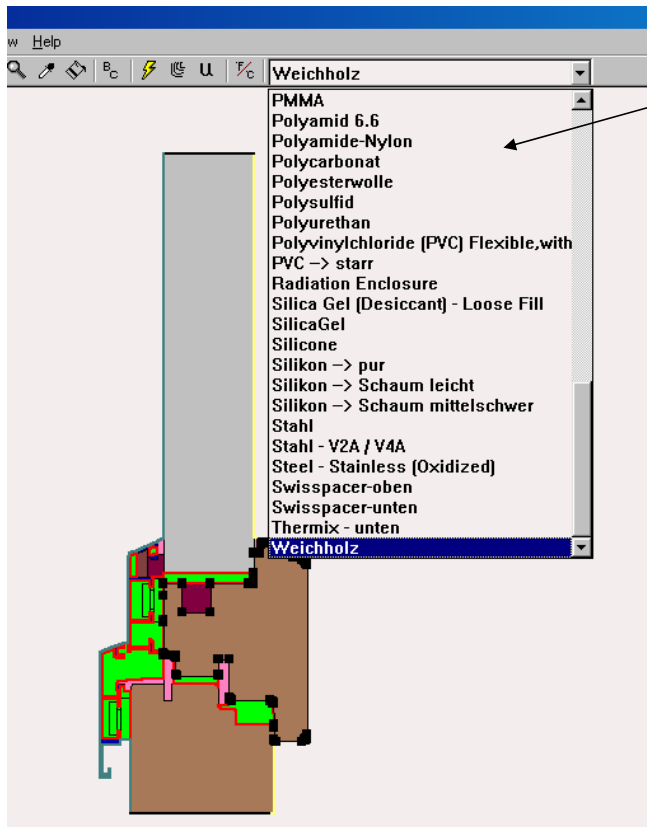
After the contour is finished,  
define the thermal quality of the element

Source:

# Working with THERM Inputs to THERM

## Finite element method

The thermal quality is defined in the material library



# Working with THERM Inputs to THERM

The screenshot displays two overlapping dialog boxes in the THERM software interface. The 'Boundary Conditions' dialog box is the primary focus, showing a dropdown menu set to 'Norm - Außen' and a 'Model' dropdown set to 'Simplified'. Below these, there are input fields for 'Convection/Linearized Radiation' with a 'Temperature' of '0' C and a 'Film Coefficient' of '25' W/m2-K. A vertical column of buttons on the right side of this dialog includes 'Close', 'Cancel', 'New', 'Delete', 'Rename', 'Color', 'Save Lib', 'Save Lib As', 'Load Lib', and a 'Protected' checkbox. The 'Farbe' (Color) dialog box is open in front of it, showing a grid of 'Grundfarben' (basic colors) and 'Benutzerdefinierte Farben' (user-defined colors). A 'Farben definieren >>' button is at the bottom of the 'Farbe' dialog. A third, smaller dialog box titled 'New Boundary Condition name:' is open, with a text input field and 'OK' and 'Cancel' buttons. An arrow points from the 'New' button in the 'Boundary Conditions' dialog to the 'New Boundary Condition name:' dialog.

