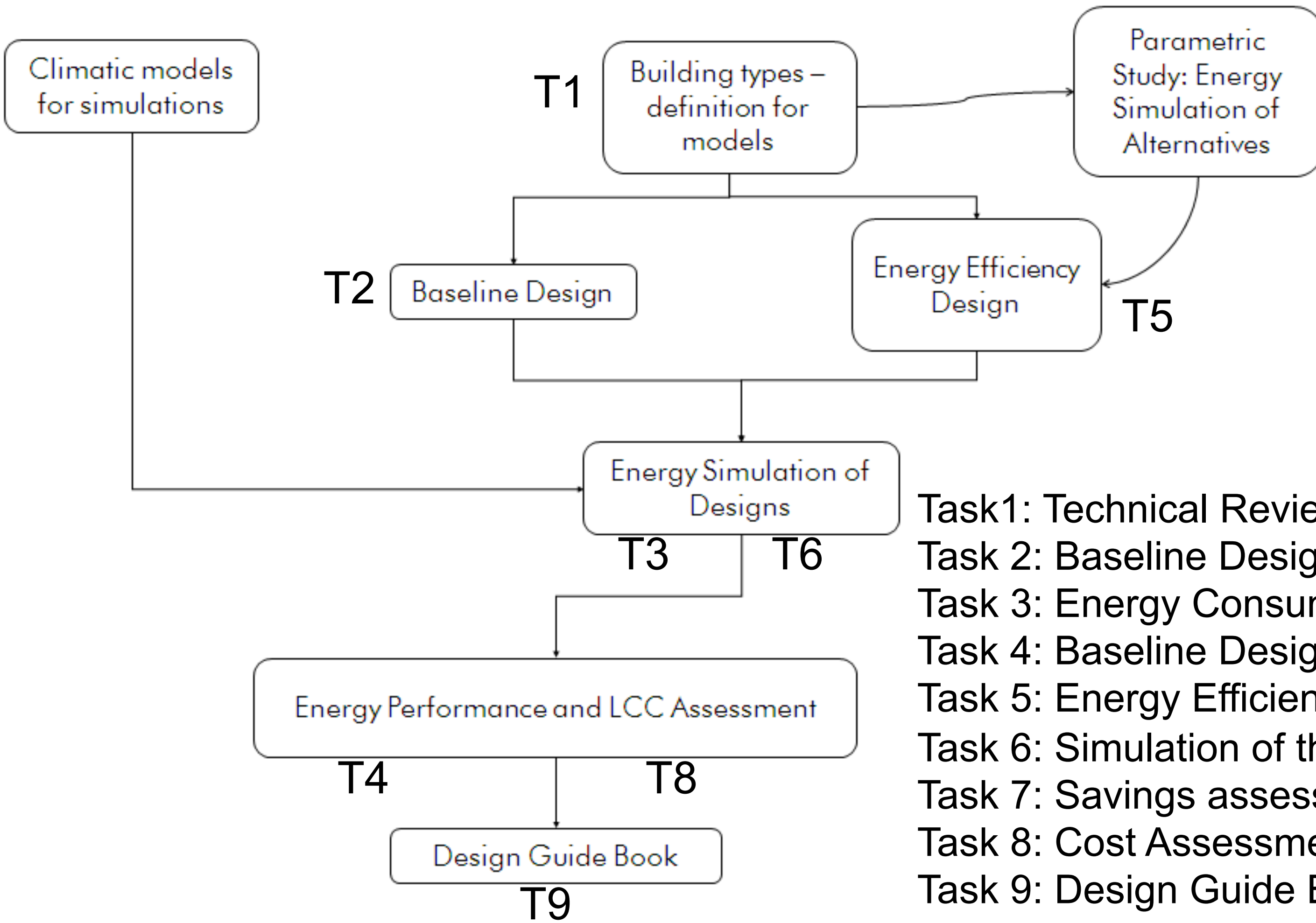
Energy Efficiency Guidelines for Office Buildings in Tropical Climate

Summary Session 28th February 2013

Organization of American States

- Develop Energy Efficiency Guidelines for Office Buildings in Tropical climates:
  - Task1: Technical Review
  - Task 2: Baseline Design
  - Task 3: Energy Consumption assessment
  - Task 4: Baseline Design Cost assessment
  - Task 5: Energy Efficiency Design
  - Task 6: Simulation of the Energy Balance
  - Task 7: Savings assessment
  - Task 8: Cost Assessment
  - Task 9: Design Guide Book

