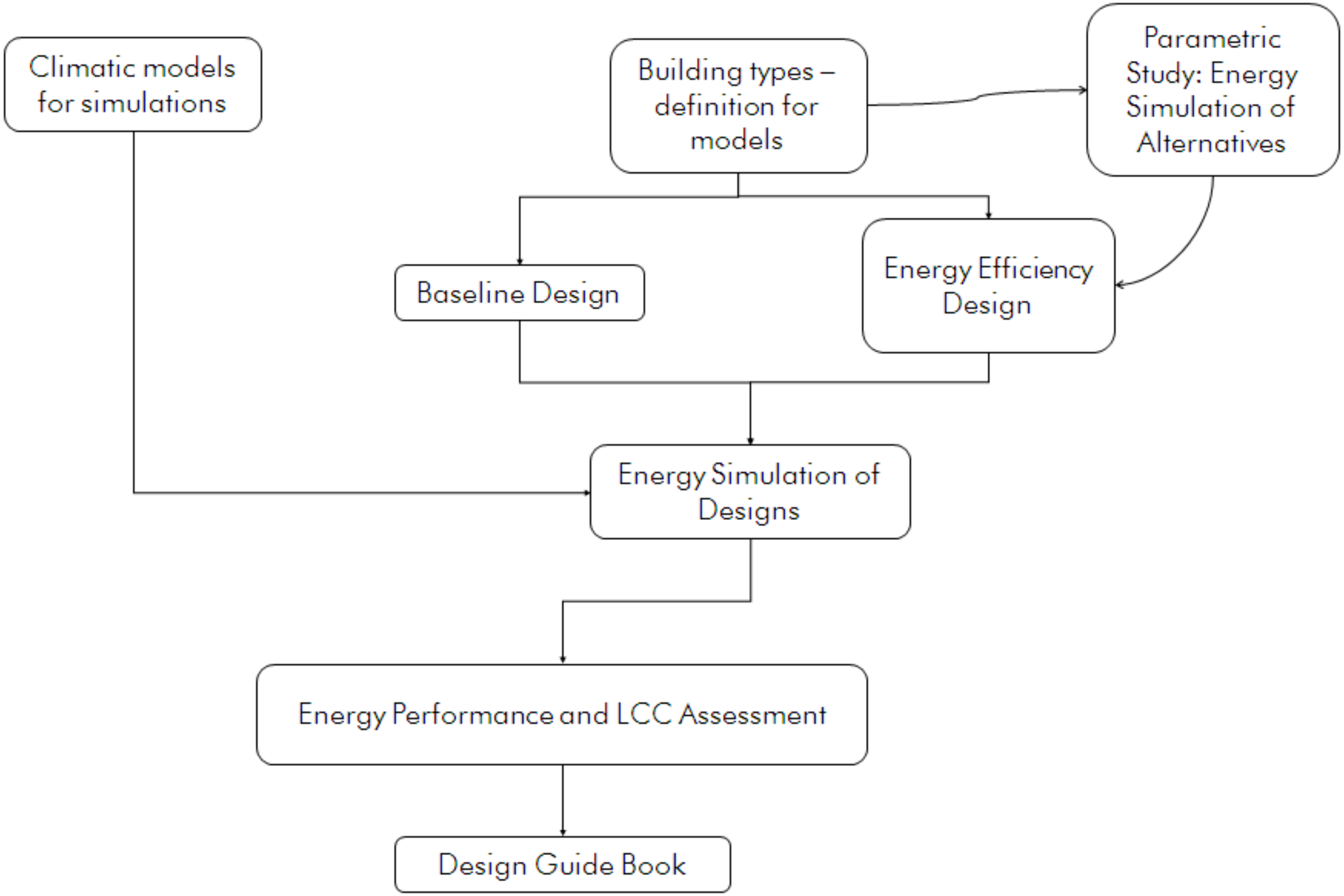
Trama TecnoAmbiental
CREVER
Universitat Rovira i Virgili
Instituto de Arquitectura Tropical Costa Rica

Energy Efficiency Guidelines for Office Buildings in Tropical Climate

Design Tools for a Low Energy Demand: Cost aspects

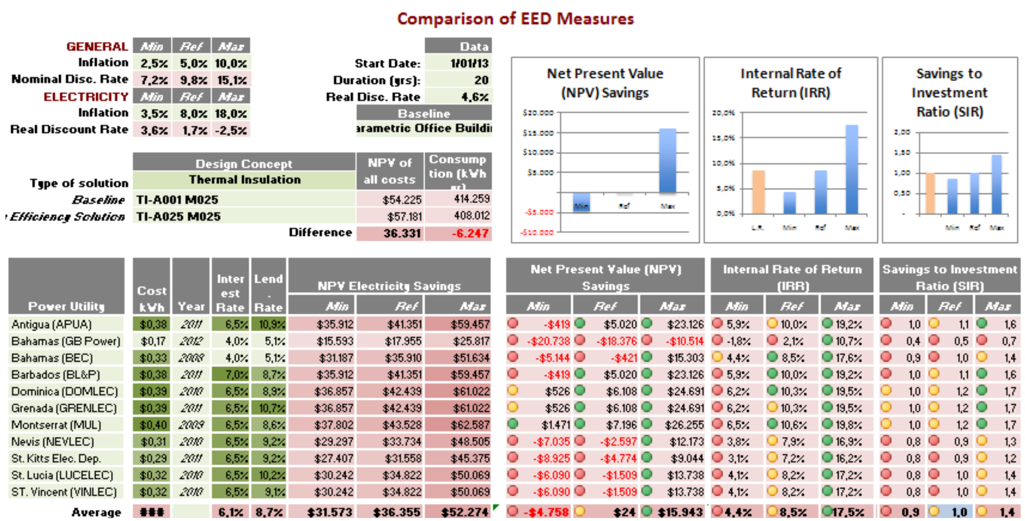
Organization of American States


Climatic models for simulations
Building types – definition for models
Parametric Study: Energy Simulation of Alternatives
Baseline Design
Energy Efficiency Design
Energy Simulation of Designs
Energy Performance and LCC Assessment
Design Guide Book

Outline

A. Life Cycle Cost analysis
   - What is LCC?
   - Comparison of LCC and other methods
   - Limitations of LCC

B. Excel based tool for LCC analysis



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

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

Net Present Value (NPV) Savings

Internal Rate of Return (IRR)

Savings to Investment Ratio (SIR)

Power Utility	Cost kWh	Year	Interest Rate	Lend. Rate	NPV Electricity Savings Min	NPV Electricity Savings Ref	NPV Electricity Savings Max
Antigua (APUA)	$0,38	2011	6,5%	10,9%	$35.912	$41.351	$59.457
Bahamas (GB Power)	$0,17	2012	4,0%	5,1%	$15.593	$17.955	$25.817
Bahamas (BEC)	$0,33	2008	4,0%	5,1%	$31.187	$35.910	$51.634
Barbados (BL&P)	$0,38	2011	7,0%	8,7%	$35.912	$41.351	$59.457
Dominica (DOMLEC)	$0,39	2010	6,5%	8,9%	$36.857	$42.439	$61.022
Grenada (GRENLEC)	$0,39	2011	6,5%	10,7%	$36.857	$42.439	$61.022
Montserrat (MUL)	$0,40	2009	6,5%	8,6%	$37.802	$43.528	$62.587
Nevis (NEVLEC)	$0,31	2010	6,5%	9,2%	$29.297	$33.734	$48.505
St. Kitts Elec. Dep.	$0,29	2011	6,5%	9,2%	$27.407	$31.558	$45.375
St. Lucia (LUCELEC)	$0,32	2010	6,5%	10,2%	$30.242	$34.822	$50.069
ST. Vincent (VINLEC)	$0,32	2010	6,5%	9,1%	$30.242	$34.822	$50.069
Average	###		6,1%	8,7%	$31.573	$36.355	$52.274

Power Utility	NPV Savings Min	NPV Savings Ref	NPV Savings Max	IRR Min	IRR Ref	IRR Max	SIR Min	SIR Ref	SIR Max
Antigua (APUA)	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Bahamas (GB Power)	-$20.738	-$18.376	-$10.514	-1,8%	2,1%	10,7%	0,4	0,5	0,7
Bahamas (BEC)	-$5.144	-$421	$15.303	4,4%	8,5%	17,6%	0,9	1,0	1,4
Barbados (BL&P)	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Dominica (DOMLEC)	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Grenada (GRENLEC)	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Montserrat (MUL)	$1.471	$7.196	$26.255	6,5%	10,6%	19,8%	1,0	1,2	1,7
Nevis (NEVLEC)	-$7.035	-$2.597	$12.173	3,8%	7,9%	16,9%	0,8	0,9	1,3
St. Kitts Elec. Dep.	-$8.925	-$4.774	$9.044	3,1%	7,2%	16,2%	0,8	0,9	1,2
St. Lucia (LUCELEC)	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
ST. Vincent (VINLEC)	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
Average	-$4.758	$24	$15.943	4,4%	8,5%	17,5%	0,9	1,0	1,4

- *Energy Payback Period* (EPP).

For example, a measure with an initial investment of $4,000 and an expected annual savings of $1,000 has an EPP of 4 years.