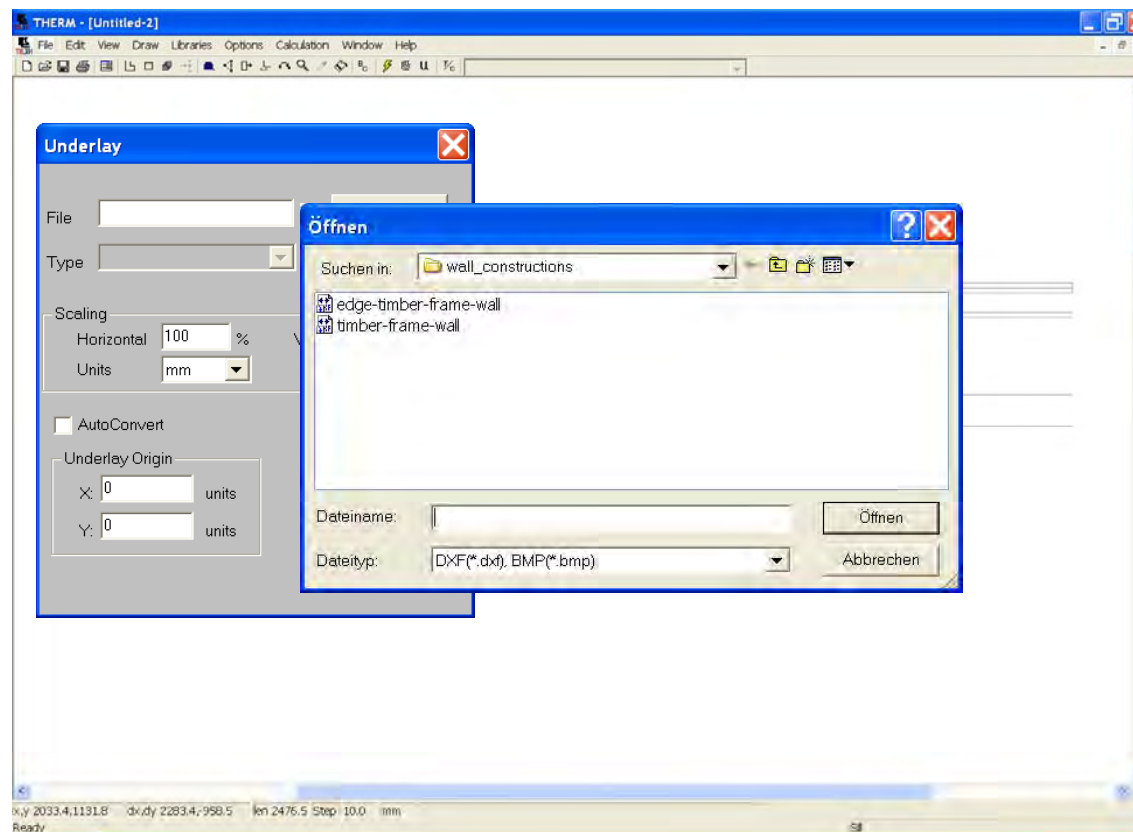
**Define the boundary conditions**

You can define all climate data you need

Source:

## Working with THERM

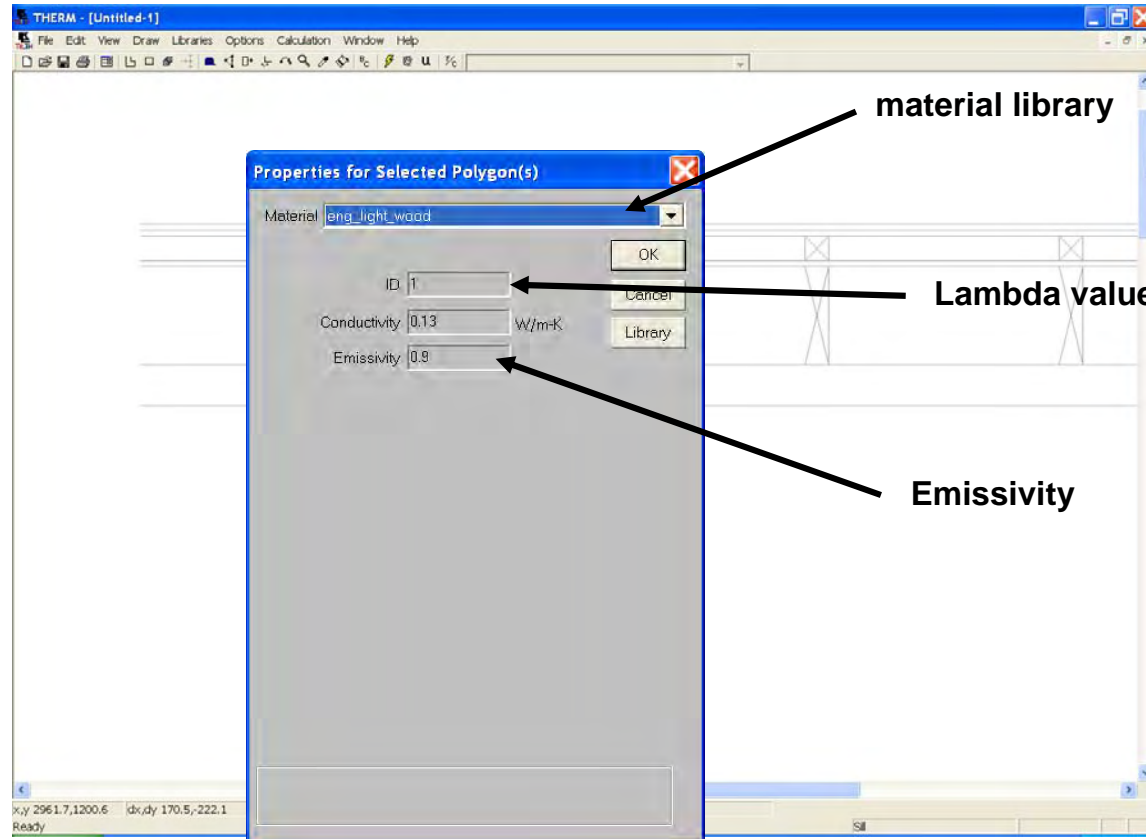
Inputs to THERM **Now its your turn. Let's call it "a timber frame wall"**



