

FACTORS AFFECTING ENERGY CONSUMPTION OF COMMERCIAL BUILDINGS IN SRI LANKA

ALAHAKOON. S.S.¹, SILVA H.A.L.V.^{2*} & KULATUNGA U.³

^{1,2,3}University of Moratuwa, Katubedda, Sri Lanka

¹shashikasathsarani22@gmail.com, ²mashal.silva@gmail.com, ³ukulatunga@uom.lk

Abstract: With the expansion and development of Sri Lanka's economic practices and the modernization, client expectations for commercial building facilities have tremendously enhanced. Therefore, commercial building management has more focused on providing more effective and efficient buildings facilities to satisfy varied client requirements. Hence, commercial buildings need to consume a huge amount of energy to provide these facilities. However high energy consumption has caused to increase the energy cost, which takes a large proportion of the operation cost of commercial buildings. Ultimately all these causes adversely impact on the profit and the overall financial performance of the commercial buildings. Therefore, identification of main affecting ices which utilize energy mostly and factors effecting for the energy consumption by different building services is highly required for commercial buildings to gain economic advantage and to be sustainable firms. Through conducting a comprehensive literature review, the energy consumption of commercial buildings, energy management, including benefits of using energy management have been reviewed. Subsequently, a qualitative research choice was used to achieve the research aim. Semi-structured interviews were accompanied with 20 participants who are working in commercial buildings who are working in building management department and financial department respondents. Collected data were analyzed using manual content analysis technique. The empirical findings revealed the challenges of high energy consumption and reasons for growing energy consumption in commercial buildings. Further, widely used energy sources in commercial buildings were and finally, factors effecting on the energy consumption of commercial buildings in Sri Lanka were identified.

Keywords: *Energy management, Energy cost, Operation cost, Energy consumption*

1. Introduction

Energy has become one of the management resources of the organization and is systematically controlled and managed with other resources (Wongtharua, et al., 2005). Energy management comprises all the planned and implemented measures to ensure minimum energy consumption for a specified performance (Turner, 2001; Kahlenborn, Kabisch, Klein, Richter, & Schurmann, 2020). A structured, organized, and integrated energy management approach will enhance the benefits of an organization performance (Carbon Trust, 2011). In recent years, building energy efficiency has been the subject of a great deal of research since buildings consume significant amount of energy in modern society (Xu, et al., 2012). Commercial buildings have a reasonably high energy consumption and thus account for a significant 40% of energy consumption in the built environment (Hagras, et al., 2008). The commercial building sector has a major role since it represents a significant proportion of national energy consumption: 23% for Spain, 25% for Japan, 28% for China, 37% for UE, 39% for the UK, 42% for Brazil, over 47% for Botswana, 47% for Switzerland, etc. (Masoso & Grobler, 2010).

In the Sri Lankan context, it can be observed that according to the sectorial energy consumption trends, commercial buildings make a considerable contribution to the total energy consumption of the country (Samarakoon & Rajini, 2013; SLSEA, 2016). From total energy consumption of the building, 77.54% of the energy is used for air conditioning, 15.97% is used for lighting, where 2.17% and 4.32% of energy are used for lift and office equipment respectively (Pathmasiri, 2010). Geekiyana and Ramachandra (2017) have mentioned that even if operational energy demand in developed countries varies between 50-7%, in Sri Lanka, more than 75% of energy consumption is accounts into HVAC system. Moreover, as mentioned in the EIA Annual Energy Outlook (2012), space lighting, space heating, and space cooling are the main three end-uses in the business sector, accounting for half of all primary energy use. According to the findings of Usman, et al (2021) in Sri Lanka, a 1% increase in ICT usage increased energy consumption by 0.037 percent, indicating that Sri Lanka is employing energy-intensive ICT goods, which has resulted in increased energy consumption in the country. However, energy management faces different challenges to mitigate the energy consumption in buildings due to low popularity of usage of renewable energy due to high costs and the process of shifting energy generation from conventional sources to renewable energy sources involves variety of

*Corresponding author: Tel: +94 767091012 Email Address: mashal.silva@gmail.com
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societal work groups and necessitates a methodical approach to developing improved technology and raising public awareness (Al-Sallal, 2014). Due to the climate parameters, building related characteristics, occupant-related characteristics, building services related characteristics, and socio-economic and legal related characteristics are the main reasons for increasing energy consumption in Sri Lankan buildings (De Silva & Sandanayake, 2012).

