ModSCO a web application based on a grey-box model to support the estimation of the energy savings in building retrofit.

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SUSTAINABLE PLACES 2021
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Sphere Project

SPHERE
BIM DIGITAL TWIN PLATFORM

Budget: 12,8 M€

SPHERE is a 4-year (2018-2022), Horizon 2020 project that aims to provide a BIM-based Digital Twin Platform to optimise the building lifecycle, reduce costs, and improve energy efficiency in residential buildings.

OBJECTIVES

- 25% Reduction in construction time
- 15% Less energy demand during the operational phase
- 25% Less CO2 and GHG emissions in buildings

CONSORTIUM

18 partners from 10 different EU countries

Coordinator: IDP

This project has received funding from the European Union's H2020 programme under Grant Agreement No. 820805.

Background

Within the last decade, the European Union has developed policies aimed at accelerating the cost-effective renovation of existing buildings, with the vision of a decarbonised building stock by 2050.

One of the potential measure to target these objectives is the EPC

Barriers:

Process complexity

Lack of information about the buildings

Uncertainty about post renovation's energy performance

(Lee et al., 2015)

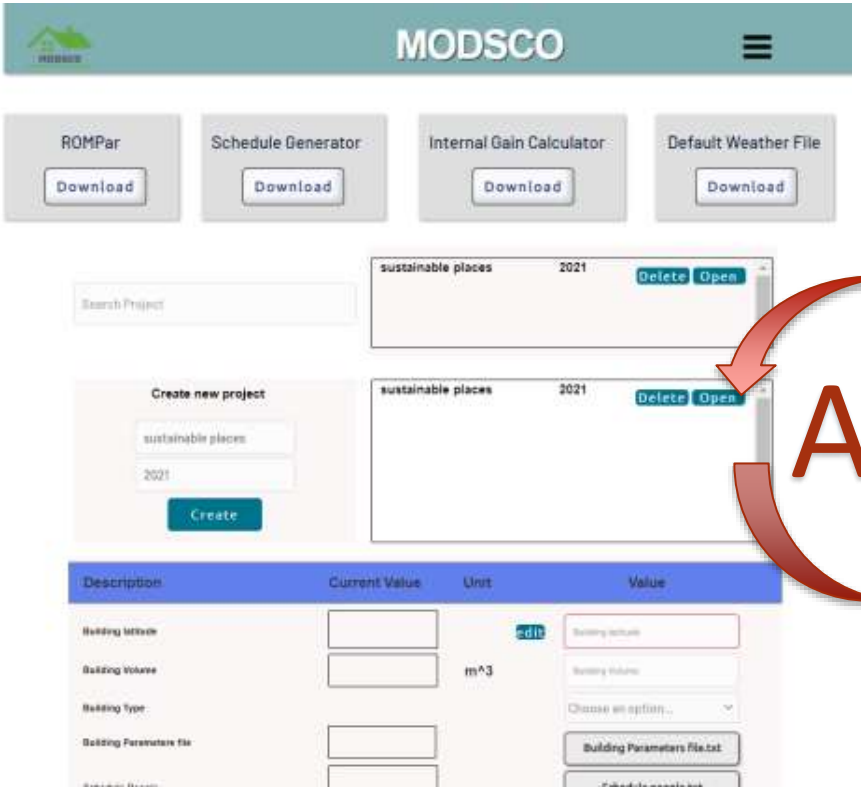
ModSCO Web Application

Estimation of energy consumption

Continuous evaluation of energy savings

ModSCO define a whole building energy model utilising 28 PARAMTERS

ModSCO Core Platform



API

Python Script

PyFMI and dependencies

```
from pyfmi import load_fmu
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import os

Folder_Name = "Shimo0"
path = Folder_Name
if os.path.exists(newpath):
    makedirs(newpath)

FMU_name = "C:\\rom\fmu\ROM_V6_CS.fmu"
model = load_fmu(FMU_name, log_level=5) #to load the file

parameters = ["Building.Volume",
              "Building.Latitude",
              "Building.AWinSouth",
              "Building.AWinNorth",
```