Source:

# Working with THERM Inputs to THERM

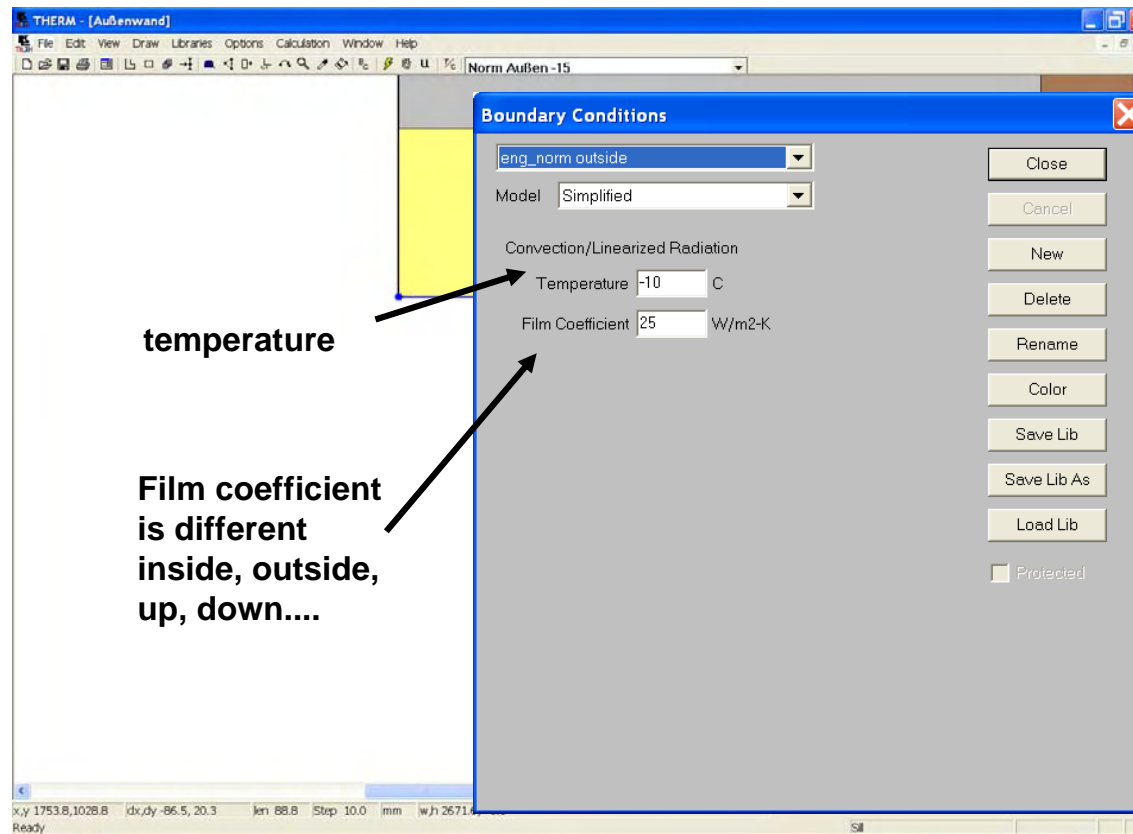
...cover the construction with material



Source:

# Working with THERM Inputs to