

# SolarChimney tool and preliminary assessment of the Auroville Language Lab

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## **ABSTRACT**

*The task was to analyze and evaluate the air flow through the proposed natural ventilation system of earth ducts, shafts and solar chimneys in the Auroville Language Laboratory in India. The unfinished ventilation system of the building needs additional verification of the design presumptions, dimensions and guidelines, which was done using the Excel-based SolarChimney Tool developed by Peter Voit. Main questions of the task were the direction of the air flow in the system, as well as dimensions of shafts and solar chimneys. The weather data like temperature were measured and collected in December of 2019.*

*Before verifying the Auroville Language Laboratory measured data, the tool was still in the design phase; in order to enhance the tool, it was necessary to carry out the extensive research of basic principles and physics of the air flow and technology of earth ducts and solar chimneys. Redesign of the tool, its user interface and differentiation of steps and all the calculations were carried out as the result of the research. The final result is logical and user-friendly tool that can adjoin verification of similar tasks with confidence.*

*With the help of the tool, it is possible to determine the direction and strength of the air flow according to outdoor and indoor conditions, as well as the air flow rate through the system. Also, the tool is helpful with verifying and / or proposing the initial (but not definite) dimensions of the zones like shafts and solar chimneys.*

## **INTRODUCTION**

Airflow is a measurement of the amount of air per unit of time that flows through a particular zone.

Air flow in ventilated rooms can be divided into different isolated flow elements, such as infiltration or supply air jets. They are separate volumes defined by their own parameters with their air movement independent from the general flow in a hypothetical room.

Natural ventilation across the building is driven by the wind pressure and temperature differences.

## **METHODS TO CALCULATE AIR FLOWS**

There are two basic methods to calculate the air flows – *Flow Elements Models* and *Field Models*.

*Flow Element Models* are used to calculate and design the air distribution system in a normal size enclosure where a single flow element is dominant over the others in a room. In large scale enclosures more than one flow element can occur in different parts of the enclosure, making *Flow Elements Models* unable to completely calculate air distribution, although they are useful in first stages of the design process. In these enclosures, more detailed analytical tools called *Field Models* are used. Field Models are based on prediction of temperature, wind speed and other properties of the air flow through a system.

Furthermore, there are two main types of Field Models to calculate the air flow – macro models and micro models, based on the same principles. In both methods the enclosure is separated into smaller units (volumes or zones) in order to calculate the air flow for each zone using the laws of conservation

of energy, mass etc. Micro models use very small zones with presumed uniform conditions of the air flow in every zone. On the other side, Macro models use larger zones.

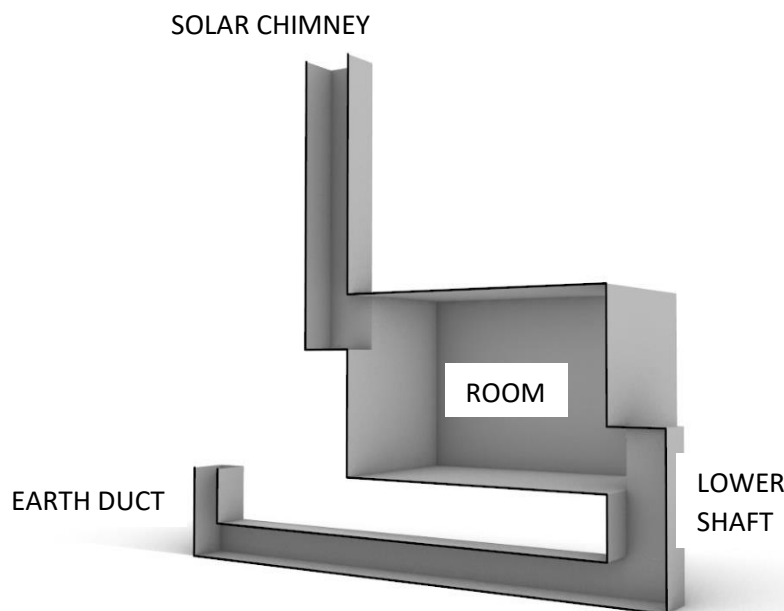
### TOOL INTRODUCTION

The purpose of real solar chimneys is to drive the air flow through the chain of rooms/zones inside the enclosure.

Driving force is the difference of pressure between inlet and outlet.