FMU FILE

Jmodelica.org

SERVER

ModSCO Core Platform

Python Script

PyFMI and dipendencies

```
from pyfmi import load_fmu
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import os


Folder_Name = "Shima5"
newpath = Folder_Name
if not os.path.exists(newpath):
    os.makedirs(newpath)

# - - - - - - - - - - - - - - - - - - - - -


FMU_name = "C:\\rom\fmu\ROM_V6_CS.fmu"
model = load_fmu(FMU_name,log_level=5) #to load the file

parameters = ["Building.Volume",
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```
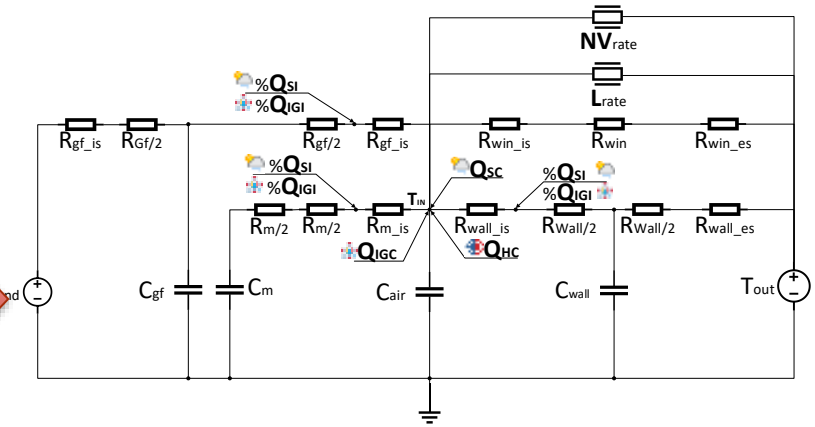
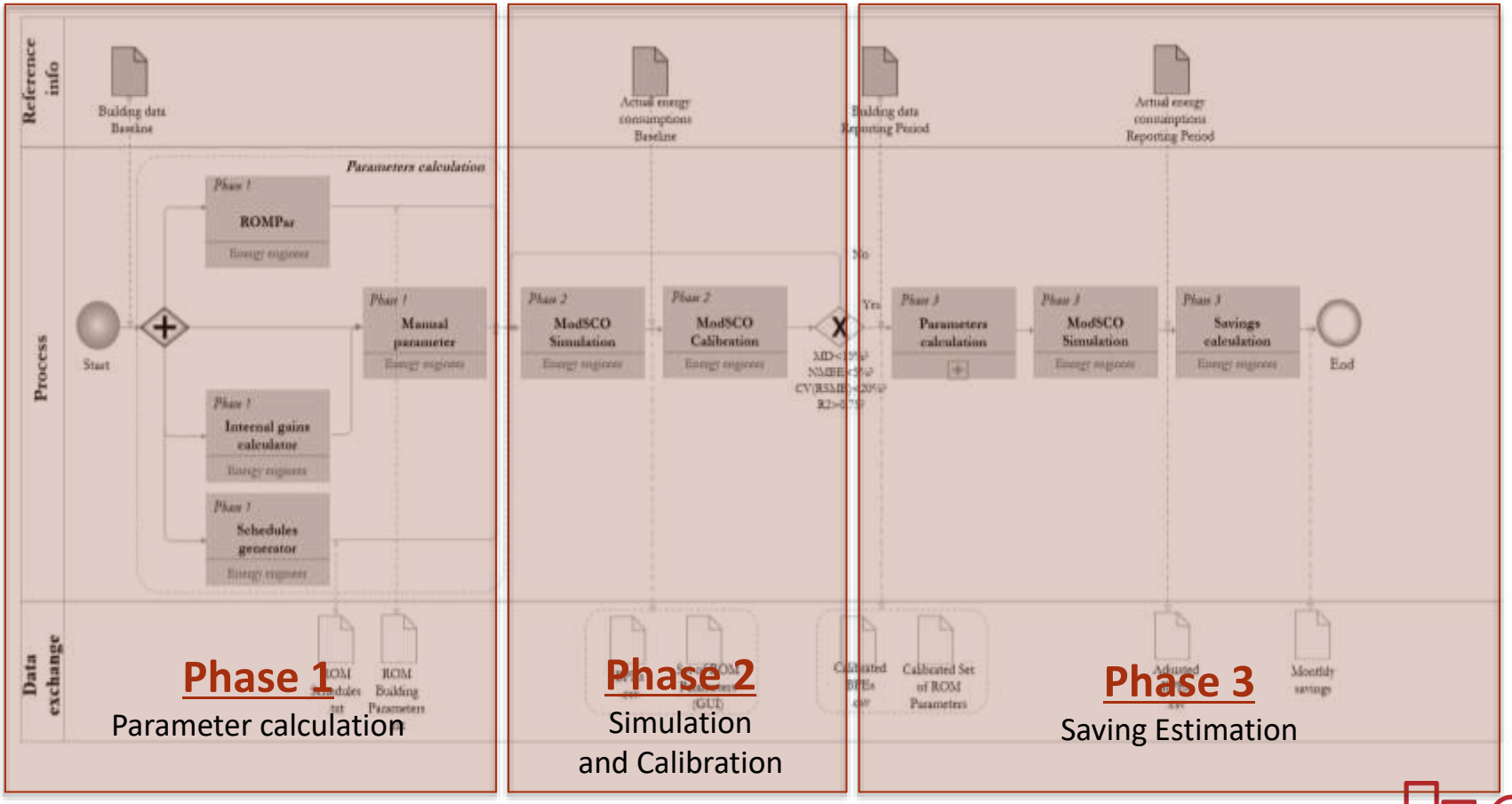



RC-Network of the ROM

- Based on the grey box modelling approach;
- Developed using Modelica in the Dymola Environment;
- Used the thermal network analogies by means of resistances and capacitances.