THERM

**...define the boundary conditions**



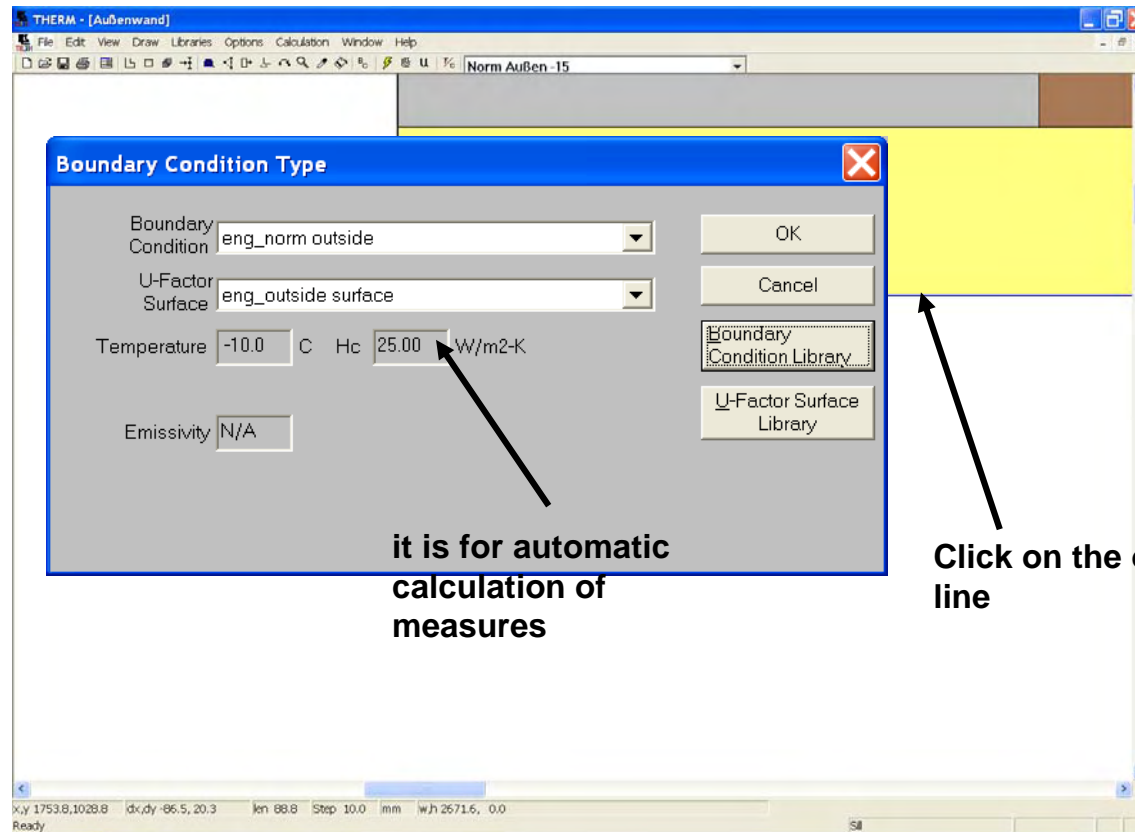
temperature

Film coefficient  
is different  
inside, outside,  
up, down....

