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The Adoption Factors of Low Loss Microwave Transmission Glass Among Green Buildings in Malaysia

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Abstract

The purpose of this study is to determine the factors perceived as adoption factors of low loss microwave transmission glass (LLMTG). The study utilised a quantitative method approach whereby employing survey instruments in order to get users' perceptions of the adoption of LLMTG. The study selects the sample from the Green Building Index (GBI) website directory. The target respondents of the study are certified buildings by GBI, which has seven types of building in Malaysia (non-residential new construction, industrial existing buildings, industrial new construction, non-residential existing buildings, residential new construction, interiors, and township). Based on GBI-certified buildings in Malaysia, the study found 226 total certified green buildings, and a total of 144 usable questionnaires were obtained from a simple random sampling technique. To address these research questions, the study performed exploratory factor analysis (EFA). The result from EFA shows that factors perceived as characteristics of LLMTG are relative advantage, complexity, compatibility, observability, and trialability. Moreover, factors perceived as users' characteristics are commitment to the product field, innovation-related core benefit, expected financial benefit, and user-manufacturer interaction. Lastly, factors perceived as external factors are technological opportunity, market demand conditions, and appropriability. This study contributes to new knowledge of innovation characteristics by applying LLMTG as a subject of innovation, whereby innovation characteristics can be categorised as characteristics of LLMTG, user characteristics, and external factors.

Keywords: low loss microwave transmission glass, saving glass energy, exploratory factor analysis

1. Introduction

One of the most important inputs for urbanization, development, and modernization is energy. Many rapidly growing countries are becoming more energy-intensive as a result of rapid urbanization and population expansion. In recent years, the residential and commercial sectors have contributed 20.7% of Malaysia's energy consumption (Hasanuzzaman et al. 2011; Ali et al. 2021). According to Ali et al. (2021), the building sector is a major energy user and emitter of greenhouse gases. Malaysian energy consumption is anticipated to rise as a result of increased appliance ownership, economic growth, and changing lifestyles (Sena et al. 2021).

According to statistics, the building sector consumes a significant amount of power in many nations, accounting for around 45% in Brazil, 40% in the USA, and 90% in Hong Kong (Alves et al. 2018; Jing et al. 2017; Nikdel et al. 2018). As a result, energy conservation strategies must be developed in order to minimize both energy use and emissions in the building sector. This is critical to meeting the long-term goal of reducing carbon intensity. Ihara et al. (2015) studied and discovered heating and cooling energy consumptions in around 45% of Japanese office buildings. Pérez-Lombard et al. (2008) reported heating, ventilation, and air conditioning (HVAC) systems, lights, and appliances utilize close to 50%, 15%, and 10% of non-residential buildings, respectively. Habib et al. (2016)

investigated energy usage in garment buildings and discovered that lighting accounts for 13% of overall energy consumption. Overall, energy consumption in the industrial, residential, and service sectors increased by 0.4%, 0.1%, and 0.9%, respectively.

To address this, several practitioners are considering incorporating glass technology into buildings. Glazing systems often have a major impact on the overall energy usage of a structure. Where heat exchange through building windows is around 25-30% (Zhao and Du, 2020). Glazed surfaces can account for more than 25% of heating and cooling energy expenditures in typical buildings. By using new technology glazing systems approaches and improving the performance of glazed surfaces, it is feasible to save up to 60% of energy in any conventional building (Kabeel et al., 2018). Reducing energy usage in buildings reduces a city's overall energy consumption (Graiz and Al Azhari, 2019).

Literature states that the numbers of users that adopt low loss microwave transmission glass (LLMTG) or also known as energy-saving glass are still low as they are lacking knowledge about LLMTG and its production (Shi et al., 2013; Musa et al., 2016). Hence, it is a positive sign to the manufacturers to produce high-quality glass as the Malaysian user's welcome new product innovation development. However, Musa and Chinniah (2016) claimed that the most challenges faced by Malaysian organizations to go green are influenced by resource availability encompasses monetary, human, and time. Additionally, many organizations are still adopting the ordinary float glass, which is exposed to infrared radiation from outside (Kwong et al., 2017; Kumar et al., 2018). Thus, examining the adoption of LLMTG in Malaysian organizations is essential as it can develop the understanding of LLMTG technology which will subsequently provide good thermal isolation and upgrade the transmission of useful signals, such as GSM mobile phones, infrared, WLAN, personal communication signal, Wi-Fi, GPS, wireless broadband, wireless network, and 3G systems. This study is crucial as studies on glass technology adoption are still lacking. Hence, the objective of the study to determine the factors perceived as adoption factors of LLMTG.

2. Literature review

The characteristics of LLMTG were utilized from attributes of innovation that founded by Roger consists of five attributes that have been a popular study in a recent year: relative advantage, compatibility, complexity, observability, and trialability. Meanwhile, user's characteristics are indicated as main objectives in innovation disciplines (Roger, 2003) consists of four attributes: commitment to product field, product innovation benefits, expected business benefits, and user-manufacturer interaction. External factors consist of three attributes: technology opportunities, market demand, and appropriability.

2.1 Characteristics of LLMTG and the adoption of LLMTG

Zaltman et al. (1973) identified more than 21 traits or qualities of innovation, largely based on research on the dissemination of innovation. Diffusion research focuses on the adoption of innovation by individual decision-makers, such as SMEs (Musa et al., 2016) and service providers (Tan et al., 2012), and assesses innovative features as seen by the individual adopter. A study of 75 studies on the relationship between perceived innovation features and innovation adoption found three qualities (compatibility, relative advantage, and complexity) to have the most consistent significant correlations with innovation adoption (Tornatzky and Klein, 1982). Rogers (1995) specifies five criteria of innovation to assess the rate of innovation: relative advantage, compatibility, complexity, trialability, and observability. These five qualities are intimately related to each innovation's acceptance. In the study, these features are utilised to classify characteristics of LLMTG adoption. This study views these five features as LLMTG characteristics that will be adoption factors in this study.

