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INFLUENCE OF BEHAVIOURAL CONSTRUCTS ON BUILDING PRACTITIONER'S MINIMAL COMPLIANCE WITH RESIDENTIAL BUILDING ENERGY PERFORMANCE STANDARDS IN AUSTRALIA

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ABSTRACT

Energy performance standards for residential buildings are essential in promoting the residential building industry's energy efficiency. Dwellings are commonly designed at the standards' minimum compliance level, which puts the industry at risk of achieving its energy-efficiency goal. One of the causes of this minimal compliance is related to building practitioners' behavioural constructs during the compliance process: Attitudes (ATT), Subjective Norms (SN), Perceived Behavioural Control (PBC) and Personal Norms (PN). This paper aims to investigate how these behavioural constructs influence minimal compliance. The data are drawn from a questionnaire survey of 73 residential building practitioners who actively deal with compliance requirements in the design stage in Australia. A framework predominantly based on the Theory of Planned Behaviour was analysed via structural equation modelling technique to illustrate the influence paths of the behavioural constructs and the extent of the influence. The results show that SN, PBC and PN positively influence behavioural intention, then the intention positively influences minimal compliance outcome. Furthermore, ATT shows the strongest extent in influencing the minimal compliance outcome, while exhibiting the lowest current performance. These findings inform policymakers of suitable interventions to trigger behaviour change toward going beyond minimal compliance. By illustrating the pathways and the degree to which behavioural constructs influence minimal compliance, policymakers can be more effectively guided on appropriate interventions to encourage behaviour change that exceeds minimal compliance.

Keywords: *Building Practitioner; Compliance Behaviour; Energy Performance Standard; Minimal Compliance; Residential Building.*

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1. INTRODUCTION

Increasing energy efficiency is a fast-track roadmap for carbon mitigation and improving residential buildings' energy performance to achieve a sustainable future. Amongst the existing regulatory instruments to promote building energy efficiency in the residential sector, the minimum building energy performance standards are recognised as an essential policy tool. However, minimal compliance in the design phase with the energy performance standards for residential buildings is commonly observed in many countries including Australia, the USA and South Korea (Shim et al., 2018; Moore et al., 2019; Lu et al., 2022). The outcome of minimal compliance is not enough for a net zero and sustainable residential building industry. Minimal compliance is defined as modest involvement with mandatory requirements. The behaviour of minimal compliance appears good in the letter of the law but does not solve the problems warranting the setting of the requirements (Chimboza, 2023). The issue of minimal compliance in the current context puts the residential building industry at risk of achieving its net zero and sustainability targets (Moore et al., 2019). Amongst other reasons, recent studies elucidate that this difficulty in going beyond minimal compliance is caused by building practitioners' various compliance behaviour constructs (attitudes toward going beyond minimal compliance, subjective norms, perceived behavioural control and personal norms).

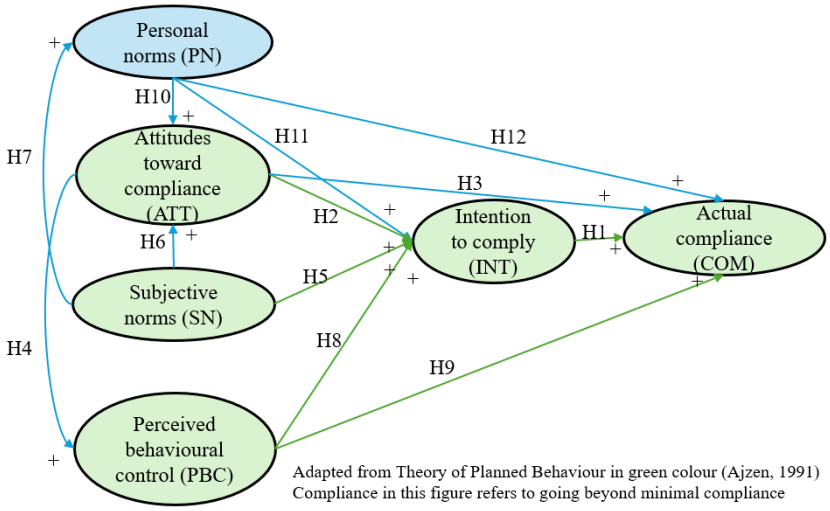
Understanding minimal compliance is crucial for policymakers as wrongfully targeted interventions have the risk of reducing the impact of policy intervention and can concurrently generate extravagant costs. However, there is a scarcity of in-depth investigation of building practitioners' minimal compliance behaviour in the existing studies (Lu et al., 2024a). Therefore, this study aims to investigate how the behavioural constructs influence building practitioners' minimal compliance with building energy performance standards in the design stage where they encounter compliance requirements. By demonstrating the paths and extent of behavioural constructs in influencing minimal compliance, policymakers can be better informed of suitable interventions to trigger behaviour change toward going beyond minimal compliance.

