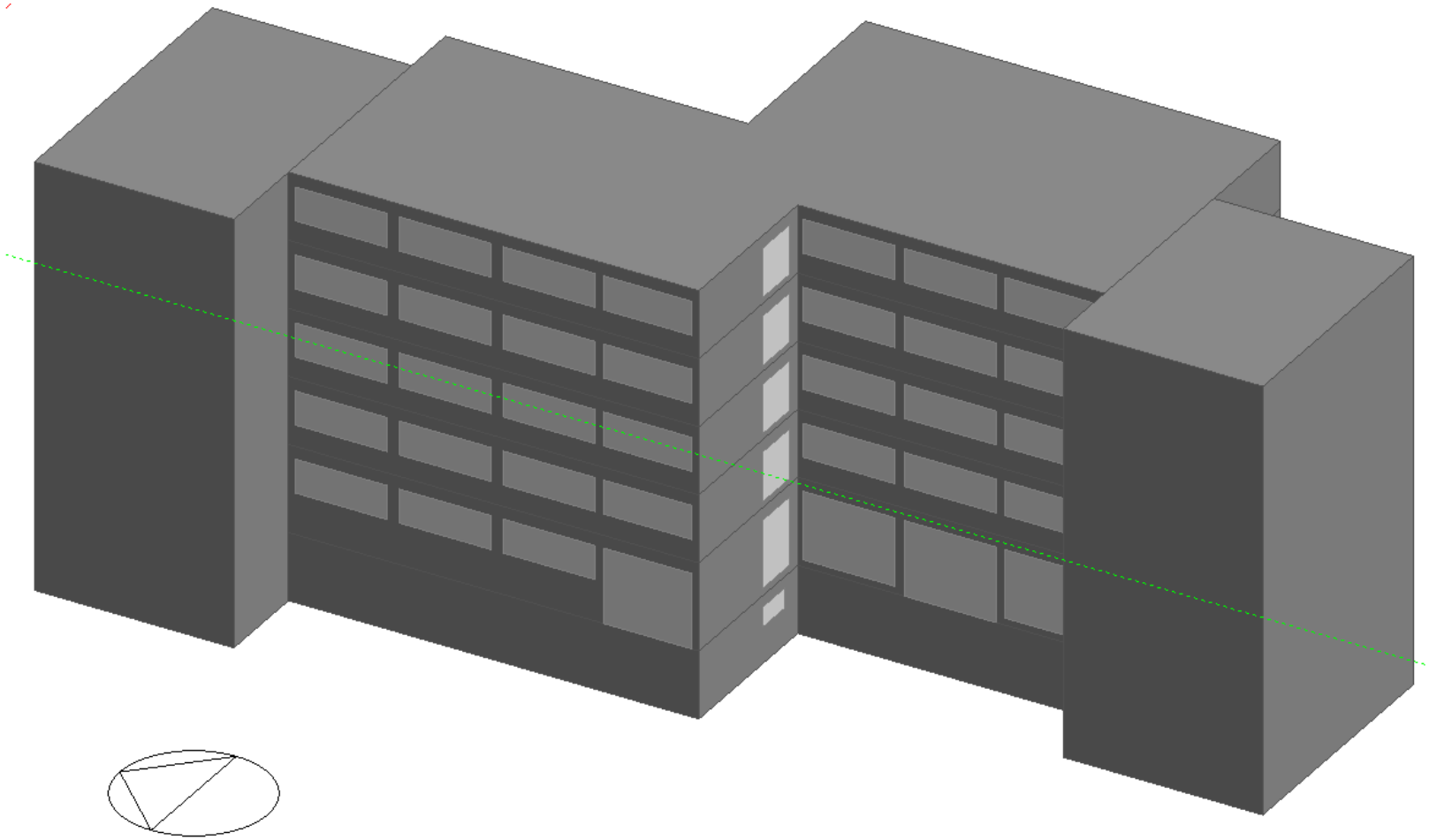
TIMEPAC The new EPC for Europe

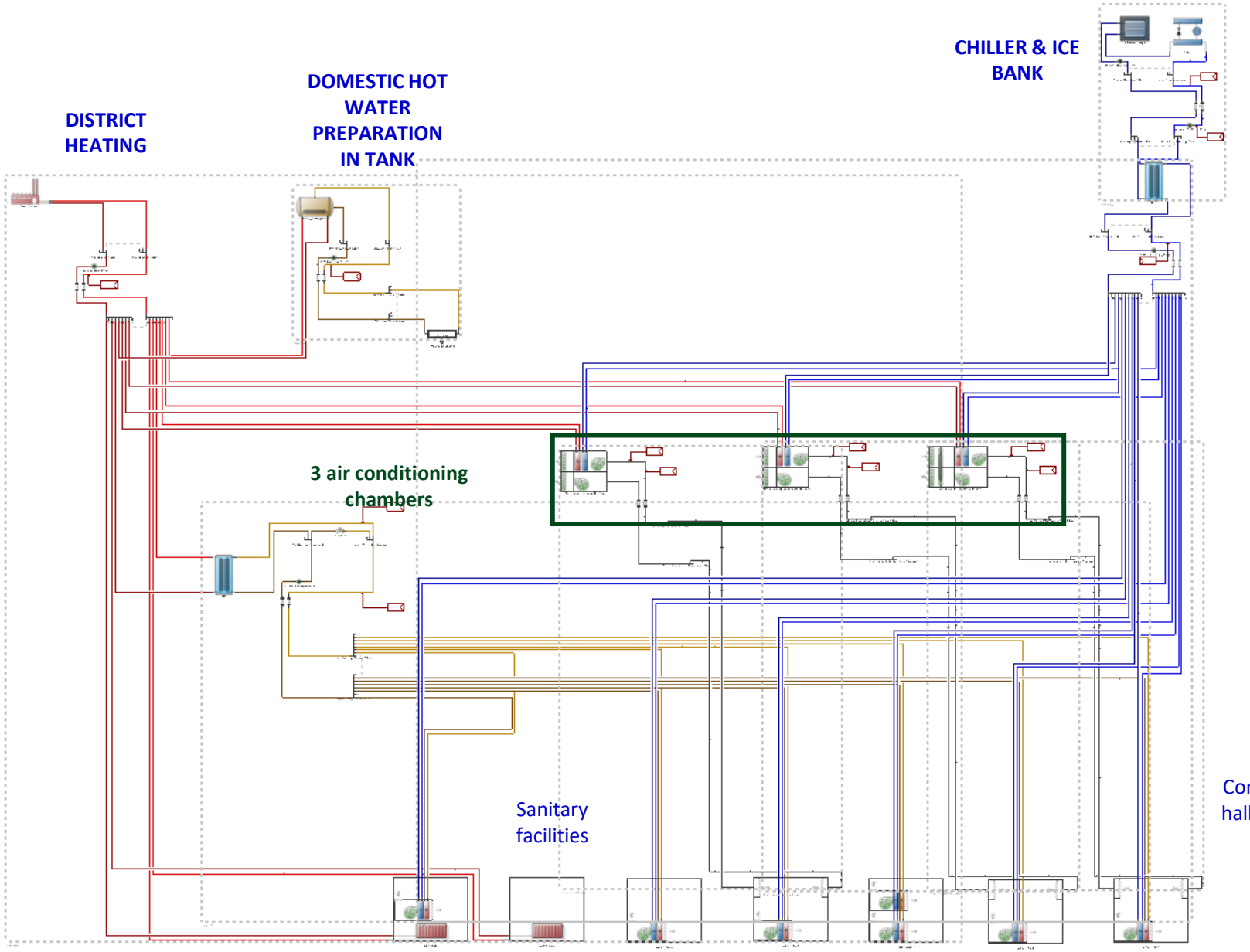
Analysis and visualization of EPC data and development of innovative energy service

Implementation of identified measures on calibrated dynamic model

Denis Dergestin

Consultant at Energy institute Hrvoje Požar





DesignBuilder

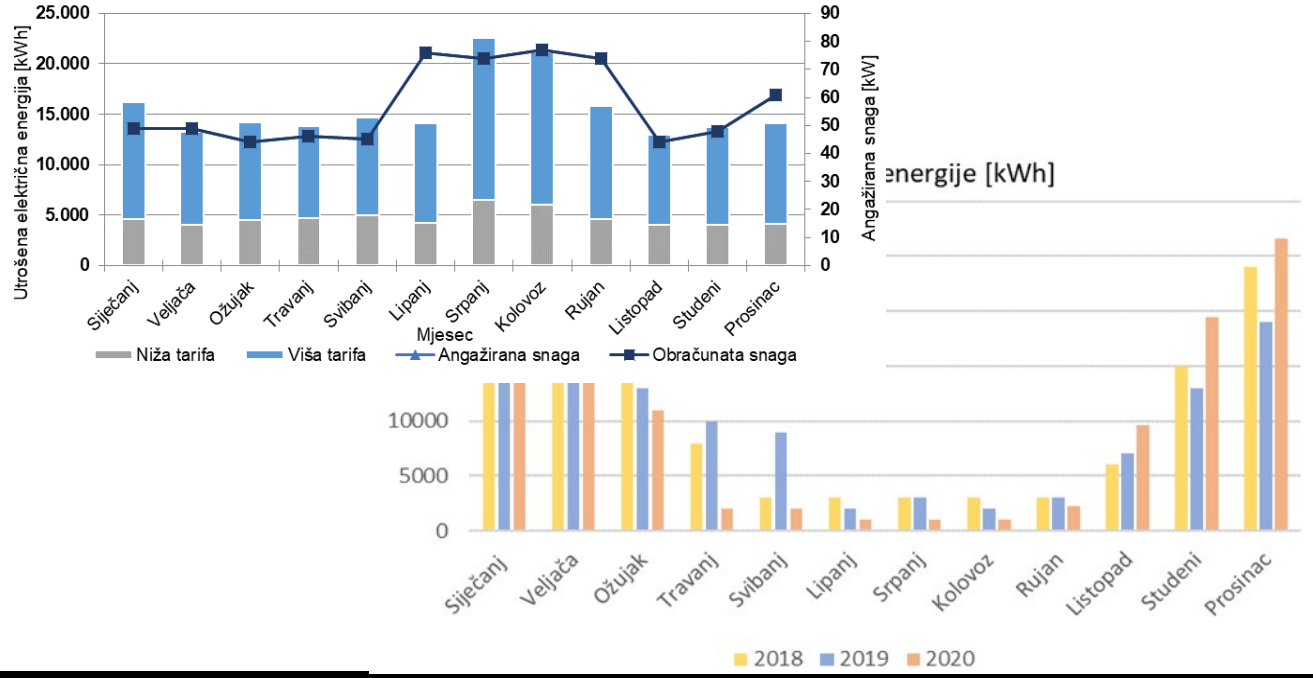
Graphic visualization in DesignBuilder of existing HVAC system at EIHP office building

Energy bills and energy audit

Reference values related to energy and water consumption for the building (2019)

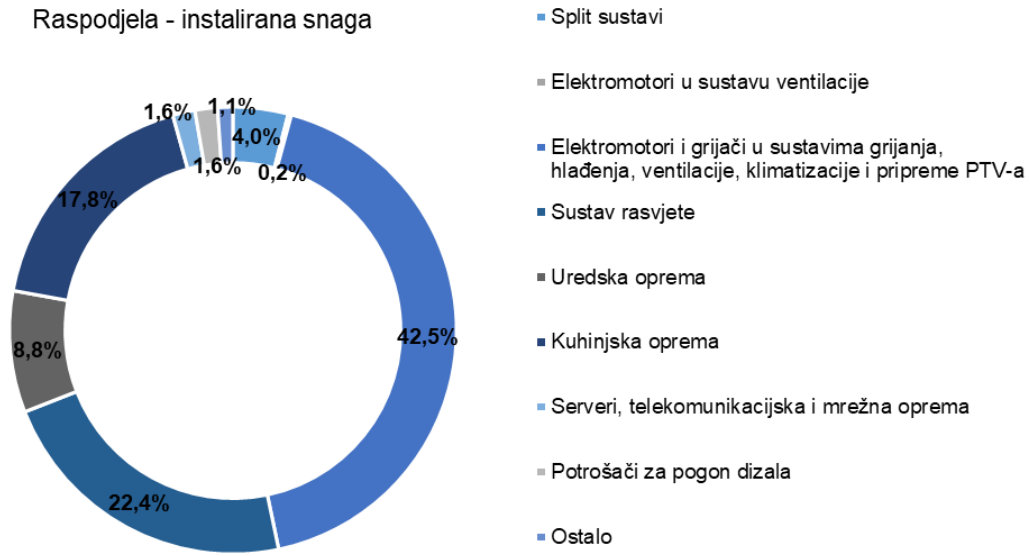
Energenti i voda	Jedinica	Referentne vrijednosti		
		Godišnja potrošnja	Godišnja potrošnja energije	Godišnja emisija CO_2
		[jedinica/god.]	[kWh/god.]	[tona/god.]
Električna energija	kWh	186.539,00	186.539,00	43,837
Toplinska energija	kWh	134.000,00	134.000,00	46,364
Voda	m^3	1.051,50	-	0,236
Ukupno			**320.539,00**	**90,437**