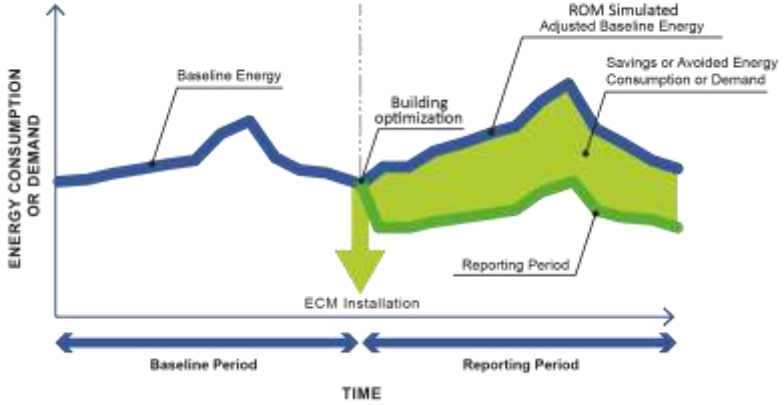
ModSCO Web App



Pilot Description

UNIVERSITY BUILDING - Aras de Brún

SCOPE: to create the Baseline Period Energy consumption to estimate the energy savings after the implementation of the ECMs (blue line)



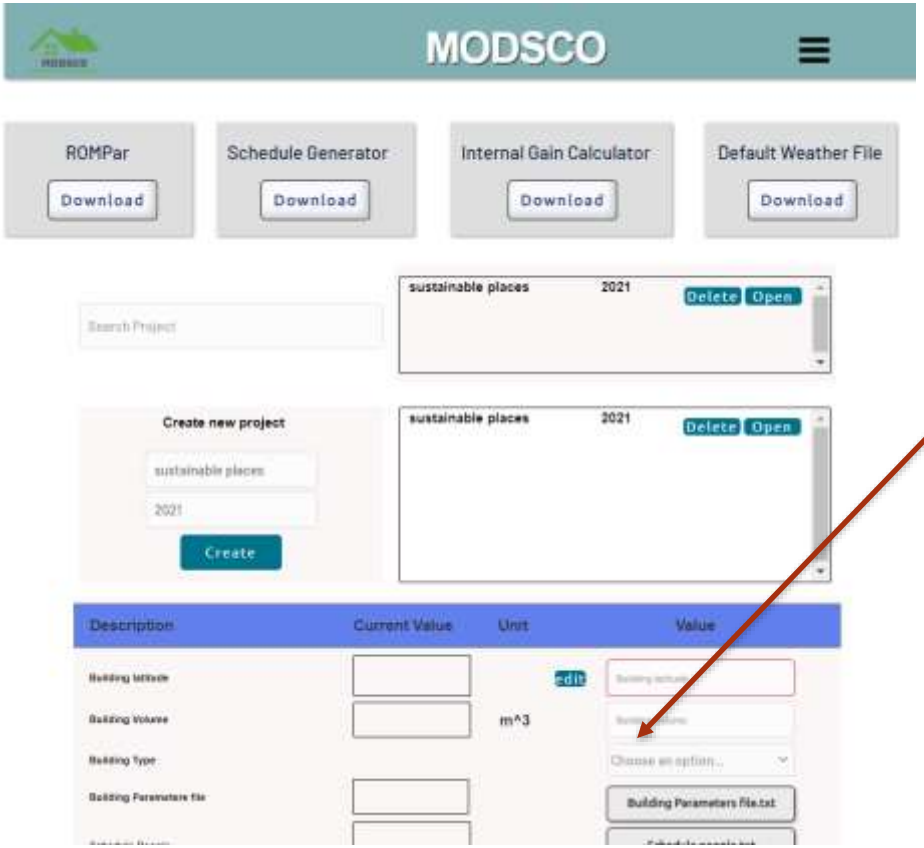
COLLECTED

ENERGY BILLS of 2 years
(2019 – 2020)

BUILDING DRAWINGS
AND SENSORS DATA

ModSCO - Phase 1

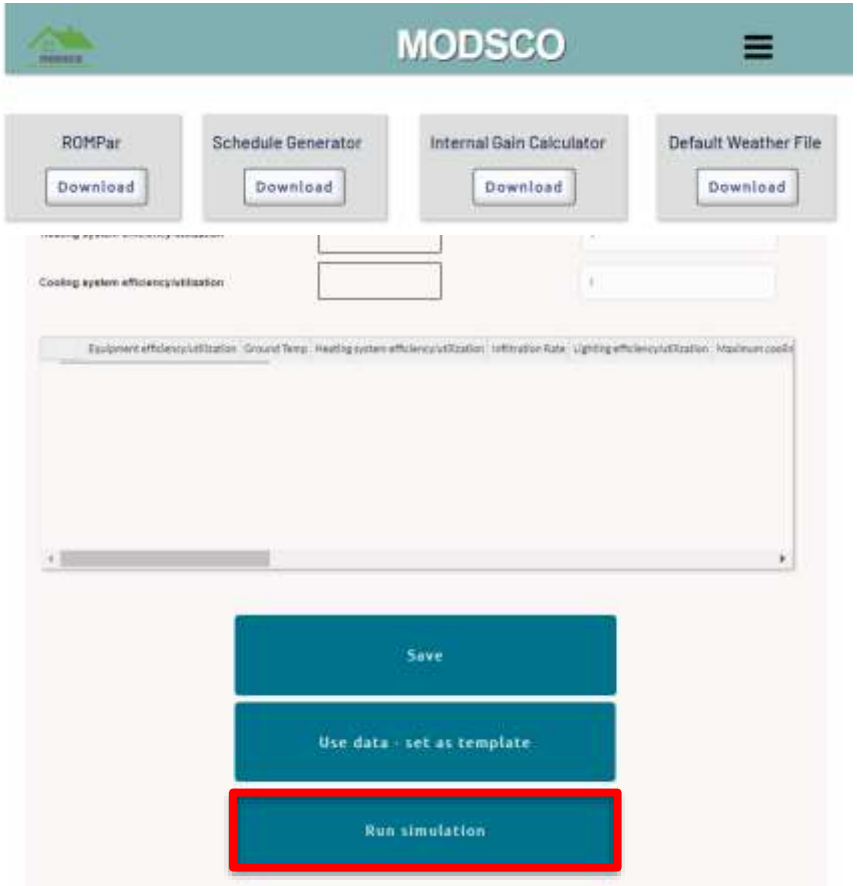
2019 Data

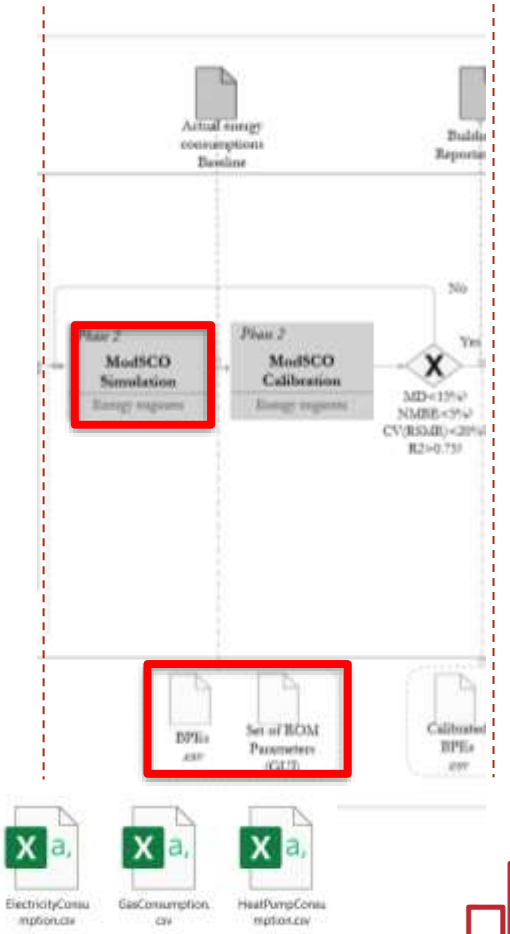


Description	Unit	Value
Building Type (residential or not residential)	-	Not residential
Building/room latitude	-	53.280417
Building/room volume	m3	9282.26
Building Parameters file	-	-
Weather data file .mos	-	Galway 2019
Ground Temperature	°C	15
Maximum heat gain per people	W	18751
Maximum electrical power per lighting	W	14374
