Energy Efficient Architecture: Unpacking Implications and Barriers

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Abstract

This study aims to pursue dual objectives. The first is to assess architects' awareness of energy efficiency techniques. Secondly, it aims to investigate the barriers and incentives to implementing energy-efficiency techniques to achieve energy conservation through building design. For this purpose, a survey was conducted among 200 architects from 5 major cities of Pakistan: Islamabad, Rawalpindi, Lahore, Peshawar, and Karachi. A survey was conducted using a questionnaire to assess architects' views on the incentives, benefits, and barriers to implementing energy-efficient designs across different projects. It measured the energy-efficiency techniques being practised and implemented in their projects, as well as the impact of energy conservation policies on current building designs. The results demonstrated that architects hold the view that energy consumption can be effectively reduced by incorporating energy-efficiency techniques into building design across all sectors of Pakistan. To address the barriers and hurdles, there is an acute need for incentives and motivation for consumers and architects alike. Additionally, there is a need to improve and practically implement the current bylaws to incorporate energy efficiency measures at the government level.

Keywords: Energy Efficiency, Building Design, Energy Consumption.

Introduction

Energy consumption, energy efficiency and energy-saving are "needs of the hour" around the globe. It is crucial for adding value to one's way of life, as well as for economic growth and improved living standards (Ritchie et al., 2022). The most promising, quickest, least expensive, and safest ways to slow climate change are generally regarded as increasing energy efficiency and decreasing energy demand. However, past initiatives to reduce energy use have not always been successful (Sorrell, 2015). However, this concern stems from the prevailing energy crisis and the worsening effects of climate change, driven by high energy consumption in the household and industrial sectors. Dzioubinski and Chipman (1999) discussed that 15% - 25% of primary energy use in developed countries is consumed in the household sector, and this percentage is higher in developing countries. Looking back over the past few decades, the importance and emphasis on energy-saving techniques such as solar panels have increased significantly within the green building design concept (Athinetis, 2008). At the same time, many other techniques, including green roof standards for buildings, were separately examined and could be used in upcoming architectural designs (Saiz, 2006; Clark, 2008; Williams, 2010). There is also a scientific consensus that global climate change is caused by increased atmospheric greenhouse gases. The emissions of carbon dioxide and other greenhouse gases from human-driven activities are primarily responsible for climate change and global warming.

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Cubasch (2001), Houghton (2001), and Frich (2002) argued that global warming and adverse climate change caused by greenhouse gases are realities that must be addressed with an imperative. It has been found that buildings account for an average of 40% of global energy consumption and are responsible for almost one-third of greenhouse gas emissions (Lou et al., 2017).

Olesen and Kvetny (2006) mentioned that the developed world is taking many steps to reduce greenhouse gas emissions and use biofuels; these initiatives are also included in the EU 2020 vision. In modern, developed societies, the construction industry is the primary source of CO2 emissions (Roaf et al., 2004). Around the world, buildings have high energy and electricity requirements for their machinery and mechanical and electrical equipment. In the EU, the construction industry and buildings account for about 40% of total energy use (Runci, 1999). Moreover, in Pakistan, household energy use accounts for 42.5%, while industry consumption accounts for 28.1% (Saghir, 2007).

Various electrical air conditioning methods are used for heating and cooling buildings. Similarly, operating different equipment and lighting systems consumes energy. A pivotal finding from the study by Papadakis and Katsaprakakis (2023) was the significant role of heating and cooling systems in energy consumption. They accounted for a significant portion, that is, 40–65%, of the total energy usage across numerous public facilities.

In Pakistan, increasing energy demand and deteriorating power infrastructure are causing severe electricity shortages, as, even though at present, 75.38% of Pakistani citizens have access to electricity, the annual consumption of energy has increased to 4243 kWh per capita, including transport, heat and cooking (Ritchie, Roser and Rosado 2022). Blackouts have not only damaged the industry but also sparked protests and riots, directly affecting individuals' daily lives on many fronts.

It is known that the construction process is fragmented; similarly, the complexity of construction procurement poses a daunting obstacle to efforts to implement energy efficiency techniques. This shows that the participation and involvement of construction professionals are crucial for conserving energy, as buildings consume significant amounts of energy. In addition, the construction experts, the responsibility, and the role of the architects are vital, as energy-efficiency techniques are likely to be more successful and effective from the outset of design.

With advances in technology, the procedures and techniques for reducing energy consumption have become more complex. Dixon et al. (2010) argued that nowadays, it is a matter of common interest across countries worldwide to adopt rules, legislation, and policies to reduce energy consumption in residential, industrial, and commercial buildings; this reduction can only be achieved by incorporating various techniques into building design. For thousands of years, simple methodologies have been practised for energy-efficient buildings, such as choosing a suitable location and using materials suited to a region's climate.

Recognising the role and responsibility of architects in achieving energy efficiency standards and reducing energy consumption, this research examined the levels of understanding, awareness, and importance of energy policies. The current practices of energy efficiency have also been studied. The survey examined the barriers to implementing laws and policies, the incentives for implementing energy-efficiency techniques, and the means to achieve energy conservation through building design.

Hence, the study's objective is twofold. The first is to assess the architects' knowledge of energy efficiency techniques. Second, investigate the barriers and incentives to implementing energy-efficiency techniques to achieve energy conservation through building design.

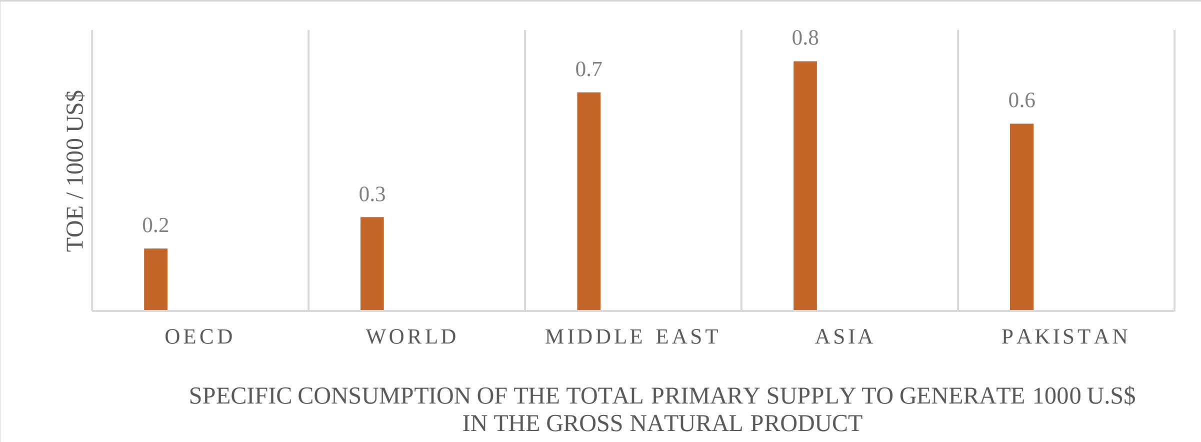
Literature Review

Context of Energy Consumption

As the world's population increases day by day, the choices for a better lifestyle and growth are also shaping people’s preferences for living. Uspenskaia et al. (2021) have noted that cities have been considered major contributors to overall greenhouse gas emissions, and this trend is only getting stronger by the day. According to the United Nations (2020), by 2050, over 70% of the global population will live in cities. While the majority of the population has opted for urban living, this creates broader issues regarding energy consumption and efficiency. Uctug (2011) states that efficient energy use is highly significant and a fundamental concept for a stable, established economy. Energy efficiency is also important for controlling environmental pollution and adverse climate change. For the last few years, Pakistan has been facing a severe energy crisis. The problem becomes even more catastrophic in the summer due to high electricity consumption. To address the energy crisis, many consumers face electricity cut-offs to prevent overloading the power grid. Usually, residents of urban areas face electricity cut-offs of 7-10 hours; in rural areas, cut-offs can reach up to 20 hours.