•It does not account for the *time value of money*: the fact that the value of money does not remain constant all the time (i.e. $1,000 in the present are worth more than the same amount in the future);

•It is not a measure *of long-term economic performance* because it only focuses on how quickly the initial investment can be recovered, ignoring all the costs and savings incurred after the point in time in which payback is reached;

•It does not account for the *opportunity cost*; this is, that this money could had been invested in something else in exchange of a potentially higher return;

- Life Cycle Cost
  - 3 indicators of economic performance:
    - Net Present Value (NPV)
    - Intenral Return Rate (IRR)
    - Savings to Investement ratio (SIR)

- Net Present Value (NPV)

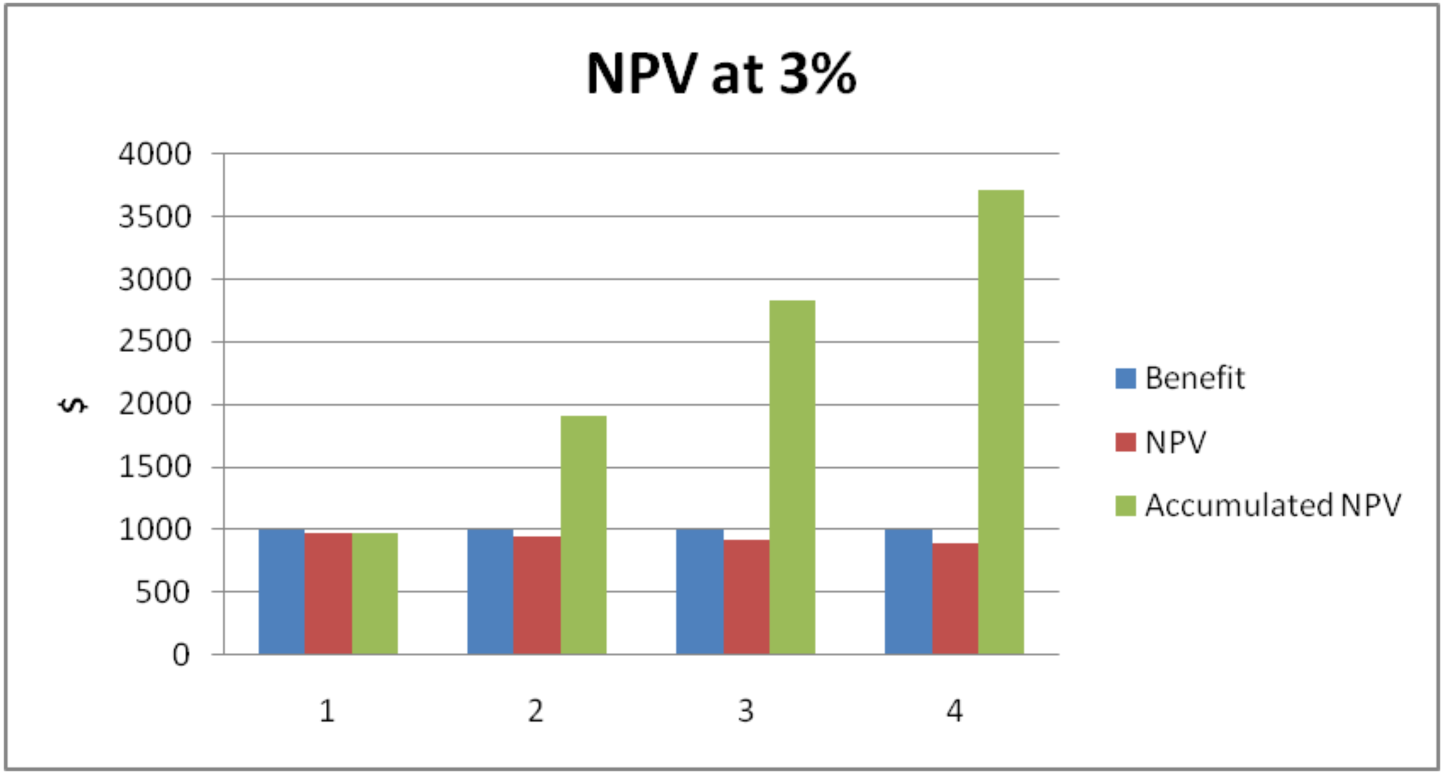
For example, imagine that the country is experiencing an annual increase in its level of prices of 3%. This rate of inflation is diminishing the future value of money as compared to their present value. At this 3% rate the present value (discounted value) of these $1,000 a year for the next four years is:

$$\$1{,}000/(1 + 3\%) + \$1{,}000/(1+3\%)^2 + \$1{,}000/(1+3\%)^3 + \$1{,}000/(1+3\%)^4$$

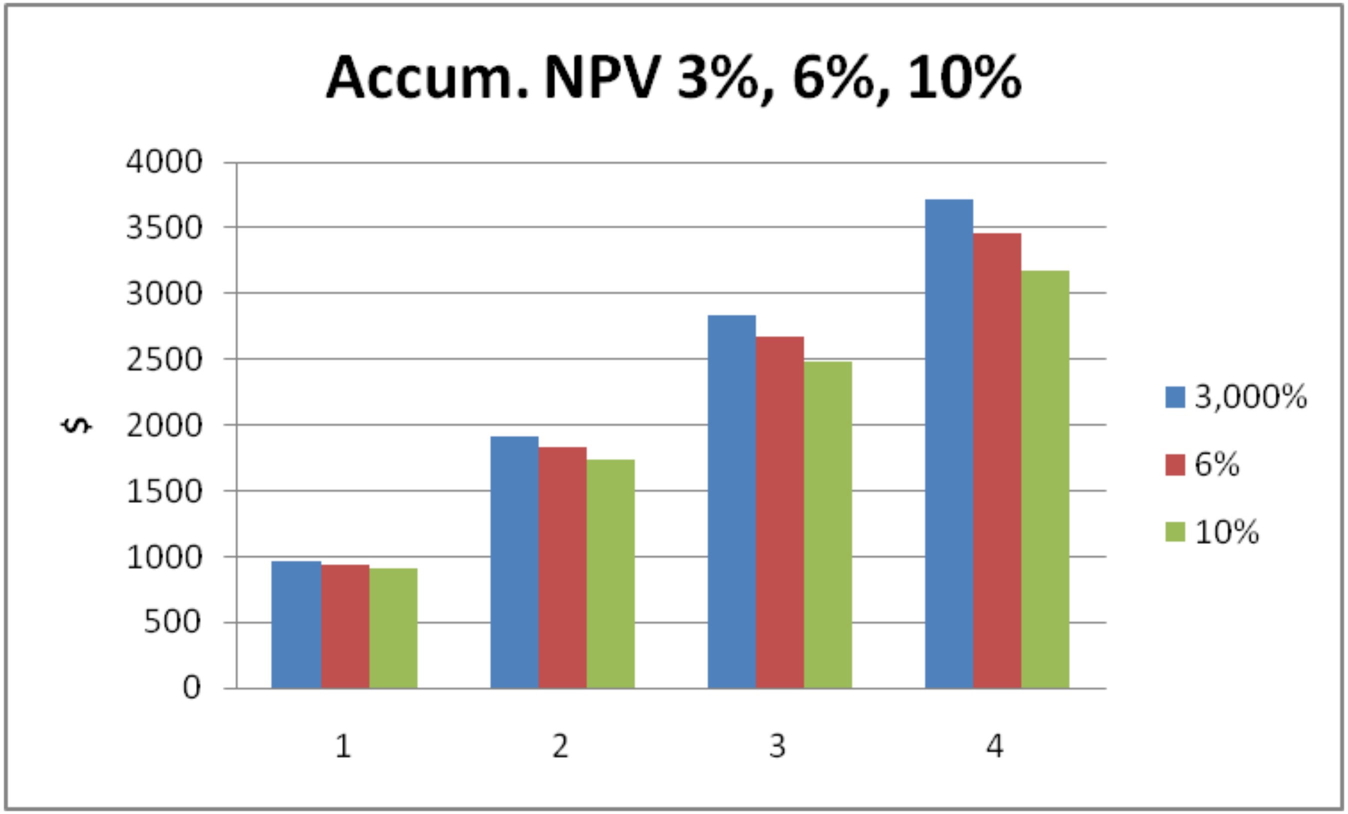
This is:

$$\$971 + \$943 + \$915 + \$888 = \$3{,}717$$

As it can be observed, the more far away in the future, the lower the present value of those $1,000. And when brought all of them to the present time, they do not add $4,000 anymore but $3,717 instead. Why? Because when we want to buy something in the future with those same $1,000 their purchasing power would have diminished due to a general increase in the level of prices of 3%.


NPV at 3%
4000
3500
3000
2500
2000
1500
1000
500
0
$
1
2
3
4
Benefit
NPV
Accumulated NPV

- NPV
    - *discount rate* operates in such a way so that the higher it is, the lower the present value of future amounts



– NPV: A measure of long-term economic performance

For example, in the previous example perhaps the savings of the energy efficiency measure are expected only for the first 6 years, in which case their NPV is

$$\$1,000/(1 + 3\%) + \$1,000/(1+3\%)^2 + \ldots + \$1,000/(1+3\%)^6 = \mathbf{\$5,417}$$

or perhaps these savings are expected to continue all over the life-cycle of the building, with the building expected to last 30 years. In such case the NPV would be:

$$\$1,000/(1 + 3\%) + \$1,000/(1+3\%)^2 + \ldots + \$1,000/(1+3\%)^{30} = \mathbf{\$19,600}$$

The difference in the NPV of this two streams of savings is considerable and this is why it is very important to also consider the long-term economic performance of the measure, something that the traditional EPP did not do.