Methodology



Task1: Technical Review
Task 2: Baseline Design
Task 3: Energy Consumption assessment
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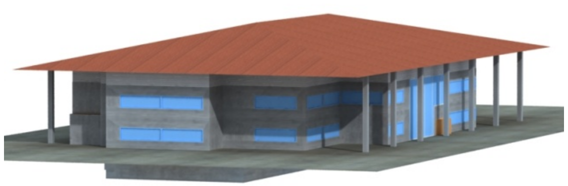
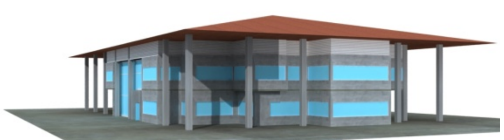
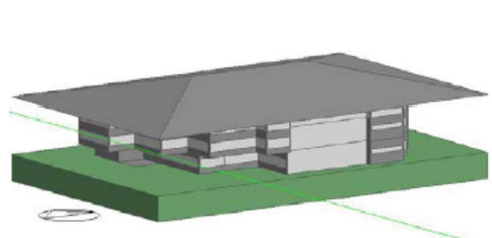
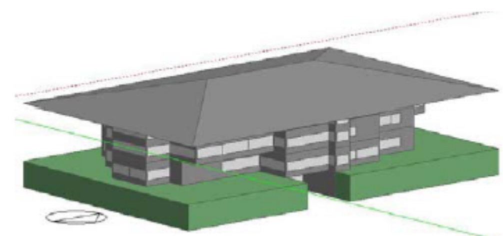
- Technical Review
  - Reviewed technical documents
    - Florida Building Code 2010
      - Energy Conservacion
      - Mechanical
    - International Energy Conservation Code 2012
    - RESET, Costa Rica, 2012
    - Casa Azul, Brasil 2010
    - Green Building Index, Malaysia, 2009
  - Reviewed Guide Books
    - Casa Ausente. Diseñar, construir y vivir en una casa ecológica, Arq. Fernando Abruña
    - Climate Responsive design, Richard Hyde
    - Eficiencia energéticana arquitectura, Roberto Lamberts, Luciano Dutra, Fernando O.R. Pereira
    - A green Vitruvius, principles and practice of sustainable architectural design

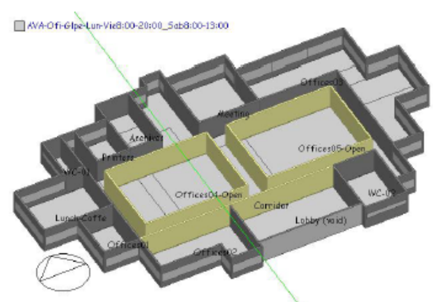
- Baseline Design-> Energy Simulation
  - Halls of Justice Project drawings
  - Other: technical codes etc.
    - (standardize drawings)
  - Two sizes: Small (3000 m2) and Medium (6000 m2)

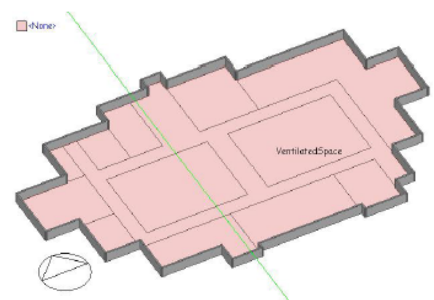




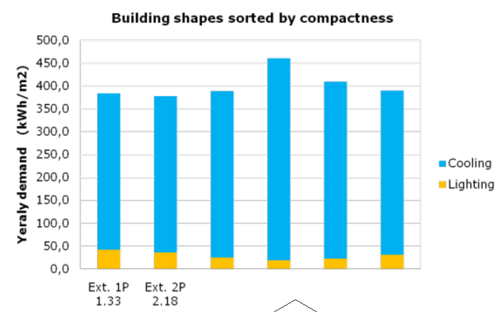


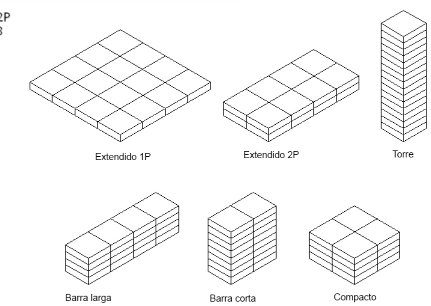


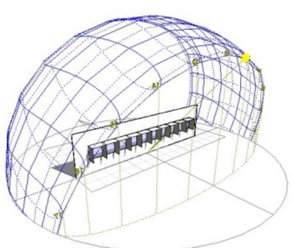


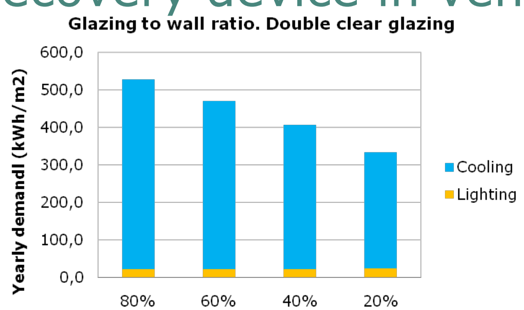


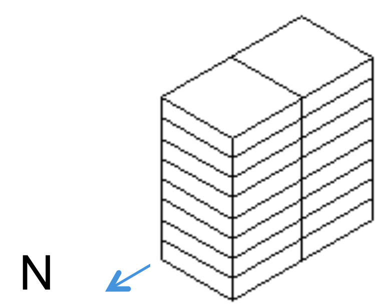
- Energy Efficiency Design-> Energy Simulation
  - Parametric Study
    - Shape of the building
    - Insulation and thermal mass
    - Glazing type and amount of glazing
    - Building Orientation
    - Solar protection – window glazing elements
    - Roof
    - Contact between building and ground
    - Night natural ventilation
    - Heat recovery device in ventilation system