Energy costs are frequently regarded as a fixed overhead by businesses, however by employing the proper energy management strategies, significant savings can be realized (Carbon Trust, 2011; Schulze, Nehler, Ottosson, & Thollander, 2016). Minoli, Sohraby, & Occhiogrosso (2017) state that energy management is where the largest operating expenditure is typically found. Energy systems are subject to high rates of optimization in terms of economic savings as the energy value varies and is influenced by a variety of factors, such as the time of day, season, and the energy source (Lazos, Sproul, & Kay, 2014). Although energy expenditures vary by industry and region, a typical company may expect to spend 5-10% of its operating costs on energy as a comparative reference number (Minoli, Sohraby, & Occhiogrosso, 2017). A major reason for businesses to manage their energy consumption is the financial benefits, including reduced price related risk exposure (EI Knowledge Service Team, 2016; Schulze, Nehler, Ottosson, & Thollander, 2016).

In the Sri Lankan context, it can be observed that according to the sectorial energy consumption trends, commercial buildings make a considerable contribution to the total energy consumption of the country (Samarakoon & Rajini, 2013; SLSEA, 2016). In addition, in Sri Lankan energy context, 2018 commercial sector energy consumption is 29% among the total consumption (Samarasekara, 2019), and from that consumes about 23% electricity (Weerasinghe, Mallawaarachchi, & De Silva, 2016). Hence, the building owners have unable to achieve expected profitability due to high energy cost. Therefore, this research has been focused to investigate the factors affecting on the energy consumption of commercial buildings in Sri Lanka.

2. Energy Consumption

2.1. GLOBAL ENERGY CONSUMPTION

Global energy consumption is continuously evolving (Tvaronaviciene, Baublys, Raudeliuniene, & Jatautaite, 2020). The planet is gradually moving into a severe energy shortage owing to a rising in energy demand relative to availability (De Silva & Sandanayake, 2012). Coyle & Simmons (2014) identified the rising life activity of the earth and global energy needs will begin to increase the world energy consumption respectively. Energy consumption is affected by a variety of social and economic influences and operators (Amasyali & El-Gohary, 2018; Belke, Dobnik, & Dreger, 2011).

Based on the findings of EIA (2019; 2020), from years 2013 to 2020 the worldwide total energy consumption has dramatically decreased and mostly used energy source was crude oil from all other energy sources and solar was the least used energy source.

Based on the findings of the EIA (2019; 2020), all regions exempt Europe make a substantial contribution to the rise in energy consumption. While Asia's Pacific region has become the world's largest contributor to energy consumption, and the African countries have been the least energy consumer.

The structure of global energy consumption will perform progressive changes, over the period up to 2040, without any dramatic changes (Kuzminov, Bereznoy, & Bakhtin, 2017). According to Tvaronaviciene, Baublys, Raudeliuniene, and Jatautaite (2020), the World Energy Council forecasts the trend of economic development and, if this occurs, global energy consumption would rise by 45%-60% (optimistic version) or 35% (pessimistic version relative to 2010) by 2030. In addition to that AGECC (2010) emphasized that according to the predictions the global economy will double in volume in the next 20 years, and that world energy demand would also rise dramatically if energy production, transmission and usage appears to be inefficient.

2.2. ENERGY CONSUMPTION IN COMMERCIAL BUILDING SECTOR

According to the U.S. Department of Commerce's (BEA, 2002), commercial buildings include office buildings, financial buildings, special care buildings, medical buildings, multi-merchandise shopping, food and beverage establishments, warehouses, and other commercial structures. The commercial building sector has consumed large electricity power produced by fossil fuels (Hong, et al., 2015; Lin & Liu, 2015). The global contribution from buildings towards energy consumption, commercial buildings, has steadily increased (Doukas, Patlitzianas, Iatropoulos, & Psarras, 2007), reaching figures between 20% and 40% in developed countries (Costa, Keane, Torrens, & Corry, 2013; Perez-Lombard, Ortiz, & Pout, 2008; WBCSD, 2009). Commercial building energy usage depends significantly on the building functionality, the behavior of the inhabitants, the environmental climate, construction materials and the operational techniques of the building (Tadokoro, 2014). In the USA, commercial buildings consume about 46% of the building energy consumption (Minoli, Sohraby, & Occhiogrosso, 2017), with a growth rate exceeding 6% and 55% of this consumption use electricity resource (Allouhi, et al., 2015). In the UK, the rate of growth in commercial energy consumption in the last 25 years has been approximately three times greater (Allouhi, et al., 2015). Furthermore, during the last 30 years, the commercial building stock in China has grown by twelve times, from 0.53 to 7.05 billion (Jiang, Wei, & Xiao, 2015). Perez-Lombard, Ortiz, & Pout (2008) highlighted that growth in population, enhancement

of building services and comfort levels, together with the rise in time spent inside buildings, have raised commercial building energy consumption.

