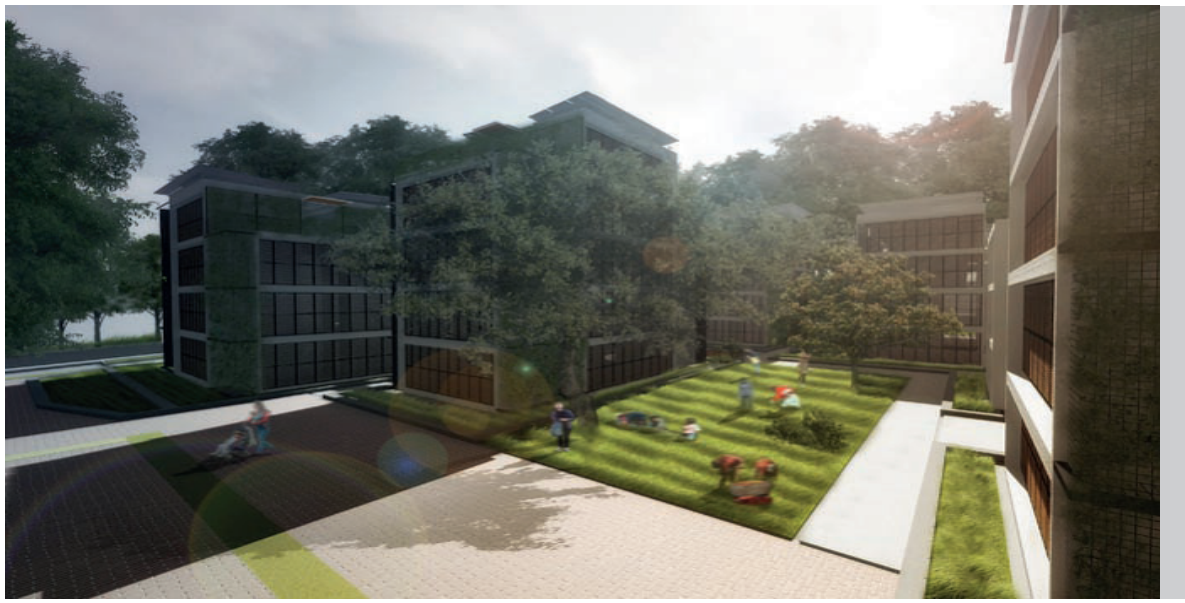
Chapter 4

Innovation



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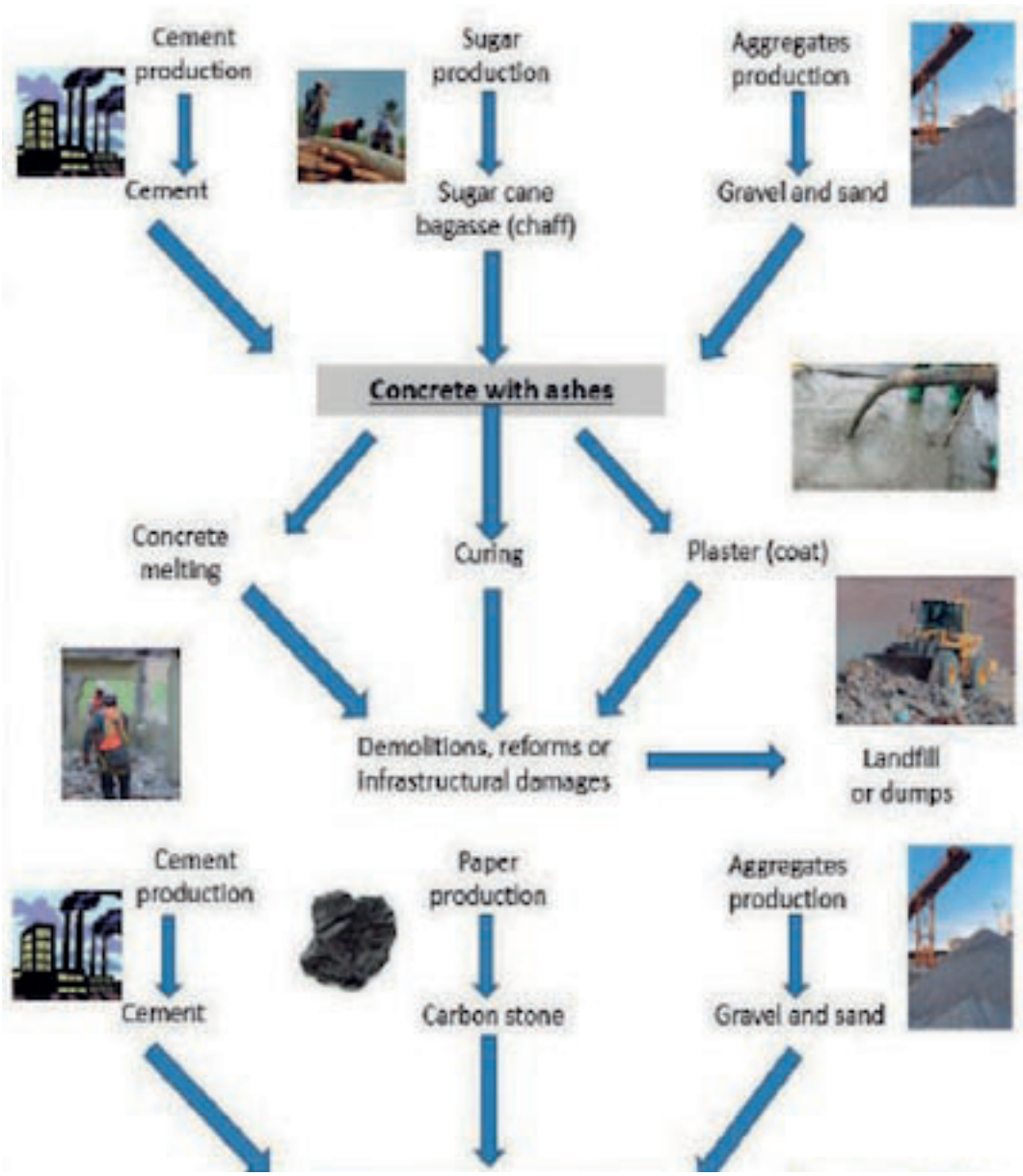
Innovation in Engineering and Construction

Mihouse prototype to be built at The Solar Village corresponds to the 5th floor of one of the proposed buildings. During the construction, prefab elements are considered, keeping the same material of the structure but making the necessary recalculations. In this way, Mihouse will be assembled during the assigned time. As for its different pieces, they will be assembled preferably with dry connections such as bolts, screws, etc., as it would be in the real building. The prototype will require active collaboration from all team members who will develop synchronized activities to achieve the effective assembly on this huge Lego. As for innovation in engineering, it has a rain collection system to be reused it in irrigation water parks. In addition, the reuse of greywater for toilets allows the reduction in potable water use. The greywater reuse in Mihouse project is a natural, innovative and economic system; because this wastewater coming from the laundry and showers is used for flushing the toilets and watering the gardens. This water is treated by a grease trap system and a wetland system, afterwards it is stored for being used allowing potable water savings.

Figure 4.1. Lifecycle analysis of materials



Source: The Authors.

The materials developed at the university for the construction of Mihouse prototype are sustainable and innovators, because during its production the carbon footprint is reduced, and a permeable concrete together with a lightweight concrete are developed, in comparison with the traditional products used for the construction sector. Following explains the details of each material and their innovation.

Permeable concrete: is a solid material which allows the passage of water in a 100 %, this characteristic is due to its specific design, which has the mechanical properties of a traditional concrete; it also has anti-slip properties, greater surface area, less expansion of the slab and is cheaper by 35 % compared to conventional concrete, these properties make permeable concrete an innovative material in Colombia.

Lightweight Concrete

Figure 4.2. Lightweight concrete.

Source: The Authors.

Figure 4.3. Lightweight concrete production process.

Source: The Authors.

Innovation refers to the changes that will be introduced to certain product intended to be useful for increasing productivity and the essential condition that their application is successful commercially.

The lightweight concrete, as traditional concrete, is a compound of aggregates, cement and water, with the difference of its low density and lower strength artificial material (Figure 4.2).

Given this, the innovative product that the Mihouse team has called lightweight concrete stone coal which is used as structural concrete and will be of low density to facilitate handling and reduced weight of the structure without losing its mechanical strength. Also, this product is environmentally friendly because the aggregates are used for manufacturing waste from the paper industry which makes the cost of this material cheaper compared with traditional concrete, both in production and in the installation. Besides, this product has a high thermal insulation power which makes it a necessary building material in warm areas (Figure 4.3)

Below in Table 4.1, a comparative table of lightweight concrete with stone coal and traditional structural concrete is presented. Built using lightweight aggregate coal as in the production of Mihouse project by replacing 10 % of the aggregates by Stone Coal, allows to reduce the weight of concrete structure from 47,52 tons until 38,02 tons. This reduction is important for the transportation and installation process of the concrete structure features.

Table 4.1. Comparative table of lightweight concrete and structural concrete

Properties/attributes	Light concrete	Structural concrete	Decrease/ difference
Compressive strenght	28 MPa	28 Mpa	=
Thermal isolation	0,4 W/m°C	1,63 W/m°C	1,23 W/m°C
Apsortion percentage	20 %	3 %	17 %

Source: The Authors.

Thermal Conductivity

The thermal conductivity is an intrinsic property of each material. There is a relationship between the porosity and heat transfer, because this feature provides the energy balance in heat transfer applications, and it is useful for the selection of materials of bioclimatic design strategies and indicates the heat flow from outside to inside the house.

In the Table 4.2 different properties between conventional and lightweight concrete are illustrated, showing that the light material has better thermal properties by increasing the thermal comfort (i.e. reducing thermal conductivity).

Table 4.2. Different properties between conventional lightweight concrete

Material	Density kg/m³	Specific heat j/kg ºc	Conductivity w/m ºc	Capacity mj/m³	Difusivity Mm²/s
Light concrete	1000	1050	0,4	1,05	0,38
Reinforced concrete	2400	1050	1,63	2,52	0,65

Source: The Authors.

Some of the consequences left by the process of urbanization and industrialization is the increase of heat islands, such effect is due to the loss of green areas, storage facilities of carbon gases, impermeability of soils and heat buildup constructions generating heat islands.

The growth of urban city develops significant changes in nature affecting global climate change, 60 % of emissions generated in the city come from transportation and construction, and 40 % come from the industrial sector.

It is established that the increase of the civilian population in urban areas and factors necessary for the development of a community such as business, transportation, consumption of food, entertainment, among others, have generated thermal, acoustic comfort and relative humidity altered, reducing the thermal comfort of homes.

The Mihouse project aims to build homes with the highest standards of quality, with architectural design and materials that permit low thermal and acoustic conductivity. The thermal capacity is the heat that can store material in its interior, the light being a low density material, has a specific heat capacity of 220,500 J / m°C.

12.5 % compared to the concrete Traditional representing 252,000 J / m°C. Thermal inertia is a property that has the specific inert material, such a characteristic is to store all the heat absorbed during the day and released in the evening hours, this behavior affects the thermal comfort of the housing. According to the climatic conditions of the city of Santiago de Cali, being a tropical city where the ambient temperature is 25° C with peak temperatures of 34° C, it is important to find a balance between thermal comfort and materials of the construction, to increase the correlation between the above conditions, a lightweight material designed with a thermal capacity 12,5 % lower than the traditional material, allowing the thermal comfort is suitable for housing.

Water Use Reduction

As for innovation in engineering, the Mihouse project proposes a rainwater collection system to reuse in irrigation for green areas and crop production. In addition, the reuse of greywater, coming from the washing machine, laundry and showers, and toilet flushing. The greywater reuse system in Mihouse project is a natural, innovative and economic system that allow the reduction of consumption of drinking water.

The projected system of rainwater collection has an innovative way to exploit the resource because it operates under an integrated model where each of its parts allow us to mitigate different types of environmental problems. For example, there is a minimum treatment costs associated with the first flush interceptor which retains an important amount of the polluting material. This rainwater exploitation system allows us to use the rainwater and to reduce drinking water consumption, because the stored volume is used for non-potable uses such as household cleaning, watering.

Innovation in Energy Efficiency

51 proposal had to be since the beginning an energy efficient, comfortable low-income home. This fact challenged us since we understood that an extremely energy efficient home, required highly efficient solar cell modules and lighting systems and modern low-consuming appliances. However, this was obtained by following an organized methodology for designing and selecting economic photovoltaic solar modules with higher power ratios, less area than similar modules and more efficient electronic technologies to convert and adequate the DC signal from the panels to the house, producing higher energy values in the useful area. We can say that Mihouse solar photovoltaic system was designed for meeting the energy demand and to produce surplus energy that could maintain charged batteries.

