USE OF BUILDING INFORMATION MODELING TO PLAN ENERGY EFFICIENT APARTMENT BUILDINGS

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Content

Introduction

- In Sri Lanka, the building sector consumes about 35% of total energy (ADB and UNDP, 2017) with a growth rate.
- BIM based energy performance assessment in the design stage is essential for the green building design (Moakher and Pimplikar, 2012)
- The life cycle cost also can be evaluated with BIM based web solutions or softwares (Moakher and Pimplikar, 2012)

Problem Statement

- Software assess the energy and cost for the materials that assigned in the BIM model
- How to select materials and systems both energy efficient and cost effective?

- This research will give optimum material combination considering both cost and energy

Scope of the study

- Conventional and alternative materials available in the local market and different systems(HVAC) are considered (Heating process is not assessed)

- Multi-storey multi-family residential buildings in Sri Lanka and related data are considered in the study

- Energy and cost components which will vary with the building envelope materials are assessed

Main objective

- Develop a practically applicable tool, which can be used to plan energy efficient and cost-effective apartment buildings

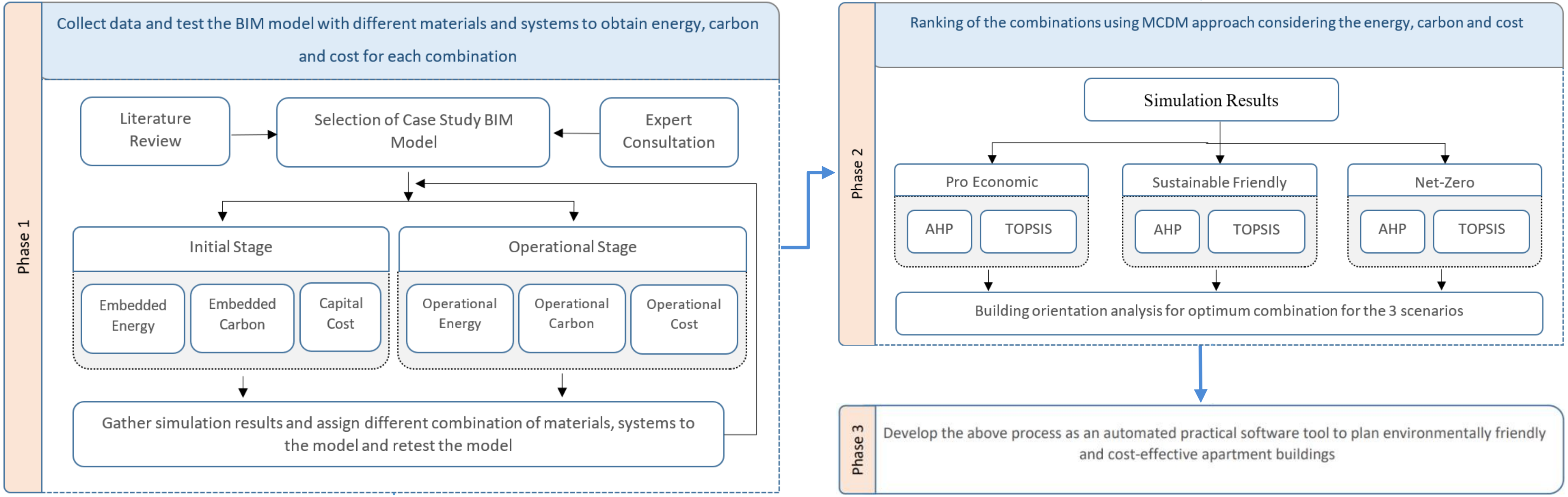
Sub objectives

- Analyze the model with various upgrades and their combinations
- Assess results using MCDM approach and develop an automated tool to select optimal upgrades for building

Literature review

Authors	Key points
Yang & Wang, (2013)	• Different LCA and LCC tools developed for specific regions North America – Athena Eco Calculator Germany – LEGEP software
Marzouk et al., (2018) *Moakher & Pimplikar, (2012)*	• Database development in Autodesk Revit • Material data extraction from the model
Moakher & Pimplikar, (2012) *Nawarathna. & Fernando, (2017)*	• Building life cycle stages for analysis purposes • Carbon emission during different stages
Rodrigues et al., (2020) *Lu et al., (2017)*	• BIM based energy and carbon analysis methods • Comparison of available methods for analyzing
Rodrigues et al., (2020)	• Building envelope upgrade options

Methodology



Selection of upgradable options (Pre defined)

- The upgradable options are selected by the major components in the building envelope (*Yang & Wang, 2013)*
  - External walls
  - External windows
  - External doors
  - External floors
  - Roof
  - Air conditioning systems
  - Building orientation

Phase 1 – Assessing energy, cost and carbon footprint

- This automated tool is developed with 2 software and can do the following steps by executing the developed Dynamo and VBA code

- **1st step**

Revit BIM model → Data extract to excel

(Dynamo)

- **2nd step**

Excel data → Simulation output

(Excel VBA)

Data extraction from BIM model (Real time)

Internal components removing

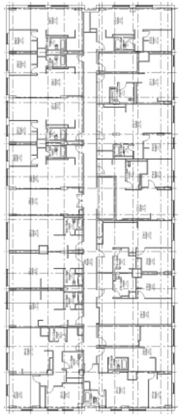
- Walls
- Windows
- Doors
- Defined rooms and tags