Relative advantage: The interpretation of relative advantage by Koebel et al. (2015) and Franceschinis et al. (2017) as the rate to what extent innovation is been viewed as an improvement than the idea it wants to replace. It chooses by the innovation's "goal" advantage, however by the person's thought as favourable

circumstances (Roger, 2003). The more noteworthy the apparent relative favourable positions of advancement, the higher its pace of reception of the development. The relative advantage is probably the best indicator of advancement and it is emphatically identified with the development's pace of appropriation. The greater part of the users believes about sustainable energy as an environmental viewpoint just like the advantage of the community in the future (Bandara and Amarasena, 2018). For green technology like LLMTG, the relative advantage is the conceivable development over the current conditions got from the advancement, for example, monetary advantages, cost decreases, enhanced picture, advancement, accommodation and fulfilment (Chou et al., 2012). According to Koebel et al. (2015), relative advantage contrasts with the new item and past forms in light of value, efficiency, and execution and is relied upon to give one of the essential legitimizations for the adoption.

Therefore, the diffusion's researchers often emphasize the investigation of the relationship between the percentage and range of innovation adoption and the perceived relative advantage of them. There were abundant of sustainability innovations been invented towards the same goal which is directly to cost savings with the criteria of a building's "green" intentions such as waste reduction, improved product design, improved efficiency, and renewable energy (Smerecnik and Andersen, 2011), and therefore the focus of profitability in economic is often expressed as the relative advantage of the innovation (Rogers, 2003; Chu et al., 2017). A study in the Asian nation for the buildings, the overall building performance indicated positively affiliated with the implementation of green initiatives. But the main concern for common buildings is to confront the initial cost to innovate towards green, which this situation is proven by one study of the primary barrier adoption of green technology for buildings was the cost of maintenance and the implementation (Balaban and de Oliveira, 2017). At this point, overall can be concluded through an abundance of empirical studies that admitted that one of the most influencing factors of the adoption of innovation is the relative advantage.

Complexity: Koebel et al. (2015) and Franceschinis et al. (2017) elaborates complexity from Rogers' theory was the rate of difficulties in understanding and utilization of innovation. Innovation complexity considerably affects stimulating advancement appropriation (Ramdhani et al., 2017). Thus, together for the adoption process ought to work fast, the advancement introduction to be less difficult. Generally, the potential adopter is probably going to adopt an innovation sooner when it is easy to understand rather than the complicated one, meanwhile, the duration of adoption may take longer when the requirement of the innovation involves new understanding and skills. However, there were conflicting findings with previous studies regarding the connection between the complexity of innovation and the adoption of it. Some previous study has claimed that complexity has a negative correlation with the adoption of innovation. Furthermore, Rogers (2003) recommends that complexity has a negative correlation with the perception of choice-maker in order to adopt an innovation. In contrast, Khorasanizadeh et al. (2016) however found that complexity is not correlated to the utilization of innovative technology adoption.

Compatibility: The rate that perceived as the consistency with the prevailing values, the requirements, and past experiences of the potential adopter been interpreted by Koebel et al. (2015) and Franceschinis et al. (2017) as the compatibility of an innovation. Premkumar (2003) asserted that compatibility is an important determinant of managerial innovation adoption. Meanwhile, description from other researchers regarding compatibility, it's may act as the compliment, supplement, or replacement which actually possesses the similarities of an existing product to the innovation (Wolske et al., 2017). The definition of compatibility from earlier scholars been concluded later as the connection between other elements and innovation, in order to influence an innovation adoption in a particular context perceived.

This is seen as one of the deep interests because, the compatibility of the innovation towards processes, nature of work, and activities in certain organizations are crucial to the desired adoption. Strengthening by Lioutas and Charatsari (2018) stated the essential result

from the changes through the adoption of innovation is appropriate with the values and the conviction frameworks of the organization. Furthermore, a building receiving maintainability of innovation depending on the innovation's compatibility with the facilities especially in the context of technology in the organization (Smerecnik and Andersen, 2011).

Observability: According to Rogers (2003), observability is the measure of the degree to which the results of an innovation are clear or visible to others. Rogers (2003) and Franceschinis et al. (2017) claimed the assessment of the innovation may be improved by the organization through the observation result of innovation adoption instead of observation towards innovation alone and the connection between innovation adoption and observability show a positive result. However, according to Smerecnik and Andersen (2011) and Du et al. (2014), this sort of innovation study may be less suitable characteristics to address with the term of observability since the quick impact of sustainability, such as proof of decreased utilization of water and electricity, commonly are not physically obvious. However, there is proof that able to strengthen the 'observability' attribute which is the comparative billing of the building's energy consumption once adopting the innovation (Wilson et al., 2015).