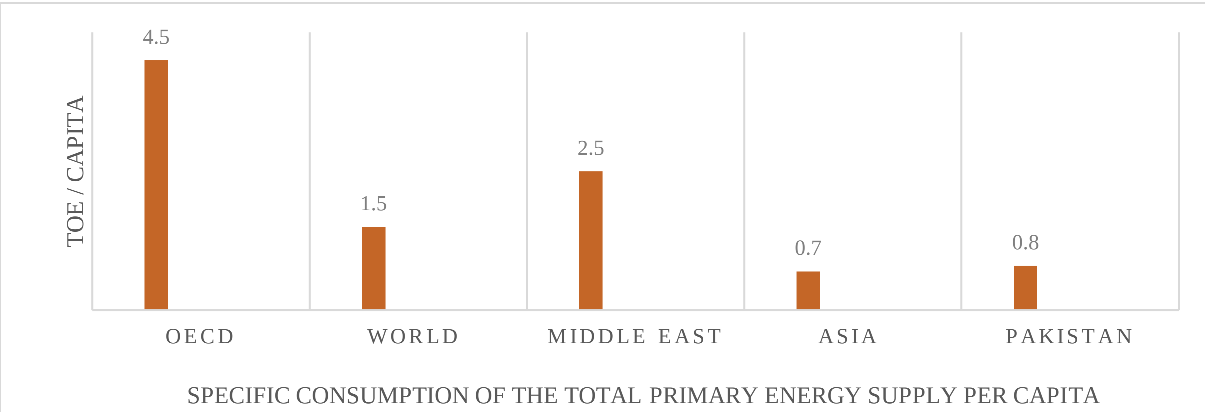
In 2006, Pakistan's total primary energy supply per $1000 of GDP was higher than that of Organisation for Economic Co-operation and Development (OECD) countries, and its average was also double the world average. See Figure 1. On the other hand, energy consumption per capita is half the world average and one-fifth that in OECD countries. See Figure 2. This shows that as gross domestic product grows and living standards rise, energy demand will increase excessively unless corrective action is taken. (TOE stands for Tonne of Oil equivalent).

Figure 1: Specific consumption of the total primary supply



Source: Saghir. K. K (2007)

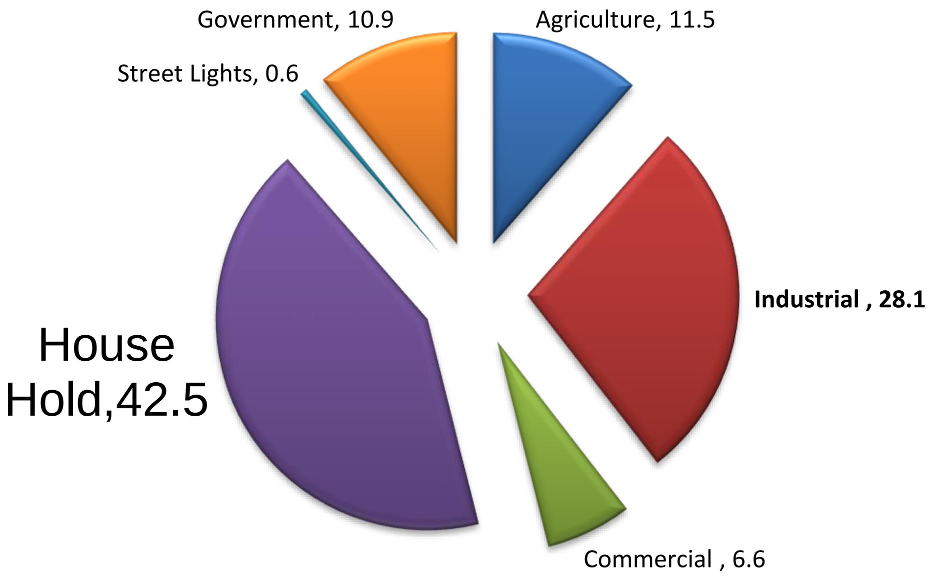
Figure 2: Specific consumption of the total primary energy supply



Source: Saghir. K. K (2007)

The household sector in Pakistan is the largest consumer of electricity. From the period of 1995-96 to 2004-05, the household sector accounted for 42.5% of overall energy consumption, whereas industrial consumption was 28.1, agriculture 11.5%, government sector 10.9, commercial 6.6 and street lights comprised 0.6. See Figure 3.

Figure 3: Consumers of electricity



Source: Saghir. K. K (2007)

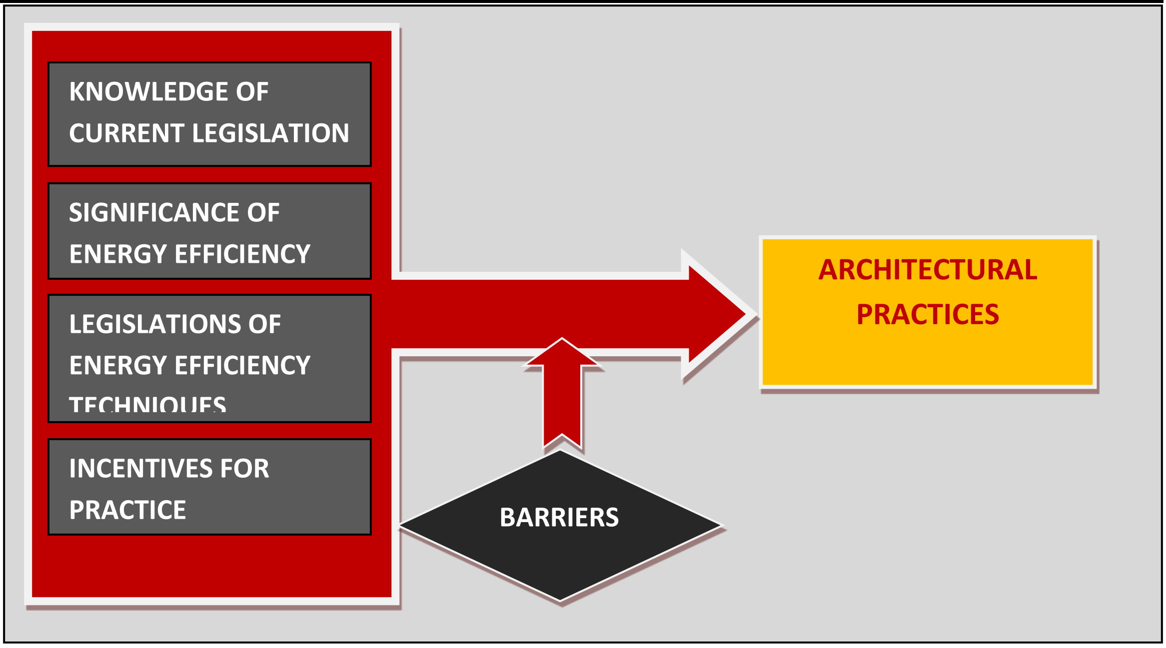
The domestic industry is the greatest consumer of electricity in Pakistan; this has been fuelled by the large use of cooling and heating devices. This increasing demand worsens the energy crisis in the country, and it also leads to environmental degradation. The close association between energy consumption in a building and the energy crisis is due to the traditional designs of buildings, which largely depend on artificial cooling, heating, and lighting systems. According to Chatura, Lucienne and Kristin (2017), end users are usually the most vulnerable in the sustainability chain since their behaviours have a huge impact on the environmental results, including global warming and resource depletion.