2. LITERATURE REVIEW

In Australia, the Nationwide House Energy Rating Scheme (NatHERS) was established as a mechanism for assessing building energy performance. According to the simulation output of the house design, an energy star rating of the modelled heating and cooling loads is provided, ranging from zero (worst) to ten stars (best). The minimum building energy performance standard before changes to the National Construction Code (NCC) 2022 was to achieve a NatHERS six stars for new housing. Latest data shows that 79.76% of new Victorian (Australian) housing was designed only to achieve the minimum NatHERS 6-star standard, 7.24% went beyond seven stars and only 1.36% achieved an environmentally and economically optimal 7.5 stars ("States and territories", 2023). Studies underlined that residential buildings demonstrating minimal compliance with the energy performance standard "*often struggle to deliver occupant comfort despite relatively high energy consumption and capital costs, let alone achieving their intended efficiency goals*" (State of South Australia, 2014). Amongst the various causes of minimal compliance, building practitioners' discrete behavioural constructs demonstrated in the compliance process are non-neglectable (Lu et al., 2024b). However, previous studies did not demonstrate how each behavioural construct influences the building practitioner's

compliance outcome, nor did they specify the extent of these constructs' influence on the compliance outcomes (Lu et al., 2024a). To pave the way toward the industry's efficiency goal, it is important to use robust compliance behaviour theories to fill this research gap.

The Theory of Planned Behaviour (TPB) was developed by Ajzen (1991). For two reasons, TPB is one of the most robust and widely accepted theories in explaining and predicting human behaviour (Hagger & Hamilton, 2024). Firstly, TPB is particularly useful in predicting compliance behaviour where individuals require both the motivations and capacities, skills or resources to perform the behaviour. Nevertheless, the majority of other compliance theories [e.g. (Nielsen & Parker, 2012)] only emphasise motivational factors but overlook the capacity to perform in correspondence to one's motivations (de Bruijn et al., 2023). Secondly, multiple studies have successfully applied TPB to understand and explain compliance behaviour relating to waste management or worker safety in the construction sector (Li et al., 2018; Liu et al., 2022). Despite the distinct advantages, several studies argued that there is a necessity to integrate personal normative factors into TPB to predict compliance behaviour (Cooper, 2017; Li et al., 2018). Accordingly, the authors (Lu et al., 2024a) developed a theoretical framework integrating TPB and the component of personal norms to underpin the current investigation (Refer to Figure 1).



Hypotheses developed:

H1: There is a positive relationship between a building practitioner's intention to go beyond minimal compliance and their actual compliance behavior.
H2: There is a positive relationship between a building practitioner's favourable attitudes toward going beyond minimal compliance and their intention to go beyond minimal compliance.
H3: There is a positive relationship between a building practitioner's favourable attitudes toward going beyond minimal compliance and their actual compliance behaviour.
H4: There is a positive relationship between a building practitioner's favourable attitudes toward going beyond minimal compliance and their perceived behavioural control.
H5: A building practitioner's subjective norms relate positively to their intention to go beyond minimal compliance.
H6: A building practitioner's subjective norms relate positively to their attitudes toward going beyond minimal compliance.
H7: A building practitioner's subjective norms relate positively to their personal norms.
H8: A building practitioner's perceived behavioral control has a positive effect on their intention to go beyond minimal compliance.
H9: A building practitioner's perceived behavioral control has a positive effect on their actual compliance behaviour.
H10: A building practitioner's personal norms relate positively to their attitudes toward going beyond minimal compliance.
H11: A building practitioner's personal norms relate positively to their intention to go beyond minimal compliance.
H12: A building practitioner's personal norms relate positively to their actual compliance behaviour.