Trialability: According to Rogers (2003), trialability is the measure of the degree to which an innovation is available to be experimented on a limited basis. Trialability has been seen extending a fairly significant effect on the users' adoption intentions across different innovations (Kapoor et al., 2015). Rogers (2003) and Franceschinis et al. (2017) claimed that the rate of the innovation which may be tested on a limited basis is the definition of trialability. This shows that trialability is about the ability to try on innovation before adopting it. For instance, Rogers's (2002) study showed a positive result in the relationship between an innovation adoption and the trialability of an innovation. Trialability may be more feasible for innovations that relate to new products such as LLMTG. In line with time circulation, researchers have essentially centered on trialability of sustainability for diffusion studies exterior of organizations (Koebel et al., 2015). Such as an example that been given by Chan and Ho (2006) about "energy performance contracting" which is buildings able to utilize the trial of sustainability innovations. Hence, these approaches regarding try sustainability innovations are suitable for building studies which able to enhance energy efficiency or produce sustainable energy (Gan et al., 2015).

2.2 User's characteristics and the adoption of LLMTG

According to Roger (2003), the primary innovation field is to find user factors that influence the acceptance of an invention. Because customers in a market adopt innovations in a time sequence rather than all at once, researchers have attempted to establish adopter groups based on when consumers first purchase a new product (Rogers, 1995). Furthermore, a large body of study has been conducted on personality qualities that may be beneficial in characterising customers of various categories (e.g., Midgley and Dowling, 1978; Hirschman, 1980; Goldsmith and Hofacker, 1991). Lüthje (2004) discovered three major user characteristics of innovation, which are the user's commitment to the product field, the innovation-related core benefit, the expected financial benefit, and the user-manufacturer interaction. These four qualities are viewed as user characteristics in this study, and they will constitute adoption variables in this study.

Commitment to product field: In the Lüthje (2004) study, 'the experiences of usage' and 'knowledge about the products' are able to show the level of user expertise. The usage experience arises by means of the repeated utilization of the products. Those who had experience with the implementation of innovation could influence others to adopt the innovation (Caird et al., 2008). In this way, clients with use experience get extremely striking, suitable and high trustworthy information about the products (Darko and Chan, 2017).

Awareness and concerns for the environment could influence users' decisions and enhance the understanding of the importance and advantages of adopting green technologies that conserve energy (Sari, 2012). Further study by Suki (2013) stated that, strong knowledge of the users encourages them to

adopt the innovation especially when they realize the advantages of the product. Strengthened by Lüthje's (2004) findings, knowledge about the products consists of the latest products' details and their potential in the current market. This knowledge is necessary for users to understand their needs and requirements to achieve the satisfaction of using an innovation. Hence, this study will find out users in Malaysia with their awareness and product knowledge of this kind of material, LLMTG as an innovation.

Innovation-related core benefit: Krause (2004) and Darko and Chan (2017), explored with their study that expectations of innovation-related benefit affected the rate of innovation. The high expectations benefit of certain products influences the user's intention to adopt innovation as a solution (Darko et al., 2017). Based on the user's capability to define the advantage of technology innovation contribution either directly or indirectly may represent their distinctive measure of involvement with the product. Hence, positive expectation always attracts users to continue using the product (Doherty and Sorenson, 2015).

An everlasting advantage of innovation is essential in determining the pace of growth of the organization (Bjornali and Ellingsen, 2014). According to von Hippel (2005), the experience of the new requirements often less dealt with existing market offers will affect the expected level of interest by users. Therefore, Lüthje (2004) concludes that normally they are often less satisfied with existing products because they felt it was not compatible with their current needs. This shows the users who always aware of the innovation are always thirsty for something new and more exciting than the existing ones (Flowers et al., 2010). By the existence of LLMTG in the global market, development can create advantages and benefits for the daily lives of consumers. LLMTG has a smarter attribute, particularly when compared with a similar range to the products of the competitor.

Expected financial benefit: Findings from Lüthje (2004), show that it is probable that users are not just desired the benefits of using the product, but certainly, the financially reward once adopting the innovation. There is no negative argumentation with the relationship between human characters and financial rewards. According to Kats (2003), Butler (2008) and Du et al. (2014), expected financial benefit is involved with the increase of productivity and health, energy conservation, environmentally friendly and cost reduction of waste, water costs, and preservation cost of the building. The expenses of building development differ between areas even though located under the same climate zone depends on the design of the building and property values of the area (Spanos and Duckers, 2004; Kneifel, 2011; Gan et al., 2015). The huge obstacle in commercializing energy-saving products is the unwillingness of users to make vital advance investments (Baden et al., 2006).

In addition, funds are required to provide financial support such as incentives towards users to encourage the development of green technology activities. Similarly, with Bjornali and Ellingsen (2014) found that financial motivators are part of important roles in top management to establish commitments towards betterment innovation. Government policy is essential to motivate and encourage the adoption of green technology (Kuusisto et al., 2013). Therefore, a study of the expected financial benefit of the Malaysian upon LLMTG was carried out and a few questions were created.

User-manufacturer interaction: There have been many terms used in earlier studies to describe users and manufacturers. According to Franceschinis et al. (2017), any organization or person who expects to gain benefit towards the usage of services or products, they can be defined as the term of users. Meanwhile, any organization that expects benefit by offering their services or products to others is manufacturers. Therefore, users and manufacturers can be distinguished from the point of acquisition and benefit costs during the innovation process (Baldwin and von Hippel, 2011). Despite these differences, both collaborations are greatly functional in enhancing innovation opportunities (Raasch and Von Hippel, 2012).

The conspicuous of this interaction are that it empowers the user-manufacturer to market a consistent stream of user innovations while and concurrently permitting the in-house user to receive an advantage directly from product innovation (Block et al., 2016).