Total reference consumption of electricity in higher and lower tariffs and engaged power by month from January to December



Shares of individual forms in reference energy consumption

Distribution of main groups of consumers according to installed power



Site and Source Energy

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	288684.49	120.62	137.46
Net Site Energy	288684.49	120.62	137.46

End Uses

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.00	0.00	130235.82	0.00
Cooling	31478.37	0.00	0.00	0.00	0.00	0.00
Interior Lighting	38702.65	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	53401.74	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	17217.96	0.00	0.00	0.00	0.00	0.00
Pumps	17638.81	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	365.77
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	158448.68	0.00	0.00	0.00	130235.82	365.77

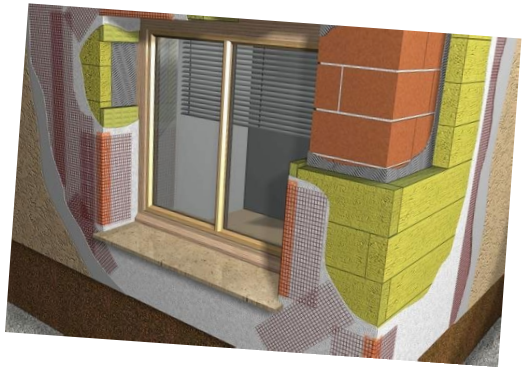
Automation process

- The possibility of implementing automation within DesignBuilder, but it is necessary to precisely define parameters and create all appropriate Templates→ additional professional knowledge and precision (possibility of errors), time and a certain number of people are required for faster inputs

- Using the automation capabilities using Python and the ability to connect EnergyPlus with Python→ previous experiences and knowledge → the idea of using databases and universal script for many buildings

Identified measures

Komb.	Koeficijent prolaska topline prozora, U [W/(m²K)]	
1	0,66	triple IZO glass with a double low-emissivity layer and reflective coating
2	0,80	triple IZO glass with a low emissivity layer
3	1,40	EXISTING – double IZO glass with a low emissivity layer



Komb.	Debljina toplinske izolacije vanjskog zida [cm]	Debljina toplinske izolacije ravnog krova [cm]
1	10	10
2	10	14
3	10	16
4	10	20
5	10	25
6	14	10
7	14	14
8	14	16
9	14	20
10	14	25
11	16	10
12	16	14
13	16	16
14	16	20
15	16	25
16	20	10
17	20	14
18	20	16
19	20	20
20	20	25

Variants of HVAC system

4 sources of heating/cooling energy:

- District heating for heating and DHW, chiller for space cooling
- Natural gas micro-cogeneration with a condensing boiler for space heating, DHW preparation and a compression chiller for space cooling
- Air/water heat pump for space heating, DHW and space cooling
- Water/water heat pump for space heating, DHW and space cooling

Zona	Prostorije unutar zone	Grijanje	Hlađenje	Mehanička ventilacija	VK*	SPLIT**	Radijator
Zona 1	*Konferencijska dvorana – 2. kat*	●	●	●	●	○	○
Zona 2	*Konferencijska dvorana - prizemlje*	●	●	●	●	○	○
Zona 3	*Sanitarni čvorovi i tuševi*	●	○	○	○	○	●
Zona 4	*Server soba*	●	●	○	○	●	○
Zona 5	*Uredi, hodnik i blagavaonica*	●	●	○	●	○	○
Zona 6	*Strojarnica*	○	○	○	○	○	○

* Ventilokonvektor ** Mono split sustav

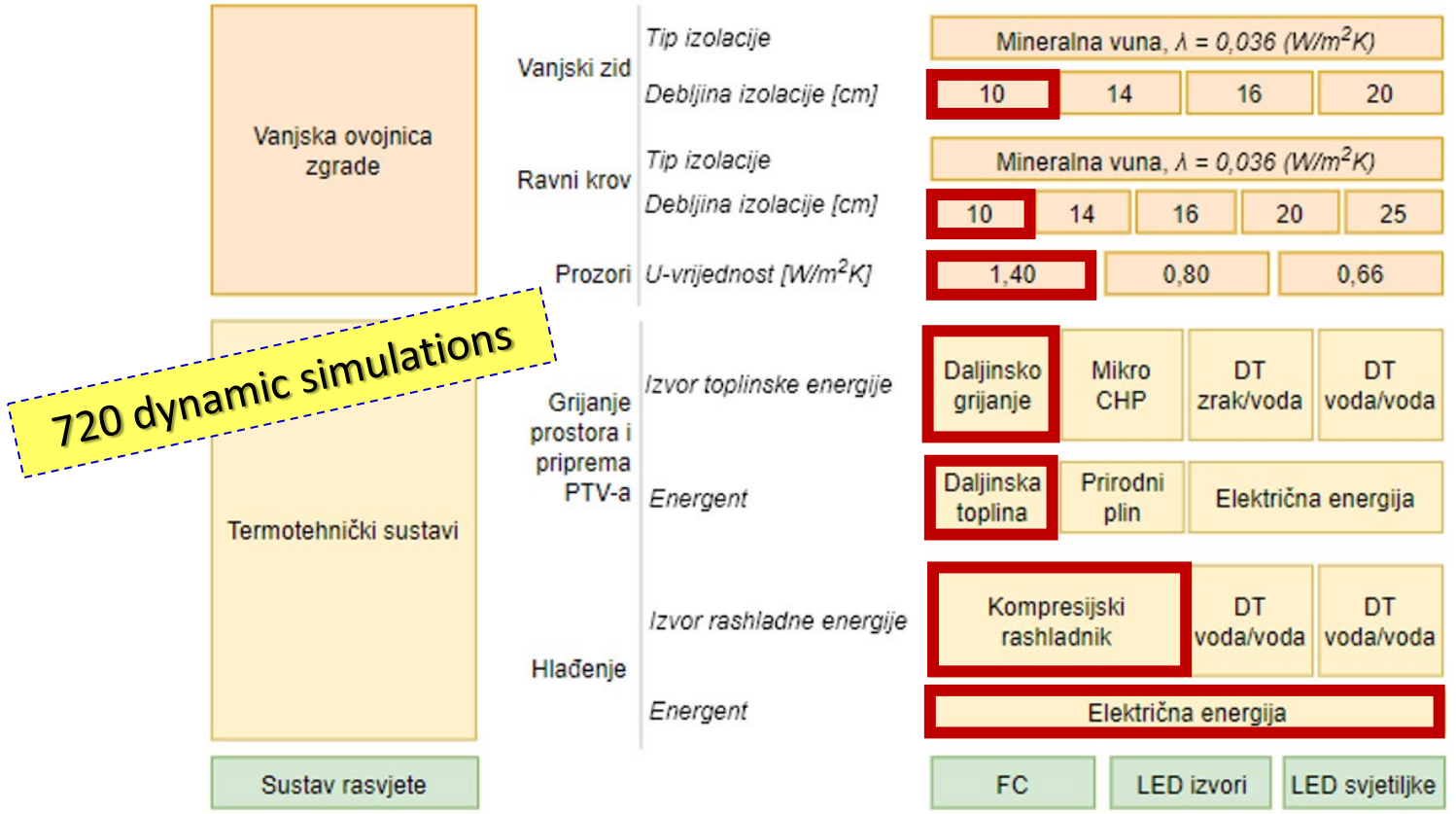
- FC – existing lighting system using lamps with fluorescent tubes and fluorescent compact bulbs

- LED sources– partially modernized lighting system- most light sources are replaced by LED light sources in existing lamps. The analysis is made for LED replacement light sources of renowned manufacturers (the control system remains the same as in the existing state with additional installation of presence sensors)

- LED lamps – complete modernization of the lighting system - installation of high-efficiency integrated LED lamps (keeping the existing wiring of the power supply to the lamps) - a modern control system via occupancy and lighting sensors - new wireless buttons that can adjust the level of the output light flux - most of the lighting can be controlled centrally via an application that also enables monitoring of consumption and malfunctions, but also occupation.

SUMMARY OF COMBINATIONS OF POSSIBLE TECHNICAL AND CONSTRUCTION SOLUTIONS

For all the mentioned combinations, an analysis of the installation of the photovoltaic system on the available surfaces of the building is also included



THE FLOW OF IMPLEMENTATION OF DYNAMIC SIMULATIONS

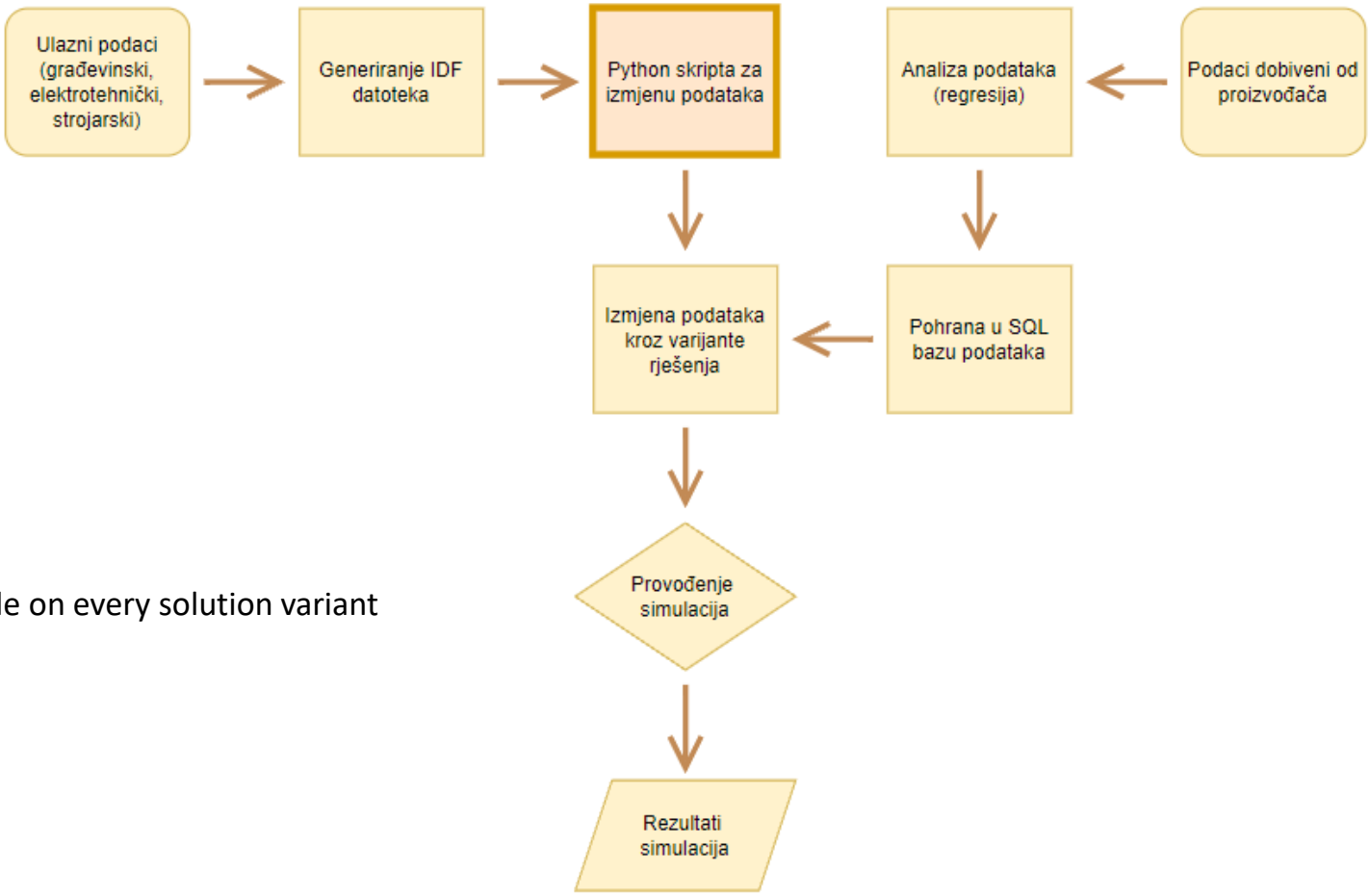
To run simulations:

- Python version 3.9.0
- EnergyPlus version 8.9.0

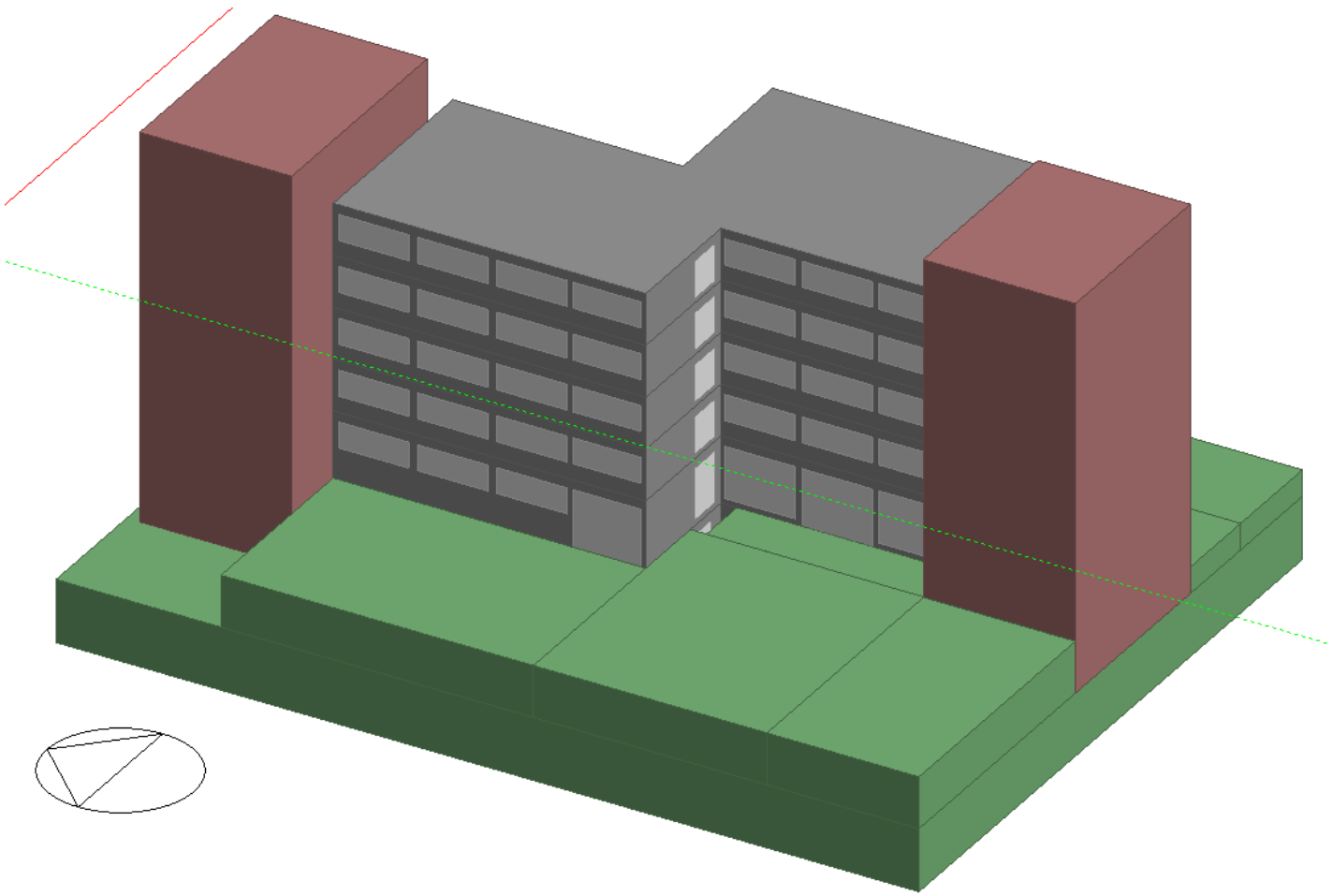
For changing data through solution variants:

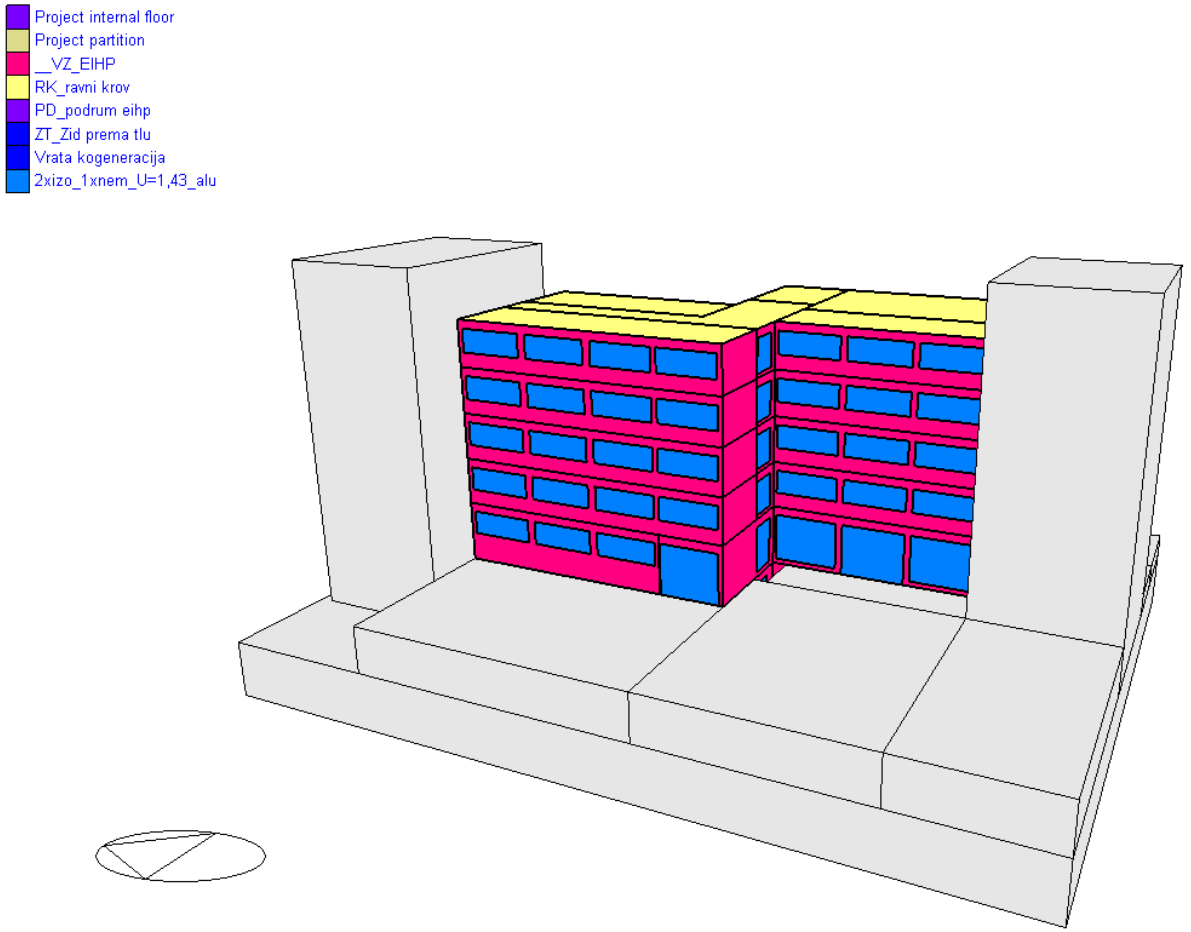
- Eppy ModelEditor (allows programmers to navigate, search and modify idf file data)
- Databases using SQL language

Communication between Python script-> SQL database -> IDF file on every solution variant

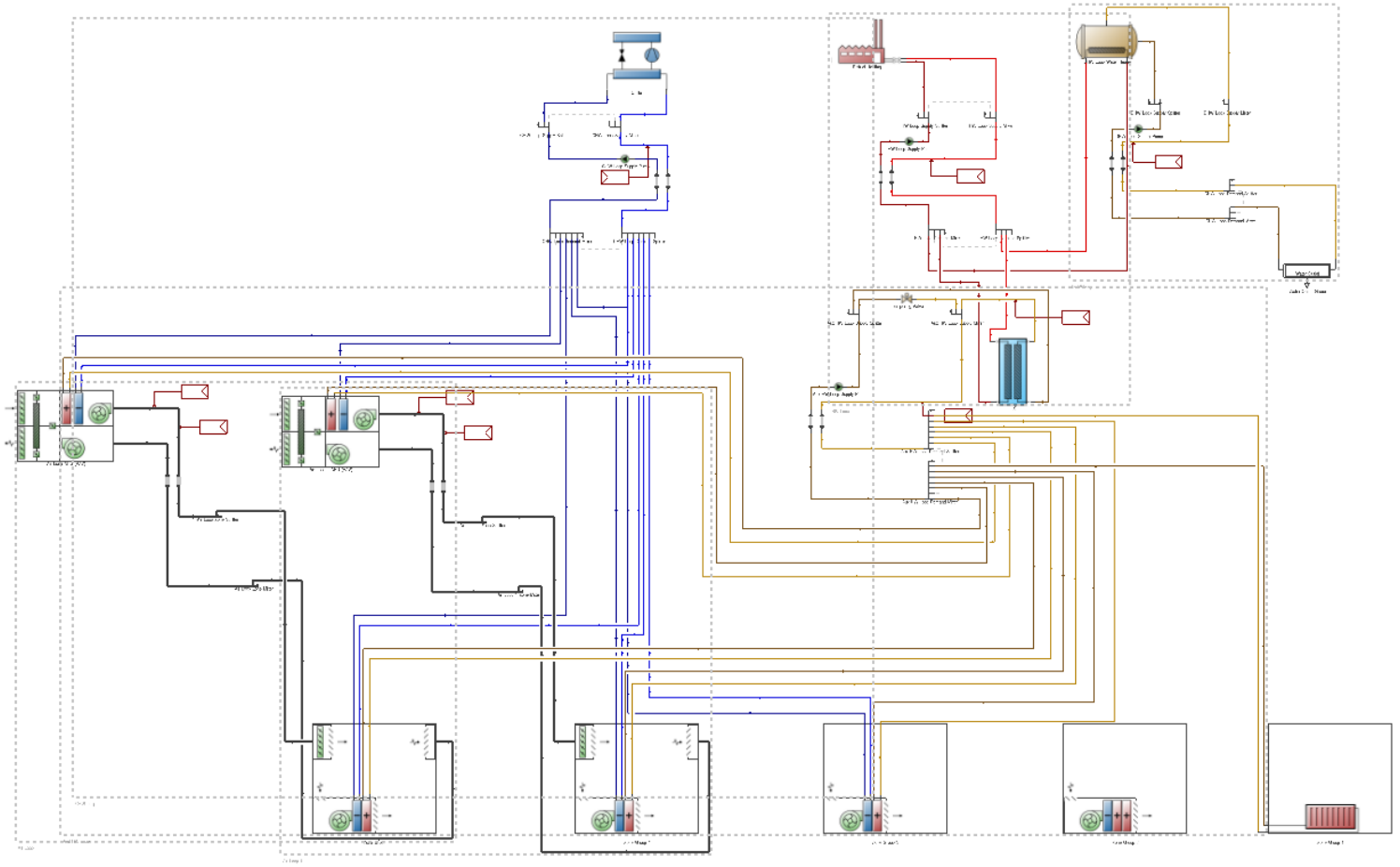


- EIHP
  - <HVAC System>
  - 1_kat
    - **Hodnik**
    - **Sanitarni_cvor**
    - **Uredi_istok**
    - Uredi_istok 1 => 1_kat, Uredi_istok
    - **Uredi_zapad**
    - Uredi_zapad 1 => 1_kat, Uredi_zapad
  - 2_kat
  - 3_kat
    - Hodnik => 1_kat, Hodnik
    - Sanitarni_cvor => 1_kat, Sanitarni_cvor
    - Uredi_istok => 1_kat, Uredi_istok
    - Uredi_istok 1 => 1_kat, Uredi_istok
    - Uredi_zapad 1 => 1_kat, Uredi_zapad
    - Uredi_zapad => 1_kat, Uredi_zapad
  - 4_kat
    - Hodnik 1 => 1_kat, Hodnik
    - Open space => 1_kat, Uredi_istok
    - Sanitarni_cvor => 1_kat, Sanitarni_cvor
    - Uredi istok => 1_kat, Uredi_istok
    - Uredi_zapad 1 => 1_kat, Uredi_zapad
    - Uredi_zapad => 1_kat, Uredi_zapad
  - Component block 1
  - Component block 10
  - Component block 11
  - Component block 12
  - Component block 13
  - Component block 2
  - Component block 3
  - Component block 4
  - Component block 5
  - Component block 6
  - Component block 7
  - Component block 8
  - Component block 9
  - Podrum
    - Athiva => 1_kat, Uredi_zapad
    - Cistacice => 1_kat, Uredi_istok
    - Hodnik 1 => 1_kat, Hodnik
    - Printer soba => 1_kat, Uredi_zapad
    - Sanitarni_cvor => 1_kat, Sanitarni_cvor
    - **Server soba**
    - **Strojarnica**
    - **Tusevi**
    - Uredi => 1_kat, Uredi_istok
  - Prizemlje
    - Hodnik => 1_kat, Hodnik
    - **Konferencijska sala**
    - **Restoran**
    - Sanitarni_cvor => 1_kat, Sanitarni_cvor