Figure 1: Theoretical framework

The green part of Figure 1 is the original behavioural constructs and influence paths as per TPB. The blue part demonstrates the additional construct of personal norms and paths. Each hypothesis is explained briefly in the remainder of this paragraph. As for hypothesis H1, Zapata-Lancaster and Tweed (2014) and State of South Australia (2014) stated that building practitioners' intention to exceed minimal compliance leads to their design techniques to materialise a high-performing residential building. In terms of hypotheses H2-4, State of South Australia (2014) implied that building practitioners' unfavourable attitude toward going beyond minimal compliance with energy performance standards influences their reluctant behavioural intention. In particular, the building practitioner's perception of the increased costs of high-energy performance design could lead to a reluctance to exceed minimal compliance (Lemprière, 2016). In addition, building practitioners' perceived profits e.g. receiving competitive advantage can also enhance the intention of surpassing code minimum (Lee & Yik, 2004). Moreover, research showed that attitudes positively influence perceived behavioural control regarding households' adherence to waste prevention programs (Corsini et al., 2018). Additionally, Bagozzi et al. (1990) and Li et al. (2022) suggested that attitudes can positively impact behaviour itself in a direct manner. Regarding hypotheses H5-7, May (2004) concluded that the desire to gain a societal reputation was an important consideration in building practitioners' compliance intention. Additionally, Hurlimann et al. (2018) showed that social benefits including reputation and respect increased intention to exceed minimal compliance. Other than social reputation, subjective norm was demonstrated via building practitioners' perceived peer pressure from other building practitioners (Enker & Morrison, 2019) and clients' requests (Zapata-Lancaster & Tweed, 2014). Furthermore, subjective norms serve as antecedents to personal norms. As outlined by Liu et al. (2020), subjective norms help verify the social correctness of safety compliance behaviours among building practitioners, aiding in their assessment of whether their personal beliefs and norms are advantageous to them. Previous research (Li et al., 2011) has demonstrated that subjective norms exert a positive influence on attitudes. In terms of hypotheses H8 and H9, building practitioners' perceived capability was shown to influence their compliance intention. May (2004) found building practitioners' capability to comply essentially affected their motivation to comply. Similarly, Moore and Higgins (2016) suggested that insufficient expertise impeded building practitioners' willingness to move beyond the code minimum. Furthermore, these perceived constraints might influence actual compliance performance. The State of South Australia (2014) indicated that building practitioner's inadequate skills negatively impacted the achievement of going beyond minimal compliance. Shergold and Weir (2018) further argued that building practitioners' minimal compliance was due to their poor comprehension of standards. The last three hypotheses H10-12 relate to normative motivation deriving from internal moral alignment with the policy's substantive goals (Gibbs, 2012). Murtagh et al. (2016) showed that architects and designers with strong internalised alignment with energy conservation and low carbon vision were more likely to deploy more energy-efficient strategies to their designs. Moreover, Enker and Morrison (2019) found that building practitioners' agreement degree with energy performance assessment guidance embedded in the standards affected their intention to comply. As per the Norm Activation Theory (Schwartz, 1977), personal norms positively influence actual behaviour. Liu et al. (2020) highlighted how construction workers' personal norms positively affect their safety compliance behaviour. Li et al. (2018) discovered a positive relationship between personal norms and attitudes.

3. METHODOLOGY

3.1 QUESTIONNAIRE DESIGN

Based on the theoretical framework (refer to Figure 1), the questionnaire measured each behavioural construct. The design followed the recommendations of Ajzen (2002) and Francis et al. (2004) and included adapted items of personal norms from Li et al. (2018). The indicators were measured on a 5-point Likert Scale. 1 represents the lowest and 5 represents the highest. As summarised in Table 1, the measurement indicators were operationalised with relation to minimal compliance with the NatHERS, i.e. delivering a project at seven stars and higher.