Interaction is important to exchange information on a novel product consequently encouraged significant firms applying information technology to create their networks to outsiders that cover all their marketing activities. Besides, decision-making procedures in the adoption of technology in a firm, frequently influenced by the role of top management (Musa et al., 2016). There has been an assortment of sectors to encourage vitality proficient structures development and retrofits in certain nations. Knowledge should be shared to enhance future attempts (Baden et al., 2006). For industrial markets, the market potential of a new product often plays an important role in influencing users' involvement in commercial exploitation (Foxall and Haskins, 1986; Foxall and Johnston, 1987; Gan et al., 2015). Hence, Lüthje (2004) and Du et al. (2014) conclude that innovation benefit is not only dependent on the result of user inventions. Innovating users should also profit from the innovating process itself. Users should experience an enjoyable situation during the process of adopting innovation. Financial rewards from the manufacturers could be expected by innovating users and convincing either they need to authorize or commercial their development (Von Hippel, 2005).

2.3 External factors and the adoption of LLMTG

According to institutional theory, external forces motivate users to implement innovations. External forces have a significant role in addressing innovation (Antonelli et al., 2013). External factors are determined by the system's structure, and external knowledge leads to the outcomes of the introduction of innovation. According to this study, normative pressures are the motivators that influence LLMTG adoption. Normative forces ensure that businesses conform in order to be perceived as participating in lawful operations (Sarkis et al., 2011). Ball and Craig (2010) discovered that normative pressures drive firms to become more environmentally conscious, and they argue that institutional research is needed to understand new social rules (e.g., ethical values and ecological thinking) and organisational responses to environmental issues. Normative drives wield strength as a consequence of a societal obligation to comply, which is based on social necessity or what an organisation or individual should be doing (March and Olsen, 1989). This element includes technological opportunities (Dosi and Nelson, 2016), market demand conditions (Lin et al., 2013), and appropriability (Harabi, 1995).

Technology opportunities: Just as important for industrial sectors innovating, ease of conducting R&D which may persist and for the relative cost yield from technological opportunities (or innovative). Enhancement of the rate of technological opportunities is anticipated to display more turbulent designs of development in terms of innovative passage and exit and the stability of firms' hierarchies (Dosi and Nelson, 2016). Without a doubt, a firm that has solid connections with providers may indirectly get innovation from the providers and consolidate it into its items, ease the innovative activities. Within the same way, a firm that has solid connections with clients can moreover get useful knowledge, reducing their endless innovative activities (Triguero and Córcoles, 2013). In this way, the endless input of the latest innovators able facilitated by technological opportunities which at the same time at the firm level, the persistence of innovation may decrease. In the same sense, the stability of the major innovators may increase due to the persistence in innovation. According to Chien and Weng (2012) the innovative advancement, behaviours of technological communities, and format able been influenced by the variety of studies that related to them with the collaboration of the social network.

Market demand: The opportunities that including the ease of passage for modern firms and the strength of rivalry often associated with the given incentives which able to exploit those opportunities. According to the study by Wilson et al. (2015), in order to analyse a high propensity of market segments in renovations or with certain particular needs which ordinarily is focused by supportive that involves financial incentives, and certification of energy performance, whereby the characteristics of a property and household are required to elaborate the purpose of energy efficiency policies. The role to embed energy-saving "measures" (devices) into the context of the users, giving comparable services that focused to decrease energy levels. The infusion

program should accurately to be pertinent to benefit necessities and to the financial matters of the measure. Expected to have been met by the interaction of market powers (Lutzenhiser, 2014). In fact, the hypothesis of demand-pull has stated that demand conditions are a major driver of the adoption of innovation even though with the existence of incentives rather than competitive pressures in clarifying the innovation process (Olubunmi et al., 2016). In this sense, technological opportunities able been exploited with the enhancement of incentives that yielded from positive demand conditions which at the same time enhance the adoption of innovation. There's a solid demand to look at user's inclination qualities when they make buying choice, in the same manner, consumer's purchasing behaviour naturally significantly can give an impact on the market performance of the product (Hamid et al., 2014).

Appropriability: The prevention of imitation innovations is an organizations' ability that related to the appropriability term, from here on, monopolistic opportunities will exist which able to extract profits (Chang and Chen, 2016). As noted above, the conditions for the appropriability context are necessary from leadership in technological activities in order to generate and maintain its revenue. As knowledge cumulativeness can not only be observed at the local and sector level, a high appropriability of innovations at the company level indicated from high average cumulativeness (persistence). On the other hand, the tendency to secure innovation from imitation and the extent to which innovative efforts are based on the linkage of appropriability and persistence that gathered from previous innovative activities. Therefore, the presence of prevention strategies opens up the probability of recognizing a sequence of innovative practices (Crossan and Apaydin, 2010).

The enhancement of cumulativeness and appropriability conditions in a firm-level would ultimately lead to a potent and relatively stable innovators' population. Based on the literature findings on the appropriability, the researcher identified that the probability has been defined in previous researches as the innovation protection from the imitators. It is due to the cases that have long been recognized when the innovating companies were losing out customers in the commercialization race to the imitators. In order to tackle this issue, various perspectives from different angles have been studied on the incompetence of an innovative company to restore its investment in innovation which known as the problem of appropriability (Paula and Da Silva, 2019). According to Montero et al. (2017), it is prevalent these days for those company that initiates the new product into the market (the innovators) to accept or realize with the facts that the return of profits for imitators or competitors is much better than the early pioneer. Sabatier and Chollet (2017) also clarifying that pioneering investment due to financial uncertainty, market, and techniques are highly risky and their attempts for new market creation, however, facilitate those who imitate gain more the advantages especially the quick follower. So, instead of investing in technology and market experiments, it is an economic benefit to imitators since they can let the pioneer to clearly identify the cohesive plan first and so they will have lower costs for the same actions (Gaubinger et al., 2018).