Source:

# Working with THERM Inputs to THERM

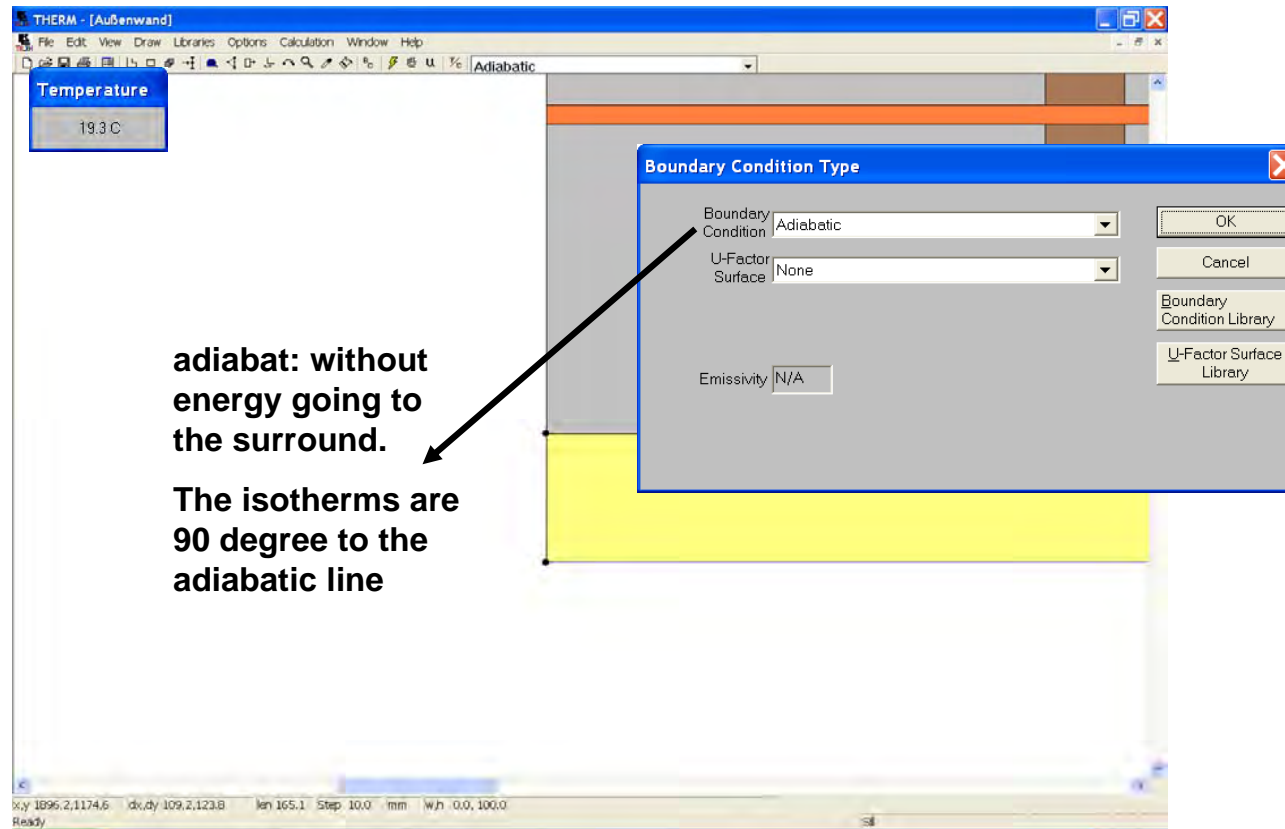
...now define the U-factor surface



Source:

# Working with THERM Inputs to THERM

...define the boundary conditions



Source:



# Working with THERM

## Inputs to THERM ...read the U- value

The screenshot shows the THERM software interface. A window titled 'U-Factors' displays the following data:

Surface	U-factor W/m <sup>2</sup> -K	delta T C
eng_inside surface	0.1036	30.0
eng_outside surface	0.1036	30.0

Below the table, the '% Error Energy Norm' is shown as 5.14%.

