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A Comparative Analysis of Energy Provisions of Pakistan Building Code with Indian and USA Building Energy Codes

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Abstract

The current energy scenario of Pakistan requires the adoption of a proper energy consumption framework to meet the demands of the Pakistani society. This paper compares the energy codes developed by ASHRAE (United States) and Bureau of Energy Efficiency (India) to suggest improvements in development of the energy conservation building codes for Pakistan. It has been realized that taking all relevant stakeholders on board is vital for the development, adoption and compliance of energy conservation building codes at provincial level. It is also evident that energy conservation culture has to be developed in all segments of the society to lessen energy consumption, reduce carbon emissions and create a sustainable future. The energy codes of Pakistan lack adoption mechanism and climatic zoning needed for building thermal performance. The comparative analysis shows that the thermal building code of Pakistan is the key instrument to reduce energy pressure while providing occupants comfortable living space. It has been concluded that the government should develop code adoption and compliance system for the reduction of energy demand in buildings.

Keywords: energy, building codes, ASHRAE, climatic zones, Pakistan, India

Introduction

Pakistan has faced a serious energy crisis for the past two decades. Saving energy is the key method to overcome the shortfall. Building sector in Pakistan consumes approximately 30% of the electricity. Internationally, many countries have decreased the amount of building sector energy consumption by adopting various measures. Developing building energy codes has proven to be of prime importance in the reduction of energy consumption. NEECA (formerly known as ENERCON) has developed Pakistan Building Code (Energy Provisions-2011). Until now, there has been no thorough discussion on the appropriateness of the energy code for Pakistan. This paper presents the comparative analysis of building energy codes of Pakistan with ASHRAE 90.1 and Indian ECBC 2006, describes the current scenario and proposes a solution to develop energy codes which are adaptable and widely accepted by the relevant professionals.

ENERCON was initiated as a USAID project in 1985 under the Ministry of Planning & Development. In 1993, it was transferred to the Ministry of Water and Power and later on to the Ministry of Environment in 1996. In 1997, it became an attached department of the Ministry of Environment but once again was transferred to the Ministry of Water and Power in 2011. In 2016, it was transformed into NEECA as an attached department of the Ministry of Water and Power. The first energy conservation building code was developed by ENERCON in 1990 along with a compliance manual but compliance was on voluntary basis. The code never came into professional practice until 2013 when a revised code was developed and endorsed by PEC.

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The enactment of a building code comes under the purview of PEC (Act of 1975-Section 25). Any code related to building construction shall be reviewed and approved by PEC. In 2011, ENERCON developed a new code called Building Code of Pakistan (Energy Provisions-2011) which was endorsed by PEC and promulgated in 2013. After the 18th amendment in the constitution of Pakistan; the role of NEECA in provinces was transposed to the provincial energy departments. Punjab took the lead and established PEECA in 2016 after the enactment of National Energy Efficiency and Conservation Act-2016. All the provinces are supposed to have an energy efficiency and conservation body. PEECA started working on the review and modification of the code developed by ENERCON/NEECA as formerly mentioned Pakistan Building Code (Energy Provisions-2011).

2. Research Objectives

The objective of this research is to improve energy conservation building codes for Pakistan by doing comparative analysis of energy codes developed by ASHRAE (United States) and Bureau of Energy Efficiency (India). PEECA is still in the process of code modification (specific to Punjab) while this process is still awaited by other provinces. Currently, PEECA has prepared a draft of the Energy Conservation Building Code for Punjab by involving all relevant stakeholders in the building sector all over the province. PEECA also held various consultations in three cities of Punjab, i.e., Multan, Rawalpindi and Lahore. PEECA has floated the draft of the proposed ECBC for review to stakeholders. Meanwhile PEECA has also planned to start a process to develop compliance procedure and tools.

3. Methodology

Building Energy Codes by ASHRAE (ASHRAE 90.1) are followed by various countries across the globe as source document. The current energy code of Pakistan BECP (Energy Provisions-2011) is also developed from the same source like Indian ECBC. To understand the gap in the current energy code of Pakistan BECP (Energy Provisions-2011), it is compared with the source code and also with another code of the same region devised for a country with similar economic conditions and construction practices, i.e., India. All of the data incorporated for comparison purposes is secondary in nature.