Table 1: Measurement indicators of compliance behaviour constructs in the questionnaire

Construct	Indicator
Attitudes (ATT) [An evaluative predisposition towards compliant behaviour as a function of its determinant personal consequences]	ATT1: Perceived economic benefits ATT2: Perceived economic costs
Subjective norms (SN) [Perceived pressure or motivation from those significant referents]	SN1: Requests from clients SN2: Expectations from building industry colleagues and peers
Perceived behavioural control (PBC) [A person's "understanding of their capacity to achieve a compliant behaviour"]	PBC1: Self-efficacy in terms of confidence to go 7 stars and higher PBC2: Self-efficacy in terms of perceived easiness to go 7 stars and higher PBC3: Perceived controllability in going 7 stars and higher
Personal norms (PN) [Self-expectations based on people's internalized values, deriving either from internalized moral agreement with the policy objective or the policy content]	PN1: Moral agreement with environmental protection PN2: Moral agreement with carbon emissions reduction PN3: Agreement regarding whether going beyond 7 stars is correct PN4: Agreement regarding whether going beyond 7 stars can lead to emissions reduction PN5: Agreement regarding whether going beyond 7 stars can lead to energy consumption reduction
Intention to go beyond minimal compliance (INT) [The extent to which practitioners are willing to try, and the extent of efforts practitioners are planning to deploy for compliance]	INT: Willingness and efforts devoted to executing compliance
Actual compliance (COM) [The extent to which practitioners are willing to try, and the extent of efforts practitioners are planning to deploy for compliance.]	COM: Actual compliance outcome delivered since 2010

3.2 CONTEXT AND SAMPLE

The research was conducted in the State of Victoria in Australia. Increasing energy efficiency in the residential building industry has long been recognised as a key strategy amongst Australia's climate change mitigation policies. Since the energy performance standards prescribed in the NCC in Australia are amended with slight variations in different states and territories, the authors selected Victoria because all dwellings in Victoria are effectively approved via the NatHERS approach (Law, 2023), which ensures research findings' consistency. This study used cluster sampling. The research included building practitioners who are actively involved in the initial phase of the compliance process. Per the categories from the National Registration Framework (Australian Building Codes Board [ABCB], 2021), these building practitioners included architects, designers/draftspersons, builders, construction supervisors, and thermal performance assessors. Survey invitations to this survey were emailed between February and June 2023. A total of 73 respondents participated in the study (refer to Figure 2). Ensuing the 10-time rule (Hair et al., 2011), the minimum sample size should be larger than ten times the largest number of paths pointed at any construct in the structural model, which is 40 in this study. Thus, 73 samples sufficed for further analysis.

