Non-Compliance with Building Energy Regulations: The Profile, Issues, and Implications on Practice and Policy in England and Wales

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Cite as: Garmston, H., Pan, W., Non-Compliance with Building Energy Regulations: The Profile, Issues, and Implications on Practice and Policy in England and Wales, J. sustain. dev. energy water environ. syst., 1(4), pp 340-351, 2013, DOI: http://dx.doi.org/10.13044/j.sdewes.2013.01.0026

ABSTRACT

The built environment consumes as much as 50% of many countries' primary energy resources. Building energy regulations aim to reduce building energy consumption. However, non-compliance risks efficacy of such regulations and monetary costs to the construction industry and consumers. This paper examines the profile, issues and implications of non-compliance internationally with a focus on the case of new-build dwellings in England and Wales. Non-compliance has been observed internationally in both developed and developing countries. The issues underlying the non-compliance include perceptions of triviality towards the energy efficiency regulations, piecemeal dissemination, and a lack of familiarisation and training. Such lack of compliance may paradoxically risk ever more stringent regulations being accompanied by persistent non-compliance. To address the underlying issues, significant attention of both policy and practice must be paid to the formation, implementation and enforcement of building energy regulations, as well as to the training and education in building practices.

KEYWORDS

Building regulation, Part L1A, Dwellings, Energy efficiency, Energy policy, Non-compliance

INTRODUCTION

Buildings consume as much as 50% of the primary energy resources in many countries [1-5]. In the UK, the built environment accounts for an estimated 40% of total energy consumption [6] and 50% of all UK carbon emissions [7]. Building energy regulations, standards and codes (grouped hereafter under the term 'building energy regulations') are used in both developed and developing countries to reduce the energy consumed by buildings [2, 5, 8-10]. The growing use of building energy regulations is supported by recognition of the importance of knowing how well builders comply with building energy regulations [2]; the suggested strong relationship between energy regulation performance and energy consumption performance [5]; and the UK Government's routine of publishing increasingly stringent editions of Building Regulations Part L for England and Wales [11]. Non-compliance with building energy regulations can undermine their efficacy in reducing building energy use and carbon emissions [12]. Non-compliance with building energy regulations has been reported internationally, e.g. in the UK [11, 13-18], the USA [2], Norway [19], and in many

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developing countries [5]. Furthermore, energy consumption reduction programmes [12], and the legal and financial ramifications arising from the non-compliance, result in costs that must be borne alike by construction professionals and consumers [20]. Therefore, this paper aims to address these concerns by examining non-compliance with building energy regulations. The examination is guided by several questions:

- What is the profile of non-compliance with building energy regulations?
- What are the underlying issues of such non-compliance?
- What are the implications of such non-compliance on policy and practice?

The paper first introduces building energy regulations, standards and codes for new-build dwellings, and then examines the profile of non-compliance and the underlying issues. Blending the results, the paper explores the implications of such non-compliance on policy and practice. The examination is carried out with a focus on the case in England and Wales, but draws on the literature in the international context.

THE INTERNATIONAL CONTEXT OF BUILDING ENERGY REGULATIONS

The core concept for the building energy regulations investigated in this paper is that of mandatory minimum energy performance standards for new-build dwellings. There are two generic approaches to building energy regulations, i.e. prescriptive (acceptable solution) and performance-based (required performance) [21]. Based on these two approaches, building energy codes can be basically grouped into four categories: 1) envelope component codes (maximum heat transfer through individual components, e.g. walls, roof, windows); 2) overall envelope codes (limit on the overall heat transfer through the building envelope); 3) codes for the limitation of heating and cooling demands; and 4) energy performance codes (the whole building is considered, including e.g. heating and cooling) [22]. Building energy regulations inevitably differ according to a country's climatic circumstances and energy policy concerns. A survey of 81 countries, found 61 as having some form of building energy regulations, eleven with proposed standards and nine with no building energy regulations [23]. Since the implementation of the Energy Performance Building Directive, building energy regulations in most European Union countries are performance-based. Similarly, Thailand uses building energy regulations that adopt system performance requirements [24]. The Gulf States, e.g. Bahrain uses prescriptive building energy regulations [10], as does China [9]. Iran uses either prescriptive or performance systems depending on the buildings' conditioned floor area [9].

