



**Carnegie Mellon University**

Building Energy Simulations (Part II)

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Dr. Miguel Martin

# Learning objectives

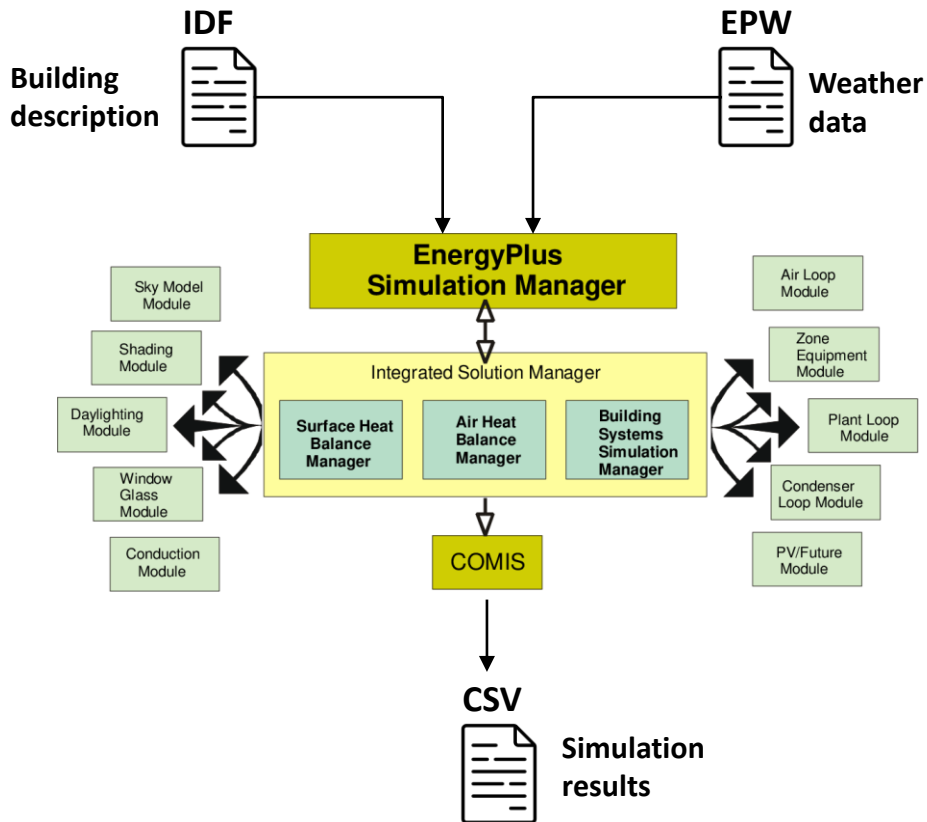
1. Perform building energy simulations
2. Visualize results of simulations
3. Co-simulations with a HVAC control system

# References

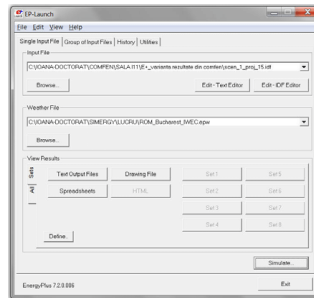
Garg, Vishal, Jyotirmay Mathur, and Aviruch Bhatia. "**Building Energy Simulation : A Workbook Using Designbuilder**". Second edition. Boca Raton, FL ; CRC Press, Taylor & Francis Group, (2021).