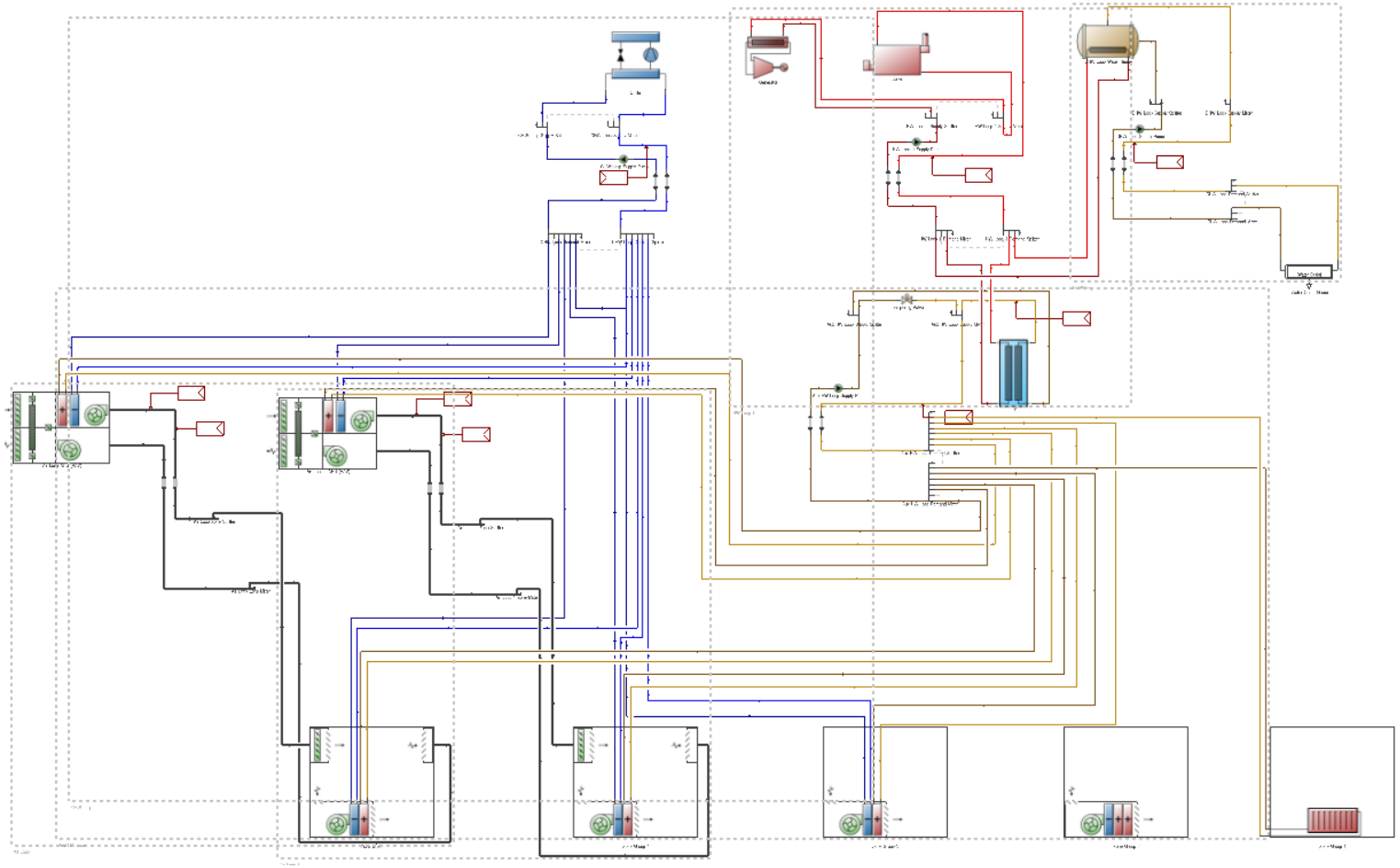



Project internal floor
Project partition
__VZ_EIHP
RK_ravni krov
PD_podrum eihp
ZT_Zid prema tlu
Vrata kogeneracija
2xizo_1xnem_U=1,43_alu

