Designing Net-Zero Energy Schools for the Azores

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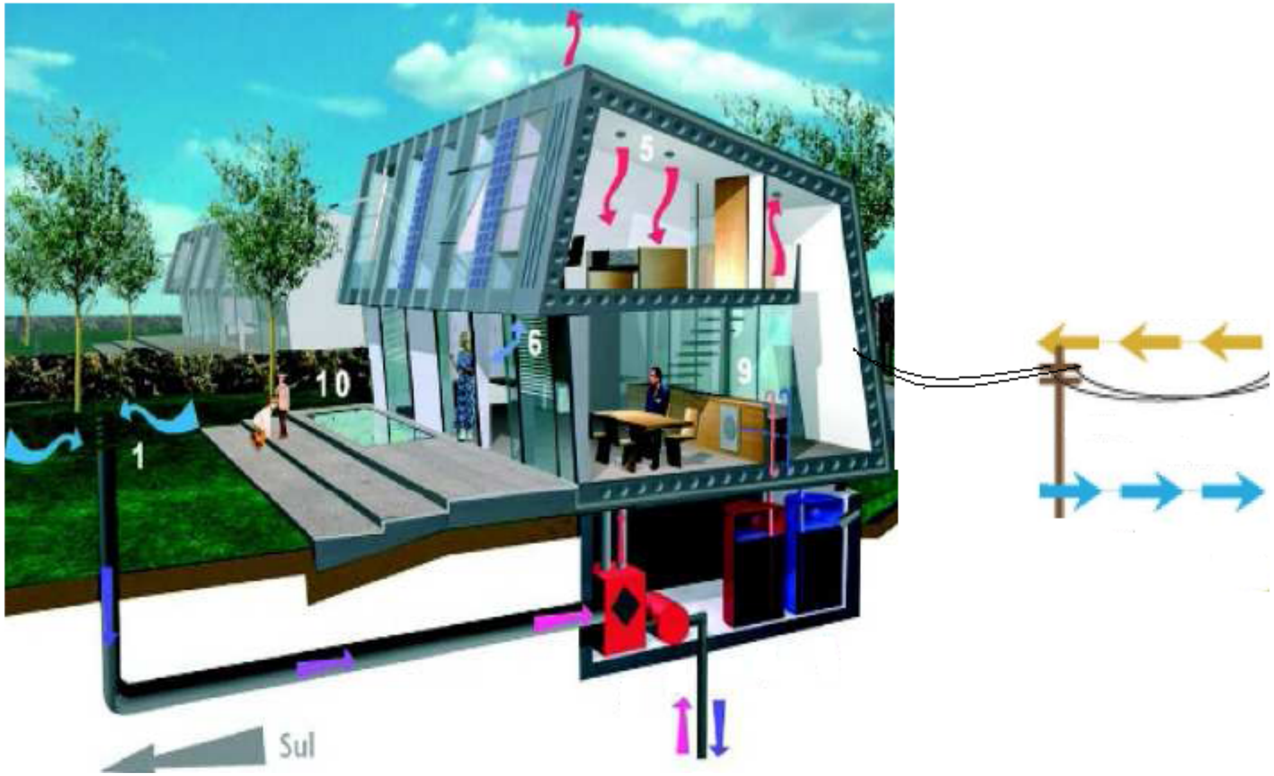
Net-Zero Energy Building Concept

- A Net-Zero Energy Building (NZEB) is a building that includes microgeneration and is bidirectionally connected to the grid so that it produces as much energy as it uses when measured on site on a annual basis



Approach

This project aims to identify the best design approaches for reaching net zero school (NZES) in the Azores. The main ideas are:

- To **offset only the non-renewable** part of the energy consumption at the site;
- To **include energy efficiency measures** so that the net zero performance does not come only just from installing a lot of Photovoltaic or other forms of micro generation. This may also help to lower significantly the cost of implementing the NZES;
- To make the energy efficiency and therefore the achievement of net-zero performance depend **on the behaviour of the occupants**, in order to maximize spreading effects beyond the school context.

Project overview

The main technical tasks are:

I. General characterization of the case study school – "Escola Antero de Quental":

1. Energy audit
2. Characterization of the school community

II. Generation and Analysis of Design Alternatives including cost-benefit assessment;

III. Production of terms of reference for design by architecture and/or engineering professionals.

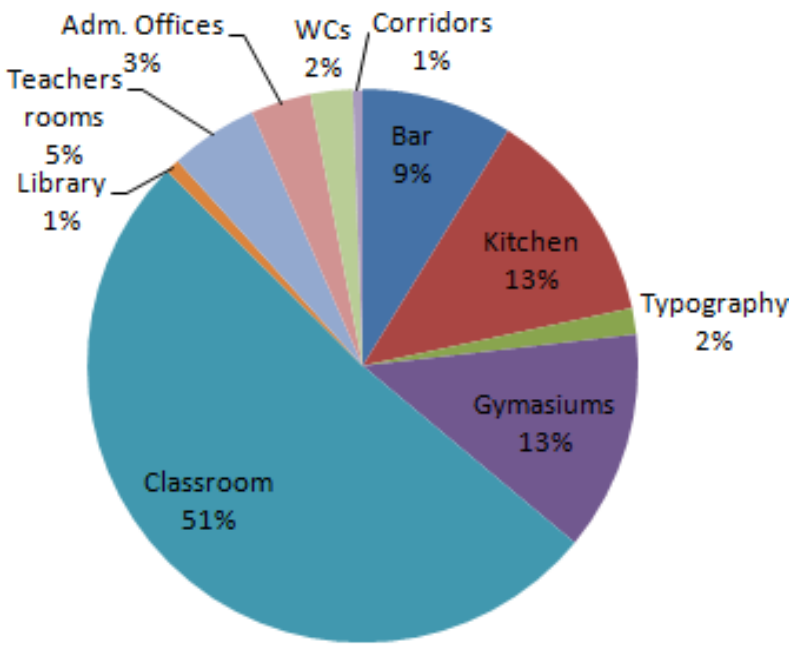
The part of the project approved so far refers to studying the design approaches including cost-benefit analysis. A decision of the actual implementation will be taken later by the Azorean Government.

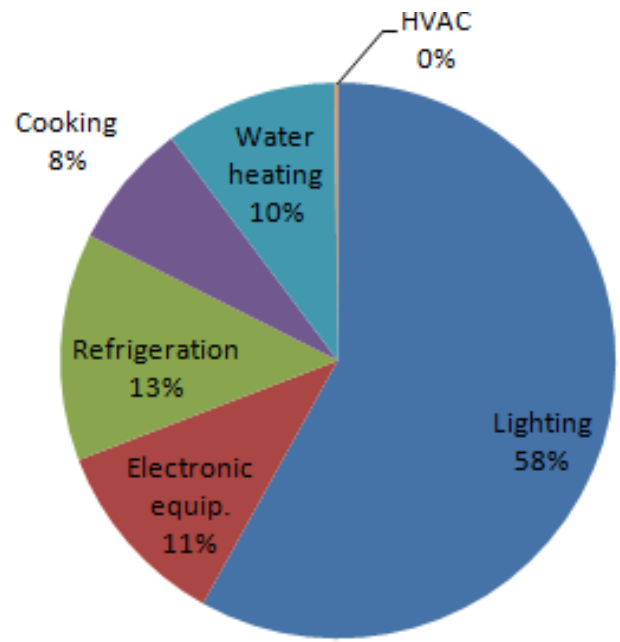
Review of the progress

Energy Characterization of the School (1)

Review of the progress

Energy Characterization of the School (2)

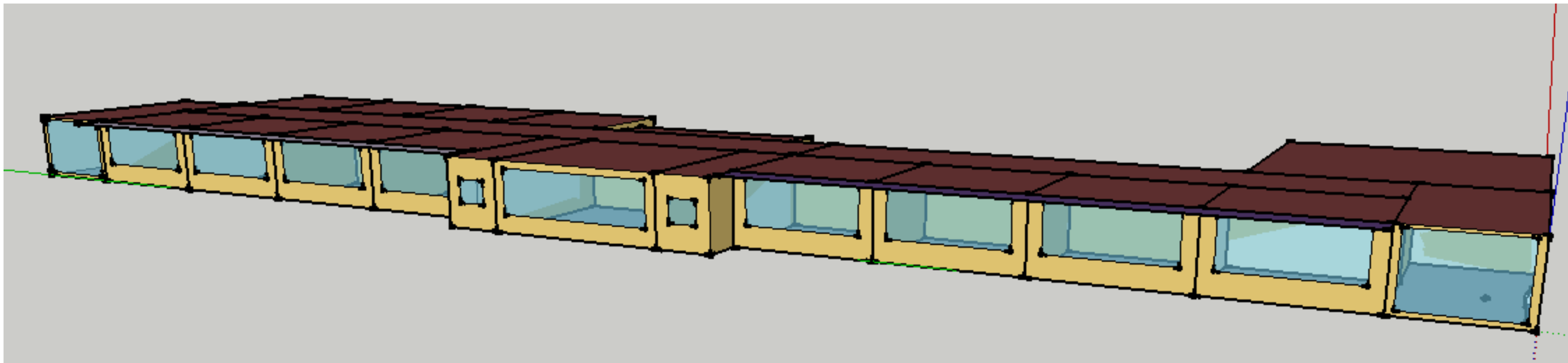




- If the School were to be turned to full net-zero performance by installing photovoltaic panels it would require about 1635 m2.
- The challenge is to bring this number significantly down through energy efficiency measures (including occupants behavior).