As long as there is no wind access to the openings, the weight difference of the air inside and outside is the driving force (buoyancy effect). The weight of the air (or density) is determined by the overall air pressure (typically around 100 000 Pa) and its humidity and temperature. The density (as a result of these parameter) determines the weight and the driving force.

Difference in density between indoor and outdoor moves the air, but the air flow is also dependent on the volumes and dimensions of the zones.



*Abbildung 1 Simplified 3D model of the earth duct and solar chimney ventilation system*

SolarChimney is a Microsoft Excel based tool that calculates the generalized air flow through simplified and basic zones of the model enclosure, with all zones connected in a chain. Purpose of the tool is to estimate the amount and the direction of airflow through the system (enclosure).

For simplicity reason, the tool doesn't consider the air humidity in detail but just the density of air at a certain volume. Determination of density is conducted through a linear regression based on temperature and a relative humidity of 50%.

With the SolarChimney tool, it is possible to analyze conditions of every particular zone like pressure, air temperature, etc. Therefore, the tool could be explained as a simple, two-dimensional type of a physical macro model for analyzing the airflow.

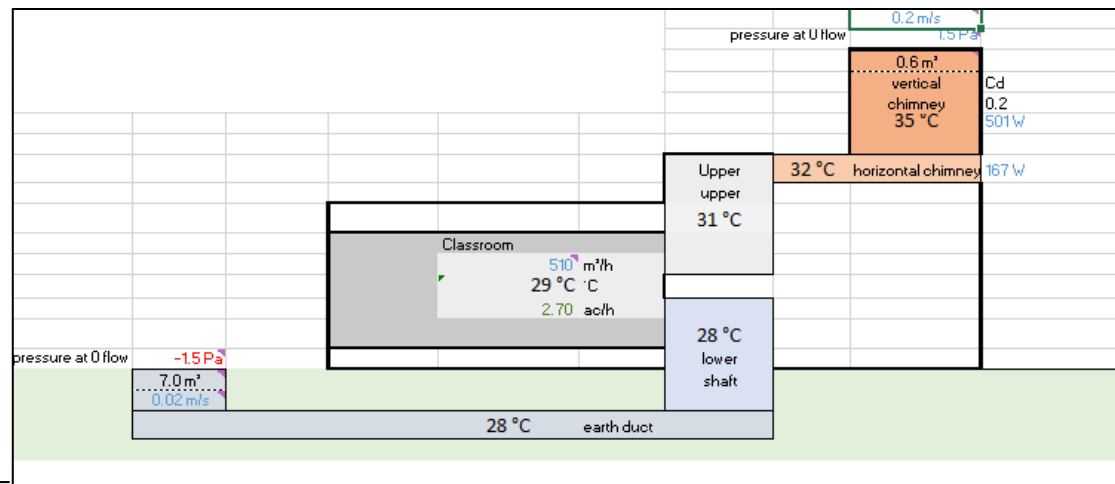


Abbildung 2: Simplified 2D model of the system in an enclosure with input values (black) and output values (blue)

Presumption of the tool is that the system is closed and tightly sealed, with only two openings per zone - air inlet and air outlet.

Also, all the conditions are chosen conditions in a particular chosen point in time, hence it describes the conditions during a snapshot. It does not calculate real or possible influence between the volumes (for example, change of temperature of the walls during the day is not taken into account).

The tool is based on the coupled interdependent equations for mass, pressure and other physical properties and conditions in and around the enclosure. All the equations are colored-coded in black (input values) and blue (output values) colors. Air flow is analyzed and calculated through the input of chosen conditions values into equations for mass, temperature, etc., not the real and measured air movement(s) inside the enclosure.

When there is air movement (wind) outside of the system, then the driving force of the air flow inside similar systems is the dynamic air pressure difference at the openings, caused by the air velocity and air density:

$$q = \rho \cdot u^2 / 2$$

Just for reason of comparison you can also calculate the pressure caused by wind.

As the tool presumes a tightly sealed and closed system, outdoor air velocity was not taken into account, as well as humidity. In addition to the driving force of the air flow in the tool system, a mass difference of air between rooms (zones) as the mass is influenced by indoor air temperature in the zone and density of air at zone's temperature is:

$$m = \rho \cdot V$$

## TOOL DESCRIPTION

The tool is visually organized into input, output and results data, represented by colors. Explanations of all the values can be seen when moving a mouse across the value.