Summary of Parametric Study

- Strong impact

Amount of glazing

Heat recovery device in ventilation system

Solar protection – window glazing elements

Shape of the building

Roof

Building Orientation

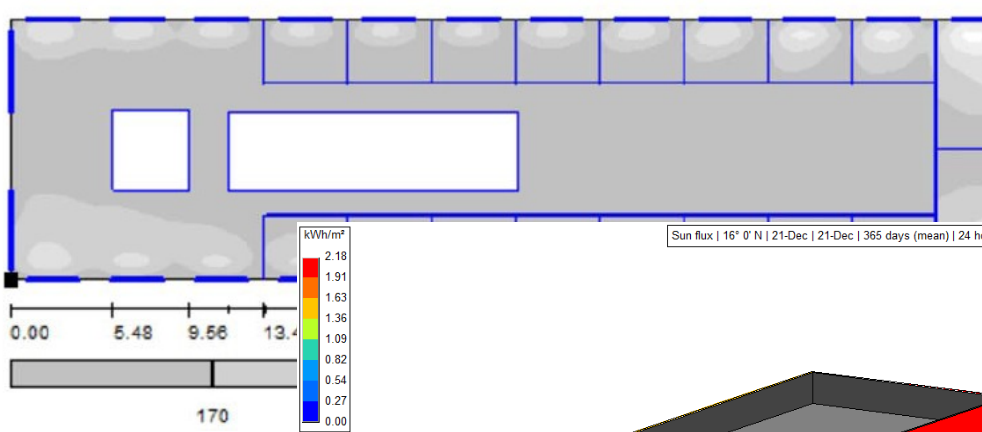
Glazing type

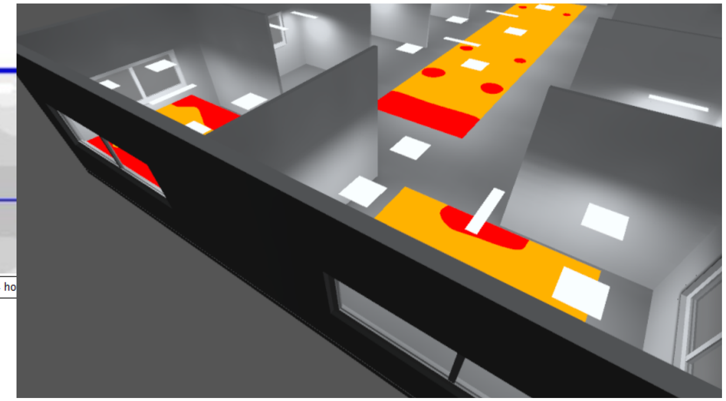
Night natural ventilation

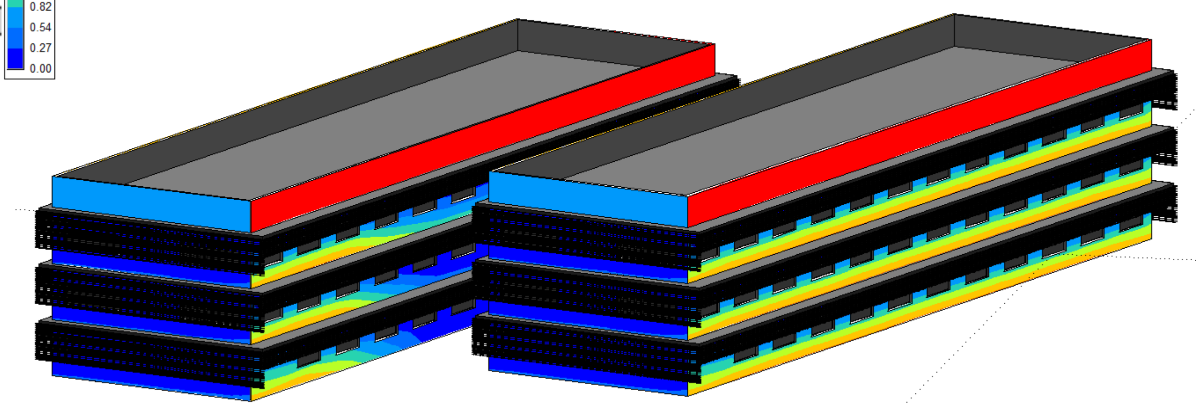
Contact between building and ground

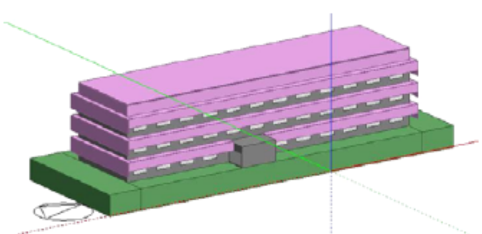
Insulation and thermal mass

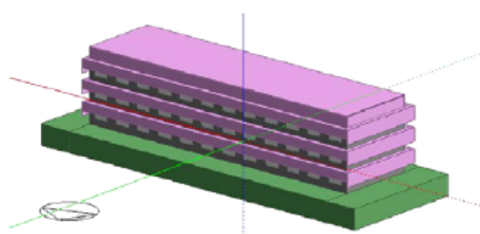
- Weak impact

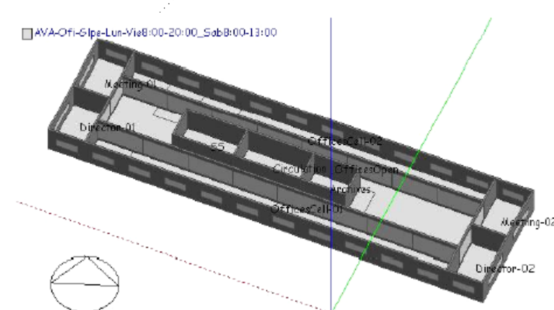

kWh/m²
2.18
1.91
1.63
1.36
1.09
0.82
0.54
0.27
0.00
0.00
5.48
9.56
170
Sun flux | 16° 0' N | 21-Dec | 21-Dec | 365 days (mean) | 24 ho