With the consolidation of the demand for thermal comfort in developed countries, HVAC systems account for almost 50% of the energy consumed in commercial buildings (Srinivas, et al., 2012) and account for 10–20% of total energy consumption (Costa, Keane, Torrens, & Corry, 2013; Perez-Lombard, Ortiz, & Pout, 2008; Vakiloroaya, Samali, Fakhar, & Pishghadam, 2014; Zhao, Henze, Plamp, & Cushing, 2013). The tendency in energy end use in commercial building differs according to the region (Allouhi, et al., 2015). For example, in China, the largest growth occurs in the demand for lighting and other applications, such as office equipment, elevators, and other electric-powered equipment (Fridley, Zheng, & Zhou, 2008). Therefore, the commercial building sector is considered as the one of the biggest single contributors to world energy consumption (Allouhi, et al., 2015; Mattinen, et al., 2014; Santoyo-Castelazo & Azapagic, 2014; Swan & Ugursal, 2009).

2.3. ENERGY CONSUMPTION IN SRI LANKAN COMMERCIAL BUILDING SECTOR

Commercial building industry is rapidly increasing (Fernando & Jayasena, 2007; Priyantha, 2016; SSEA, 2016), with implications for energy consumption. As in most nations, the most energy-consuming sector in Sri Lanka is the commercial building industry (Fernando & Jayasena, 2007). Sri Lanka’s energy figures show that the commercial building industry has made a substantial contribution to the energy sector, beyond the manufacturing and transport industries (De Silva & Sandanayake, 2012). Also, the author stated that occupants’ behavior against energy usage has a huge effect on energy demand, and the establishment of large-scale infrastructure projects since the three decades of war lays the foundation for rising energy demand.

According to the figures from Sri Lanka, the commercial building industry is also the main contributor to the overall national energy intake (De Silva & Sandanayake, 2012; Samarasekara M. B., 2019), which in 2003, the amount of household and commercial sector usage was 51.10% relative to the other two manufacturing and transport industries, 24.41% and 24.80% respectively (Fernando & Jayasena, 2007). In 2010 commercial buildings contribution to energy consumption is approximately 48.5% and the rest of national energy consumption is contributed by transport (26.64%), industrial (24.75%) and agriculture (0.11%) sectors (SSEA, 2010). Therefore, Sri Lankan energy statistics also confirm that the commercial building sector has contributed heavily on the energy, exceeding the other major sectors of industrial, agriculture and transportation. Total energy consumption in commercial buildings can generally be categorized as shown Figure 1.

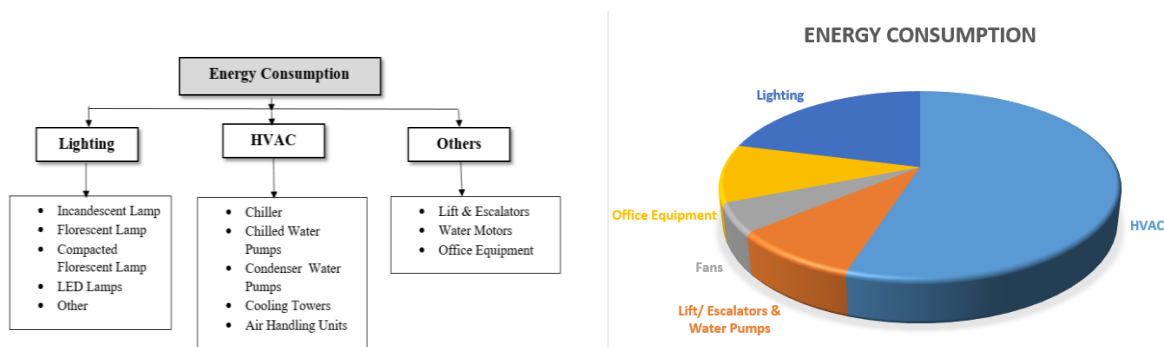


Figure 1, Common Energy Consumption Categories in Commercial Buildings (Source: Arachchi (2004))

The energy demand for the above activities may differ based on the size of the building and the number of occupants (Arachchi, 2004). However most of the buildings use energy in the form of electrical energy only and higher percentage of that is consumed for air conditioning (De Silva & Sandanayake, 2012) and lighting (John, Steve, & Francis, 2000; SSEA, 2008; Priyantha, 2016; SSEA, 2016). For most of the high-rise buildings for Sri Lanka, energy prices are typically 50% of the monthly operational expenditure (Mendis, 2003).