- IRR:
  - IRR is the rate of return that makes the net present value (NPV) of all savings (positive cash flows) and costs of maintenance (negative cash flows) from a particular energy efficiency measure equal to the original investment

For example, let's imagine that the previous energy efficiency measure is expected to bring savings for the first 6 years only, in which case their NPV is $5,417. Considering that its initial investment is $4,000, what would be the rate of return (i) that equals the NPV of that stream of $1,000 a year in savings to $4,000

$$\$1{,}000/(1 + \mathbf{i}) + \$1{,}000/(1+\mathbf{i})^2 + \ldots + \$1{,}000/(1+\mathbf{i})^6 = \$4{,}000$$

This rate is 13%

This is:

$$\$1{,}000/(1 + \mathbf{13\%}) + \$1{,}000/(1+\mathbf{13\%})^2 + \ldots + \$1{,}000/(1+\mathbf{13\%})^6 = \$4{,}000$$

This 13% can then be compared to:

- *Cost of the loan required to finance such measure*
- *Weighted Average Cost of Capital (WACC) of the organizations*
- *Alternative investments*

With what it is to be compared would depend on how this energy efficiency measure is to be financed:

- With a new loan from a financial institution (+liability) ⟶ Cost of the loan
- With a share capital increase (+equity) ⟶ WACC
- With the organization's own reserves (equity) ⟶ Alternative investments

- IRR:
  - the higher the IRR obtained the better the measure
  - compared to the rate of return offered by alternative investments
  - Is directly related to the cash-flows

- Savings to Investment ratio (SIR)

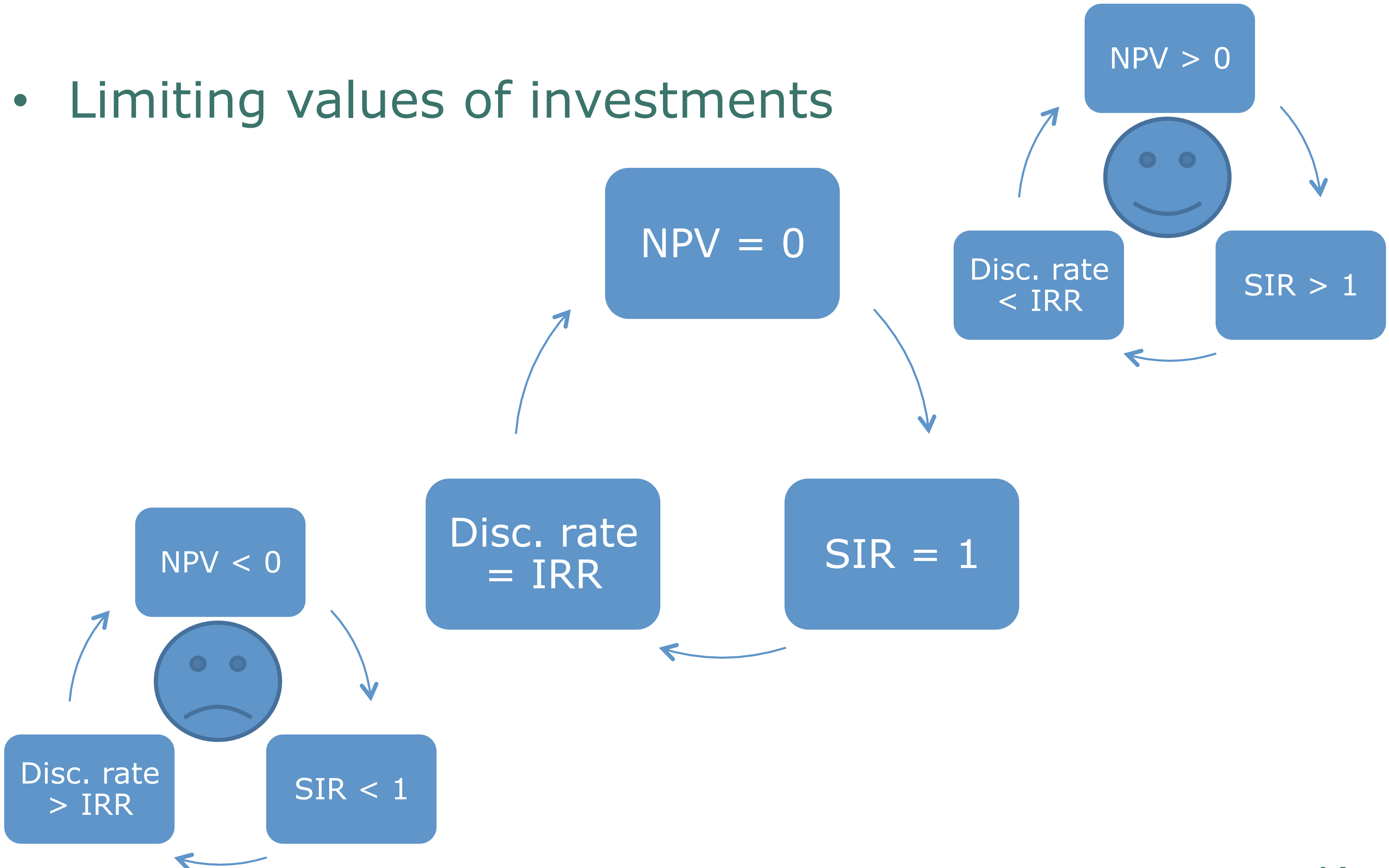
  SIR=Total savings / initial cost of the measure

Following the above examples, for a measure with a capital cost of $4,000 and expected savings of $1,000 a year for a period of 6 years and a discount rate of 3% the SIR is:

$5,417/$4,000 = 1.35

The discount rate applied would had to be higher than 13% for the SIR to fall below 1, in which case it could be said that the project does not pay for itself.

- Limiting values of investments

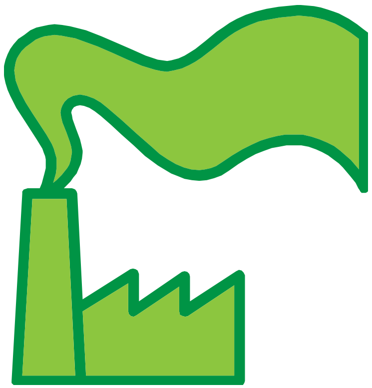


- Life Cycle Cost with
  - NPV
  - IRR
  - SIR

...limitations?

- Limitations of LCC
  - Externalities
  - Based on assumptions and hypotheses
  - Increased resilience

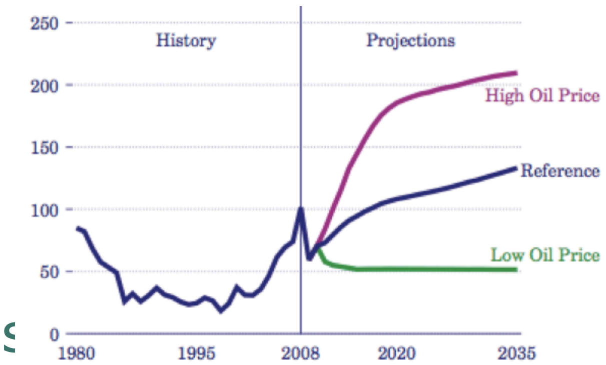
- Limitations of LCC
  1. Externalities: LCC is purely financial
     - Does not account for other costs: e.g. pollution
     - Comfort of users



- # Limitations of LCC

  2. Based on assumptions and hypotheses

     - Long-term analysis
     - difficult is to translate those future consumptions into future costs.
       - Need to use Scenarios
       - LCC as an ongoing decision-making tool



For example, an organization has to choose between two possible options:

1. A business as usual approach,
2. An energy efficient approach, which involves an additional investment of $10,000 and savings of 5,000 kWh a year for the next 15 years.

What would be the more viable option considering that the current electricity price is 20 cents of dollar per kWh?

The answer would depend on the percentages applied for the increase in electricity prices and the discount rate. For example:

For an expected increase in electricity prices of 3% a year and a discount rate of 12% a year, the business as usual approach is financially preferable, because the NPV of the future savings is $8,187, which is lower than the $10,000 in extra investment (SIR = 0.82)

But for an expected increase in electricity prices of 8% a year and the same discount rate, the energy efficiency approach is financially more viable, with a NPV of the future savings of $11,352 (SIR=1.13).

- # Limitations of LCC
  - ## Increased resilience

For example, the extra $10,000 of the above example are for a design that avoids the need of air-conditioning.

The organization applies a 3% increase in electricity prices at a 12% discount rate, obtaining a SIR of 0.82. As a result decides to go for the conventional (baseline) option.

Later on, due to frequent blackouts, it quickly realizes that it needs to invest in a power generator. If the energy efficiency approach had been chosen, the building would not need air conditioning and would have a good source of natural light, without need for extra power. But as a result of choosing the conventional building, an extra investment of $1,000 is required for a power generator. The power generator produces electricity at a cost of $1 per kWh and it has to run for 10% of the time.

Under such circumstances, the difference in investment is not $10,000 anymore, but $9,000 Savings of energy efficiency option: $11,462 instead of the $8,187.

SIR of the energy efficient option increases from 0.82 to 1.27 the moment that the power generator is added into the equation.

This is how an option that financially looked less attractive, ends up being the more viable one thanks to the better resilience it offers to power shortages and future increases in the cost of energy.

- Conclusion on LCC analysis

  a. To evaluate the financial viability of investing in an energy efficiency measure and