BUILDING ENERGY REGULATIONS IN ENGLAND AND WALES

An overview

The mandatory minimum requirements for energy efficiency, in the built environment in England and Wales, are laid down in Part L 'Conservation of Fuel and Power' of The Building Regulations 2010 [25]. First issued in 1990 in response to an oil crisis [7, 8], Part L has evolved over subsequent editions (1995, 2002, 2006, the latest edition: 2010, and the upcoming edition: 2013) to aid in the reduction of emissions, namely carbon dioxide, contributing to global warming [8, 26]. In 2011, carbon dioxide accounted for 83.5% of the total UK greenhouse gas emissions [27]. Preceding editions of Part L that are still in use, i.e. 2002 and 2006, are related to The Building Regulations 2000 [28]. From 2005, the UK Government started incorporating the requirements of the EU Energy Performance of Buildings Directive (EPBD) 2003 [29] into Part L. The assimilation of the EPBD's requirements, e.g. adopting a calculation methodology; setting minimum energy performance requirements; requiring an energy performance

certificate; and boiler and air conditioning inspections, was completed with the enforcement of Part L 2006 on 4th April 2006 (well within the EPBD deadline of 4th January 2009) [7]. Part L encompasses new and existing, and domestic and non-domestic buildings; the focus of this paper however is on Part L for new-build dwellings. Part L aims to achieve 'zero carbon homes' through a 70% reduction in carbon emissions over Part L 2006 standards [30] (Figure 1). While the UK Government remains committed to implementing 'zero carbon homes' from 2016 [31], it has had concerns as to whether the aim is possible in all cases [32]. Modelling by the Zero Carbon Hub (ZCH) [32] evidenced some infeasibility in achieving a 70% reduction in carbon emissions. The ZCH [32] also reported variations in performance by dwelling type and suggest that they be subject to different limits, namely, 60% for detached houses, 56% for attached houses, and 44% for low-rise apartments (high-rise apartments require further specialised work before their limit can be set). It is worth noting, that the debate on 'zero carbon' definitions, which involves the UK and other countries, (e.g. [33, 34]) is on-going. The UK's 'zero carbon' definition in relation to homes was originally intended to include regulated and unregulated energy, yet in 2011; the definition was amended to exclude non-regulated energy [35]. Heffernan et al. [36] critiqued the definitions of zero carbon homes and concluded that to use the term 'zero carbon' is a misnomer if such term does not account for regulated, unregulated and embodied primary energy, plus other energy reducing measures.

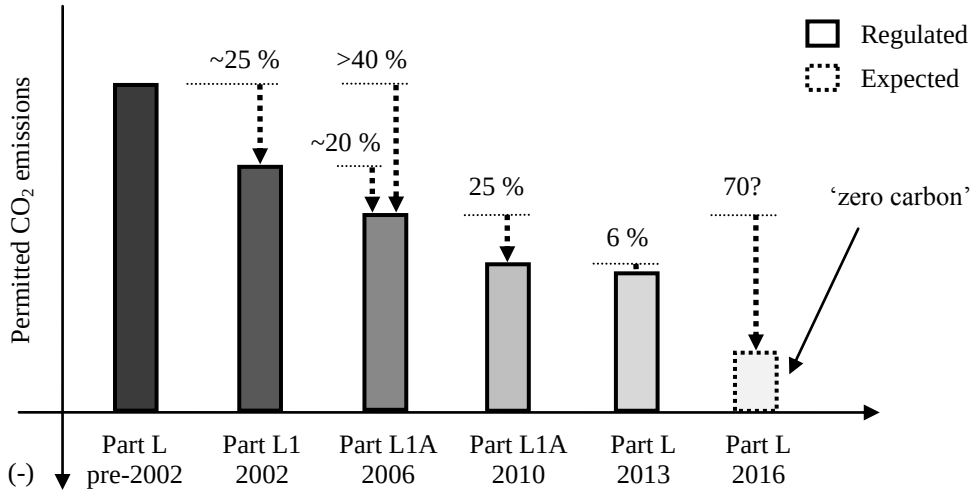

Figure 1. Evolution of requirement on carbon emissions (England & Wales) (after [18]) (note: Part L, in the case of new-build dwellings, covers space heating, hot water heating, ventilation and internal lighting, but not cooking or appliances).