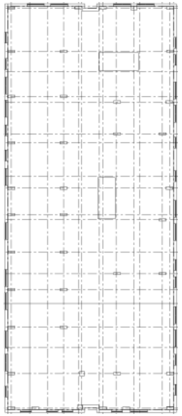
Schedule creation

- Window schedule
  - Direction, Height, Width
- Wall schedule
- Door schedule
- Floor schedule

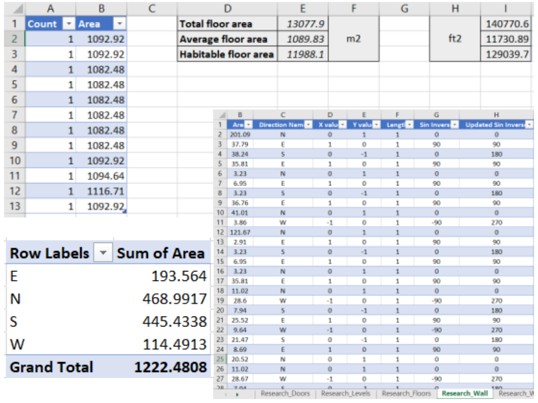
Schedule export

- Created schedules export to excel





AUTODESK REVIT ⟷ Dynamo



	A	B	C	D	E	F	G	H	I
1	Count	Area		Total floor area	13077.9				140770.6
2	1	1092.92		Average floor area	1089.83	m2		ft2	11730.89
3	1	1092.92		Habitable floor area	11988.1				129039.7
4	1	1082.48							
5	1	1082.48							
6	1	1082.48							
7	1	1082.48							
8	1	1082.48							
9	1	1082.48							
10	1	1092.92							
11	1	1094.64							
12	1	1116.71							
13	1	1092.92							

Row Labels	Sum of Area
E	193.564
N	468.9917
S	445.4338
W	114.4913
Grand Total	1222.4808

	B	C	D	E	F	G	H
1	Are	Direction Nam	X valu	Y valu	Lengt	Sin Invers	Updated Sin Invers
2	201.09	N	0	1	1	0	0
3	37.79	E	1	0	1	90	90
4	38.24	S	0	-1	1	0	180
5	35.81	E	1	0	1	90	90
6	3.23	N	0	1	1	0	0
7	6.95	E	1	0	1	90	90
8	3.23	S	0	-1	1	0	180
9	36.76	E	1	0	1	90	90
10	41.01	N	0	1	1	0	0
11	3.86	W	-1	0	1	-90	270
12	121.67	N	0	1	1	0	0
13	2.91	E	1	0	1	90	90
14	3.23	S	0	-1	1	0	180
15	6.95	E	1	0	1	90	90
16	3.23	N	0	1	1	0	0
17	35.81	E	1	0	1	90	90
18	11.02	N	0	1	1	0	0
19	28.6	W	-1	0	1	-90	270
20	7.94	S	0	-1	1	0	180
21	25.52	E	1	0	1	90	90
22	9.64	W	-1	0	1	-90	270
23	21.47	S	0	-1	1	0	180
24	8.69	E	1	0	1	90	90
25	20.52	N	0	1	1	0	0
26	11.02	N	0	1	1	0	0
27	28.67	W	-1	0	1	-90	270

Dynamo code (With case study model data)

- Width
- Height
- Area

Doors
(39)

- Elevation
- Area

Floors
(12)

Walls
(310)

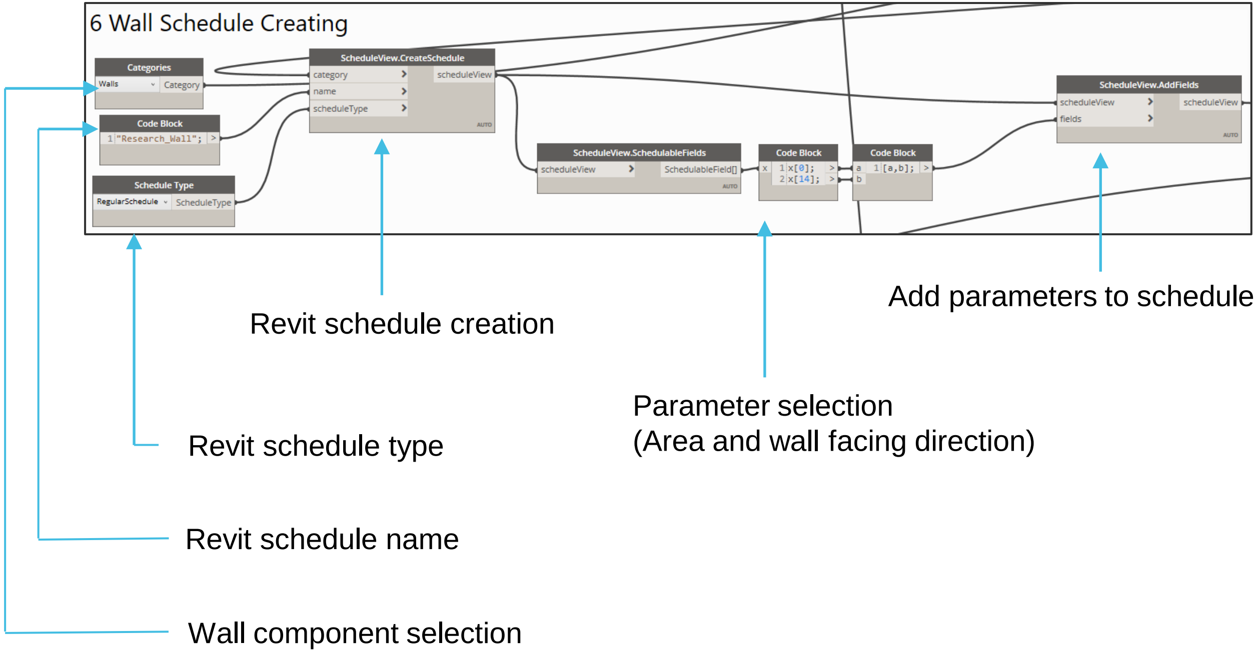
- Area
- Direction to north

Windows
(347)

