Performance Based Standards for Building Energy Efficiency

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1. Background and Issues

Energy use and Carbon Dioxide emissions related to buildings account for at least 30% and 35% respectively from their corresponding global values [1]. In addition, a similar percentage of the world's landfill wastes are generated by buildings. Buildings could last for decades and hence the decisions made on them today have a long lasting impact on the future global energy consumption and emissions. Also it is found that people spend almost 90% of their time inside buildings and as a result the indoor pollutant levels may reach 2 to 5 times higher than outdoor levels [1]. The built environment is booming all over Asia with China constructing almost half of the world's new buildings. The buildings in India have doubled from 2000 to 2005 [1]. It is recorded that buildings in Asia are consuming more energy and producing more Green House Gas (GHG) emissions and it is predicted that this will rise at a rapid rate during the next decade. In the present context, great emphasis is imparted to minimize or more specifically optimize the energy efficiency and the Carbon footprint related to buildings. This includes all categories of buildings including residential. In an overall perspective, building performance encompasses energy performance, indoor environment and air quality for human comfort & health respectively and also in environmental degradation and economic aspects. This paper intends to highlight the potential of performance based building standards over the widely used prescriptive standards for building energy performance. The paper discusses the distinct characteristics between the two and the potential advantages of the performance based standards. It further attempts to quantify the energy efficiency gains in adopting performance based standards compared to those with prescriptive elements through a suitable case study. Furthermore, the current status of the application of such standards, their evolution in the recent past, key benefits that they have brought about into the sector of building performance together with challenges in adopting the same in the local building sector is highlighted.

2. Trend towards Energy Efficient Buildings

Building performance standards have played a very significant role and in particular, in view of pushing the sector above a globally acceptable minimum energy performance level since the first petroleum crisis in 1973. This trend subsequently evolved to other aspects of building performance such as indoor air quality, comfort etc. There have been several major government initiatives for promoting the concept of Energy Efficient Buildings globally. Some of them are the Directive on the Energy Performance of Buildings implemented by the European Union in 2003, G8 Gleneagles Program on Building Energy Efficiency in 2005 and European Commission Green Building Program of 2005 [2]. Also there are market driven programs such as Leadership in Energy and Environmental Design (LEED) developed by the US Green Building Council in 1998 and ENERGY STAR originated in US by the Environmental Protection Agency and the Department of Energy in 1992 [3]. LEED consists of a suite of rating systems for the design, construction, operation and resource utilization of energy efficient buildings. ENERGY STAR is an international standard for energy efficient consumer products [3]. A growing market for energy services has been established with the emergence and growth of Energy Service Companies (ESCOs). A trend of mushrooming

Green Building Projects around the world is also observed. Furthermore, there are clear evidences of a transformation that envisaged a change of the market prices of the building industry.

Energy efficiency policy measures related to buildings can be broadly categorized as fiscal, financial and regulatory. Fiscal policy measures are mainly concerned with granting tax credits, tax reduction on equipment appliances, tax reduction on energy tax and implementation of tax schemes on inefficient appliances. Financial measures establish and implement policies related to granting of subsidies or soft loans for energy efficient buildings and systems. Also it promotes the concept of *Energy Auditing* for enhancing the energy performance of systems and processes. Regulatory measures emphasize on Minimum Energy Performance Standards (MEPS) and Energy Performance Labelling for buildings, which has become a newly rising trend.

Lighting, HVAC, and Office equipment consume the most energy in a typical commercial building as shown in figure 1. Most savings can be achieved by implementing energy efficiency measures around these elements. High-impact measures can significantly reduce energy consumption and cost.