Gu (2006) points out that the concept of energy is core in sustainable housing design. Different energy-saving measures have been devised over the years, incorporating renewable energy sources and less reliance on traditional energy. Most of the buildings in Pakistan, however, are still inefficient in terms of energy consumption and need a lot of energy to be thermally comfortable (Gul et al., 2018). In spite of the fact that some institutions like ENERCON and PEC implemented the building energy code in 2011, its application is still poor, as it is not tightly integrated into local building codes. The possibilities of cost-effective insulation and waterproofing methods are also evidenced by recent government projects, such as the ENERCON-UN-HABITAT cooperation program as part of the ONE UN-Pakistan program. Many interventions of this kind done throughout the country can cause a substantial decrease in energy use and greenhouse gas emissions.

Theoretical Framework
Variables
The proposed variables of the study comprise four independent variables which affect architectural practices (Ar. P) (Dependent Variable) with respect to energy efficiency. The Independent variables include Knowledge of Current legislation (KCL), Significance of Energy Efficiency (SEE), Legislation of Energy Efficiency techniques (LEET) and Incentives for Practice (IP). There is also a moderating variable, Barriers (Ba.), which affects the relationship between the independent variables (KCL, SEE, LEET, IP) and the dependent variable (Ar. P).

- Knowledge of Current Legislation - It is the awareness and consciousness related to the current legislation by the government.
- Significance of Energy Efficiency - It deals with the importance and implications of energy-efficient architectural tools and techniques.
- Legislation of Energy Efficiency - This variable is related to the effective guidelines for the minimisation of energy consumption.
- Incentives - They are the benefits and rewards associated with energy efficiency practices.
- Barriers - Implementation of energy efficiency techniques is disturbed due to several difficulties being faced. This variable deals with those difficulties which prove themselves to be a hindrance in architectural practices.
- Architectural practices - A dependent variable which explains the intervention and practices of energy conservation in building design.

Figure 4: Schematic diagram



Research question
The research questions of this study are two-fold:

1. Does architectural intervention play a role in energy conservation?
2. Do barriers affect the relationship between architectural intervention and energy conservation?

Hypothesis statement

Ha1: Knowledge of current legislation about energy efficiency has a significant impact on Architectural practices.

H0: Architectural practices are not affected by the knowledge of energy efficiency.

Ha2: There is a positive relationship between the significance of energy efficiency and architectural practices.

H0: Energy efficiency and architectural practices have no significant relationship.

Ha3: Legislation and architectural practices are positively related to each other.

H0: There is no relationship between legislation and architectural practices.

Ha4: Incentives have a positive relationship with architectural practices.

H0: Incentives do not affect architectural practices.

Ha5: Knowledge of current legislation about energy efficiency has a significant impact on architectural practices, with barriers as a moderator.

H0: Barriers do not affect the relationship between the knowledge of current legislation about energy efficiency and architectural practices.

Ha6: Barriers affect the relationship between the significance of energy efficiency and architectural practices.

H0: The relationship between the significance of energy efficiency and architectural practices is not affected by the barriers.

Ha7: Legislation and architectural practices are affected by the barriers.

H0: Barriers play no significant role in the relationship between legislation and architectural practices.

Ha8: Barriers minimise the relationship between the incentives and architectural practices.

H0: There is no impact of barriers on the relationship between incentives and architectural practices

Theoretical Debate and Conceptual Framework

Diffusion of Innovations

Implementation of energy-efficient design measures relies on five characteristics, namely relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Practically, low-complexity, visible design gestures (e.g., site orientation, cross-ventilation, simple shading) propagate more quickly due to the ability of the clients to recognise and discern their benefits sooner. In comparison, envelope insulation, higher performance glazing or commissioning or post-occupancy evaluation frequently have less immediate or less visible payoffs and are seen as more complicated to implement on-site, which is counterproductive to usual diffusion when finances and trust are limited.

Theory of Planned Behaviour (TPB)

Attitudes (efficiency is worthwhile), subjective norms (what peers, clients and professional bodies expect), and perceived behavioural control (confidence in persuading clients, getting products/labour, passing code) influence the intention by architects to specify efficient options (Ajzen, 1991). Good attitudes and norms notwithstanding, translation between intent and actual specification can be blocked by low perceived control owing to client cost constraints, supply-chain distances, or on-site capabilities.

Institutional Theory

Practice is guided through pressure of coercion (laws, bylaws, permitting and enforcement), normative pressures (curricula, professional standards, awards) and mimetic pressures (copying visible exemplars) (DiMaggio and Powell, 1983). In cases of imbalanced enforcement and when the validity of case studies is low, companies will have weak legitimacy signals to use higher-performance detailing, and consequently, they do not adopt it even when they are technically familiar with it (Sorrell, 2015).

Socio-technical Systems Perspective

Architectures are the products of the relationships between clients, designers, contractors, suppliers, utilities, financiers, and regulators. Transitions need coordination within the system rather than technical solutions (Geels, 2002). Path dependencies Standard information, procurement habits and permitting habits can entrap business as usual, retarding adoption of superior envelopes, commissioning or renewables.

Insights of Behavioural/Energy-Cultures

Realised savings are often mediated by occupant behaviour (thermostat set-points, window operation, appliance choices), when it is poorly user-fitted, design intent is likely to be undermined (Stern, 2000; Janda, 2011). The design decisions must therefore be accompanied by slim controls, user instructions and strong defaults to maintain the performance when used in daily routine.

Practice in Technology Acceptance

The sense of usefulness and ease of use, and the existence of enabling conditions, such as trustworthy suppliers and explicit detailing, determine the specification of new products/workflows (Venkatesh et al., 2003). Plausible performance data and direct implementation of the upgrades on-site increase acceptance of envelope and system upgrades.

Methodology

Research Design

In this research, an attempt to study the relationships between major variables is conducted with the help of a structured Likert-like survey. A questionnaire was designed that would help in capturing the perceptions of the architects towards their understanding of energy efficiency and its importance, the legislation that applies to energy efficiency, incentives that encourage the adoption and obstacles associated with its application, as well as the level to which energy efficient methods are utilised in their projects. It also determines the perceived effects of energy conservation policies on the existing building design practices. The tool contained five-point Likert scale questions (1 = lowest to 5 = highest) and open-ended questions to get more information. 200 Islamabad, Rawalpindi, Lahore, Peshawar, and Karachi-based architects were contacted, and 153 responded (76.5%). The respondents were both in the public (17.6%) and the private sectors (82.3%). The sample is regarded to be sufficient and representative. The research is based on the hypothesis-testing approach, but in a natural and non-contrived environment with limited researcher interventions. The sampling was done by probability, and correlation and regression will be used to identify the relationship significance and strength based on this cross-sectional individual-level research.