- Width
- Height
- Direction to north

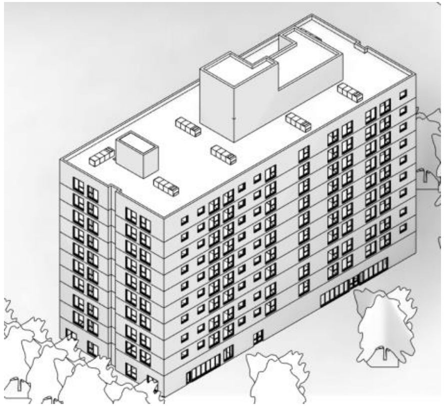
Excel

Dynamo code

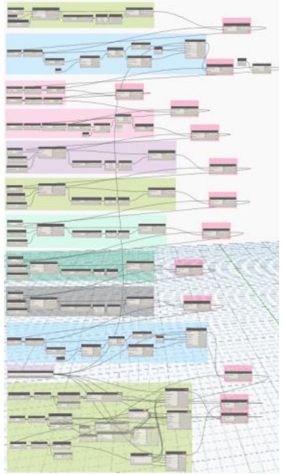

6 Wall Schedule Creating
Categories
Walls
Category
Code Block
1 "Research_Wall";
Schedule Type
RegularSchedule
ScheduleType
ScheduleView.CreateSchedule
category
name
scheduleType
scheduleView
ScheduleView.SchedulableFields
scheduleView
SchedulableField[]
Code Block
x
1 x[0];
2 x[14];
Code Block
a
b
1 [a,b];
ScheduleView.AddFields
scheduleView
fields
scheduleView
Revit schedule creation
Add parameters to schedule
Parameter selection
(Area and wall facing direction)
Revit schedule type
Revit schedule name
Wall component selection

Dynamo Coding

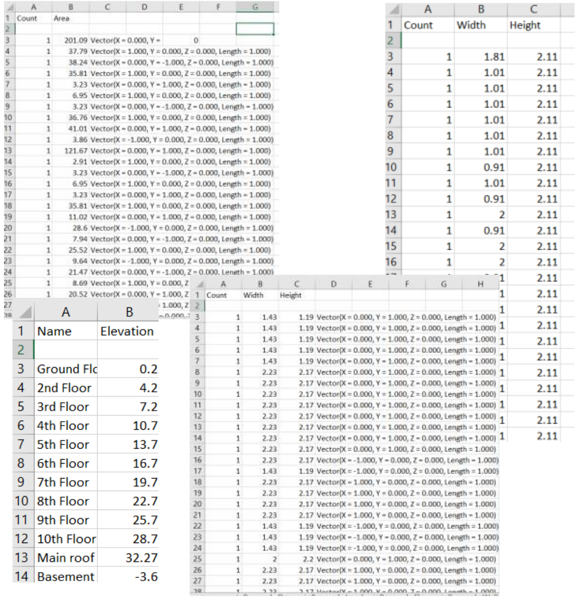
Summary of the dynamo coding output



(BIM model)



(Dynamo script)



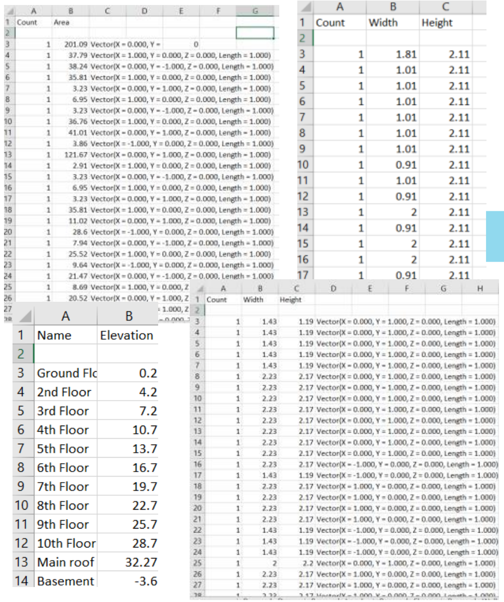
	A	B	C
1	Count	Width	Height
2			
3	1	1.81	2.11
4	1	1.01	2.11
5	1	1.01	2.11
6	1	1.01	2.11
7	1	1.01	2.11
8	1	1.01	2.11
9	1	1.01	2.11
10	1	0.91	2.11
11	1	1.01	2.11
12	1	0.91	2.11
13	1	2	2.11
14	1	0.91	2.11
15	1	2	2.11
16	1	2	2.11