# How do we perform building energy simulations?

# EnergyPlus simulation engine



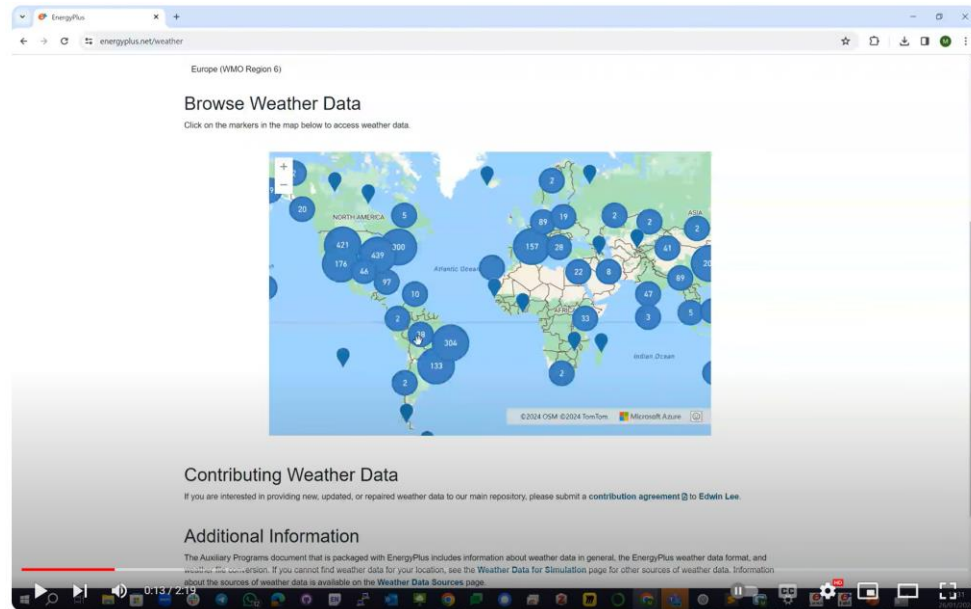
## EP-launch



## Python code

```
idf_relative_filepath='sim\1ZoneUncontrolled.idf'
epw_relative_filepath='sim\USA_CA_San.Francisco.Intl.AP.724940_TMY3.epw' #
output_relative_directory='sim'
c1_st=(f'''{energyplus_install_dir}\\EnergyPlus" '
      + '--readvars' # included to create a .csv file of the results
      + f'--output-directory "{output_relative_directory}" '
      + f'--weather "{epw_relative_filepath}" '
      + f'"{idf_relative_filepath}" ''')
print(c1_st)
```