The UK Treasury saw the tightening emissions standards in Part L 2013 as placing a burden on house builders [37] and the UK Coalition Government promised in 2010 "to reduce the regulatory burden on the house-building industry" [38] (The original aim of improving emissions by 44% over Part L 2006 standards was "likely to increase construction costs by around five per cent above Part L 2006" [39].) The Part L 2013 Consultation Review saw a reduction in the emissions improvement for new-build homes from an anticipated 25% to just 8% over Part L 2010 standards [40]. Part L 2013 is however now confirmed as delivering a 6% improvement in emissions for new-build homes over Part L 2010 [41] (Figure 1). Some builders may not even be using Part L

2010 yet. A Local Authority Building Control survey revealed that at least 178,400 new homes were registered between 1 July-30 September 2010, as opposed to 24,240 in the same period in 2009 [42, 43]. Homes pre-registered prior to the enforcement of Part L 2010 can be built to Part L 2006 standards provided work starts within one-year, even if work has not started on site. This is different to the Part L 2006 transition, where work was required to have started on site. This loophole has allowed entire schemes to be registered and could see Part L 2006 continue to be used over the next few years.

Part L implementation and enforcement

There exist specific time periods leading up to and after the enforcement of new building energy regulations in England and Wales that serve to aid their implementation. Pre-enforcement there exists the publication date and 'familiarity period'; while post-enforcement, there exists the transitional period. The 'familiarity period' (a phrase coined in relation to Part L of the Building Regulations, by Pan and Garmston [11, 18]) is provided by the UK Government with the aim of improving practitioners' familiarity with the requirements of the new Building Regulations prior to their enforcement. This 'familiarity period' has been of differing lengths with previous editions of Part L. While six-months is the UK Government's target for this preparatory period, the 'familiarity period' is governed partly by the enforcement date (convention dictates that significant regulatory changes occur in either April or October [40, 44]) and partly by the publication date. The Part L 2013 publication was originally scheduled for April 2013 [45], with enforcement in October 2013 [46]. However, Part L 2013 is now confirmed as coming into force on 6th April 2014, with publication promised to occur during summer 2013 to allow the construction industry time to prepare for the new regulations [41]. If Part L 2013 had been enforced in October 2013, the 'familiarity period' was likely to have been far shorter than the UK Government's six-month target. This would have been a point of concern, considering that a lack of Building Control Bodies' (BCB) knowledge in Part L for new-build dwellings was attributed to the dramatically reduced 'familiarity period' from Part L 2002 to Part L 2006 (from 6-months to 3-weeks respectively), which reduced the time for BCB training prior to enforcement [11]. Furthermore, concerns had been raised about the short time-frame to update, release and trial the latest edition of the Standard Assessment Procedure (SAP) should the new Part L have been enforced in October 2013 [40]. The SAP is the UK Government's adopted methodology for calculating the energy performance of new-build dwellings, and at the time of writing, the upcoming SAP 2012 is still pending the addition of data from the revised building regulations [47]. Publication of the new calculation methodology is however promised to occur during summer 2013 [41]. At the time of writing this paper, the publication dates for Part L 2013 and SAP 2012 are unknown. The transitional period (also provided by the UK Government) serves to "allow the building industry to get its house in order" as the newly enforced editions start to take effect [48]. The transitional period allows work that fulfils the transitional provisions to be exempt from the new Part L requirements, while all other building work must comply immediately [49, 50]. The Part L 2002 transitional period was 3-years, after which it was reduced to 12-months for Part L 2006 [49] and Part L 2010 [50] to demonstrate the UK Government's dedication to speeding the regulatory impact on practice [48]. The transitional period for Part L 2013 is unknown.

Demonstrating compliance with Part L for new-build dwellings

The UK Government provides technical guidance to aid in the application of Part L for new-build dwellings, namely, Part L1A for editions 2010 and 2006, and Part L1 for 2002. Compliance with Part L1A 2010 can be demonstrated by meeting five intrinsically