	A	B
1	Name	Elevation
2		
3	Ground Flc	0.2
4	2nd Floor	4.2
5	3rd Floor	7.2
6	4th Floor	10.7
7	5th Floor	13.7
8	6th Floor	16.7
9	7th Floor	19.7
10	8th Floor	22.7
11	9th Floor	25.7
12	10th Floor	28.7
13	Main roof	32.27
14	Basement	-3.6

(Extracted data)

Excel & VBA coding

Creating combinations and analyze each combination for energy and cost



	A	B
1	Name	Elevation
2		
3	Ground Flc	0.2
4	2nd Floor	4.2
5	3rd Floor	7.2
6	4th Floor	10.7
7	5th Floor	13.7
8	6th Floor	16.7
9	7th Floor	19.7
10	8th Floor	22.7
11	9th Floor	25.7
12	10th Floor	28.7
13	Main roof	32.27
14	Basement	-3.6

(Extracted data)

(Excel VBA script)
5524 lines

Cooling Load (kWh/year)	Embodied Energy (MJ)	Cost (LKR)
1241999.587	67310.77443	6291119.758
1242895.168	68128.14381	6318365.404
1249036.29	68618.56543	6269323.242
1244953.451	70307.79548	5691715.55
1245849.032	71125.16485	5718961.196
1251990.154	71615.58648	5669919.033
1242028.718	67224.79193	6286820.633
1242924.299	68042.16131	6314066.279
1249065.421	68532.58293	6265024.117
1244982.582	70221.81298	5687416.425
1245878.163	71039.18235	5714662.071
1252019.285	71529.60398	5665619.908
1420758.565	66088.29363	6046623.598
1421654.146	66905.66301	6073869.244
1427795.268	67396.08463	6024827.082
1423712.429	69085.31468	5447219.39
1424608.01	69902.68405	5474465.036
1430749.132	70393.10568	5425422.873
1420787.696	66002.31113	6042324.473
1421683.276	66819.68051	6069570.119
1427824.398	67310.10213	6020527.957
1423741.56	68999.33218	5442920.265
1424637.14	69816.70155	5470165.911
1430778.262	70307.12318	5421123.748

(Simulation output)

Excel VBA code structure (With case study model data)

1. Formatting Exported Data

Doors → Total area

Floors → Total floor area, Avg. area, Population calculation, Building height

Walls → Area by wall facing direction. (N, NE, E, SE, S, SW, W, NW)

Windows → Area by window facing direction. (N, NE, E, SE, S, SW, W, NW)

2. Database development

Alternative material details

Windows -

Window Name	Shading Coefficier	U Value (W/m²K)	:mbodied Energy (MJ/	Embodied Carbon (kg/	Rate per sq.m
Window 1	0.7	0.2	4.5	4	1000
Window 2	0.9	0.4	3.5	3	800
Window 3	0.8	0.6	3	2	600

Doors -

Door Name	U Value (W/m²K)	:mbodied Energy (MJ/	Embodied Carbon (kg/	Rate per sq.m
Door 1	0.1	2	1.5	250
Door 2	0.15	1	0.75	200

Roofs -

Roof Name	U Value (Btu/hr.ft2.F	:mbodied Energy (MJ/	Embodied Carbon (kg/	Rate per sq.m	6	7	8	9	10	11	12	13
4In L.W. Concrete	0.213	3	2	150	-3	-3	1	9	20	32	44	55
V. Concrete with 1In. Ins	0.206	3.75	1.75	175	-1	-1	3	11	20	30	41	51
6In L.W. Concrete	0.158	4.2	1.3	130	3	1	1	3	7	15	23	33

AC Systems -

AC System Name	Capacity (kW)	Cost (Rs.)
Wall mounted - Inverter (24000BTU)	7.034	372800
Ceiling Mounted - Inverter (48000BTU)	14.067	780000
Floor mounted - Inverter (48000BTU)	14.067	749240

3. Energy Calculation (Cooling Load)

ASHRAE cooling and heating load calculation manual is followed

Cooling_Load_Calculation

Select the nearest city	Colombo
Select the environment	Industrial
Design Temperature (c)	26
Design Relative Humidity	0.5
Total Floor area	11988.08417
Avg. Relative Humidity	0.74
Atmosperic Pressure	100.8

Co2 emission per Unit energy (kg/kWh)	0.299
Life cycle period of Building (Years)	50
AC system replacement period (Years)	10
Average unit energy cost (LKR/kWh)	30