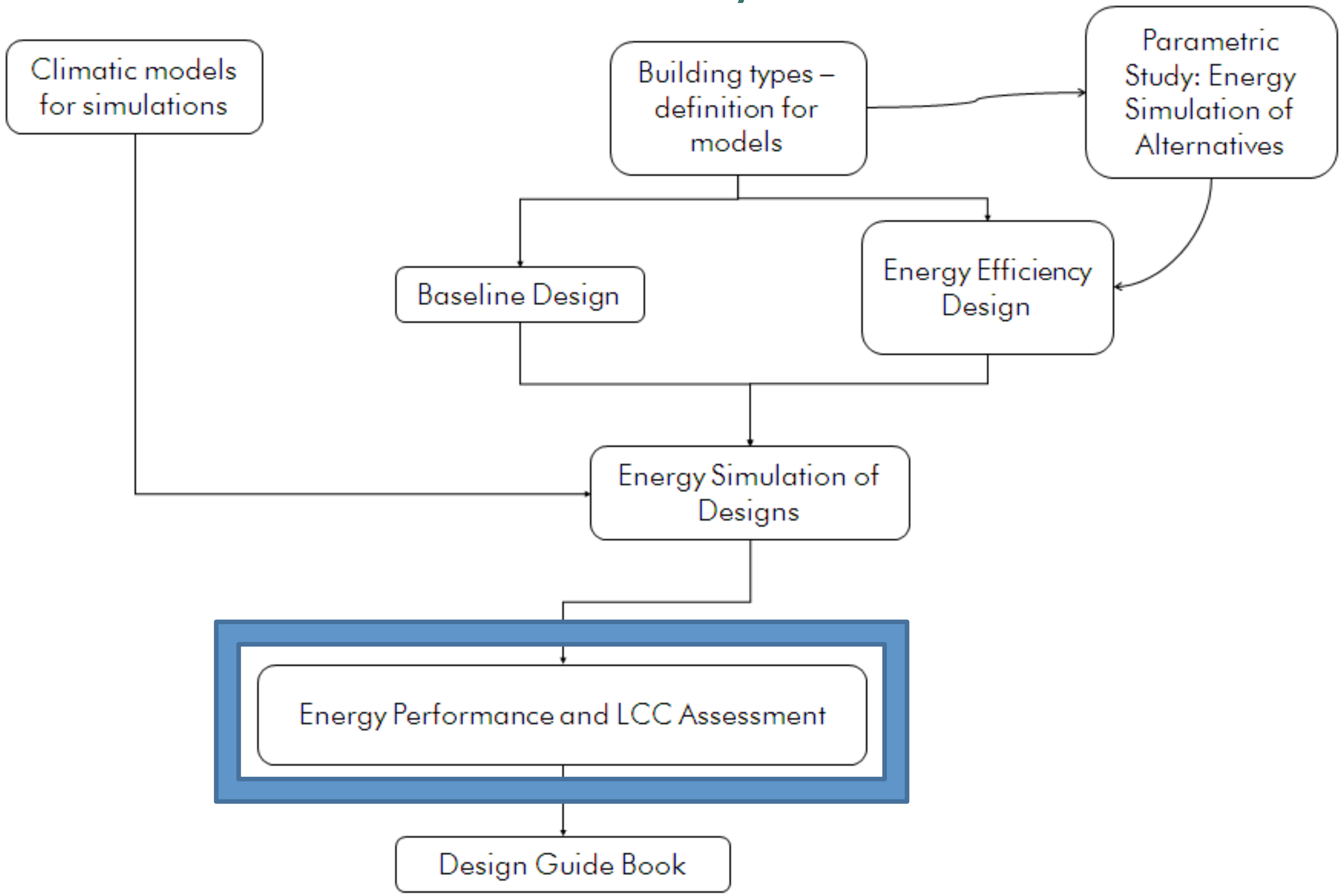
  b. To compare design alternatives that can perform the same function, in order to determine which one is the most cost effective for a certain purpose.

  Has limitations:

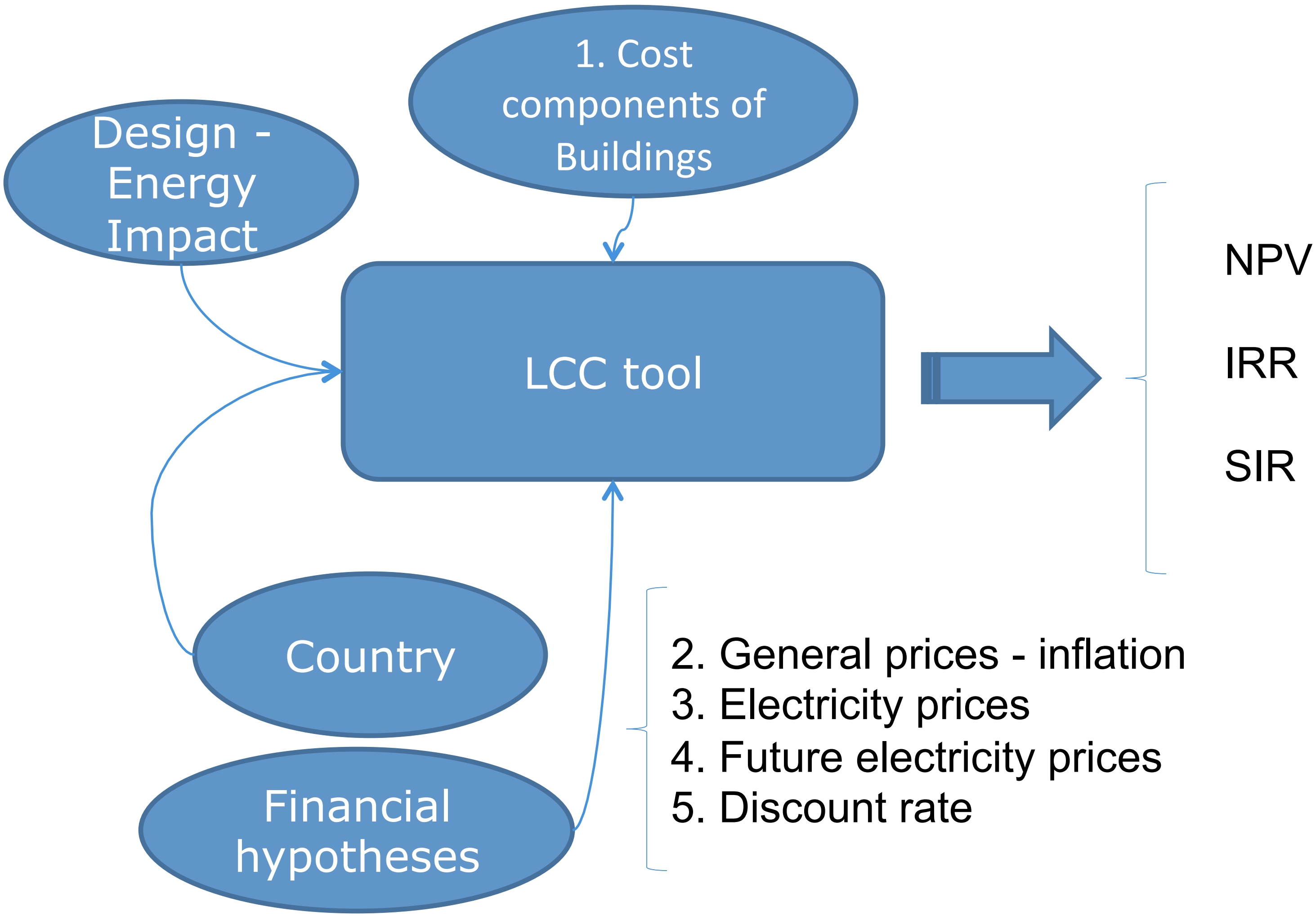
  – Options should not be disregarded because SIR < 1 or IRR lower than alternative

  – Options should not be disregarded because high initial investment

Excel based tool for LCC analysis



- Desired outputs; needed inputs



- Excel Tool – LCC analysis
  1. Cost components of Buildings

     Financial parameters:

     2. Projected future increase in general prices
     3. Current electricity prices
     4. Projected future increase in electricity prices
     5. Discount rate

1. Costs components in LCC Analysis

- **Initial project costs**: They include all the costs required for constructing the building. They are usually divided between 'soft' costs such as: *design fees, permits*, and 'hard' costs such as: *materials, labor, equipment, furnishing*, etc.
- **Utility Costs**: They are usually divided between *Energy Utility Costs* such as: *electricity, gas, steam water*, and *Non-Energy Utility Costs* such as: *reticulated water, sewer services*.
- **Maintenance cost**: they refer to those costs incurred to keep the building running properly.
- **Service costs**: They are costs that depend more on use it is made of a building rather than on its design or the materials utilized. For example: cleaning, pest control, etc.
- **System replacements**: it is the replacement of building systems at the end of their useful lives.

2. Projected future increase in general prices

- Three scenarios:
  - Low inflationary Scenario
    - » 2.5% - current events as punctual
  - Reference Scenario
    - » 5% - Follow USA trend
  - High inflationary Scenario
    - » 10% - affected by oil price increase and scarcity of food supplies

3. Current electricity prices

Name	Electricity Cost		
	Surveyed	*Year*	*2013*
	USD kWh		*USD kWh*
Antigua (APUA)	$0.38	2011	0.42
Bahamas (GB Power)	$0.16	2011	0.18
Bahamas (BEC)	$0.33	2008	0.44
Barbados (BL&P)	$0.38	2011	0.41
Dominica (DOMLEC)	$0.39	2010	0.44
Grenada (GRENLEC)	$0.39	2011	0.43
Montserrat (MUL)	$0.40	2009	0.49
Nevis (NEVLEC)	$0.31	2010	0.36
St. Kitts Electricity Department	$0.15	2007	0.21
St. Lucia (LUCELEC)	$0.32	2010	0.39
ST. Vincent (VINLEC)	$0.32	2010	0.37
Average	**$0.32**		**$0.38**

4. Projected future increase in electricity prices

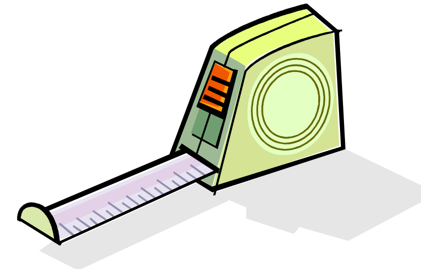
- Electricity generation mix determines vulnerability
- Three energy price increase scenarios:
  - Low inflationary Scenario
    - » 3,5% - EIA in the Global Energy Outlook 2011
  - Reference case Scenario
    - » 7-8% - Caribbean – dependency on oil imports for el.
  - High escalation Scenario
    - » All countries except for Barbados vulnerable

4. Discount rate

- Applied for general prices and electricity prices
- Will depend upon the inflation scenario

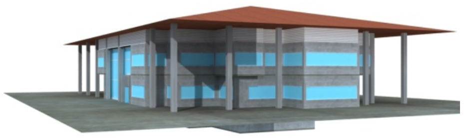
Name	Central Bank Discount rate 2011	Commercial Bank Lending Rate
Antigua & Barbuda	6.5%	10.9%
Bahamas	4.0%	5.1%
Barbados	7.0%	8.7%
Dominica	6.5%	8.9%
Grenada	6.5%	10.7%
Montserrat	6.5%	8.6%
St. Kitts & Nevis	6.5%	9.2%
St. Lucia	6.5%	10.2%
ST. Vincent	6.5%	9.1%
Source	CIA	CIA
Average	6.3%	9.0%