3. Energy Management

The challenges of sustainability in terms of energy and environment are tremendous (Allouhi, et al., 2015; Dovi, Friedler, Huisingsh, & Klemes, 2009; Van - Vuuren, et al., 2012). Furthermore, in due to the growing tendency in building energy consumption, decision-makers and public authorities around the world have embraced policies and measures directed at minimizing energy usage and encouraging energy efficiency in buildings (Bull, Chang, & Fleming, 2012; Mardookhy, Sawhney, Ji, Zhu, & Zhou, 2014; Painuly, Park, Lee, & Noh, 2003). Respectively, more effective utilization of energy is essential because improved exposure to energy management is a major concern (Goldemberg & Johansson, 2004).

Energy management is described in literature in numerous ways, in generation to generation. Energy management 'as applicable both to resources and to the supply, processing, and electricity consumption. This basically involves monitoring, measurement, recording, analysis, and critical examination, controlling and

transferring energy and material flows via systems ensure that the minimum amount of power is expended to reach valuable goals (O'Callaghan & Probert, 1977). Obviously, energy management involves all initiatives which could affect energy demand, such as actions to resist inefficient energy consumption and steps to minimize the energy consumption (Lefurgy, et al., 2003; Miceli, 2013) and enhancing energy performance (Lefurgy, et al., 2003) with optimizing the energy use (Lee, Teng, Fan, Yang, & Horng, 2011). Energy management emphasizes on the introduction of energy-efficient systems, the removal of obsolete machinery and the preservation of technology (Carbon Trust, 2011; Backlund, Thollander, Palm, & Ottosson, 2012). It is a series of strategies intended to ensure minimum energy consumption, although the degree of comfort and output maintains the same (Anvari, Monsef, & Rahimi, 2015).

3.1. BENEFITS OF ENERGY MANAGEMENT IN COMMERCIAL BUILDING SECTOR

Increasing energy efficiency is one of the most important directions for sustainable economic development in all states, economic and social structures, ensuring fulfillment of the expectations of human existence (Tvaronaviciene, Baublys, Raudeliuniene, & Jatautaite, 2020). Also, energy management increases the performance and productivity of the workplace, but it is difficult to measure, which leads to adding economic value to the building operation (Priyantha, 2016). Building energy management directly applies to the comfort of the occupants (Fan, Xiao, Madsen, & Wang, 2015). The study further concludes that energy efficiency saves money, lower carbon emissions and decreases country's dependence on foreign energy supplies (Karanfil & Li, 2015). Energy management can be beneficial for economic, environmental, or societal reasons (Christoffersen, Larsen, & Togeby, 2006; Kannan & Boie, 2003) is essential to the national security, protection of the environment and economic growth (Turner, 2001). Energy management output and other critical results such as expense, availability, flexibility, distribution quality and time must be considered simultaneously (Schonsleben, 2007). Improving the energy performance of buildings will decrease electricity consumption by up to 90%, help lower operating costs, minimize carbon pollution, increase indoor air quality, and keep residents safe and productive (Lucon, et al., 2014). Moreover, optimizing the energy usage of a commercial building will reduce operational costs and increase profitability (Harvey, 2009). Energy management is a crucial element in meeting ambitious sustainable development targets and practices relevant to air pollution and climate change (European Community, 2006). It applies to the elimination of CO₂ emission (Bunse, Vodicka, Schonsleben, Brühlhart, & Ernst, 2011; Miceli, 2013) and greatly decreases other global greenhouse gas (GHG) emissions (Bunse, Vodicka, Schonsleben, Brühlhart, & Ernst, 2011). Turner (2001) revealed that energy management helps improve environmental quality.

Building energy management is used to enhance indoor environmental conditions with minimal energy requirements (Rojchaya & Konghirun, 2009; Priyantha, 2016). Bunse, Vodicka, Schonsleben, Brühlhart, and Ernst (2011) stated that customers change their buying behavior when it comes to 'green' and energy-efficient brands, companies and end-users recognize energy efficiency at the product utilization stage to be an essential factor for their buying decisions. More consumers would like to buy 'green products' produced in an environmentally friendly manner (Manget, Roche, & Munnich, 2009). Various standards motivate organizations to utilize their energy more efficiently (Jovanovic & Filipovic, 2016). Corporations that strengthen their energy efficiency and thus their carbon footprint will increase their ability to cope with threats and costs arising from existing and potential CO₂ regulations (Bunse, Vodicka, Schonsleben, Brühlhart, & Ernst, 2011; Zhao, Yin, & Zhao, 2016).