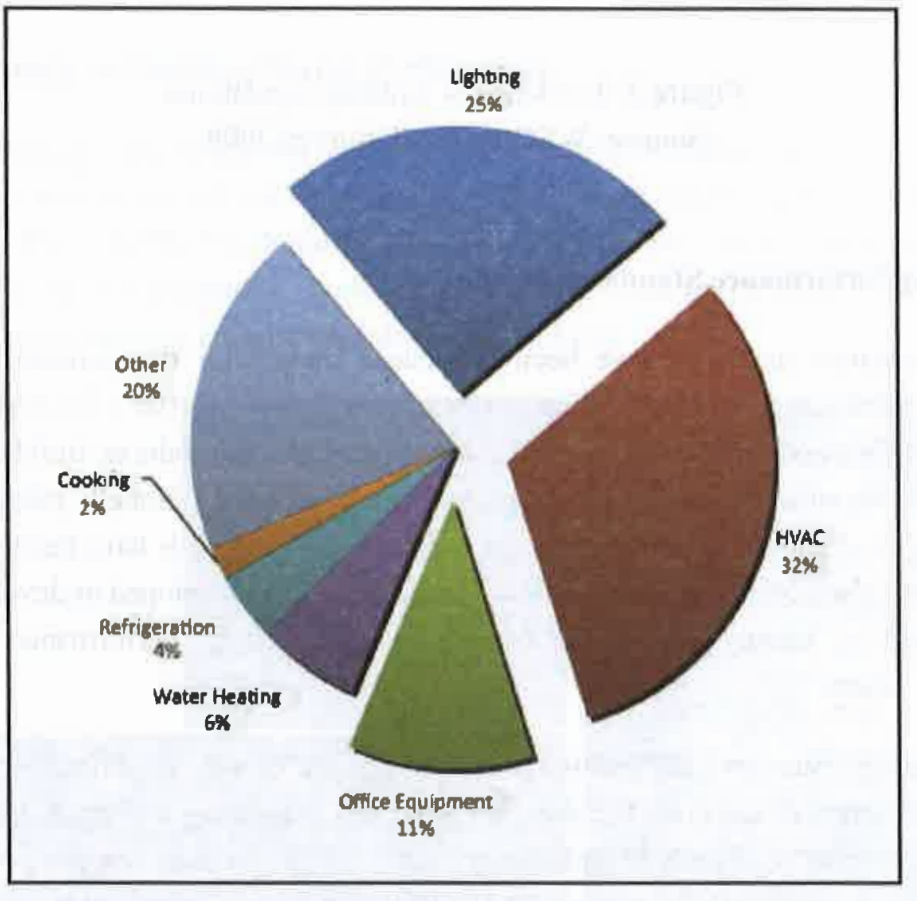

Figure 1: End use energy consumed by components of the building
Source: Building Energy Data Book, US Department of Energy, 2006

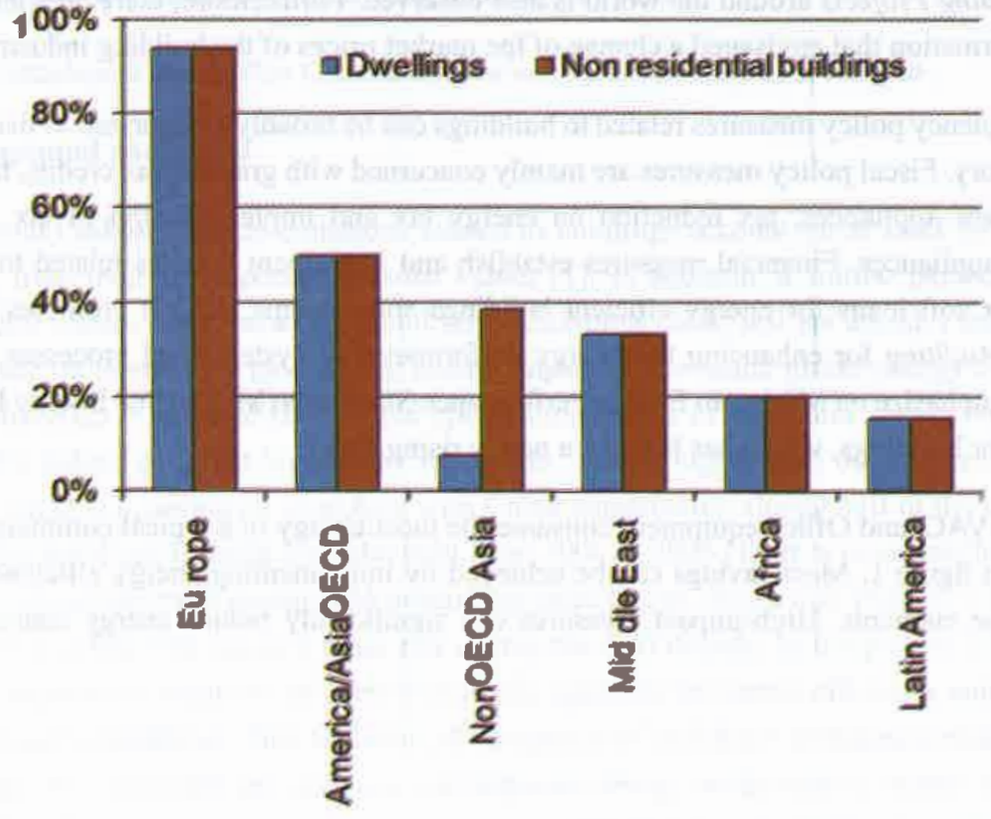

Figure 2: Existence of building regulations
Source: WEC, ADEME Survey 2009

3. Building Performance Standards / Codes

Building performance standards have been introduced mainly for the purpose of establishing the regulatory minimum level for building performance. They also offer a level playing field for relevant stakeholders and ensure the elimination of non-conforming products. Building performance standards which are either of mandatory or voluntary nature have traditionally played an important role in building regulations. As of now, building performance standards have been established and adopted by many countries irrespective of whether they are in the developed or developing world as shown in figure 2 [4]. Energy performance labeling makes the energy performance "visible" to the public and consumers.