Input data are colored **black**, and it represents measured indoor and outdoor climate conditions on site as well as the geometry of the building. In the tool, input data is located in the first excel chart named Table 1 Input Data. All the input data is also linked to and shown on the reference sketch of the system (enclosure), in order to visualize the overall conditions in every zone of the system. Input data is further divided into Input of indoor data, Input of outdoor data and Input of additional data.

TABLE 1 INPUT DATA				TABLE 2 OUTPUT DATA			TABLE 3 RESULTS DATA		
T1.1 INPUT INDOOR DATA				T2.1 OUTPUT INDOOR DATA			T3.1 RESULTS DATA		
ZONE	HEIGHT m	CROSS-SECTION AREA m²	TEMPERATURE °C	AIR VOLUME m³	AIR DENSITY kg/m³	AIR MASS kg	AIR FLOW DIRECTION	VALUE	UNIT
VERTICAL CHIMNEY	3.10	1.6	35 °C	4.56	1.185	5.40			
HORIZONTAL CHIMNEY	1.00	1.6	32 °C	1.6	1.1816	1.89		516.18	kg
UPPER SHAFT	1.00	1.6	31 °C	1.6	1.1853	1.90		516.44	kg
ROOM	3.25	58	29 °C	188.3	1.1743	221.33			
LOWER SHAFT	0.63	0.77	23 °C	0.48	1.1745	0.57			
EARTH DUCT	3.00	711	29 °C	213.3	1.1762	250.97			
INLET	2.00	9.66	28 °C	18.70	1.1778	23.23			
RESULT	18.528	144.63	28.53	439.79128	1.1744	516.48			
T1.2 INPUT OUTDOOR DATA				T2.2 OUTPUT OUTDOOR DATA			T3.2 RESULTS DATA		
	VALUE	UNIT		VALUE	UNIT				
WIND VELOCITY	0.5 m/s	m/s	AIR PRESSURE	0.1 Pa	Pa	AIR CHANGE RATE LW	1.159	1/h	
TEMPERATURE	28 °C	°C	AIR DENSITY	1.1782	kg/m³	VOLUME FLOW RATE	529.81	m³/h	
T1.3 INPUT ADDITIONAL DATA				T2.3 OUTPUT ADDITIONAL DATA			T3.3 RESULTS DATA		
	VALUE	UNIT		VALUE	UNIT				
INLET AREA	7.0 m²	m²	AIR V2	0.0091	m³	ARCHIVE RATE-ZONE	2.70	1/h	
OUTLET AREA	0.6 m²	m²	Δ TEMPERATURE	0.55	K	MASS FLOW RATE	0.17	m³/s	
FLOW FACTOR	0.7					REQUIRED HEAT FLOW Q	850	W	
						PRESSURE DIFFERENCE	870	Pa	

Abbildung 3 Input, Output and Results tables

Output data is mostly colored **blue**, and it represents calculations of input conditions and geometry of the zones. In the tool, output data are located in the second Excel chart named Table 2 Output Data. Output data are data that is calculated directly from the values of the Input data and is needed for the third table – calculating the Results data. Results data are located in the third excel sheet named Table 3 Results data and is also colored **blue**. Two most important result values are colored

FLOW DIRECTION - Δ MASS	1.68 kg
AIR CHANGE RATE LW	1.159 1/h
$LW \left[ \frac{1}{h} \right] = 3600 \frac{Cd \cdot A}{V} \cdot \sqrt{9.81 \cdot H \cdot \Delta \theta / 600} \cdot 1/0,7$	

Abbildung 4 Final results of the Volume flow direction (mass) and Air change rate calculations steps colored orange

**orange** to emphasize they are the result we are looking for (Δ Mass and Air change rate). There are results values that can be colored **red** (pressure) if the value of calculation is negative, indicating the airflow goes into opposite (negative) direction. This result can be seen on the Reference sketch and is positioned on the inlet and outlet of the enclosure.

First three tables are interdependent and follow each other in an order. They are needed for the calculations of the result values we need (Abbildung 4). On the right, tables are followed by two additional parts – Supplementary table of output data and two reference sketches of a simplified system in an enclosure.

A table with supplementary output data is output data that is useful for additional checkup and

better understanding of the system. This table also allows possible additions to the tool in the future. Reference sketches of the model are useful for better understanding and overview of the conditions and geometry of the system (enclosure). Some output data is also located in the reference sketch. Bellow all the tables is a chart of variants. It is only a data reminder for the user about the conditions in variants.