Meeting-01
Director-01
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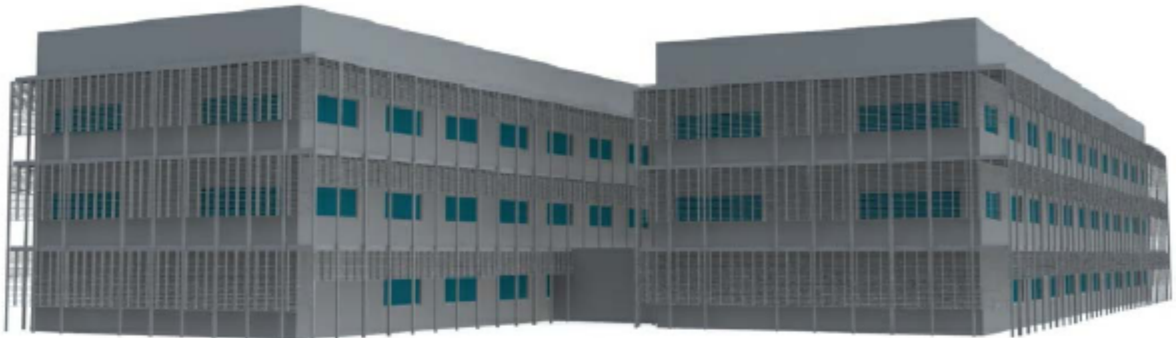
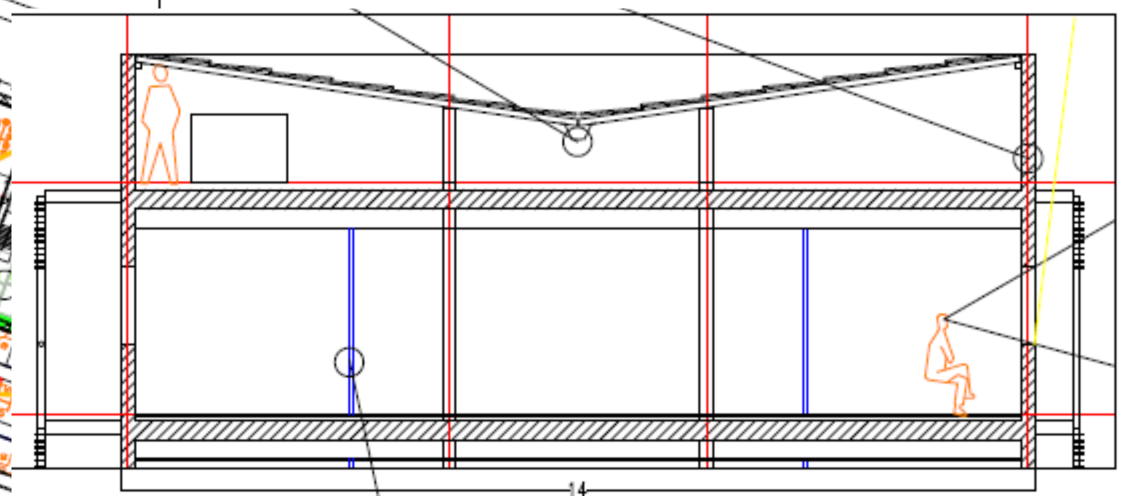
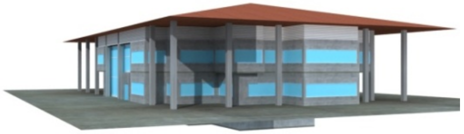
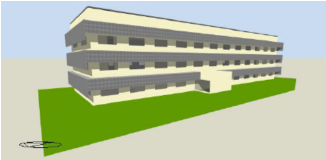
OfficesCell-01
Meeting-02
Director-02

- Energy Efficient Design





Models	Lighting	Cooling (electricity)	Cooling (thermal)	Total (light.+cool./ elect.)	Total (ligth.+cool /therm)	Improvement
	kWh/m2	kWh/m2	kWh/m2	kWh/m2	kWh/m2	
Baseline*(BD)	54,0	128,2	320,5	182,2	374,5	Ref (0%)
Baseline**(BD)	37,9	128,2	320,5	358,4	358,4	Ref (0%)
Energy Efficient B. (EED)**	54,0	111,7	279,3	165,7	333,3	9,1%
EED**+TR	54,0	93,7	234,2	147,7	288,2	19,0%
EED+TR+LC	31,3	81,3	203,2	112,6	234,5	38,2%
EED+TR+LL	20,3	76,6	191,4	96,8	211,7	46,9%
EED+TR+LL+LC	11,7	71,7	179,3	83,4	191,0	54,2%
EED+TR+LL+LC+PV	11,7	71,7	179,3	17,9	191,0	90,2%
EED+TR+LL+LC+PV+ST	11,7	71,7	179,3	16,5	191,0	90,9%