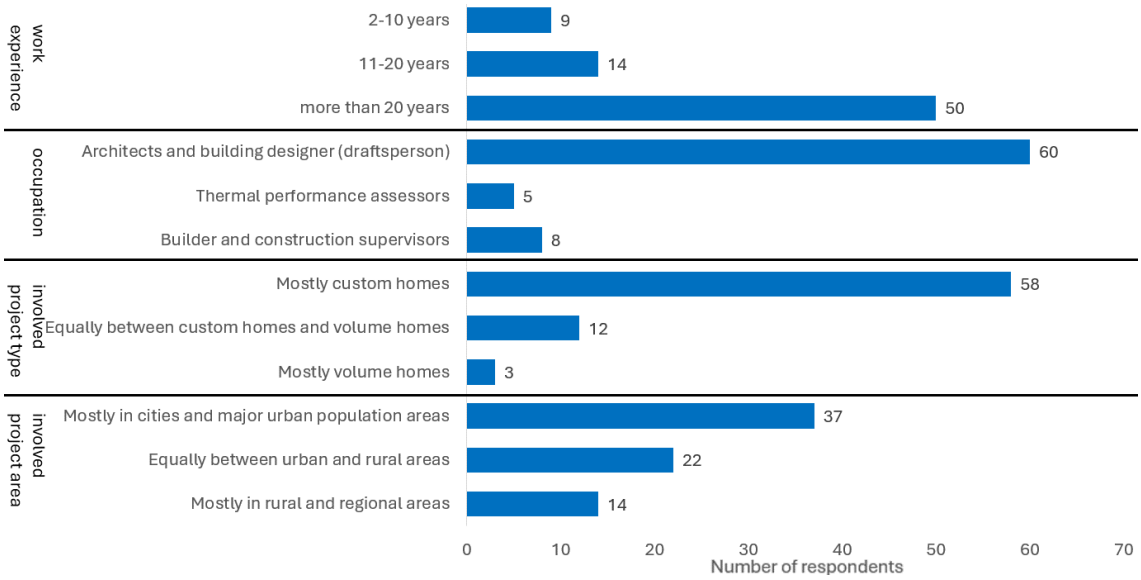


Figure 2: Profile of the 73 building practitioners

3.3 DATA ANALYSIS

The collected data was analysed using the Structural Equation Modelling (SEM) method in SmartPLS 4.0. SEM has two types: Partial least squares SEM (PLS-SEM) and covariance-based SEM (CB-SEM). The study adopted PLS-SEM. First, PLS-SEM is appropriate for small sample sizes. The study sample (n=73) was small, which was deemed unsuitable for the CB-SEM method requiring over 200 cases. Thus, PLS-SEM was considered appropriate. Second, this study intended to test the theoretical framework from a prediction perspective, and the PLS-SEM approach has advantages in exploratory research and is prediction-oriented. Analysis of the SEM modelling results comprises several steps (Hair et al., 2021), as illustrated in Table 2.

Table 2: Analysis steps pertaining to the PLS-SEM modelling technique

Steps	Sub-steps	Analysis technique
1. Evaluation of the modelling results	1a. Evaluating quality of measurement model, i.e. the relationship between constructs and indicators	Factor analysis through reliability and validity tests via computing: Factor loading: >0.7 Composite reliability: >0.7 Average variance extracted (AVE): >0.5 Heterotrait-monotrait (HTMT) ratio: <0.85
	1b. Evaluating the quality of the structural model i.e. the relationship between constructs	Ensuring no collinearity issue exists via computing VIF: <5 Evaluating the theoretical and predictive power of the model via computing: Interpretable variance of endogenous constructs (R^2): >0.1 (if >0.2, indicating high predictive power, especially in behavioural studies) Stone-Geisser's (Q^2): >0 (suggesting the predictive relevance of the structural model)
2. Interpretation of the modelling results	2a. Influence paths (Section 4.1)	Path analysis via computing: path coefficient (β) *p*-value: <0.1
	2b. Extent of influence (Section 4.2)	Importance-performance map

As Table 2 shows, the analysis mainly involves two steps. Step 1 was related to the evaluation of the quality of the modelling results. The detailed parameters for indicating sufficient quality are demonstrated in the third column. After ensuring the quality in step 1, the authors proceeded with the step 2. In sub-step 2a, path analysis was used to illustrate the degree and significance of the relationships between constructs, via computing path coefficient (β) and p-value. Generally, when the p-value is lower than 0.05, the path coefficient is statistically significant. However, as Dahiru (2008) noted, the threshold value of p-value at 0.05 is merely a convention in hypothesis testing. Researchers can make the significant test less stringent moving the p-value borderline to 0.1, as is seen in recent studies (Bag & Gupta, 2017; Tian et al., 2021; Sopha et al., 2024). Hence, the current research placed 0.1 as the p-value threshold. In sub-step 2b, to explore the extent of behavioural constructs and indicators' influences on actual compliance outcome, and identify which construct needs to be targeted more urgently to improve compliance outcome, the analysis of th eimportance-performance map was also conducted.

4. INFLUENCE PATH AND EXTENT OF BEHAVIOURAL CONSTRUCTS

Following the analysis steps in Table 2, the quality of the modelling results was evaluated. The factor loadings of most indicators were bigger than the threshold value of 0.7, ensuring the reliability of indicators. There were only two exceptions. The factor loading of the indicator PBC3 was 0.578, which was below the threshold of 0.7. According to Francis et al. (2004), the variable of perceived behavioural control must include two dimensions i.e. (i) controllability (PBC3), and (ii) self-efficacy (PBC1 and PBC2).

Therefore, the authors chose to accept PBC 3 despite its low loading index. A similar approach was used by Nielsen and Parker (2012). Another indicator PN5 had a factor loading of 0.699, which was below the cutoff of 0.7. Hair et al. (2019) argued that in exploratory research, a coefficient greater than 0.6 was also deemed acceptable. Hence, this indicator was deemed reliable and was kept. The other parameters (composite reliability, AVE, HTMT ratio, R^2 and Q^2) all met the required threshold. Since the model quality is confirmed, the next section reports the main results.