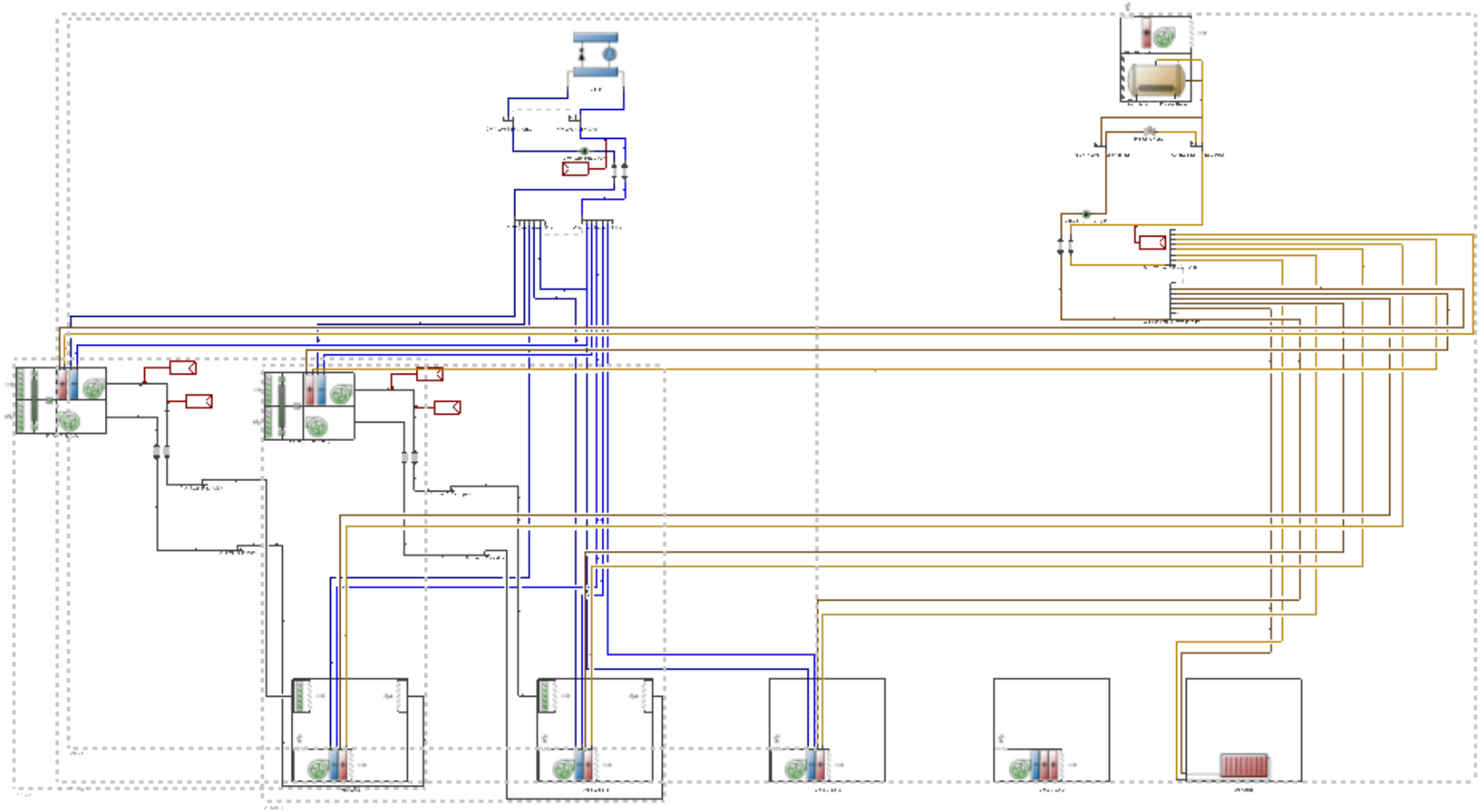
District heating scheme

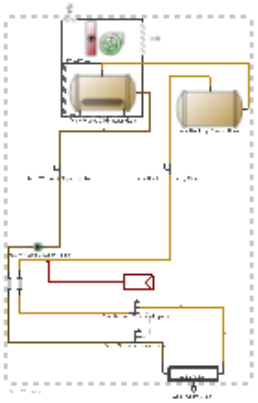


Natural gas micro-cogeneration with a condensing boiler scheme

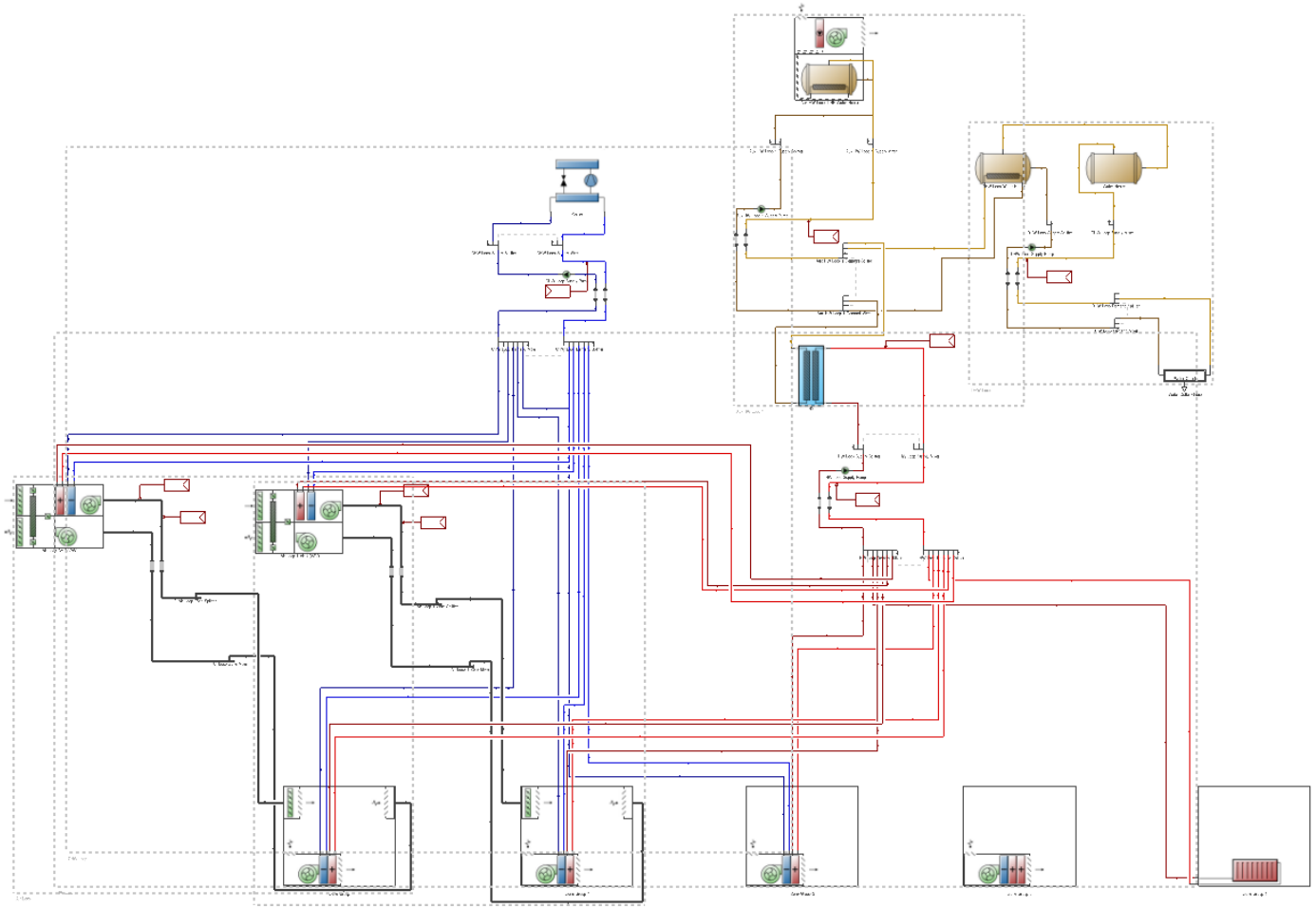


Air/water heat pump scheme



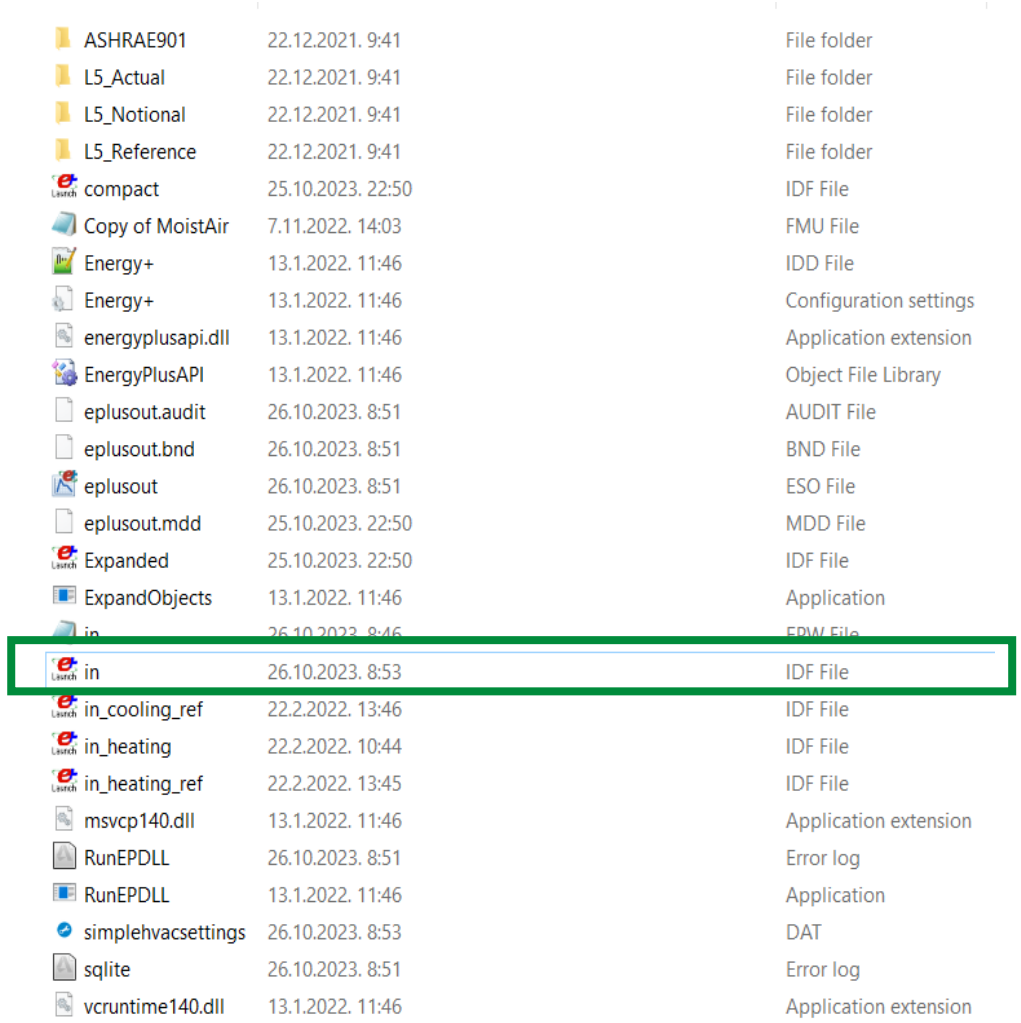


Water/water heat pump scheme



IDF File

- We have created 4 IDF files that contain the geometry and characteristics of the building, the lighting system and 4 combinations of thermotechnical systems with all the appropriate Loops and "fields" for data exchange
- IDF (Intermediate Data Format) – “are used to interoperate between electronic design automation (EDA) software and solid modeling mechanical computer-aided design (CAD) software. The format was devised by David Kehmeier at the Mentor Graphics Corporation. "



IDF File

```
Version, 8.9.0.001;                          !- Version Identifier

RunPeriod,                                   !- Annual simulation
   Energetski institut Hrvoje Pozar (01-01:31-12),!- Location
   1,1,                                      !- Start Month , Day
   12,31,                                    !- End Month , Day
   UseWeatherFile,                           !- will use day as shown in weather file
   No,                                       !- Use weather file holidays/special day periods
   No,                                       !- Use WeatherFile DaylightSavingPeriod - will use daylight saving time shown below
   Yes,                                      !- Apply Weekend Holiday Rule - will reassign weekend holidays to Monday
   Yes,                                      !- use weather file rain indicators
   Yes,                                      !- use weather file snow indicators
   1;                                        !- Number of years in simulation

RunPeriodControl:DaylightSavingTime, Last Sunday in March,Last Sunday in October;  !- Daylight saving dates - one hour is added to local mean time to obtain the locally observed time during this period

! Hourly weather file: C:\ProgramData\DesignBuilder\Weather Data\Zg-meteo2.epw

Site:Location,Energetski institut Hrvoje Pozar (01-01:31-12)  (01-01:31-12),  !- Location Name
   45.82,                                    !- Latitude
   16.03,                                    !- Longitude
   1,                                        !- Time Zone
   128;                                      !- Elevation {m}
```

Idf object

Field / fieldname:
Field 1 / Location /
Energetski institute Hrvoje Pozar (01-01:31-12)

IDF File

```
        ! 4_kat, Uredi_zapad  1, Roof - 39,357 m2, Surface Area: 39,357m2
        BuildingSurface:Detailed,                     !- Surface
```

```
! 4_kat, Uredi_zapad  1, Roof - 39,357 m2, Surface Area: 39,357m2
BuildingSurface:Detailed,                     !- Surface
   4Xkat:UrediXzapad1_Roof_1_0_0,             !- Surface name
   Roof, RK_ravni krov,                       !- Class and Construction Name
   1Xkat:UrediXzapad,                         !- Zone Name
   Outdoors, ,                                !- Outside Face Environment
   SunExposed,                                !- Sun Exposure
   WindExposed,                               !- Wind Exposure
   AutoCalculate,                             !- View Factor to Ground
   4,                                         !- Number vertices
   -7.2034358807,-55.2798794081, 16.58,       !- Vertex 1
   -2.6034358808,-55.2798794081, 16.58,       !- Vertex 2
   -2.6034358808,-46.7239907654, 16.58,       !- Vertex 3
   -7.2034358808,-46.7239907678, 16.58;       !- Vertex 4
```

```
 ! MW Glass Wool (standard board)- thickness 0,1
 Material, MW Glass Wool (standard board)_01,
    Rough,                                    !- Roughness
    .1,                                       !- Thickness {m}
    0.036,                                    !- Conductivity {w/m-K}
    20,                                       !- Density {kg/m3}
    840,                                      !- Specific Heat {J/kg-K}
    0.9,                                      !- Thermal Emittance
    0.6,                                      !- Solar Absorptance
    0.6;                                      !- Visible Absorptance
```

IDF File

```
DistrictHeating,
   District Heating,
   District Heating Water Inlet Node,
   District Heating Water Outlet Node,
   [redacted],
   On 24/7;
```

```
                                                    ! - Component name
                                                    ! - Boiler water inlet node
                                                    ! - Boiler water outlet node
                                                    ! - Nominal capacity (W)
                                                    ! - Capacity fraction schedule
```

```
ZoneHVAC:Baseboard:RadiantConvective:Water,
   1Xkat:SanitarniXcvor Water Radiator,
   _EIHP_HEATING,
   1Xkat:SanitarniXcvor Water Radiator Hot Water Inlet Node,
   1Xkat:SanitarniXcvor Water Radiator Hot Water Outlet Node,
   45.500,
   [redacted],
   HeatingDesignCapacity,
   [redacted],
   ,
   [redacted],
   0.0100,
   0.300,
   0.100,
```

```
! - Component name
! - Availability schedule
! - Water inlet node name
! - Water outlet node name
! - Rated average water temperature (C)
! - Rated water mass flow rate (kg/s)
! - Heating design capacity method
! - Heating design capacity (W)
! - Heating design capacity per floor area (W/m2)
! - Fraction of auto-sized heating design capacity
! - Maximum water flow rate (m3/s)
! - Convergence tolerance
! - Fraction radiant
! - Fraction of radiant energy incident on people
```

Eppy ModelEditor & Python

EIHP_zgrada.py

```python
from eppy import modeleditor
from eppy.modeleditor import IDF
import csv
import pandas as pd
#Ucitavanje funkcija za broj kombinacija s debljinama
from BAZE import Get_Kombinacije_Mjera
from BAZE import Get_Kombinacije_Mjera_Rasvjeta
from BAZE import GetWindowConstructionDict
from BAZE import GetWindowsBaseValues
from BAZE import GetVentValues
from BAZE import Choose_Fancoil_and_Radiator
from BAZE import Insert_Avg_Temp

####GRAĐEVINSKI DIO
#Ucitavanje funkcija za promjenu VZ i RK-a
from get_objects_VZ_RK import get_andCH_VZ, change_thickness_VZ_RK
#Ucitavanje funkcija za promjenu prozora
#from Replace_Windows import get_AllWindows, modify_windows, remove_windows
from Windows import modify_windows, ChangeWindowConstruction
#Ucitavanje funkcije za promjenu CF-a
from get_object_CF import change_CF, change_thickness_CF
#Ucitavanje funkcije za promjenu KR
from get_object_KR import change_KR

#Ucitavanje funkcije za promjenu protoka NatVent
from NatVent_dfr import change_NV
#Ucitavanje funkcije za promjenu protoka uslijed infilitracije
from Infiltr_dfr import change_INF

#Ucitavanje funkcije za validaciju
from Validate import validate_op

#Ucitavanje funkcije za promjenu toplinskih mostova
from construction_database import GetConstValues
from Change_Construction import Change_linear_bridging

####RASVJETA
#Ucitavanje funkcije za promjenu rasvjete
from Lights import change_lights

####STROJARSKI SUSTAVI
#ucitavanje funkcija za izmjenu kapaciteta kotla i daljinskog
from Boiler import Change_boiler, Choose_boiler, Change_boiler_boiler1, Change_boiler_curve
from capacity import Change_capacity, Change_name
from District_heating import Change_district_heating , Choose_district_heating, Change_district_heating_district_heating1
#Ucitavanje funkcije za odabir chillera
from heat_pumps import Choose_ASHP, Choose_WSHP, Choose_ASHP_chiller
#Ucitavanje funkcije za dohvacanje chillera iz baze
from DT_database import Get_base_HP, Get_WSHP_base_WP
#Ucitavanje funkcija za promjenu template-a i podataka kod ASHP-a
from ASHP_ch import change_ASHP, change_ASHP_chiller, Get_Curves
#Ucitavanje funkcije za dohvacanje kapaciteta za split iz baze
from Design_capacity_database import GetValues, GetZoneGroupValues
#Ucitavanje funkcije za promjenu kapaciteta splita
from SPLIT import ChangeSPLIT
from Ogrjevna_tijela import ChangeFanCoil, ChangeWaterRadiator, ChangeHWLoop
#Ucitavanje funkcije za dobavu direktorij
from find_directory import Find_directory
import pprint
from collections import OrderedDict

```

BAZE	✓	23.2.2022. 14:01	File folder
CSV_outputs	✓	23.2.2022. 14:01	File folder
Glavni program	✓	3.5.2022. 11:07	File folder
IDF_ref	✓	23.2.2022. 14:02	File folder
ObjectDes_WeatherData	✓	23.2.2022. 14:02	File folder
Simulation_input	✓	3.5.2022. 11:01	File folder
Simulation_output	✓	31.3.2022. 17:45	File folder

ASHP	✓	20.9.2021. 14:03
ASHP_ch	✓	24.9.2021. 16:58
BAZE	✓	21.9.2021. 12:22
Boiler	✓	20.9.2021. 15:48
capacity	✓	26.3.2021. 8:16
Change_Construction	✓	29.4.2021. 9:53
construction_database	✓	1.3.2021. 8:45
Design_Capacities	✓	16.9.2021. 14:54
Design_Capacities_1	✓	16.9.2021. 14:54
Design_capacity_database	✓	8.9.2021. 12:46
District_heating	✓	17.9.2021. 13:56
DT_database	✓	21.9.2021. 16:39
EIHP_zgrada	✓	24.9.2021. 11:42
find_directory	✓	14.1.2021. 14:46
get_object_CF	✓	1.6.2020. 10:37
get_object_KR	✓	18.3.2020. 15:31
get_objects_VZ_RK	✓	27.8.2021. 9:41
heat_pumps	✓	21.9.2021. 16:37
Infiltr_dfr	✓	27.8.2021. 11:22
INPUT	✓	3.5.2022. 11:07
Lights	✓	2.9.2021. 13:59
NatVent_dfr	✓	27.8.2021. 11:57
ODABRANI FANCOILOVI	✓	17.9.2021. 12:45
Ogrjevna tijela	✓	27.7.2021. 15:51
Ogrjevna_tijela	✓	17.9.2021. 16:56
Ploče	✓	8.9.2021. 17:50
Ploče	✓	8.9.2021. 13:30
Prozori	✓	26.8.2021. 12:17
Replace_Windows	✓	31.5.2020. 9:33
SPLIT	✓	29.3.2021. 13:07