linked criteria (Table 1) [51]. Criterion 1, the only mandatory criterion out of the five criteria, is regarded as the most important requirement for compliance with Part L1A 2006 [11, 17, 18] from which Part L1A 2010 originates. Criterion 1 in Part L1A 2010, states that "[w]here a building is erected, it shall not exceed the target CO_2 emission rate [TER] for the building [thus, the dwelling CO_2 emission rate] DER must be no worse [no greater] than the TER" [51]. The TER is the emissions rate of a notional dwelling of corresponding size and shape to the proposed new dwelling, theoretically 'built' to Part L 2002 standards. In Part L1A 2010, the TER (calculated using SAP 2009 [52]) is "expressed in terms of the mass of CO_2, in units of kg per m^2 of floor area per year, emitted as a result of the provision of the specified fixed building services for a standardised household" [51], and represents an average 25% emissions improvement over Part L 2006 [51]. Part L1A 2006 remains in parallel use to Part L1A 2010 due to the Part L 2010 transitional arrangements [50]. As the root source of the current edition, its compliance criteria are likewise intrinsically linked (Table 1; [11]), with Criterion 1 seen as the most important requirement for proving Part L 2006 compliance for new-build dwellings [11, 17, 18]. In Part L1A 2006, the TER (calculated using SAP 2005 [53]) represents an average 20% emissions improvement over Part L 2002 [7]. Part L 2002 is unlikely to be in widespread current use, except where houses registered and started within the bounds of the Part L 2006 transitional arrangements are still under construction today. Part L1 2002 offers three alternative methods of showing compliance for new-build dwellings (Table 1; [11]). Listed in increasing order of flexibility, the carbon index method (calculated using SAP 2001 [54]) provides most flexibility in the design of new-build dwellings [11].

Table 1. Methods for demonstrating compliance with Part L for new-build dwellings

Conditions for compliance	Requirements to meet the conditions
Part L1A 2010 criteria	All five criteria to be met (1: mandatory, 2-5: guidance)
1 - Achieving the TER	As designed and as constructed DER ≤ TER
2 - Limits on design flexibility	Achieve reasonable overall standards set in Part L 2010, e.g. U-values, air permeability, fixed services/lighting
3 - Limiting the effects of solar gains in summer	Dwelling design to demonstrate passive controls to limit overheating due to solar gain
4 - Building performance consistent with DER	As constructed dwelling performance consistent with the DER, e.g. air permeability ≤10 $m^3/(h.m^2)$ at 50 Pa
5 - Provisions for energy-efficient operation of the dwelling	Provide owner with sufficient knowledge/instructions for the energy efficient operation of fixed services
Part L1A 2006 criteria	All five criteria to be met (1: mandatory, 2-5: guidance)
1 - Achieving the TER	As constructed DER ≤ TER
2 - Limits on design flexibility	Building performance, e.g. U-values, air permeability, fixed services/lighting, to be ≤ Part L 2006 design limits
3 - Limiting the effects of solar gains in summer	Dwelling design to demonstrate passive controls to limit overheating due to solar gain
4 - Building fabric and fixed services commissioning	As constructed dwelling performance consistent with the DER, e.g. air permeability ≤10 $m^3/(h.m^2)$ at 50 Pa
5 - Operating and maintenance instructions	Provide owner with sufficient knowledge/instructions for the energy efficient operation of fixed services
Part L1 2002 alternative methods	One of three methods to be met (each mandatory)
Elemental	Construction element U-values ≤ that stated in Part L 2002; boiler efficiency ≥ that stated in Part L 2002
Target U-value	Consider door, window, and roof light areas; building envelope elements' insulation level; heating system efficiency; and solar gain to meet Part L 2002 U-values
Carbon index	Carbon Index ≥ that specified in Part L 2002

NON-COMPLIANCE WITH BUILDING ENERGY REGULATIONS

An international overview of the non-compliance profile

The effectiveness of building energy regulations varies significantly from country to country, due mainly to difficulties in compliance and enforcement [55, 56]. In developing countries, building energy regulations are often ineffective or less effective than predicted, as international donor agencies often cover their implementation only [55]. Africa, Latin America and the Middle East are still far behind in terms of building energy regulation development, implementation and compliance [5]. However, non-compliance with building energy regulations also exists in developed countries. It is a key issue in the EU (see [57]). Failures have also been investigated in Norway [19], in the USA [2], and in Canada and Australia [58]. The international context of non-compliance with building energy regulations for new-build dwellings may vary from country to country; however, a clear pattern of non-compliance exists, with problematic implementation and enforcement.