Detailed qualitative textual analysis is done to identify the changes to be incorporated in the next edition of Pakistan BECP (Energy Provisions-2011). The paper suggests amendments to optimize development, adoption and compliance/enforcement of the energy code in Pakistan. Numerical impact is not addressed in this analysis. This study has three aspects. It marks the difference of BECP (Energy Provisions-2011) from ASHRAE 90.1-2013 and Indian ECBC 2006, characterizes the change for each component of the code and recommends the amendments for subsequent revision of BECP (Energy Provisions-2011).

4. Results and Discussion

All energy codes are developed on the basis of region specific conditions, i.e., energy consumption behavior, economic and climatic conditions and construction practices. Usually these codes are revised after a fixed cycle which in ASHRAE 90.1 case is three year cycle. Indian ECBC is subject to revision after 10 years. It was their first code so it took them a comparatively longer time to evaluate and devise adoption and compliance mechanism. Both ASHRAE 90.1 and Indian ECBC have their well-established compliance and enforcement mechanism while the Pakistani Code has none. ASHRAE 90.1 and Indian ECBC focus on their major consumption areas in building sector which is non-residential whereas in Pakistan residential buildings are the major consumers of energy in the building sector. Comparative analysis of building codes is shown in the following Table 1.

Table 1
Comparison of Building Code of Pakistan (Energy Provisions-2011), ASHRAE 90.1-2013 & Indian ECBC 2006

Table 1: Comparison of Building Code of Pakistan (Energy Provisions-2011), ASHRAE 90.1-2013 & Indian ECBC 2006

Building Energy Code of Pakistan (Energy Provision 2011)	**ASHRAE 90.1-2013**	**Energy Conservation Building Code of India 2006**	**Comparative Analysis**
CODE DEVELOPMENT			
- The Energy Provisions-2011 is developed by a task force of the Pakistan Engineering Council with ENERCON. - NEECA serves in a national coordination role for energy efficiency and policy. - There are requirements to revise the Energy Provisions on a three-year cycle.	- ASHRAE Standard 90.1 is developed using ANSI consensus-based process that focuses on technical feasibility and life-cycle cost-effectiveness. - The U.S Department of Energy is a participant in this process. - New versions of Standard 90.1 are released on a three-year cycle.	Developed by International Institute for Energy Conservation (IIEC) funded by United States Agency for International Development (USAID) for Indian Bureau of Energy Efficiency (BEE)	After 18th amendment the adoption and enforcement of the code is required to be done by provincial governments. So, provincial governments have to modify these codes according to their own dynamics, climate and with the consultation of their relevant stakeholders.
PURPOSE			
To provide minimum requirements for energy efficient design and construction of buildings.	To establish the minimum energy efficiency requirements of buildings other than low-rise residential buildings for **a.** *design, construction, and a plan for operation and maintenance*; and **b.** *utilization of on-site, renewable energy resources.*	To provide minimum requirements for energy efficient design and construction of buildings.	In the current scenario, energy has become a defining factor in the progress of nations. For Pakistan, it is absolutely imperative that we improve energy efficiency in buildings by incorporating international best practices appropriate to our

			environment coupled with traditional materials, technologies, and craftsmanship developed indigenously over a very long period of time. While sustainable alternate energy sources must be developed and harnessed, it is more important that we use existing energy resources in a more efficient way.
SCOPE			
Large buildings - Design and construction - New buildings and their systems - New portions of buildings and their systems - New systems and equip. in existing buildings - Specific mention of building types not covered (low energy, historical, or industrial or manufacturing) - Statement that standard shall not be used to circumvent any safety, health, or environmental requirements	All buildings - Design and construction - New buildings and their systems - New portions of buildings and their systems - New systems and equip in existing buildings - Specific mention of what building types are not covered - Statement that standard shall not be used to circumvent any safety, health, or environmental requirements	All buildings - Design and construction - New buildings and their systems - New portions of buildings and their systems - New systems and equip. in existing buildings - Specific mention of what building types are not covered - Statement that standard shall not be used to circumvent any safety, health, or environmental requirements	Consider expanding scope of code to include smaller buildings or buildings with smaller connected loads. In ASHRAE 90.1 New equipment or buildings specifically identified in the standard that are part of industrial or manufacturing processes. In ASHRAE 90.1 a plan for operation is considered.
Definitions, Abbreviations, and Acronyms			
17 pages Back of document	16 pages Front of document	11 pages Back of document	Both documents contain a considerable number of specifically defined terms that should be considered when using either document.
Administration and Enforcement			
a. Mandatory requirements b. New buildings	4.1.1 Scope 4.1.2 Administrative Requirements	3. Administration and enforcement	- The Energy Provisions – 2011 does not contain a compliance