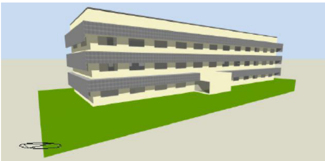
- LCC tool
  - Perform long-term LCC analysis
  - Compare “Efficient” against “Baseline”
  - Different results for different countries (or utilities)



1. Whole building comparison: Energy Efficient Design against Baseline Design

2. Choose between design alternatives considering LCC:
-Insulation
-Glazing types
-…





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											

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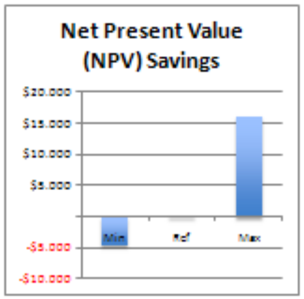

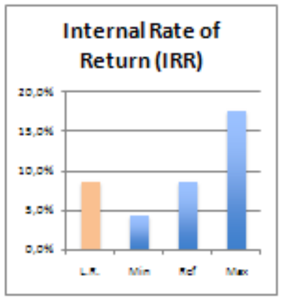

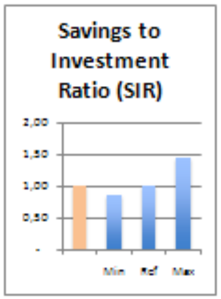

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					Min	*Ref*	*Max*	*Min*	*Ref*	*Max*	*Min*	*Ref*	*Max*	*Min*	*Ref*	*Max*
Antigua (APUA)	$0,38	2011	6,5%	10,9%	$35.912	$41.351	$59.457	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Bahamas (GB Power)	$0,17	2012	4,0%	5,1%	$15.593	$17.955	$25.817	-$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
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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**

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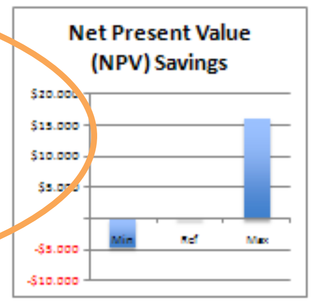
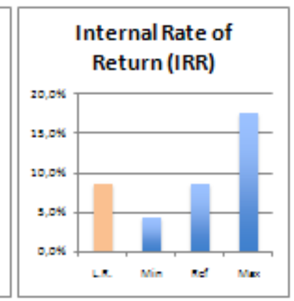
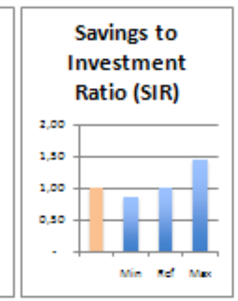
	Data
Start Date:	[illegible]
Duration (yrs):	20
Real Disc. Rate	4,6%

Baseline
arametric Office Buildi

	Design Concept	NPV of all costs	Consumption (kWh yr)
Type of solution	Thermal Insulation		
Baseline	TI-A001 M025	$54.225	414.259
Efficiency Solution	TI-A025 M025	$57.181	[illegible]
	Difference	[illegible]	-6.247







Power Utility	Cost kWh	Year	Interest Rate	Lend. Rate	NPV Electricity Savings *Min*	NPV Electricity Savings *Ref*	NPV Electricity Savings *Max*
Antigua (APUA)	$0,38	2011	6,5%	10,9%	$35.912	$41.351	$59.457
Bahamas (GB Power)	$0,17	2012	4,0%	5,1%	$15.593	$17.955	$25.817
Bahamas (BEC)	$0,33	2008	4,0%	5,1%	$31.187	$35.910	$51.634
Barbados (BL&P)	$0,38	2011	7,0%	8,7%	$35.912	$41.351	$59.457
Dominica (DOMLEC)	$0,39	2010	6,5%	8,9%	$36.857	$42.439	$61.022
Grenada (GRENLEC)	$0,39	2011	6,5%	10,7%	$36.857	$42.439	$61.022
Montserrat (MUL)	$0,40	2009	6,5%	8,6%	$37.802	$43.528	$62.587
Nevis (NEVLEC)	$0,31	2010	6,5%	9,2%	$29.297	$33.734	$48.505
St. Kitts Elec. Dep.	$0,29	2011	6,5%	9,2%	$27.407	$31.558	$45.375
St. Lucia (LUCELEC)	$0,32	2010	6,5%	10,2%	$30.242	$34.822	$50.069
ST. Vincent (VINLEC)	$0,32	2010	6,5%	9,1%	$30.242	$34.822	$50.069
Average	**###**		**6,1%**	**8,7%**	**$31.573**	**$36.355**	**$52.274**

Power Utility	NPV Savings *Min*	NPV Savings *Ref*	NPV Savings *Max*	IRR *Min*	IRR *Ref*	IRR *Max*	SIR *Min*	SIR *Ref*	SIR *Max*
Antigua (APUA)	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Bahamas (GB Power)	-$20.738	-$18.376	-$10.514	-1,8%	2,1%	10,7%	0,4	0,5	0,7
Bahamas (BEC)	-$5.144	-$421	$15.303	4,4%	8,5%	17,6%	0,9	1,0	1,4
Barbados (BL&P)	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Dominica (DOMLEC)	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Grenada (GRENLEC)	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Montserrat (MUL)	$1.471	$7.196	$26.255	6,5%	10,6%	19,8%	1,0	1,2	1,7
Nevis (NEVLEC)	-$7.035	-$2.597	$12.173	3,8%	7,9%	16,9%	0,8	0,9	1,3
St. Kitts Elec. Dep.	-$8.925	-$4.774	$9.044	3,1%	7,2%	16,2%	0,8	0,9	1,2
St. Lucia (LUCELEC)	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
ST. Vincent (VINLEC)	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
Average	**-$4.758**	**$24**	**$15.943**	**4,4%**	**8,5%**	**17,5%**	**0,9**	**1,0**	**1,4**

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											

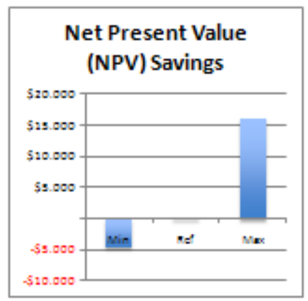
Comparison of EED Measures

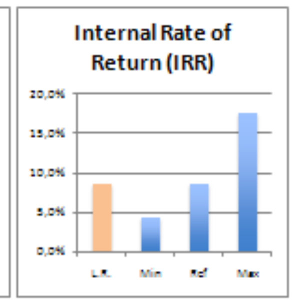
GENERAL	Min	Ref	Max
Inflation	2,5%	5,0%	10,0%
Nominal Disc. Rate	7,2%	9,8%	15,1%
ELECTRICITY	**Min**	**Ref**	**Max**
Inflation	3,5%	8,0%	18,0%
Real Discount Rate	3,6%	1,7%	-2,5%

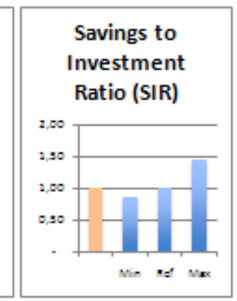
	Data
Start Date:	1/01/13
Duration (yrs):	20
Real Disc. Rate	4,6%

Baseline
arametric Office Buildi

	Design Concept	NPV of all costs	Consumption (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	$45.27[illegible]	-$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	[illegible]	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**	**-$4.75[illegible]**	**$24**	**$15.943**	**4,4%**	**8,5%**	**17,5%**	**0,9**	**1,0**	**1,4**

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											
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#3											
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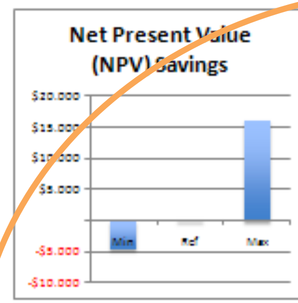
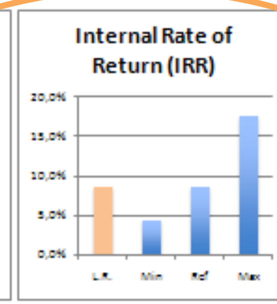
Comparison of EED Measures

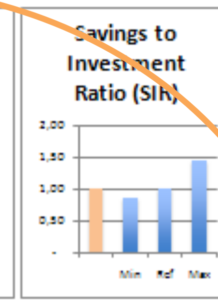
GENERAL	Min	Ref	Max
Inflation	2,5%	5,0%	10,0%
Nominal Disc. Rate	7,2%	9,8%	15,1%
ELECTRICITY	**Min**	**Ref**	**Max**
Inflation	3,5%	8,0%	18,0%
Real Discount Rate	3,6%	1,7%	-2,5%

	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 Min	NPV Electricity Savings Ref	NPV Electricity Savings Max
Antigua (APUA)	$0,38	2011	6,5%	10,9%	$35.912	$41.351	$59.457
Bahamas (GB Power)	$0,17	2012	4,0%	5,1%	$15.593	$17.955	$25.817
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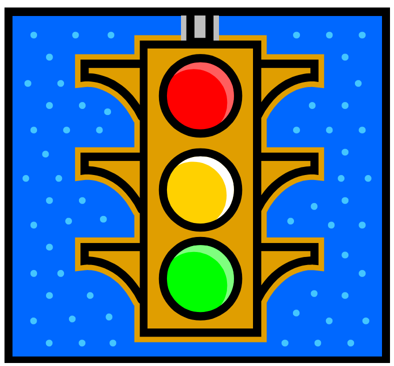
Barbados (BL&P)	$0,38	2011	7,0%	8,7%	$35.912	$41.351	$59.457
Dominica (DOMLEC)	$0,39	2010	6,5%	8,9%	$36.857	$42.439	$61.022
Grenada (GRENLEC)	$0,39	2011	6,5%	10,7%	$36.857	$42.439	$61.022
Montserrat (MUL)	$0,40	2009	6,5%	8,6%	$37.802	$43.528	$62.587
Nevis (NEVLEC)	$0,31	2010	6,5%	9,2%	$29.297	$33.734	$48.505
St. Kitts Elec. Dep.	$0,29	2011	6,5%	9,2%	$27.407	$31.558	$45.375
St. Lucia (LUCELEC)	$0,32	2010	6,5%	10,2%	$30.242	$34.822	$50.069
ST. Vincent (VINLEC)	$0,32	2010	6,5%	9,1%	$30.242	$34.822	$50.069
Average	**###**		**6,1%**	**8,7%**	**$31.573**	**$36.355**	**$52.274**

