# User Manual

# EasyPipes Basic

(Pre-dimensioning tool for earth air tunnels)



Easy Pipes prepared by Dr. Pierre Hollmuller, University of Geneva

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# Preface

'EasyPipes Basic' is a tool developed by **Dr. Pierre Hollmuller, University of Geneva**, Switzerland for pre-dimensioning of earth air tunnels. Under the **Indo-Swiss Building Energy Efficiency Project (BEEP)**, a two day training programme on Earth Air Tunnel Design was organised in which Dr. Pierre Hollmuller, University of Geneva, Switzerland was the lead trainer. He has an extensive experience of designing and monitoring earth air tunnels. He has developed two tools – EasyPipes Basic (pre-dimensioning tool) and EasyPipes Plus (detailed dimensioning tool) for designing of earth air tunnels. Participants of the training programme were demonstrated how to use these tools and they were also provided with these tools for further use.

This user manual on EasyPipes Basic, developed by the BEEP project team, will help the professionals working on earth air tunnels in understanding and using this tool. In this manual all the steps involved are explained with the help of screen shots to make it user friendly.

# General Instructions

The 'EP.Basic' folder provided in the CD contains:

a. 'EP.Basic.xlsm' file – the excel based tool for pre-dimensioning of 'Earth Air Tunnels'.

b. 'Doc' folder – it contains a document on general description of the tool and the mathematical model on which it works.

c. 'Meteo' folder – it contains weather data files for 5 locations (Geneva, New Delhi, Jaipur, Bangalore and Mumbai).

**Copy the 'EP.Basic' folder from the CD and save it in the 'C drive' (the drive on which OS is installed) of your computer.**

# How to use the tool

## 1.1. Estimate air flow rate

First do a calculation to estimate the volume flow rate of air required to condition the space under consideration. This can be estimated based on the volume of the space to be conditioned and the required air change rate. (Air change rate for different categories of spaces/buildings can be found at National Building Code of India, 2005.)

*For example, if there is a building with 1000 $m^2$ area and 3 m height, and the air change rate recommended for this category of building is 3 ach, then the air flow rate would be 1000 x 3 x 3 = 9000 $m^3$/h.*

## 1.2. Select dimension of tunnels

For optimum performance of earth air tunnels, the velocity of air in the tunnels should be in accordance with the diameter of tunnels. The recommended range of velocity, for a diameter of 0.1-1.2 m, is 2-14 m/s (For larger pipes {0.6 m and above} the velocity should be 2-12 m/s and for smaller pipes it should be 1-4 m/s. For details, please refer to the nomographs provided with EasyPipes CD). The diameter of tunnels should be accordingly chosen. Length and the number of tunnels are constrained by the ground space available.

*For example, to meet the required flow rate of 9000 $m^3$/h, the following combination of velocity and diameter are possible:*

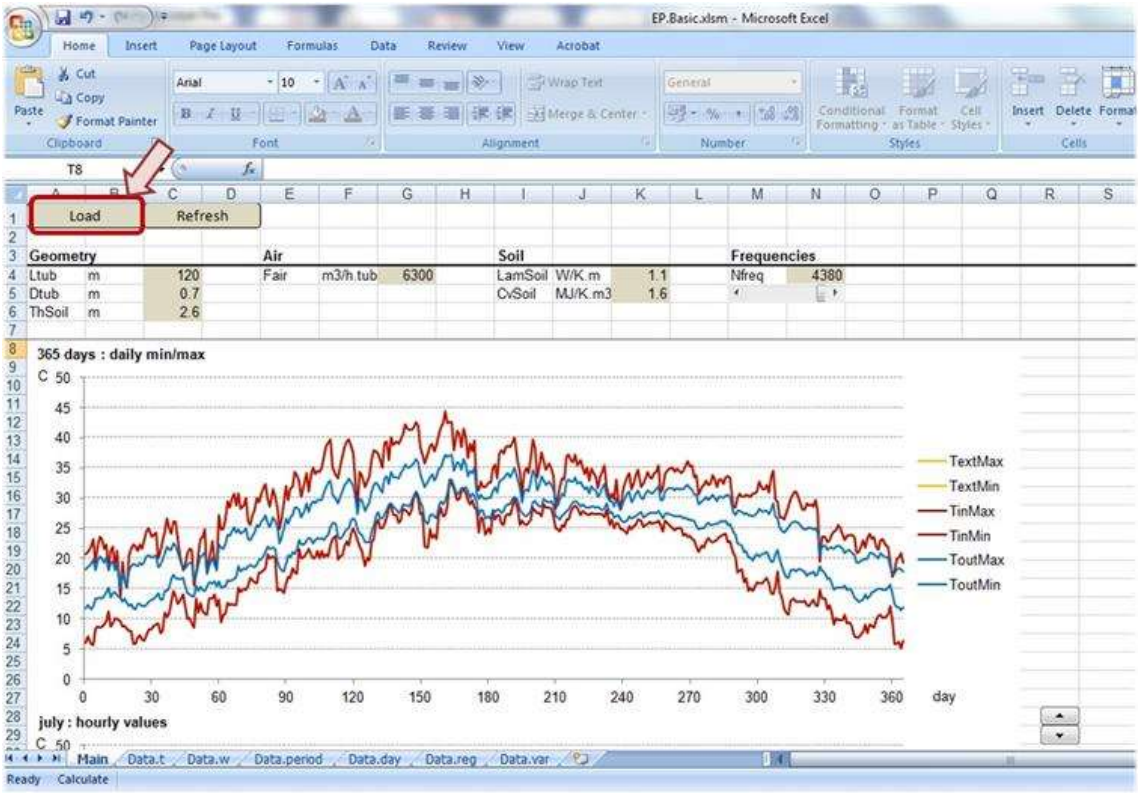
| *Diameter (m)* | *Calculated velocity (m/s)* | *Remarks* |
|---|---|---|
| *0.3* | *35.4* | *Not recommended as the velocity is beyond the recommended range. However, if ~10 pipes are used the velocity would fall within the recommended range.* |
| *0.7* | *6.5* | *Recommended.* |
| *1.0* | *3.2* | *Not recommended, as the velocity is below the recommended range given in nomograph.* |

## 1.3. Load weather data

Open the pre-dimensioning tool (EP.Basic.xlsm).