Another 'U-Factors' window is open, showing a more detailed view:

Surface	U-factor W/m <sup>2</sup> -K	delta T C	Length mm	Rotation
eng_inside surface	0.1033	30.0	2671.6	N/A
eng_outside surface	0.1033	30.0	2671.6	N/A

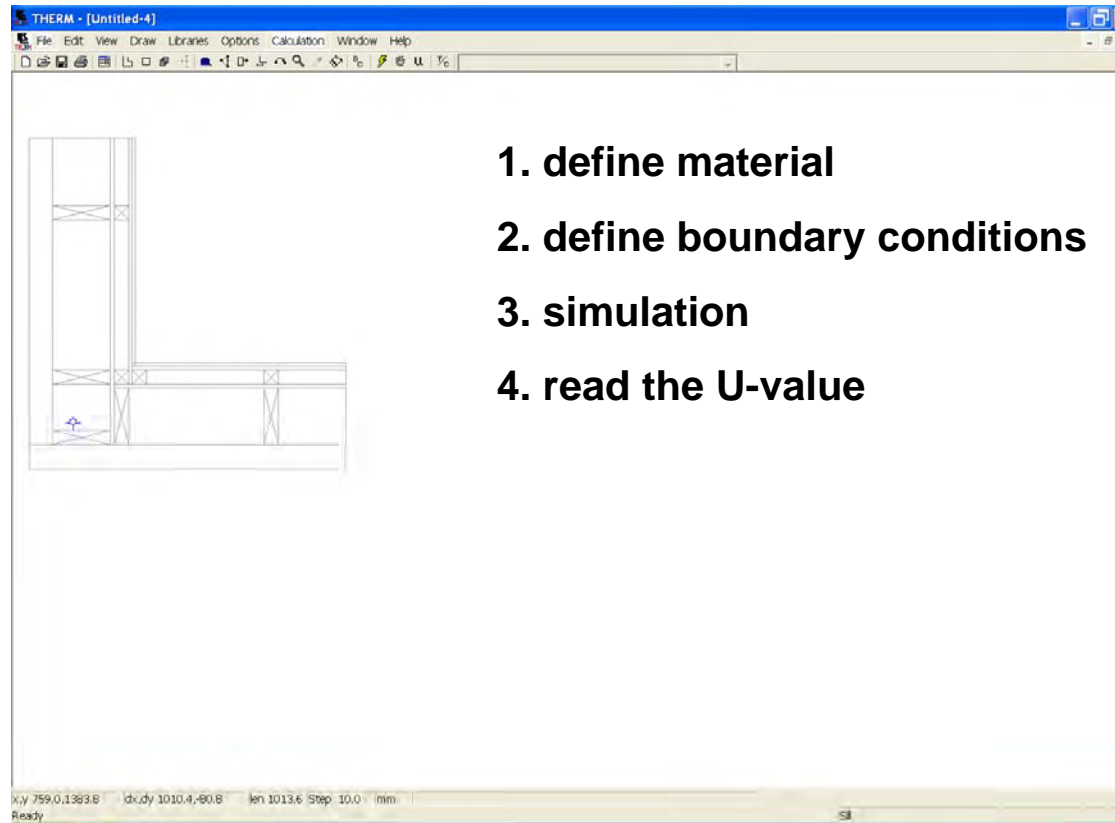
The '% Error Energy Norm' in this window is 2.23%, which is circled in red. The text 'put in the maximum of error' points to this value.

The 'Simulation' preferences window is also visible, showing 'Quad Tree Mesh Parameter' set to 8 (labeled 'measure of the grill'), 'Maximum % Error Energy Norm' set to 10 (labeled 'maximum error'), and 'Maximum Iterations' set to 5 (labeled 'number of iteration').