Power Utility	NPV Savings Min	NPV Savings Ref	NPV Savings Max	IRR Min	IRR Ref	IRR Max	SIR Min	SIR Ref	SIR Max
Antigua (APUA)	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Bahamas (GB Power)	-$20.738	-$18.376	-$10.514	-1,8%	2,1%	10,7%	0,4	0,5	0,7
Bahamas (BEC)	-$5.144	-$421	$15.303	4,4%	8,5%	17,6%	0,9	1,0	1,4
Barbados (BL&P)	-$419	$5.020	$23.126	5,9%	10,0%	19,2%	1,0	1,1	1,6
Dominica (DOMLEC)	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Grenada (GRENLEC)	$526	$6.108	$24.691	6,2%	10,3%	19,5%	1,0	1,2	1,7
Montserrat (MUL)	$1.471	$7.196	$26.255	6,5%	10,6%	19,8%	1,0	1,2	1,7
Nevis (NEVLEC)	-$7.035	-$2.597	$12.173	3,8%	7,9%	16,9%	0,8	0,9	1,[illegible]
St. Kitts Elec. Dep.	-$8.[illegible]25	-$4.774	$9.044	3,1%	7,2%	16,2%	0,8	0,9	1,2
St. Lucia (LUCELEC)	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	1,0	1,4
ST. Vincent (VINLEC)	-$6.090	-$1.509	$13.738	4,1%	8,2%	17,2%	0,8	[illegible],0	1,4
Average	**-$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**

  - NPV:
    - Red light: Negative values
    - Orange light: Positive, lower than $1,000
    - Green light: Positive, above $1,000

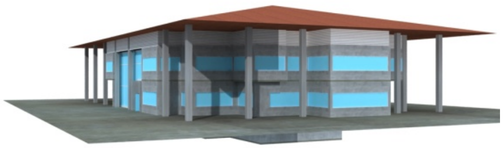
– IRR:
  - Red Light: When the IRR falls below the interest rate.
  - Orange light: When the IRR falls between the interest rate and the lending rate.
  - Green light: When the IRR is higher than the lending rate

Power Utility	Interest Rate	Lend. Rate	Internal Rate of Return (IRR)		
			Min	*Ref*	*Max*
Antigua (APUA)	6.5%	10.9%	8.1%	12.3%	21.5%
Bahamas (GB Power)	4.0%	5.1%	-0.2%	3.7%	12.5%
Bahamas (BEC)	4.0%	5.1%	6.5%	10.6%	19.8%
Barbados (BL&P)	7.0%	8.7%	8.1%	12.3%	21.5%
Dominica (DOMLEC)	6.5%	8.9%	8.4%	12.6%	21.8%
Grenada (GRENLEC)	6.5%	10.7%	8.4%	12.6%	21.8%
Montserrat (MUL)	6.5%	8.6%	8.7%	12.9%	22.2%
Nevis (NEVLEC)	6.5%	9.2%	5.8%	9.9%	19.0%
St. Kitts Elec. Dep.	6.5%	9.2%	5.1%	9.2%	18.3%
St. Lucia (LUCELEC)	6.5%	10.2%	6.1%	10.3%	19.4%
ST. Vincent (VINLEC)	6.5%	9.1%	6.1%	10.3%	19.4%
Average	6.1%	8.7%	6.5%	10.6%	19.7%

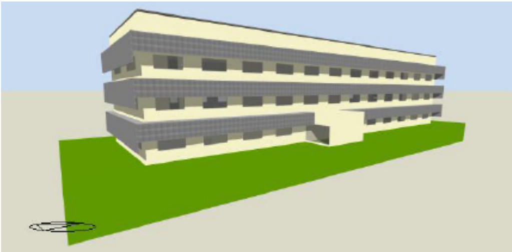
– SIR:
  - Red Light: For a SIR below 1
  - Orange light: For a SIR between 1 and 2
  - Green light: For a SIR above 2

Power Utility	Savings to Investment Ratio (SIR)		
	Min	*Ref*	*Max*
Antigua (APUA)	1.2	1.4	2.0
Bahamas (GB Power)	0.5	0.6	0.9
Bahamas (BEC)	1.0	1.2	1.7
Barbados (BL&P)	1.2	1.4	2.0
Dominica (DOMLEC)	1.2	1.4	2.0
Grenada (GRENLEC)	1.2	1.4	2.0
Montserrat (MUL)	1.3	1.5	2.1
Nevis (NEVLEC)	1.0	1.1	1.6
St. Kitts Elec. Dep.	0.9	1.1	1.5
St. Lucia (LUCELEC)	1.0	1.2	1.7
ST. Vincent (VINLEC)	1.0	1.2	1.7
Average	**1.1**	**1.2**	**1.7**

- LCC tool
  1. Baseline Building vs. Energy Efficient Building LCC
     - Differences in
       – Cost Components
       – Yearly electricity demand

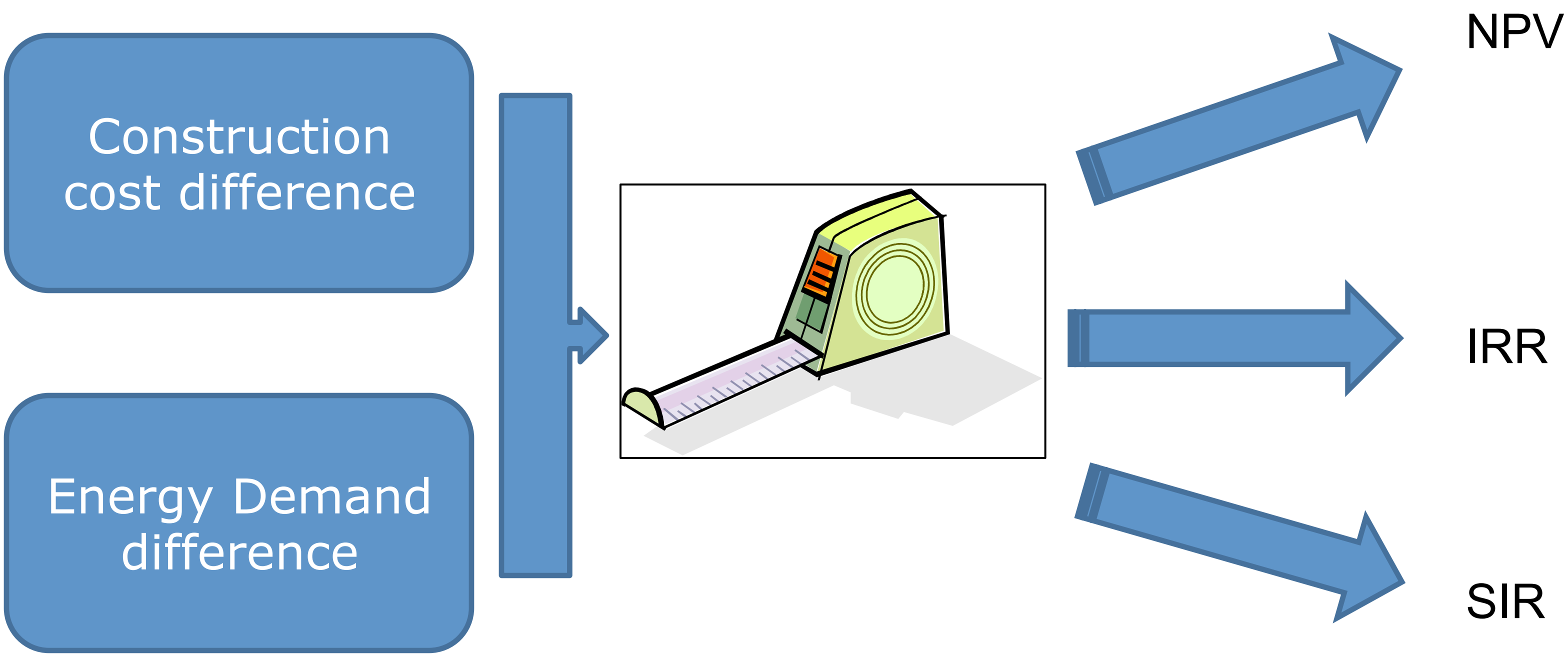


Baseline Building
More costly to operate



Energy Efficient Design
More costly to build

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



1. Baseline Building vs. Energy Efficient Building LCC

Construction cost difference

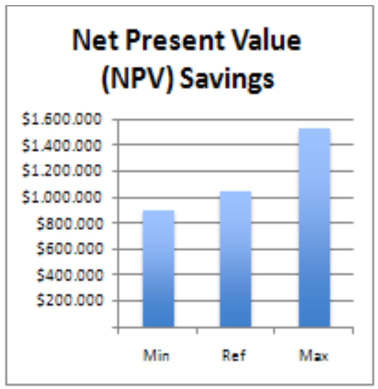
Component	EED	BD
Pitched roof columns	-	X
Ventilation grills	-	X
Pitched roof (PV vs vent. roof)	XX	X
Flat Roof	X	XX
Facades	XX	X
Windows	X	X
Solar protection	XX	-
Heat Recovery	X	-
Lighting	XX	X
Solar thermal	X	-
Light control	X	-