(*Upon opening the tool, a message will pop-up saying that the calculation has been set to "manual". It will set the calculation option as "manual" for other excel files also. This means the calculation results in other excel files will not automatically get updated. To set the calculation option to "automatic" mode, go to "Formula" tab and select "Calculation options" as "Automatic" via drop-down menu.*)

To load weather data, click on the 'load' button provided at top-left corner in the 'main' worksheet of the tool as shown below:



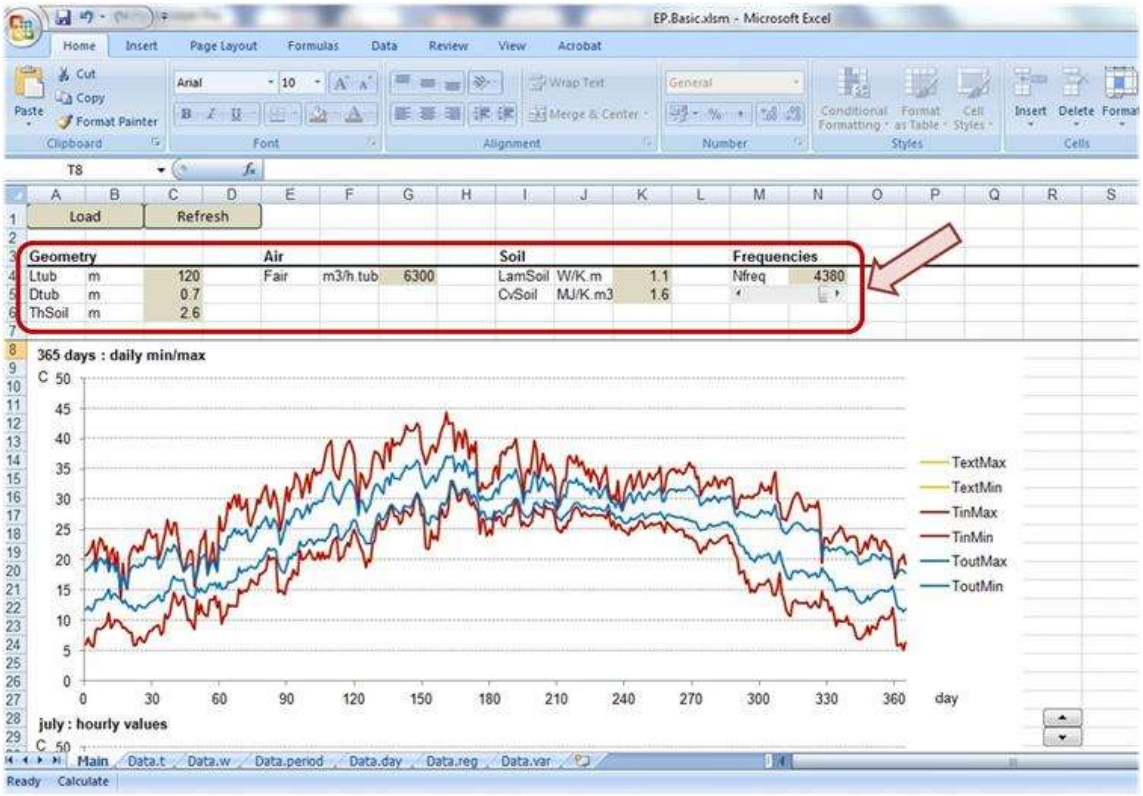

Upon clicking on the load button, specify the location of weather data file as

(EP.Basic →Meteo→Data) and select the weather data file for the specific location.

Weather data is provided for few locations only. Procedure to generate weather data for other locations is explained in **Annexure – I**.

## 1.4. Enter the values of input parameters

Input parameters are to be entered at top portion of the 'main' worksheet of tool as shown below:




Geometry:

***Ltub***: Enter the length of a single tunnel.

***Dtub***: Enter the diameter of the tunnel.

***ThSoil***: Enter the thickness of soil surrounding each tunnel. The recommended value is 2.6 m for annual dampening and 0.2 m for daily dampening.

Air:

$F_{air}$: Enter the volume flow rate of air through **one** tunnel.

Soil:

***LamSoil***: Enter the value of thermal conductivity of soil. (Typical values may vary from 0.6-2.0 W/m.K)

***CvSoil***: Enter the value of heat capacity of soil. (Typical values may vary from 1.5-3.0 $MJ/m^3.K$)

Frequencies:

***Nfreq***: This parameter is used to calculate the the air inlet temperature from the ambient air temperature. If the frequency is set to 4380, the tunnel inlet air temperature would be exactly same as ambient air temperature. However, a value of

100 and above can be used for quick calculations and near accurate results calculations.

Note: This tool is designed to do the calculation for a **single** tunnel. If an option of multiple tunnels has to be evaluated using this tool, then also values for geometry related parameters have to be entered for a single tunnel. Accordingly, the air flow rate (Fair) through a single tunnel is to be entered.