SUPPLEMENTARY OUTPUT DATA										ZONE
GENERAL OUTPUT INDOOR DATA									TRIAL - OUTPUT INDOOR	
Temp. Diff	Heat Flow	mass flow rate	volume flow rate	speed vertical flow	pressure diff	density outdoor	mass diff	pressure on ceiling		
K	kw	kg/s	m <sup>3</sup> /h	m/s	Pa	kg/m <sup>3</sup>	kg	Pa		
3.0K	0.501	0.17	533.89	0.09	3.978	1.1782	0.42	2.99		VERTICAL CHIMNEY
1.0K	0.167	0.17	516.33	0.09	1.005	1.1782	0.03	0.16		HORIZONTAL CHIMNEY
2.0K	0.33	0.17	513.51	0.09	2.010	1.1782	0.02	0.12		UPPER SHAFT
0.1K	0.02	0.17	509.93	0.09	401	1.1782	0.77	0.10		ROOM
0.4K	0.07	0.17	503.75	0.18	402	1.1782	0.00	0.03		LOWER SHAFT
0.4K	0.07	0.17	503.04	0.00	402	1.1782	0.44	0.00		EARTH DUCT
0.1K	0.02	0.17	508.33	0.01	101	1.1782	0.01	0.00		INLET
7.0K	1.17	0.17	509.61		7.735		1.88	2.00		RESULT

Abbildung 5 Supplementary output data table

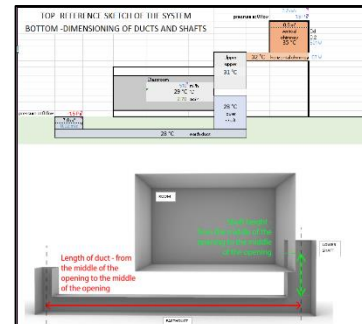


Abbildung 6 Reference sketches

## USING THE TOOL

The workflow of calculating the air flow through the system (enclosure) is organised in three steps:

- 1) Defining the air flow direction
- 2) Defining the air flow strength
- 3) Volume Flow calculation.

### 1 Defining the air flow direction

First step is calculated using the first three tables. Air flow direction result appears in the Table 3 results data.

Table 1 can be divided into *Input of outdoor conditions data*, *Input of indoor conditions data* and *Input additional data*. Those values help us to calculate the output data in the Table 2 and Results in the Table 3.

*Input indoor data* are Indoor air temperature, Height and Area (dimensions) of every zone. We need those parameters to calculate the Density, Volume and Mass for each of the zones. Those are called *Output Indoor data (Table 2 Output data)*.

Temperatures of the zones in the tool can be defined in Table 1 and are also linked to the reference sketch of the system for each room separately. The tool assumes the temperature is the same in all parts of the zone, without temperature height stratification or changes caused by radiation or convection on the contact with different surfaces. Free convection flow, happening when air heats up or cools down because of the difference in temperature of air and a touching surface, is therefore not taken into account. Dimensions and volumes of the zones can be defined in the same Table, right next to the column for temperature. Density and volume of each zone help us to calculate the masses of air volume for every zone. Addition of all masses of all zones in the building is called the Real Mass of air volume.

*Input outdoor data* are Outdoor air velocity and Outdoor air temperature.

Outdoor air velocity helps us to calculate the Outdoor air pressure (equation above), and Outdoor air temperature helps us to calculate the Outdoor air density. Those two values are *Outdoor output data*. (Table 2 Output data).

1_2 INPUT OUTDOOR DATA			2_2 OUTPUT OUTDOOR DATA		
	VALUE	UNIT		VALUE	UNIT
WIND VELOCITY	0.5 m/s	m/s	AIR PRESSURE	0.1 Pa	Pa
TEMPERATURE	28 °C	°C	AIR DENSITY	1.1782	kg/m <sup>3</sup>

Abbildung 7 Outdoor data

Outdoor air temperature is crucial, since it is the reference and also helps us to calculate the Theoretical Mass of air volume between building's inlet and outlet. Theoretical Mass of air volume is the whole mass of air that is presumably contained in the enclosure and is defined by the Outdoor air temperature and entire volume of the model building. With theoretical mass we presume the air density and temperature in the building are the same as outside.