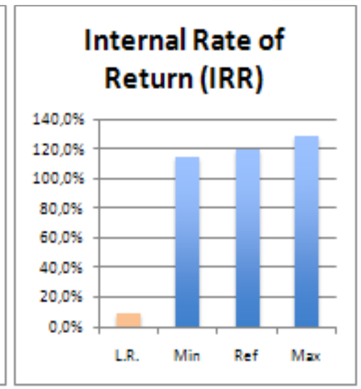
1. Baseline Building vs. Energy Efficient Building LCC

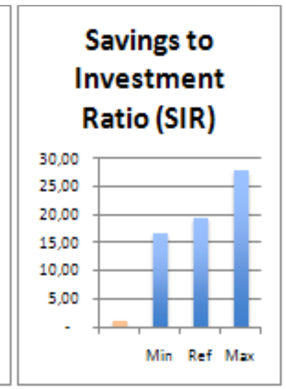
Energy Demand differnece

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%

	Design Concept	NPV of all costs	Consumption (kWh yr)
Type of solution	Whole Building		
Baseline	Baseline Design		423.986
Energy Efficiency Solution	EED	$56.650	235.154
	Difference	$56.650	-188.832

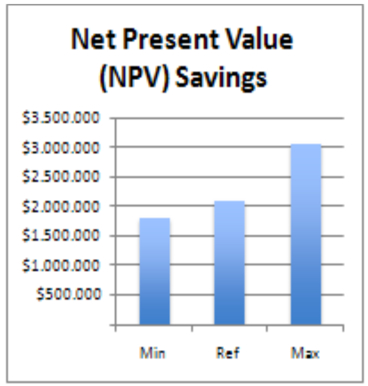


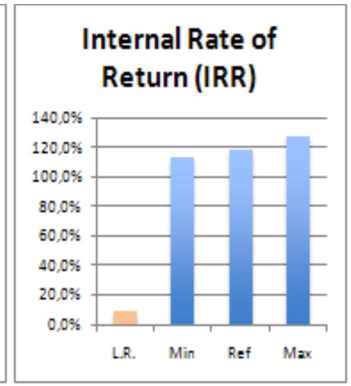


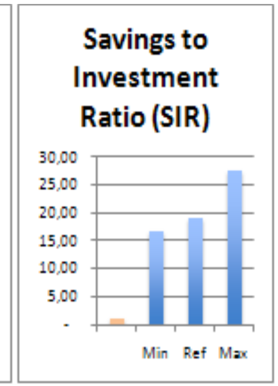


Power Utility	Net Present Value (NPV) Savings			Internal Rate of Return (IRR)			Savings to Investment Ratio (SIR)		
	Min	*Ref*	*Max*	*Min*	*Ref*	*Max*	*Min*	*Ref*	*Max*
Antigua (APUA)	$1.028.906	$1.193.320	$1.740.632	130,2%	134,7%	144,7%	19,2	22,1	31,7
Bahamas (GB Power)	$414.710	$486.100	$723.748	58,5%	63,0%	73,0%	8,3	9,6	13,8
Bahamas (BEC)	$886.070	$1.028.850	$1.504.147	113,5%	118,0%	128,0%	16,6	19,2	27,6
Barbados (BL&P)	$1.028.906	$1.193.320	$1.740.632	130,2%	134,7%	144,7%	19,2	22,1	31,7
Dominica (DOMLEC)	$1.057.473	$1.226.214	$1.787.929	133,5%	138,0%	148,0%	19,7	22,6	32,6
Grenada (GRENLEC)	$1.057.473	$1.226.214	$1.787.929	133,5%	138,0%	148,0%	19,7	22,6	32,6
Montserrat (MUL)	$1.086.041	$1.259.108	$1.835.226	136,8%	141,3%	151,3%	20,2	23,2	33,4
Nevis (NEVLEC)	$828.935	$963.062	$1.409.553	106,8%	111,3%	121,3%	15,6	18,0	25,9
St. Kitts Elec. Dep.	$771.801	$897.275	$1.314.960	100,2%	104,7%	114,7%	14,6	16,8	24,2
St. Lucia (LUCELEC)	$857.502	$995.956	$1.456.850	110,2%	114,7%	124,7%	16,1	18,6	26,7
ST. Vincent (VINLEC)	$857.502	$995.956	$1.456.850	110,2%	114,7%	124,7%	16,1	18,6	26,7
Average	$897.756	$1.042.307	$1.523.496	114,9%	119,4%	129,4%	16,8	19,4	27,9

	Design Concept	NPV of all costs	Consumption (kWh yr)
Type of solution	Whole Building		
Baseline	Baseline Design		423.986
Energy Efficiency Solution	EED+HR+LED+LC	$115.034	45.418
	Difference	$115.034	-378.568





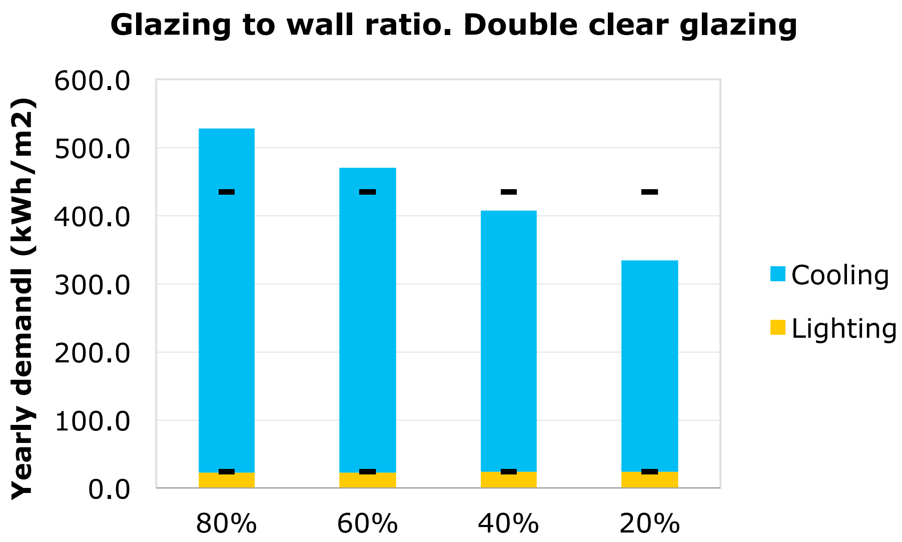


Power Utility	Net Present Value (NPV) Savings			Internal Rate of Return (IRR)			Savings to Investment Ratio (SIR)		
	Min	*Ref*	*Max*	*Min*	*Ref*	*Max*	*Min*	*Ref*	*Max*
Antigua (APUA)	$2.061.274	$2.390.890	$3.488.132	128,6%	133,1%	143,1%	18,9	21,8	31,3
Bahamas (GB Power)	$829.942	$973.065	$1.449.499	57,8%	62,3%	72,3%	8,2	9,5	13,6
Bahamas (BEC)	$1.774.918	$2.061.163	$3.014.031	112,1%	116,6%	126,6%	16,4	18,9	27,2
Barbados (BL&P)	$2.061.274	$2.390.890	$3.488.132	128,6%	133,1%	143,1%	18,9	21,8	31,3
Dominica (DOMLEC)	$2.118.546	$2.456.835	$3.582.952	131,8%	136,3%	146,3%	19,4	22,4	32,1
Grenada (GRENLEC)	$2.118.546	$2.456.835	$3.582.952	131,8%	136,3%	146,3%	19,4	22,4	32,1
Montserrat (MUL)	$2.175.817	$2.522.780	$3.677.772	135,1%	139,6%	149,6%	19,9	22,9	33,0
Nevis (NEVLEC)	$1.660.376	$1.929.272	$2.824.391	105,5%	110,0%	120,0%	15,4	17,8	25,6
St. Kitts Elec. Dep.	$1.545.833	$1.797.381	$2.634.751	98,9%	103,4%	113,4%	14,4	16,6	23,9
St. Lucia (LUCELEC)	$1.717.647	$1.995.218	$2.919.211	108,8%	113,3%	123,3%	15,9	18,3	26,4
ST. Vincent (VINLEC)	$1.717.647	$1.995.218	$2.919.211	108,8%	113,3%	123,3%	15,9	18,3	26,4
Average	$1.798.347	$2.088.141	$3.052.821	113,4%	117,9%	127,9%	16,6	19,2	27,5