Besides, a better recommendation suggested by Filippetti and D'Ippolito (2017) based on the company's level of appropriability. If the degree is high for appropriability, companies would still have time to improve the idea, experiment with effective design research, and gain advantages of any technological success. Just as important, the innovative company should integrate laterally to create a solution thoroughly or look forward to developing a contract that solid with the complementary products' suppliers and at the same time gains abilities to patent the innovation.

3. Methods

3.1 Population and sampling of the study

This study selects a population from the Green Building Index (GBI) website directory. The GBI is an entity in Malaysia owned by Persatuan Arketik Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM), to administrate GBI accreditation and training of GBI Facilitators and Certifiers. Based on GBI-certified buildings in Malaysia, the study found 226 total certified green buildings. Thus, this population was based on GBI's progress updates released at the time of

research. Table 1 shows the categories of building certified by GBI.

Table 1: Building category certified by GBI

#	**Category of buildings**	**Number of certified buildings**
1.	Non-residential new construction (NRNC)	41
2.	Industrial existing building (IEB)	6
3.	Industrial new construction (INC)	15
4.	Non-residential existing building (NREB)	17
5.	Residential new construction (RNC)	130
6.	Interiors	3
7.	Township	14
	Total certified building	226

Source: *extracted from GBI website (https://www.greenbuildingindex.org/how-gbi-works/gbi-certified-buildings/)*

This study employed the probability sampling design known as simple random sampling. The motivation of employing simple random sampling is that it reduces bias by giving an equal and independent chance to every member of the population in which it was drawn (Kumar et al. 2013). Simple random sampling was applied to select the respondents based on the directory records. The study randomly finds the sampling unit was to visit the GBI directory website to obtain data such as a full address, name of the company, type of industry, email address, telephone number, and contact person. Meanwhile, Based on GBI's population, the number of certified is 226 buildings, thus, the study refers to Krejcie and Morgan's (1970) sample size table to determine an appropriate sample size. Hence, the study considered 230 known populations based on the sample size table, the minimum required for the main survey is 144 samples. Based on the source of the sample (GBI website), the study obtained 144 respondents who participated in the main survey. Therefore, the study achieved minimum standards of sample size.

3.2 Exploratory factor analysis

Factor analysis is commonly used in the areas of psychology and education (Hogarty et al., 2005) and is considered the method of choice for interpreting self-reporting questionnaires (Bryant et al., 1999). The measurement tools used in this study are collecting data through a questionnaire, and this is suitable for the study. The study analysed the variables by using exploratory factor analysis (EFA). In EFA, researchers have no expectations of the number or nature of the variables, and as the title suggests, the method is exploratory in nature (Williams et al., 2010). Thus, it allows researchers to explore the main dimensions to generate a theory or model from a relatively large set of latent constructs often represented by a set of items (Pett et al., 2003; Swisher et al., 2004; Thompson, 2007; Henson and Roberts, 2006). The goal of EFA is to reduce a large number of variables to a smaller set of underlying factors which categorize and summarize the essential information contained in the variables (Dobni, 2008). Moreover, Kaiser-Meyer-Olkin measure of sampling adequacy (KMO-MSA) and Bartlett's test of sphericity should be used to access the suitability of sample size for factor analysis (Williams et al., 2010). The KMO index rages from 0 to 1, with 0.50 considered suitable for factor analysis, and Bartlett's test of sphericity should be significant ($p<0.05$) for factor analysis to be suitable (Hair et al., 1995; Tabachnick et al., 2007).

For structuring the factor, the study must extract factors to analyse the sufficiency of the factor loading. The most commonly used extraction methods is principal component analysis (PCA) (Thompson, 2007; Henson and Roberts, 2006; Tabachnick et al., 2007). PCA's key advantages are its low noise sensitively, the decreased requirement for capacity and memory and increased efficiency because the process takes place in smaller dimensions (Karamizadeh et al., 2013). Thompson (2007) noted that PCA is the default method in many

statistical programs and thus is most commonly used in EFA. However, PCA is also recommended when no prior theory or model exists (Gorsuch, 1983). Pett et al. (2003) suggested using PCA in establishing preliminary solutions in EFA. Meanwhile, the rotation method is a technique used to decide the number of factors that might be related to more than one factor. Orthogonal varimax rotation, first developed by Thompson, is the most commonly used rotational technique in factor analysis (Thompson, 2007). According to Costello and Osborne (2005), orthogonal rotation produces uncorrelated structures, whereas oblique rotation produces a correlated factor which is often seen as a more accurate result. Regardless of which rotation method is used, the main objectives are to provide an easier interpretation of results and produce a solution that is more parsimonious (Hair et al., 1995; Kieffer, 1999). Thus, EFA was conducted to fulfil research objective.

4. Results and discussions

The study justified why EFA is conducted. In this section the study presented the result and discussion of the EFA whereby to address the research objective.

4.1 Analysis of characteristics of LLMTG

Table 2 shows KMO-MSA and Bartlett's test of sphericity for characteristics of LLMTG factors. KMO-MSA showed the value above 0.50 which was 0.657. Thus, variables value of characteristics of LLMTG factors was accepted because the value was greater than 0.50. Furthermore, Bartlett's test of sphericity showed p-value less than 0.05 which is this factor was significant for factor analysis.