*without light control ** with light control (LC)

EEB: Energy Efficient Building

TR: Thermal recovery

LC: Lighting Control

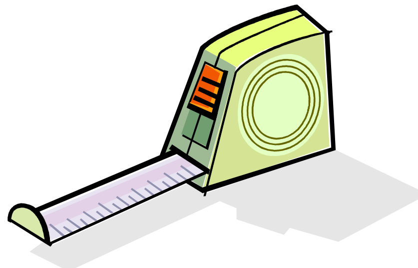
LL: LED lighting

PV: Phtovoltaics

ST: Solar Thermal

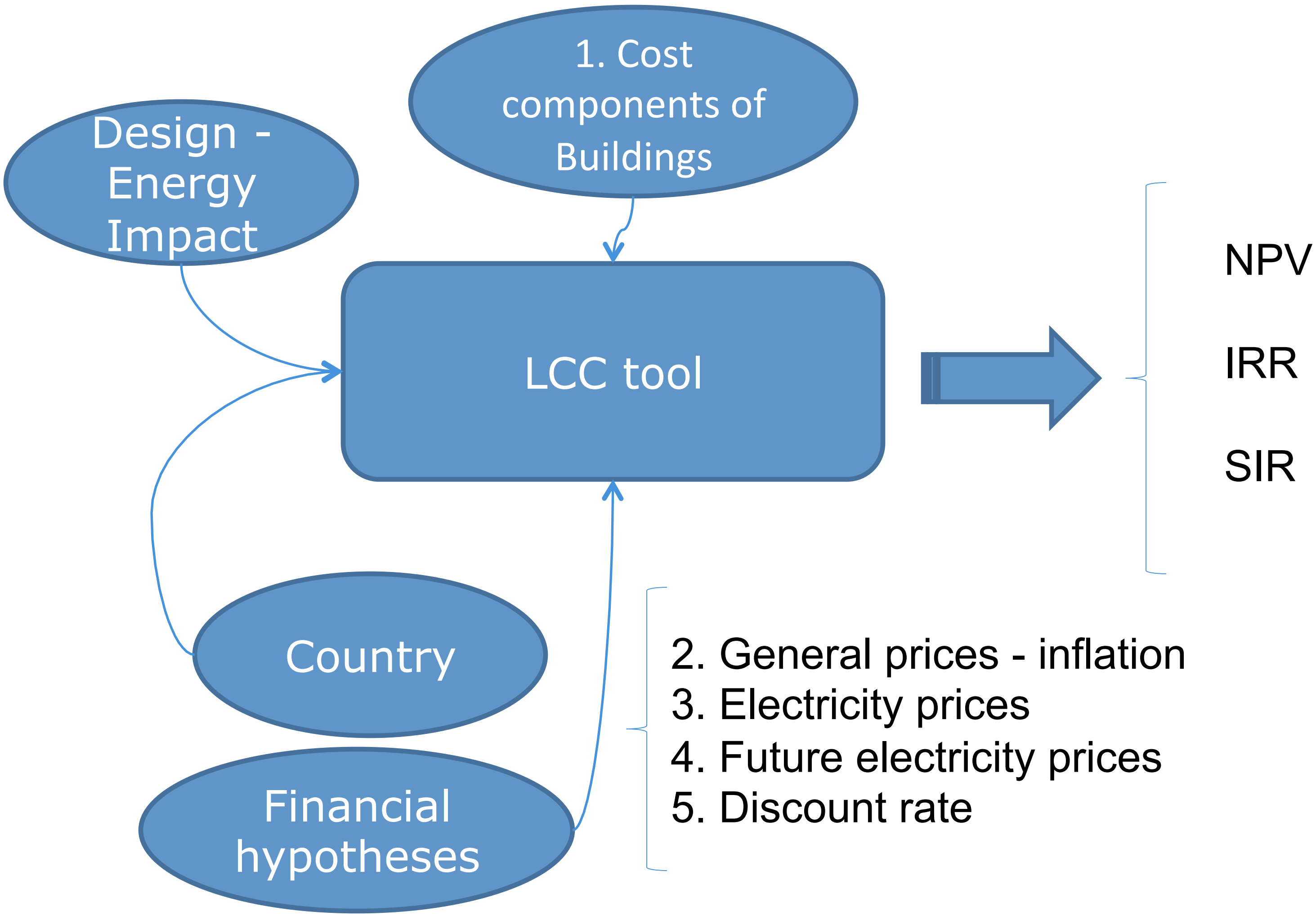
COP: 2,5

- Life Cycle Cost:



  - Net Present Value
  - Internal Return Rate
  - Savings to Investment Ratio

- Desired outputs; needed inputs



2. General prices - inflation
3. Electricity prices
4. Future electricity prices
5. Discount rate

Costs of Measures

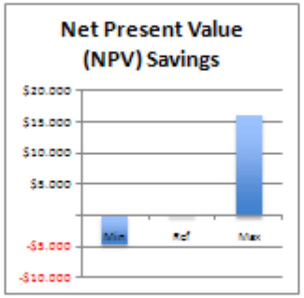
	Type of Solution	Solution	Type Baseline	Base Cost	Starting Date	Type of Cost	Recurrence	Net Present Value	Salvage Value	Number Installments	Duration (Years)
#1											
#2											
#3											
#4											
#5											
#6											
#7											
#8											