Source:

## Working with THERM Inputs to THERM

... now we are able to calculate the Psi-value of a corner



1. define material
2. define boundary conditions
3. simulation
4. read the U-value

Source:

## Working with THERM Inputs to THERM

...input the excel file linear-psi-value

Psi value		
U-Wert 1-dim	0,103	W/m2K
U-Wert 2-dim	0,084	W/m2K
length of construction	2,706	m
Q 1-dim	0,280	W/mK
Q 2-dim	0,227	W/mK
psi	-0,052	W/mK

$$\Psi = \frac{Q_{2Dim} - Q_{1Dim}}{I \times DJ}$$

simply

$$Q_{1Dim} = (I_1 \times h \times U_1 + I_2 \times h \times U_2) \times G_t$$

$$Q_{2Dim} = (I_1 \times h \times U_1 + I_2 \times h \times U_2 + h \times \Psi) \times G_t$$

precise

I: length of the termal bridge

DJ: difference of temperature inside outside

Q<sub>2Dim</sub>: stream of heat 2 dimensional (aus FEM)

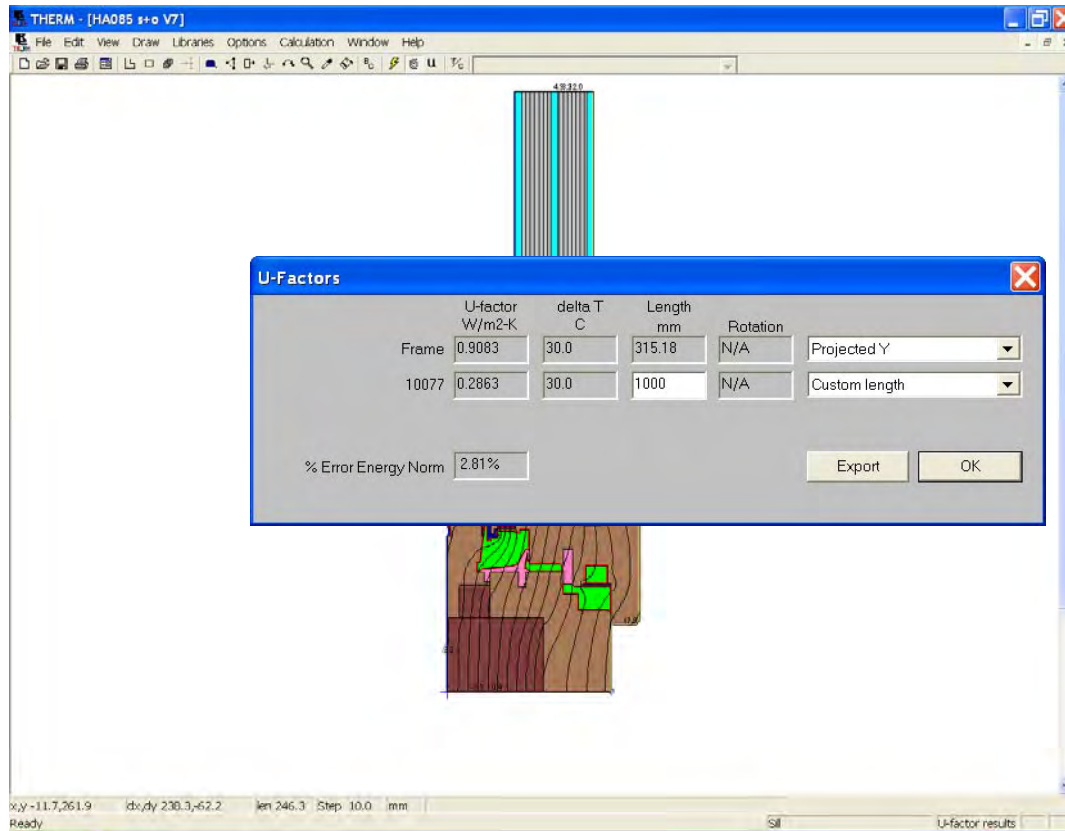
Q<sub>1Dim</sub>: stream of heat 1 dimensional (at an example out of PHPP)

Ψ: psi value (linear thermal bridge)

Source:

# Working with THERM Inputs to THERM

## A window example



Source: