control strategy. The multiple factors need to be analyzed for optimum decision-making. Based on the adaptive thermal comfort study, it is highly probable that integrating occupants' adaptation to the environment will save energy (R. Yao et al., 2010). Nowadays, simulation tools are growing in monitoring and measuring of building energy performance but there is no method or architectural simulation program that allows the evaluation of the energy efficiency of the buildings in terms of smart sensors and systems directly.

DEPLOYMENT OF SMART SYSTEMS

Smart systems according to their applications in buildings are classified into different categories. These categories could be changed from architectural to other building fields such electrical and mechanical and etc. In recent times examples of smart systems as sensors in architecture field are being used to monitor Indoor Environmental Quality (IEQ) and outdoor environmental condition. They are classified into three categories self-sensing, self-diagnostic, and self-adapting sensors. The developed sensors can also measure environmental factors such as mean air temperature, relative humidity, CO2 concentration, light, reliable occupancy, ventilation and etc. For example sensor systems have potential to measure environmental factors simultaneously in a device (Figure 1).

Figure 1. *A sensor nodes with various sensing modules*

Nowadays, demand for intelligent buildings, especially in the field of energy savings are significantly growing. Smart systems and sensors as a part of intelligent buildings not only can improve indoor environment in the residential, office buildings even in the commercial buildings but also they have the most important role in making smart cities and improving outdoor environment. In realm of buildings, workplaces are significantly more affected by smart systems and sensors. To illustrate smart systems can indicate to new technologies in industry building such as smart materials, smart control systems and sensor systems to monitoring indoor and outdoor environmental condition.

It is evident that workplace design has undergone significant changes over the last two decades. A whole range of embedded smart sensors (ESS) was introduced amongst many other technologies in tandem with the new workplace patterns. There is a growing recognition that with wider incorporation of ESS as an integral part to newly evolving intelligent workplace pattern may enhance the level of such interdependence toward increasing the operational efficiency of buildings and productivity at large (G. Shabha, ,2006).

SMART AND INDOOR BUILT ENVIRONMENT

As mentioned above, smart systems are not only limited to sensors. There are many smart ways to create indoor quality in the built environment. To promote sustainable practices and smart solutions in the buildings understanding of needs and users' requirements are key factors to reach energy efficiency. Real time monitoring is one of the important feature of smart systems that can significantly reduce energy consumption.

For instance, Building Automation Systems (BASs) are used to both improve the indoor climate in buildings and to reduce the operational costs. Originally, BAS mostly consisted of heating, ventilation and air-conditioning (HVAC) systems. To further increase management and re-duce costs, both lighting, safety, security, and transportation supervision have been integrated into BAS (F. Osterlind et al. 2007).

METHODOLOGY

Experimental methods have advantageous in measurement of Indoor Environmental Quality (IEQ) in the buildings, but in this paper evaluation of processes will be determined by calculated methods especially simulation programs such as Daysim, Ecotect and Revit. In the design of a control environmental framework model in relation to smart sensors and systems, the first consideration should be to understand user behavior, so that it can be used play an effective role to meeting energy demand and control process. Firstly, in this paper will be considered a work environment without any sensor or smart system and will be analyzed energy consumption and users' behaviors in order to calculate the internal environment loads. Secondly, process, it will be considered to address smart systems and alternatives that have the ability to improve the indoor environment conditions. It also emphasizes the influence of user behavior in real time behaviors and needs which are concentrated for addressing potential impacts in energy saving.

The proposed project is located in Bologna-Italy at the latitude 42.4 N^{o} in Mediterranean climate zone. In this paper ASHRAE standard 90.1-2007 is designed as reference guide and the proposed project can be de-fined as climate zone "4" (mixed-humid) in ASHRAE standard 90.1-2007 (ANSI/ASHRAE/IESNA Standard 90.1-2007, 2007). To understand Energy behavior and daylighting performance of the reference building which was modelled by Ecotect 2011 energy needs are chosen to energy consumption. The energy needs are including cooling and heating loads to perform HVAC, lighting systems and other electric equipment in the buildings. This process were calculated by means of Ecotect 2011 simulation program, which enabled the detailed dynamic analysis. To predict the daylighting performance including illumination was also simulated by Ecotect and Daysim with different conditions both in summer (summer design 21 June) and winter (winter design 21 December).Table 1 shows an overview of modeling of the reference building.

Table 1. *Relevant data of the reference building*

Total Surface Area	12396.356 m^2 (561.9% floor area)
Total Exposed Area	2642.040 m^2 (119.8% floor area)
Total South Window	92.475 m^2 (4.2% floor area)
Total Window Area	310.648 m^2 (14.1% floor area)
Height/stories	ground floor(3.80 m)& 1th floor (3.50 m) / 2 stories
Total Surface Area	12396.356 m^2 (561.9% floor area)

In order to determine study zone in the reference building (Figure 2) it was simulated to solar access analysis. This analysis was performed by Ecotect 2011 to understand which faces or walls receive the maximum solar during a year. Energy consumption including heating, cooling and lighting is indeed the amount energy that the reference building required to maintain lower and upper band degree for thermal comfort and electricity required for electric lighting needs and other equipment. This amount should be considered as reference loads to compare consumption of the selected zone before and after the implementation of improvement strategies. In this paper the total energy savings of the selected zone will be compared with the reference building.

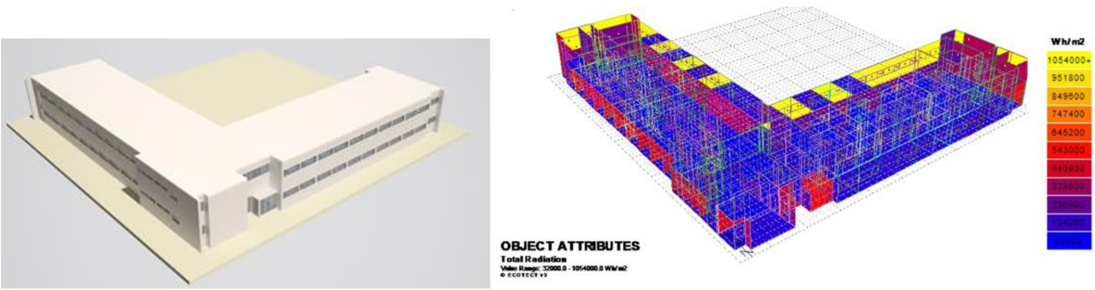

Figure 2. *3D view of the reference building (right) and solar access analysis of the reference building (left)*

In this process total heating and cooling loads which calculated by Ecotect 2011 and shown in the Figure 3 should be reviewed. The total loads of the reference building were mostly high demand of heating loads in January and of cooling loads in July.

In addition, internal gains including calculation loads from lights, people and equipment based on schedules were about 29.7% which should be considered to reduce by natural day lighting and it is so important to replace electric by day lighting when users do not need to use.

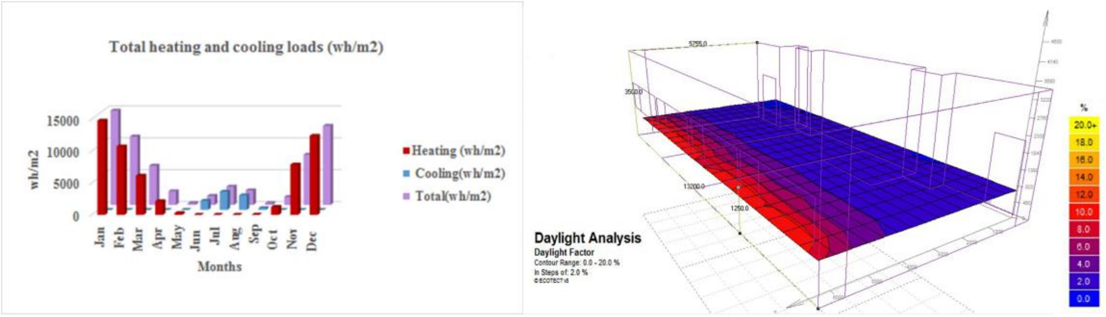

Figure 3. *Total heating and cooling loads of the reference building (left) and view of daylight factor analysis of the reference zone (right)*

As shown above, two methods both DF and DA were used to compare and measure adequacy of the inside illumination. The daylight factor is defined as the ratio of the internal illuminance at a point in a building to the unshaded, external horizontal illuminance under a CIE overcast sky (Moon P, et al., 1942). Daylight Autonomy (DA), uses work plane illuminance as an indicator of whether there is sufficient daylight in a space so that an occupant can work by daylight alone (Reinhart C F. et al., 2006). For instance, in the reference zone (Figure.3 right) percentage of the occupied times of the year when the minimum illuminance requirement for each the sensor (electric light) is 500 lux, it should be met this amount by means of daylight. So, to understand initial energy consumption and daylight performance of the reference zone, it was simulated for summer design (21 June) and winter design (21 December) period at 12 hour. The reference zone was proposed to have 3 workplaces by height 80 cm and 3 users.