Review of the progress

Modelling of the School “Escola Antero de Quental”



- Simulation of the energetic behavior of a representative floor of the school – 2nd floor of the “Secção”;
- Assessment of the thermal comfort of the occupants;
- Assessment of the impact of different energy efficiency strategies on the overall energy consumption.

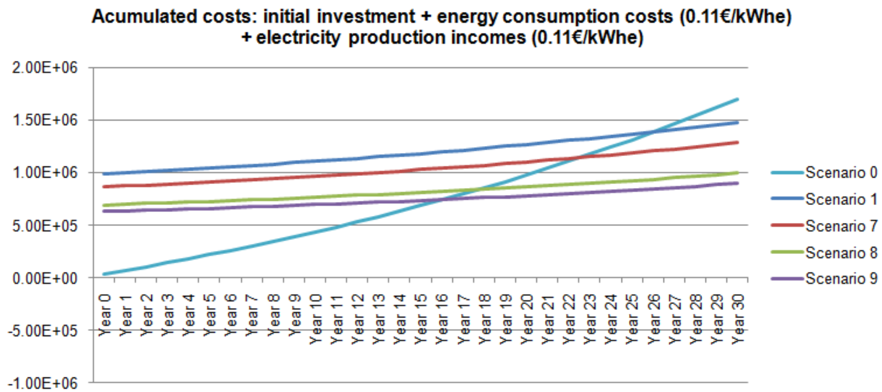
Recent developments

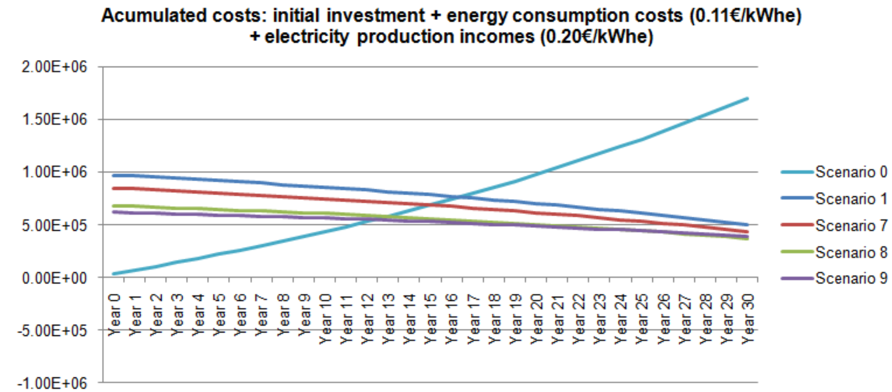
Energy Efficiency Measures and Impact on the Final Energy Consumption