c. Alterations to the existing buildings d. Building Envelope e. HVAC f. Service Water Heating g. Lighting h. Electric Power & Motors i. Administrative requirements j. Compliance Documents k. Supplementary information	*4.1.3 Alternative Materials, Methods of Const. or Design* *4.1.4 Validity* 4.1.5 Other Laws *4.1.6 Referenced Standards* *4.1.7 Normative Appendices* *4.1.8 Informative Appendices* 4.2.1 Compliance Paths 4.2.2 Compliance Documentation *4.2.3 Labeling of Materials and Equipment* *4.2.4 Inspections*	3.1 compliance requirements 3.2 compliance approaches 3.3 Administrative requirements 3.4 Compliance Documents 3.4.2 Supplemental information	mechanism. Each province has to develop their own mechanism and framework.
Building Envelop			
One set of requirements for all buildings - 1 roof U-factor - 1 wall U-factor - 2 window U-factors (above/below 40% glass) - 2 window SHGC (above/below 40% glass) - Air Leakage - Air sealing - Vestibules, Fenestration and doors	three space conditioning types (nonresidential, residential, and semi heated) - three roof U-factors (flat roof, metal building roof, and attic roof) - 4 wall U-factors (wood-framed, metal framed, mass, and metal building) - 4 vertical glass U-factors (all below 40% glass) - 4 vertical glass SHGC (all below 40% glass) - Air Leakage - *Continuous air barrier*, Air sealing - Vestibules, Fenestration and doors	One set of requirements for all buildings - 3 roof U-factor - 3 wall U-factor - 3 window U-factors (above/below 40% glass) - 6 window SHGC (above/below 40% glass) - Air Leakage - Air sealing - Vestibules, Fenestration and doors	The building envelope requirements of an energy standard should be the foundation of the standard, as the building envelope section addresses many of the controllable loads in a building (heat loss, heat gain, solar heat gain, infiltration, etc. Other loads (such as occupants) are not controllable.
	- 6 foundation U, F, or C-factors - 2 door U-factors - 6 skylight U-factors - 6 skylight SHGC - Roof solar reflectance - Roof solar emittance - Minimum Skylight Area - Maximum Skylight Area - Daylight Area under Skylights - Fenestration Orientation	- 2 door U-factors - Unrated vertical glazing - Roof solar reflectance - Roof solar emittance - Daylight Area under Skylights - Fenestration Orientation	There is a chance to improve stringency of Energy Provisions-2011 by adding these additional requirements, especially those related to roof solar reflectance and emittance. - Consider implementing multiple climate

	- Building Envelope Trade-off Option - Product Information and Installation Requirements	- Building Envelope Trade-off Option	zones in the Energy Provisions - Consider envelope requirements by "building type" - Consider adding more solar heat gain requirements including "cool" roofs and window SHGC - Consider air sealing of building envelope for buildings without natural ventilation

Building Envelop Stringency

Energy Provisions-2011 has good vertical glass U-factor requirements relative to Standard 90.1-2013 Climate Zone 1. Standard 90.1-2013 has much better roof requirements (U-factor, emittance, and reflectance) and much better vertical glass SHGC.

Climate Zones

Only one zone is considered, i.e., Karachi	10 Zones including all US, Canadian Cities and selected cities around the world.	5 climate zones - Composite - Hot & Dry - Warm & Humid - Moderate - Cold	Energy Provisions-2011 currently only has a single climate zone defined for the building envelope. ASHRAE Standard 90.1-2013 lists Pakistan as Climate Zone 1 (based on Karachi). Yet there is variation in the climate across Pakistan and zoning for thermal performance is required.

Heating, Ventilating & Air-Conditioning

1. Controls - System Control - Temperature Control - Deadband - Mechanical Ventilation - Kitchen Space - Cooling Towers	1. Controls - System Control - Temperature Control - Deadband - Mechanical Ventilation - Kitchen Space - Cooling Towers *- Plus additional control requirements*	1. Controls - System Control - Temperature Control - Deadband - Mechanical Ventilation - Kitchen Space - Cooling Towers	System efficiencies are not in detail and not mandatory. Natural Ventilation also needs fine tuning and can be credited in whole building tradeoff. Alternate energy can also be credited in whole building tradeoff.
2. Piping and Ductwork 3. System Balancing 4. Condenser 5. Equipment Efficiency *(7 tables) (Voluntary)* 6. Economizers *(Voluntary)*	2. Piping and Ductwork 3. System Balancing 4. Condenser 5. Equipment Efficiency *(13 tables) (Required)* 6. Economizers *(Required)*	2. Piping and Ductwork 3. System Balancing 4. Condenser 5. Equipment Efficiency 6. Economizers	