## 1.5. Simulation

Upon entering the input parameters, click on the 'Refresh' button at the top left corner of the 'Main' worksheet of the tool to perform the simulation.

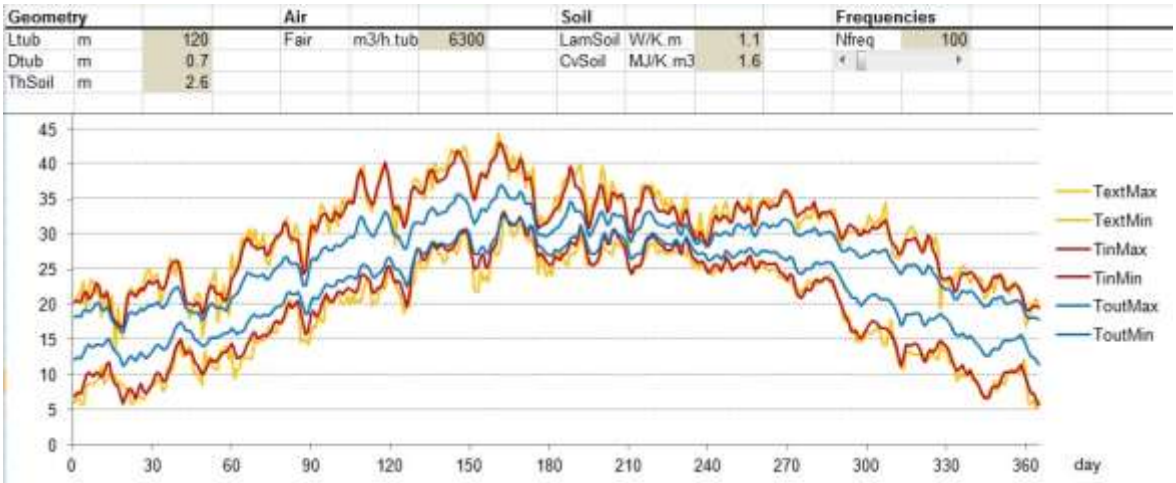
## 1.6. Results

### a. Graphs

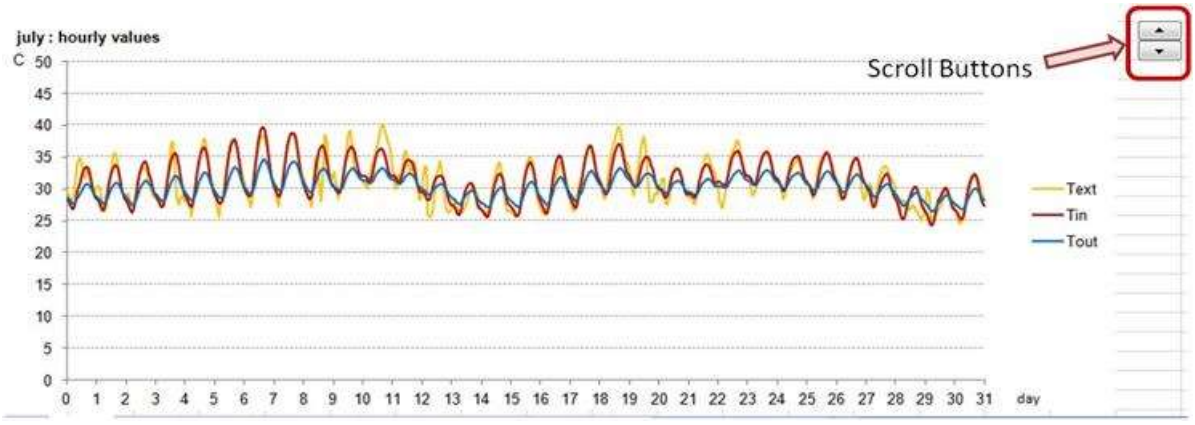
The first graph in the 'Main' worksheet of the tool depicts the annual performance of the tunnel. The yellow curves represent the daily minimum and maximum external temperatures (The data source can be found in columns 'D' & 'E' of worksheet "Data.day"). The red curves represent the daily minimum and maximum air inlet temperatures of the tunnel (The data source can be found in columns 'H' & 'I' of worksheet "Data.day").

(*Ideally the external temperature and the air inlet temperatures should be equal that is the yellow and red curves should coincide. This will happen when we enter the frequency value (Nfreq) as 4380 but this will increase the simulation time. So for pre-dimensioning purpose and for evaluating various options we may select the frequency value anything around 100 or above to reduce the simulation time which would be very approximate to the ideal case.*)

The blue curves represent the daily minimum and maximum air outlet temperatures of the tunnel (The data source can be found in columns 'M' & 'N' of worksheet "Data.day").



The second graph depicts the month-wise performance of the tunnel. The yellow, red and blue curves represent hourly variation of external temperature, air inlet temperature and air outlet temperature respectively for a particular month (The data source can be found in columns 'D', 'E' & 'F' of worksheet "Data.period"). The months can be selected by clicking on the scroll buttons provided at the top right corner of the graph as shown in the figure below:




## b. 'Data.t' worksheet

Hourly values of external temperature (Text), air inlet temperature (Tin) and air outlet temperature (Tout) are provided in this sheet for a year.