Eppy ModelEditor & Python

```python
#Glavna putanja do mape Glavni program
path_N = Find_directory()
idd_f = f"{path_N}ObjectDes_WeatherData\\eplus.idd"

Weather_file = 'Zg-meteo2.epw'
epw_f = f"{path_N}ObjectDes_WeatherData\\{Weather_file}"

IDF.setiddname(idd_f)

csv_ref_path = f"{path_N}\\IDF_ref\\Inputs_idf_ref.csv" # Iz csv datoteke povlace se nazivi (koji se rucno upisuju)
idf_ref_path = f"{path_N}\\IDF_ref\\"                   # Nakon dohvacenog naziva iz csv-a povlaci se pravi idf tog naziva
#Automatizirano spremanje naziva: idf, komb_temp, komb_mjera -> npr. in_5054321_komb_0101R.idf, 5054321, 0101R
csv_sim_file = f"{path_N}Simulation_input\\Inputs_idf_sim.csv"

building = 'EIHP'
building_year = 'EIHP_nakon_2005'

pp = pprint.PrettyPrinter(indent=4)

Kombinacije_mjera = Get_Kombinacije_Mjera()
#print(Kombinacije_mjera)
Kombinacije_Mjera_Rasvjeta, LightingDict = Get_Kombinacije_Mjera_Rasvjeta()
#pp.pprint(Kombinacije_Mjera_Rasvjeta)
Kombinacije_Mjera_Prozori = ['1', '2', '3']

NatVentDict,InfiltrationDict, ZoneGroupNumber = GetVentValues()

Nazivi_kombinacija = []
```

```python
with open(csv_ref_path, 'r') as cref_f:
    content = csv.reader(cref_f, delimiter=',')
    for refIDF in content:
        print(refIDF)
        idf1_sim = IDF(f"{idf_ref_path}{refIDF[0]}", epw_f)

        sustav = refIDF[1]
        m_name = refIDF[0][:-8]
        m_name = m_name[3:]
        print(f'm_name : {m_name}')

        for key,value in Kombinacije_mjera.items():
```

```python
                        db_name = 'WSHP'
                        db_tables = ['WSHPS', 'WSHP_heating', 'WSHP_cooling']
                        Q_new = Choose_WSHP(db_name, heating_capacity, theta_pol_gr, theta_proj_heating_WSHP, cooling_capacity, theta_pol_h1, theta_proj_cooling_WSHP)
                        WP = Get_WSHP_base_WP(db_name, db_tables, Q_new)

                        Curves = Get_Curves(idf1_sim)
                        change_ASHP(idf1_sim, WP, Q_new, m_name, refIDF[4], Curves)

                    elif m_name == 'daljinsko grijanje':

                        print('Mijenjam daljinsko grijanje!')
                        Q_heating = Choose_district_heating(heating_capacity)
                        Change_district_heating(idf1_sim,Q_heating)

                        print('Mijenjam ASHP chiller!')
                        Q_new = Choose_ASHP_chiller('ASHP', 'Cooling_Capacity', cooling_capacity, theta_pol_h1, theta_proj_cooling)

                        db_name = 'ASHP'
                        db_tables = ['ASHPS', 'Heating_Coefficients', 'Cooling_Coefficients']
                        HP = Get_base_HP(db_name, db_tables, Q_new)
                        print(HP)
                        Curves = Get_Curves(idf1_sim)
                        change_ASHP_chiller(idf1_sim, HP, Q_new, Curves)

                    elif m_name == 'ashp':

                        print('Mijenjam ASHP!')
                        #heating_capacity = heating_capacity - 9.44
                        db_name = 'ASHP'
                        db_tables = ['ASHPS', 'Heating_Coefficients', 'Cooling_Coefficients']
                        Q_new = Choose_ASHP(db_name, heating_capacity, theta_pol_gr, theta_proj_heating, cooling_capacity, theta_pol_h1, theta_proj_cooling)
                        HP = Get_base_HP(db_name, db_tables, Q_new)
                        Curves = Get_Curves(idf1_sim)
                        change_ASHP(idf1_sim, HP, Q_new, m_name, refIDF[4], Curves)

                    elif m_name == 'chp':

                        print('Mijenjam kogeneraciju!')
                        Q_heating = Choose_boiler(heating_capacity)
                        Change_boiler(idf1_sim, Q_heating)
                        #Change_boiler_curve(idf1_sim)


                        print('Mijenjam ASHP chiller!')
                        Q_new = Choose_ASHP_chiller('ASHP', 'Cooling_Capacity', cooling_capacity, theta_pol_h1, theta_proj_cooling)

                        db_name = 'ASHP'
                        db_tables = ['ASHPS', 'Heating_Coefficients', 'Cooling_Coefficients']
                        HP = Get_base_HP(db_name, db_tables, Q_new)
                        #print(HP)
                        Curves = Get_Curves(idf1_sim)
                        change_ASHP_chiller(idf1_sim, HP, Q_new, Curves)

                Nazivi_kombinacija.append(naziv_komb_sim)
                idf1_sim.saveas(f"{path_N}\\Simulation_input\\{naziv_komb_sim}.idf")
                with open(csv_sim_file, 'a', newline='\n') as c_file:
                    writer = csv.writer(c_file, delimiter=',')
                    key_novo = f"{key}{key_W}{key_R}"
                    writer.writerow([f"{naziv_komb_sim}.idf", refIDF[1], key_novo, refIDF[2], refIDF[3],refIDF[4]])
```

Eppy ModelEditor &Python

```python
def change_thickness_CF(idf_ch, d_CF, mats_name):
    """Funkcija mijenja debljinu materijala VZ i RK-a
    INPUTI: - idf_ch - idf datoteka
            - d_CF - debljina materijala za pojedinu kombinaciju mjera
            - mats_name - naziv izolacijskog materijala stropa/poda
    """

    Materijali = idf_ch.idfobjects['MATERIAL']


    for m in Materijali:
        if m.Name == mats_name:
            m.Thickness = d_CF
```

- The whole manual work for changing inputs is replaced with Python functions to change “fields” in IDF objects

```python
"""MODUL za rasvjetu"""
from eppy import modeleditor
from eppy.modeleditor import IDF


def change_lights(idf_ch, LightingDict, key_comb):
    """Funkcija zamjenjuje vrijednosti za rasvjetu po zonama
    INPUTI: - idf_ch -> idf file
            - lux_npd_st -> Lista za rasvjetu, elementi liste:
                            1.) Target Illuminance [lux] - 3 vrijednosti
                            2.) Normalised power density [W/m2100lux] - 3 vrijednosti
                            3.) Broj koraka - 3 vrijednosti
                            NAPOMENA: mora biti tocno ovakav redoslijed!
            - zones_name -> nazivi zona gdje se mijenja rasvjeta
            - key_comb -> naziv kljuca kombinacije (iz rijecnika)
    """

    Obj_Lights = idf_ch.idfobjects['LIGHTS']
    Obj_DayL = idf_ch.idfobjects['DAYLIGHTING:CONTROLS']

    for key,value1 in LightingDict.items():

        if key_comb == key:
            print(key_comb,key)
            keys2 = frozenset(value1)
            for key2 in keys2:


                for obj in Obj_Lights:
                    if obj.Name == value1[key2][1]:
                        Watts_izracun = (value1[key2][3]/100)*value1[key2][4]
                        print(obj.Watts_per_Zone_Floor_Area, Watts_izracun)
                        obj.Watts_per_Zone_Floor_Area = Watts_izracun

                        obj.Fraction_Radiant = value1[key2][6]
                        obj.Fraction_Visible = value1[key2][7]
                        print(key_comb,key,obj)


                for obj in Obj_DayL:

                    if value1[key2][8][2:] != 'Linear/off':

                        if obj.Name == value1[key2][1]: #Glavna prostorija - prizemlje
                            obj.Lighting_Control_Type = value1[key2][8][2:]
                            obj.Number_of_Stepped_Control_Steps = value1[key2][9]
                            obj.Minimum_Input_Power_Fraction_for_Continuous_or_ContinuousOff_Dimming_Control = ''
                            obj.Minimum_Light_Output_Fraction_for_Continuous_or_ContinuousOff_Dimming_Control = ''
                            print(key_comb,key,obj)

                    else:
                        if obj.Name == value1[key2][1]:
                            obj.Lighting_Control_Type = 'ContinuousOff'
                            obj.Number_of_Stepped_Control_Steps = 1
                            obj.Minimum_Input_Power_Fraction_for_Continuous_or_ContinuousOff_Dimming_Control = value1[key2][10]
                            obj.Minimum_Light_Output_Fraction_for_Continuous_or_ContinuousOff_Dimming_Control = value1[key2][11]
                            print(key_comb,key,obj)
```

Input File

A	B	C	D	E	F	G	H
Komb. Py	Kombinacija	Naziv elementa	Izolacijski	VZ	Naziv elementa	Izolacijski	RK
1	1010	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.1	10	RK_ravni krov	MW Glass Wool (standard board)_O.1	10
2	1014	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.1	10	RK_ravni krov	MW Glass Wool (standard board)_O.14	14
3	1016	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.1	10	RK_ravni krov	MW Glass Wool (standard board)_O.16	16
4	1020	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.1	10	RK_ravni krov	MW Glass Wool (standard board)_O.20	20
5	1025	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.1	10	RK_ravni krov	MW Glass Wool (standard board)_O.25	25
6	1410	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.14	14	RK_ravni krov	MW Glass Wool (standard board)_O.1	10
7	1414	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.14	14	RK_ravni krov	MW Glass Wool (standard board)_O.14	14
8	1416	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.14	14	RK_ravni krov	MW Glass Wool (standard board)_O.16	16
9	1420	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.14	14	RK_ravni krov	MW Glass Wool (standard board)_O.20	20
10	1425	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.14	14	RK_ravni krov	MW Glass Wool (standard board)_O.25	25
11	1610	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.16	16	RK_ravni krov	MW Glass Wool (standard board)_O.1	10
12	1614	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.16	16	RK_ravni krov	MW Glass Wool (standard board)_O.14	14
13	1616	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.16	16	RK_ravni krov	MW Glass Wool (standard board)_O.16	16
14	1620	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.16	16	RK_ravni krov	MW Glass Wool (standard board)_O.20	20
15	1625	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.16	16	RK_ravni krov	MW Glass Wool (standard board)_O.25	25
16	2010	__VZ_EIHP	VZ_MW Glass Wool (standard board)_O.2	20	RK_ravni krov	MW Glass Wool (standard board)_O.1	10