4.1 INFLUENCE PATHS

Table 3 reports the influence paths of the behavioural constructs.

Table 3: Results of the hypotheses test

Hypothesis of influence path	Path coefficient (β)	*P*-value	Interpretation
H1: INT -> COM	0.133	0.077	Supported
H2: ATT -> INT	-0.045	0.307	**Not supported**
H3: ATT -> COM	0.333	0.003	Supported
H4: ATT -> PBC	0.254	0.047	Supported
H5: SN -> INT	0.187	0.085	Supported
H6: SN -> ATT	0.300	0.007	Supported
H7: SN -> PN	0.503	0.000	Supported
H8: PBC -> INT	0.235	0.033	Supported
H9: PBC -> COM	0.191	0.050	Supported
H10: PN -> ATT	0.346	0.001	Supported
H11: PN -> INT	0.408	0.006	Supported
H12: PN -> COM	0.120	0.124	**Not supported**

As Table 3 shows, the influence path between attitudes and actual compliance outcome was supported, while the path between attitudes and intention was not supported. This finding suggests that, when building practitioners have favourable attitudes toward going higher energy stars than the minimum six stars, they are more likely to directly deliver beyond minimal compliance projects. It further implies that their level of effort to deliver higher energy star houses is low. In addition, the results supported the influence path between personal norms and intention. However, the path between personal norms and actual compliance was not supported. Rather, personal norms indirectly influence actual compliance either through intention or attitudes. This finding implied that building practitioners who have high agreement with NatHERS guidance or moral obligation with industry net zero vision, will not necessarily deliver the houses exceeding minimum requirements. Furthermore, the influence path between attitudes and perceived behavioural control was supported, meaning that building practitioners with favourable attitudes generally perceive going beyond compliance as easy.

While the direct influence path between attitudes and compliance outcome findings appears contrasting to the original TPB which posits that attitude only indirectly influences behaviour through intention, it is consistent with several empirical studies. For instance, in a study examining the attitude-behaviour relationship about recycling, Schultz and Oskamp (1996) found attitudes' direct influence on recycling behaviour.

Earlier studies supported these findings (Bagozzi & Yi, 1989; Bagozzi et al., 1990). According to these studies, when a behaviour needs a high level of effort, then the mediating effect of intention will be high, hence no direct relationship between attitude and actual behaviour can be found. In contrast, if the level of effort needed to execute the behaviour is little, the mediating role of intention will be weak, and attitude can predict the behaviour directly. In the current study, most of the responding building practitioners are those who work on custom homes. They do not need to rely on standardised designs and thus are more likely to deliver innovative energy-efficient designs. In other words, the level of effort needed for these building practitioners to go beyond minimal compliance is relatively low. Therefore, their attitudes directly influence the compliance outcome. Furthermore, the positive and significant influence of subjective norms on attitudes is also confirmed. This influence path is not present in the original TPB as well. However, this additional relationship was also supported by Courneya and McAuley (1995) who found that the more one feels that important others think one should carry out the behaviour, the more favourable one's attitude toward executing the behaviour should be.

4.2 EXTENT OF INFLUENCE

The extent of influence of each behavioural construct and indicator on minimal compliance was explored, and their current performance was identified (refer to Figure 3).