## c. 'Data.period' worksheet

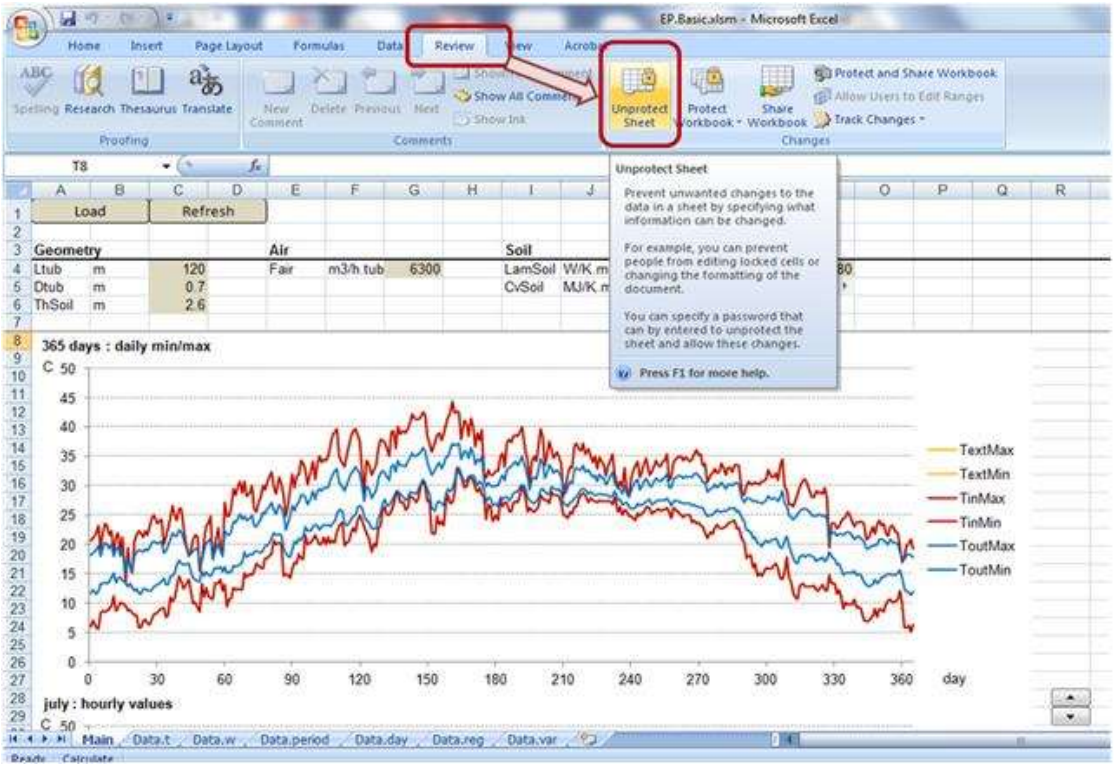
Hourly values of external temperature (Text), air inlet temperature (Tin) and air outlet temperature (Tout) are provided in this sheet for each day of a particular month. The month for which these data has to be extracted can be selected by the scroll buttons provided in the second graph in the 'Main' worksheet.

## d. Other worksheets

- Data.w & Data.reg: These worksheets are used to calculate intermediate parameters which are used in simulation.
- Data.var: This worksheet gives key thermal parameters calculated from the simulation.

Note: This excel based tool is protected and it will not allow making any changes in the sheet or copying the result's graph to be used for presenting the results or any other purposes. To do this, it is first required to unprotect the sheets. Care should be taken while working with the tool in unprotected mode and it should be protected again once the purpose is served.

To unprotect/protect the tool, go to review tab of the tool and click on 'unprotect sheet/ protect sheet' as shown below:



# Annexure – I

Procedure to generate weather data files (*.fourier.xlsm)

Weather data files for some of the prominent locations of India are available on EnergyPlus website. But these files are in *.epw format which has to be converted in *.fourier.xlsm format before it can be used in the EP.Basic tool. The procedure has been illustrated in the following steps:

## Steps

1. Download weather data for the required location from the following link (for India):

   http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data3.cfm/region=2_asia_wmo_region_2/country=IND/cname=India

   Now extract the .zip file in a folder. Extracted folder contains the *.epw file.

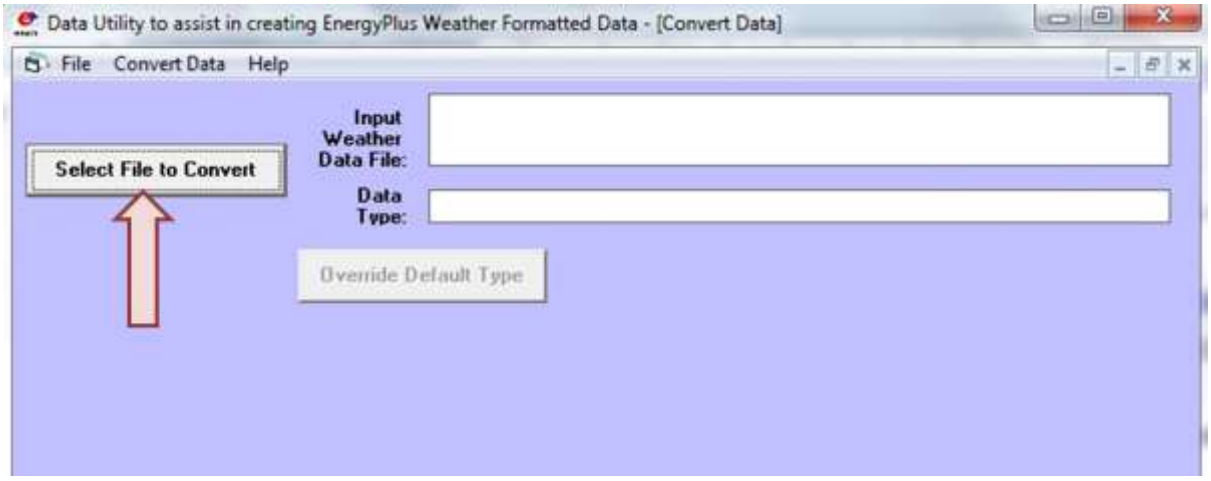
2. Now download EnergyPlus software and install it on your computer. It can be downloaded from the following link:

   http://apps1.eere.energy.gov/buildings/energyplus/register.cfm?goto=eplus

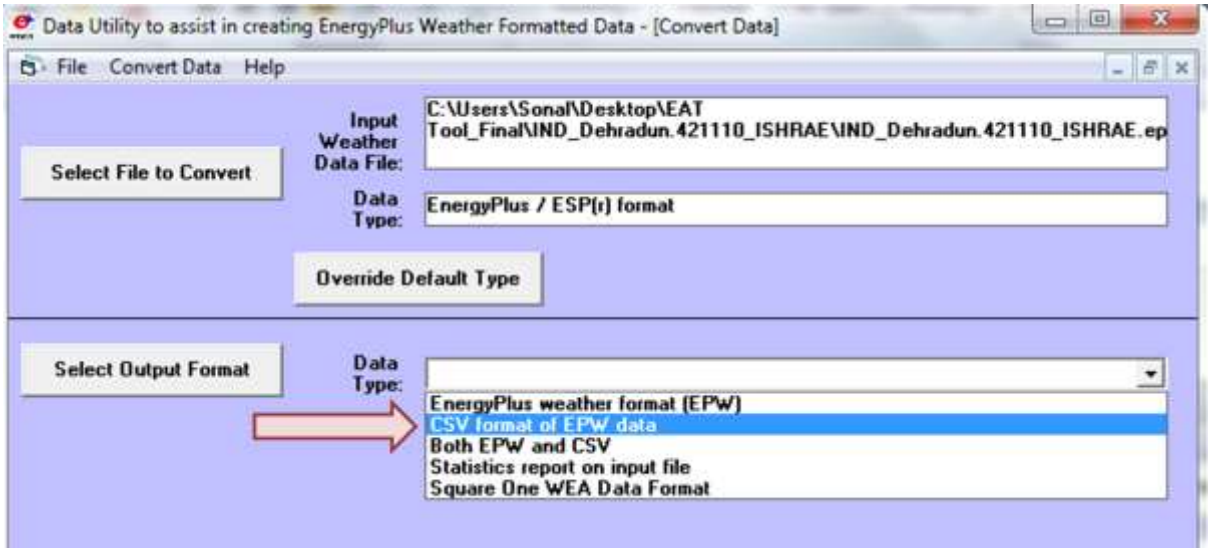
3. Now open the 'weather statistics and conversions' tool of the EnergyPlus software as shown below:

   START Menu → All Programs → EnergyPlus → Weather Statistics and Conversions

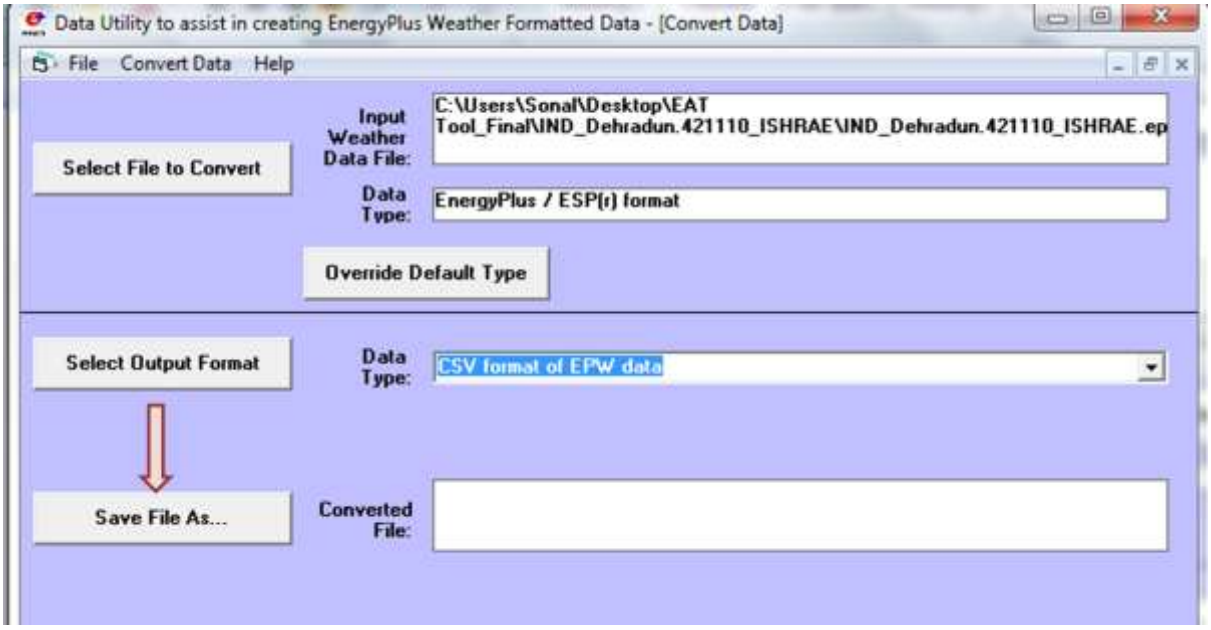
   Following window will come up:



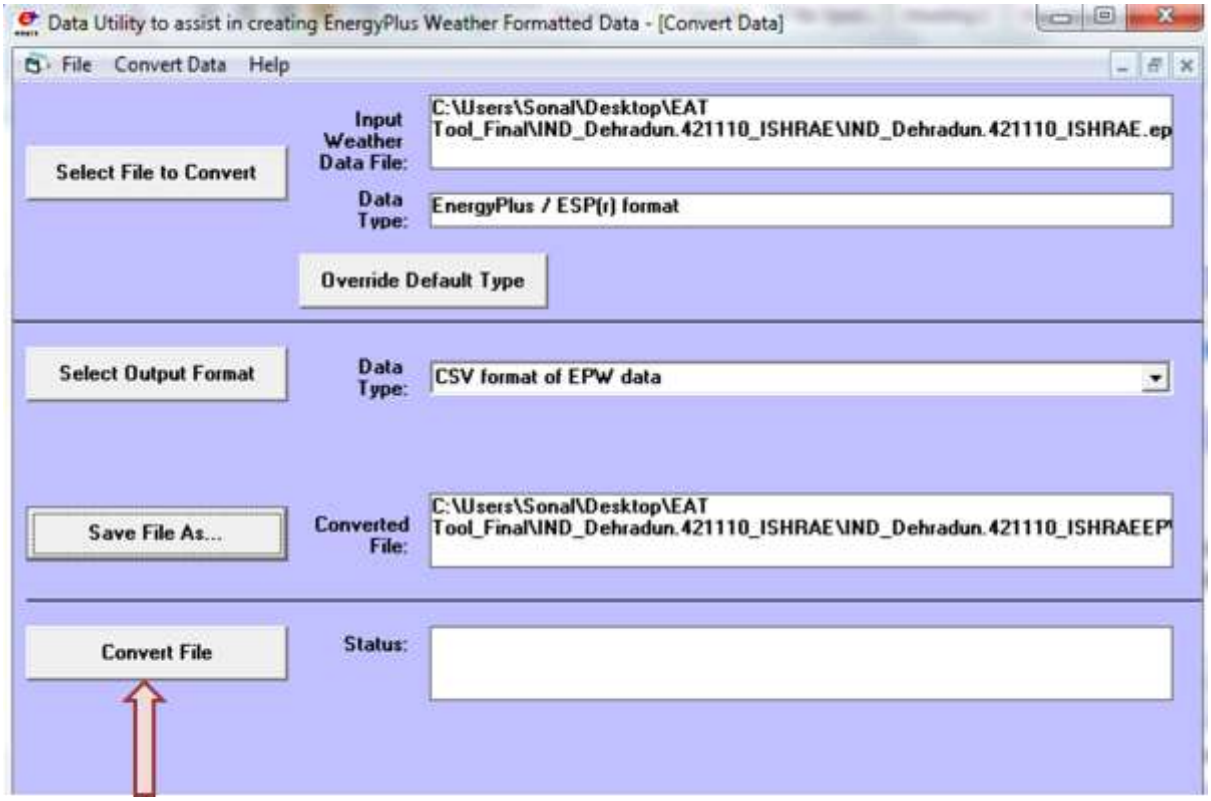

4. Now click on the 'Select File to Convert' as shown in the above figure and specify the path to locate the *.epw file. Now select the 'CSV format of EPW data' as the output format from the drop-down menu as shown below:




5. Click on ‘Save File As...’ tab as shown and specify the path of the location where the output data in *.csv format is desired to be saved.




Now click on ‘Convert File’ tab as shown below:

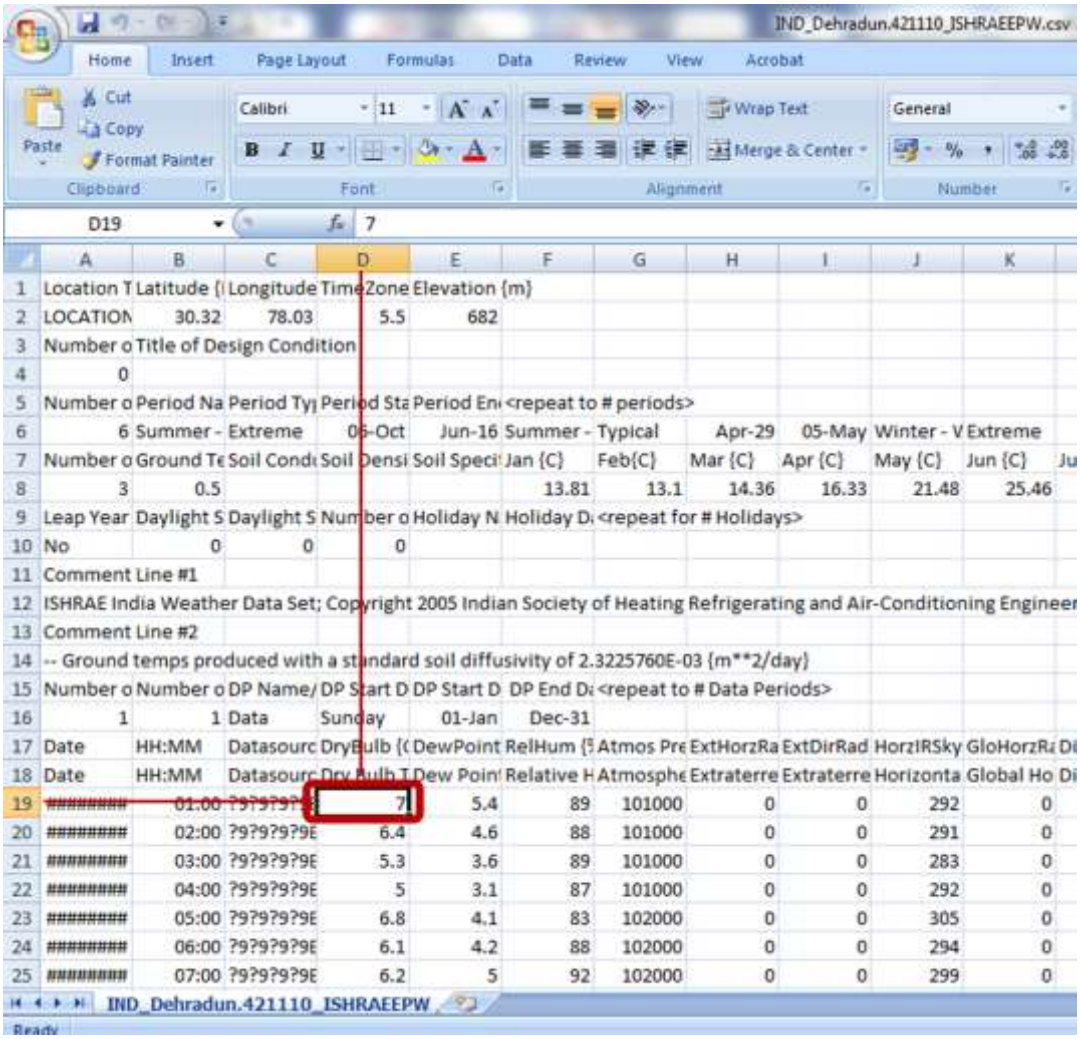



Click on 'Ok' when the conversion is complete and close the EnergyPlus tool. With this the weather data file has been converted from *.epw format to *.csv format.

6. Open 'MeteoFourier.xlsm' file from 'EP.Basic' folder. It is located at EP.Basic → Meteo → MeteoFourier.xlsm.

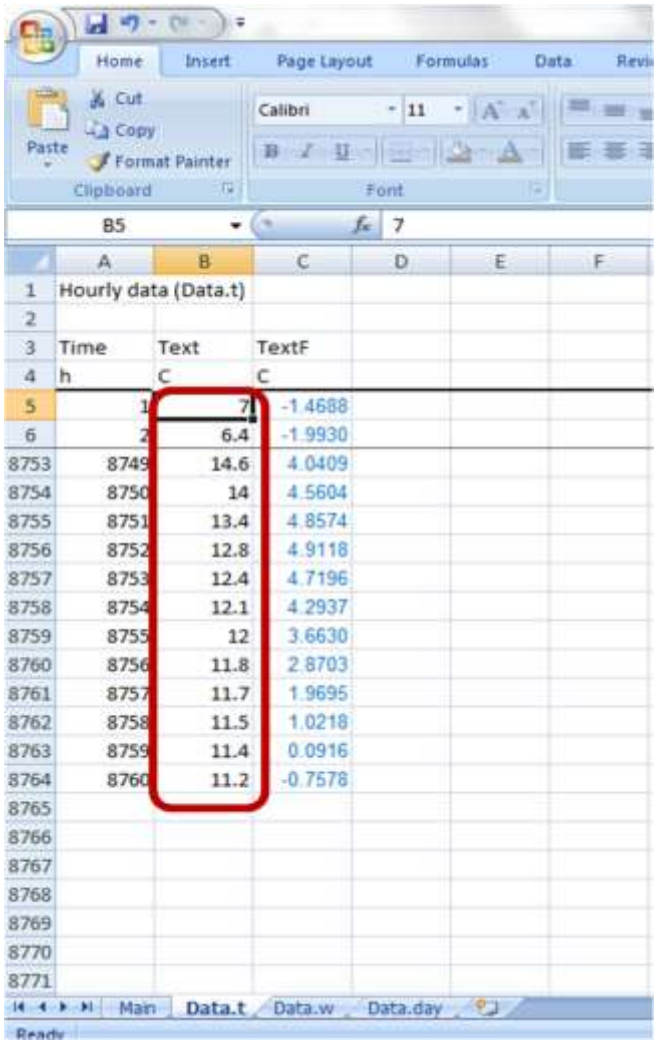
> Note: Make sure that EP.Basic folder is located on the same drive of your computer on which Operating System (OS) is installed (generally C-drive). Otherwise it may not work properly and there would be some error.

7. Open the weather data file generated in Step-5 in *.csv format. Now copy the 'Dry Bulb Temperature' data (from cells D19 – D8778) from this as shown below:

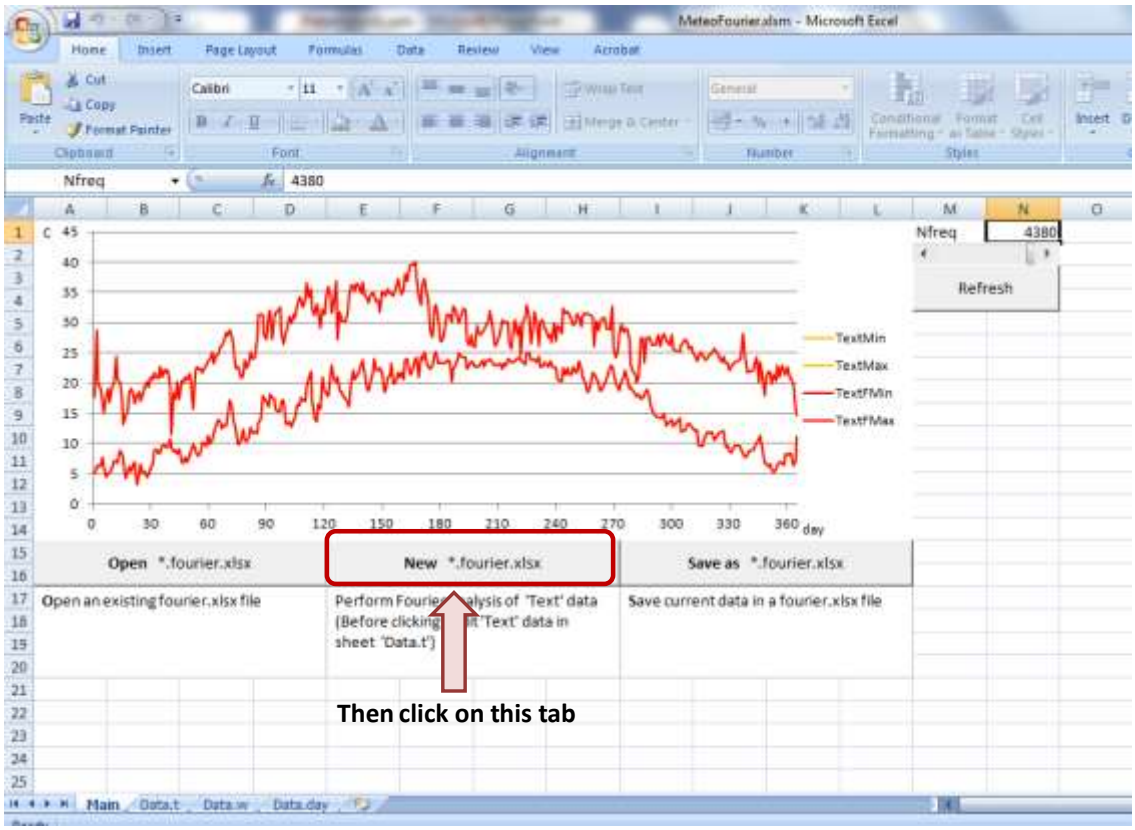



| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Location T | Latitude (I | Longitude | TimeZone | Elevation (m) | | | | | | |
| 2 | LOCATION | 30.32 | 78.03 | 5.5 | 682 | | | | | | |
| 3 | Number o | Title of Design Condition | | | | | | | | | |
| 4 | 0 | | | | | | | | | | |
| 5 | Number o | Period Na | Period Ty | Period Sta | Period En | <repeat to # periods> | | | | | |
| 6 | 6 | Summer - | Extreme | 06-Oct | Jun-16 | Summer - | Typical | Apr-29 | 05-May | Winter - V | Extreme |
| 7 | Number o | Ground Te | Soil Cond | Soil Densi | Soil Speci | Jan (C) | Feb(C) | Mar (C) | Apr (C) | May (C) | Jun (C) |
| 8 | 3 | 0.5 | | | | 13.81 | 13.1 | 14.36 | 16.33 | 21.48 | 25.46 |
| 9 | Leap Year | Daylight S | Daylight S | Number o | Holiday N | Holiday D | <repeat for # Holidays> | | | | |
| 10 | No | 0 | 0 | 0 | | | | | | | |
| 11 | Comment Line #1 | | | | | | | | | | |
| 12 | ISHRAE India Weather Data Set; Copyright 2005 Indian Society of Heating Refrigerating and Air-Conditioning Engineer | | | | | | | | | | |
| 13 | Comment Line #2 | | | | | | | | | | |
| 14 | -- Ground temps produced with a standard soil diffusivity of 2.3225760E-03 (m**2/day) | | | | | | | | | | |
| 15 | Number o | Number o | DP Name/ | DP Start D | DP Start D | DP End Da | <repeat to # Data Periods> | | | | |
| 16 | 1 | 1 | Data | Sunday | 01-Jan | Dec-31 | | | | | |
| 17 | Date | HH:MM | Datasourc | DryBulb (C | DewPoint | RelHum (% | Atmos Pre | ExtHorzRa | ExtDirRad | HorzIRSky | GloHorzRa |
| 18 | Date | HH:MM | Datasourc | Dry Bulb T | Dew Point | Relative H | Atmosphe | Extraterre | Extraterre | Horizonta | Global Ho |
| 19 | ######## | 01:00 | ?9?9?9?9 | 7 | 5.4 | 89 | 101000 | 0 | 0 | 292 | 0 |
| 20 | ######## | 02:00 | ?9?9?9?9E | 6.4 | 4.6 | 88 | 101000 | 0 | 0 | 291 | 0 |
| 21 | ######## | 03:00 | ?9?9?9?9E | 5.3 | 3.6 | 89 | 101000 | 0 | 0 | 283 | 0 |
| 22 | ######## | 04:00 | ?9?9?9?9E | 5 | 3.1 | 87 | 101000 | 0 | 0 | 292 | 0 |
| 23 | ######## | 05:00 | ?9?9?9?9E | 6.8 | 4.1 | 83 | 102000 | 0 | 0 | 305 | 0 |
| 24 | ######## | 06:00 | ?9?9?9?9E | 6.1 | 4.2 | 88 | 102000 | 0 | 0 | 294 | 0 |
| 25 | ######## | 07:00 | ?9?9?9?9E | 6.2 | 5 | 92 | 102000 | 0 | 0 | 299 | 0 |

Paste it in the ‘Data.t’ worksheet of ‘MeteoFourier.xlsm’ under the head ‘Text’ (from cells B5 – B8764) as shown below:




8. Go to the ‘Main’ worksheet of ‘MeteoFourier.xlsm’ and click on ‘New *.fourier.xlsm’ tab as shown in the figure below:




It will then execute the calculation. Once the calculation is over then click on the ‘Save as *.fourier.xlsm’ tab in the same worksheet and specify the path of location where this weather data file in *.fourier.xlsm format is to be saved. It is recommended to save this weather data file in the folder ‘EP.Basic → Meteo → Data’.