Results and Discussion

Reliability

The Cranach's alpha of the instrument is .731, which makes it reliable for the research and findings.

Table 1: Reliability Statistics

Cronbach's Alpha	N of Items
.731	6

Regression

The multiple regression model explains the goodness of the research model. If the value of R-squared is equal to 1, that means the model is perfect. $0 \leq R^2 \leq 1$

The value of adjusted R-squared of this research is equal to 0.822, which is near to 1, which means that the research model is near perfect and the independent variables explain the dependent variable.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.908[a]	.825	.822	.30822
a. Predictors: (Constant), Incentives, Knowledge, Significance, Legislation				

On the other hand, the value of the adjusted R-squared, which is the moderating variable, is less than the value of the adjusted R-squared without the moderating variable. Moderating variables decrease the effect of independent variables (KCL, SEE, LEET, IP) on the dependent variable (Ar. P).

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.794[a]	.630	.169	.85970
a. Predictors: (Constant), Barriers, Significance, Knowledge, Incentives, Legislation				

Correlation

The relationship between the variables is as follows:

Table 4: Correlations

		Knowledge	Legislation	Significance	Incentives	Barriers	Practices
Knowledge	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	**153**					
Legislation	Pearson Correlation	**.825****	1				
	Sig. (2-tailed)	**.000**					
	N	**153**	**153**				
Significance	Pearson Correlation	**.338****	**.445****	1			
	Sig. (2-tailed)	**.000**	**.000**				
	N	**153**	**153**	**153**			
Incentives	Pearson Correlation	**.521****	**.678****	**.815****	1		
	Sig. (2-tailed)	**.000**	**.000**	**.000**			
	N	**153**	**153**	**153**	**153**		
Barriers	Pearson Correlation	**-.115**	**-.220****	**-.065**	**-.107**	1	
	Sig. (2-tailed)	**.158**	**.006**	**.424**	**.186**		
	N	**153**	**153**	**153**	**153**	**153**	
Practices	Pearson Correlation	**.695****	**.808****	**.652****	**.819****	**-.273****	1
	Sig. (2-tailed)	**.000**	**.000**	**.000**	**.000**	**.001**	
	N	**153**	**153**	**153**	**153**	**153**	**153**

**. Correlation is significant at the 0.01 level (2-tailed).

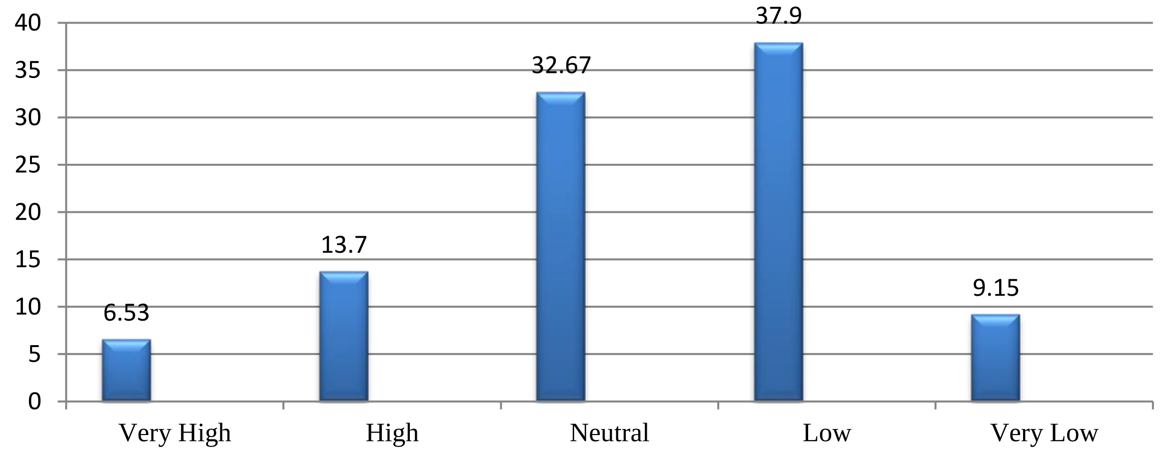
It is quite evident from the results that knowledge of the rules, policies and legislation has a very significant effect on architectural practices. Similarly, the significance of energy efficiency plays a very important role in architectural practices with significance at the .000 level.

Pearson's correlation of incentives is 0.819, showing a higher significance level with the dependent variable (Ar. P). On the other hand, when we see the moderating variable "barriers in energy efficiency", it shows a negative relationship with architectural practices, which means that barriers prove themselves as one of the major reasons for the lack of energy efficiency techniques in architectural practices. Correspondingly, the relationship shows that if one unit of barriers increases, it will decrease energy efficiency by one unit.

Energy Conservation drivers

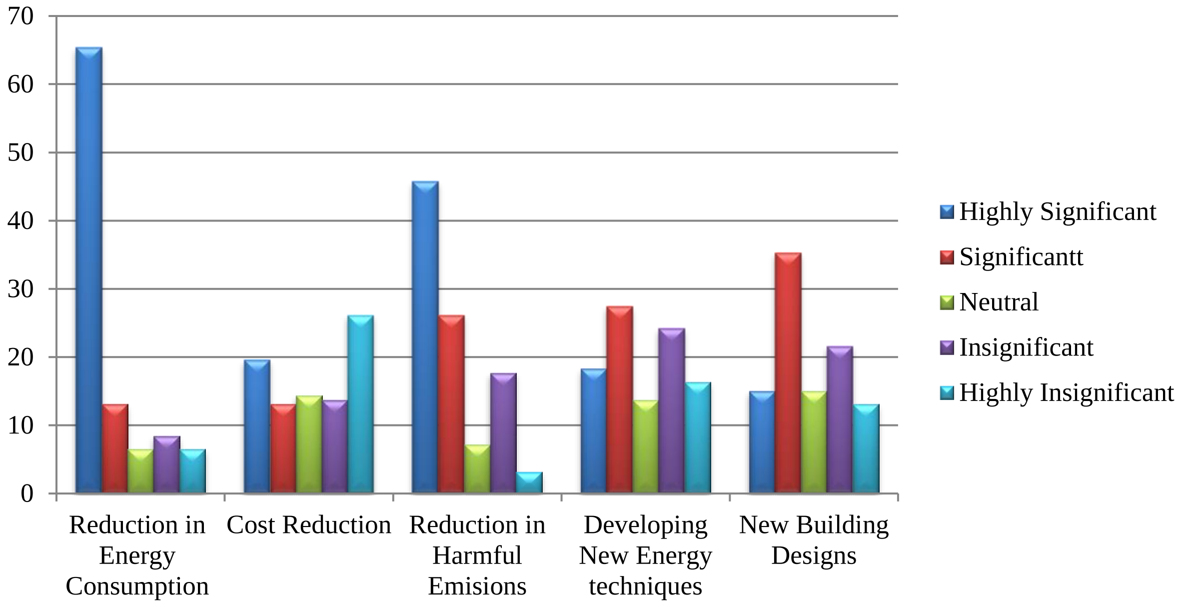
In this section, respondents were asked about their knowledge of current legislation and policies, and also the importance of different practices of energy efficiency. Only 20.23% architects have the exact knowledge of current policies regarding energy efficiency. Architects are of the viewpoint that there is not much legislation available, and if there are such bylaws, then governments have not done anything to raise awareness of such rules and policies. The need of the day is that federal and provincial governments should construct policies and make it mandatory for everyone to follow rules to attain the desired result. See Figure 4.