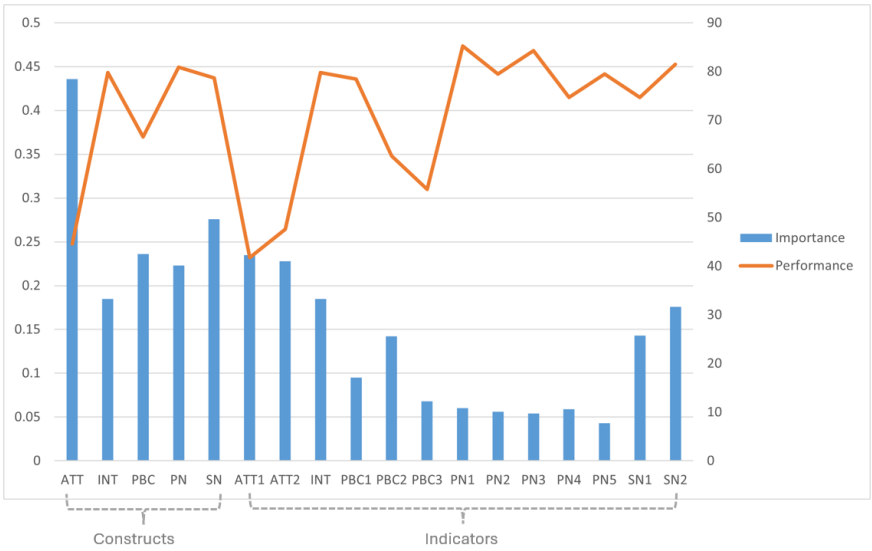


Figure 3: Importance-performance map of the behavioural constructs and indicators

As Figure 3 displays, in explaining minimal compliance, building practitioner's attitude has the largest influence, followed by subjective norm, perceived behavioural control, personal norm and intention. However, the performance of ATT is the lowest. Further, as indicated by the bottom part of Figure 3, indicators ATT1 and ATT2 have the highest influence on minimal compliance. It implies reducing compliance costs or increasing profits are strong motivating strategies to enhance attitudes, and can thus further encourage more people to go beyond minimal compliance. Victorian authorities can thus introduce more financial incentives such as the 7 Stars Home Rebate provided by ABCB (2021) to building practitioners who design houses at higher compliance levels, thus lowering building practitioners' perceived costs and generating more favourable attitudes toward going beyond minimal compliance. Further, the low value of indicators PBC1-3

indicates that targeting perceived behavioural control (e.g., training to increase building practitioner's knowledge regarding energy-efficient design techniques) may not be a very effective intervention strategy as people thought.

As highlighted, the study suggests that the most effective path to improve energy compliance was to increase attitude. Gunningham's notion of economic license supported this recommendation (Gunningham et al., 2003). As similarly highlighted in research conducted in the UK, Singapore, and Indonesia (Sun et al., 2015; Shan et al., 2020; Fitriani & Ajayi, 2023), enhanced governmental incentives, such as subsidies to mitigate the added costs of developing projects beyond a 7-star rating, are pivotal for motivating building practitioners to adopt more energy-efficient practices.

5. CONCLUSIONS AND THE WAY FORWARD

This study provides an in-depth investigation regarding building practitioners' behaviour in going beyond minimal compliance with residential building energy performance standards in the Australian context. The study results support the positive and significant influence paths between SN, PBC, PN and INT, INT and COM, as well as ATT and COM. The study reveals that, amongst the performance of all building practitioners' behavioural constructs, attitude toward going beyond minimal compliance is the lowest. Nevertheless, attitude influences minimal compliance to the largest extent than any other construct. The contributions of this study are two-fold. Theoretically, it contributes to the existing literature on the role of social and psychological factors regarding behaviour going beyond minimal compliance. The theoretical framework extends the original TPB and enriches the understanding of minimal compliance behaviour. Practically, the study implies the prioritised urgency and effectiveness in targeting attitudes for promoting compliance level, thus providing guidance to building authorities in promoting a high-performing residential building industry.

There are limitations. While the use of PLS-SEM has increased over decades for effectively exploring complex relationships among variables and predicting outcomes, it has several limitations such as biased parameter estimates and the lack of measurement error estimation (Lee et al., 2021). These limitations could potentially affect the robustness of the findings if hypothesis testing and parameter estimation precision are critical. Nevertheless, the researcher has calculated model fit indices and criteria. The results ensure the validity of the developed PLS-SEM model. Furthermore, compared to CB-SEM, PLS-SEM achieves greater statistical power at all sample sizes, but particularly smaller sample sizes as in the current study (Hair Jr et al., 2017). Hence, PLS-SEM was deemed the most suitable method for this research, providing a robust framework for analysing complex relationships within the data while accommodating the study's sample size feature.

Having identified the influence paths and extent of the behavioural constructs affecting minimal compliance, this study lays a foundation to examine external policy interventions' effectiveness in triggering behaviour change. As an ongoing research, the authors are in the process of extending this study's findings to assess the amount of behaviour change under different policy scenarios.

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