Basic details

					6am	7am	8am	9am	10am	11am	12am	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm
A	Estimation of External Loads																				
	Sensible Load																				
													Hour								
A.1	**Heat transfer through opaque surfaces**				6am	7am	8am	9am	10am	11am	12am	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm
			U	A									CLTD								
	External sunlit walls - North		0.05	24975.9	-1.6	-2.6	-2.6	-1.8	-1.8	-2.8	-2.8	-2.8	-2.8	-1	-1	0	-1.8	-0.8	-0.8	-1.6	-1.6
	External sunlit walls - NE		0.05	0	0.4	-0.6	-1.6	0.2	0.2	0.2	0.2	1.2	1.2	4	5	5	3.2	4.2	4.2	3.4	3.4
	External sunlit walls - East		0.05	15681.7								8.2	9.2	12	13	14	12.2	13.2	13.2	11.4	11.4
	External sunlit walls - SE		0.05	0								13.2	14.2	17	18	19	18.2	18.2	19.2	17.4	17.4
	External sunlit walls - South		0.05	18491								17.2	17.2	19	20	21	20.2	21.2	22.2	20.4	21.4
	External sunlit walls - SW		0.05	0	16.4	15.4	14.4	15.2	14.2	14.2	13.2	12.2	12.2	14	14	15	14.2	15.2	17.2	16.4	17.4
	External sunlit walls - West		0.05	14890.4	10.4	10.4	9.4	10.2	9.2	8.2	7.2	7.2	6.2	8	8	8	7.2	8.2	10.2	9.4	11.4
	External sunlit walls - NW		0.05	0	2.4	2.4	1.4	2.2	1.2	1.2	0.2	0.2	-0.8	1	1	2	0.2	1.2	2.2	1.4	2.4
	Roofs		0.158	11730.9										-12	-12	-12	-13.8	-13.8	-13.8	-15.6	-15.6
		U	A	Ti																	
	Floors	0.1	1089.83	26										26	26	26	25	25	25	24	24
	Doors	0.15	85.9825	26										26	26	26	25	25	25	24	24
A.2	**Heat transfer through fenestration/transparent surfaces**																				
	Heat transfer by conduction																				
	Window glass	0.2	1222.48	26											26	26	25	25	25	24	24
		A in ft	SHGF_max	SC									CLF								
	Heat transfer by solar radiation																				
	Windows - North	5048.23	31	0.7	0.34	0.41	0.46	0.53	0.59	0.65	0.7	0.74	0.75	0.76	0.74	0.75	0.79	0.61	0.5	0.42	0.36
	Windows - NE	0	55	0.7										0.28	0.26	0.24	0.21	0.17	0.15	0.13	0.11
	Windows - East	2083.52	215	0.7										0.29	0.26	0.23	0.21	0.17	0.15	0.13	0.11
	Windows - SE	0	247	0.7										0.36	0.33	0.29	0.25	0.21	0.18	0.16	0.14
	Windows - South	4794.65	179	0.7	0.08	0.11	0.14	0.21	0.31	0.42	0.52	0.57	0.58	0.53	0.47	0.41	0.35	0.29	0.25	0.21	0.18

Heat gain through walls

Heat gain by roof, floor & doors

Heat gain by window - Conduction

Heat gain by window - Radiation

Cooling_Load_Calculation | Pro_Economic | Sustainable_Friendly | Net-Zero | Combination_Results | Alternative_Materials | City_Details

3.1 Basic details

- User should enter relevant values to the highlighted cells

		Cooling_Load_Calculation	
Select the nearest city	Colombo	Co2 emission per Unit energy (kg/kWh)	0.299
Select the environment	Industrial	Life cycle period of Building (Years)	50
Design Temperature (c)	26	AC system replacement period (Years)	10
Design Relative Humidity	0.5	Average unit energy cost (LKR/kWh)	30
Total Floor area	11988.08417		
Avg. Relative Humidity	0.74		
Atmosperic Pressure	100.8		

- ***Selecting city*** → Import relevant climatic data for calculation
- ***Selecting environment*** → Alter the variables in the calculation

3.2 Heat gain through walls and roof

				Hour																
A.1	**Heat transfer through opaque surfaces**			6am	7am	8am	9am	10am	11am	12am	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm
		U	A	CLTD																
	External sunlit walls - North	0.05	24975.9	-1.6	-2.6	-2.6	-1.8	-1.8	-2.8	-2.8	-2.8	-2.8	-1	-1	0	-1.8	-0.8	-0.8	-1.6	-1.6
	External sunlit walls - NE	0.05	0	0.4	-0.6	-1.6	0.2	0.2	0.2	0.2	1.2	1.2	4	5	5	3.2	4.2	4.2	3.4	3.4
	External sunlit walls - East	0.05	15681.7	7.4	6.4	5.4	7.2	6.2	7.2	7.2	8.2	9.2	12	13	14	12.2	13.2	13.2	11.4	11.4
	External sunlit walls - SE	0.05	0	13.4	13.4	12.4	13.2	13.2	13.2	13.2	13.2	14.2	17	18	19	18.2	18.2	19.2	17.4	17.4
	External sunlit walls - South	0.05	18491	19.4	18.4	17.4	19.2	18.2	17.2	17.2	17.2	17.2	19	20	21	20.2	21.2	22.2	20.4	21.4
	External sunlit walls - SW	0.05	0	16.4	15.4	14.4	15.2	14.2	14.2	13.2	12.2	12.2	14	14	15	14.2	15.2	17.2	16.4	17.4
	External sunlit walls - West	0.05	14890.4	10.4	10.4	9.4	10.2	9.2	8.2	7.2	7.2	6.2	8	8	8	7.2	8.2	10.2	9.4	11.4
	External sunlit walls - NW	0.05	0	2.4	2.4	1.4	2.2	1.2	1.2	0.2	0.2	-0.8	1	1	2	0.2	1.2	2.2	1.4	2.4

Imported by created material database

Imported by exported data tables

Imported by created ASHRAE database

$$Q = U * A * CLTD$$

$$CLTD = [(CLTD_{raw} + LM) * K + (78 - T_r) - (T_o - 85)$$

Solar time

Wall direction

Wall type

Wall direction

Month

Surrounding condition

Inside temperature

Outside temperature hour by hour

Variation of CLTD values

- Vary with 12 months
- Vary with hour by hour for a given month
- Vary with latitude of the building location
- Vary with Environment type (Industrial, rural)
- Vary with wall material (7 types)