Figure 5: Knowledge of Current Legislation



Surprisingly, 39.86% of architects think that observing and implementing energy-efficient designs will not reduce cost, because these designs incur a higher initial cost in constructing an energy-efficient building. On the other hand, 71.89% acknowledge that energy-efficient buildings will decrease greenhouse emissions, which will result in a better environment. 78.42% of architects think that energy-efficient buildings will minimise energy consumption, which will help to resolve the prevailing energy crisis in the country. See Figure 6.

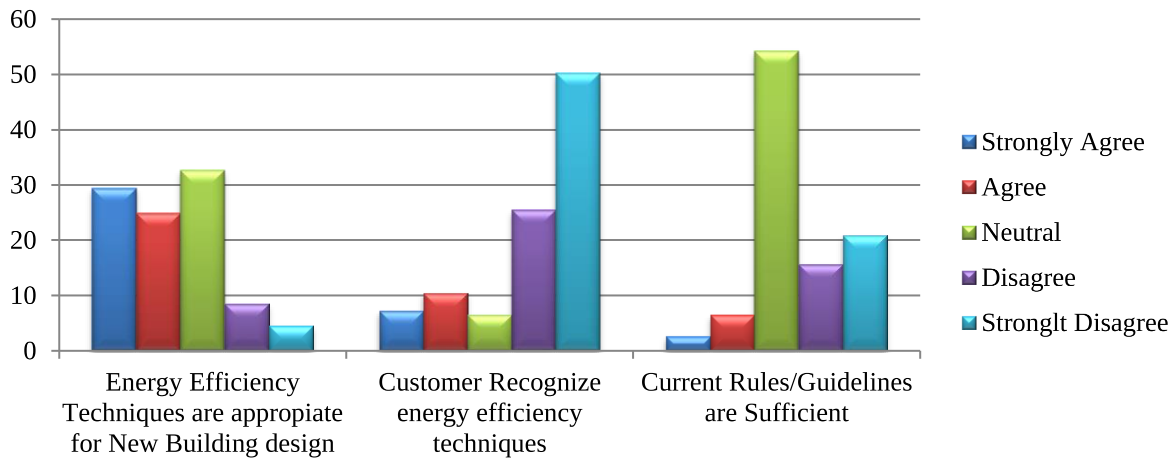
Figure 6: Significance of Energy Efficiency



Policies and Legislation for Buildings

Almost 76% of architects said that the clientele does not recognise the energy-efficient techniques. There is an acute need to start an awareness campaign for the customers. Similarly, 36.59 % architects believe that energy-efficient policies are not sufficient, and the government has to come up with new and effective guidelines for the minimisation of energy consumption. See Figure 7.

Figure 7: Policies and Legislation

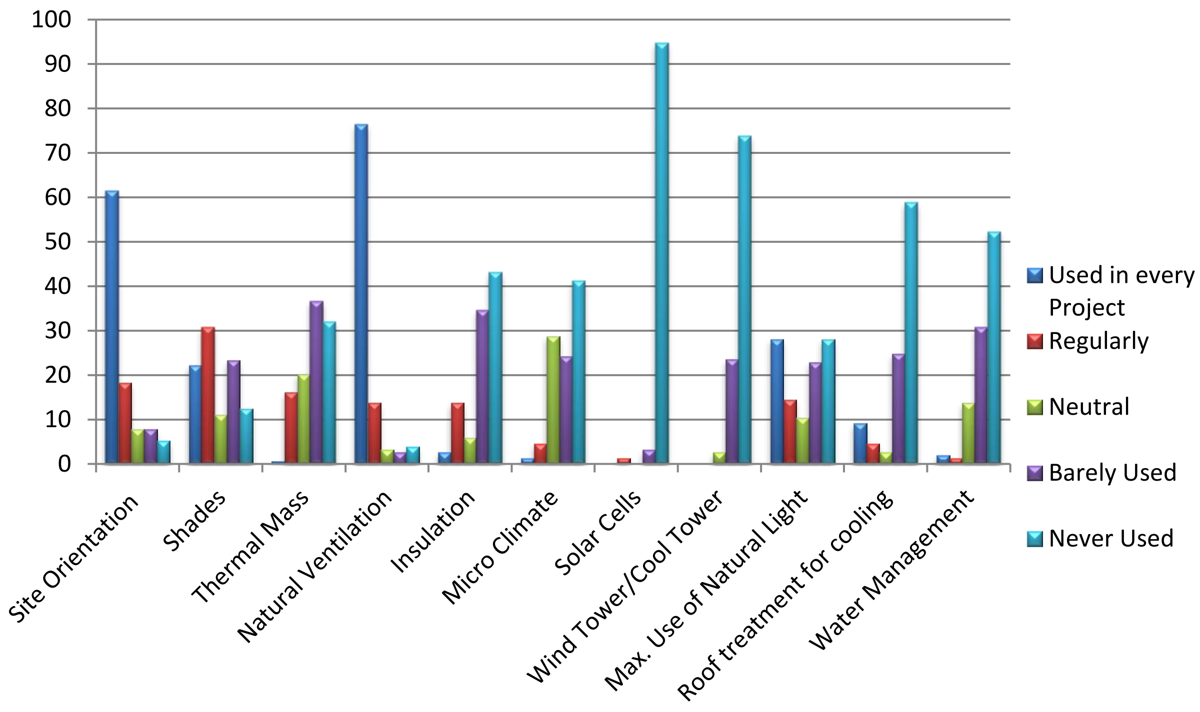


Practice of Energy Conservation Techniques

The results of energy conservation techniques are quite surprising. The only technique which was used by the maximum number of architects was natural ventilation; 76.47% of architects used natural ventilation in each project. Similarly, 61.43% of architects gave importance to site orientation in every project. On the other hand, techniques such as water management, micro-climate and insulation are barely used. Moreover, if we discuss solar cells and cool towers, these techniques are never used by architects in their projects, but they are of the viewpoint that these techniques can be used if a proper arrangement can be made.

The results of this section that are the most vital in this study are the use of energy conservation techniques by the architects, which indicates perplexity in the system and regular practices while building buildings. An article in Express Tribune (2018) stated that Pakistani buildings are mostly insulated in a poor manner, which results in excessive heating and cooling loads in both residential and commercial sectors. The article highlights that it is due to inadequate air congestion, poor insulation of roofs and lack of energy practices that have played an exemplary role in the energy load.