3.2. ENERGY MANAGEMENT APPROACHES IN COMMERCIAL BUILDINGS

Many of the organizations, particularly in the commercial building industry, are searching for effective options to manage the energy usage of buildings, among other structures, as a major energy user (Liang, Peng, & Shen, 2016; Weerasinghe, Mallawaarachchi, & De Silva, 2016; Bertone, et al., 2018). According to demand side Control, energy usage in this field can be limited by introducing different energy efficiency measures over the building life cycle (Fernando & Jayasena, 2007). Much research has demonstrated that there are a variety of key approaches to implementing and enhancing energy management in commercial buildings (Chidiac, Catania, Morofsky, & Foo, 2011; Sesana, Grecchi, Salvalai, & Rasica, 2016) throughout the evolution of energy management approaches (Ionescu, Baracu, Vlad, Necula, & Badea, 2015). Among those some of the most popular concepts are green building, (Allen, et al., 2015; Dwaikat & Ali, 2016), net zero energy building (AlAjmi, Abou-Ziyan, & Ghoneim, 2016; Sun, 2015) and smart building (Jia, Komeily, Wang, & Srinivasan, 2019; Sembroiz, Careglio, Ricciardi, & Fiore, 2018).

4. Factors affecting energy consumption in commercial building sector

Since the industrialization, energy has mainly obtained from natural energy flows and human and animal power (Bhattacharyya, 2011). As civilizations evolved, increasing human population, urbanization, and modernization the demand for energy progressively increased by creating energy as one of the fundamental human needs (Asif & Muneer, 2007). Addition to above factors industrial expansion, mechanization and automation of manufacturing operations, increased transportation, the demand of superior working environments and higher demands of comfort and other factors have led to rising energy requirements (Coyle & Simmons, 2014; Tvaronaviciene, Baublys, Raudeliuniene, & Jatautaite, 2020). Due to that energy has been a pillar of exponential economic development and globalization over the last century (Coyle & Simmons, 2014). This is due to the crucial role of energy in the daily life of any person, and to its significance as a primary input into manufacturing processes that turn raw materials into final products (Bhattacharyya, 2011).

However, the globe is rapidly moving towards a serious energy crisis, with an ever-increasing demand for energy rising beyond its supply (Manieniyana, Thambidurai, & Selvakumar, 2009; Bhattacharyya, 2011; Cherp, Jewell, & Goldthau, 2011; Holmberg & Erdemir, 2017). Energy systems face numerous serious challenges include increasingly growing energy demand in the response to rising regional depletion of the existing reserves of fossil fuels; the require reducing the effect of energy systems on the climate; and the absence of access to modern sources of energy for billions of people (IEA, 2009; AGECC, 2010; IEA, 2014). There are four major concerns regarding fossil fuels, such as the exhaustion of fossil fuel supplies, global warming, energy security issues and increasing energy costs (Asif & Muneer, 2007; Karlsson-Vinkhuyzen, 2010). In fact, researchers have discovered that that increasing energy consumption has a significant effect on environmental pollution (Goldemberg & Johansson, 2004; Asif & Muneer, 2007; Manieniyana, Thambidurai, & Selvakumar, 2009; Bhattacharyya, 2011; Allouhi, et al., 2015), and have a major effect on climate change (Goldemberg & Johansson, 2004), which in the long run would contribute to a harmful rise in global temperature (Cherp, Jewell, & Goldthau, 2011; Tvaronavičienė, Baublys, Raudeliūnienė, & Jatautaite, 2020). Tvaronavičienė, Baublys, Raudeliūnienė, & Jatautaite (2020) reported, if existing patterns prevail, greenhouse gasses will grow to 43.1 Gt or 38% by 2035. A considerable number of researchers have observed a positive and noticeable relationship between energy consumption and CO2 emission (Pao & Tsai, 2010; Nasir & Ur Rehman, 2011; Sharif, 2011; Sharma S. S., 2011; Saboori, Sapri, & Bin Baba, 2014; Allouhi, et al., 2015; Hostettler, 2015; Qureshi, Rasli, & Zaman, 2016). According to the Cherp, Jewell, & Goldthau (2011) each of the above issues are massive, immediate, global-wide, and systemic.

5. Data collection

The focus of this study was to identify the main factors effecting the energy consumption of commercial buildings in Sri Lanka in order to gain economic advantage to the owners of the commercial buildings. The data collection was conducted under interpretivism research philosophy and using an inductive research approach since the research required qualitative data to fulfill the research objectives. Qualitative data collection method was utilized and accordingly, interviews were undertaken to collect their views and experiences on energy use of commercial buildings in Sri Lanka. Purposive sampling was used to select interviewees as they entail the researcher utilizing their discretion to select a sample that is most appropriate for testing purposes (Sharma, 2017). Twenty (20) interviewees who are involved in the current energy management process of commercial buildings, at both the employee and managerial level, were chosen from building management teams and finance management teams to collect data. Interviewees were chosen based on their function in the energy management of the commercial building. The profile of the interviewees is set out in Table 1.