Difference between the Real and Theoretical Mass of the air volume gives the  $\Delta$ mass, which can be explained as the strength of impact of the air flow to the outlet. It is located in the Table 3 Results data.  $\Delta$ mass tells us what the flow direction is. If  $\Delta$ mass is negative, real air in the system is heavier so it falls to the lower parts (air goes to the opposite direction than wanted. If  $\Delta$ mass is positive, real air is lighter, so it lifts up air goes in the direction as wanted). In this step, we defined the direction of the air flow:

$$\Delta\text{mass} = m_{(\text{Theor.})} - m_{(\text{Real})}$$

TABLE 3 RESULTS DATA		
AIR FLOW DIRECTION		
	VALUE	UNIT
THEOR. MASS	518.13	kg
REAL MASS	516.44	kg
FLOW DIRECTION - $\Delta$ MASS	1.68	kg

Abbildung 8 Defining the air flow direction

### Correlation between zones dimensions and Output Indoor data

*Input Indoor* data are Height, Area and Temperatures in the zones

*Output Indoor* data are Volume, Density and Mass.

Zero line ("0" line) is the ground level or more precisely: the height level of the lower opening of the total system. Below this line are earth ducts, while the rest of the building is above. While calculating the height of zones, all the parts of zones above the Zero line have positive values, and all the parts below ground have negative values. It is so because of the direction of the air flow – when air is pulled up, flow direction value is positive, and if it is pushed down, flow mass direction is negative. Height difference is also one of the drivers of air flow because it affects volume and therefore mass. Negative values are needed for calculating the height difference for the volume flow calculation in

the step 3 but are ignored for the calculation of volume as the temperature is the same throughout the entire duct.

Zero line ("0" line) exists in cases when earth ducts are directly under the ground floor as well as cases when they are deeper underground.

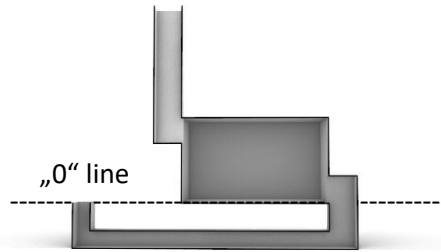


Abbildung 9 Schematic of the "0" line, or the ground line

Volume flow direction can be additionally evaluated in the Supplementary output data table and the reference sketch with the value of the pressure on the ceiling ("Pressure at 0 flow"). Pressure at 0 flow is the pressure of air on an imagined ceiling of the outlet (pressure of air inside the vertical chimney that would press the closed opening of the outlet). Negative (red) value means that the air is entering the solar chimney outlet. Positive (blue) value means that the air is exiting the solar chimney outlet.

## 2 Defining the air flow strength

Knowing the direction of air flow through the system, next step is determining the resistance to the airflow.

1_3 INPUT ADDITIONAL DATA		
	VALUE	UNIT
INLET AREA	7.0 m <sup>2</sup>	m <sup>2</sup>
OUTLET AREA	0.6 m <sup>2</sup>	m <sup>2</sup>
FLOW FACTOR Cd	0.2	

Abbildung 10 Defining the air flow strength - Flow factor in a table 1-3 Input Additional data

Airflow resistance is defined as the opposition to flow caused by the forces of friction. Lower resistance means stronger air flow. Aerodynamic flow factor (Cd) shows the level of resistance. If the Factor = 1, it is an ideal theoretical situation where there is no resistance (the air flows without any bounds). Resistance depends on a surface around the airflow; if there are more surfaces or angles in the system the air flows through, there will be more resistance. Bigger resistance affects the airflow strength, making it closer to the factor value 0. Usually, in systems, factor value between 0.7 and 0.85 are considered as very little to no resistance. Here the only significant flow resistances are the openings. Hence factor 0.85 might be applied at natural window ventilation of a room without any additional shafts (volumes).

In the tool, Aerodynamic flow factor can be defined in the Table 1 Input data under the Input additional data. The Factor value is an estimation because the tool doesn't provide information about real resistances on inlets and outlets between the zones. It is a predefined value according to the geometry of the system which (ideally) has to be calculated separately from the tool. It is also a geometrical property, meaning that it doesn't change with the temperature. If we want to put in the real value, additional inspection of all resistances on all openings in the system should be carried out.

The Aerodynamic flow factor will be needed in the next step to calculate the Air change rate.

### 3 Volume Flow calculation

In this step, we calculate the results of the air flow in the Table 3 results data. Results of this step describe what happens in total system. Values calculated in this step are the Air change rate, Volume flow rate, Air change rate for the zone we are analyzing (the particular room), Mass flow rate and Required heat flow.