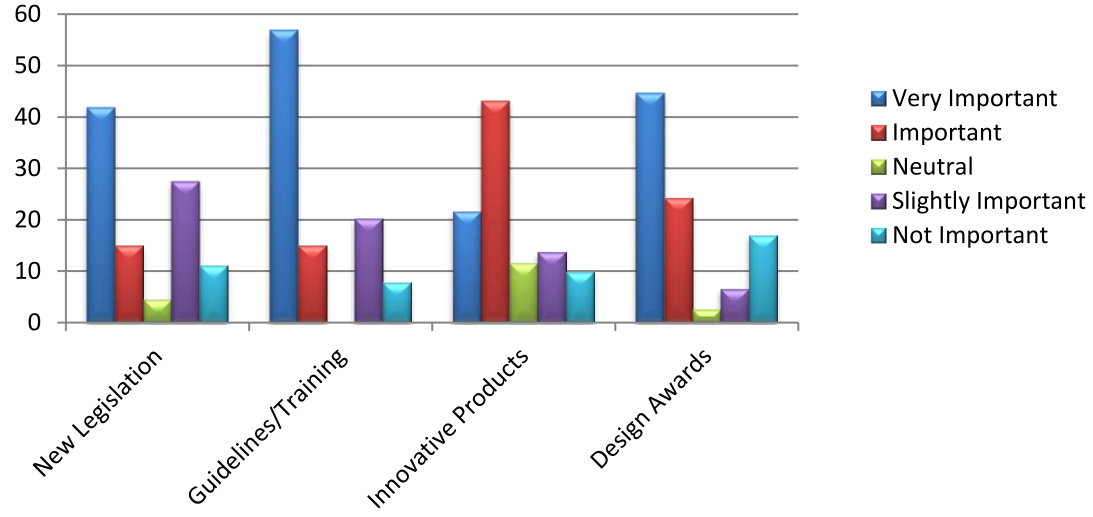
Figure 8: Practice of Energy Conservation Techniques



Incentives

A consensus among the architects of Pakistan is that new legislation related to energy conservation must be introduced, which should be a part of building bylaws. Similarly, 56.86% architects said that training is very important for both architects and consumers. Design awards can also play a very important role in the implementation of energy efficiency techniques.

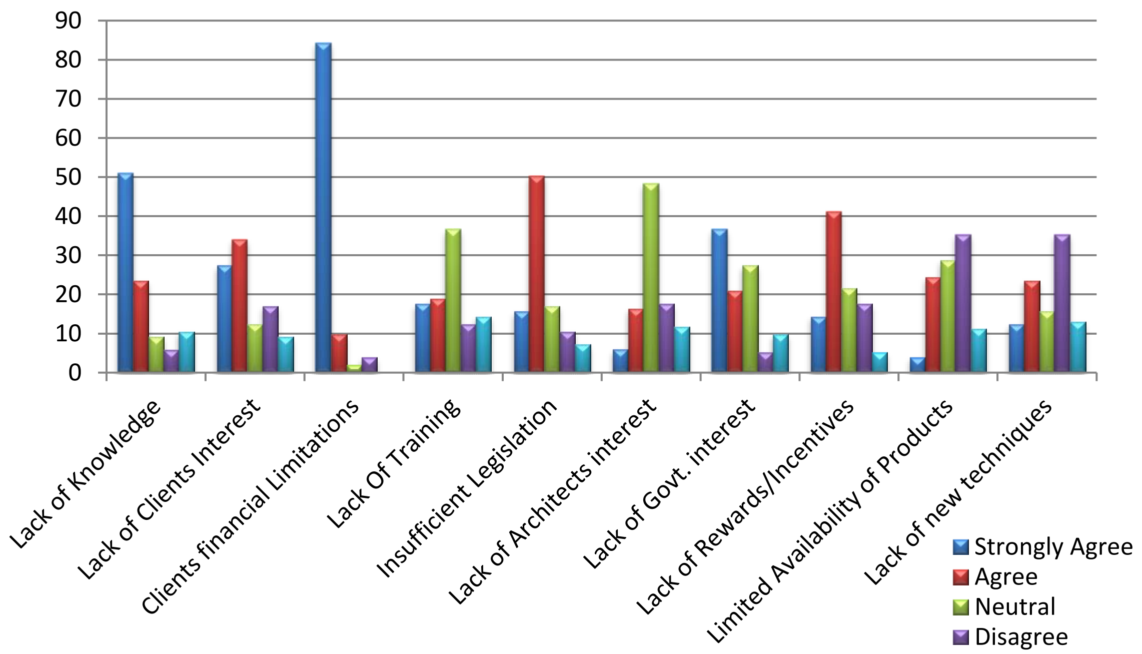
Figure 9: Incentives



Barriers

According to the architects, a client's financial limitation is the biggest barrier for the implementation of energy efficiency techniques; similarly, 74.5% architects agree that lack of knowledge is also a big hurdle for energy conservation in building design. The majority of the architects (65.95%) think that the lack of legislation/bylaws related to energy efficiency is a problem which needs to be addressed on an imperative basis. On the other hand, the availability of energy efficiency products is not a concern, but the execution and use of these products in buildings is a big concern.

Figure 10: Barriers



Discussion: Theoretical and Societal Interpretation of Findings

What the statistics are suggesting from a theoretical point of view

There are positive relationships between practice and incentive, legislation, knowledge, and perceived significance, and negative relationships between barriers. When barriers act as moderators, the explanatory power declines sharply (the Adjusted R2 falls). This pattern is expected:

- *Institutional Theory:* The effectiveness of the detailing is legitimized by strong roles in legislation and incentives, suggesting that both coercive (code/bylaw/enforcement) and normative signals (recognition, standards) are exercised (DiMaggio and Powell, 1983; Sorrell, 2015).
- *Diffusion of Innovations*: Consistency in the widespread adoption of low-complexity, visible interventions (orientation, natural ventilation) and the slower adoption of envelope/commissioning is in line with Rogers's (2003) notion of making innovation complex and observable.
- *TPB*: The observed attenuating influence of barriers on predictors that would otherwise be strong reflects low perceived behavioural control; even positive attitudes and norms are ineffective in translating into behaviour as budgets, supply chains, site skills, or time pressures circumscribe behaviour delivery (Ajzen, 1991).
- *Socio-technical perspective*: The results indicate system-wide incompatibility (lack of uniform enforcement, few role models, lack of integrated supply chains), which tends to encourage practices beyond first movers (Geels, 2002).

Why would this make sense in the Pakistani society

Some contextual issues can explain the trends reported by the respondents:

- *Low cost and low payback:* With macroeconomic pressure, customers are now more concerned with the lowest initial investment, and investments with longer payback periods (insulation, glazing, commissioning) will become more difficult to justify when they do not show any visible returns or financing (NECP, 2023).
- *Gaps in enforcement*: Energy provisions are in place but not incorporated into municipal bylaws or regularly monitored on-site, which undermines the coercive drive towards better envelopes and verification (ENERCON, 2011; NECP, 2023).
- *Information asymmetry and trust*: Unstable product quality and third-party insurability increase risk aversion; the lack of credible case studies and quantifiable results leads clients to select what they already know (Sorrell, 2015).
- *Occupant behaviour*: Design can be countered by cooling behaviour, window use, appliance choices, and product and service choices, which underscores the importance of user controls and operating advice (Stern, 2000; Janda, 2011).
- *Climate and demand profile*: Space-conditioning loads are dominant, indicating that passive cooling and solar control should be very large, and the orientation and ventilation dependence of respondents align with this factor (Ritchie, Roser, and Rosado, 2022).