Table 1: Profile of the Respondents

Respondent	Designation	Work experience
IR1	Head of Facilities Manager	11 Years
IR2	Electrical Engineer	15 Years
IR3	Mechanical Engineer	12 Years
IR4	Electrical Supervisor	33 Years
IR5	Mechanical Supervisor	27 Years
IR6	BMS Operator	25 Years
IR7	Electrical Technician	13 Years
IR8	Mechanical Technician	12 Years
IR9	Senior Finance Manager	12 Years
IR10	Assistant Manager Finance	17 Years
IR11	Head of Operations	22 Years
IR12	Assist. Facility Manager	16 Years
IR13	Facility Manager Hard Services	10 Years
IR14	Shit Engineer 1	8 Years
IR15	Shit Engineer 2	6 Years
IR16	BMS Operator	6 Years
IR17	Electrical Technician	11 Years
IR18	Electrical Technician	7 Years
IR19	Mechanical Technician	13 Years
IR20	Senior Finance Executive	5 Years

6. Data Analysis

In order to find the factors affecting for the energy consumption in commercial buildings in Sri Lanka, challenges of energy management in commercial buildings in Sri Lanka, primary building services that utilizes more energy in Sri Lankan commercial buildings, and reasons for growing energy consumption in commercial buildings were analyzed using the data collected from the semi-structured interviews. Based on the findings, main factors affecting the energy consumption of Sri Lankan commercial building sector were summarized.

6.1. CHALLENGES OF ENERGY MANAGEMENT IN COMMERCIAL BUILDINGS IN SRI LANKA

The researcher noted several key points relating to the challenges of energy consumption in the literature. The foremost challenge that relates to Sri Lanka's commercial buildings was explored with rationalization.

In the interview, IR1 asserted that the consumption of energy in commercial buildings is challenging to comprehend owing to the broad variety of building uses and owners, differentiation in the size and complexity of building energy systems, discrepancies in the operation of the energy system as well as other considerations. He further emphasized that "Increasing energy costs and sustainability expectations are key challenges that drive them to strengthen the energy efficiency of their organizations". With respect to the interview conducted with IR12, his idea was supported to the opinion of IR1 that "...because of the lack of capacity and facilities in Sri Lanka's power plants, the government would not be able to supply the required level of energy and that would lead to an increase in energy costs, which would be extremely troublesome with the managing of energy consumption of country's commercial building industry". Further, IR15 has commented the same fact that energy consumption of commercial building in Sri Lanka would be one of the major problems in building management, due to low resources and facilities with the country and which cause to high charges for energy utilities in Sri Lanka.

In addition, IR3 and IR15 endorsed the statement of IR1, noting that commercial buildings' energy usage is enormously contributing to the rise in greenhouse gas emissions. Besides that, IR11 commented that "...while it might not be noticeable, there is a clear correlation between energy consumption and the environment". Moreover, he explained that once buildings consume less energy, it helps to decrease the volume of poisonous fumes emitted by power plants, preserve the planet's natural resources, and protect biodiversity from deterioration. By implementing action to lessen energy consumption, it would prompt a healthy world.

Considering the views of the interviewees, it can be argued that high energy costs and environmental pollution would be the key two challenges to the energy consumption in the commercial building sector in Sri Lanka. Moreover, all the interviewees were highly concerned about higher energy cost in Sri Lanka when considering the challenges in energy consumption of the commercial building. In addition, some of the respondents reported the environmental pollution challenge due to high energy usage in commercial buildings. The peculiarity here is that the many of participants who discussed environmental destruction were only employees at the executive level.

Nevertheless, as per literature, detrimental environmental effects have become the most widely discussed energy consumption challenges in the global context. In fact, many researchers such as Allouhi, et al. (2015), Manienyan, Thambidurai, & Selvakumar (2009), Goldemberg & Johansson (2004), Asif & Muneer (2007) and Bhattacharyya (2011) have claimed that rising energy use has a major impact on environmental degradation. Further to the literature reviews, Pao & Tsai (2010), Nasir & Ur Rehman (2011), Sharif (2011), Sharma S. S. (2011), Saboori, Sapri, & Bin Baba (2014), Qureshi, Rasli, & Zaman (2016), Allouhi, et al. (2015) and Hostettler (2015) found that a positive and obvious correlation between energy consumption and greenhouse gas emissions, supporting the opinion of B2R1. The issue of high energy cost which was major issue in here also stated by Asif & Muneer (2007) and Karlsson-Vinkhuyzen (2010).