Below is the equation for the air change rate (LW):

$$LW \left[ \frac{1}{h} \right] = 3600 \frac{Cd \cdot A}{V} \sqrt{9.81 \cdot H \cdot \Delta T / 600} * 1/0,7$$

LW = Air change rate, related to the total system volume. Air change rate is a measure of the air volume added to or removed from a space (normally a room) divided by the volume of the space.

Cd = Aerodynamic flow factor, result of a more complex physical and practical calculation

Cd<sub>optimal</sub> = 0.7 = value considered optimal for the low air flow resistance

Gravity factor g = 9.81 m/s<sup>2</sup>

H = height difference between inlet and outlet opening. Negative values have to be calculated.

A = Opening area of the outlet or inlet, or combined opening area of all outlets or inlets if there are more than one in the system.

V = SUM - Total air volume of the system

ΔT = difference between outdoor temperature and weighted average of temperatures of all the zones in the system

600 K = the rough estimate of the outside air temperature times two in K. The equation is as follows:

$$600 \text{ K} \approx 586 \text{ K} = 293 \text{ K} * (1+(A1^2/A2^2))$$

where 293 K is the outdoor air temperature in Kelvins, A1 is the opening area of the outlet and the A2 is the opening area of the inlet.

With the result for air change rate in the system and knowing the sum of the volumes of the zones, it is possible to calculate the Volume flow rate of the system. Volume flow rate is the volume of fluid which passes per unit time; usually represented by the symbol Q (sometimes  $\dot{V}$ ). The equation is:

$$V_{\text{flowrate}} = LW * V_{\text{sum}}$$

Now, the Air change rate of the room can be calculated by dividing the room (zone) volume from the overall volume flow rate of the system:

$$Ac/h = V_{\text{flowrate}} / V$$

Volume flow rate of the system can also be calculated by division of mass flow rate and density:

$$V_{\text{flow}} = m_{\text{flowrate}} / \rho * 3600$$



Mass flow rate is the amount of a substance which passes per unit of time. Mass flow rate can be calculated by dividing the Volume flow rate  $V_{flow}$  and multiplication of density  $\rho$  with particular time (usually, 3600 seconds), according to the equation above. But it can also be calculated by multiplication of the temperature difference between solar chimney to outside air and the heat flow, divided with the Heat capacity of air value of 1.005 kJ/kg:

$$m_{flowrate} = (\Delta T_{chimney/air} * Q) / C_p$$

Heat flow or Heat transfer  $Q$  is the theoretical amount of energy (in watts) needed in the ducts to increase the air temperature. According to the equation above, it can be calculated:

$$Q = \Delta T_{chimney/air} * C_p * m_{flowrate}$$

VOLUME FLOW CALCULATION		
	VALUE	UNIT
AIR CHANGE RATE LW	1.159	1/h
$LW \left[ \frac{1}{h} \right] = 3600 \frac{Cd \cdot A}{V} \sqrt{9.81 \cdot H \cdot \Delta \theta / 600} \cdot 1/0,7$		
VOLUME FLOW RATE	509.81	m <sup>3</sup> /h
AIR CHANGE RATE - ZONE	2.70	ac/h
MASS FLOW RATE	0.17	m (kg/s)
REQUIRED HEAT FLOW Q	154	W

Abbildung 11 Volume flow calculation chart

## DATA EVALUATION

The tool was tested using the real measured conditions and TRNFLOW data. Data were measured on site in the Language Laboratory building in Auroville, India, except the solar chimney temperature which was extrapolated from TRNSYS. Room chosen to be analyzed is the Indian language classroom, as it is one of the most used rooms in the building. As building is almost finished, some zones dimensions are predetermined (earth ducts, the Room). Dimensions of the unfinished solar chimneys are proposed in initial design and should be evaluated with the tool. Data were evaluated for December 21<sup>st</sup>. Highest temperature of the day is at 13:00 h. Wind velocity was always 0.5 m/s in order to have a more stable and predictive system to analyze.