Linkage to prior evidence

The analysis of upgrades to public buildings reveals that envelope improvements and commissioning deliver strong savings but fail due to insufficient enforcement and capacity development (Papadakis and Katsaprakakis, 2023). Global evidence demonstrates the significance of space conditioning in residential demand, which justifies the focus on passive cooling in warm climates (Ritchie, Roser, and Rosado, 2022). The trend of urbanization also increases the level of stakes in decisions at the design stage (United Nations, 2018).

8 Policy and Practice Implications

- *Make it mandatory:* Provide energy requirements in municipal bylaws and tie permits to basic inspections (e.g., roof/edge insulation, glazing ratios, fixed external shading) (Enercon, 2011; NECP, 2023).
- *Show value:* Incorporate payback and NPV summaries in proposals to have clients also view lifetime value in addition to first cost (Sorrell, 2015).
- *First-cost barriers by Target:* Provide rebates/credit lines for envelope upgrades, efficient HVAC, and commissioning (NECP, 2023).
- *Develop the capacity to build:* Short building physics courses, locally adapted library detail, and site quality assurance/checklists (Papadakis and Katsaprakakis, 2023).
- *Enforce norms:* Rewards of proven performance at the professional level; teaching energy modelling and post-occupancy evaluation in the curriculum (DiMaggio and Powell, 1983).
- *Design for users:* Pair design with one-page operating instructions to achieve the intended savings (Stern, 2000; Janda, 2011).

Recommendations

In light of the results discussed above, it is recommended that the ultimate aim of the architects should be to implement various plans for the awareness of building professionals to introduce sustainable buildings that might reduce the consumption of energy to a greater extent. Modern technology is no longer a surprise in this era; installing sensory switchboards can have a drastic effect on energy consumption, turning on or off automatically when sensing any presence. LED lighting is another option to minimize energy consumption.

It has been observed that the government has designed numerous policies for energy conservation that mandate energy audits for both commercial and household buildings. The policy states the use of energy-efficient equipment and insulation materials, and the building Energy Code (NECP, 2023). The policy also recommends public training to raise awareness and provide adequate education for managers, engineers, and relevant authorities to promote energy-efficient techniques. Furthermore, it emphasizes promoting and training housewives and working women to adopt effective measures to save energy in household chores such as cooking, washing, and driving. However, the implementation and awareness of such policies are lagging, affecting energy consumption sources to a greater extent.

The building design should prioritize passive design strategies to enhance natural light and ventilation. Energy-efficient systems, such as HVAC, should be incorporated.

Daylight saving time is practised worldwide. It was implemented in Pakistan to save energy; however, shops were announced to close earlier at night, but this did not achieve the desired results. Natural daylight was still not used. Proper implementation can enhance the project's efficacy.

It is highly recommended to plan courses and workshops to raise awareness about installing roof insulation and using heating and cooling equipment. Awareness of renewable energy resources such as solar panels and wind turbines should be emphasized. The use of shading, planting, and adopting a natural lifestyle can be highly beneficial. Additionally, sustainable building materials can help reduce the construction industry's carbon footprint. Building commissioning could lead to waste management to ensure and prioritize that all building systems operate efficiently.

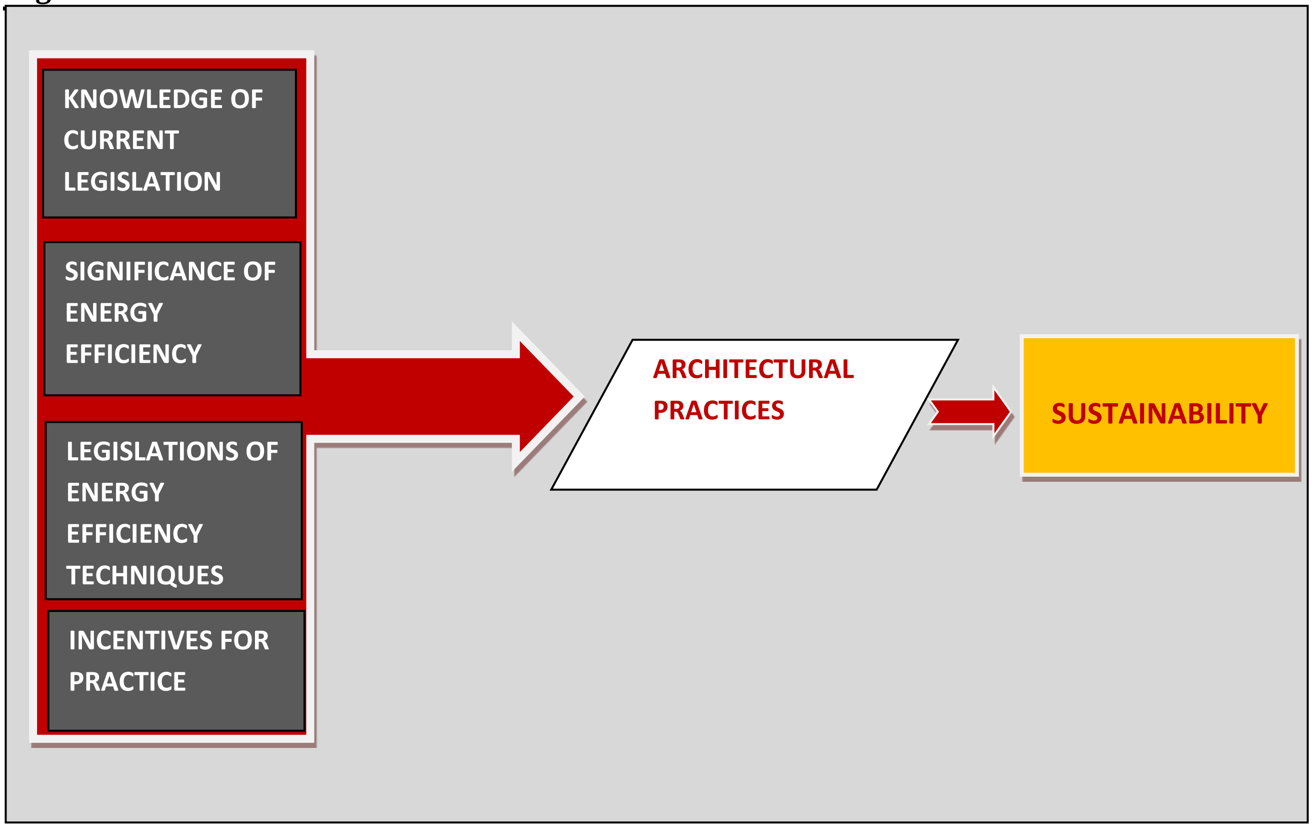
Conclusion

This research examined energy use and the need for energy-efficiency techniques in building designs in Pakistan. The goal of the questionnaire survey was to assess architects' awareness of the practices, implementation, barriers, and incentives associated with energy conservation methods. The results show that energy conservation is the need of the hour, and the household and industrial sectors are the biggest consumers of energy in Pakistan. Architects believe that energy consumption can be effectively reduced by incorporating energy-efficiency techniques into building design across all sectors of Pakistan. It is also concluded that a lack of knowledge and interest is the biggest barrier to energy-efficient building design; similarly, consumers' financial limitations pose a hurdle to the implementation of such techniques. However, reliance on passive techniques is only partially in practice, and further encouragement and motivation are needed.