Input File

A	B	C	D	E	F	G	H	I	J	K	L
Varijar	Zona	Schedule_Name	Target_Illuminan	Normalised_Power_Densi	Return_Air_Fraction	Fraction_Radiant	Fraction_Visible	Lighting_Control_Type	Number_of_Stepped_Control	Minim	Minim
1	Prizemlje:Restoran	_EIHP_rasvjeta_restoran	500	7,46	0	0,4	0,3	3-Stepped	6	-	-
1	Prizemlje:KonferencijskaSala	_EIHP_rasvjeta_sastanci	500	7,50	0	0,1	0,3	3-Stepped	6	-	-
1	1Xkat:Hodnik	_EIHP_rasvjeta_hodnik	100	14,70	0	0,1	0,3	3-Stepped	3	-	-
1	1Xkat:UrediXzapad	_EIHP_rasvjeta_ured	500	3,78	0	0,4	0,3	3-Stepped	3	-	-
1	1Xkat:SanitarniXcvor	_EIHP_rasvjeta_sanitarni	200	4,98	0	0,1	0,3	3-Stepped	4	-	-
1	1Xkat:UrediXistok	_EIHP_rasvjeta_ured	500	3,78	0	0,4	0,3	3-Stepped	3	-	-
1	2Xkat:KnfrncjskXdvrnX2kt	_EIHP_rasvjeta_sastanci	500	7,50	0	0,1	0,3	3-Stepped	6	-	-
1	Podrum:ServerSoba	Misc24Hr_ServerRoom_Light	200	3,78	0	0,4	0,3	3-Stepped	3	-	-
1	Podrum:Strojarnica	_EIHP_rasvjeta_pomocno	200	5,60	0	0,4	0,3	3-Stepped	2	-	-
1	Podrum:Tusevi	_EIHP_rasvjeta_sanitarni	200	4,98	0	0,1	0,3	3-Stepped	4	-	-
2	Prizemlje:Restoran	_EIHP_rasvjeta_restoran	500	2,50	0	0,4	0,3	3-Stepped	6	-	-
2	Prizemlje:KonferencijskaSala	_EIHP_rasvjeta_sastanci	500	2,70	0	0,1	0,3	3-Stepped	6	-	-
2	1Xkat:Hodnik	_EIHP_rasvjeta_hodnik	100	2,80	0	0,1	0,3	3-Stepped	3	-	-
2	1Xkat:UrediXzapad	_EIHP_rasvjeta_ured	500	2,50	0	0,4	0,3	3-Stepped	3	-	-
2	1Xkat:SanitarniXcvor	_EIHP_rasvjeta_sanitarni	200	2,80	0	0,1	0,3	3-Stepped	4	-	-
2	1Xkat:UrediXistok	_EIHP_rasvjeta_ured	500	2,50	0	0,4	0,3	3-Stepped	3	-	-
2	2Xkat:KnfrncjskXdvrnX2kt	_EIHP_rasvjeta_sastanci	500	2,70	0	0,1	0,3	3-Stepped	6	-	-
2	Podrum:ServerSoba	Misc24Hr_ServerRoom_Light	200	2,50	0	0,4	0,3	3-Stepped	3	-	-
2	Podrum:Strojarnica	_EIHP_rasvjeta_pomocno	200	1,50	0	0,4	0,3	3-Stepped	2	-	-
2	Podrum:Tusevi	_EIHP_rasvjeta_sanitarni	200	2,80	0	0,1	0,3	3-Stepped	4	-	-
3	Prizemlje:Restoran	_EIHP_rasvjeta_restoran	500	0,90	0	0,4	0,3	2-Linear/off	1	0,1	0,1
3	Prizemlje:KonferencijskaSala	_EIHP_rasvjeta_sastanci	500	0,90	0	0,1	0,3	2-Linear/off	1	0,1	0,1

IDF File combinations

A	B	C	D	E	F	G	H	I	J	K
	Šifra	Vanjska ovojnica	Prozori	Rasvjeta	QH_gen_in [kWh]	QH_gen_out [kWh]	W_FE [kWh]	Wgnr_aux [kWh]	W_P [kWh]	eta_H [-]
daljinsko grijanje	0111R	01	1	1R	90904,38614	90904,38614	3686,61	0	8010,81	1
daljinsko grijanje	0112R	01	1	2R	96340,97821	96340,97821	3625,55	0	7756,73	1
daljinsko grijanje	0113R	01	1	3R	100659,2513	100659,2513	3595	0	7508,85	1
daljinsko grijanje	0121R	01	2	1R	80504,16379	80504,16379	3760,07	0	8382,08	1
daljinsko grijanje	0122R	01	2	2R	86912,85774	86912,85774	3629,4	0	8018,94	1
daljinsko grijanje	0123R	01	2	3R	92118,00851	92118,00851	3553,69	0	7702,18	1
daljinsko grijanje	0131R	01	3	1R	84161,12769	84161,12769	3414,38	0	6926	1
daljinsko grijanje	0132R	01	3	2R	91767,98807	91767,98807	3286,68	0	6473,63	1

Name	Status	Date modified
in_ashp_komb_0111R	✓	23.9.2021. 16:50
in_ashp_komb_0112R	✓	23.9.2021. 16:50
in_ashp_komb_0113R	✓	23.9.2021. 16:50
in_ashp_komb_0121R	✓	23.9.2021. 16:50
in_ashp_komb_0122R	✓	23.9.2021. 16:50
in_ashp_komb_0123R	✓	23.9.2021. 16:50
in_ashp_komb_0132R	✓	22.9.2021. 16:57
in_ashp_komb_0133R	✓	22.9.2021. 16:57
in_ashp_komb_0211R	✓	22.9.2021. 16:57
in_ashp_komb_0212R	✓	22.9.2021. 16:57
in_ashp_komb_0213R	✓	22.9.2021. 16:57
in_ashp_komb_0221R	✓	22.9.2021. 16:57
in_ashp_komb_0222R	✓	22.9.2021. 16:57
in_ashp_komb_0223R	✓	22.9.2021. 16:57
in_ashp_komb_0231R	✓	22.9.2021. 16:57
in_ashp_komb_0232R	✓	22.9.2021. 16:57
in_ashp_komb_0233R	✓	22.9.2021. 16:57
in_chp_komb_0111R	✓	23.9.2021. 10:19
in_chp_komb_0112R	✓	23.9.2021. 10:19
in_chp_komb_0113R	✓	23.9.2021. 10:19
in_chp_komb_0121R	✓	23.9.2021. 10:19
in_chp_komb_0122R	✓	23.9.2021. 10:19
in_chp_komb_0123R	✓	23.9.2021. 10:19
in_chp_komb_0131R	✓	23.9.2021. 10:19
in_chp_komb_0132R	✓	23.9.2021. 10:19
in_chp_komb_0133R	✓	23.9.2021. 10:19
in_chp_komb_0211R	✓	23.9.2021. 10:19
in_chp_komb_0212R	✓	23.9.2021. 10:19
in_chp_komb_0213R	✓	23.9.2021. 10:19
in_chp_komb_0221R	✓	23.9.2021. 10:19
in_chp_komb_0222R	✓	23.9.2021. 10:19

Dynamic simulations – results and outputs - office building

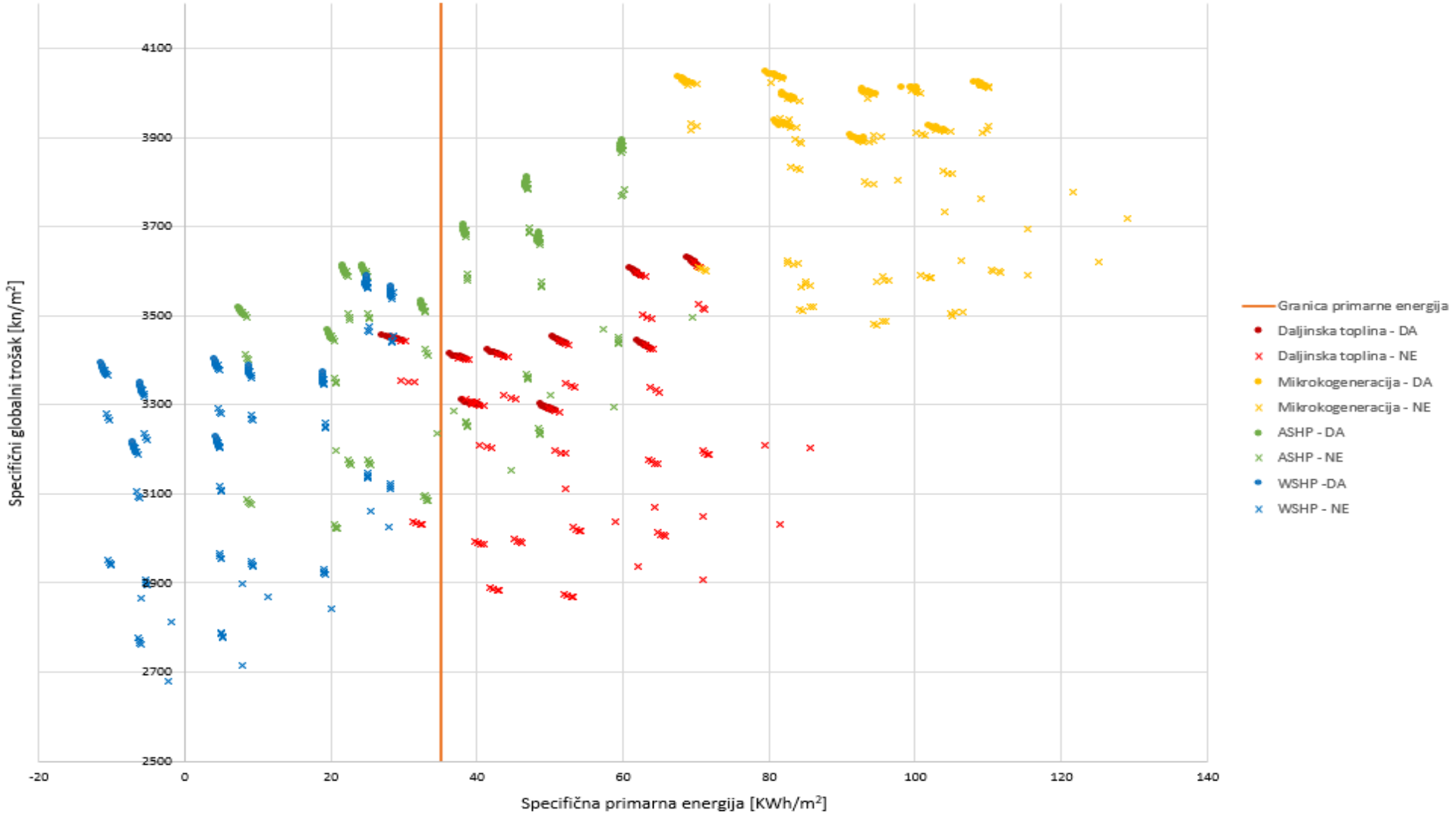
- Annual energy required for space heating
- Annual energy required for space cooling
- Heating and cooling capacity of the heat/cooling energy source
- Capacities of heating/cooling units for each zone
- Energy consumption
- Electricity production - photovoltaic system and micro cogeneration
- CO_2 emmisions

↓

- **PRIMARY ENERGY**
- **GLOBAL COST**

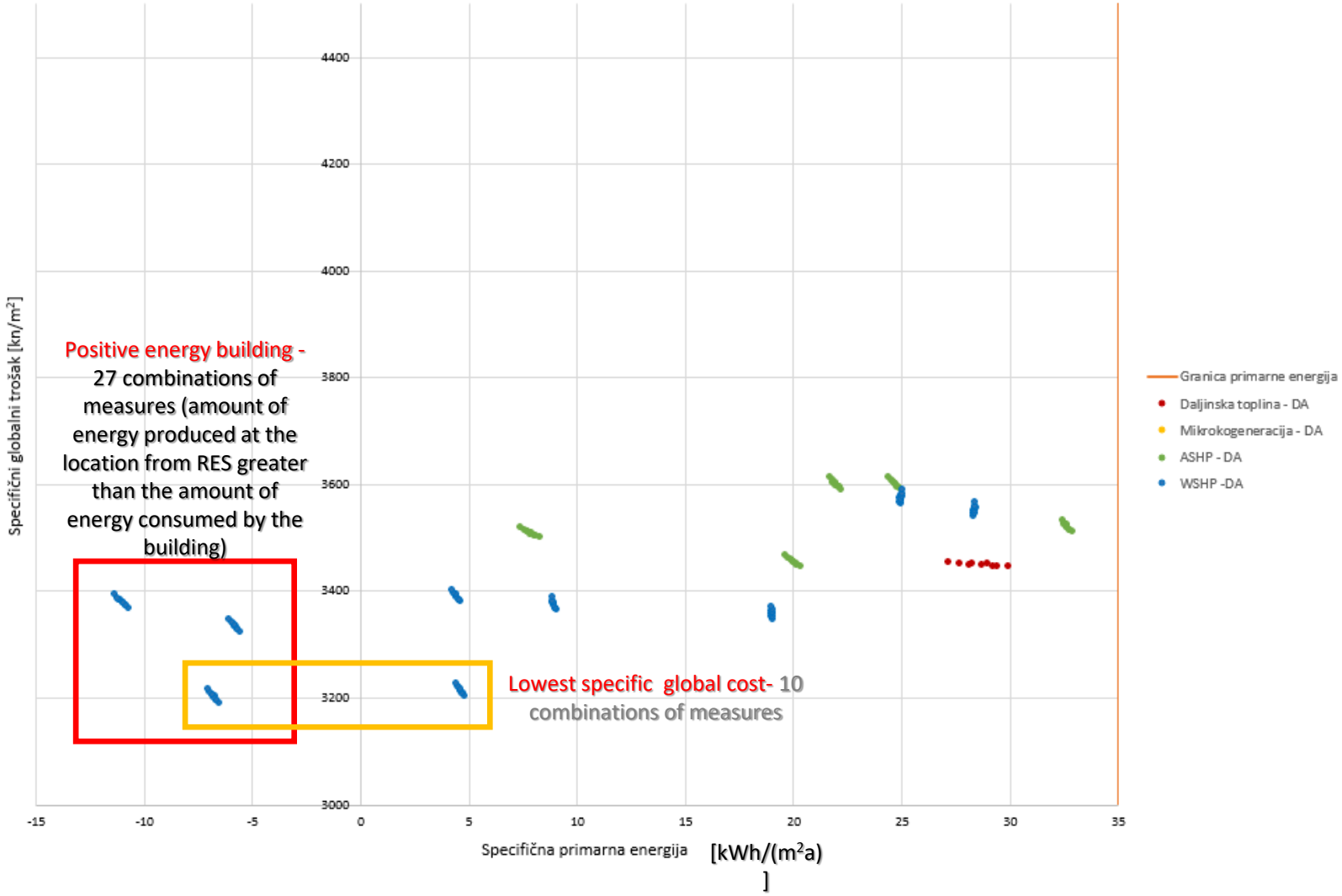
OPTIMAL SOLUTION→ min. (primary energy) & min. (global cost)