Maximum electrical power per equipment	W	18907
StandBy electrical power per lighting/equipment.	W	5991
Maximum cooling Power of the system	W	-10000
Maximum heating Power of the system	W	220000
System equipment electrical power (pumps, fans)	W	9090
StandBy heating power	W	10000
StandBy cooling power	W	0
Heating Setpoint	°C	20
Cooling Setpoint	°C	24
Schedule People (3rd spreadsheet)	-	-
Schedule Lighting (3rd spreadsheet)	-	-
Schedule Equipment (3rd spreadsheet)	-	-
Schedule Heating System (3rd spreadsheet)	-	(test 2)
Schedule Cooling System (3rd spreadsheet)	-	-
Infiltration Rate		2
CALIBRATION PHASE PARAMETER		
Lighting efficiency/utilization	-	1
Equipment efficiency/utilization	-	1
People system influence	-	Not used
Heating system efficiency/utilization	-	1
Cooling system efficiency/utilization	-	1

TIME : 2 hours to calculate the parameters

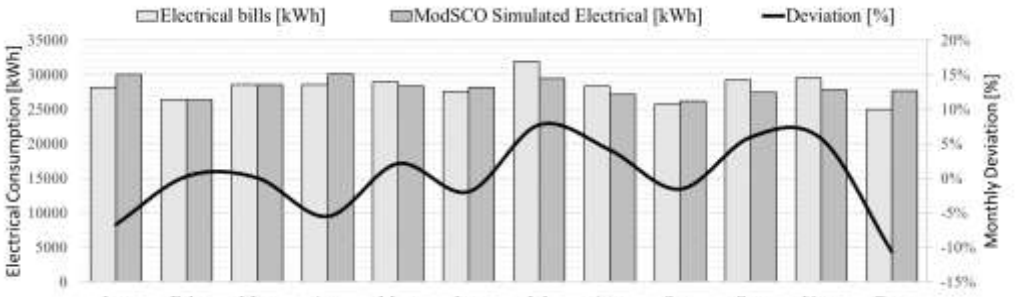
ModSCO - Phase 2

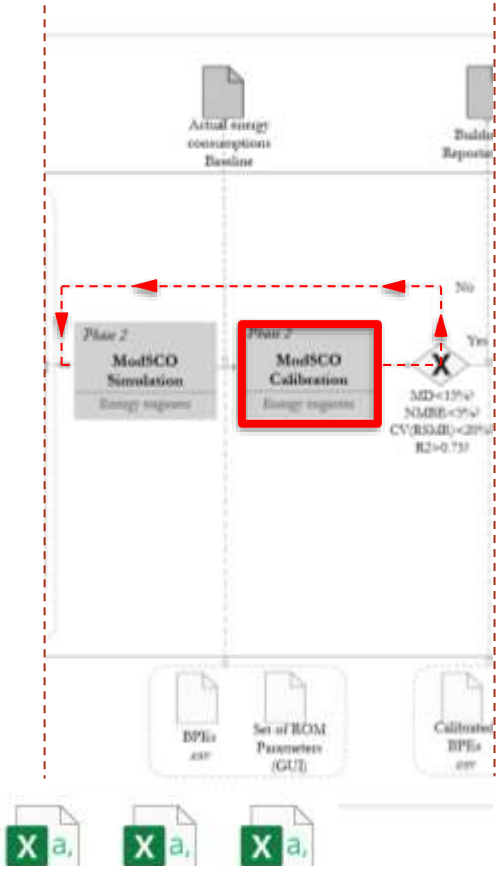




ModSCO - Phase 2

Electricity	Natural Gas		IPMVP limits
ModSCO	**ModSCO**		
0.25%	2.70%	NMBE	< ±5%
6.06%	15.05%	CV-RMSE	< 20%
0.965	0.978	R^2	> 75%

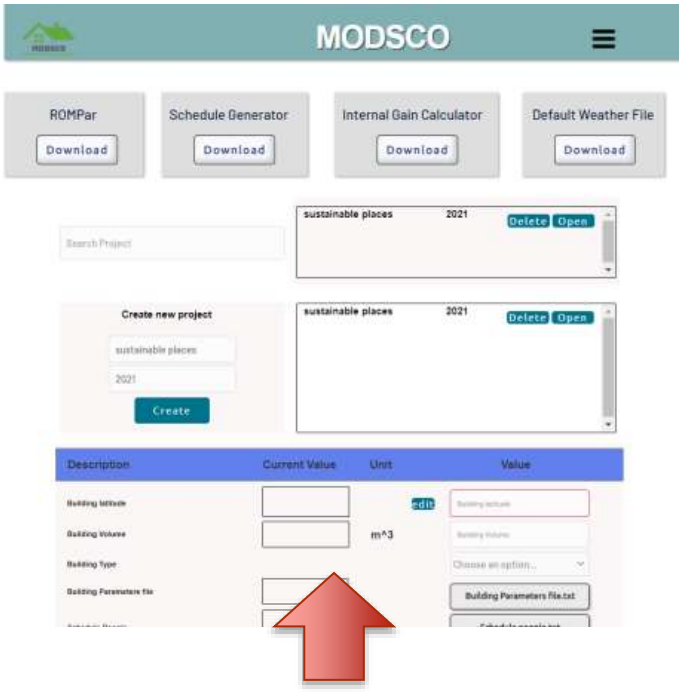




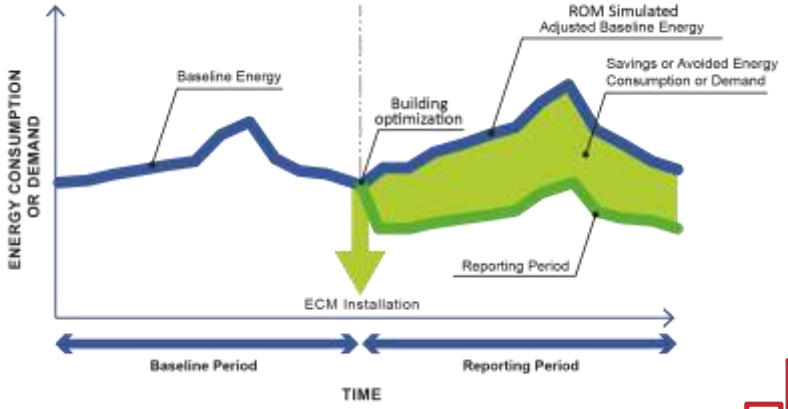
TIME : 4 hours to calibrate the ModSCO

ModSCO - Phase 3

Energy Saving Estimation



Updated with data referred to the Reporting Period (after implementation ECMs)



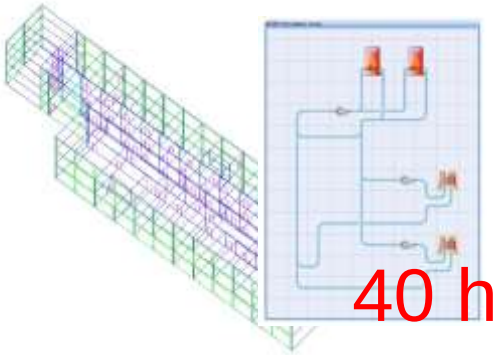
ModSCO vs IES-VE comparison

ModSCO Model

6 hours

VS

IES-VE Model



40 hours

	Electricity			Natural Gas			IPMVP limits
	ModSCO	**IES-VE**		**ModSCO**	**IES-VE**		
	0.25%	1.18	NMBE	2.70%	-0.66	NMBE	< ±5%
	6.06%	7.49	CV-RMSE	15.05%	13.30	CV-RMSE	< 20%
	0.965	0.93	R^2	0.978	0.983	R^2	> 75%

ModSCO conclusion

The MODSCO Web application provides :

- A quick and accurate method for a reliable quantification of energy savings achieved through Energy Conservation Measures (ECMs);
- A easy to use tool for quick evaluation of Building energy consumption;
- A novel methodology to support Measurement and Verification (M&V) in case of uncertainty in building retrofit;

The ModSCO Web Application will be available by the end of December 2021

Thank you for your attention

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Questions?

NUI Galway OÉ Gaillimh

Ryan Institute

SPHERE BIM DIGITAL TWIN PLATFORM

IRISH RESEARCH COUNCIL An Chomhairle um Thaighde in Eirinn

R2M RESEARCH TO MARKET SOLUTION