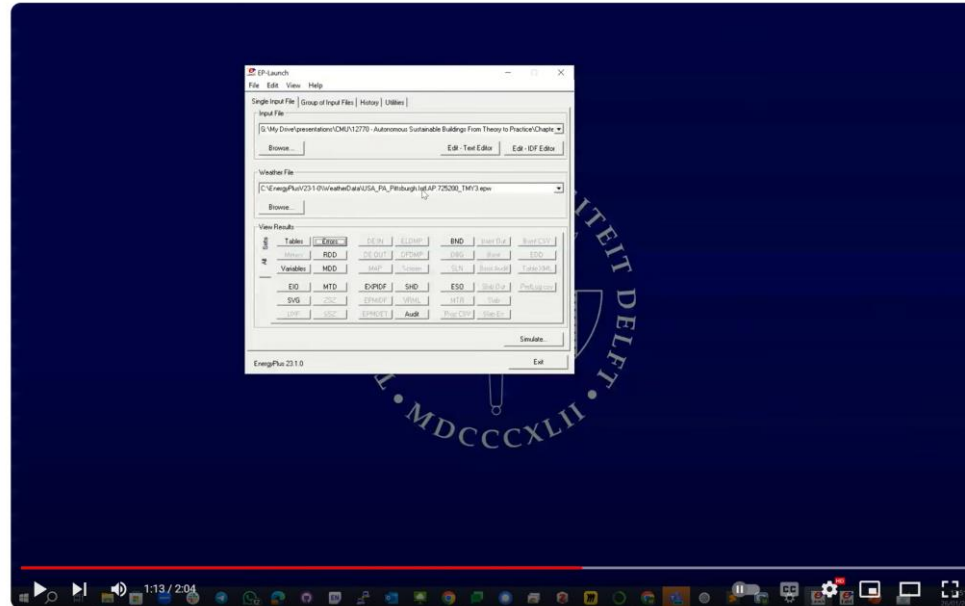
# Collect weather data



Tutorial EnergyPlus - Collect Weather Data

<https://youtu.be/Cn8vhfg8mBA>

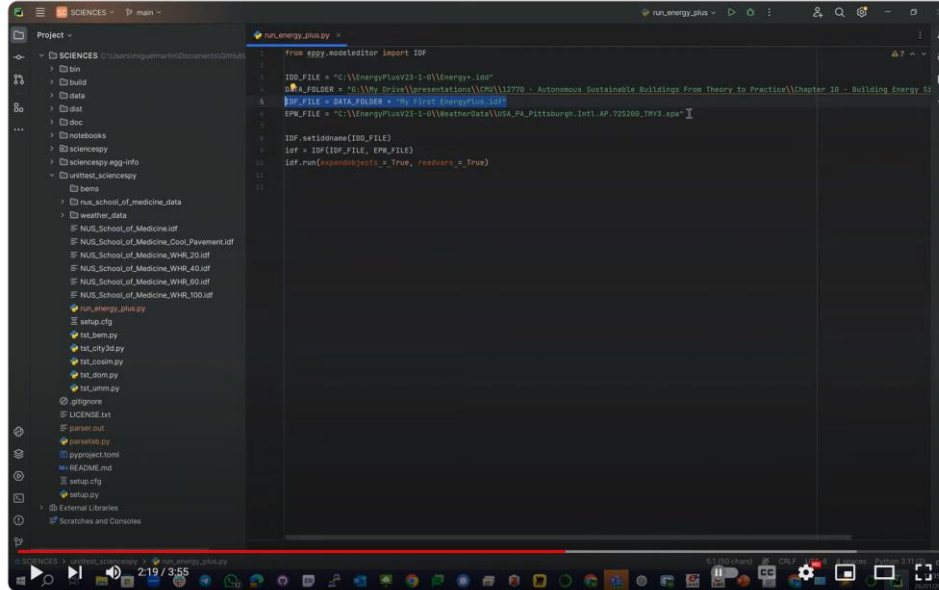
# Perform simulations using EP-launch



Tutorial EnergyPlus - Perform Simulations using EP launch

<https://youtu.be/sc85BYxloq0>

# Perform simulations using Python code



```
from eppy.epluseditor import IDF

IDF_FILE = "C:\\EnergyPlus2-1-0\\Energy-Idf"
DATA_FOLDER = "C:\\My 2014\\simulations\\CWS\\12779 - Autonomous Sustainable Buildings from Theory to Practice\\Chapter 10 - Building Energy S
IDF_FILE = DATA_FOLDER + "\\Eppy\\scenarios\\12779
EPL_FILE = "C:\\EnergyPlus2-1-0\\WeatherData\\USA_PA_Pittsough_Intl.AP-725208_TMY3.epw"

IDF.setIDName(IDF_FILE)
idf = IDF(IDF_FILE, EPL_FILE)
idf.run(expandobjects = True, reverts = True)
```