Meanwhile, Table 3 shows analysis of EFA. The results show that five factors which collectively explained 76.07% of the variance. Factor 1, with eigenvalue of 6.77, captured seven items that counted for 32.22% of the variance. The items loaded on the first factor show good factor loadings, ranging from 0.639 to 0.877 and communalities ranging from 0.668 to 0.889. The first factor portrays a cluster of the relationship among attributes: "reduce utilization of energy", "better resilience of the building", "improved brightness", "environmentally product", "reliability in process of environmental", "comfortable environment" and "energy conservation". According to the factor analysis, item RA7 loaded with the highest factor loading which is 0.877 that represents energy conservation.

Factor 2, with eigenvalue of 3.18, captured three items that counted for 15.16% of the variance. However, 1 item in this factor which is CX1 was deleted due to the factor loading less than 0.50. For the second factor, the item loaded ranging from 0.781 to 0.912 and communalities ranging from 0.803 to 0.841. This factor portrays a cluster of the relationship among attributes: "adoption towards employees", "difficulty to replace existing glass" and "difficulty to maintaining the quality". The factor analysis shows that items CX3 and CX4 loaded with the highest factor loading which is 0.912 respectively that represents the difficulty in replacing the existing glass and maintaining the quality of LLMTG.

Moreover, Factor 3 with 2.34 of eigenvalue and captured four items that counted 11.16% of the variance. The third factor loaded the item ranging from 0.809 to 0.897 and communalities ranging from 0.677 to 0.984. This factor portrays a cluster of the relationship among attributes: "compatible with the organization's working environment", compatible with the changes towards LLMTG", "compatible with existing technology" and "compatible with the climate in Malaysia". The factor analysis shows that item CP1 and CP4 loaded with the highest factor loading which is 0.897 respectively that represents compatible with existing technology and compatible with the climate in Malaysia.

Meanwhile, Factor 4 with 2.08 of eigenvalue and captured three items that counted 9.89% of the variance. The fourth factor loaded the item ranging from 0.617 to 0.841 and communalities ranging from 0.783 to 0.886. This factor portrays a cluster of the relationship among attributes: "observe others company being adopting LLMTG", "observe the experience of adopting LLMTG" and "observe the benefits of LLMTG". The factor analysis shows that item OB3 loaded with the highest factor loading which is 0.841 that represents observe the benefit of adopting LLMTG by other organization.

Lastly, Factor 5 with 1.61 of eigenvalue and captured three items that counted 7.64% of the variance. The study also performed reliability test for each factor in order to test the consistency of each factor. The fifth factor loaded the item ranging from 0.596 to 0.765 and

communalities ranging from 0.670 to 0.868. This factor portrays a cluster of the relationship among attributes: "being able to try before deciding to implement", "being able to try before the company occur loss" and "being able to try to see the benefits of LLMTG". The factor analysis shows that item TR1 loaded with the highest factor loading which is 0.765 that represents the company have to try the LLMTG before deciding to implement.

The study also performed reliability test for each factor in order to test the consistency of each factor. According to Bagozzi (1994), coefficient value for Cronbach's Alpha (α) were accepted whereby the value greater than 0.60 to indicate reliability for the measurement. The first factor was 0.846, second factor was 0.770, third factor was 0.706, fourth factor was 0.709 and fifth factor was 0.726. This value is accepted, indicating reliability for this measurement.

In the theoretical fundamentals, there are five attributes in innovation characteristics founded by Roger (2003). This study utilised this theory as a characteristic of LLMTG on account of this subject as an innovation of green technology. The study tested these attributes by applying EFA in order to reduce a large number of variables to a smaller set of underlying factors that categorise and summarise the essential information contained in the variables. Thus, five main factors are perceived as characteristics of LLMTG: The relative advantage (factor 1) was found to be the most dominant in the characteristics of LLMTG, whereby it is portrayed that adoption of LLMTG will bring energy conservation to the users; Complexity (factor 2) portrayed that LLMTG is difficult to adopt, as users need to replace the existing glass and maintain the quality of the buildings; compatibility (factor 3) portrayed that LLMTG is compatible with the working environment and climate in Malaysia; observability (factor 4) portrayed that users should consider this LLMTG because the new glass technology has uncertainties. The study has found all attributes in innovation characteristics as an adoption factor that portrays characteristics of LLMTG. These results are consistent with the literature by Nørskov et al. (2015) and Choshaly (2019), whereby they take into consideration these attributes in the adoption of innovative products. Thus, relative advantage, compatibility, complexity, observability, and trialability are perceived as characteristics of LLMTG.

Table 2: KMO-MSA and Bartlett's test for characteristics of LLMTG

KMO-MSA		.657
Bartlett's test of sphericity	Approx. Chi-Square	1013.245
	df	153
	Sig.	.000

Table 3: EFA analysis for characteristics of LLMTG

Factor component	**Items**	**Factor loading**	**Communalities**	**Variance explained (%)**	**Eigenvalues**	**α**	**Cumulative of variance explained (%)**
1	RA1	0.803	0.756	32.22	6.77	0.846	76.07
	RA2	0.775	0.740				
	RA3	0.858	0.804				
	RA4	0.874	0.780				
	RA5	0.813	0.782				
	RA6	0.639	0.668				
	RA7	0.877	0.889				
2	CX1	deleted	deleted	15.16	3.18	0.770	
	CX2	0.781	0.803				
	CX3	0.912	0.841				
	CX4	0.912	0.841				

3	CP1	0.897	0.984	11.16	2.34	0.706	
	CP2	0.809	0.667				
	CP3	0.863	0.670				
	CP4	0.897	0.984				
4	OB1	0.617	0.783	9.89	2.08	0.709	
	OB2	0.784	0.852				
	OB3	0.841	0.886				
5	TR1	0.765	0.868	7.64	1.61	0.726	
	TR2	0.596	0.670				
	TR3	0.711	0.801				

Extraction method: Principal component analysis.
Rotation method: Orthogonal varimax.
Sig. factor loading values more than 0.50 acceptable based on sample size 120 (Hair et al., 2006).
Factor communalities values more than 0.60 are acceptable (Nargundkar, 2004).