3.3 Heat gain through floor and doors

		U	A	Ti	To																
Floors		0.1	1089.83	26	24	24	24	25	25	25	25	25	25	26	26	26	25	25	25	24	24
Doors		0.15	35.9825	26	24	24	24	25	25	25	25	25	25	26	26	26	25	25	25	24	24

Imported by created material database

Imported by exported data tables

Imported by created Climatic database

3.4 Heat gain through windows - Conduction

A.2	Heat transfer through fenestration/transparent surfaces																					
			U	A	Ti	To																
	Heat transfer by conduction																					
	Window glass		0.2	1222.48	26	24	24	24	25	25	25	25	25	25	26	26	26	25	25	25	24	24

Imported by created material database

Imported by exported data tables

Imported by created Climatic database

3.5 Heat gain through windows - Radiation

			A in ft	HGF, max	SC	CLF																
	Heat transfer by solar radiation																					
	Windows - North		5048.23	31	0.7	0.34	0.41	0.46	0.53	0.59	0.65	0.7	0.74	0.75	0.76	0.74	0.75	0.79	0.61	0.5	0.42	0.36
	Windows - NE		0	55	0.7	0.21	0.36	0.44	0.45	0.4	0.36	0.33	0.31	0.3	0.28	0.26	0.24	0.21	0.17	0.15	0.13	0.11
	Windows - East		2083.52	215	0.7	0.18	0.33	0.44	0.5	0.51	0.46	0.39	0.35	0.31	0.29	0.26	0.23	0.21	0.17	0.15	0.13	0.11
	Windows - SE		0	247	0.7	0.14	0.26	0.38	0.48	0.54	0.56	0.51	0.45	0.4	0.36	0.33	0.29	0.25	0.21	0.18	0.16	0.14
	Windows - South		4794.65	179	0.7	0.08	0.11	0.14	0.21	0.31	0.42	0.52	0.57	0.58	0.53	0.47	0.41	0.35	0.29	0.25	0.21	0.18
	Windows - SW		0	247	0.7	0.09	0.1	0.12	0.13	0.15	0.17	0.23	0.33	0.44	0.53	0.58	0.59	0.53	0.41	0.33	0.28	0.24
	Windows - West		1232.38	215	0.7	0.09	0.09	0.1	0.11	0.12	0.13	0.14	0.19	0.29	0.4	0.5	0.56	0.55	0.41	0.33	0.27	0.23
	Windows - NW		0	55	0.7	0.09	0.1	0.11	0.13	0.15	0.16	0.17	0.18	0.21	0.3	0.42	0.51	0.54	0.39	0.32	0.26	0.22

Imported by created material database

Imported by created ASHRAE database

$$Q = A * SC * SHGF_{max} * CLF$$

Window area

Glass type

8 window directions

Month

Latitude

8 window directions

Solar time

3.6 Heat gain through ventilation

Vary with : outside hourly temperature, Humidity ratio, air pressure, ventilation rate and relative humidity

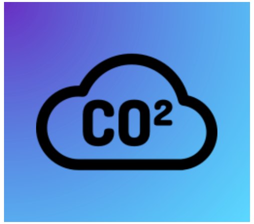
3.7 Heat gain by occupants

Vary with : number of people, sensible heat gain per person, building type

3.8 Heat gain due to lighting, conduction through doors, windows and floors

Vary with : heat transfer coefficients, area and temperature differences

4. Results at the end of phase 1



Energy

Peak cooling load
Annual cooling load
Embodied energy
Operational energy (A/C)