### December 31<sup>st</sup> conditions

#### AIR TEMPERATURES

Ambient: 28.78°C  
 Solar chimney: 27.95°C  
 Room indian class: 27.49°C  
 Shaft: 26.99°C  
 Earth duct: 26.67°C  
 Inlet: 26.14°C

#### DIMENSIONS OF ZONES height / area

Solar chimney: 9.00 m / 1.6 m<sup>2</sup>  
Room indian class: 3.25m / 58 m<sup>2</sup>  
Shaft: 0.63m / 0.77 m<sup>2</sup>  
Earth duct: 3.00m / 71.1 m<sup>2</sup>  
Inlet: 2.00m / 9.86 m<sup>2</sup>

Although the temperature difference between the zones is low, there is some air movement. The result of the  $\Delta_{\text{mass}}$  was negative (-3.11 kg), meaning that the air flows in opposite direction than intended. After enlarging any dimension (height, area or both) of any zone,  $\Delta_{\text{mass}}$  only slightly increased. That means that the geometry of the system and zones has an effect on the air flow in the system, but it is of secondary or lesser importance to the temperature difference. Addition of any new zone, like a horizontal chimney with medium temperature of the two neighboring zones temperatures had almost no effect at all (+0.01 kg). That shows that the larger temperature difference between zones is the main driving force of the airflow.

Next step was changing the air temperature of the ambient air and zones to examine the impact of it.

First, we have to analyze the correlation between the ambient air temperature and the air temperature of the most dominant volume – the Room. If we lower the ambient temperature slightly below than the Room zone air temperature (27.00°C),  $\Delta_{\text{mass}}$  value became slightly positive (+0.08 kg), meaning that the higher temperature in the most dominant volume of air drives the air from the earth duct up to the solar chimney. Volume of the Room zone air plays important role, as its amount makes it a significant factor of the air flow. In the variant where the Room zone temperature is lower than the ambient temperature, the air in the Room becomes stagnant as it is heavier and therefore stays on the lower level of the system. If the Room air temperature and ambient air temperature are the same, there will be no air movement because there would be no pressure difference.

Next step is to inspect the solar chimneys. Enlarging the solar chimney dimension ( $h=10$  m,  $A= 2$  m<sup>2</sup>) slightly increases the  $\Delta_{\text{mass}}$  (+0.10 kg), proving what was concluded in the previous paragraph. If the temperature in the chimney became lower than in the room,  $\Delta_{\text{mass}}$  value fell almost to the zero. If it became higher (29.00°C),  $\Delta_{\text{mass}}$  value also rose. This shows that, for the effectiveness of the system, it is important to have a gradual change of temperatures in every zone one after another. For the air to flow in a positive direction, lower temperatures have to be at the inlet, highest temperature should be at the outlet of the system, and the air temperature of the biggest zone has to be higher than the ambient air temperature.

This can be checked in the tool. If we keep the ambient air temperature at 27°C, increase the room air temperature to (for example) 29°C and the solar chimney air temperature to 30 °C, we achieved an increase in  $\Delta_{\text{mass}}$  of +1.39 kg.

Therefore, a chain of gradually increasing temperatures in zones is needed for the air flow. Bigger difference in air temperatures between zones means better flow. Also, the biggest air volume needs to have a higher temperature than the ambient air in order to have a flow in positive direction, leaving through the solar chimney outlet.

## **CONCLUSION**

Dimensions of the solar chimneys proposed in the original architectural project can cause the air flow, but a very small one and only at the right conditions.

To increase the air temperature inside the solar chimney, it is advisable to build it from highly thermally conductive materials like metals. Also, the Room air temperature shouldn't be too high in order to maintain the necessary comfort levels.

The solar chimney is a useful tool for initial analysis of the solar chimney system in the design phase. It is a good tool for dimensioning the building elements, and to give an impression what parts new building should contain to have a functional ventilation and cooling system. Although it is good as a reference, this tool is not designed or developed to give exact and precise dimensions and values. It should only be used as an initial analysis of the design phase for several reasons.

One is that it is based on presumptions and conditions of a closed system, where many factors are excluded. Air humidity, climate, impact of winds or thermal conduction are not considered. Other smaller or larger air flows that would in real situations interfere with the air flow in the system are excluded.

The tool proved that the proposed solar chimney dimensions could be beneficial to achieving the positive air flow through the building, but on a rather small scale. Larger dimensions of the chimneys show better results, but it is important to understand that the chain of gradually increasing temperatures through the zones is what drives the air flow.

The analysis of the tool was carried through the redesign of its layout. New, more user-friendly layout is considerably more informative and simpler to use. There is a big potential in further improving the tool, which can now be done more easily.