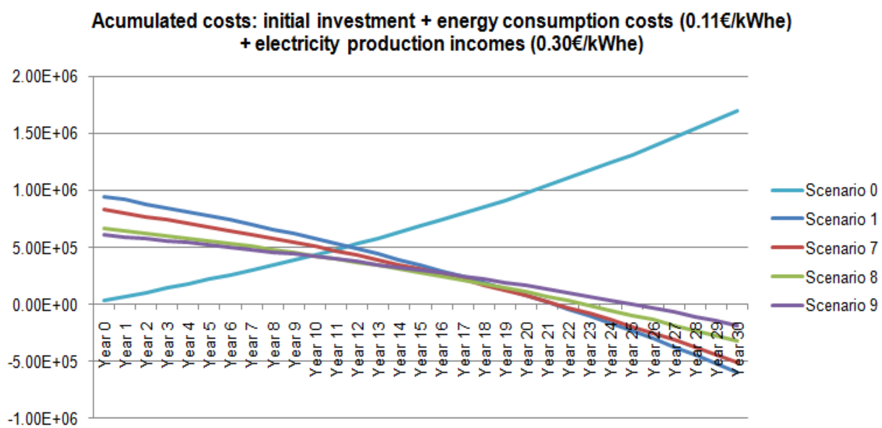
Scenario	Type of energy use	Technology and control	Behavioral changes	Description	Assumptions	Overall Final Energy Reduction (%)	Estimated EE cost (€)	PV area (m2)
1	All	-	-	-	η PVSystem =11%, EProd≈135kWh/year	-		**1635**
2A	Lighting	-	X	Manual On/Off control	Trigger Illuminance 2000lux	19%	0	-
2B		X	-	Ideal dimming control	Target Illuminance 500lux	33%	45000	-
2C		X	-	Lamps T8 → T5	ηT8=50lm/W; ηT5=100lm/W	14%	6000	
2D		X	X	Lamps T8 → T5 + Manual On/Off control	ηT8=50lm/W; ηT5=100lm/W; Target Illuminance 2000lux	25%	6000	
2E		X	-	Lamps T8 → T5 + Ideal dimming control	ηT8=50lm/W; ηT5=100lm/W; Target Illuminance 500lux	37%	51000	
3A	Refrigeration	X	-	Equipment Class C → Class A+	ηEquipRefrig=+50%	5%	5500	-
4A	Water heating	X	-	Solar collectors and condensing boilers - Gym1	Solar fraction = 55% ηCond.Boilers=90%	5%	43240	-
4B		X	-	Solar collectors and condensing boilers - Gym2	Solar fraction = 55% ηCond.Boilers=90%			
5A	Electronic equipment	-	X	To define with the Azores team		-	0	-
6A	Cooking	-	X	To define with the Azores team		-	0	-
7	Lighting	X		Scenario 2C	η PVSystem =11%, EProd≈135kWh/year	**14%**	**6000**	**1410**
8	Lighting	X		Scenario 2E	η PVSystem =11%, EProd≈135kWh/year	**37%**	**51000**	**1040**
9	Lighting +Refrigeration+Water heating	X	-	Scenario 2E, 3A and 4A	η PVSystem =11%, EProd≈135kWh/year	**47%**	**99740**	**850**

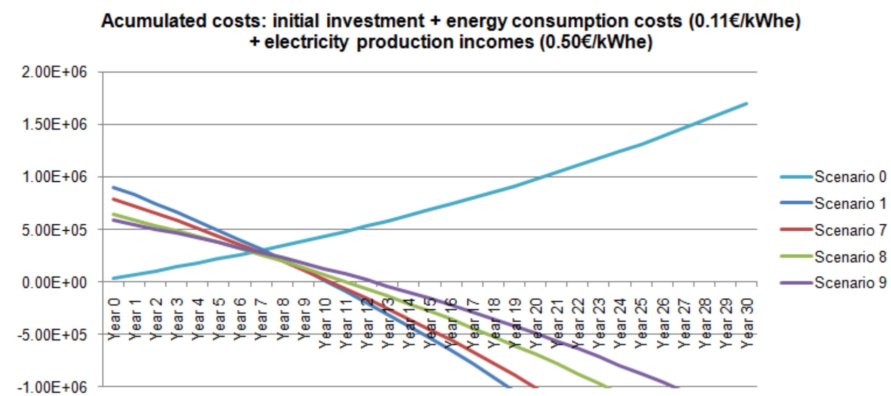
Recent developments

Economic Analysis – Four different feed-in tariff scenarios









Scenario 1	PVs
Scenario 7	Lamps T8 → T5
Scenario 8	Lamps T8 → T5 + Ideal dimming control
Scenario 9	Lamps T8 → T5 + Ideal dimming control + Solar collectors and cond. Boilers + Refrig. Equipment Class C to Class A

Preliminary conclusions

- Upgrade to NZES can be cost effective in 30 years life cycle, even without feed-in tariffs;
- In the "no feed-in tariff" scenarios, the most economically viable solutions are those that use more energy efficiency (instead of PVs);
- The adoption of feed-in tariffs can reduce considerably the payback time of NZES retrofit;
- However, feed-in tariffs, if too high tend to unlevel the field against energy efficiency.

Ongoing work

- Refinement of the school energy model - detailed monitoring data;



- Refinement of data costs information;
- Definition of monitoring variables and points regarding building use;
- Estimating costs of Architectural and Construction Design;
- Political decision on feed-in tariffs.

Behavioral front

- Characterization of behaviors, attitudes and motivations of the school community through a multi-method approach (survey questionnaire and behavioral mapping): field work complete, analysis ongoing;
- Part of the efficiency gains to be made critically dependant on the behaviors [e.g. lighting left with manual control in one floor];
- Building performance to be displayed in real-time.

Expected Outcomes

- Report on the School Energy Audit;
- Report on the Characterization of the School Community Behaviors, Attitudes and Motivation for Action;
- Report on the Generation and Analysis of NZES Design Alternatives;
- Terms of Reference for Architectural and Construction Design.



Thank You