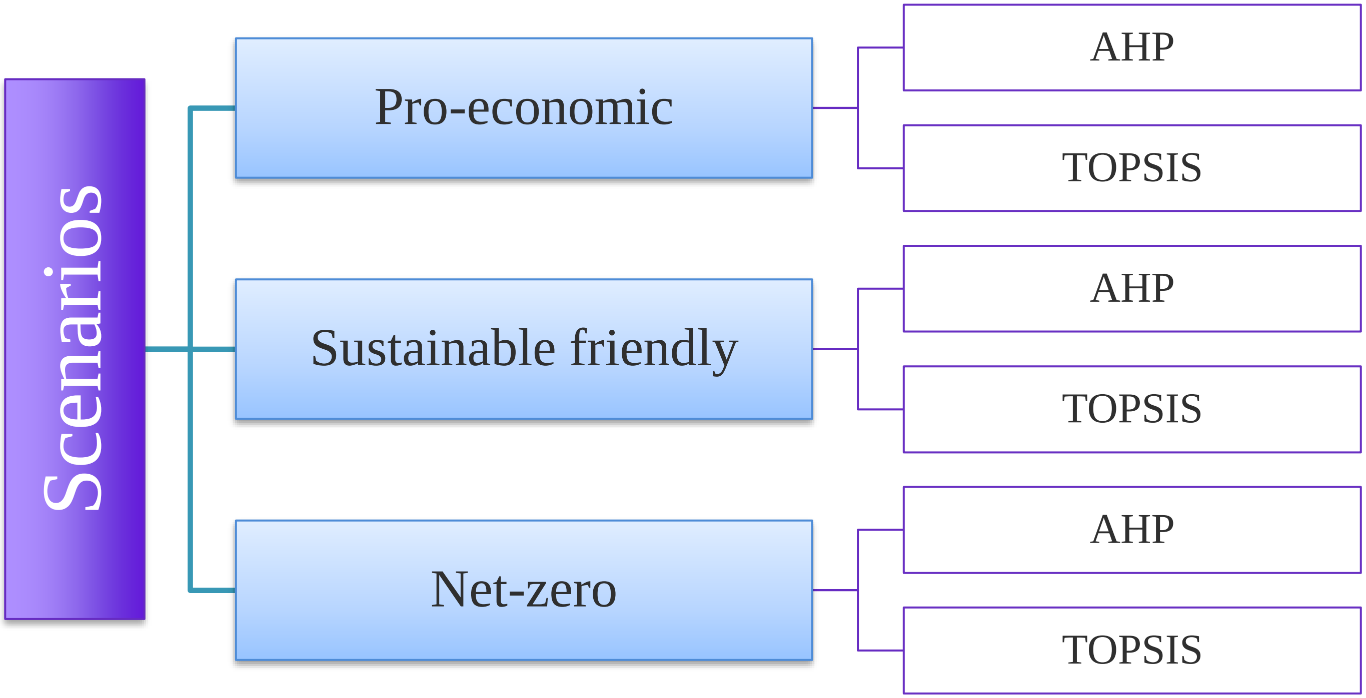
Cost

Capital cost
Operational cost (A/C)
A/C system cost

Carbon footrint

Embodied carbon
Operational carbon (A/C)

Phase 2 – MCDM approach and orientation analysis



Weightages for TOPSIS and AHP

1. Pro economic scenario
   - High weightages to cost components

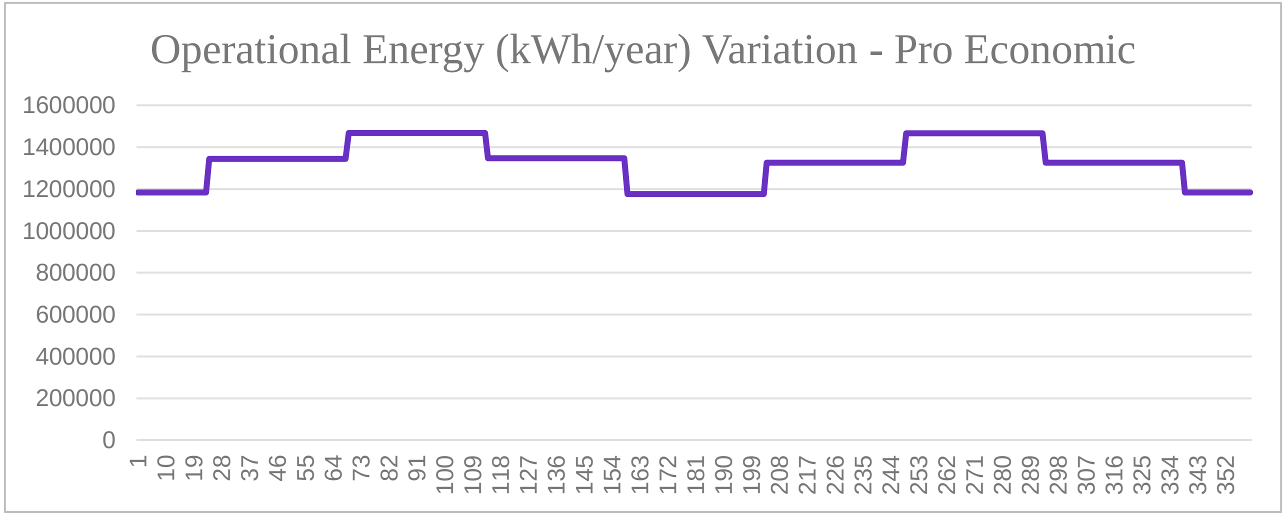
2. Sustainable friendly scenario
   - High weightages to energy and carbon emission components

3. Net-zero scenario
   - Operational cost not considered
   - Operational carbon not considered
   - High weightages to energy and carbon emission components

Optimization of orientation

Steps of analysis

- Assign optimum material combination
- Every angle of 360 degree is analyzed for the energy
- Select the most energy-efficient orientation



Case study BIM model

Revit BIM model

- Floors of the building - 10
- Residential units - 126
- Total floor area - 11,076.6 m^2

Results

Results generated by the developed Dynamo and Excel VBA code

Maximum Load kWh/hr	460.1984263
No. AC Systems	33
Cooling Load (kWh/year)	1366100.598
Embodied Energy (MJ)	47359.63573
LC Operational Energy (MJ)	245898107.6
Capital Cost (LKR)	6332337.659
Operational Cost (LKR)	2049150896
System Cost (LKR)	123624600
Embodied Carbon (Metric T)	25.9845251
Operational Carbon (Metric T)	20423.20393
Total Energy (MJ)	245945467.2
Total Cost (LKR Million)	2167.869234
Total Carbon (Metric T)	20449.18846

Validation

Validation of results by manual calculation, web services and software

The calculation process	Accuracy percentage	Validation method
Embodied energy	100%	Manual calculation
Operational energy	99.54%	Revit cooling load analysis
Capital cost	100%	Manual calculation
Operational cost	100%	Manual calculation
A/C system cost	100%	Manual calculation
Embodied carbon	100%	Manual calculation
Operational carbon	100%	Manual calculation
AHP	100%	Manual calculation
TOPSIS	100%	Manual calculation
Orientation analysis	100%	Autodesk Insight