4.2 Analysis of user's characteristics

Table 4 shows KMO-MSA and Bartlett's test of sphericity for these factors. KMO-MSA showed the value above 0.50 which was 0.628. Thus, variables value of user's characteristics factors was accepted because the value was greater than 0.50. Furthermore, Bartlett's test of sphericity showed p-value less than 0.05 which is this factor was significant for factor analysis.

Meanwhile, Table 5 shows analysis of EFA. The results show that four factors which collectively explained 64.10% of the variance. Factor 1, with eigenvalue of 6.18, captured six items that counted for 30.92% of the variance. The items loaded on the first factor show good factor loadings, ranging from 0.530 to 0.883 and communalities ranging from 0.654 to 0.847. The first factor portrays a cluster of the relationship among attributes: "improve energy efficiency", "concern about energy consumption", "effectiveness of communication", "minimize the use of energy" and "become an influencer to others organizations". According to the factor analysis, item CPF1 loaded with the highest factor loading which is 0.847 that represents the adoption of LLMTG can improve energy efficiency.

Factor 2, with eigenvalue of 2.86, captured five items that counted for 14.28% of the variance. The items loaded on this factor show good factor loadings, ranging from 0.556 to 0.812 and communalities ranging from 0.634 to 0.723. This factor portrays a cluster of the relationship among attributes: "offer high value for the organizations", "high-quality product", "fulfil customer needs about the green product" and "offer the uniqueness of the organization". According to the factor analysis, item ICB1 loaded with the highest factor loading which is 0.812 that represents the adoption of LLMTG can offer high value for the organizations.

Moreover, Factor 3 with 2.16 of eigenvalue and captured three items that counted 10.79% of the variance. The items loaded on this factor show good factor loadings, ranging from 0.508 to 0.928 and communalities ranging from 0.602 to 0.869. This factor portrays a cluster of the relationship among attributes: "cost reduction", "funding allocation" and "sponsorship". According to the factor analysis, items EFB2 and EFB3 loaded with the highest factor loading which is 0.926 respectively that represents the funding allocation and sponsorship.

Meanwhile, Factor 4 with 1.62 of eigenvalue and captured six items that counted 8.11% of the variance. The items loaded on this factor show good factor loadings, ranging from 0.521 to 0.783 and communalities ranging from 0.604 to 0.693. This factor portrays a cluster of the relationship among attributes: "willing to purchase", "willing to spend", "product preferring", "product comparison", "product unique" and "sustainability". According to the factor analysis, item UMI3 that loaded with the highest factor loading which is 0.783 that represents the LLMTG become the product preferring to the organizations.

The study also performed reliability test for each factor in order to test the consistency of each factor. According to Bagozzi (1994), coefficient value for α were accepted whereby the value greater than 0.60 to indicate reliability for the measurement. The

first factor was 0.862, second factor was 0.764, third factor was 0.693, and fourth factor was 0.630. This value is accepted, indicating reliability for this measurement.

The study tested these attributes by applying EFA in order to reduce a large number of variables to a smaller set of underlying factors that categorise and summarise the essential information contained in the variables. Thus, four main factors are perceived as users' characteristics: commitment to product field (factor 1) portrayed that adoption of LLMTG will improve energy efficiency for the users in Malaysia; innovation-related core benefit (factor 2) portrayed that LLMTG will offer high value for organizations; expected business benefits (factor 3) portrayed that the adoption of LLMTG will result in cost reduction and sponsorship; user-manufacturer interaction (factor 4) portrayed that the adoption of LLMTG contributes to energy efficiency. These results aligned with findings by previous studies stating that commitment to the product field (Zhang et al., 2015), innovation-related core benefit (Mao and Weathers, 2019), expected financial benefit (Anbari, 2018), and user-manufacturer interaction (Block et al. 2016) is perceived as a user's characteristics whereby associated with product innovation. Thus, commitment to the product field, innovation-related core benefit, expected financial benefit, and user-manufacturer interaction are perceived as characteristics of LLMTG.

Table 4: KMO-MSA and Bartlett's test for user's characteristics

KMO-MSA		.628
Bartlett's test of sphericity	Approx. Chi-Square	1757.398
	df	136
	Sig.	.000

Table 5: EFA analysis for user's characteristics

Factor component	**Items**	**Factor loading**	**Communalities**	**Variance explained (%)**	**Eigenvalues**	**α**	**Cumulative of variance explained (%)**
1	CPF1	0.883	0.847	30.92	6.18	0.862	64.10
	CPF2	0.864	0.843				
	CPF3	0.530	0.654				
	CPF4	0.599	0.682				
	CPF5	0.700	0.699				
	CPF6	0.867	0.800				
2	ICB1	0.812	0.723	14.28	2.86	0.764	
	ICB2	0.689	0.654				
	ICB3	0.566	0.686				
	ICB4	0.556	0.634				
	ICB5	0.751	0.702				
3	EFB1	0.508	0.602	10.79	2.16	0.693	
	EFB2	0.926	0.869				
	EFB3	0.926	0.869				
4	UMI 1	0.642	0.697	8.11	1.62	0.630	
	UMI 2	0.726	0.617				
	UMI 3	0.783	0.693				
	UMI 4	0.521	0.604				

	UMI 5	0.521	0.604				
	UMI 6	0.754	0.641				
Extraction method: Principal component analysis. Rotation method: Orthogonal varimax. Sig. factor loading values more than 0.50 acceptable based on sample size 120 (Hair et al., 2006). Factor communalities values more than 0.60 are acceptable (Nargundkar, 2004).							