7. Hydronic Variable Flow *(Voluntary)* 8. Natural Ventilation *(Voluntary)* 9. Alternative Energy Sources *(Voluntary)*	7. Hydronic Variable Flow *(Required)* 8. Natural Ventilation *(Credited in whole building tradeoff)* 9. Alt. Energy Sources *(Credited in whole building tradeoff)*	7. Hydronic Variable Flow 8. Natural Ventilation 9. Alt. Energy Sources	
Service Water Heating			
- Piping Insulation - Equipment Efficiency - Swimming Pools (covers, heaters) - Heat Recovery *(Voluntary)* - Solar/Renewable Energy *(Voluntary)*	- Piping Insulation - *Load calculations* - Equipment Efficiency - Swimming Pools (covers, heaters, *time switch)* - *Controls (4 types)* - Heat Recovery *(Required for large systems)* - Solar/Renwbl. Energy *(Credited in whole building tradeoff)*	- Piping Insulation - *Load calculations* - Equipment Efficiency - Swimming Pools (covers, heaters, *time switch)* - *Controls (4 types)* - Heat Recovery *(Required for large systems)* - Solar/Renwbl. Energy	There is a minor option for improvement. The most important factor is the quality of equipment and its standardization.
Electric Power			
- Power Distribution Systems - *Power Correction Factor* - Check Metering - Transformer Efficiency - Motors	- Voltage Drop - *Automatic Receptacle Control* - Electrical Energy Metering - Transformer Efficiency - (Motors covered in Other Equipment)	- Power Distribution Systems - *Power Correction Factor* - Check Metering - Transformer Efficiency - Motors	There is a minor option for improving stringency by adding automatic receptacle control. The most important factor is the quality of equipment and its standardization.
Lighting			
- Lighting control - Exit Signs - Exterior Lighting Efficacy - Interior Lighting Power - Exterior Lighting Power - Automatic Lighting Shutoff *(Voluntary)* - Daylighting Control *(Voluntary)* - Energy Saving Systems *(Voluntary)* - Alternate Energy *(Voluntary)*	- Lighting control - Exit Signs - Exterior Lighting Efficacy - Interior Lighting Power - Exterior Lighting Power (*by lighting zone*) - Automatic Lighting Shutoff *(Required)* - Daylighting Control (Required) - Energy Saving Systems (*Unknown)* - Alternate Energy *(Credited in whole building tradeoff)* - *Functional Testing*	- Lighting control - Exit Signs - Exterior Lighting Efficacy - Interior Lighting Power - Exterior Lighting Power (*by lighting zone*) - Automatic Lighting Shutoff *(Required)* - Daylighting Control *(Required)*	There is a minor option for improving stringency. The most important factor is the quality of equipment and its standardization.

		- Energy Saving Systems - Alternate Energy *(Credited in whole building tradeoff)*	
Other Equipment			
- (Motors covered in Power section)	- Electric Motors - *Service Water Pressure Booster Systems* - *Elevators* - *Escalators and Moving Walks* - *Whole Building Energy Monitoring*		Option for improving stringency by expanding scope of Energy Provisions-2011 to include these additional building systems.
Trade Offs			
	- Envelope only tradeoff - Economizer tradeoff - Whole building tradeoff for determining compliance - Performance Rating Method for determining percent better than code	- Envelope only tradeoff - Economizer tradeoff - Whole building tradeoff to determine compliance	Tradeoffs provide flexibility for designers who don't like the prescriptive options. Performance rating method allows code developers to control how "better than code" is measured.
Appendices			
None of these	- Assembly R-value, U-factor, C-factor and F-factor calculations - Building Envelope Climate Criteria - Envelope Tradeoff Methodology - Climatic Data - Informative References - Addenda Description Information - Performance Rating Method	- Assembly R-value, U-factor, C-factor and F-factor calculations - Building Envelope Climate Criteria - Envelope Tradeoff Methodology - Climate zone map - Informative References - Compliance forms	All relevant information is required including compliance and performance rating method.
Support Material			
Guideline for Energy Provisions-2011 under development) Pakistan Engineering Council (PEC) Training Materials for Mechanical and Lighting (with one page for Building Envelope)	ASHRAE 90.1-2013 User's Manual ASHRAE Training Classes DOE Training Materials ASHRAE Compliance Checklists DOE COM*checkTM*Compliance Software	ECBC User Guide GREHA Trainings ECOnirman software for whole building performance ECBC android application	User guide, training manual, whole building performance software, compliance paths, compliance checklists and compliance forms.