Conclusion

- Research aim achieved (Developing of software tool)
- High accuracy of developed software
- Any user can operate the tool
- According to the case study;
    - 20.6% reduction of operational energy and cost
    - 40.7% reduction of embodied energy
    - 18.7% reduction of capital cost
    - 24.2% reduction of A/C system cost
    - 19.9% operational energy reduction due to optimum orientation
    - 6.3% reduction of A/C system cost due to optimum orientation

Contribution for the research (Conference paper)

- Presenting a research paper titled on “A review on cost-effective energy-efficient building planning for urban sectors: A life cycle thinking based approach” at ICSECM 2021

ICSECM 2021 – 44

A REVIEW ON COST-EFFECTIVE ENERGY-EFFICIENT BUILDING PLANNING FOR URBAN CENTRES: A LIFE CYCLE THINKING-BASED APPROACH

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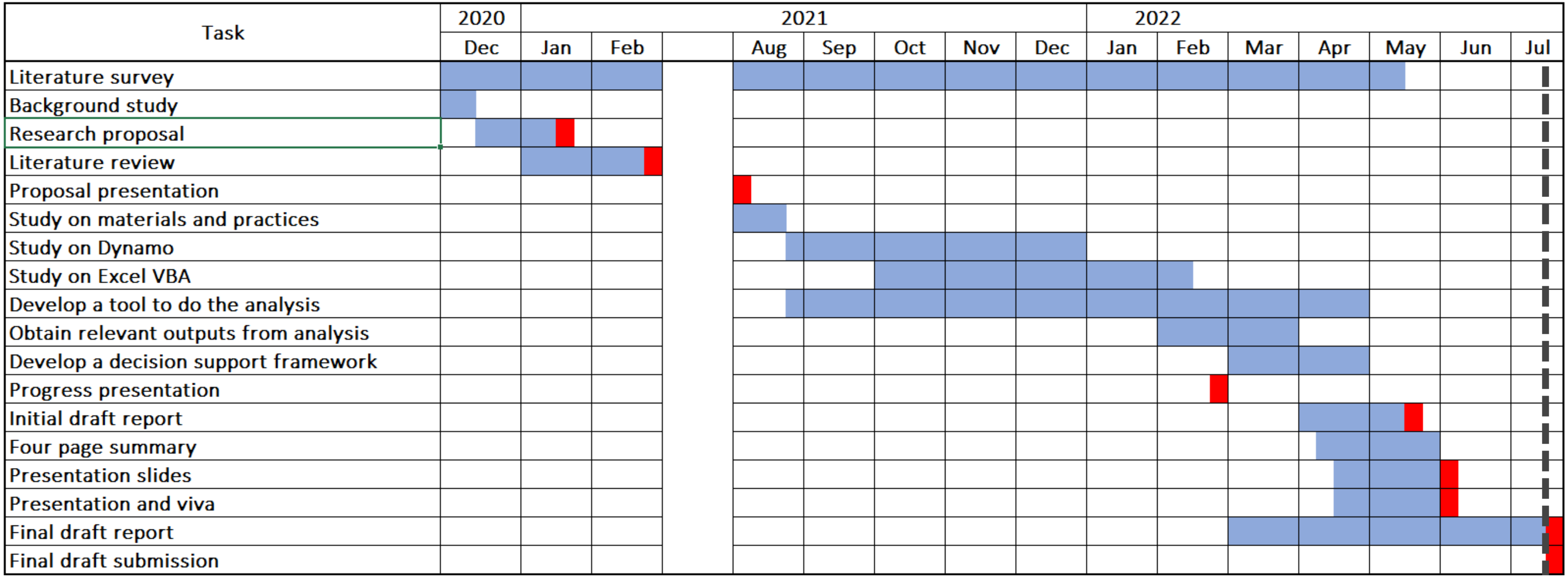
Abstract: Extensive energy use and resultant greenhouse gas (GHG) emissions in urban centres are rapidly increasing due to the population growth and implications of urban sprawl. Among different energy uses, the building sector energy consumption accounts for 40% of global energy consumption and results in 18% GHG emission. Literature reveals that there is a significant amount of research studies that are focused on building energy efficiency from a global and local perspective. In most of these studies, the authors have identified the life cycle thinking approach as a very important technique to compare different energy-efficient building materials, construction technologies, and practices. However, there is a lack of knowledge on the life cycle thinking-based building planning approach considering the Sri Lankan context. The objective of this study is to explore and develop a conceptual research framework for planning sustainable buildings for tropical climatic conditions using building planning parameters that are related to costs, emissions, and social impacts, of locally available building materials and technologies. Here, the literature available on life cycle cost, life cycle emissions, and social life cycle impacts were considered. Expert interviews were conducted to develop the above-mentioned methodology using industry norms and locally available construction technologies. The framework developed in this research will help to select construction materials for future sustainable buildings for tropical climatic conditions. BIM software integrated tools that can be used to get a more reliable and quick analysis of buildings were explored in this study.

Time frame


Task
2020
2021
2022
Dec
Jan
Feb
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Literature survey
Background study
Research proposal
Literature review
Proposal presentation
Study on materials and practices
Study on Dynamo
Study on Excel VBA
Develop a tool to do the analysis
Obtain relevant outputs from analysis
Develop a decision support framework
Progress presentation
Initial draft report
Four page summary
Presentation slides
Presentation and viva
Final draft report
Final draft submission

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Thank You!