In consideration of all the above factors, the author argued that the problems of energy consumption differ with industry and country to country. Considering Sri Lanka's commercial building sector, the most tremendous energy consumption problem would be high energy costs. According to the literature findings and the data collected, the key reasoning for high energy costs would be a rapid rise in commercial building constructions and its energy demand in Sri Lanka due to civilizations, increasing human population, urbanization, modernization and increment of human desires, but as a developing country Sri Lanka unable to provide the energy required due to lack of resources and facilities. Therefore, building managers and energy managers need to take viable measures to address this high energy cost issue.

6.2. REASONS FOR GROWING ENERGY CONSUMPTION IN COMMERCIAL BUILDINGS

As per the opinions shared by the interviewees, there are several factors that lead to a rise in energy use in commercial buildings. IR12 has reported that, due to the population and economic development, demand for energy usage in commercial buildings growing rapidly. Hence, IR14 have further opposed the fact of development of economy as "...because of the rising economy, building users are getting wealthy, their lifestyles also improve, and they are expecting more facilities from the commercial buildings as tenants, and which requires more energy to fulfill that tenant requirements". Moreover, IR4 and IR16 highlighted the same perspective as IR14 upon on reason for increasing the energy usage in commercial buildings. Further, IR1 explained in depth the population increase factor supporting the IR12 argument which was originally stated in this subsection. According to him, growing population and urbanization often means more energy consumption in commercial buildings. The population is rapidly distributed in towns and cities, speeding up the rate of urbanization. Urbanization continues to increase the need for different facilities and energy. At the same time, B1R7 demonstrated that "increasing incomes, urbanization and expanded access to energy are contributing to a rise in energy demand".

Nevertheless, some varying variables have arose from some of the respondents as follows. IR1 ascertained those numerous variables, such as climate, building envelope and energy services facilities, operation and repair

and maintenance, indoor comfort, and occupant behavior, have an impact on the energy usage of buildings. According to IR5, the operation hours in commercial buildings may be longer than conventional office buildings and there was various service insulation that required energy, such as HVAC, lighting, and even certain building facilities, which also were used a lot of energy. Further IR5 commented that, “...the buildings are used by various type of occupants throughout the day. So, we need to provide the services they expect to make them satisfied and to attract more tenants to the building. When these services are provided, the energy consumption of commercial buildings gradually increases”. Both IR8 and IR5 suggested same reason for increasing energy consumption in commercial buildings. As they stated, the growth in energy usage in commercial buildings is due to the broadened use of existing electrical equipment and various building facilities and the introduction of modern building installations.

When considering the massively utilized energy source in Sri Lankan commercial buildings, according to the knowledge and opinion of the respondents, all the respondents noted that electricity would have been the commonly used energy source and De Silva & Sandanayake (2012) revealed this statement in literature review. According to the Allouhi, et al. (2015), in USA, 55% of the energy source used for commercial buildings would be electricity. The author justified this as, electricity the highly consumed source of energy in commercial buildings in every region. However, almost all other building services in commercial buildings being powered by electricity would be the main reason for the above-mentioned statement. Furthermore, according to all the respondents, from all these systems, HVAC is the system which utilizes more electricity in commercial buildings. Also, in the literature, De Silva & Sandanayake (2012) reported that most buildings use a higher percentage of energy for the HVAC system. The sub-components within the HVAC system such as motors, fans and pumps would be one of the key reasons for high energy consumption of HVAC system. Moreover, the researcher has noted that the size of the building one of the factors to determine the energy usage level of the HVAC system. However, according to the data gathered from the interviews, HVAC systems utilize approximately 42% of the total energy used in building. Nevertheless, some commercial buildings have used more than 50% of the building's total energy consumption for HVAC.

6.3. FACTORS EFFECTING ENERGY CONSUMPTION OF COMMERCIAL BUILDINGS IN SRI LANKA

According to the literature findings and the data interpretation, there are variety of impacts on the increasing energy consumption of the commercial buildings. As a result, the above-mentioned causes for increased energy consumption in commercial buildings outlined in both the literature review and the data analysis could be summarized as following Table 2 for more comprehension.