Building performance standards fall into two generic categories, namely, prescriptive and performance based. In the prescriptive category, the standard stipulates mandatory and prescriptive criteria for generic building elements, equipment and energy supply conditions to be complied by the user. This includes building envelope, HVAC equipment, lighting system, hot water system, power supply and auxiliary equipment. The system analysis approach adopted in this regard is illustrated in figure 3.

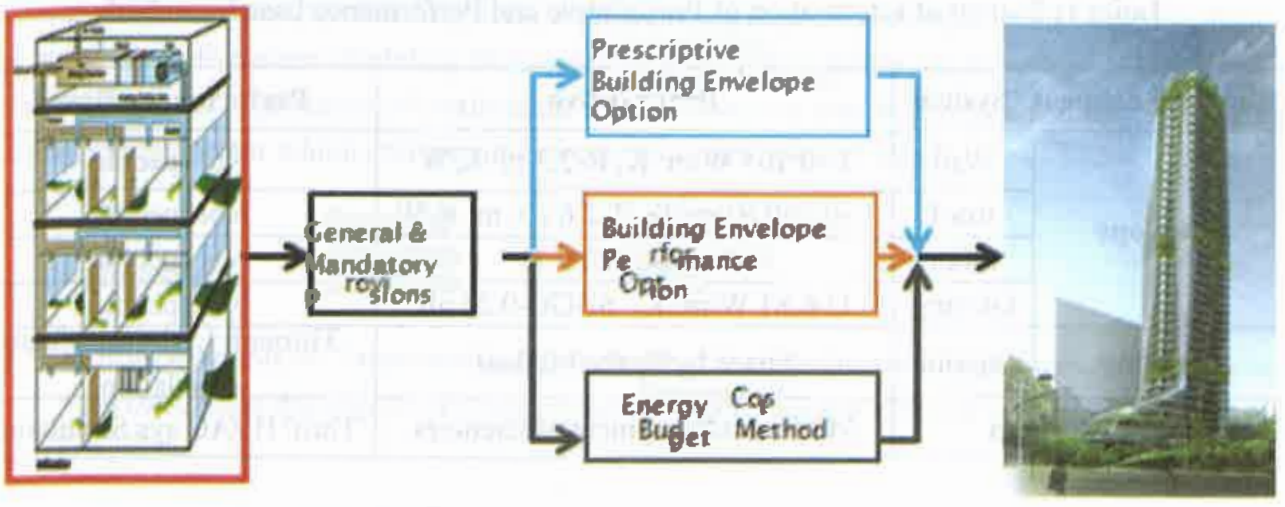

Figure 3: Designing for Energy Performance – System Analysis Approach

In case of performance based standards, the compliance is based on stipulated performance metrics that have to be established by pre-determined methods. This approach mainly utilizes design tools and building performance modeling techniques. Modeling for performance based approach considers Peak (usually) design loads estimation, Lighting & receptacle power allowance calculation, Annual energy consumption estimation, parametric analyses and Energy efficiency measures.

4. A Case Study on Building Energy Performance

An energy performance case study of a two story building which has an automobile repair work shop and office spaces will be considered below. It has 6846 Sq. ft of conditioned area with Window-to-Wall Ratio (WWR) of 24.5%. This building is located in the climate zone of 1 A as per the ASHRAE classification [5]. The computational model of the building is shown in figure 4. Table 1 gives the prescriptive and performance based standards for the building.