Non-compliance in England and Wales

Studies into compliance with Building Regulations Part L for new-build dwellings in England and Wales appear to commence with Part L 2002, from which point, there exists a continued and growing interest by policy-makers and researchers. The non-compliance studies reviewed in this paper are for Part L1 2002 [13, 14, 58] and Part L1A 2006 [11, 15-18] (Table 2). Many of these studies contribute to the qualitative understanding of the compliance of new-build dwellings with building energy regulations in England and Wales [13, 17, 58], while others provide quantitative findings [14-16]. However, some are reporting on either perceptions [13, 17] or a limited (small) [14, 15] or 'filtered' dataset of dwellings [16]. In addressing these limitations, Pan and Garmston [11] quantitatively examined the compliance profile of a total of 404 dwellings assessed under Part L1 2002 and Part L1A 2006. The combined result of these studies indicates the continued presence of poor compliance. This non-compliance profile suggests that Part L has not been implemented properly. According to Burr [12] "[n]ot enough is known about compliance with regulations, upon which estimated savings depend". This desk study reveals qualitative and quantitative insights into non-compliance in relation to Part L 2002 and 2006; however, there remains a need for further quantitative studies into compliance with current and future editions of Part L for new-build dwellings in England and Wales [59].

ISSUES UNDERLYING NON-COMPLIANCE WITH BUILDING ENERGY REGULATIONS

Non-compliance with Part L for new-build dwellings has been attributed to the BCBs lack of knowledge [11, 17, 18], training [17], and access to SAP software to implement the regulations [17], and to their feelings of triviality towards Part L [13, 16]. BCBs are not the only stakeholders to which non-compliance has been attributed. A study into the implementation of Part L 2006 examined the relationships between industry groups, construction professionals, and house-builders, and found that better knowledge and communication is required overall [17]. Likewise, Baiche et al. [58] found a lack of training in tradespersons and operatives, stating that "tradesmen who are well trained and tutored make a lot of difference to compliance with the Building Regulations" for England and Wales. The Department of Communities and Local Government (DCLG) [59] has provided definitions of non-compliance that appear to relate to stakeholder behaviour regarding the management of Part L activities (as opposed to 'simply'

achieving the TER): *direct non-compliance*, is considered to occur through the "wilful or inadvertent substitution of substandard specifications or poor construction practice"; while *underperformance* "occurs even when regulatory guidance is followed diligently" [59]. Dissemination of the regulations is also a contributory factor to non-compliance.

Table 2. Summary of non-compliance (NC) with building energy regulations: new-build dwellings in England and Wales

Source	Building energy regulations	Type of data collection	Dwellings *(n)*	Non-compliance definition	Non-compliance evidenced
Grigg [14]	Part L1 2002	Field study	99	Air permeability >10 $m^3/(h.m^2)$ at 50 Pa	32%
Baiche et al. [58]	Part L1 2002	Site inspections; questionnaire survey; semi-structured interviews	11 housing projects	Incidents relating to, e.g. thermal insulation; air tightness	Yes, but not quantified (note: this study investigates NC with the Building Regulations as a whole)
Cox [13]	Part L1 2002	Structured interviews	-	12 technical areas, e.g. U-values; window areas; air leakage	Yes, but not quantified
Mawditt and Palmer [15] (note: this is the Pilot study preceding the main report by Trinick et al. [16])	Part L1A 2006	Site inspections; documentary evidence	18	Air permeability >10 $m^3/(h.m^2)$ at 50 Pa; DER > TER	Air permeability >10 $m^3/(h.m^2)$ in 2 dwellings; unknown compliance status for 7 dwellings (DER and TER absent) and for 3 dwellings (TER absent)
Trinick et al. [16]	Part L1A 2006	Field study; unstructured discussions	82	DER > TER	20%
Bell et al. [17]	Part L1A 2006	Workshops	-	DER > TER	Yes; but not quantified
Pan and Garmston [18]	Part L1A 2006	Documentary evidence; semi-structured interviews	376	DER > TER	0.53% NC; 21% 'grey' NC; 4% 'grey' compliance
Pan and Garmston [11]	Part L1 2002 & Part L1A 2006	Documentary evidence; semi-structured interviews	404	A 'fail' displayed for either the elemental, target U-value, or carbon index method. DER > TER	0.5% NC; 24% 'grey' NC; 42.1% 'grey' compliance

The UK Government acknowledged that the "previous piecemeal way of reviewing the regulations made it difficult for industry and the building control service alike to keep abreast of the regulatory changes" [60]. Building energy regulation training is seen as an important on-going requirement [13, 16, 61]; however, the lack of knowledge and

training with Part L 2006 appears to have been exacerbated by its short familiarisation and transitional periods. Part L 2013 and SAP 2012 are expected to be published during summer 2013 to allow the construction industry time to prepare for the new regulations [41].