Dynamic simulations – results - office building



Dynamic simulations – results – office building

Dependence of specific primary energy and specific global investment cost for combinations of measures that meet the requirements prescribed by the Technical Regulation



Dynamic simulations – results – office building

OPTIMAL SOLUTION→ min. (primary energy) & min. (global cost)

Combinations of measures with the lowest specific global costs

Termotehnički sustav	E_{prim} [kWh/(m^{2}a)]	Specifični globalni trošak [kn/m^2]	Sustav rasvjete	Debljina izolacije vanjskog zida [cm]	Debljina izolacije ravnog krova [cm]	*U* - vrijednost prozora [W/(m^{2}K)]
DT voda/voda	-6	3.191	LED svjetiljke	14	16	1,40
DT voda/voda	-7	3.195	LED svjetiljke	14	20	1,40
DT voda/voda	-7	3.195	LED svjetiljke	16	16	1,40
DT voda/voda	-7	3.200	LED svjetiljke	16	20	1,40
DT voda/voda	-7	3.202	LED svjetiljke	14	25	1,40
DT voda/voda	-7	3.205	LED svjetiljke	20	16	1,40
DT voda/voda	5	3.206	LED izvori	14	16	1,40
DT voda/voda	-7	3.206	LED svjetiljke	16	25	1,40
DT voda/voda	5	3.210	LED izvori	16	16	1,40
DT voda/voda	-7	3.210	LED svjetiljke	20	20	1,40

Min. (global cost)

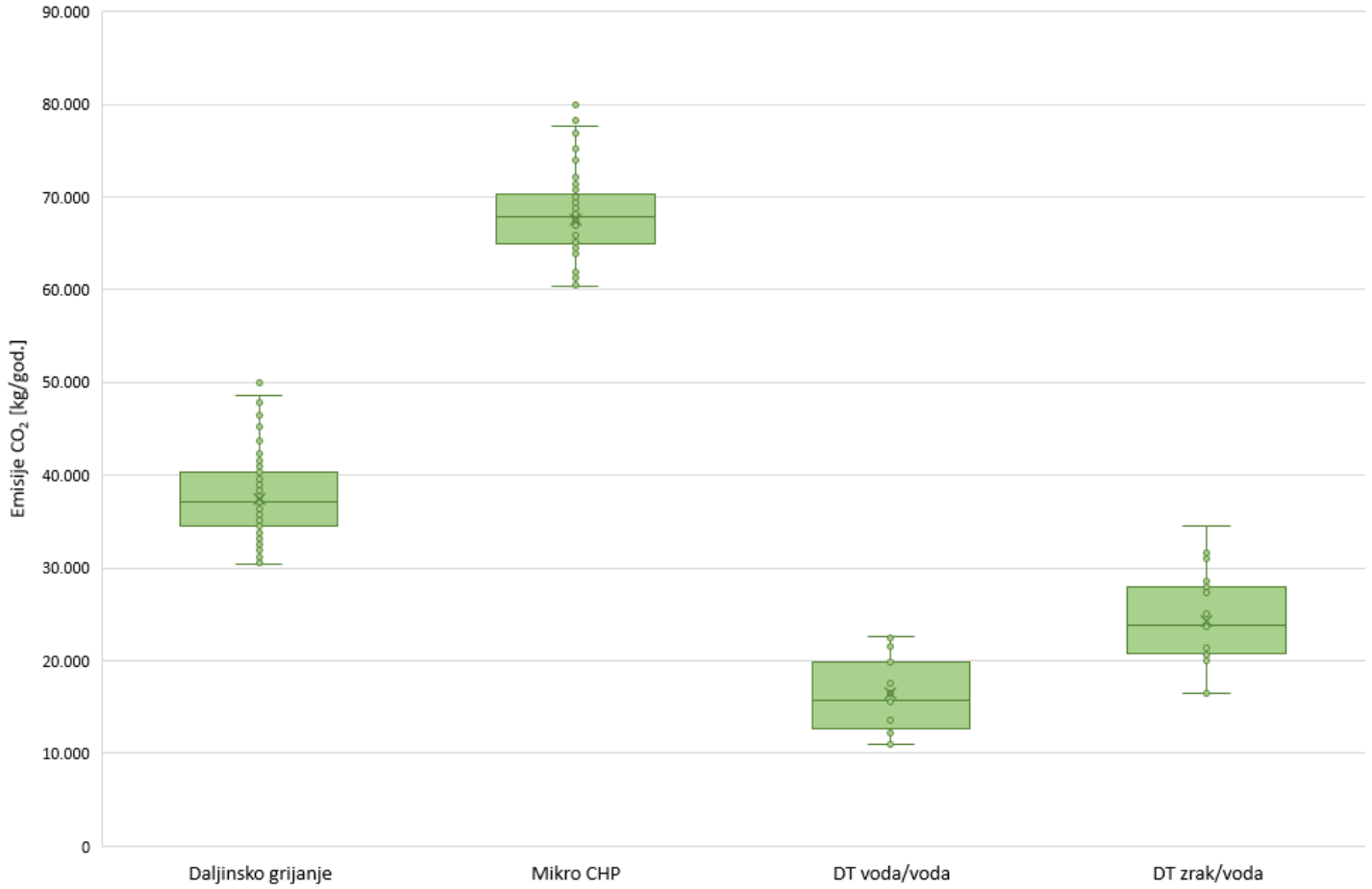
Dynamic simulations – results – office building

Combinations of measures for achieving ZEB

Termotehnički sustav	E_{prim} [kWh/(m²a)]	Specifični globalni trošak [kn/m²]	Sustav rasvjete	Debljina izolacije vanjskog zida [cm]	Debljina izolacije ravnog krova [cm]	*U* - vrijednost prozora [W/(m²K)]
DT voda/voda	-6	3.191	LED svjetiljke	14	16	1,40
DT voda/voda	-6	3.322	LED svjetiljke	14	16	0,80
DT voda/voda	-11	3.367	LED svjetiljke	14	16	0,66
DT voda/voda	-7	3.195	LED svjetiljke	14	20	1,40
DT voda/voda	-6	3.327	LED svjetiljke	14	20	0,80
DT voda/voda	-11	3.372	LED svjetiljke	14	20	0,66
DT voda/voda	-7	3.202	LED svjetiljke	14	25	1,40
DT voda/voda	-6	3.333	LED svjetiljke	14	25	0,80
DT voda/voda	-11	3.378	LED svjetiljke	14	25	0,66
DT voda/voda	-7	3.195	LED svjetiljke	16	16	1,40
DT voda/voda	-6	3.327	LED svjetiljke	16	16	0,80
DT voda/voda	-11	3.372	LED svjetiljke	16	16	0,66
DT voda/voda	-7	3.200	LED svjetiljke	16	20	1,40
DT voda/voda	-6	3.332	LED svjetiljke	16	20	0,80
DT voda/voda	-11	3.377	LED svjetiljke	16	20	0,66
DT voda/voda	-7	3.206	LED svjetiljke	16	25	1,40
DT voda/voda	-6	3.338	LED svjetiljke	16	25	0,80
DT voda/voda	-11	3.383	LED svjetiljke	16	25	0,66
DT voda/voda	-7	3.205	LED svjetiljke	20	16	1,40
DT voda/voda	-6	3.336	LED svjetiljke	20	16	0,80
DT voda/voda	-11	3.382	LED svjetiljke	20	16	0,66
DT voda/voda	-7	3.210	LED svjetiljke	20	20	1,40
DT voda/voda	-6	3.341	LED svjetiljke	20	20	0,80
DT voda/voda	-11	3.386	LED svjetiljke	20	20	0,66
DT voda/voda	-7	3.216	LED svjetiljke	20	25	1,40
DT voda/voda	-6	3.347	LED svjetiljke	20	25	0,80
DT voda/voda	-11	3.393	LED svjetiljke	20	25	0,66

Min. (primarna energija)

Dynamic simulations – results – office building



A combination that results in generally the lowest emissions CO_2 (10.965 kg CO_2/a.) is:

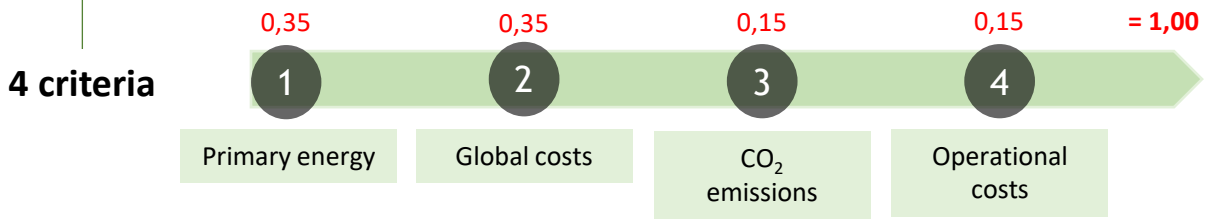
- Heating/cooling source: **water/water heat pump**,
- lighting: **LED lamps**,
- the thickness of the outer wall insulation: **20 cm**,
- flat roof insulation thickness: **25 cm**,
- *U*-coefficient of windows: **0,66 W/(m²K)**.

Multicriteria analysis

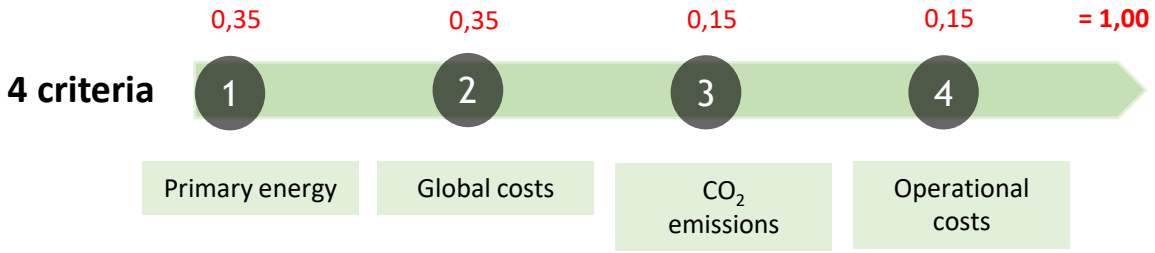
To select the FINAL OPTIMAL SOLUTION, a multi-criteria analysis was carried out, which takes into account:

- **Primary energy,**
- **Global costs,**
- **CO_2 emissions**
- **Operational cost,**

The multi-criteria analysis was performed exclusively for combinations (135 combinations in total) that meet the requirements of the Technical Regulations on the Rational Use of Energy and Thermal Protection in Buildings (NN 128/15, 70/18, 73/18, 86/18, 102/20)



Multicriteria analysis – optimal solution



Optimal solution!

Opis	Mjerna jedinica	Vrijednost
Izvor toplinske/rashladne energije	-	Dizalica topline voda/voda
Debljina izolacije vanjskog zida	cm	16
Debljina izolacije ravnog krova	cm	20
U-vrijednost prozora	$W/(m^2K)$	1,40
Tip rasvjete	-	LED svjetiljke
Godišnja potrebna toplinska energija za grijanje, $Q_{H,nd}$	kWh/m^2	12,86
Kapacitet grijanja	kW	119
Kapacitet hlađenja	kW	112
Proizvodnja električne energije	kWh	60.786
Potrošnja električne energije	kWh	52.409
Operativni trošak	kn	0
Emisije CO_2	$kgCO_2/god.$	12.306
Specifični globalni trošak	kn/m^2	3.200
Apsolutni globalni trošak	kn	6.407.905

TIMEPAC The new EPC for Europe

If you would like more information, please visit www.timepac.eu or contact us at

ddergestin@eihp.hr

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