4.3 Analysis of external factors

Table 6 shows KMO-MSA and Bartlett's test of sphericity for these factors. KMO-MSA showed the value above 0.50 which was 0.693. Thus, variables value of external factors was accepted because the value was greater than 0.50. Furthermore, Bartlett's test of sphericity showed p-value less than 0.05 which is this factor was significant for factor analysis.

Meanwhile, Table 7 shows analysis of EFA. The results show that three factors which collectively explained 86.59% of the variance. Factor 1, with eigenvalue of 6.12, captured five (5) items that counted for 55.67% of the variance. However, 1 item in this factor which is TO5 was deleted due to the factor loading less than 0.50. The items loaded on this factor show good factor loadings, ranging from 0.919 to 0.951 and communalities ranging from 0.922 to 0.963. The first factor portrays a cluster of the relationship among attributes: "influence of technology", "industrial opportunities", "effective innovation", "environmental interaction", "reduce risk in technology advancement" and "economic opportunities". According to the factor analysis, items TO1 and TO3 loaded with the highest factor loading which is 0.951 respectively that represents the adoption of LLMTG was influenced by technology advancement and reduce the risk in the organizations.

Factor 2, with eigenvalue of 0.96, captured two items that counted for 17.81% of the variance. The items loaded on this factor show good factor loadings, ranging from 0.709 to 0.873 and communalities ranging from 0.832 to 0.910. The first factor portrays a cluster of the relationship among attributes: "green marketing concept" and "supporting by the government". According to the factor analysis, item MD1 loaded with the highest factor loading which is 0.837 that represents the adoption of LLMTG was influenced by the green concept of marketing.

Lastly, Factor 3 with 1.44 of eigenvalue and captured three items that counted 13.11% of the variance. The items loaded on this factor show good factor loadings, ranging from 0.557 to 0.819 and communalities ranging from 0.650 to 0.701. The first factor portrays a cluster of the relationship among attributes: "green practice", "value-added in the organizations" and "appropriate with organizations resource capability". According to the factor analysis, item API3 loaded with the highest factor loading which is 0.819 that represents the adoption of LLMTG appropriate with organizations resource capability.

The study also performed reliability test for each factor in order to test the consistency of each factor. According to Bagozzi (1994), coefficient value for α were accepted whereby the value greater than 0.60 to indicate reliability for the measurement. The first factor was 0.904, second factor was 0.799, and third factor was 0.755. This value is accepted, indicating reliability for this measurement.

The study tested these attributes by applying EFA in order to reduce a large number of variables to a smaller set of underlying factors that categorise and summarise the essential information contained in the variables. Thus, three main factors are perceived as external factors: Technological opportunities (factor 1) were found to be the most dominant in the users' characteristics, whereby it is portrayed that the users intend to adopt LLMTG based on the influence of technology and effective innovation; market demand condition (factor 2) portrayed that the users intend to adopt LLMTG based on green marketing concepts; and appropriability (factor 3) portrayed that the adoption of LLMTG is appropriate with organizations' resource capability. These results aligned with findings by previous studies stating that technological opportunities (Lee, 2015), market demand conditions (Boon and Edler, 2018), and appropriability (Miozzo et al., 2016) are

perceived as external factors that are associated with product innovation. Thus, technological opportunities, market demand conditions, and appropriability are perceived as external factors.

Table 6: KMO-MSA and Bartlett's test for external factors

KMO-MSA		.693
Bartlett's test of sphericity	Approx. Chi-Square	1990.301
	df	153
	Sig.	.000

Table 7: EFA analysis for external factors

Factor component	Items	Factor loading	Communalities	Variance explained (%)	Eigenvalues	α	Cumulative of variance explained (%)
1	TO1	0.951	0.963	55.67	6.12	0.904	86.60
	TO2	0.919	0.922				
	TO3	0.951	0.963				
	TO4	0.919	0.922				
	TO5	deleted	deleted				
	TO6	0.930	0.927				
2	MD1	0.873	0.910	17.81	1.96	0.799	
	MD2	0.709	0.832				
3	API1	0.557	0.650	13.11	1.44	0.755	
	API2	0.712	0.690				
	API3	0.819	0.701				

Extraction method: Principal component analysis.
Rotation method: Orthogonal varimax.
Sig. factor loading values more than 0.50 acceptable based on sample size 120 (Hair et al., 2006).
Factor communalities values more than 0.60 are acceptable (Nargundkar, 2004).

5. Conclusions

The result from EFA shows that factors perceived as characteristics of LLMTG are relative advantage, complexity, compatibility, observability, and trialability. Moreover, factors perceived as users' characteristics are commitment to the product field, innovation-related core benefit, expected financial benefit, and user-manufacturer interaction. Lastly, factors perceived as external factors are technological opportunity, market demand conditions, and appropriability.

Thus, this study contributes to a new knowledge of innovation characteristics by applied LLMTG as a subject of innovation. Although the common term used by scholars is energy saving glass, the study decided to rebrand the term become low loss microwave transmission glass as both are actually the same glass, due to lowering the loss of energy transmitted by the glass. LLMTG is a new innovation whereby the potential user doesn't have any knowledge about this kind of innovation. By applying innovation characteristics by Roger, the study has found all the attributes perceived as an innovation characteristic on LLMTG.

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