IMPLICATIONS OF NON-COMPLIANCE

Implications of non-compliance on practice

DCLG's *Final risk assessment guidance* has been designed to aid BCBs' decision making in relation to the inspection of building work; it is an optional advisory guide for use by BCBs in England [62]. The guide defines risk "in the context of identifying construction stages to be notified to Building Control Bodies, as the likelihood of non-compliance with building regulations and the potential extent of harm to current and future users of building and the environment associated with non-compliance. The risk to the environment includes the aggregate impact of the use of buildings on climate change" [62]. Since energy efficiency improvement and energy consumption reduction programmes result in direct expenditure and compliance costs that cost businesses and households a total of around £2.6 billion per year [12], it is unsurprising that non-compliance with building energy regulations is said to potentially have "serious legal and financial ramifications for construction professionals and consumers alike" [20].

Implications of non-compliance on policy

In the face of continued non-compliance with building energy regulations, Part L may need to become more 'prescriptive' (despite its 'performance-based' nature), in terms of eliminating opportunities for loopholes and giving mandatory directions in place of suggested guidance. For example, in a bid to reduce non-compliance, Part L 2010 now contains an as designed, as well as an as constructed TER/DER submission [59]. Under Part L 2010, Regulation 20D, the house builder is mandatorily required to provide the BCB with an as designed TER/DER calculation (not later than one-day prior to starting work) in addition to an as constructed TER/DER (not later than five-days after the work is completed) [51]. In Part L1A 2006, the as designed submission stage is present, but it is just guidance, stating how "it would be useful to both builder and building control body if the builder carries out a preliminary calculation before construction starts based on the plans and specifications and shares the results" [63]. The Part L1A 2006 as constructed submission is however mandatory as per Regulation 20D [63].

The lack of clear quantification as to the extent of Part L non-compliance [59] (or in other words, the gap between the as designed and the as constructed energy and carbon performance of buildings), supports the necessity for further quantitative studies into compliance with Part L for new-build dwellings. Research into current and future editions of Part L is important since "[t]here is a growing recognition that non-compliance may undermine the effectiveness of Building Regulations, especially as they become increasingly stringent" [12]. It may be too early to evaluate the impact that the Part L 2010 changes (e.g. within Regulation 20D) might have had on compliance [59]. To ascertain the effect of the Part L1A 2010 legislation, such studies should gather data, at the earliest, from the point at which the Part L1A 2010 transition ended. The reason for this suggestion is two-fold: firstly, the BCBs will have had the 12-month transition to become accustomed to the new requirements; and secondly, all dwellings registered from that point should be being built to Part L1A 2010 standards. Some new dwellings will have been built to Part L1A 2010 from its point of enforcement, but it may be challenging

to acquire a reasonable data set at an early stage in its transition, due to the mass of houses pre-registered prior to 1 October 2010 [42].

CONCLUSIONS

This paper has examined the profile, underlying issues and implications of non-compliance with building energy regulations for new-build dwellings. In England and Wales such non-compliance is generally seen as failure to achieve Criterion 1 specified in Part L1A of the Building Regulations. Research into the performance of new-build dwellings constructed to the 2002 and 2006 editions of Part L reveals a continued level of non-compliance. A legal loophole excusing participating builders from using Part L 2010 (and thus ensuring continued widespread use of Part L 2006) does not bode well for future reduced non-compliance. There is a need for further quantitative studies into compliance with building energy regulations for new-build dwellings in England and Wales, though it may be too soon to evaluate the impact of implementing Part L 2010.

Non-compliance with building energy regulations also exists internationally, in developed and developing countries, though the level of such non-compliance varies from country to country. Non-compliance risks the energy efficiency goals of the nations concerned, which in turn risks the common goal of reducing the built environment's impact on global warming. There are also cost implications to the construction industry and consumers in terms of the non-compliance and the cost of energy efficiency improvement programmes. To address the underlying issues, significant attention of both policy and practice must be paid to the formation, implementation and enforcement of building energy regulations, as well as to the training and education in building practices.

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Paper submitted: 28.06.2013
Paper revised: 15.07.2013
Paper accepted: 14.08.2013