From the consumer's side, it was previewed the use of Led lights, high efficient microwaves, and low consumption appliances without reducing the families' comfort represented on items such as the internet connection, Led TVs or sound systems.

We also incorporated in Mihouse project the usage of grid interactive inverters, charge controllers and batteries. It means that this system will use its own produced electricity but additionally, it will also be able of selling the surplus (excess) energy to the city's grid at a reasonable price, making the system sustainable during the time. Subsequently, this urban complex will be ready to sell energy to the national grid as soon as the new Colombian

Renewable Energies Law (1715 May 2014) announces the trading price. This law promotes the installation and integration of renewable energies into the electrical network of the National Regulator Commission (CREG).

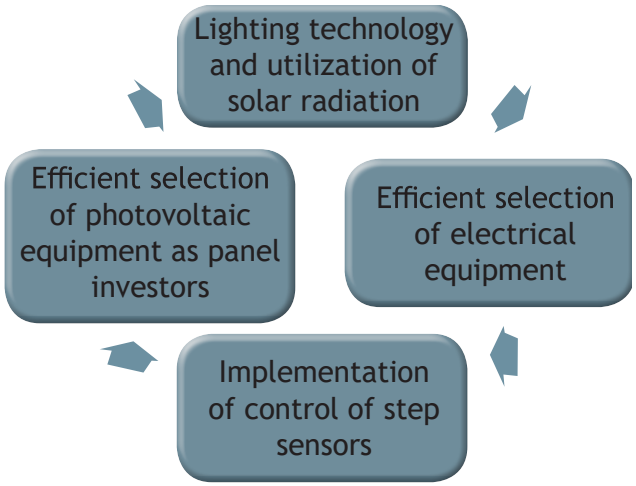
After all the ideas, researches and decisions taken during many meeting hours, Mihouse team designed an efficient project in terms of solar power generation and consumption. It is believed that with Mihouse prototype we can demonstrate to The Solar Village visitors the state of art in photovoltaic solar technologies that can be integrated as architectural elements in low income living units.

For example, the total solar electric PV system consists of 544 Canadian 310-watt panels for a total peak power of 168kW placed on a roof system. This system is connected to the electronic subcomponents that will connect the solar power to the living unit. This system is large enough to supply the living unit with enough power during daytime for three days without sunlight.

Innovation Through Energy Efficiency.

The proposed energy efficiency should have as its main focus the social sector, for that reason it should be evaluated at technically and financially processes to implement. It will be established target energy saving strategies, such as the selection of high efficiency PV modules, cost-benefit systems, energy efficient lighting, the use of new technologies, and finally the selection of equipment (electrical) with low power consumption.

Figure 4.4. Energy Efficiency strategies for sustainable social housing in developing countries

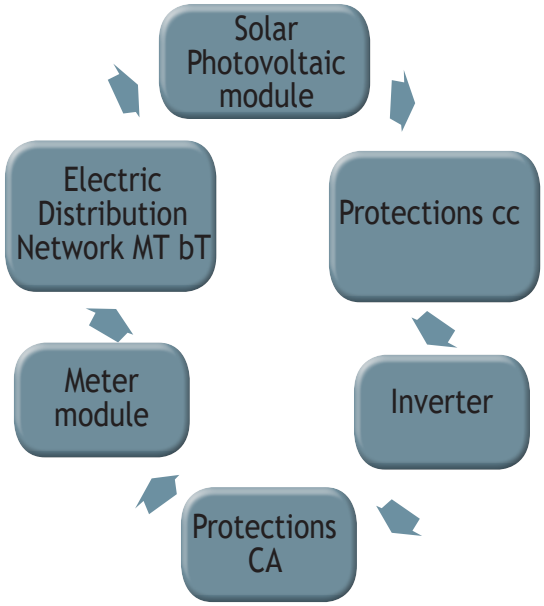


Source: The Authors.

Benefits of efficient selection of components of the electrical and photovoltaic system equipment.

- Energy saving.
- Reduction of the emission of greenhouse gases.
- Savings on energy bills.
- Protection of human beings, flora, fauna, property and the environment.
- Rational use of energy using equipment without oversizing the system

Figure 4.5. Efficient selection of photovoltaic equipment



Source: The Authors.

Benefits of deployment of control sensors step.

- Energy saving.
- Reduction of the emission of greenhouse gases.
- Savings on energy bills.
- Efficient use of new technologies.
- Easy to implement.