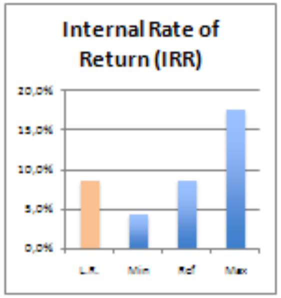
Comparison of EED Measures

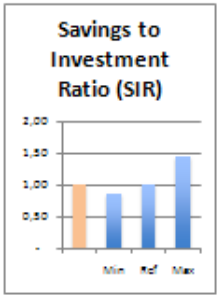
GENERAL	Min	Ref	Max
Inflation	2,5%	5,0%	10,0%
Nominal Disc. Rate	7,2%	9,8%	15,1%
ELECTRICITY	**Min**	**Ref**	**Max**
Inflation	3,5%	8,0%	18,0%
Real Discount Rate	3,6%	1,7%	-2,5%

	Data
Start Date:	1/01/13
Duration (yrs):	20
Real Disc. Rate	4,6%
Baseline	
arametric Office Buildi	

	Design Concept	NPV of all costs	Consump tion (kWh yr)
Type of solution	Thermal Insulation		
Baseline	TI-A001 M025	$54.225	414.259
Efficiency Solution	TI-A025 M025	$57.181	408.012
	Difference	36.331	-6.247

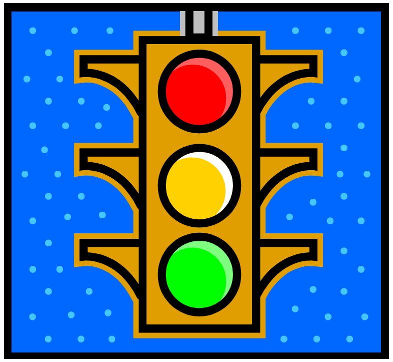






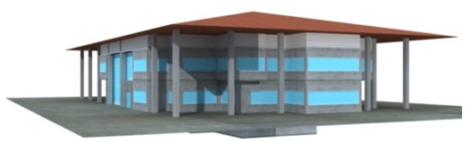
Power Utility	Cost kWh	Year	Interest Rate	Lend. Rate	NPV Electricity Savings			Net Present Value (NPV) Savings			Internal Rate of Return (IRR)			Savings to Investment Ratio (SIR)		
					Min	Ref	Max	Min	Ref	Max	Min	Ref	Max	Min	Ref	Max
Antigua (APUA)	$0,38	2011	6,5%	10,9%	$35.912	$41.351	$59.457	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Bahamas (GB Power)	$0,17	2012	4,0%	5,1%	$15.593	$17.955	$25.817	-$20.738	-$18.376	-$10.514	-1,8%	2,1%	10,7%	0,4	0,5	0,7
Bahamas (BEC)	$0,33	2008	4,0%	5,1%	$31.187	$35.910	$51.634	-$5.144	-$421	$15.303	4,4%	8,5%	17,6%	0,9	1,0	1,4
Barbados (BL&P)	$0,38	2011	7,0%	8,7%	$35.912	$41.351	$59.457	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Dominica (DOMLEC)	$0,39	2010	6,5%	8,9%	$36.857	$42.439	$61.022	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Grenada (GRENLEC)	$0,39	2011	6,5%	10,7%	$36.857	$42.439	$61.022	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Montserrat (MUL)	$0,40	2009	6,5%	8,6%	$37.802	$43.528	$62.587	$1.471	$7.196	$26.255	6,5%	10,6%	19,8%	1,0	1,2	1,7
Nevis (NEVLEC)	$0,31	2010	6,5%	9,2%	$29.297	$33.734	$48.505	-$7.035	-$2.597	$12.173	3,8%	7,9%	16,9%	0,8	0,9	1,3
St. Kitts Elec. Dep.	$0,29	2011	6,5%	9,2%	$27.407	$31.558	$45.375	-$8.925	-$4.774	$9.044	3,1%	7,2%	16,2%	0,8	0,9	1,2
St. Lucia (LUCELEC)	$0,32	2010	6,5%	10,2%	$30.242	$34.822	$50.069	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
ST. Vincent (VINLEC)	$0,32	2010	6,5%	9,1%	$30.242	$34.822	$50.069	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
Average	**###**		**6,1%**	**8,7%**	**$31.573**	**$36.355**	**$52.274**	**-$4.758**	**$24**	**$15.943**	**4,4%**	**8,5%**	**17,5%**	**0,9**	**1,0**	**1,4**

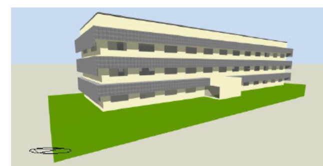
- Interpretation of results:

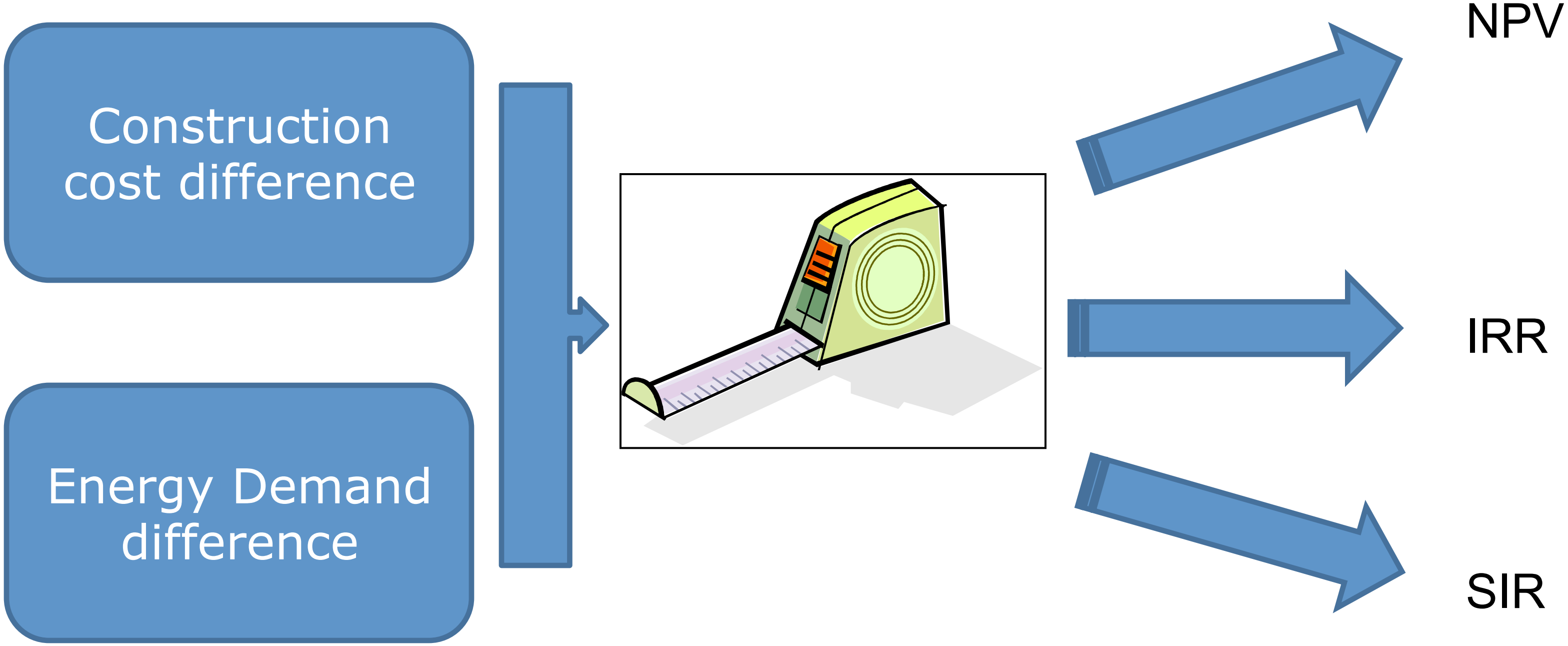


Power Utility	Net Present Value (NPV) Savings		
	Min	*Ref*	*Max*
Antigua (APUA)	$5,912	$11,351	$29,457
Bahamas (GB Power)	-$14,407	-$12,045	-$4,183
Bahamas (BEC)	$1,187	$5,910	$21,634
Barbados (BL&P)	$5,912	$11,351	$29,457
Dominica (DOMLEC)	$6,857	$12,439	$31,022
Grenada (GRENLEC)	$6,857	$12,439	$31,022
Montserrat (MUL)	$7,802	$13,528	$32,587
Nevis (NEVLEC)	-$703	$3,734	$18,505
St. Kitts Elec. Dep.	-$2,593	$1,558	$15,375
St. Lucia (LUCELEC)	$242	$4,822	$20,069
ST. Vincent (VINLEC)	$242	$4,822	$20,069
Average	**$1,573**	**$6,355**	**$22,274**