Table 2. *Properties of daylighting analysis of the reference zone*

Category	Quantity	**Values (21 June)**			DA (%) 0.0- 1%
		Min.	Ave.	Max.	
The Reference Zone **Total Area:** $325.018\ m^2$ **Floor Area:** $91.308\ m^2$ **Volume:** $300.442\ m^3$	DF (%)	0.00 %	4.25%	20.00 %	Annual average value 0.02 %
	Daylight illuminance	0.00 Lux	361.30 Lux	1000 Lux	
		Values (21 December)			DA (%) 0.0-0.50%
		Min.	Ave.	Max.	Annual average value 0.02 %
	DF (%)	0.00 %	4.36%	20.00 %	
	Daylight illuminance	0.00 Lux	361.65 Lux	1400 Lux	

Table 3. *Properties of daylighting analysis of the reference zone*

Category	Heating (wh/m^2)	Cooling (wh/m^2)	Total (wh/m^2)
The Reference Zone	44711	10303	55014

The Tables 2 and 3 above show the values of daylight factor, daylight illuminance for June (summer design), December (winter design) and total heating and cooling loads of the reference zone. According to results of daylighting in the reference zone (Table 2) target illumination level (500 lux) and the distribution of the light were not met for summer and winter design. Therefore, it is expected to use electric lighting in period of work.

DISCUSSION

In this study, the reference zone was chosen as a working office, with 3 user. It should be considered to implement a smart device and automation control to optimize energy when users are not presence or do not need to electrical equipment it can be performed. It is considered to be out of working hours between from 13 to 14 the hours as break time. It also is assumed to install the automatic sensor lighting and heating and cooling in the absence of users for a certain period. It will be turn off autocomplete. For instance, automatic sensors will be used to adjust electric lighting based on the available users in the space. Regarding heating and cooling mode it is so important to highlight that automation heating and cooling devices must not turn the systems completely off rather reduce inside temperature to a returnable comfortable temperature position to avoid the consumption of energy wasted by this time .

To connect users to smart systems can indicate a simple device such as Arduino. It is a tool for making computers that can sense and control more of the physical world than desktop computer (Arduino, 2014). It can be considered simply connect to office's computers with a micro-USB cable or power in order to detect the users whether are present or not. This information must be sent online to smart devices to control process.

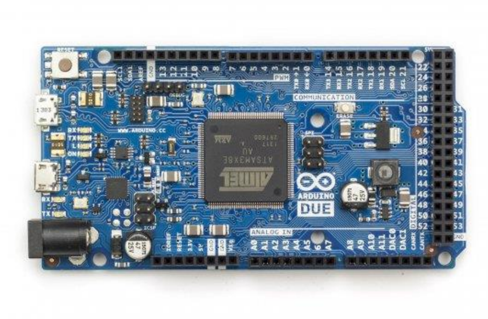

Figure 4. *View of one example of Arduino microcontroller*

After applying hypothesis mentioned in the above, schedule fields used with heating, cooling and lighting loads was changed to new schedule which includes a specific time between the hours as break time. Figure 5 shows the total heating, cooling loads and lighting savings of the reference zone with new schedule.

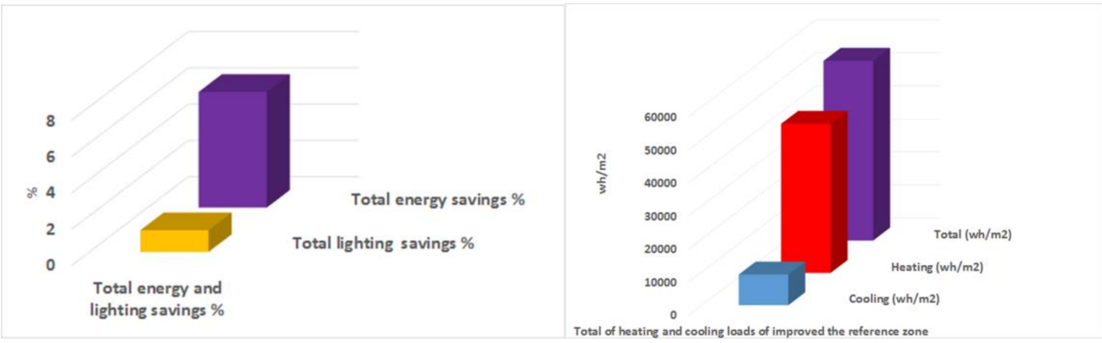

Figure 5.*Total of energy and lighting savings (left) and heating and cooling of improved the reference zone (right)*

CONCLUSION

Smart sensors and systems are capable of reducing energy consumption in the buildings considerably. This paper found that the role of smart sensors and systems in improving Indoor Environmental Quality (IEQ) in an office building in which smart solutions had not been implemented. As shown in Figure 5 it has been deduced that the reference zone has potential to save energy by means of smart sensors. To fulfil the purpose of the study the following research questions can be investigated from different perspectives in particular from architectural de-sign to architectural technologies points of view for future studies.

- Which methods can be applied to measure comfort conditions (in relation to smart systems strategies in terms of environmental factors)?
- Is there appropriate technologies for improving energy efficiency in new buildings

from the point of view smart sensors, systems and responsive building envelopes? This study has confirmed that physical features of smart systems affect energy consumption and comfort for user. Although, this paper did not evaluate performance of whole the reference building in relation to smart systems but it could show that these types of systems or sensorization will be able to be integrated indoor and outdoor environment to monitor real time user’s requirements and provide intelligent control process.

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