- Easy maintenance.
- Relatively cheap.
- Protection of human beings, flora, fauna, property and the environment.
- Facilitates quality of life of the inhabitants, by not about turning on or off the light.

Use of Natural Light

To increase energy efficiency and reduce power consumption, sun radiation is used to illuminate naturally, which is available throughout the day directly or through the sky.

Using this source of natural and clean energy, needs the following criteria to be applied:

- Large windows. They allow daylight by diffusion and reflection of sunlight into the interior and must be taken into account during building design unless the living unit is permanently in zones with very high temperatures, thus direct sunlight would create high interior temperatures.
- Avoid direct sunlight on the work planes.
- It is considered and analyzed the potential of natural light resource, which helps to coordinate design between natural and artificial lighting devices, according to the sun schedule. On the other hand, the equipment selection to control artificial and natural lighting could be an efficient strategy for saving and to reduce air conditioning systems.
- Resource of natural outside light, both in their levels of radiation and its duration periods has to be clear.
- Interior lighting should consider also the following objectives:

  To maximize light transmission through window glass. It is measured per unit area of window.

  To check the clarity contrast, especially between windows and walls.

  To minimize veiling glare on work surfaces, resulting from direct sun light in the upper windows.

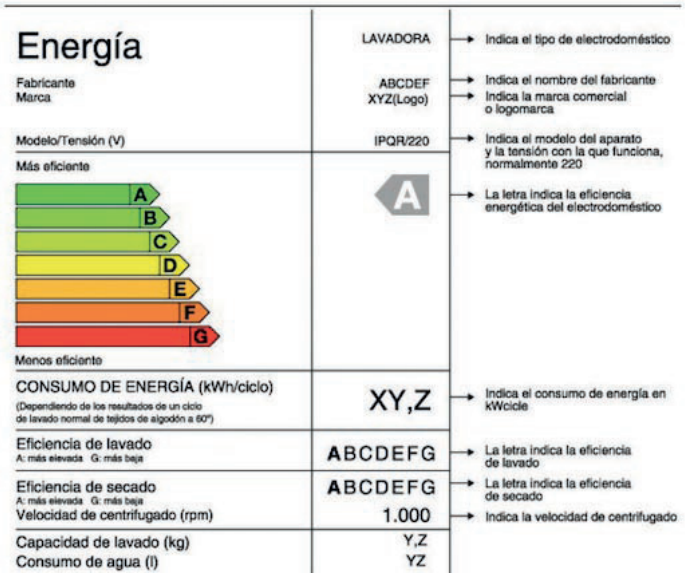
  To minimize the daytime heat during sunny days, using eaves or umbrellas.

Use of Led Lighting

Mihouse project increase and promotes the use of Led lights that are brighter and consume up to 90 percent less energy than conventional lighting methods. The reason why the process is efficient, is because light is produced by the electric current passing, so the energy is not too wasted as heat. Normally, incandescent bulbs have a 10 lumen per watt (lm/W), efficiency while Led have 90-110 lm/W, which is obviously more efficient than incandescent or fluorescent. They also work for more than 10 000 thousand hours, which make them cheaper in long term and reduce environmental contamination because they do not use gas. Finally, they are made by electronic devices easy to replace and reuse.

The main objective of Mihouse equipment is to properly selected home appliances, which should take into account the clear need for what is needed in each area or workspace, select the rating label for energy-efficient appliances among the items of class A and B because they generate savings around 45 % and 25 % according to the following figure.

Figure 4.6. Energy rating label



Source: Etiquetado energético Colombia Available on: http://www.etiquetaenergetica.gov.co

Another feature of the H_2O innovation system is that has been inspired by the global movement "Liter of Light" which aims to be an environmentally and economically sustainable light source for low-income housing. The correct selection of luminaires with LED technology or

automation dimerization, since the selection of the light source depend on various features such as: Led Brand recognized lifetime of the luminaire, light output, efficiency above 90 %, temperature color, and issues guarantees.

Benefits of using luminaires with LED technology.

- Energy saving.
- Reduction of the emission of greenhouse gases.
- Better color reproduction and visual comfort.
- Low maintenance.
- Protection of human beings, flora, fauna, property and the environment.
- Ecological at the end of its life (aluminum, plastic and glass, easily separable and recyclable).

The following figure shows a comparison between incandescent and LED technology, financially and technically.