Tutorial EnergyPlus - Perform Simulations using Python

<https://youtu.be/X6fFSZGPOxE>



**How do we visualize results of simulations?**

# Define output variables

```

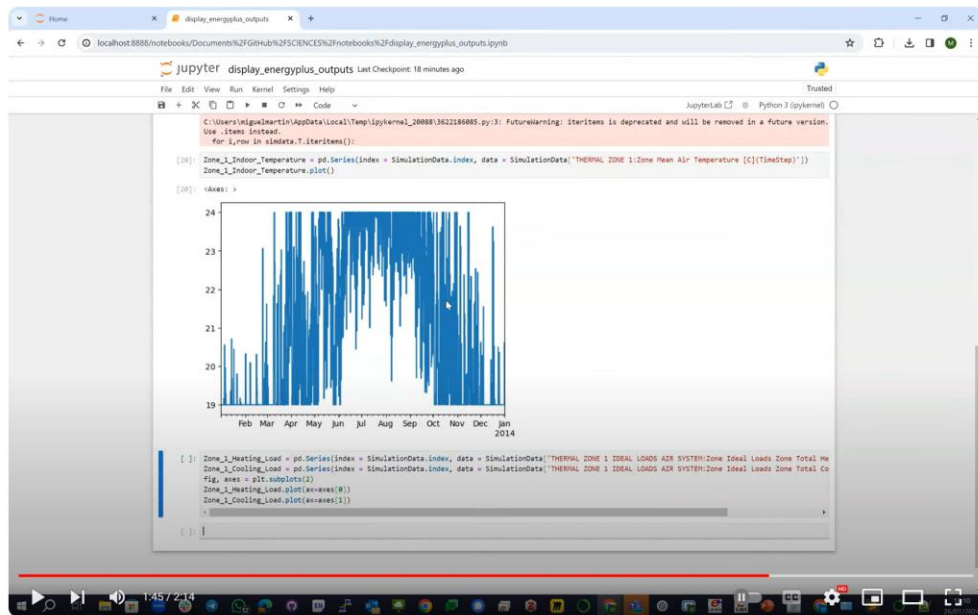
My First EnergyPlus - Notepad
File Edit Format View Help
OutputVariable,"Zone Predicted Sensible Load to Heating Setpoint Heat Transfer Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone Predicted Sensible Load to Cooling Setpoint Heat Transfer Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone System Predicted Sensible Load to Setpoint Heat Transfer Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone System Predicted Sensible Load to Heating Setpoint Heat Transfer Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone System Predicted Sensible Load to Cooling Setpoint Heat Transfer Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone Predicted Moisture Load Humidifying Setpoint Moisture Transfer Rate,hourly; I- HVAC Average [kgwater/s]
OutputVariable,"Zone Predicted Moisture Load to Humidifying Setpoint Moisture Transfer Rate,hourly; I- HVAC Average [kgwater/s]
OutputVariable,"Zone System Predicted Moisture Load to Humidifying Setpoint Moisture Transfer Rate,hourly; I- HVAC Average [kgwater/s]
OutputVariable,"Zone System Predicted Moisture Load to Dehumidifying Setpoint Moisture Transfer Rate,hourly; I- HVAC Average [kgwater/s]
OutputVariable,"Zone Thermostat Air Temperature,hourly; I- HVAC Average [C]
OutputVariable,"Zone Thermostat Control Type,hourly; I- Zone Average [I]
OutputVariable,"Zone Thermostat Heating Setpoint Temperature,hourly; I- HVAC Average [C]
OutputVariable,"Zone Thermostat Cooling Setpoint Temperature,hourly; I- HVAC Average [C]
OutputVariable,"Zone Adaptive Comfort Operative Temperature Set Point,hourly; I- Zone Average [C]
OutputVariable,"Zone Predicted Sensible Load Room Air Correction Factor,hourly; I- HVAC Average [I]
OutputVariable,"Zone List Sensible Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone List Sensible Heating Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone List Sensible Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone List Sensible Cooling Rate,hourly; I- HVAC Average [W]
OutputVariable,"HVAC System Solver Iteration Count,hourly; I- HVAC Sum [I]
OutputVariable,"Air System Solver Iteration Count,hourly; I- HVAC Sum [I]
OutputVariable,"Air System Relief Air Total Heat Loss Energy,hourly; I- HVAC Sum [J]
OutputVariable,"HVAC System Total Heat Rejection Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Sensible Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Latent Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Total Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Sensible Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Latent Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Total Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Zone Sensible Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Zone Latent Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Zone Total Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Zone Sensible Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Zone Latent Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Zone Total Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Outdoor Air Sensible Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Outdoor Air Latent Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Outdoor Air Total Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Outdoor Air Sensible Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Outdoor Air Latent Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Outdoor Air Total Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Heat Recovery Sensible Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Heat Recovery Latent Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Heat Recovery Total Heating Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Heat Recovery Sensible Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Heat Recovery Latent Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Heat Recovery Total Cooling Energy,hourly; I- HVAC Sum [J]
OutputVariable,"Zone Ideal Loads Supply Air Sensible Heating Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone Ideal Loads Supply Air Latent Heating Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone Ideal Loads Supply Air Total Heating Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone Ideal Loads Supply Air Sensible Cooling Rate,hourly; I- HVAC Average [W]
OutputVariable,"Zone Ideal Loads Supply Air Latent Cooling Rate,hourly; I- HVAC Average [W]

```

Tutorial EnergyPlus - Define Output Variables

<https://youtu.be/FhcLGJsvtt4>

# Plot the results



Tutorial EnergyPlus - Plot Outputs of EnergyPlus Simulations using Jupyter

<https://youtu.be/SAzmLr638Qc>

**How do we co-simulate the building energy model  
with an HVAC control system?**

# Co-simulation with EnergyPlus using Python