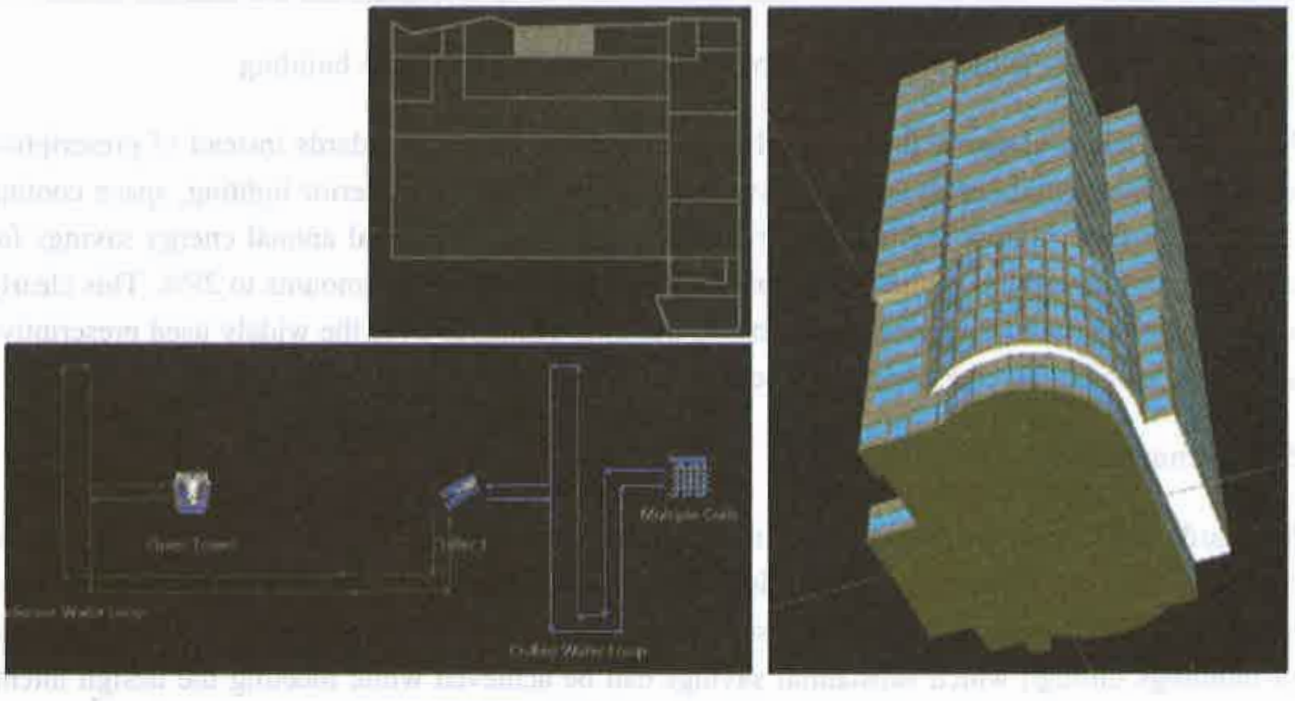

Figure 4: Computational model of office building

Table 1: Extract of information of Prescriptive and Performance based standards

Building Element / System		Prescriptive	Performance Based
Envelope	Wall	U-0.705 W/m².K, R-2.3 m².K/W	Not specific
	Roof	U-0.360 W/m².K, R-2.6 c.i. m².K/W	Not specific
	Floor	U-1.986 W/m².K	Not specific
	Glazing	U-6.81 W/m².K, SHGC-0.25 all	Not specific
Lighting	Interior	Space by Space Method	Through Lighting system simulation
HVAC System		Minimum Equipment efficiencies	Thro' HVAC sys Simulation

Table 2 gives a comparison of the energy performance of the office building when the prescriptive and performance based standards are applied separately.

	Energy Consumption p.a. [kWh]		
End Use	Prescriptive Method	Performance Rating Method	Percent Energy Savings p.a. (%)
Interior Lighting	48,474	29,611	39
Task Lighting	1,430	1,430	0
Receptacle Equipment	131,461	131,461	0
Space Heating	0	0	-
Space Cooling	92,890	53,506	42
Heat Rejection	0	2,740	-
Pumps & Auxiliary items	0	12,531	-
Fans - Interior	53,377	2,435	95
Exterior Usage	2,935	2,935	0
Total	**330,566**	**236,649**	**28**

Table 2: Comparison of energy performance of the building

From table 2 it is observed that by applying performance based standards instead of prescriptive standards, substantial energy savings have been achieved through interior lighting, space cooling and interior fans without sacrificing the design intent. Hence the total annual energy savings for the building through the application of performance based standards amounts to 28%. This clearly shows the potential of the performance based building standards over the widely used prescriptive standards for building energy performance.

5. Conclusion

Standards and Labels are found to be an effective energy efficiency improvement strategy in the building industry. Prescriptive standards establish minimum energy performance levels for the building sector where as performance based standards proceed further and optimize the performance of buildings through which substantial savings can be achieved while meeting the design intent. However performance based methods demand additional effort in order to make use of their full

potential. In this context, the building designer is expected to possess competencies related to design and building performance modeling tools together with optimization methodologies. The lessons learnt through the application of performance based methods can be extended to the Sri Lankan building energy sector which still remains mostly as an unexplored area.

6. References

[1] D. Mumovic and M. Santamouris, *A Handbook of Sustainable Building Design & Engineering – An Integrated Approach to Energy, Health and Operational Performance,* 1st ed., Earthscan, UK, 2009.

[2] W. F. Wagner, *Energy-efficient Buildings*, McGraw-Hill, 2007

[3] L. Reeder, *Guide to Green Building Rating Systems: Understanding LEED, Green Globes, Energy Star, the National Green Building Standard, and More*, Wiley, 2010.

[4] WEC, ADEME Survey 2009.

[5] ANSI/ASHRAE/IESNA Standard 90.1 2007.

Acknowledgement

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