Figure 4.7. Comparative between incandescent and LED lightning

Source: Viribright. Available on: https://www.viribright.com/lumen-output-comparing-led-vs-cfl-vs-incandescent-wattage

It is essential to analyze and understand this table in order to select an efficient light source. And that this should ensure a lower consumption, less environmental impact, lower cost over time, better color rendering index.

Reducing power and maintaining, or improving light output, are the two main factors to achieve lower consumption. An incandescent bulb with a power of 100 (W) and a flow of 1 650 (Lm), can now be replaced by a bulb Led lamp 22 (W) and a flow of 1 760 (Lm), a saving of 78 W. A house with led lighting will save enough energy and, obviously, enough money, making a more efficient home system, as shown in table 4.3

Currently stratum 1 and 2 in Colombia are sectors which are subsidized by the stratum 3, 4, 5, 6, which means that the more you save in the home the more you benefit the poor.

It is very important in the selection of light sources the issue of security, efficiency, color temperature, since these largely determine the energy and cost savings.

Table 4.3. Comparison of Consumption Among incandescent lighting and LED lighting

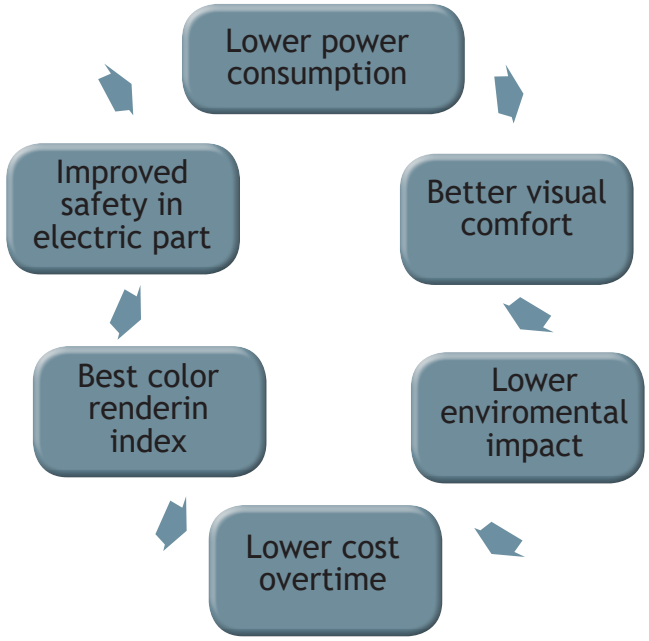
Quantity	Charge	Voltage V	Power W	Daily hours	Total energy kWh/ dia	Monthly energy KWh
1	Led luminaire room	120	10	5	0,05	1,5
2	Led luminaire bathroom	120	10	2	0,04	1,2
1	Led luminaire kitchen	120	10	5	0,05	1,5
1	Led luminaire dining room	120	10	3	0,03	0,9
1	Led luminaire yard	120	10	2	0,018	0,54
1	Led luminaire bedroom 1	120	10	4	0,04	1,2
1	Led luminaire bedroom 2	120	10	4	0,04	1,2
1	Led luminaire bedroom 3	120	10	4	0,04	1,2
1	Blender	120	370	0.2	0,074	2,22
1	Washing machine 31 LBS	120	125,6	1	0,1256	3,768
1	Fridge 222L	120	100	12	1.2	36
1	TV led 22’	120	30,4	3	0,0912	2,736

Quantity	Charge	Voltage V	Power W	Daily hours	Total energy kWh/ dia	Monthly energy KWh
1	Stereo	120		4	0	0
1	Phone charger	120	12	3	0,036	1,08
1	Laptop charger	120	65	6	0,39	11,7
1	Microwave	120	800	1	0,8	24
1	Stove	120	1 000	1	1	30
1	Grildde	120		0.2	0	0
			2 583			
					4 0248	120,744
					$ / kWh	300
Bill						36223,2

Source: The Authors.

Aesthetics plays an important role and should be accompanied by adequate levels of average illumination (lx), high levels overall uniformity which foster uniform illumination in all relevant areas of the illuminated space, low glare (UGR) that result to reduce loss of visual perception by absence or excess lighting and other factors according to regulatory guidelines and / or regulatory Retilap (technical Regulation of lighting and lighting). Table 410.1 UGR index and maximum illuminance levels due to different areas and activities Source for UGR, UNE EN 12464-1 2003.

Figure 4.8. Benefits of good lighting in each scene



Source: The Authors.