Table 2: Factors affecting the Energy Consumption

Factors derived from literature findings	Source
Building functionality	Tadokoro (2014)
Occupant behavior	
Climate	
Construction materials	
Operational techniques of the building	
Population growth	Perez-Lombard, Ortiz & Pout (2008)
Enhancement of building services	
Increasing comfort levels	
Rise in time spent inside buildings	
Factors derived from data analysis	Source
Growing population	IR1, IR12
Economic development	IR4, IR12, IR14, IR16
Increment of tenants' requirements	IR2, IR3, IR4, IR5, IR11, IR14, IR16, IR19
Urbanization	IR1, IR7
Increasing income	IR7, IR11
Climate	IR1
Building envelope	IR1
Broadened use of existing electrical equipment and various building facilities	IR1, IR2, IR3, IR8, IR11, IR13, IR15, IR17, IR18
Operation, repair and maintenance	IR1, IR3, IR11, IR17
Indoor comfort	IR1, IR6
Occupant behavior	IR1
Long operation hours	IR5, IR6, IR19
Introduction of modern building services	IR8, IR13, IR15, IR18

Only Literature Findings
 Only Data Analysis
 Both Literature Findings and Data Analysis

As indicated in the above Table 2, the extensive use of existing electrical appliances and numerous building installations would be the cause for the rise in energy usage in commercial buildings, which was claimed by most of

the respondents. Further, this outlined in both the literature findings and the data collected from the interviews. Based on the literature and data analysis, 19 factors were identified which affects for the energy consumption of Sri Lanka. Other than the findings from the literature, economic development, increment of tenants' requirements, urbanization, increasing income, building envelope, operation, repair and maintenance, and indoor comfort are the factors effecting for the high energy consumption of commercial buildings in Sri Lanka. Factors such as climate, broadened use of existing electrical equipment and various building facilities, occupant behaviour, long operation hours, and introduction of modern building services are the other factors of effecting energy consumption of commercial buildings in Sri Lanka which were confirmed from both the literature findings and data analysis.

According to Yau and Hasbi (2012), buildings in areas where temperatures are expected to rise will typically require more cooling and less heating load and it is anticipated that during the building's operational phase, energy use and carbon emissions will increase.

Moreover, as mentioned by Wang, et al. (2013), actual energy use depends on human habits, a building's physical layout, and its electrical and mechanical systems and the building's energy asset remains largely stable until building retrofit, even though inhabitants and their energy consumption habits may alter often. Depending on how a building is utilized or run, these components, such as the building envelope (roof, walls, and windows), lighting, service hot water, and heating, cooling, and air conditioning (HVAC) systems, have a big impact on how well it performs. In the world, building occupants are driven to utilize the systems exactly as they were intended to be used and have a basic understanding of how they operate. However, there is a lot of evidence to suggest that users aren't taking full use of the systems in buildings because they don't understand how they work (Karjalainen, 2016). Therefore, occupant behaviour is highly effected factor on energy consumption of commercial building projects (Karjalainen, 2016; Menezes, et al., 2012; Pan, et al., 2016).

7. Conclusion

Presently, high energy consumption has become a serious concern of the world, due to the consequences of high energy costs, depletion of energy sources, environmental degradation and so on. Compared to developed countries, developing countries like Sri Lanka primarily suffering from high energy cost, due to the lack of adaptation of advanced energy management technologies. As a result, cost for energy consumption has been dramatically increased over the past years in Sri Lanka, where commercial buildings contribute high part of the energy consumption in Sri Lanka. Therefore, the study aimed to explore the factors affecting for the energy consumption of commercial buildings in Sri Lanka has been accomplished.

Both literature findings and data collected through interviews have been contributed to identify that Sri Lanka commercial building sector has made a considerable contribution to the total energy consumption of the country. In addition, electrical energy would be the highly consuming energy source for this sector and most of this power is used for HVAC. Data collection and data analysis revealed that high energy cost would be the major challenge in the Sri Lankan commercial building context. Therefore, energy consumption of commercial building projects by different building services was analyzed and factors affecting the energy consumption of commercial building projects in Sri Lanka was identified by analyzing both literature and data collected through the semi-structured interviews.

According to the findings of literature and data collection, building functionality, occupant behavior, climate, construction materials, operational techniques of the building, population growth, enhancement of building services, increasing comfort levels, rise in time spent inside buildings, growing population, economic development, increment of tenants' requirements, urbanization, increasing income, building envelope, broadened use of existing electrical equipment and various building facilities, operation, repair and maintenance, indoor comfort, long operation hours and introduction of modern building services are the 19 factors which have been recognized as the factors impact on the rising energy consumption of commercial buildings in Sri Lanka. Further, the analysis confirmed that HVAC system is the most energy-consuming commercial building service installation in Sri Lankan commercial buildings.

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