		ECBC Compliance Checklists CBP for hospitals CBP for hotels

5. Conclusion

In Pakistan, it is absolutely imperative that we should improve energy efficiency in buildings by incorporating the internationally recognized best practices appropriate to our environment. ASHRAE Standard 90.1 is developed using ANSI consensus-based process that focuses on technical feasibility and life-cycle cost-effectiveness. The U.S Department of Energy is a participant in this process. New versions of Standard 90.1 are released in a three-year cycle. The Energy Provisions-2011 were developed by a task force of the Pakistan Engineering Council. NEECA serves in a national coordination role for energy efficiency and policy. The code needs to be revised on the basis of a three-year cycle. New requirements for the next version of the Energy Provisions shall be developed in consultation with stakeholders. The code shall be developed considering local economy, climate, construction practices, local materials and assemblies and local skills.

6. Compliance and Enforcement of Code

In the U.S., compliance is the responsibility of the design professionals and enforcement is the responsibility of state and local code officials. If design professionals do not submit plans and specifications that meet the requirements of the code, the building will not get a building permit. If the building is not constructed to meet the standards of the code as shown during inspection, the building will not receive a certificate of occupancy.

In Pakistan, compliance is the responsibility of design professionals and enforcement is the responsibility of provincial and local code officials whose framework is still not developed. District Building Control Authorities issue building permits, inspect buildings and issue occupancy permits.

6.1. Scope

The scope shall be expanded by including smaller buildings or buildings with smaller connected loads because the energy consumption mix of Pakistan is very different and residential buildings consume more energy than any other sector.

6.2. Envelope

The building envelope requirements of an energy standard should be the foundation of the standard, as the building envelope section addresses many of the controllable loads in a building (heat loss, heat gain, solar heat gain, infiltration, etc). Other loads (such as occupants) are not controllable. Specific differences between Standard 90.1-2016 and the Energy Provisions-2011 mentioned in the comparison will improve the code. The code shall consider envelop requirements by “building type”, specifying various climate zones for the whole country. By adding more solar heat gain requirements including “cool” roofs and window, SHGC will improve thermal performance including air sealing of building envelope for buildings without natural ventilation.

6.3. Mechanical

Making equipment efficiency and economizers mandatory instead of voluntary will not only increase energy savings but will also be helpful in standardization and market stability. It will also help if efficiency requirements for equipment is raised. Commissioning has a vital impact on the proper implementation of the code.

6.4. Service Water Heating

Adding controls requirement and making solar/renewable energy requirement mandatory instead of voluntary will improve SWH performance of code compliant buildings.

6.5. Lighting

Addition of functional testing, making automatic lighting shutoff mandatory instead of voluntary and making daylight control mandatory for some space types will improve the impact of the code.

6.6. Tradeoffs and Whole Building Performance

Energy Provisions-2011 do not have tradeoffs and whole building performance because compliance mechanism is not developed. Including a whole building tradeoff approach that can serve as a link to the code and green building programs (PGBC etc.) will increase the interest of design professionals.

7. Appendices

There is plenty of room for adding appendices of useful information like R-value to U-factor conversions and climatic data of Pakistan. Support materials for the code should be added. In the U.S. many organizations (including DOE) develop support materials for Standard 90.1. User’s manual (from ASHRAE), code training materials, code compliance software and training for code officials ought to be added as well.

8. Recommendations

The comparative analysis of energy codes presented above clearly indicated the main issues related to the implementation of the codes. Energy code development, adoption, and enforcement are all vitally important aspects of a complete energy code program. A code that is not adopted can’t be enforced. A code that is not enforced is not going to give results. The details of how an energy code is developed, adopted, and enforced are important. A code that is developed without consensus with most stakeholders will be hard to adopt and enforce. A national requirement for provinces to adopt the code without any penalty for not adopting will be only partially successful. The enforcement of codes depends on provincial/local government priorities and funding. A proper framework should be developed based on regional parameters embedded in the socio-cultural framework for successful implementation of codes.

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