- LCC tool
  1. Baseline Building vs. Energy Efficient Building LCC



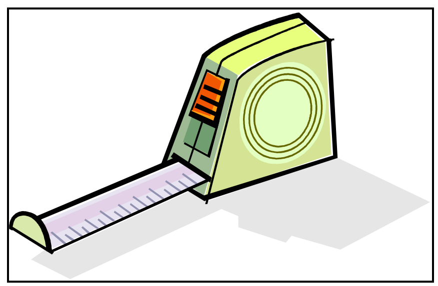




- LCC tool
   2. Choose between design alternatives considering LCC

Cost difference

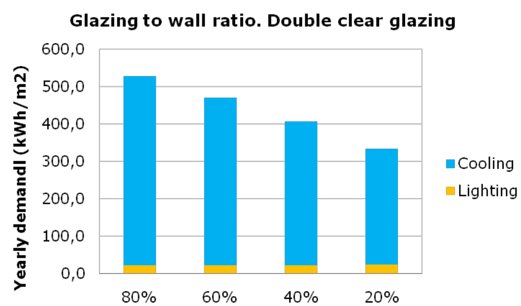
Energy Demand difference



NPV

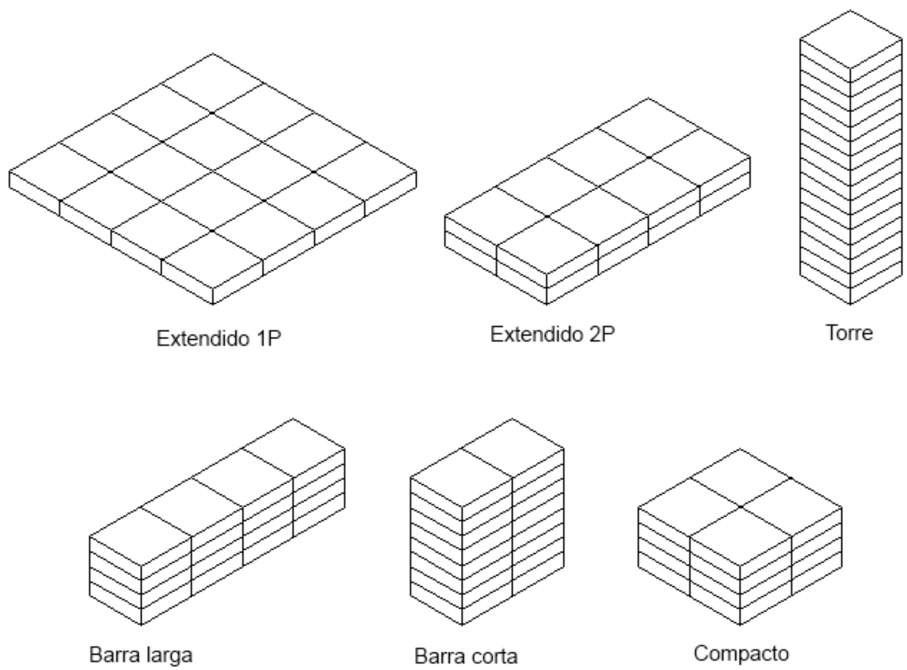
IRR

SIR



- Draft of the Guide Book

- Form factor/compactness
  - The shape of the building has an impact on the energy demand
  - Shapes more similar to “Long bar” rather than “Tower”



- Glazed surface
  - Window glazing over façade surface (window-to-wall ratio): low values
- Glazing types
  - An improved glazing quality reduces the energy demand for cooling the building
- Orientation
  - In the case of a building with long and short façades the improvement of energy performance depends strongly on the adequate orientation
  - Best results when largest façades oriented South and North - minimize the surfaces oriented East and West
  - Consider the dominant wind direction at the location

- Solar protection
  - Strong influence on cooling demand while relative increase in lighting demand
- Roof design
  - Roof surface receives highest solar radiation
  - It is recommended to provide shading to roof + ventilation
- Ground contact
  - The results of the simulations do not show big differences; the best option would be keeping the contact with the ground without any thermal insulation

- Night ventilation
  - Limited to the dry period of the year.
  - Renovations and thermal mass adjusted
- Daylighting
  - South and North orientation of the largest façades.
  - Not excessive depth
  - Homogeneous distribution of glazing around 20% of the façade surface.
  - Fixed protections complemented with mobile protections

- Ventilation heat recovery
  - heat is exchanged between the external, hot and humid air and the inside, exhaust air
- Efficient lighting
  - LED: effect in whole energy demand is double, as not only this means a reduction in demand for lighting, but also a reduction in heat gains from lighting and thus a lower demand for cooling
- Lighting control
  - Motion control or control of artificial lighting depending on the amount of daylight can decrease overall energy demand

- HVAC equipment
  - efficient chillers that can work in the most usual conditions of local climate; possibility of modulating power depending upon demand (inverter).
  - if local conditions allow, possibility to combine with “free cooling”
  - Distribution of cooling at moderate temperatures; prefer radiant solutions to very low temperature air distribution.
  - High degree of zoning.
  - Control: possibility to turn off emitters if open windows are detected or in moments of no occupancy.

- Photovoltaics
  - Electricity generation
  - Contribute to reduced cooling demand
  - Also, rainwater harvesting
- Solar thermal
  - If the building has hot water demand (such as public buildings with kitchen /restaurant/ cafeteria/ toilets/ dressing rooms etc.) a solar thermal installation can provide part of such hot water demand.

- Other recommendations
  - Vegetation in the exterior of the building: medium of big size vegetation (e.g. trees) provide shading to walls and windows but also cool the ambient air through evapotranspiration.
  - Buffer spaces: these zones, located between the external and internal spaces of the building, can provide: a decreased temperature difference, improved solar protection, can have vegetation, cool down external air temperature.
  - Reducing infiltration and uncontrolled loss of conditioned air improving the building airtight
  - Materials that enhance use of daylight (bright colors)
  - specific demands are similar

Next suggested steps

1. Writing the final version of the Energy Efficiency Guidelines with recommendations for the design of new office buildings with energy efficiency criteria:

- architectural design
- passive solutions
- active in energy efficiency solutions
- integration of renewable energy in buildings

2. analysis of the Guide as a reference document for the building code in energy efficiency

3. adaptation of the guidelines to energy refurbishment of existing buildings
4. determine the mandatory energy efficiency measures for all new construction project (new or renovated buildings)
5. determine specific values of mandatory minimum efficiency (kWh/m2 year) for different types of buildings for energy demand linked to the design of the building and not to its activity
6. apply a common regulation in the interconnection to the grid of the power generation equipments with renewable sources, with net metering

Thank you

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