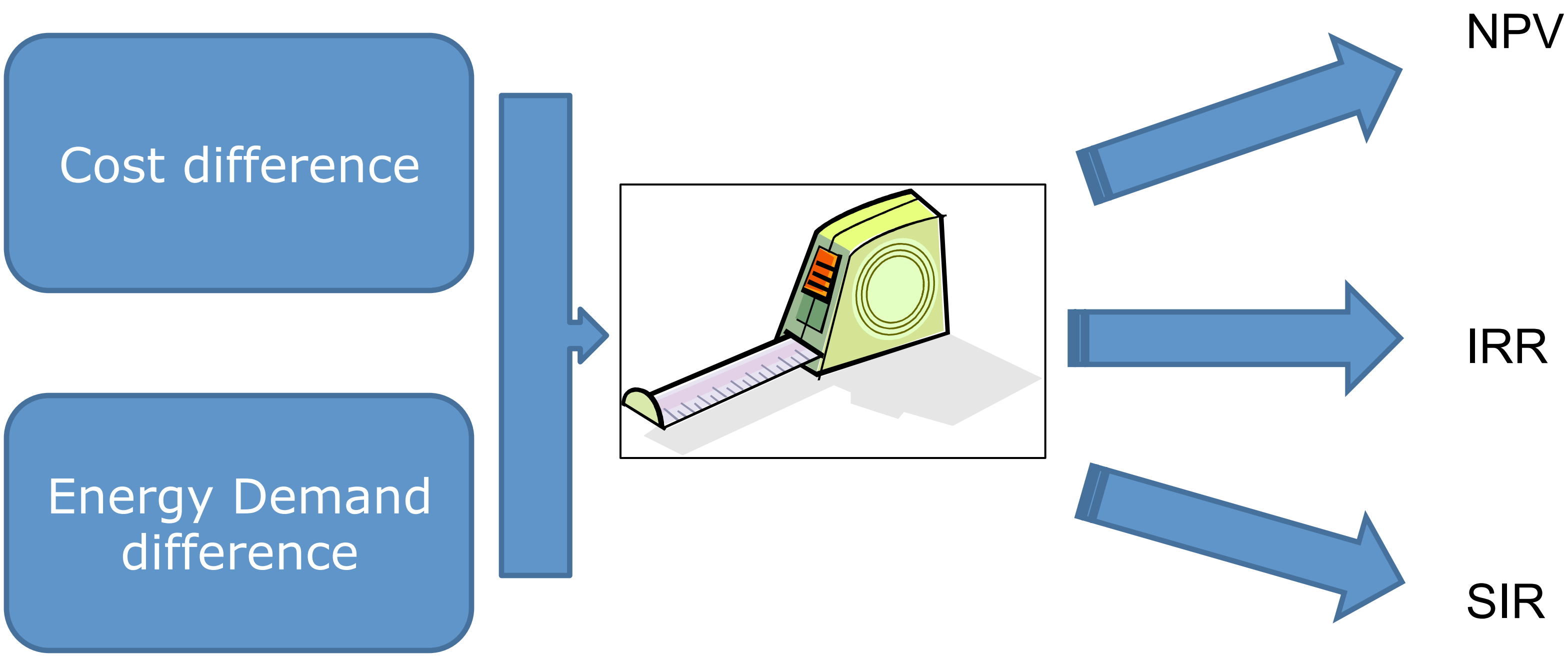
- Summary

Cases compared		Difference: Efficient - Baseline		Average electricity price/Average inflation scenario		
Baseline case	Energy Efficient case	Cost, USD	Electricity demand, kWh/year	NPV, USD	IRR, %	SIR
BD	EED	$521.746,61	-381.866	$ 1.700.622,00	31,9	4,3
BD	EED + HR	$561.123,85	-461.728	$ 2.126.021,00	35,1	4,8
BD	EED + HR + LED	$656.909,39	-686.908	$ 3.340.728,00	42,7	6,1
BD	EED + HR + LC	$572.931,85	-617.037	$ 3.018.071,00	43,8	6,3
BD	EED + HR + LED + LC	$668.717,39	-746.192	$ 3.673.939,00	45,1	6,5

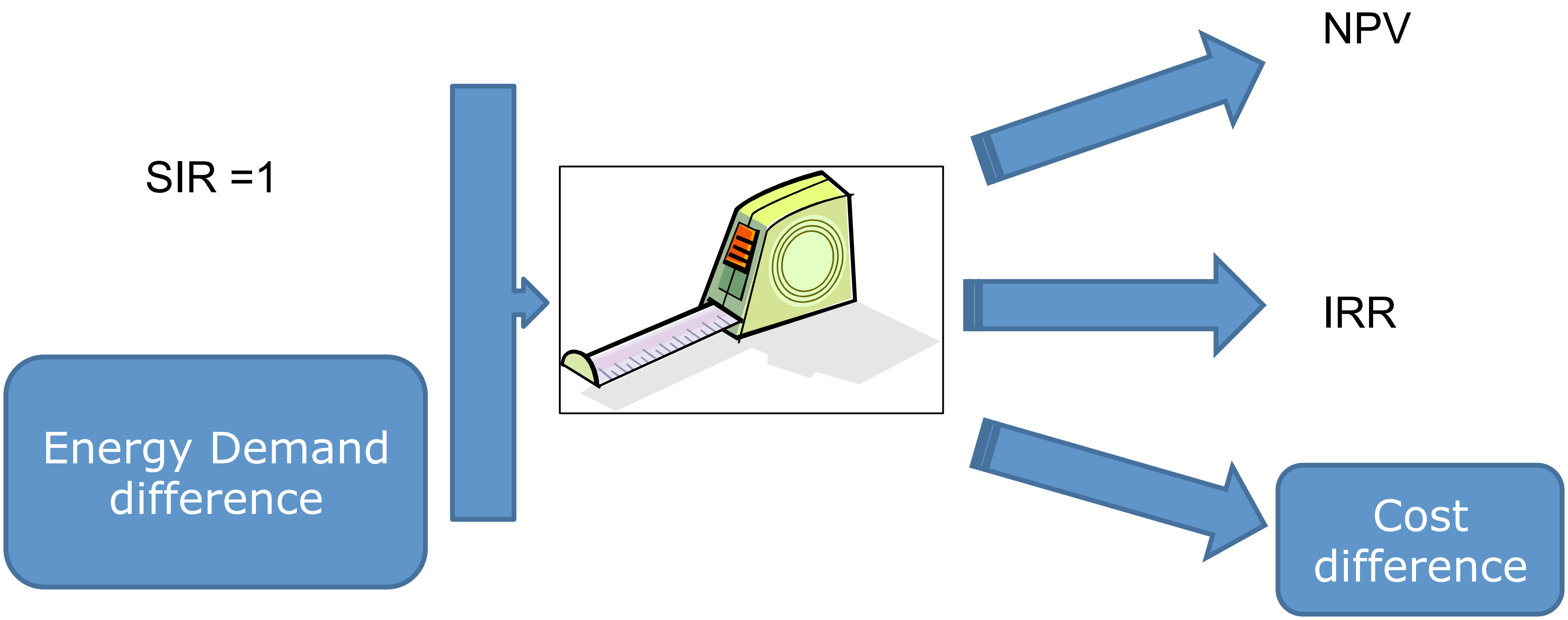
- LCC tool
  2. Choose between design alternatives considering LCC :
     - Compare alternatives among design strategies (from the Parametric Study strategies)
     - Based on:
       - Cost difference between alternatives
       - Difference in energy performance (assessed by Parametric Study)



- LCC tool
  2. Choose between design alternatives considering LCC

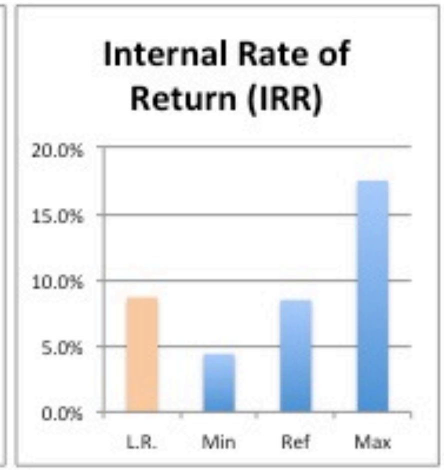


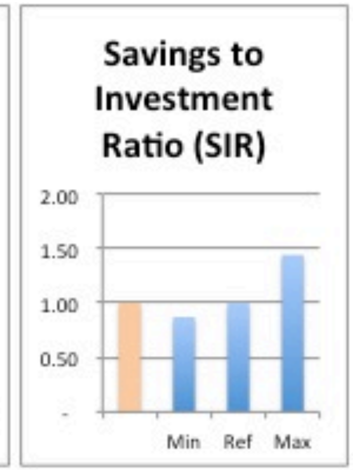
- LCC tool
  2. Alternative Point of view: what is the Cost difference, to make the alternative cost-effective



- LCC tool
  2. Choose between design alternatives considering LCC
     - SIR = 1 as a limit (Reference inflation Scenario)
       - Which utility/country case?
         - » Lowest electricity rate (all the other power utilities offer positive NPV, IRR and SIRs (green lights).
         - » The average case
         - » Most expensive electricity rate
     - 3 results:
         - » The lower threshold that makes the energy efficiency alternative financially viable for all the locations
         - » An average value
         - » A maximum difference beyond which the energy efficiency alternative starts not being viable for any of the locations

- Solar protection:
  - $403,000 for the average location





Power Utility	Net Present Value (NPV) Savings			Internal Rate of Return (IRR)			Savings to Investment Ratio (SIR)		
	Min	Ref	Max	Min	Ref	Max	Min	Ref	Max
Antigua (APUA)	-$4,708	$55,554	$256,159	5.9%	10.0%	19.2%	1.0	1.1	1.6
Bahamas (GB Power)	-$229,828	-$203,661	-$116,557	-1.8%	2.1%	10.7%	0.4	0.5	0.7
Bahamas (BEC)	-$57,062	-$4,728	$169,481	4.4%	8.5%	17.6%	0.9	1.0	1.4
Barbados (BL&P)	-$4,708	$55,554	$256,159	5.9%	10.0%	19.2%	1.0	1.1	1.6
Dominica (DOMLEC)	$5,763	$67,611	$273,494	6.2%	10.3%	19.5%	1.0	1.2	1.7
Grenada (GRENLEC)	$5,763	$67,611	$273,494	6.2%	10.3%	19.5%	1.0	1.2	1.7
Montserrat (MUL)	$16,233	$79,667	$290,830	6.5%	10.6%	19.8%	1.0	1.2	1.7
Nevis (NEVLEC)	-$78,003	-$28,842	$134,810	3.8%	7.9%	16.9%	0.8	0.9	1.3
St. Kitts Elec. Dep.	-$98,944	-$52,955	$100,138	3.1%	7.2%	16.2%	0.8	0.9	1.2
St. Lucia (LUCELEC)	-$67,532	-$16,785	$152,145	4.1%	8.2%	17.2%	0.8	1.0	1.4
ST. Vincent (VINLEC)	-$67,532	-$16,785	$152,145	4.1%	8.2%	17.2%	0.8	1.0	1.4
Average	-$52,778	$204	$176,573	4.4%	8.5%	17.5%	0.9	1.0	1.4

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Thank you

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