Future Research Directions

After reviewing the literature and variables, there is evidence that architectural practices can mediate the relationship between architectural interventions and sustainability. Research in this direction will help researchers and practitioners adopt energy-efficiency practices, thereby advancing architectural sustainability. To deal with the barriers and hurdles, there is an acute need for incentives and motivation for consumers and architects, such as training programs. A design award and the introduction of innovative products would help motivate designers/architects to incorporate sustainability into future designs. To address this gap at the basic level, it needs to be integrated into architectural education alongside architectural practice. In addition to these, energy efficiency techniques must be incorporated into building bylaws and legislation, and the government must ensure they are integrated into every building in Pakistan. Further research on bylaws and energy legislation will be of great importance to the government and architects of Pakistan. Architecture in Pakistan has been shaped by the past seven decades of chaos and instability; therefore, development in this field is essential to address the nation's energy crisis.

Figure 11: Future research directions



References

- Ajzen, I. (1991). The theory of planned behaviour. *Organisational Behaviour and Human Decision Processes, 50*(2), 179 - 211.
- Arif, S., Khan, A., & Alamgir, K. (2011). Environmental issues and energy conservation in buildings in Pakistan: Role of architectural intervention. *The Nucleus, 48*(2), 137 - 142. http://www.thenucleuspak.org.pk/index.php/Nucleus/article/view/849
- Athinetis, A. (2008). Design of advanced solar homes aimed at net-zero annual energy consumption in Canada. In *ISES-AP 3rd International Solar Energy Society Conference - Asia Pacific Region*, Sydney, Australia.
- Chatura, W., Lucienne, B., & Kristin, W. (2017). Design challenges in energy conservation strategies for shared spaces. In *21st International Conference on Engineering Design (ICED17)*, 5, Vancouver, Canada, 21 - 25.
- Clark, C., Adriaens, P., & Talbot, F. B. (2008). Green roof valuation: A probabilistic economic analysis of environmental benefits. *Environmental Science & Technology, 42*(6), 2155 - 2161.
- Cubasch, U., Meehl, G. A., Boer, G. J., Stouffer, R. J., Dix, M., Noda, A., Senior, C. A., Raper, S., & Yap, K. S. (2001).
  Climate change 2001: The scientific basis. In J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, & C. A. Johnson (Eds.), *Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
- Dixon, R. K., McGowan, E., Onysko, G., & Scheer, R. (2010). U.S. energy conservation and efficiency policies: Challenges and opportunities. *Energy Policy, 38*(11), 6398–6408. https://doi.org/10.1016/j.enpol.2010.01.038
- Dzioubinski, O., & Chipman, R. (1999). Trends in consumption and production: Household energy consumption. United Nations DESA Discussion Paper No. 6, ST/ESA/1999/DP.6.
- Enercon Pakistan. (2011). *Building Code of Pakistan*.
- Express Tribune. (2018, March 31). Energy efficiency: Pakistan can conserve up to 1,100MW, says expert. https://tribune.com.pk/story/685315/energy-efficiency-pakistan-can-conserve-up-to-1100mw-says-expert/
- Frich, P., Alexander, L. V., Della-Marta, P., Gleason, B., Haylock, M., Tank, A. M. G. K., & Peterson, T. (2002). Observed coherent changes in climatic extremes during the second half of the twentieth century. *Climate Research, 19*, 193–212. https://doi.org/10.3354/cr019193
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes. *Research Policy, 31*(8 - 9), 1257 - 1274.
- Gu, Z. H., & Wennersten, R. (2006). A study about Chinese developing strategies to energy efficient housing development from an architect's perspective, combined with Swedish experiences and Game Theory. *Journal of Housing and the Built Environment*.
- Gul, S., Khalil, W. A., Owais, S., Akbar, R., & Sajid, M. B. (2018). Energy consumption profile of a K-12 school building and identification of energy conservation and energy efficiency measures. In the *1st International Conference on High Performance Energy Efficient Buildings and Homes (HPEEBH)*, Lahore, Pakistan.
- Hartungi, R., & Jiang, L. (2012). Energy efficiency and conservation in an office building: A case study. *International Journal of Energy Sector Management, 6*, 175 - 188.
- Houghton, J. T., et al. (2001). *Climate change 2001: The scientific basis*. Cambridge University Press.
- Janda, K. B. (2011). Buildings don't use energy: People do. *Architectural Science Review, 54*(1), 15–22.

- Lou, S., Tsang, E. K. W., Li, D. H. W., Lee, E. W. M., & Lam, J. C. (2017). Towards zero energy school building designs in Hong Kong. *Energy Procedia, 105*, 182 - 187.
- Moeen, S., Muhammad, M., Memon, F., & Hafeez, N. (2022). *Pakistan Energy Outlook Report (2021 - 2030).*
- National Energy Conservation Policy. (2023).
- Olesen, G. B., & Kvetny, M. (2006). Sustainable Energy Vision 2050. INFORSE–EURFORES–EREF Seminar, Brussels.
- Papadakis, N., & Katsaprakakis, D. A. (2023). A review of energy efficiency interventions in public buildings. *Energies, 16*, 6329.
- Rahul, V., & Rajiv, G. (2012). Review of intelligent building construction: A passive solar architecture approach. *Energy, 14*, 2238 - 2242.
- Ritchie, H., Roser, M., & Rosado, P. (2022). Energy. *Our World in Data*. https://ourworldindata.org/energy
- Roaf, S., Crichton, D., & Nicol, F. (2004). *Adapting buildings and cities for climate change: A 21st-century survival guide*. Elsevier Architectural Press.
- Runci, P. (1999). *Energy efficiency in the European Union*. Pacific Northwest National Laboratory.
- Saghir, K. (2007). *Energy and poverty in Pakistan*. World Bank.
- Saghir, K. (2007). *Prospects of energy efficiency business in Pakistan*. Energy Associates Ltd., Pakistan.
- Saiz, S., Kennedy, C., Bass, B., & Pressnail, K. (2006). Comparative life cycle assessment of standard and green roofs. *Environmental Science & Technology, 40*(13), 4312 - 4316.
- Shah, S., & Bhatti, M. K. L. (2016). Crisis of electrical energy in Pakistan and future guidelines for policymakers. *International Journal of Basic & Applied Sciences, 9*(9).
- Sorrell, S. (2015). Reducing energy demand: A review of issues, challenges and approaches. *Renewable and Sustainable Energy Reviews, 47*, 74 - 82.
- United Nations. (2018). 68% of the world population is projected to live in urban areas by 2050. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
- Uspenskaia, D., Specht, K., Kondziella, H., & Bruckner, T. (2021). Challenges and barriers for net-zero/positive energy buildings and districts: Evidence from the SPARCS smart city project. *Buildings, 11*(2), 78.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425 - 478.
- Walker Art Centre. (1977). Design Quarterly: Architecture as energy. *Issues in Architecture III*, 7–14.
- Williams, N., Rayner, J. P., & Raynor, J. P. (2010). Green roofs for a wide brown land: Opportunities and barriers for rooftop greening in Australia. *Urban Forestry & Urban Greening, 9*, 245 - 251.